Final category: Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

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An update on the satellite interference to dark skies

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

This talk will focus on the satellite threat to observational astronomy. As a member of the Satellite constellation Working Group: Observatories sub group a recommendation was drafted for the Dark and Quiet Skies 2 Report, which shall be discussed. I shall also discuss the SatHub and the Education of observers about satellite constellations for regular citizens, amateur astronomers and professional astronomers and the Outreach activities planned. A recent update on the present status will be presented.

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SIRI: A Risk Assessment Tool for Satellite Interference on Ground-Based Astronomy

Emma Louden

Yale University

Abstract

Ground-based telescopes have long been pivotal, generating the majority of astronomical data by volume and coverage. However, the influx of satellites is reshaping ground-based astronomy. Satellites now streak across once-clear fields of view, disrupting radio signals. In 2010, there were fewer than 1,000 satellites; by September 2023, there were over 9,000. This rise concerns astronomers, particularly with the impending launch of around 500,000 more satellites alongside the development of 30-meter, billion-dollar telescopes. The increasing saturation of our skies with artificial satellites threatens the functionality of ground-based observatories. To address this, we propose a proactive measure: identifying the most vulnerable ground-based astronomy cases and developing a ranking system to prioritize resource allocation. By determining which scientific investigations are most at risk from planned satellite constellations, we can prioritize the development of solutions, such as new space-based telescopes or advanced mitigation strategies. Our risk matrix, the Satellite Interference Risk Index (SIRI), categorizes ground-based astronomical cases based on threat level, mitigation abilities, and importance to the scientific community. This ranking system will inform policy decisions, helping space agencies and funding bodies decide which ground-based projects to continue funding, which projects will require space-based alternatives, and which ground-based instruments and observatories most need mitigation techniques.

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The IAU Centre for the Protection of Dark and Quiet Skies Industry and Technology Hub - an update

Tim Stevenson[1], Patricia Cooper[2], Chris Hofer[3]

[1]SKAO. [2]Constellation Advisory, LLC. [3]Amazon Project Kuiper

Abstract

The Industry and Technology Hub of the IAU CPS has a number of functions in providing an interface to the satellite industry - operators and manufacturers (both systems and technology). Firstly, the Hub is an 'attractant' to bring industry stakeholders to the CPS and its Hubs and to promote common understanding of both the problem of dark and quiet sky and the potential solutions. Secondly, the I&T Hub offers support to industry in a number of ways, including briefings, background documents and active support in the form of Astronomer guides. Thirdly, the Hub meets a need for industry players to share experiences amongst themselves in terms of the efficacy of solutions and how to take dark and quiet sky considerations into account in design, mission planning and operations. Finally, the Hub is promoting the necessary research into further solutions both for the deleterious optical/infra-red effects and into mitigations in the radio wavelengths.

The Hub actively seeks out industry participation, and has been highly successful in attracting major actors and getting them to interact, begin to contribute to wider CPS activities such as observation campaigns and to share the understanding of the threats to ground based astronomy in order to address them.

This contribution provides an update to the work of the I&T Hub and looks forward to further developments in mitigations.

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SpaceAble and the Dark Sky: Sky observation by and for citizen astronomers

Dr Cantegreil Julien[1], Yannis Zancanaro[1], Pr. Dr. Zouhair Benkhaldoun[2,3], Dr Franck Marchis[4,5], Dr Abdelkarim Boskri[2,3,1], Dr Raoul Canameras[6], Dr Tom Esposito[4,5], Dr Morgan Gray[6], Dr Ryan Lambert[4,5], Dr Pierre Janin-Potiron[6], Dr Benoit Neichel[6]

[1]SpaceAble. [2]Oukaïmeden Observatory. [3]Cadi Ayyad University. [4]SETI. [5]Unistellar. [6]Laboratoire d'Astrophysique de Marseille

Abstract

The proliferation of satellite constellations in orbit poses significant challenges to ground-based astronomical observations and space sustainability. Collaboration between institutional and private entities is essential to address the light pollution generated by these satellites, spanning from optical to radio frequencies, and mitigate debris impact on space operations.

To mitigate this pollution, accurate tracking of orbiting objects is crucial. SpaceAble, a French startup specializing in Space Situational Awareness (SSA), is developing a scalable optical sensor network to improve the accuracy of orbit predictions. Partnering with organizations like the IAU-CPS since 2022 and collaborating with citizen astronomers, SpaceAble aims to establish a global community dedicated to safeguarding space observation.

SpaceAble's initiatives include joining the France 2030 funding program with the DOSSA project - Decentralization of Space Situational Awareness, in partnership with Unistellar, to develop remote telescope control and image processing capabilities. DOSSA is also a collaboration with academic institutions like the Laboratoire d'Astrophysique de Marseille and Cadi Ayyad University, to enhance detection algorithms to improve sensitivity to smaller objects with deep-learning techniques.Furthermore, SpaceAble is working on commercializing standardized data for space traffic management and space weather, catering to both institutional and private sector needs.

This session provides an opportunity to showcase the progress and commitments of this international collaboration, inviting additional observatories to join efforts under the IAU-CPS to address orbiting object pollution for ground-based observations.

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Project West Ford, the IAU's response, and the framing of the Outer Space Treaty 1961–1967

Dr John Barentine

Dark Sky Consulting, LLC

Abstract

Since the dawn of the Space Age, astronomers have contended with uses of outer space that sometimes conflict with their research goals and priorities. Military users in particular created early friction with the astronomical community as exemplified by the U.S. military program known as 'Project West Ford' (PWF). Against the backdrop of the emergent Cold War, the U.S. tested an 'artificial ionosphere' for radio propagation by placing thousands of copper dipoles into an orbiting belt. Despite the relative openness with which the U.S. conducted PWF, astronomers worried that the experiment would adversely impact ground-based (and future space-based) astronomy. The IAU expressed serious concerns about the planned PWF test at the XIth General Assembly, "warning of the grave moral and material consequences which could stem from a disregard of the future of astronomical progress". While PWF ultimately did no harm to astronomy, the affair informed the framing of Article IX of the Outer Space Treaty, which requires launching states to exercise "due regard" in conducting activities that could yield "potentially harmful interference with … the peaceful exploration and use of outer space". In this presentation I will review the history of PWF as it prompted astronomers of the era to react, providing important historical context for the ongoing issues involving astronomy and commercial space operators regarding large satellite constellations.

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Toward an Enhanced Civil Space Situational Awareness System Based on Compact Semi-Professional Tools for Satellite Observation and Monitoring

Mr Vladimir Pashkovsky, Mr Stanislav Karpikov

StealthTransit Laboratories, StealthTransit, Germany

Abstract

The increasing number of satellites in low Earth orbit has revealed the limitations of current Space Situational Awareness (SSA) services and tools in accurately predicting trajectories of satellites and space debris within images. Previous reports have highlighted errors in time and position calculations based on available data (NORAD, for example). There remains a shortage of public services for predicting trajectories and coordinating observations. This process involves estimating probabilities, variations in traffic density by season and location, and classifying brightness and iridescence, among other factors. A service implementing a big data approach would be suitable for all kinds of tools, including post-processing techniques, trail avoidance strategies, observation scheduling, or employing mid-exposure shuttering (following the approach proposed by StealthTransit).

The task of gathering information of hundreds of thousands objects can be done through a distributed system – data grid (Space Surveillance Grid) engaging both professional and amateur astronomers. This study analyses the requirements for such a system and discusses an approach that integrates relatively inexpensive (and thus accessible for widespread use) yet self contained tools based on individual telescopes and cameras, joined into a global data collection network.

The potential scale and parameters of such a system are examined. For instance, it could enable the creation of a real-time 2D map of the sky featuring tracked objects, with some level of estimation for the third coordinate, with the error depending of the number of devices in a given area.

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1032

Active spaceborne RFI mitigation strategy for VLBI

Matthias Schartner, Benedikt Soja

ETH Zurich

Abstract

The increase in radio frequency interference (RFI) from satellites in space is causing issues for Very Long Baseline Interferometry (VLBI) observations. In particular, satellite mega-constellations such as Starlink pose a significant threat since these satellites will emit signals in the upper-frequency range of the VLBI Global Observing System (VGOS). The power of these signals may saturate the amplifiers of VGOS antennas, causing nonlinearities within the observations.

As an active mitigation strategy, we have extended the VLBI scheduling software VieSched++ to account for satellite orbit information in the form of two-line-element (TLE) files. Based on this information, observations in the direction of potentially harmful satellites can be avoided to reduce the impact of spaceborne RFI. However, this strategy adds additional constraints to the scheduling algorithm, affecting the efficiency of VLBI observations. We will share simulation results comparing the impact of these constraints on parameter precision with and without our active avoidance approach. While our active mitigation approach helps, we will also discuss its limitations and future development steps.

Additionally, we will highlight the deployment of a user-friendly database (https://satdb.ethz.ch/) to simplify access to satellite TLE information within a specific time span and based on an observed frequency sequence. The database is publicly accessible via a web interface and an application programming interface (API).

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1130

Satellites' Radio Frequency Interference: its impact on radio astronomy.

Dr Nadeem Oozeer

South African Radio Astronomy Observatory (SARAO), Cape Town, South Africa. Centre for Radio Astronomy Techniques and Technologies, Department of Physics and Electronics, Rhodes University, South Africa

Abstract

Radio frequency Interference (RFI) is any unwanted radio signal that affects/impacts astronomical data. RFI comes from different sources, both artificial and natural. By analysing radio data from the MeerKAT, I will present the various sources of RFI around the future Square Kilometre Array (SKA) mid-site, and how it impacts radio astronomy.

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1157

Protection of Dark and Quiet Skies at the National Level: Conclusions and Recommendations

LLM. Yana Yakushina[1], Marieta Valdivia Lefort[2]

[1]University of Ghent. [2]University College London

Abstract

The protection of dark and quiet skies (D&QS) has garnered heightened attention across various regulatory levels. This surge in interest is attributed to the widespread proliferation of artificial light at night (ALAN), leading to terrestrial light pollution (LP), and separately, an escalating deployment of mega-constellation satellites in low-earth orbit (LEO), resulting in orbital light and radio spectrum pollution. Changes in nighttime brightness have resulted in complex concerns ranging from detrimental effects on astronomical observations to adverse impacts on the environment. These concerns have prompted some national states to take action to address challenges related to the disappearance of D&QS with a focus on the adoption of ground-based light and noise pollution prevention measures.

Following the preliminary work presented at the IAUS385, this presentation will introduce the final conclusions and recommendations of the research conducted by the IAU CPS Policy Hub, WP 2, National Analysis team. The team has investigated over 70 different jurisdictions worldwide to identify approaches towards protection D&QS. The presentation outlines the research methodology, delivers conclusions and recommendations, and provides illustrative examples from national regulatory frameworks. For a more comprehensive analysis, the research was focused on three primary dimensions: (1) protection of dark skies (addressing aspects of LP); (2) protection of quiet skies (addressing aspects of radio/noise pollution); and (3) satellite regulations (encompassing registration, authorization, and technological requirements). Overall, the work builds an understanding of national approaches aimed at D&QS protection and allows for the identification of potential regulatory improvements in this realm.

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1201

The scientific importance of Laser Guide Star AO Systems and impacts arising from the protection of LEO satellites.

Dr. Warren Skidmore[1], Dr. Julian Christou[2]

[1]Thirty Meter Telescope. [2]NOIRLab/Gemini Observatory

Abstract

The scientific output of ground based observatories is becoming increasingly dependent on the us use of laser support adaptive optics systems. I will show that as we move toward the era of the ELTs, the majority of the envisioned science will depend on laser guide star supported AO. Presently, any ground based observatory related to the United States is required to adhere to the US Laser Deconfliction Policy, which means that laser propagation from the ground has to stop as and when set by the Laser Clearinghouse. With the continuing rise in the number of LEO satellites, a situation will arise where laser supported adaptive optics operations will become essentially impossible. I report on efforts to evaluate the risk to space assets from astronomical lasers and moves to adapt the policies to enable laser guide star supported science by US facilities.

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1206

The IAU CPS SatHub: Updates on observation campaigns, services and software to mitigate satellite constellation interference

Dr. Siegfried Eggl[1,2], Dr. Meredith Rawls[3,2], Dr. Mike Peel[4,2], Michelle Dadighat[5,2], Dr. Constance Walker[5,2], Federico Di Vruno[6,2], Dr. Richard Green[7,2]

[1]University of Illinois at Urbana-Champaign, IL, USA. [2]IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference, 98-bis Blvd Arago, F–75014 Paris. [3]University of Washington, WA, USA. [4]Imperial College London, UK. [5]NSF NOIRLab, AZ, USA. [6]Square Kilometre Array Observatory, Lower Withington, Macclesfield, Cheshire, SK11 9FT, UK. [7]Steward Observatory, AZ, USA

Abstract

SatHub is one of the four hubs of the IAU Centre for the protection of the Dark and Quiet Sky from Satellite Constellation Interference (IAU CPS). SatHub focuses on observation campaigns, brightness data analysis and software curation to improve our understanding of the impact of satellite constellations on astronomy and observers worldwide. That includes online services hosted in concert with our contributing members that simplify satellite constellation mitigation in astronomical observation planning. In this contribution we will give a summary of services offered by SatHub and its members and discuss the current status of satellite constellation observation campaigns for several operators and across the electromagnetic spectrum. Online services such as SatChecker and the Satellite Constellation Observation REpository (SCORE) will be presented.

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Spectrum Management at ALMA

Dr Giorgio Siringo[1,2], Dr. Sean Dougherty[1]

[1]Atacama Large Millimeter/submillimeter Array - ALMA. [2]European Southern Observatory - ESO

Abstract

We present here the work carried out by the Joint ALMA Observatory Spectrum Management Office (JSMO) and its commitment to RFI protection and prevention at the ALMA site. Coordination efforts between the Chilean national radio-communication authority SubTel and the ALMA European and North American representatives in Chile in 2023 made possible a 10-year renewal of the exempt resolutions that give ALMA radio protection in a 30 km radius and coordination in a 120 km radius on Chilean territory. Thanks to the efficient collaborative relationship with SubTel, we are evaluating the possibility of extending the two areas to the neighboring territories of Argentina and Bolivia. Another topic of conversation with SubTel is to impose a minimum distance from ALMA to new satellite-constellation gateway stations installed on Chilean territory.

Our office is also involved at both national and international levels in developing synergies with groups active in the field of spectrum management, e.g. the radio committee of the SoChiAs, the multidisciplinary initiative CLEOSat, the CARF in Europe, the NRDZ in the USA. An aspect of particular importance for ALMA is the extension of the ITU Recommendations related to Radio Astronomy to cover frequencies from 275 GHz upwards , where more than 70% of ALMA's observation spectrum falls, and which is currently without any protections. We plan to maintain active participation in the preparatory work for the next WRC in 2027.

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The potential impact of satellite constellations on Cosmic Microwave Background experiments

Dr Mike Peel[1,2], Dr Dave Clements[1], Dr Allen Foster[3]

[1]Imperial College London. [2]IAU CPS. [3]Princeton

Abstract

Cosmic microwave background experiments observe large angular scale emission at extremely high sensitivity at 10-1,000GHz. At these frequencies, satellites both actively transmit (currently around 10GHz, extending up to ~200GHz in the future), and will be thermal black bodies/reflectors of thermal emission. While small numbers of satellites can be ignored as glitches, the dramatic increase in satellite numbers over recent years means this component has to be taken into account with future ground-based CMB experiments. This presentation will describe work so far to understand the effect of satellites on CMB experiments, using observations of individual satellites by the Atacama Cosmology Telescope (ACT), the South Pole Telescope (SPT), and the SCUBA-2 instrument on the James Clerk Maxwell Telescope (JCMT). The presentation will also cover the extrapolation of these observations to make predictions of the overall impact on observations by entire satellite constellations.

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Overview of ESA Space Debris Mitigation Requirements and compliance verification guidelines applied for dark and quiet skies

Dr Jan Siminski[1], Beatriz Jilete[2]

[1]ESA. [2]GMV for ESA

Abstract

The ESA Space Debris Mitigation Policy was updated in October 2023 accounting for the new ESA Zero Debris Approach. The new ESA Space Debris Mitigation standard (ESSB-ST-U-007, which exceeds the previous standard ECSS-U-AS-10C Rev.2) specifies design and operational measures that a mission needs to adopt through its lifetime to prevent space debris release and proliferation, control system break-up risk, control collision risk, control system failure risk, improve orbital clearance, assure safe re-entry and minimise impact on astronomy.

The requirements for the protection of dark and quiet skies encompass the limitation of optical and radio frequency interferences with ground and LEO astronomy, prediction and sharing of information of the brightness during the mission design, and promotion of mitigation actions.

The paper will explain in detail the new dark and quiet skies requirements included in the standard.

In addition to the mitigation standard, ESA is preparing an update to the compliance verification handbook to be released before summer 2024. The handbook provides the guidelines on verification methods (e.g. prediction of brightness during mission design phase) and recommend mitigation measures in support to ESA missions to facilitate the compliance with the ESA Space Debris Mitigation requirements. The new version will be aligned with the current space debris mitigation standard. The paper will give an overview on the methods, guidelines and formulas that mission developers would be required to follow in order to be compliant with the new standard.

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1579

List of radio astronomy stations as a database for sharing and compatibility studies

Mr Boris Sorokin[1,2], Mr. Federico Di Vruno[1,2], Mr Mike Peel[3,2]

[1]Square Kilometre Array Observatory. [2]IAU CPS. [3]Imperial College London

Abstract

In the evolving landscape of spectrum sharing between radio astronomy observatories and satellite operators, the interplay between them becomes more and more important. Historically it was national administrations to support data exchange between different radio spectrum users. However, with rapid satellite development a need for a more global approach arises.

Our discussion extends to the development and utilization of a CPS-based database, incorporating data from a snapshot of the Master International Frequency Register (MIFR) to house radio astronomy observatories' characteristics. This database not only serves as a vital resource for sharing and compatibility studies within the IAU CPS framework but also addresses gaps in existing registries by including data from unfiled observatories, like the South Pole Telescope.

Furthermore, we introduce a novel tool designed to help those with access to the ITU database, allowing for efficient retrieval of radio astronomy station data. This tool, aimed at both the radio astronomy and satellite communities, promises to streamline the process of conducting sharing and compatibility studies by providing comprehensive access to essential parameters, including station and antenna specifics, frequency bands, and operational details. This initiative represents a significant step forward in ensuring the harmonious coexistence of satellite and radio astronomy operations, bolstering the efficacy of global regulatory frameworks.

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Hunting for satellite trails in astronomical images with machine learning

Dr. Jeremy Tregloan-Reed, Ms María Romero-Colmenares

Instituto de Astronomía y Ciencias Planetarias, Universidad de Atacama

Abstract

The proliferation of Low Earth Orbit (LEO) satellite constellations raises concerns for ground-based and space-based astronomy due to their impact on the night sky. Research groups like CLEOsat and the IAU's CPS are working to quantify this impact, but doing so requires dedicated observing time, diverting resources from scientific astronomy.

This work proposes a solution using pre-existing data from wide-field surveys, which inevitably capture satellite trails. However, analyzing terabytes of data containing a mix of clear and contaminated images is computationally expensive.

We address this challenge by developing a supervised machine learning algorithm trained on datasets with equal numbers of clear and satellite trail-contaminated images. This approach leverages existing "wait and catch" observations from the CLEOsat network, ensuring balanced training sets and mitigating potential bias.

Our algorithm is currently undergoing validation on public data from WASP and HATNet, with initial results showing promising accuracy (96%). This work paves the way for utilizing machine learning to efficiently analyze existing astronomical data and alleviate the burden on dedicated observing time, ultimately aiding astronomers in understanding and mitigating the impact of LEO constellations on the night sky.

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1702

The impact of large satellite constellations on radio astronomy

Mr Federico Di Vruno

SKA Observatory

Abstract

This talk will give a broad overview of the different effects that large satellite constellations (existing and planned) can have on radio astronomy receivers and science.

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CLEOsat: Combating Satellite Constellation Impacts on Astronomy through Research, Policy, and Collaboration

Dr. Jeremy Tregloan-Reed

Instituto de Astronomía y Ciencias Planetarias, Universidad de Atacama

Abstract

The Chilean Low Earth Orbit Satellite (CLEOsat) group actively researches the impact of satellite constellations on astronomy through collaborative observational campaigns with the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS), currently focusing on AST SpaceMobile's Bluewalker 3 and Starlink V2 mini-satellites.

Additionally, CLEOsat conducts independent campaigns utilizing its network of telescopes across Chile, Spain, Mexico, Vietnam, and South Korea, aiming to characterize the multi-wavelength reflective brightness of OneWeb and Starlink satellites and assess the accuracy of supplemental Two Line Elements (TLEs) for orbit determination.

Beyond research, CLEOsat actively contributes to national and international policy and regulations. Members participate in developing regulations to minimize ground-based light pollution and protect observatories in Chile. Notably, they provide expertise and advice to the Chilean Ministry of Transport and Telecommunications regarding the licensing of ground stations used by satellite operators. Furthermore, CLEOsat members represent Chile within the IAU CPS policy hub group of friends, contributing to international dialogue and policy formation.

This multifaceted approach empowers CLEOsat to effectively address the challenges posed by satellite constellations, ensuring the continued viability of astronomical research and the protection of the night sky.

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Engaging with diverse stakeholders about satellite constellations: foundations of the CPS Community Engagement Hub

Dr John Barentine[1,2], Ms Jessica Heim[3,2]

[1]Dark Sky Consulting, LLC. [2]IAU CPS. [3]University of Southern Queensland

Abstract

Large satellite constellations are rapidly remaking the continuum of environment from Earth to space in important ways, yet the input of many affected people and groups continues to be left out of decisions affecting the uses of outer space. The IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS) aims to help bridge this gap where the effects of constellations on astronomy is concerned. The mission of the CPS Community Engagement (CE) Hub is to provide stakeholders outside of professional astronomy with a venue in which to be heard and to help clearly communicate their views and opinions to a wider audience. This presentation will focus on how CE Hub is engaging with stakeholders, raising awareness of the issue and providing important factual information and resources to inform ongoing discussions. We will review events, conferences, and actions of the astronomical community that led to the creation of the CE Hub and informed its foundations. We will then describe how the outcomes of those interactions have been incorporated into the CE Hub strategy and its initial plans and activities.

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OneWeb Satellites Photometric Modelling: Specular and DiffuOneOneWeb satellites Photometric Modelling: Specular and Diffuse Components

Maria Isabel Romero-Colmenares[1,2], PhD Jeremy Tregloan-Reed[1,2]

[1]INCT - Universidad de Atacama. [2]Chilean low Earth orbit satellite (CLEOsat)

Abstract

The proliferation of Low Earth Orbit (LEO) satellite constellations, with tens of thousands planned from companies like OneWeb and Starlink, raises concerns for ground-based astronomy. These satellites leave trails in astronomical images, impacting research across various disciplines. Studies have measured the reflective brightness of Starlink satellites (Boley et al. 2022; Tregloan-Reed et al. 2020, 2021; Tyson et al. 2020) to quantify these risks.

This study investigates the impact of the OneWeb constellation and its reflective brightness, whilst, considering satellite design, solar phase angle, range, effective albedo, and effective cross-section. Observations of over 300 OneWeb satellites from the 0.6m telescope at the Chungbuk National University Observatory (CbNUO), combined with diffuse sphere models (e.g. Boley et al. 2022; Pradhan et al. 2019), demonstrate the feasibility of identifying operational ("On-station") and non-operational ("Off-station") satellites based on their brightness. Additionally, the phase angle can be used to provide an estimate of the observation direction. This research provides valuable insights into the impact of OneWeb constellations on astronomical observations and lays the groundwork for further mitigation strategies.

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Determining the efficiency, accuracy, and precision between supervised and unsupervised machine learning algorithms in hunting for satellite streaks in astronomical survey images

Isabel Romero-Colmenares[1,2], Jeremy Tregloan-Reed[2,1]

[1]INCT - Universidad de Atacama. [2]CLEOsat

Abstract

The increasing presence of LEO satellite constellations like Starlink raises concerns for astronomical observations. These satellites leave faint trails, impacting data quality across various disciplines, including space telescopes. Machine learning offers a promising avenue for addressing this challenge through anomaly detection techniques.

Both supervised and unsupervised methods can be utilized. Supervised learning requires pre-labeled data, while unsupervised methods identify deviations from "normal" astronomical images. Ground-based observations from diverse locations provide valuable data for training and validating these models, ultimately enabling the identification and mitigation of satellite constellation trails.

Research groups like CLEOsat and the IAU's CPS have studied the impact of LEO satellites, relying on observations from various observatories at the expense of dedicated science time. ML offers a solution by automatically identifying satellite trails in existing data, such as long-term astronomical surveys. Unsupervised methods have proven successful in other astronomical applications, prompting its exploration for satellite trail detection.

This work presents the development and accuracy of an unsupervised ML method for classifying images with and without satellite trails. While both supervised and unsupervised methods could potentially identify contaminated images, their comparative performance remains unaddressed. This research aims to compare their effectiveness in detecting satellite trails in publicly available surveys, ultimately providing a valuable tool for astronomers and satellite operators to study and mitigate these potential impacts.

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The Impact of Satellite Constellations on the Vera C. Rubin Observatory Legacy Survey of Space and Time

Professor Zeljko Ivezic[1,2], Dr. Meredith Rawls[2,3,4]

[1]AURA/Vera C. Rubin Observatory. [2]University of Washington/DiRAC Institute. [3]Vera C. Rubin Observatory. [4]IAU CPS

Abstract

Beginning in 2025, the Rubin Observatory Legacy Survey of Space and Time (LSST) will survey the southern sky with unprecedented cadence and depth and open new windows to discovery in all areas of astrophysics. At the same time, satellite companies are launching new hardware into low-Earth orbit (LEO) at a rapid pace, and estimates predict about 50,000-100,000 active LEO satellites during the decade of LSST Operations. This presentation will begin with an overview of how streaks from LEO satellites due to reflected sunlight can affect LSST data products and science goals. It will then discuss work underway to quantify and mitigate the science impacts, such as modifying the observing strategy to avoid some satellites, identifying glints and flares, and detecting streaks so the LSST alert stream does not include them.

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The effect of behavioral norms on developing Dark and Quiet Sky Protection frameworks in emerging spacefaring nations

Tamara Blagojevic

Space Court Foundation. OSA Consulting LLC. IAU CPS

Abstract

The preliminary results of the International and National Analysis teams of the IAU CPS Policy Hub showcased multiple benefits of implementing integrative, multidisciplinary and holistic research methods.

The International lens analysis revealed the necessity of due consideration of appropriate environmental principles and norms in dark and quiet skies protection, along with the Space Law framework. The benefits of an integrative approach were evidenced by the recent progressive shift in consciousness around space sustainability, which further influenced the emergence of various initiatives in the international and regional Space Law frameworks.

The examination of particular examples of the national Dark and Quiet Sky protection frameworks, showcased that many emerging space faring nations carry out initiatives which can support the progressive development of the protection of dark and quiet skies and astronomical activities.

As a result of the overview through both international and national lenses, behavioral science mechanisms have been identified as a cohesive element that can enable a more integrative, inclusive and culture sensitive approach. Behavioral science incentives have been tested in the environmental sector and showcased positive results in influencing policy making globally. Moreover, since nonbinding legal instruments, known as soft law, can guide the development of binding, hard laws, human behavior inspiring normative developments should be considered early on in the norm life cycle.

This presentation will examine the adequacy of the behavioral science mechanisms to contribute to the progressive development of the Dark and Quiet Skies protection framework, by analyzing particular initiatives and incentives in exemplary national contexts.

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1921

The IAU CPS - Characterizing Threats and Catalyzing Mitigations

Richard Green[1,2], Connie Walker[3,2], Federico Di Vruno[4,2]

[1]University of Arizona. [2]IAU CPS. [3]NSF's National Optical/Infrared Astronomy Laboratory. [4]Square Kilometre Array Observatory

Abstract

As astronomers are acutely aware, satellite constellations in Low Earth Orbit create sunlight streaks impacting optical/infrared observations and produce radio emissions affecting radio observations. While technology advancement pushes for more and larger satellites, measurements also show effective approaches to reducing effects on optical/IR and radio observations. In addition to radio communication signals, electronics in satellites create unintended low-frequency emissions that are detectable from the ground.

The IAU's Centre for the Protection of the Dark & Quiet Sky from Satellite Constellation Interference (IAU CPS) is taking multiple approaches to mitigate negative impacts. At least 12 operators meet under their auspices to share best practices and understand astronomical concerns. Observing campaigns are organized, and predictive software for position and brightness of satellites impacting planned observations is well into development. Educational videos about satellite constellations are available, and ongoing efforts are underway to engage with broader interested groups. CPS-affiliated policy and space law experts have developed and are refining recommendations for ultimately turning best practices into a model regulatory framework. Through the efforts of the IAU and other astronomy organisations, UN COPUOS is now adopting a five-year agenda item to consider astronomy and satellite constellations and the ITU-R is discussing protections for radio-quiet zones and radio astronomy bands from satellites. The IAU is leveraging its international constituency to address this urgent global issue.

Session

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Creating educational resources to inform and engage diverse stakeholders on satellite constellation issues

Jessica Heim[1,2], Dr. John Barentine[3,2]

[1]University of Southern Queensland Centre for Astrophysics. [2]IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference. [3]Dark Sky Consulting, LLC

Abstract

The IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS) Community Engagement (CE) Hub was established to provide stakeholders outside of the professional astronomy community with a venue in which to be heard and to help clearly communicate their views and opinions about large satellite constellations to a wider audience. However, in its efforts to engage with various constituencies on the topic of satellite constellations, CE Hub found that some stakeholders felt that they did not have enough information on the subject to form an opinion. While many were aware of the increasing numbers of satellites launched in recent years and that many of these were intended to provide broadband internet services, they were often not aware of more details related to these activities. Thus, CE Hub decided to develop unbiased, fact-based educational materials to help fulfill the need for resources on this subject readily understandable by the public. In this presentation, we will give a brief summary of the CE Hub's experience with this initiative to date; present some of our educational materials and resources; and discuss current and anticipated challenges in our efforts to aid in increased awareness of and interest in satellite constellation issues.

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A look into preliminary impacts of satellite constellations on amateur astronomers' activities and research

Jessica Heim

University of Southern Queensland Centre for Astrophysics. IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference

Abstract

The advent of large satellite constellations has become a subject of interest and concern for the field of professional astronomy. Increasing work is being done to better quantify the current and potential impacts to various subfields of astronomical research and to identify possible mitigations to reduce data loss and other challenges. However, little research has been conducted with the aim of exploring specifically, the nature and extent of impacts on amateur astronomy activities. In this presentation, I will present findings from surveys distributed to amateur astronomers. The purpose of these surveys was to obtain data that can help to understand both qualitative and quantitative impacts of large satellite constellations on the observations and research of these communities and to inform possible ways forward to minimize adverse effects on amateur astronomy activities.

Session

Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

1959

Satellite education: "No, it's not a UFO, it's Starlink"

Dr Samantha Lawler

University of Regina

Abstract

Satellites are already changing the night sky worldwide, and many other companies are lined up to follow the same operational model. Despite efforts to reduce their brightness, Starlink satellites are easy to observe in the night sky, especially shortly after launch when they form "trains" and very low orbital altitudes while they gradually raise to their operating orbits. These have been seen all over the world by users of the night sky, whether or not they have the funds or government approval to use Starlink internet. Thus far, satellite operators' messaging to the public has been primarily focused on the services they aim to provide, but they do not appear to have put much emphasis to date on educating the general public about these highly visible satellites, or about the increasing number of satellites and rocket body re-entries that can be seen around the world. The lack of public education about these easily visible phenomena means that local astronomy departments in universities and amateur astronomy clubs have received a large burden of UFO calls from the general public, and spend a large amount of time doing this education work for free for large, for-profit private companies. In this talk, we provide some pointers for satellite operators to educate the general public about the changes that their activities are causing in the night sky.

Session

Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

2082

The Impact of Large Satellite Constellations on Optical Astronomy

Dr. Constance Walker

IAU CPS. NSF's NOIRLab

Abstract

The deployment of communication satellite constellations in Low Earth Orbit (LEO) may represent a valuable step forward in improving world connectivity. However, the sun-reflected luminosity and radio-frequency emissions from a large number of satellites can have a serious impact on astronomical observations, as well as on the pristine appearance of the night sky. In recent years, various strategies for co-existence in terms of optical astronomy have been developed. There are now better models and data for satellite brightness, which are key to enabling mitigation, active avoidance, or use in compliance checks. Future observations of commercial LEO satellites will determine, for instance, whether some coatings and Bragg mirrors on reflective surfaces of Starlink satellites will help and how well. For spectroscopy, better modelling and understanding of satellite spectra will enable the emission from satellites to be calibrated out of astronomical data. Autonomous imagers on large spectroscopic facilities can help identify when an exposure was contaminated. For observatories, there are software solutions for streak detection and elimination that may help. During the presentation, we will discuss mitigation strategies through software and observation and provide updates in the areas of policy, industry and community engagement, some of which is being led by the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference.

Session

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2385

Characterising unintended emission from satellite constellations with LOFAR

Dr Hao Qiu

SKA Observatory

Abstract

With the recent rapid development of satellite constellations, we face an increasingly challenging radio spectrum environment for observations. While the communication frequencies of these satellites are already known to the international community and regulated by the International Telecommunication Union (ITU), instruments onboard satellites are prone to generate certain electromagnetic leakage. Recent studies such as Di Vruno et al. (2023) and Grigg et al. (2023) have revealed unintended emission from the starlink satellite constellations where strong radio frequency interference has been observed at 110-188 MHz for unknown reasons. We present results from an extended observing campaign with the LOFAR radio telescope, focusing on Starlink, OneWeb and other satellite systems, to discuss the statistical impact of such unintended electro-magnetic radiation(UEMR) on low frequency radio astronomy and possible mitigation solutions.

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EPFL Coordinates Research and Community Interests in Switzerland for the Protection of Dark and Quiet Skies

Stephan Hellmich[1], Carolyn Marie Crichton[1,2], Mathieu Udriot[1], Adrien Saada[1], Emmanuelle David[1], Jean-Paul Kneib[1]

[1]EPFL Laboratory of Astrophysics. [2]SKACH

Abstract

EPFL is facilitating the Swiss conversation on Dark and Quiet Skies through multiple initiatives. To unite EPFL's forces in the domain of sustainability in space, eSpace recently launched the Sustainable Space Hub (SSH). In order to coherently manage and foster the growth of these topics at EPFL, the hub connects the individual projects in a workflow that rests on three intertwined domains: measure, understand, and act. The presentation will focus on the activities within these domains related to the Dark and Quiet Skies initiative. The research initiatives that we will present are: (i) a project that evaluates the influence of space activities on astronomical observations using the methodology of the Space Sustainability Rating (SSR) with the goal of extending SSR by a new module such that it can account for that influence of future space missions, (ii) a research project to develop methods to detect satellites and space debris in large astronomical data archives that will help to better understand the growing influence of space objects on astronomical observations, (iii) tools that support engineers to incorporate space sustainability aspects already during mission design and (iv) community building activities to raise the voice of Swiss experts to for the Swiss delegation to the UNCOPOUS facilitated by the SKACH (Square Kilometre Array Switzerland). With this contribution we will help stimulate further activities aimed at bridging the gap between scientists, industry and policy makers in understanding and quantifying sustainability in space.

Session

Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

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Development of a Python script for calculating orbital parameters and satellite magnitude: Validation through observational data from BlueWalker 3

AYOUB ABDOU[1], Professeur Zouhair Benkhaldoun[2], Doctor Abdelkarim BOSKRI[1], PhD Student Hamid IDELBACHA[1,3]

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Abstract

In this abstract, we present our developed Python script for processing images of artificial satellites and space debris observed through telescopes at the Oukaimeden Observatory. The script calculates the orbital parameters and apparent magnitudes of observed objects, allowing for calibration of their luminosity to standard parameters such as distance and phase angle. to allow a direct comparison of their reflective brightness in different observations. Validation results will be present from observational data of the bright constellation BlueWalker 3, confirming the reliability and accuracy of the script.

Session

Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

2515

Enhancing Satellite Trajectory Monitoring: A Machine Learning Approach for Anomaly Detection and Classification

PhD Student IDELBACHA HAMID[1,2], Dr. Olivier Beltramo-Martin[2], Pr. Zouhair Benkhaldoun[1], Dr. Mohamed Kaab[1,3], Dr. Abdelkarim Boskri[1], PhD Student Ayoub ABDOU[1]

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Abstract

Given the continual increase in the number of satellites in orbit, there is an escalating need to enhance trajectory models and operational risk management to gain a deeper understanding of orbital anomalies, such as unexpected changes in a satellite's orbit, which can have a significant impact on satellite operations and threaten human and financial resources. This study aims to employ machine learning techniques to identify abnormal or divergent changes in satellite trajectories, from datasets containing multiple sets of Two-Line Elements (TLEs). The automatic detection of these behaviors has the advantage of avoiding the computation of satellite position and velocity. In this case, which is an unsupervised framework, we have selected the LOOP(Local Outlier Probability), One-Class SVM(Support Vector Machine), and Isolation Forest methods. We choose these methods for their different perspectives on density and distance. Once anomalies are detected, it is interesting to categorize them based on their causes using supervised machine learning methods, namely Random Forest, SVM, and artificial neural networks. The quality of classification is evaluated using standard metrics such as the confusion matrix, precision, recall, and F1 score, with achieved results of an average precision of 89\%, a recall of 90\%, and an F1 score of 88\% for four anomalies classes: Propulsion, Deliberate, Battery, and AccidentalCollision.

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The Development of Dark and Quiet Skies Standards in Government and Industry

Dr Andrew Williams[1,2], Dr Sara Lucatello[3,4]

[1]European Southern Observatory. [2]International Astronomical Union CPS. [3]European Astronomical Society. [4]INAF

Abstract

The astronomical community has made significant strides in highlighting the ramifications of satellite constellations within political and industrial spheres. Despite this success, the absence of specific government regulations safeguarding optical reflections remains a concern. Current measures, albeit limited, are in place under the auspices of the International Telecommunication Union (ITU). This presentation focuses on the initiatives undertaken by the European Space Agency—the development of the Space Debris Mitigation Standard, and also the European Union, Space Sustainability Labels. Remarkably, these standards may represent a crucial milestone as the first mandatory directives addressing the preservation of dark and quiet skies. In the absence of comprehensive regulatory frameworks and their protracted timescale for development, the establishment of voluntary standards and guidelines becomes imperative.

This talk reviews the progress of these mandatory and voluntary standards, reviewing their efficacy and potential for future development. By examining the evolving landscape of dark and quiet skies standards, we provide insights into the ongoing efforts, challenges, and prospects within the astronomy community.

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Protection of Dark and Quiet Skies: Recommendations for the decision-making process

Marieta Valdivia Lefort[1], Robert Massey[2]

[1]University College London. [2]Royal Astronomical Society

Abstract

The protection of dark and quiet skies (D&QS) is starting to get more attention from governments and interest groups worldwide due to the work done by astronomical and environmental societies in this respect. This work has involved raising awareness on the proliferation of artificial light at night (ALAN) and the increased terrestrial light pollution (LP), an also the escalating deployment of mega-constellation satellites in low-earth orbit (LEO) affecting astronomical observations. Nevertheless, and despite these efforts, the process of achieving national policy and legislation on the protection of D&QS has not been straightforward or sufficiently effective in many cases.

Considering the above, this presentation gives some recommendations to be taken into account in the negotiation and decision-making process regarding the protection of D&QS at the legislative level. Thus, this presentation highlights both the strategies necessary to promote this issue and include it in the political agenda (advocacy, negotiating with interest groups, involving charities, etc.) and the elements of the decision-making process that could hinder the legislative process but that should indeed be considered (bureaucracy, legislative interest in the matter, etc.). Although with more emphasis on the British experience in this respect, the recommendations presented here can be extended to the rest of the countries.

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2682

Simulating the impact of satellites on astronomical observations

Dr Ana Cecilia Soja, Pedro Henrique Rocha de Andrade, Maycon Jorge Deláqua da Silva

Fluminense Federal Institute

Abstract

A new era begins in Astronomy, with the launch in the coming years of several terrestrial and space telescopes that will increase by thousands of times the amount of data we have available to understand the sky. Along with the challenge of analyzing this unprecedented volume of information, there is a difficulty that is not well understood to date: the negative impact that satellite luminosity can have on observations. It is estimated that a project like the Vera Rubin telescope, for example, will have 30 to 40% of its images compromised. From a political point of view, we know limiting these launches is unfeasible. For this reason, the alternative for observational Astronomy is to develop new strategies to deal with the satellite luminosity contamination. One of them is building image processing pipelines that allow terrestrial observations to continue. Many working groups have already developed mitigation strategies and carried out tests of their efficiency on real images. In our research, we investigated the models used to date and their efficiency. It became clear that the simplest alternative, the single mask, is not efficient enough to make the images scientifically suitable. Therefore, it is necessary that more complex models, for example, that adapt the variation in luminosity to the trail, are developed.

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Enhancing Satellite Observation Capabilities: The Role of Oukaimeden Observatory

Dr Abdelkarim BOSKRI, Prof Zouhair Benkhaldoun, PhD Student Ayoub Abdou, PhD student Hamid Idelbacha

Oukaimeden Observatory, High Energy Physics and Astrophysics Laboratory, FSSM, Cadi Ayyad University, Marrakech, Morocco.

Abstract

The Oukaimeden Observatory, as a proud partner of the IAU-CPS center, plays a crucial role in satellite observation initiatives. Equipped with a diverse array of professional and amateur telescopes, the observatory offers comprehensive satellite observation services and actively engages in daily monitoring activities. Moreover, it serves as a hub for collaboration with other observation programs, providing both facilities and training opportunities for academic and professional development in observational techniques. Leveraging advanced orbital data processing techniques, the observatory has developed innovative platforms to streamline observation planning, thereby maximizing its contributions to the scientific objectives outlined by the IAU-CPS center. In this contribution, we highlight the progress made by the Observatory team and the facilities available to observatories worldwide, fostering a collaborative environment for advancing satellite observation and data analysis programs.

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Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference institutional meeting

2938

An environmental approach to protect the dark and quiet skies for astronomy and society

Mr Pedro Sanhueza

Ministry of Foreign Affairs, Chile

Abstract

The impact on optical and radio astronomy from satellite constellations has been systematically studied in recent years. These adverse effects are highly relevant, posing a risk to the continuation of astronomical activities conducted from Earth. However, the proliferation of satellites in orbit and the re-entry of such satellites and space debris is currently affecting the natural darkness of the night sky and can also affect the stratospheric ozone layer and compromise the radiative balance of this layer. The metals produced by satellite particles burning upon re-entry into the atmosphere disperse throughout the stratosphere, potentially contributing to the destruction of portions of the ozone layer through chemical reactionsThese environmental effects are currently unpredictable, though potentially very serious. It is urgent to study these effects and apply the preventive environmental principle to regulate the proliferation of satellite constellations based on current indications of possible damage, even though there is still no certainty about these environmental harms, which are already evident to astronomical science. This approach will safeguard the stratospheric ozone layer and protect astronomical science, providing a stable and predictable scenario for satellite operators to conduct their activities.

Session

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Final category: Division A Fundamental Astronomy

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A study on the periodic orbits in the Copenhagen problem with non spherical primaries

Dr. Om Prakash Meena

Hans Raj College, University of Delhi

Abstract

In this paper, we have drawn the periodic orbits in the Copenhagen problem. The test particle of infinitesimal mass moves under the Newtonian gravitational law due to two mass points with constant angular velocity. We have studied the dynamics of the third body in the Copenhagen problem with non-spherical primaries. We have determined the periodic orbits by using the Fourier series method around the libration points. The effects of the orbital parameter ε ($0 < \varepsilon < 1$), which controls the size of the orbit, on the periodic orbits and their period are investigated. In order to study the effect of this parameter, we have retained the terms up to third order with respect to the orbital dimensions. We have unveiled that how oblateness influence the shape, size, and period of the periodic orbits.

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Study on the Angular Distance between Celestial Bodies in Korean Astronomical Records during the 11-18th Centuries

Ph.D Student Hyojun Lee[1,2,3], Dr. Hong-Jin Yang[2,4], Prof. Suk-Jin Yoon[3], Prof. Myeong-Gu Park[5]

[1]Korea National University of Science and Technology (UST). [2]Korea Astronomy and Space Science Institute (KASI). [3]Department of Astronomy, Yonsei University. [4]Korea Natioanl University of Science and Technology (UST). [5]Department of Astronomy and Atmospheric Sciences, Kyungpook National University

Abstract

There remain numerous astronomical observations such as eclipses, comets, SNe, close approaches, etc. in Korean chronicles. Records of close approaches between celestial objects use specific terms to describe the angular distance. We study five commonly used terms, namely, *Entry* (*En*), *Invasion* (*In*), *Occultation* (*Oc*), *Eclipse* (*Ec*), and the unit *Chi*. We analyze over 2,300 records from the Goryeo (918-1392 CE) and Joseon (1392-1910 CE) Dynasties. We convert the lunisolar calendar to the Julian and Gregorian date and utilize ephemeris DE431 to calculate the angular distance. By finding the closest angular distances for all records, we determine their quantitative definitions through statistical analysis. We find that the angular distances of the four terms are in the range of 1-6 times the Moon's radius. The terms *En*, *In*, *Oc*, and *Ec* represent decreasing angular distance in that order and this ordering was consistent in both dynasties. To examine the angular size of the unit *Chi*, we additionally use the comet drawings in 1664-1665 and find that 1 *Chi* corresponds to ~1.11°. Furthermore, we investigate the correlation between the angular distance and planets' apparent magnitude.

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Nonlinear Terrestrial Reference Frame and EOP Determination Based on Singular Spectrum Analysis *Xiaoya Wang [1,2,3],Qiuxia Li[1,4], Yabo Li[1]*(1. Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China; 2. University of Chinese Academy of Sciences, Beijing 100049, China; 3. Shanghai Key Laboratory of Space Navigation and Positioning Techniques, Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China; 4. School of Environmental and Chemical Engineering, Shanghai University, Shanghai 200444, China;)

Prof. Xiaoya Wang[1,2,3], Miss Qiuxia Li[1,4], Miss Yabo Li[1]

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Abstract

With the application promotion of space geodesy, the popularization of remote sensing technology and the development of artificial intelligence, a more accurate and stable Terrestrial Reference Frame (TRF) has become more and more urgent. For example, sea level change detection, crustal deformation monitoring, driverless and so on require the accuracy of the terrestrial reference frame to be better than 1 mm in positioning and 0.1 mm/a in velocity respectively. However, the current frequently used ITRF2014 and ITRF2020 don't satisfy such requirements. Therefore, this paper study and reveal that there are time-dependent periodic signals especially in the GNSS coordinate residual data, which can lead to incorrect estimation of the station coordinates and velocities, further affecting the accuracy and stability of the TRF. These nonlinear periodic signals could be modeled well by the Singular Spectrum Analysis (SSA). After SSA corrections the re-calculate the TRF and the consistent EOP, based on the Chinese Earth Rotation and Reference System Service (CERS) Terrestrial Reference Frame (TRF) and Earth Orientation Parameters (EOP) determination software package (CERS TRF&EOP) developed by the Shanghai Astronomical Observatory (SHAO) (He et al., 2017) could be obtained. Then their accuracy could be evaluated corresponding to ITRF2014 or ITRF2020 and IERS 14 C04 or IERS 20 C04, respectively. The results show that the accuracy and stability of the newly established nonlinear terrestrial reference frame and EOP have been greatly improved and better than linear TRF.

Session

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The prospection of an astronomical site to build the first USMS university observatory

Saadia Oujaoura

Faculty of Sciences and Techniques of Beni Mellal, Morocco

Abstract

We present a preliminary astroclimatical study of the Tassemit site. It is located in the Middle Atlas Mountains of Beni Mellal, Morocco, (2204m a.b.s, 32°18'00" N and 6°15'00" W). This site is no far from Sultan Moulay Slimane Campus. Tassemit is easily accessible by a good road, and not affeted by the Beni Mellal city light pollution.

Our research focused on evaluating Tassemit's astronomical potential, comparing its calculated seeing using satellite data with the ORM site's in situ measurements. The results unveiled remarkably good seeing conditions at Tassemit, affirming its suitability as an optimal astronomical observation site with pristine skies and minimal atmospheric interference.

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Gravimetric excitation of polar motion from SLR+GRACE/GRACE-FO hybrid solutions

professor Jolantaa Nastula[1], dr Justyna Śliwińska-Bronowicz[2], dr Małgorzata Wińska[3]

[1]Centrum Badań Kosmicznych PAN (Space Research Centre PAS). [2]Centrum Badań Kosmicznych PAN (Space Research Centre PAS). [3]Faculty of Civil Engineering, Warsaw University of Technology, Warsaw, Poland

Abstract

The Earth's rotational motion is highly complex, and currently, no comprehensive analytical model exists for it. Temporal variations in this motion are influenced by various geophysical phenomena, including changes in mass distribution within the atmosphere, oceans, hydrosphere, and cryosphere.

The GRACE and GRACE-FO missions have provided essential data to comprehend the time-variable gravity field resulting from global mass distribution changes. The changes in the degree-2 order-1 coefficients of geopotential (C21, S21) are proportional to changes in the equatorial components of PM excitation.

However, limitations in GRACE/GRACE-FO solutions, particularly in determining geopotential coefficients of lower degrees, have been identified.

We use time-variable gravity solutions obtained from a combination of GRACE/GRACE-FO data and Satellite Laser Ranging (SLR) observations from Institut für Geodäsie und Geoinformation, Universität Bonn (IGG) and Centre National D'Etudes Spatiales (CNES) to calculate Hydrological Angular Momentum (HAM). We assess the HAM series by comparing them with the hydrological signal in observed PM excitation, known as geodetic residuals (or GAO), focusing on both seasonal and non-seasonal variations.

The results are promising and demonstrate high agreement between HAM obtained from SLR+GRACE/GRACE-FO and the GAO. Our findings indicate that the excitation functions derived from the hybrid solution closely align with the GAO. In fact, they exhibit similar or even better consistency with the GAO than the series derived from single GRACE/GRACE-FO solutions. Worth noting is the high correlation (at the level of 0.8) and variance agreement (up to 80%) observed in the long-term part of the spectrum.

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Calculating the trajectory of a gram-scale interstellar spacecraft moving at relativistic speeds

Mr. Nicky Ishaak[1], Dr. Mark C. Baumann[2], Dr. Justin C. Feng[3]

[1]The University of Texas at Dallas. [2]St. Edward's University. [3]Leung Center for Cosmology and Particle Astrophysics, National Taiwan University,

Abstract

PoMiN is a relativistic N-body gravitational dynamics solver that uses a Post-Minkowski approximation to general relativity (GR) and is accurate at ultra-relativistic speeds. It was originally written in the C language, but recently has been ported to the Julia language. An application of interest for PoMiN is the computation of trajectories of relativistic spacecraft, such as those proposed by the Breakthrough Starshot Initiative. The goal of the Breakthrough Starshot Initiative is to develop an interstellar spacecraft capable of traveling to the nearest star in less than a human lifetime. It proposes building a gram-scale spacecraft that is attached to a light sail and accelerated to 0.2c, either by a ground- or spaced-based laser array. The spacecraft is microchip-sized and equipped with miniaturized sensors and communications. It would have minimal propulsion of its own; therefore, after the initial acceleration, it would be left to make the 20-year trek to Proxima Centauri, approximately 4.25 light years away, with minimal course corrections. The question to be answered is: how can the trajectory of the spacecraft be computed? To compute the trajectory of the spacecraft involves accounting for gravitational dynamics between many bodies, for example, the Sun, Earth, Moon, other planets in our solar system, Alpha Centauri A and B, Proxima Centauri, and the spacecraft itself. To begin the investigation, a set of initial data was created. Online astronomical databases were used to obtain orbital elements, masses, and accurate positions and velocities. This presentation will discuss the initial conditions, detailed results, challenges and implications.

Session

Division A Fundamental Astronomy

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Mass measurement of a Local group dwarf spheroidal galaxy using Gaia EDR3

Dr Zolile Mguda

University of South Africa

Abstract

Dwarf spheroidals (dSph) are dense spherical galaxies with high mass-to-light ratios. They vary greatly in mass, star formation history and dynamical properties. The proper motions of stars in almost all the Milky Way DSphs can be resolved in Gaia EDR3 data. This allows for the measurement of the dynamics of the dSph galaxies and thus allows us to probe the mass-to-light ratios of these galaxies using 2-dimensional velocity measurement instead of 1-dimensional line-of-sight velocities, as used in the virial theorem.

In this study we use the Leonard-Merritt method to measure the masses of one of the Milky Way Galaxy satellites. The mass distribution is modeled by fitting the photometric characteristics of the dwarf galaxy to the King model. The gravitational potential is modeled using the proper motion data from the GAIA space telescope. This allows us to measure the masses of some of our closest dwarf spheroidal galaxies using a single data set and one mass measurement technique. this is an important step in the study of the dark matter content of galaxies in the Local group and the search for intermediate mass black holes. The dSph galaxies provide an intermediate arena between the dynamics of massive elliptical galaxies and globular clusters. This allows us to probe the formation scenarios of the MW globular clusters as in-situ formation or galaxy infall.

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A new post-Newtonian long-term precession model for the Earth

Kai Tang[1], Michael Soffel[2], Jin-He Tao[1], Zheng-Hong Tang[1]

[1]Shanghai Astronomical Observatory, Chinese Academy of Sciences. [2]Lohrmann Observatory, Dresden Technical University

Abstract

Long-term precession represents the secular motion of the Earth's axis for a long time interval. In 2015, we calculated the Earth's long-term precession in a relativistic framework. However, our previous works involving the ecliptic in the Geocentric Celestial Reference System are deficient, because the natural definition of this ecliptic is still ambiguous. To obtain a long-term precession model in accordance with general relativity, improvements are made including the following: all calculations are no longer carried out in the reference related to any ecliptic; a new hybrid integrator is designed and used for this precession model; ecliptic-independent precession parameters are calculated and provided. A detailed comparison analysis is performed to estimate the importance of various relativistic influences on the precession parameters. Valid within the interval of ±1 Myr around J2000.0, a consistent post-Newtonian long-term precession model for the Earth has been achieved and is presented here.

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Comparative Analysis of the Parameters of Pulsars with Breaking Indices n<0 and n>0

Dr Chika Onuchukwu

Chukwuemeka Odumegwu Ojukwu University

Abstract

We analyzed the timing parameters (the rotational frequency, the first and second time-derivatives of frequency) and the derived parameters of a sample of pulsars for which second time-derivatives of frequency (470 pulsars) were recorded in the Australian Telescope National Facility (ATNF) pulsar catalog. We formed various subsamples, those with breaking indices n<0 and n>0 , and glitching and non-glitching pulsars. Our statistical analyses of the timing and derived parameters indicated some level of differences and similarities in the parameters analyzed. Glitching pulsars appear to a have higher rotational frequency than non-glitching pulsars, and pulsars with n>0 appear to rotate faster than those with n<0 . Our results also suggest that glitching pulsars have lower values of |n| (where |n| is the absolute value of breaking index), and is it lower for subsample with n>0 than for subsample with n<0.

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Study of the small body dynamics with variable mass in the presence of reactive forces in the framework of the restricted three-body problem with variable masses

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Abstract

Among the actual problems of modern astronomy is the question of the origin and evolution of small bodies in planetary systems.

The goal of our work is to investigate the secular perturbations of a restricted three-body problem with masses varying at different rates. The masses of the bodies change non-isotropically and there occur reactive forces. The motion equations of the bodies are described in a relative coordinate system with the origin at the center of the most massive body. The problem was investigated by methods of perturbation theory [1] on the basis of aperiodic motion along a quasiconical section developed for non-stationary gravitating systems.

We obtained the differential equations of perturbed motion in the osculating elements of aperiodic motion along quasiconical section. In the non-resonant case, we obtained evolution equations that determine the orbital element changes in large time intervals [2].

The obtained evolution equations are applied to the non-stationary restricted three-body problem (Sun-Jupiter-Asteroid) and investigated by numerical methods.

This research was funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP14869472).

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Session

Division A Fundamental Astronomy

1052

Exploring the impact of a priori errors on dUT1 estimations from intensive VLBI sessions

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Abstract

One of the primary objectives of very long baseline interferometry (VLBI) is to obtain accurate Earth orientation parameters (EOP), which play a crucial role in geodesy, space navigation and adjacent sciences. In particular, VLBI is the only technique capable of independently determining dUT1, the difference between the Universal Time (UT1, based on the Earth's phase of rotation) and Coordinated Universal Time (UTC, based on atomic clocks). For this purpose, intensive 1-hour VLBI sessions are conducted daily, usually involving up to three antennas. The limited observation time of 1 hour, compared to the 24 hours usually reserved for EOP determination, along with a minimal station network configuration, only allows for the determination of the EOP associated with the UT1-UTC difference (dUT1). The remaining EOP parameters are fixed at their a priori values, thereby making the precision of this parameter significantly reliant on the a priori data.

We aim to deepen our comprehension of how errors in a priori information influence the determination of dUT1. Our approach involves systematically introducing variations in key parameters to quantify their impact on resulting dUT1 estimations. The overall sensitivity of this parameter to different sources of error is analyzed leveraging real data from intensive sessions published by the International VLBI Service (IVS).

Session

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1067

Improving the geodetic budget closure by combining geophysical excitations of polar motion from different models of atmospheric and oceanic angular momentum

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Abstract

Processes occurring within the Earth's system continually alter the distribution of mass within geophysical fluids, including the atmosphere, ocean, and land hydrology, consequently influencing the Earth's rotation. The mass redistribution and its movements within the Earth system excite the Earth's rotational changes at different time scales. The significance of atmospheric and oceanic angular momentum (AAM and OAM, respectively) signals in polar motion (PM) excitation on seasonal and interannual timescales is well recognized. Nonetheless, variations exist among various estimates of AAM and OAM obtained from different geophysical models. Despite the smaller impact on PM, taking into account hydrological angular momentum (HAM) is important in closing the geodetic budget, i.e. achieving full agreement between AAM+OAM+HAM and the observed geodetic angular momentum (GAM).

The aim of this study is to demonstrate the potential extent of differences among diverse AAM and OAM representations derived from various models. We intend to show that using different combinations of mass and motion terms of AAM and OAM may considerably influence in the correspondence with GAM. We also present a combined time series of AAM and OAM computed using the three-cornered hat (TCH) method, in which the internal noise level is reduced to a minimum, and compare them with the GAM. Additionally, we present the level of consistency between the sum of AAM+OAM+HAM and GAM. This analysis could indicate whether exploiting such a combination calculated with TCH method, with representation of HAM added, can lower the errors in the geodetic budget closure.

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1125

An updated value of the dynamical ellipticity of the Earth

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Abstract

The current value of the dynamical ellipticity of the Earth *H* comes from International Astronomical Union (IAU) precession model —IAU2006 precession— derived in Capitaine et al. (2003). That value is also considered in the International Earth Rotation and Reference System Service (IERS) numerical standards, which are described in chapter 1 of IERS Conventions (2010).

To update *H* we follow the same procedure as in Souchay & Kinoshita (1996) —also in Williams (1994) and Capitaine et al. (2003). It is based on determining *H* from the numerical value of the general precession in longitude, which is expressed as a part proportional to *H* —first order lunisolar precession— plus second order contributions.

Specifically, we enhance the modeling of second order contributions with the help of the Hamiltonian formalism. First, we introduce the terms arising from a perturbation theory at the second order, absent in IAU 2006, for the non-rigid Earth (Baenas et al. 2017). Second, we incorporate the contributions due to the redistribution of mass of tidal origin in a clear and systematic way. Their values are computed from Love sets from IERS Conventions (2010, chapter 6) and Williams & Boggs' (2016) direct oceanic tides.

Such systematic approach allows us, in contrast to other astronomical studies, indicating the tidal system that is used for giving *H*. In particular, we recommend H to be provided in the zero-frequency convention (Escapa et al. 2022, 2023). This policy is necessary to get a consistent system of numerical constants as such used in Astrodynamics, Astronomy, Geodesy, etc.

Session

Division A Fundamental Astronomy

1259

Analysis of Tropospheric Delay Mapping Functions with co-located WVRs on VLBI Stations

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Abstract

Tropospheric delay is one of the major error sources for the high-accuracy Very Long Baseline Interferometry (VLBI) technique due to the rapid water vapor variation. Over the past years, Niell mapping function (NMF) and Global Mapping Function (GMF) are commonly devised aiming at mapping the delay of radio waves from the zenith direction down to the observational direction in real-time deep space exploration. China's VLBI measurement and control network includes 4 radio telescope stations located in Shanghai, Kunming, Urumqi, and Beijing and a VLBI data processing center located in Shanghai, which is used to observe and determine spacecraft trajectory. Therefore, we validate the accuracy of different Real-time Mapping Functions (RMFs) on VLBI signal corrections, based on postprocessing Vienna Mapping Function 3 (VMF3) and Water Vapor Radiometers (WVRs) applied to track Tianwen-1 spacecraft simultaneously. Meanwhile, the accuracy of different RMFs at low elevation angle intervals (1°-30°) are analyzed compared with VMF3 at China's VLBI stations. Comparisons of tropospheric delay quantitatively demonstrate that Global Pressure and Temperature 3 (GPT3) is slightly better than NMF and GMF overall, which belongs to RMFs. This study can provide a reference for tropospheric delay calibration of the spacecraft or other radio observations using VLBI technique, especially at low elevation angles.

Session

Division A Fundamental Astronomy

1471

Cryospheric Excitation on the Earth's Chandler Wobble

Mr. Cancan Xu[1,2], Qiqi Shi[1,2], Chengli Huang[3,2], Yonghong Zhou[3,2]

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Abstract

Leveraging GRACE mascon products during 2002 and 2023, we for the first time ascertain the substantial influence of mass variations in cryosphere on the Earth's Chandler wobble (CW). In addition, in contrast to traditional analysis conducted in the excitation domain, our study focuses on the polar motion domain and incorporates the wavelet analysis technique. The findings reveal some intriguing phenomena: between 2006 to 2020, the cryosphere contributed an average amplitude of approximately 4.85 mas to CW, equivalent to 5.05%, with its impact escalating to about 11 mas from 2018 to 2022, representing a fourfold rise in its contribution ratio to approximately 20%. This marked surge can be attributed to more erratic glacier mass balance resulting from ongoing climate change. Moreover, there is a pronounced decrease in the CW signal post-2018, which starkly contrasts with cryospheric contribution, suggests a potential linkage to climate change yet warrants further investigation.

Session

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1487

Origins of the intradecadal oscillations in length-of-day and implications

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Abstract

Variations in Earth rotation rate defined by length-of-day (LOD) on the intradecadal scales present two primary periodic (i.e., 6yr and 8.6yr) oscillations, the specific physical mechanisms responsible for them (especially the 8.6yr oscillation) are still less clear. Using the latest core surface flow data inferred from the modern continuous satellite magnetic observations for 1999-2021, we calculate the electromagnetic torque exerting on the mantle, where two obviously periodic (i.e., 6yr and 8.6yr) components are detected and accurately extracted in time domain to present the existence of the core waves with the same periods. Based on the predicted LOD change data from the previously geostrophic core flow model for 1962-2021, this work supports that the observed 6yr LOD oscillation mainly reflects the signatures of geostrophic torsional waves, while the 8.6yr LOD oscillation cannot be interpreted by these waves. In order to explore the origin of 8.6yr oscillation, we develop the LOD change model due to the quasi-geostrophic Magneto-Coriolis (QG-MC) waves, which relates to the azimuthal core surface flow data. Our results suggest that the eastward propagating QG-MC waves can give a good interpretation of the 8.6yr LOD oscillation (including the amplitude and phase), providing the strong evidence to exhibit that 6yr and 8.6yr LOD variations originate from the different core wave mechanisms. This work is significant to understand the fast dynamics of the core-mantle system.

Session

Division A Fundamental Astronomy

2132

THE ASTROPHYSICAL DYNAMICS AND EARTH'S CLIMATE CHANGE

Mr Kaguamba Minjire

University of Nairobi

Abstract

The Earth's climatic changes are mainly attributed to artificial causes such as deforestation, carbon emissions from use of fossil fuels and other greenhouse gases. However, a few studies (Haigh J. 2011) have pointed towards a possible astrophysical and outer space contribution to the Earth's climate change, which requires further investigation given the significance of this problem to the future existence and sustainability of life on our planet Earth. Interactions between energy from the Sun, the Earth, and the atmosphere contribute to what is known as the global energy balance. Solar output is characterized by changes which can alter the energy balance. This can play a role in regulating the Earth's climate. Scientists (see e.g. Seitz 1996) have disagreed with the popular notion of attributing climatic changes to human causes. The main intent of this research work is to comprehend the role of solar activity and any probable astrophysical interactions in altering the Earth's climate. This will be achieved by modeling the manner in which solar radiation interacts with the Earth's atmospheric layers. We utilize data from various institutions that deal with climate change, and theoretical framework from the scientific disciplines that encompass climate science such as space physics, solar physics, atmospheric physics and astrophysics. The Earth's climate will be examined during the periodic variations of the Sun and establish the effect of the varying solar irradiance on the global energy balance. Occasional changes in the environment influenced by celestial objects present between the Earth and the Sun will be studied extensively in this research.

Session

Division A Fundamental Astronomy

2158

Development of lunar ephemeris with an Earth tide model compatible to the IERS conventions

Dr Wei Tian

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Abstract

Earth tide plays important roles in the development of modern planetary and lunar ephemeris. At present, several Earth tide models used by ephemeris groups differ to each other at the detectable level and are not fully consistent with the one recommended by the International Earth Rotation and Reference Systems Service (IERS) conventions (2010). This work aims to investigate impacts of different Earth tide models on the development of planetary and lunar ephemeris, especially on fitted results of dynamical parameters of the Earth-Moon system. With accumulated high-precision lunar laser ranging (LLR) measurements and updated planetary measurements, a new version of planetary and lunar ephemeris is built, meanwhile, sensitivity of several dynamic parameters of the Earth-Moon system to the adopted earth tide models is investigated.

Session

Division A Fundamental Astronomy

2227

Investigating Merger-Induced Asymmetries in HI Spectra of Nearby Galaxies: A Full ALFALFA Sample Analysis

MISS YANDISA PEKO

UNIVERSITY OF THE WESTERN CAPE

Abstract

This project will examine the properties of the environments in which these galaxies reside by utilizing optical counterparts cross-matched with ALFALFA galaxies. Leveraging Data Release 15 of the Sloan Digital Sky Survey (SDSS), environmental densities and other properties will be determined. The main scientific question is: What evidence does the full ALFALFA sample offer for merger-induced asymmetries in the HI spectra of galaxies in the nearby Universe? The global HI profile, representing the frequency distribution of spatially integrated HI content, contains valuable information about a galaxy's rotational properties and HI distribution. Any observed asymmetries in an isolated galaxy's HI profile are typically attributed to recent merger activity. Traditionally, optical observations have been employed to study merger activity, but detecting and quantifying interactions solely through stellar disks can be challenging due to their small and densely distributed nature. Late-type galaxies, however, also contain substantial amounts of neutral atomic hydrogen (HI), distributed in a rotationally-supported disk extending beyond the stellar disk. The disturbed HI morphology is a durable tracer of a galaxy's interaction history.

Session

Division A Fundamental Astronomy

2486

The Milky Way as Einstein's paradigm in the Gaia era

Dr Mariateresa Crosta[1], William Beordo[1,2], Dr Mario Gilberto Lattanzi[1], Dr Paola Re Fiorentin[1], Dr Alessandro Spagna[1]

[1]INAF-OATo. [2]University of Turin, Physics Dept.

Abstract

General astrometric relativistic models matched with Gaia data offer the unique possibility of establishing a multi-laboratory for extensively testing gravity theories and the Milky Way kinematic/dynamics, in other words a coherent frame to probe our whole Galaxy as the product of cosmological evolution shaped by gravity (Local Cosmology), i.e. the relations among baryonic structures (and their evolution) and the dark components of the Universe.

The presentation will focus on the latest results on the Milky Way rotational curve as obtained by comparing an exact general relativistic approach with the (Λ)CDM and MOND, namely un update with Gaia DR3 on what was first obtained with Gaia DR2 (https://www.cosmos.esa.int/web/gaia/iow_20200716). Furthermore, it will be evidenced how some selected "geometries" of the Galaxy can play a reference role for other galaxies, just like the Sun for star models.

Session

Division A Fundamental Astronomy

2512

Proposed Grid System and Projected Coordinate Reference Systems for Lunar Surface Navigation and The Artemis Missions

Geodesist Mark McCleran

United States Geological Survey

Abstract

Artemis is a milestone in human space exploration. It is the first project to return astronauts to the Moon since 1972. Fundamentally the success of each Artemis Mission will be based on the ability to navigate. To date, a navigational standard has not been developed for lunar surface navigation.

The Artemis Geospatial Data Team has tasked USGS Astrogeology to develop a grid and associated projected coordinate reference systems optimized for lunar navigation. The Data Team has specified the PCRS must have a specified map scale error and the grid must be high precision utilizing a limited number of coordinate characters.

USGS is assessing the feasibility of a PCRS for surface operations. We propose developing a new Lunar Transverse Mercator (LTM), the Lunar Polar Stereographic (LPS), and the Lunar Grid Reference Systems (LGRS)[1]. We have also embedded additional grids designed to NASA requirements for astronaut navigation, referred to as Artemis Condensed Coordinates (ACC) [1].

LTM, LPS, and LGRS are similar in design and use to the Universal Transverse Mercator (UTM), Universal Polar Stereographic (LPS), and Military Grid Reference System (MGRS)[2]; but adhere to NASA requirements [3]. LGRS ACC format is similar in design to Apollo orthotopophoto charts for navigation [4].

PCRSs and grids are subject to change based on results from field testing by the Joint EVA Test Team, NASA, and USGS [3].

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Session

Division A Fundamental Astronomy

2603

New paradigm of close approach analysis of NEOs: likelihood of close encounter

Dr. Dmitrii Vavilov, Dr. Daniel Hestroffer

IMCCE, Observatoire de Paris

Abstract

For a large set of asteroids – in particular newly discovered NEAs – the precise orbits are unknown. The area of possible positions of an asteroid (uncertainty region) can be large, and even reach the whole revolution around the Sun, while being extremely thin and stretched mostly along the nominal orbit of an asteroid. Because of that, the close approach data of asteroids is generally incomplete. On the other hand, a nominal position of an asteroid can be far from the Earth, but at the same time the asteroid can actually have a close approach or even collide with the Earth. This is one of the reasons why different centers for asteroid dynamics study (Minor Planet Center, Jet Propulsion Laboratory NASA, IMCCE,…) publish different results for asteroids close approach data: They have different nominal solutions that lead to difference in outcome.

In this work we propose the paradigm of assessing the probability that an asteroid comes closer to the Earth on a certain distance (0.05 au) rather than publishing the close approach information for only the nominal solution. We assume that the errors of coordinates of a special curvilinear coordinate system have Gaussian distribution during the whole period of consideration (this Century). This assumption is quite reasonable and allows us to take into account the fact that uncertainty region looks like a thin curvilinear ellipsoid stretched mostly along the nominal asteroid's orbit. We made some modifications to the 'Partial Banana Mapping' method to compute the required information.

Session

Division A Fundamental Astronomy

2803

Numerical Standards for Fundamental Astronomy Current Best Estimates

Dr Susan Stewart

US Naval Observatory

Abstract

IAU Division A Commission A3 (CA3) on Fundamental Standards continues to fill an important and necessary role in the IAU and wider astronomical research community by identifying, researching, coordinating and communicating fundamental astronomical standards. IAU Resolution B2 in 2009 recommended that the IAU establish a permanent body to maintain the Numerical Standards for Fundamental Astronomy (NSFA) Working Group's list of Current Best Estimates (CBE). One of the CA3's first tasks was to take over responsibility for the upkeep of CBE list, which is now hosted on the CA3 website: https://iau-a3.gitlab.io/. The CBE gives both constants fixed by convention as well as those which are measurable and determined by currently available research. The CA3 has updated those constants which current research produces better values. We will present updates to the CBE list which include new standard masses for several solar system planets and planetary satellites.

Session

Division A Fundamental Astronomy

2883

The Cartographic Lunar Reference Frame

Dr. Brent Archinal

Astrogeology Science Center, U. S. Geological Survey

Abstract

Two different coordinate systems have long been in use for the Moon. These are the Mean Earth/polar axis (ME) and the Principal Axis (PA) systems. ME is defined by having 0° longitude in the mean direction of the Earth and an equator defined by the mean direction of the lunar pole, whereas PA is defined by the axes of the principal moments of inertia. The IAU Working Group on Cartographic Coordinates and Rotational Elements (WG) previously has recommended the use of the JPL DE421 ephemeris, rotated to an ME frame for defining lunar coordinates (https://doi.org/10.1007/s10569-017-9805-5).

Over the last 3 years both the Artemis III SDT report https://www.nasa.gov/wp-content/uploads/2015/01/artemis-iii-science-definition-report-12042020c.pdf) and the LEAG-MAPSIT LCDP SAT report (https://www.lpi.usra.edu/mapsit/reports/leag_mapsit_report_2022-01-11.pdf) have included recommendations for an updated frame. Park et al. (https://iopscience.iop.org/article/10.3847/1538-3881/abd414) have published new Solar System ephemeris results that include a lunar laser ranging solution and lunar orientation ephemerides. The latter includes the DE440 ephemeris in the ME frame, which is compatible with their earlier DE421 ME frame recommended for use by the WG. The WG is considering and accepting input on whether this new frame and ephemeris should be recommended for lunar cartographic use.

There has been some recent discussion that a PA-based frame should be used for mapping instead. That would be a major change to how lunar data are currently acquired, and how data and mapping products are created and archived, searched for, accessed, and used. The benefits of such a change are not apparent.

Session

Division A Fundamental Astronomy

2910

Special Configurations of PlanetsIn Section A of the Astronomical Almanac, phenomena are listed forthe year under consideration. This includes both geocentric and heliocentricphenomena. The conjunctions of one planet with another are defined as the timewhen the difference of the right ascensions of the two planets is zero. At thistime the difference in the declinations will be the separation between theplanets in the sky.When we come to considering configurations of three planets in the night sky,two situations are frequently sought: times when they appear closest to eachother and when they appear aligned. A more precise definition of these can be,when the three planets are contained in the circle with smallest diameter andif they are aligned and so lie on the same great circle of the celestialsphere. In the book Astronomical Algorithms by Meeus (1991) he addressed theseproblems. So although these configurations cannot be defined as precisely asclassical astronomical phenomena they may still be of interest to observers ofthe night sky.Two special configurations involving three planets are considered: (i) agrouping with the diameter of the smallest circle containing the bodies,(ii) analignment on a great circle of the celestial sphere. Dates for suchconfigurations were found with only the planetsvisible with the naked eye considered. Preliminary analysis showed nearperiodicity in time interval in some sequences of dates of (i), and for (ii)occurrences of different alignments on the same date.

Dr. Steven Bell, Dr. Donald Taylor

HMNAO, UK Hydrographic Office

Abstract

Special Configurations of Planets

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Two special configurations involving three planets are considered: (i) a grouping with the diameter of the smallest circle containing the bodies,(ii) an alignment on a great circle of the celestial sphere. Dates for such configurations were found with only the planets visible with the naked eye considered. Preliminary analysis showed near periodicity in time interval in some sequences of dates of (i), and for (ii) occurrences of different alignments on the same date.

Session

Division A Fundamental Astronomy

2935

Central configurations in the general four body coplanar problem with different masses

Dr Muhammad Shoaib[1], Dr Brahim Benhammouda[2], Professor Bonnie Steves[3], Dr Winston Sweatman[4]

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Abstract

The research described in this paper, solves the outstanding problem of finding central configurations in the general four body coplanar problem for four different masses, with no need for symmetrical restrictions.

We have used a novel approach where three masses are distributed on the vertices of a triangle, with the fourth mass allowed to be at any other point in the plane forming either convex or concave central configurations. A necessary condition is derived for the existence of central configurations and for requiring the masses to be positive. Using both analytical and numerical techniques, regions of possible central configurations can be derived.

We have identified new non-symmetric different mass central configuration solutions in the four body coplanar problem. And we have shown that through using our general four body coplanar model for central configurations, we can replicate all the known symmetrical four body non-collinear central configurations. The cases derived include: the isosceles trapezoid, the right trapezoid, the convex kite, the concave kite, the right quadrilateral and a number of cases both convex and concave with no symmetry restrictions or equality of masses. Various cases are also identified where no central configurations are possible.

Session

Division A Fundamental Astronomy

2977

UKIRT Hemisphere Survey Status, Details and Data Access

Justice Bruursema[1], Frederick Vrba[1], Jeffrey Munn[1], Michael Irwin[2], Andy Lawrence[3], Watson Varicatt[4], Klaus Hodapp[5], Tom Kerr[4], Mike Read[3]

[1]United States Naval Observatory. [2]Institute of Astronomy, University of Cambridge. [3]Royal Observatory, Edinburgh. [4]United Kingdom Infrared Telescope. [5]Univeristy of Hawaii

Abstract

We present details and the current status of the United States Naval Observatory (USNO)-led continuation of the UKIRT Hemisphere Survey (UHS) program. The UHS was originally begun in 2012 by a United Kingdom (UK)-based collaboration with the United Kingdom InfraRed Telescope (UKIRT) in the J band. The goal was to fill in all areas of the northern celestial hemisphere with latitudes from $\delta=0^{\circ}$ to 60° that were not already observed in the UKIRT Infrared Deep Sky Surveys (UKIDSS) program. The UHS, together with UKIDSS, provides imaging that has a substantially improved depth and finer PSF than 2MASS data and provides a next-generation all-sky infrared map when combined with complementary VISTA Hemisphere Survey (VHS) data for the southern hemisphere. The J band data were released in 2018 and at that time, USNO took the lead in continuing the UHS project in the K band, in collaboration with UK and University of Hawaii (UH) partners. The K band data (both imaging and source catalogs) were released in 2023 and are available through the WFCAM Science Archive (WSA) from the Royal Observatory, Edinburgh, along with the other relevant UKIRT data. The H band data should be publicly available in early 2025. We have also begun a second epoch of J band observations with simultaneous Y band imaging that will be available in the future. The poster presented here will orient you to the parameters and details of the surveys and how to access the data.

Session

Division A Fundamental Astronomy

3127

Standards of Fundamental Astronomy

Miss Antonia Wilmot

HM Nautical Almanac Office

Abstract

Standards of Fundamental Astronomy (SOFA) is a Division A functional working group which continues to provide an accessible and authoritative set of algorithms and procedures that implement standard models used in fundamental astronomy. This poster gives an overview of the service that SOFA provides including the current software in the collection which comprises of fourteen areas including Astrometry, Earth Rotation and Precession-Nutation and current usage of SOFA software.

Session

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3179

Rubin's LSST as an astrometric and a photometric survey

Zeljko Ivezic

AURA/University of Washington and the Rubin Observatory Team

Abstract

The Legacy Survey of Space and Time (LSST), the first project to be undertaken at the new Vera C. Rubin Observatory, will be the most comprehensive optical astronomical sky survey ever undertaken. Starting in 2025, Rubin Observatory will obtain panoramic images in ugrizy passbands covering the sky visible from its location in Chile every clear night for ten years, resulting in close to a thousand observations of each position across half of the celestial sphere. About 20 billion galaxies and a similar number of stars will be detected using this 60 petabyte image dataset. LSST data will be used for investigations ranging from cataloging potentially hazardous near-Earth asteroids, to stellar and black hole astrophysics, and fundamental physics such as the characterization of dark matter and dark energy. I will briefly overview scientific goals behind this project, provide a construction status update, and finish with a discussion of astrometric and photometric accuracy expected for LSST.

Session

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3192

Gaia BH3: a 33 $M_\odot$ dormant BH discovered in Gaia preliminary astrometry

Dr Pasquale Panuzzo[1], Dr Tsevi Mazeh[2], Dr Frédéric Arenou[1], Dr Berry Holl[3]

[1]CNRS – Observatoire de Paris – Université PSL. [2]School of Physics and Astronomy, Tel Aviv University. [3]Department of Astronomy, University of Geneva

Abstract

The validation activities in preparation of the Gaia DR4 resulted in the discovery, in the preliminary astrometry, of a binary system, hosting a dormant black hole with an exceptional mass. Black holes of these masses have been detected only in BH mergers in distant galaxies via gravitational waves. The fact that the stellar companion is an old very metal-poor giant of the Galactic halo supports the scenario that the progenitors of the high-mass BHs detected by gravitational-wave telescopes are metal-poor massive stars. The Galactic orbit of the system and its metallicity indicate that it might belong to the ED-2 stream, likely a globular cluster accreted by the Milky Way, giving hints on the formation mechanism of this binary system. The discovery is an example of the impressive impact of the Gaia mission on all branches of stellar astrophysics. We will describe the discovery of Gaia BH3, its implications, and report on results obtained by the community on this astonishing object.

Session

Division A Fundamental Astronomy

3194

RECOMMENDATIONS FOR INTERNATIONAL STANDARDS FOR CISLUNAR PNT

SUSAN G STEWART

US NAVAL OBSERVATORY

Abstract

The escalation of planned activity in the cislunar environment by international space programs and scientific communities creates a pressing need for the development of fundamental standards to support cislunar navigation and research. The International Astronomical Union (IAU) and its international partner organizations in geodesy and time have well-established precedents in coordinating astronomical standards for international adoption. The IAU Commission A3 (CA3) on Fundamental Astronomical Standards is leading efforts to establish standards in lunar reference frames in coordination with partner organizations. As a first step, IAU CA3 proposes three recommendations for resolutions at this IAU General Assembly. Specifically, there is a call from the astronomical community for a relativistic reference system and coordinate time based on the lunar center-of-mass to support lunar-based activities, much like the convenience of a geocentric coordinate system (GCRS) for Earth- based observations. The proposed Lunar Celestial Reference System (LCRS) and its associated Lunar Coordinate Time (LTC) will be defined. The IAU CA3, the IAU Working Group on Time and Metrology and representatives from The International Bureau of Weights and Measures (BIPM) have collectively recognized the need for the adoption of a coordinated universal lunar time standard. Preliminary discussion on this and other issues for next steps for cislunar standards will be presented.

Session

Division A Fundamental Astronomy

3197

Validation of KSA-Geoid by vertical deflection Observations

OTHMAN ALRUBAYYI[1], Sultan Al-Shahrani[2], Iurii Golubinka[2], Eslam Abdulsamie[2], Abdullah Al-Qahtani[2], Tariq Alqarni[2], Rossen Grebenitcharsky[2]

[1]Head of SRS Department, GEOSA, Kingdom of Saudi Arabia,. [2]

Abstract

The KSA-GEOID21 is the latest geoid model for the territory of the KSA and service as 3D vertical datum of the National Vertical Reference System. The KSA-GEOID21 includes two versions: gravimetric and hybrid and allows computing orthometric heights all over the KSA with an accuracy of 1.5 - 2.5 cm The Executive Directorate of Geodesy (EDG) of GEOSA intends to initiate a project of independent validation of its most recent geoid models KSA-GEOID21 (gravimetric and hybrid versions) and its densification in specific regions of KSA by utilization of astronomical observations of deflections of the vertical (deflection of the plumb line) conducted, using DIGITAL-ZENITH CAMERA (DZC). The results of the DZC observation will be an important source of accurate, reliable, and independent data that can be utilized for geoid model validation and improvement of its accuracy. The main project objective is to perform observations of deflections of the vertical on 500 benchmarks of the National Vertical Network utilizing DZC. The basic unit of DZC observation activities is a rotation position at which the acquisition of a number of images and tiltmeter data are taken, typically it takes 1.5 - 2 minutes to collect the data, rotate to the next position and level the instrument. The minimal observation session constitutes 16-30 rotation observations. and the larger number of observations in the session improves the accuracy of vertical deflection.

The relation between session duration and expected accuracy of vertical deflection are as follows:

Accuracy level Duration Number of Session Expected Accuracy

Minimum accuracy up to 50 minutes 1 0.1-0.2 arcsec

Average accuracy ~2 hours 2-3 <0.1 arcsec

Maximum accuracy 2-3 hours 5-10 0.05 arcsec

Session

Division A Fundamental Astronomy

3215

Enhancing the studies of reference frame ties and millisecond pulsar formation channels with high-precision VLBI astrometry of millisecond pulsars

Dr Hao Ding

Mizusawa VLBI Observatory, National Astronomical Observatory of Japan

Abstract

Millisecond pulsars (MSPs) are the fastest-spinning neutron stars. Thanks to their superb time-keeping ability, MSPs have provided sharp tests of gravitational theories, and have been collectively used to constrain the stochastic gravitational-wave background (GWB). Precise astrometric studies of MSPs are desired in many ways. In this talk, I will mainly focus on two scientific prospects promised by MSP astrometry. Firstly, as I will explain in the talk, the velocity distribution of MSPs is likely multi-modal. VLBI astrometry of MSPs holds the key to constraining the MSP velocity distribution, which is directly linked to the formation channels of MSPs. Secondly, VLBI and timing observations of MSPs can jointly refine the connection between the kinematic and dynamic reference frames, which would better quantify the systematics in pulsar timing array studies. Alongside the scientific discussions, I will describe the main challenges the two studies are facing, and outline some innovations in data reduction and analysis that may help us overcome the challenges.

Session

Division A Fundamental Astronomy

3216

Analytical Methods for Celestial Mechanics: applications and some examples

Dr Irene De Blasi

University of Turin (Italy)

Abstract

Many problems coming from Celestial Mechanics can be studied using the tools coming from Nonlinear Analysis and Dynamical Systems Theory. Some of those models concern for example the motion of bodies subjected to the mu- tual gravitational attraction (the celebrated N-body problem) or the geocentric motion of a satellite, influenced both by the Earth's shape and the third-body gravitational attraction of external masses. The seminar aims to describe some of these models, focusing on the analytical techniques which can be used, case by case, to study their dynamical properties.

Session

Division A Fundamental Astronomy

3240

Time on the Moon in the context of various relativistic time scales in the Solar System

Sergei Klioner

Lohrmann Observatory, Technische Universität Dresden, 01062 Dresden, Germany

Abstract

Recent plans of various space agencies to boost their activities on the Moon and in its neighborhood makes it necessary to define the relativistic coordinates for the Moon and in particular, to carefully discuss all aspects on the relativistic time suitable for the Moon. The IAU 2000 framework for relativistic reference systems establishes the fundamental principles for physically adequate reference systems and should be used to define the local relativistic reference systems for each solar system body of interest. The corresponding relativistic coordinate time are always integral part of those reference systems. The proposed IAU Resolution use that framework to define the reference system for the Moon. After a brief introduction into the IAU 2000 framework, we will discuss the remaining freedom of those reference system: the orientation of the spatial axes and an arbitrary scaling of the time and spatial axes (e.g. TDB-compatible vs. TCB-compatible quantities). We put the discussion into context of the similar definition for other bodies of the Solar System: Mars and Mercury. And discuss pros and contras of various choice of the scaling.

Session

Division A Fundamental Astronomy

Final category: Division B Facilities, Technologies and Data Science

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speckle

The dependence of the statistical characteristic parameters of speckle pattern on both roughness variance and its phase correlation Mohamed farag

faculty of science helwan university

Abstract

The advent of the James Webb Space Telescope (JWST) marks a transformative era in planetary science and exoplanetary research. With its unparalleled capabilities in observing across the electromagnetic spectrum, JWST promises to unveil the secrets of planetary atmospheres, surfaces, and compositions both within our solar system and in distant exoplanetary systems. Furthermore, when coupled with speckle imaging techniques, JWST's imaging capabilities are enhanced, enabling the resolution of finer details and the mitigation of atmospheric distortions. This abstract explores the symbiotic relationship between JWST and speckle imaging, demonstrating how their combined power propels our understanding of planetary phenomena. From deciphering the atmospheric dynamics of exoplanets to mapping the surface features of celestial bodies, this integrated approach opens new horizons for planetary exploration, offering insights into the diversity and complexity of worlds beyond our own. we study the dependence of the statistical characteristic parameters of speckle pattern on both roughness variance and its phase correlation under the condition of dependent phases of the scattered waves.

Session

Division B Facilities, Technologies and Data Science

320

Star cluster membership with DBSCAN

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In this paper, we apply the machine learning clustering algorithm Density Based Spatial Clustering of Applications with Noise (DBSCAN) to study the membership of stars in nine open clusters (NGC~2264, NGC~2682, NGC~2244, NGC~3293, NGC~6913, NGC~7142, IC~1805, NGC~2352, NGC~2243) based on Gaia DR3 Data.

This sample of clusters spans a variety of parameters like age, metallicity, distance, extinction and a wide parameter space in proper motions and parallaxes. We obtain reliable cluster members using DBSCAN as faint as $G_{mag}\approx 20^m$ and also in the outer regions of clusters. With our revised membership list, we plot color-magnitude diagrams and we obtain cluster parameters for our sample using ASteCA and compare it with the catalog values. We also validate our membership sample by spectroscopic data from APOGEE and GALAH. This paper demonstrates the effectiveness of DBSCAN in membership determination of clusters.

Session

Division B Facilities, Technologies and Data Science

343

Open star cluster membership limitations with Gaussian Mixture Modelling

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

We have used Gaussian Mixture Modelling to determine membership in twelve star clusters with Gaia DR3 data. We have a varied sample of clusters in terms of distance, age and galactic position. We assess the results using a metric called the Modified Siluette Score and find that GMM does not work too well with clusters at distances larger than 3 kpc. We confirm our membership results using Spectroscpic data from APOGEE and GALAH and use ASteCA to determine parameters of our cluster sample.

Session

Division B Facilities, Technologies and Data Science

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Rubin's LSST as a large-scale time-domain photometric survey

Professor Zeljko Ivezic

AURA/University of Washington

Abstract

The Legacy Survey of Space and Time (LSST), the first project to be undertaken at the new Vera C. Rubin Observatory, will be the most comprehensive optical astronomical sky survey ever undertaken. Starting in 2025, Rubin Observatory will obtain panoramic images in ugrizy passbands covering the sky visible from its location in Chile every clear night for ten years, resulting in close to a thousand observations of each position across half of the celestial sphere. About 20 billion galaxies and a similar number of stars will be detected using this 60 petabyte image dataset. LSST data will be used for investigations ranging from cataloging potentially hazardous near-Earth asteroids, to stellar and black hole astrophysics, and fundamental physics such as the characterization of dark matter and dark energy. I will briefly overview scientific goals behind this project, provide a construction status update, and finish with a discussion of tools and plans relevant for time-domain science with LSST.

Session

Division B Facilities, Technologies and Data Science

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The Habitable Worlds Observatory: Mission Overview and the Path to Discovery

Prof. Kevin France

University of Colorado

Abstract

The discovery of thousands of planets orbiting stars beyond the solar system has fundamentally shifted our view of Earth's place in the Universe, has captivated the public imagination, and has transformed research priorities in astrophysics. Those accomplishments have put us in a position to ask the fundamental question "Are we alone?" and on a path to developing the technical tools to answer this question. The US 2020 Astrophysics Decadal Survey (Astro2020) has recommended the development of a space observatory to investigate the frequency of habitable exoplanets, search them for signs of global biospheres, and perform a wide range of transformative astrophysics.

NASA has dubbed that telescope the Habitable Worlds Observatory (HWO). In this talk, I will present the recommendation for the development of HWO based on Astro2020's key science goals in exoplanets and astrophysics. Maturing the science, technical, and programmatic path to HWO will require enthusiastic collaboration between a wide range of disciplines, interests, and stakeholders. I will discuss NASA's efforts for maturation of the HWO concept; highlighting how this process builds on the LUVOIR and Habex mission studies, key challenges, current activities, and opportunities for the global astronomical community to get involved in the mission development. Continuing out into future decades, HWO will serve as the first mission in a new generation of Great Observatories that will revolution our understanding of the Universe and our place in it.

Session

Division B Facilities, Technologies and Data Science

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Gearing the 32-metre radio telescope for data-intensive opportunities

Dr Emmanuel Proven-Adzri[1], Dr Theophilus Ansah-Narh[1], Dr Johannes Allotey[2], Dr Emmanuel Bempong-Manful[3]

[1]Ghana Space Science and Technology Institute. [2]University of Cambridge. [3]University of Manchester

Abstract

This abstract presents an overview of the data-intensive research capabilities and collaborative initiatives associated with Ghana's 32-metre radio telescope. The telescope conducts cutting-edge astrophysical investigations focusing on methanol masers in star-forming regions, radio continuum sources, pulsars, and active galactic nuclei (AGN). With full Very Long Baseline Interferometry (VLBI) operation expected by the close of this year, substantial data volumes, reaching multiple gigabytes daily will be generated by the telescope. Beyond traditional astronomical research, the high-performance computing resources at the telescope site have been instrumental in solving complex machine-learning problems. Notably, these applications include the detection of pulmonary diseases in chest X-rays and predicting corporate bankruptcy in financial institutions, showcasing opportunities and impact on data science. Collaborations with DARA Big-data and the University of Bristol have been established, fostering cross-disciplinary projects and knowledge exchange. This collaboration enhances the functional computing infrastructure for data storage, curation, calibration, and access. As a result, students and researchers, regardless of location, will have the opportunity to remotely access and contribute to the wealth of data generated. We seek further collaborations to leverage the data-intensive opportunities presented by Ghana’s 32-metre radio telescope. This extends beyond astrophysical research, opening doors for interdisciplinary studies and promoting the development of advanced computing infrastructures. We invite interested parties to explore new collaborative ventures that will not only benefit Ghana but also contribute to the advancement of science in the broader sub-region.

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ULTRASAT: Revolutionizing our view of the transient universe

Dr. Yossi Shvartzvald

Weizmann Institute of Science

Abstract

ULTRASAT is an Isreali-led scientific satellite, that is planned to be launched to a geo-stationary orbit in 2027. It will carry a telescope with an unprecedentedly large field of view (200 squared degrees) and UV (230-290nm) sensitivity. These unique properties will enable us to detect and systematically study transient astronomical events within an extra-Galactic volume that is hundreds of time larger than that accessible to current observatories. ULTRASAT's measurements will have a broad science impact across the fields of gravitational wave sources, supernovae, variable and flare stars, active galactic nuclei, tidal disruption events, compact objects, and galaxies. In this talk I will review ULTRASAT's key science goals, its unique technical properties, and the project's structure and status.

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Division B Facilities, Technologies and Data Science

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Synergies between ngVLA and SKA

Dr Anthony Beasley[1], Prof. Philip Diamond[2]

[1]National Radio Astronomy Observatory. [2]Square Kilometer Array Observatory

Abstract

The coming decade will see the construction and early science operations of several new radio instruments, operating across a wide range of sensitivities, frequencies and angular scales. The multi-national SKA is under construction in South Africa and Australia, ngVLA is being planned for a construction start later this decade, and instruments like CHIME, DSA-2000, ngEHT and others will explore the radio universe like never before. In this talk, we will discuss the scientific, technical and operational synergies being planned for the SKA and the ngVLA, and provide an overview/status of the projects. Following a highly-successful international conference in 2023, we are continuing to explore and coordinate our efforts to enable new opportunities for the global research community.

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The VO and Education: Data accessibility in developing nations and access by underprivileged groups within developed nations

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad

Abstract

The Virtual Observatory is a very useful tool for Education, not only in Astronomy, but also in Data Analysis and Statistics. With the help of funds from IAU-OAD, we designed a complete set of Astronomy Data Analysis Lab Experiments for Undergraduate and Postgraduate Students at Copperbelt University, Zambia. The complete manual is ready to be released at the General Assembly and in this talk I will give a brief overview of the Sciences Cases described and the various levels at which students can complete the task. The set of experiments can be useful for any undergraduate and post graduate university program.

Session

Division B Facilities, Technologies and Data Science

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Automatized 8inch reflective telescope

Mr Biruk Abrham Abte

Space Science and geospatial institute

Abstract

This project presents the design and construction of an automated 8-inch reflective telescope, tailored for the advancement of personal experience in amateur astronomy and educational purposes, particularly in regions with limited access to sophisticated astronomical equipment. Motivated by the lack of resources and knowledge prevalent in developing countries, this initiative seeks to empower individuals with the tools and understanding necessary to engage meaningfully with the wonders of the cosmos.

The telescope's design prioritizes accessibility and ease of use, utilizing readily available materials and components wherever possible. The automated functionality enhances user experience by simplifying the process of locating celestial objects, thereby reducing barriers to entry for amateur astronomers. Detailed instructions and guidelines accompany the telescope, catering to individuals with varying levels of technical expertise.

Through hands-on engagement with the construction process and subsequent use of the telescope, users gain valuable insights into optical principles, mechanical engineering, and celestial navigation. This experiential learning approach fosters a deeper appreciation for science and technology while nurturing curiosity and critical thinking skills.

Furthermore, the telescope serves as a valuable educational tool in formal and informal settings, facilitating astronomy outreach programs and classroom activities. By democratizing access to astronomical equipment and knowledge, this project aims to inspire and empower the next generation of scientists and enthusiasts, regardless of geographical or socioeconomic constraints.

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Present and future development of neutrino telescopes

Prof Soebur Razzaque

University of Johannesburg

Abstract

A new era of neutrino astronomy has begun with detection of high-energy neutrinos by the IceCube telescope in Antarctica from astrophysical sources. A few other telescopes such as the KM3NeT in the Mediterranean and Baikal-GVD are under construction or in the expansion phase. Many more are in the proposal stage. Data from all these facilities will transform the field and lead to a precision era of neutrino astronomy. In this talk I will discuss the performance of the present neutrino telescopes and discuss future developments to make neutrino astronomy truly possible.

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Division B Facilities, Technologies and Data Science

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Updates from the Australian SKA Regional Centre (AusSRC)

Dr Karen Lee-Waddell

Australian SKA Regional Centre

Abstract

The Australian SKA Regional Centre (AusSRC) is part of an international computing and data delivery network that will enable ground-breaking science by providing the connection between the SKA telescopes and the science community. Currently, AusSRC is working with SKA precursors, primarily ASKAP and the MWA, to test and develop scalable data analysis strategies and automated workflows that can eventually be applied to data from the SKA telescopes. We are also part of the increasing effort to prototype various aspects of the international SRC Network (SRCNet), such as testing data distribution and archiving frameworks, establishing operational requirements and pipelines, and building user interfaces. I will provide an update on our progress and an overview of how the AusSRC is facilitating the scientific output of the SKA research community.

Session

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The Bulgarian Astronomical Observatory Rozhen - present equipment and future development

Prof. Evgeni Semkov

Institute of Astronomy and NAO, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract

National Astronomical Observatory Rozhen is situated in the Rhodope Mountains at 1750 m altitude and it is a leading astronomical center in the South-East Europe. The observatory is equipped with four telescopes for photometric and spectral observations: 2 m RCC telescope, 1.5 m RC robotic telescope, 50/70 cm Schmidt telescope and 60-cm Cassegrain telescope. Since the Rhodope Mountains are one of the few places in Europe preserved from light pollution, we plan to develop optical observations in the future as well. The advantage of our observatory is its location in Europe in the UTC+02:00 time zone, where very few large telescopes are located. This allows us to participate in many international collaborations for observations of rapidly changing objects: variable stars, blazars, occultation by asteroids and by trans-Neptunian objects, near-Earth object, etc.

Thanks to the national funding of scientific infrastructure, we are successfully renewing the observation equipment at the Rozhen observatory. Our most recent acquisition is the 1.5 m robotic telescope, with which regular observations have begun since the summer of 2023. We are also planning to replace the old Cassegrain telescope with a new 80 cm RC remote control telescope. New CCD cameras and spectrographs needed for quality astronomical observations will also be delivered in the coming years. As part of the Rozhen observatory, in 2025, the construction of a station of the LOFAR low-frequency radio telescope will begin.

Session

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The Cherenkov Telescope Array Observatory

Prof. Markus Boettcher[1], The CTA Consortium[2]

[1]North-West University. [2]N/A

Abstract

The Cherenkov Telescope Array Observatory (CTAO) is the next generation ground-based gamma-ray telescope
facility, currently under construction. It is envisioned to ultimately consist of about 100 Cherenkov telescopes on two sites: a northern site on the Canary Island of La Palma, Spain, and a southern site near Mt. Paranal, Chile. The initial array (called "Alpha configuration") with over 60 telescopes is currently
expected to be completed by 2028. The CTAO is expected to be about 10 times more sensitive than currently
operating Cherenkov telescope facilities (H.E.S.S., MAGIC, VERITAS) and provide significantly improved spatial resolution and extended energy coverage, towards both lower and higher energies. A prototype of the large-sized telescopes (LSTs) is already fully operational on the northern site of La Palma (called LST-1). This review presents the current status of the CTAO construction and science prospects for the full CTAO.

Session

Division B Facilities, Technologies and Data Science

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Machine Learning Explorations in GRB Studies: From Classification to Extended Emission Identification

Mr. Keneth Garcia-Cifuentes[1], Dr. Fabio De Colle[1], Dr. Rosa Becerra[2]

[1]Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México. [2]Università degli Studi di Roma Tor Vergata

Abstract

Gamma-ray bursts (GRBs) have traditionally been categorized based on their durations. However, the emergence of extended emission (EE) GRBs, characterized by durations higher than two seconds and properties similar to short GRBs, challenges conventional classification methods. In this talk, we delve into GRB classification, focusing on a machine-learning technique (t-distributed stochastic neighbor embedding, t-SNE) for classification and the identification of extended emission in GRBs, and its hyper-parameter optimisation.

Furthermore, we introduce an innovative tool, ClassipyGRB, designed for astronomers whose research centers on GRBs. This versatile Python3 module enhances the exploration of GRBs by offering nteractive visualizations of their light curves and highlighting shared attributes. With ClassipyGRB, astronomers can swiftly compare events, identifying resemblances and exploring their high-frequency characteristics. This tool uses the power of proximity analysis, enabling rapid identification of similar GRBs within seconds.

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Division B Facilities, Technologies and Data Science

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The Technologies Needed for HWO Including the Role of Cubesats and Small Space Missions In Paving the Path to HWO

Dr Paul Scowen

NASA Goddard Space Flight Center

Abstract

The Habitable Worlds Observatory has been identified as the top recommendation by the US National Academy of Sciences (NAS) in their 2021 Decadal Report. The ambitious mission will deliver groundbreaking coronagraphy performance to directly measure reflection spectra from exoplanets in search of habitability while at the same time providing a suite of instruments to perform transformational astrophysics. Enabling ultraviolet throughput together with remarkable optical stability all present a series of challenges. NASA has established a program to develop both science and technology at the recommendation of the NAS - the Great Observatories Maturation Program (GOMAP) - which is studying both the science drivers and the technological capabilities the community can bring to bear within the next 5 years to establish a working architecture. The path to delivering the Observatory's needs will be rooted in leveraging existing technological investments by NASA and other agencies, but a range of development strategies is needed which includes both laboratory and space-based demonstration and advancement. In this talk we will discuss the state of the art of several key technologies and plans in place to advance them using a range of methodologies.

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A Fiber-fed Mobile Telescope and Enclosure for the CHARA Array

Dr Christopher Farrington, Dr Gail Schaefer, Dr Douglas Gies, Dr Edgar Ligon, Dr Theo ten Brummelaar, Dr Nicolas Scott, Dr Nils Turner, Dr Rainer Kohler

Georgia State University - CHARA

Abstract

The CHARA Array is currently developing a 7th telescope to extend the existing 6 telescope array. This new telescope is the pathfinder for the Michelson Array concept and is a mobile 1-meter telescope that can be placed at multiple locations around the Mt. Wilson site. Each location will consist of a concrete pad and end points of optical fibers from the CHARA optical delay and combiner lab. This will enable new short baselines of 20-30m for imaging the surfaces of large stars and new long baselines on the order of ~600m for resolving small stars. This can be expanded to 1km maximum baseline. These baselines will be used in conjunction with the existing 15 baselines that range from 34 to 331m. The new telescope is a custom 1m Ritchey-Chretien made by Planewave Instruments. Moving such a telescope around the observatory presents some unique challenges. To house and move the telescope we have designed a mobile enclosure that will utilize a heavy-duty trailer, skid-steer, a lifting system, and a customized telescope dome. Once in place on the pad the telescope will be unlocked and raised and a kinematic pier adapter placed underneath the telescope. The telescope is then lowered onto the adapter, ensuring a stable connection to the ground and isolation from the enclosure. A connection box at each pad will have hook-ups to power, communications, and the optical fibers. Then the telescope can make use of the same optical delay lines and beam combiners as the other CHARA Array telescopes.

Session

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Revealing quasar surroundings using coronagraphs

Dr. Bin Ren

Côte d'Azur Observatory

Abstract

The host galaxies of bright quasars have been difficult to image due to the overwhelming light from the quasars. Using coronagraphs and well-chosen reference stars, we can block a quasar and remove its residual light to reveal the surrounding environments. With Hubble Space Telescope's STIS coronagraph, we recently tested this approach for the first time for 3C 273 the prototypical quasar. Being the only operating space-based coronagraph in visible light, our study validates the coronagraph usage on extragalactic sources into the central kilo parsec region of quasars. This bridges the gap between classical imaging and interferometric studies, allowing for new insights for quasar host studies.

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A Purpose-built Stellar Intensity Interferometer Array SIITAR for high angular resolution imaging of stellar surfaces and the study of stellar dynamics

Dr Colin Carlile[1], Prof Dainis Dravins[1], Dr Brian Thorsbro[2]

[1]Astrophysics, Lund Observatory, Lund University, Sweden. [2]Observatoire de la Côte d'Azur, Laboratoire Lagrange, Nice, France

Abstract

Stellar Intensity Interferometry (SII) promises significant gains in angular resolution. Hanbury Brown et al. measured the diameters of 32 MS stars with their SII setup at Narrabri at resolutions of ~2mas. This iconoclastic work heralded the age of Quantum Optics. In order to realise the potential of SII further, arrays of 10s, 100s or even 1000s of telescopes (light collectors) located kilometers apart are required. The number of telescopes & their separations (baselines) determine the quality of the derived images.

Recently SII has undergone a renaissance. Data from existing Cherenkov arrays: VERITAS, H.E.S.S. & MAGIC are very encouraging. ASTRI, a 9-telescope array under construction, will access 36 static baselines, increasing to ~400 as the target traverses the sky. Studies that edge towards an imaging of the star itself are on the horizon. With the Cherenkov Telescope South's potential 96 telescopes, angular resolutions of ~40μas will become possible. Recording ~50,000 baselines in a single night will yield detailed images of bright stars.

Intriguingly, even higher resolution images (~5μas) of bright MS stars would result from a dedicated SII array. Here we present a concept for such an SII Telescope ARray, SIITAR, with up to 2048 light collectors on a ~20 km elliptical footprint. We are inspired by the ambitious Deep Synoptic Array 2000 to be built in the Nevada desert. Partnering with DSA-2000 on an already chosen site would reduce both construction time & cost, promising concurrent measurements in both the radio & optical bands.

1. R H Brown, "The Intensity Interferometer", Taylor & Francis (November 1974)

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Using GIS for Site Suitability Analysis for Siting a Radio Telescope in Kenya

Mr. Francis Ochieng[1,2], Dr. Ing. Sammy Musyoka[1]

[1]University of Nairobi. [2]NEPAD/APRM Kenya Secretariat

Abstract

Radio sources in outer space emit radio signals that travel to the Earth. Even though the radio signals are very weak, they can reach the earth's surface because they can penetrate dust in the atmosphere. However, because of constant man-made radio frequency interference, it is challenging to detect them from any location. This is the reason why sites hosting radio telescopes are carefully chosen. The objective of this study is to use GIS in finding suitable sites for siting a radio telescope in Kenya. Multiple-Attribute Decision Making (MADM) process of GIS-based Multi-Criteria Decision Analysis (MCDA) in AHP was employed in the search for suitable locations. The main datasets used in the study are: wind speed, national electricity grid network, rainfall, national mobile cell towers, DEM, and land use land cover (LULC). Suitable sites are: Turkana, Marsabit, Mandera, Wajir, Isiolo, Samburu, West Pokot, Trans Nzoia, Bungoma, Baringo, Laikipia, Meru, Nakuru, Tana River, Narok, Kajiado, Nyeri, and Nyandarua

Whereas there are proposals from radio astronomy enthusiasts in Kenya to have Longonot Earth Station refurbished to a radio astronomy site as was with Ghana Radio Astronomy Observatory (GRAO), it was observed that the defunct earth station currently suffers from higher RFI caused by increasing human settlement around the station. This study clearly shows that GIS can be applied in an MCDA to perform site suitability analysis in radio astronomy. It is recommended that further RFI, wind gradient, atmospheric dust, precipitable water vapor, and site suitability analysis be conducted in each suitable county.

Session

Division B Facilities, Technologies and Data Science

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Enabling X-ray astronomy from anywhere – XMM-Newton data analysis in the cloud

Dr Peter Kretschmar[1], Ms Esin Gübalhar[1], Mr Aitor Ibarra[2], Dr Ivan Valtchanov[2], Dr Richard Saxton[2], Dr Anthony Marston[1]

[1]European Space Agency, ESAC, Spain. [2]Telespazio UK for European Space Agency, ESAC, Spain

Abstract

ESA's XMM-Newton satellite has been operating as an open X-ray observatory since the year 2000, producing high quality scientific results over all these years and with an unflagging interest by the community.

The public XMM-Newton Science Archive (XSA) makes XMM-Newton data freely available to the world. Together with the data the XMM-Newton project provides the Science Analysis Software (SAS) which is also free to download and use but requires specific installation.

As an additional service to the community the XMM-Newton Science Operations Centre has been providing a Remote Interface for Science Analysis (RISA) via the XSA but with somewhat limited functionality compared to the full software suite.

In this poster we report on the efforts to make the full range of XMM-Newton science analysis accessible via cloud platforms, specifically via the ESA Datalabs initiative. Common analysis threads are being made available via user-friendly Python interfaces and the full set of tools are accessible for more experienced users, who can freely access the public data in the archive.

This initiative opens new possibilities for any interested researcher via the internet and web browsers, lowering the barriers for access to the exciting world of X-ray astronomy.

Session

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Imaging the sky with the Tianlai Cylinder Array: simulation and analysis

Dr. Kaifeng Yu, Dr Shifan Zuo, Dr. Fengquan Wu, Dr. Yougang Wang, Xuelei Chen

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

The Tianlai cylinder array is a pathfinder for developing and testing 21cm intensity mapping techniques. It observes the sky by drift scan. We use numerical simulation to assess how its measurement is affected by thermal noise and the errors in calibration and map-making process, and the error in the sky map reconstructed from a drift scan survey, in the single frequency, unpolarized case. The beam is modelled by fitting to the electromagnetic simulation of the antenna, and the variations of the complex gains of the array elements are modelled by Gaussian processes. Mock visibility data is generated and run through our data processing pipeline. We find that the accuracy of the current calibration is limited primarily by the absolute calibration, where the error comes mainly from the approximation of a single dominating point source. We then studied the map-making algorithm with regularization. Discarding modes with singular values smaller than a threshold could generate visible artifacts in the map, though these are less visible in the Tikhonov regularization. The angular power spectrum of the reconstructed map show that the current Tianlai cylinder pathfinder, which has a shorter maximum baseline length in the North-South direction, would lose a significant fraction of higher angular modes when noise is present. The performance can be improved by reconfiguration of the array feed positions.

Session

Division B Facilities, Technologies and Data Science

1158

The VO, FAIR Principles and Open Science

De Bruce Berriman

Caltech/IPAC

Abstract

The Virtual Observatory (VO) is a global ecosystem of interoperating services that connect worldwide data archives. The VO is implemented in all major astronomy archives through common interfaces developed by the 22 members of the International Virtual Observatory Alliance (IVOA). It was founded in 2002, and the latest members, the SKA Observatory and the Kazakhstan Virtual Observatory, joined in 2022. The IVOA has since its inception supported the goals of Open Science and what are now known as FAIR principles: Findable, Accessible, Interoperable, Reusable. Implementation of the common interfaces, defined and documented as what are called VO protocols, go a long way towards implementing the FAIR principles. A total of eleven of the 16 enumerated FAIR principles are or will be implemented when VO protocols are employed. The remainder are generally out of scope for the IVOA. The VO acts a democratizing influence in astronomy: it provides equal access to worldwide public data sets to under-served communities as to large data centers, and enables international participation in scientific research and education. Thus astronomers from many different communities are positioned to participate in the big science questions emerging in astronomy in the 2020s.

Session

Division B Facilities, Technologies and Data Science

1176

Astronomical Polarimetry across the Spectrum

Dr. Juan Diego Soler

INAF

Abstract

Initially a fringe technique amongst the ones more traditionally used in observational astronomy, polarimetry has become a mainstream tool to explore the physics of the Universe in the past few decades. Large and small observatories now offer polarimeters, with technological developments in instrumentation and computing (including modelling) as major drivers of this flourishing. The whole electromagnetic spectrum is now actively being explored through polarimetry. I will briefly review the recent and forthcoming advancements in astronomical polarimetry, from gamma and X-rays to far-infrared and radio, and the paths of astronomical discovery they are opening.

Session

Division B Facilities, Technologies and Data Science

1216

The Characterization and Discovery of Solar System Small Bodies in Modern Astronomical Surveys

Dr. Joachim Moeyens

University of Washington

Abstract

Starting in 2025, the Vera C. Rubin Observatory will conduct a comprehensive survey named the Legacy Survey of Space and Time (LSST). LSST is predicted to discover six million minor planets. Claims in the literature have suggested that optically-derived asteroid diameters are only accurate to within 50% compared to IR-based estimates. We show that optical measurements can be used to constrain diameters with 0.4% bias and scatter of only 17%. LSST will discover minor planets by observing "tracklets": intranight linkages of two or more observations. The requirement to observe tracklets places a strong constraint on cadence and makes datasets not constructed with such a cadence unsuitable for discovery searches. We developed "Tracklet-less Heliocentric Orbit Recovery" (THOR), a cadence-independent discovery algorithm that does not require tracklets. We applied THOR to two weeks of observations from the Zwicky Transient Facility (ZTF) and show that it can recover 1.5-2x as many asteroids as its tracklet-based counterparts. We deployed THOR on the Asteroid Discovery, Analysis, and Mapping (ADAM) platform – a cloud-based discovery service which we name ADAM::THOR. We used ADAM::THOR to search just 0.2% of the exposures contained in the NOIRLab Source Catalog (NSC) and discovered 104 new minor planets. More recently, we have continued processing the remaining 99.8% of the NSC with a production-version of ADAM::THOR and will report on its status and latest results, including discovery yields, processing time, and the implications for tracklet-less discovery in the era of LSST.

Session

Division B Facilities, Technologies and Data Science

1281

TCSpy: Multiple Telescope Control System for 7 Dimensional Telescope (7DT)

Mr Hyeonho Choi[1,2,3], Dr Myungshin Im[1,2,3], Dr Ji Hoon Kim[1,2,3]

[1]Seoul National University. [2]SNU Astronomy Research Center (SNUARC). [3]Center for the Gravitational Wave Universe

Abstract

In this poster, we introduce TCSpy, an innovative software which is designed to efficiently control an array of multiple telescopes through the network-based communication. The primary objectives of TCSpy contain centralized control of multiple telescope, realization of diverse observation modes with multiple telescopes and a swift response to the follow-up transient observations. To achieve these objectives, TCSpy utilizes the ASCOM Alpyca, establishing robust communication among multiple telescopes. Through the integration of Alpyca, TCSpy achieves three distinctive observation modes with the rapid follow-up capabilities. 1. Spectroscopic mode: synchronizes all telescopes precisely to target the same coordinate with different filters, 2. Deep mode: controls all telescopes to observe the same coordinate, but with identical filter. 3. Search mode: all telescopes operate separately to scan wide regions for capturing time-sensitive astronomical transients swiftly. For the practical application of TCSpy, we implement TCSpy within the 7 Dimensional Telescope (7DT). 7DT is a telescope array consisting of 20 0.5-m telescopes, each equipped with a different filter set. The main scientific goals of 7DT encompass detecting the optical counterparts of gravitational wave sources and identifying kilonovae through fast follow-up spectroscopic observation. In addition to these goals, 7DT embarks on the 7 Dimensional Survey (7DS), acquiring time-series spectroscopy across the entire southern hemisphere sky. Here, we show how these scientific goals are accomplished with TCSpy and preliminary performance of TCSpy.

Session

Division B Facilities, Technologies and Data Science

1325

Analysis of Kepler “KIC 8462852” Light Curves using ML Techniques

Ms Fatemeh Fazel Hesar[1,2], Prof. Bernard Foing[1,2,3], Dr. Atefeh Javadi[4], Dr. Leila Sadeghi[5,4]

[1]EuroSpace Hub Academy. [2]Leiden University. [3]EuroMoonMars. [4]Institute for Research in Fundamental Sciences (IPM). [5]SPCRI

Abstract

The intricate patterns and hidden secrets embedded within celestial light curves hold immense potential for understanding the underlying physical processes governing the cosmos and identifying potentially habitable worlds in the context of exoplanet research. However, deciphering these patterns is often hindered by the complexity and noise inherent in light curve data. To address this challenge, we propose a novel multi-model regression approach that combines the strengths of Gaussian Process Regression (GPR), Linear Regression, and Random Forest Regression (RFR) to analyze light curve data effectively. This comprehensive approach enables us to uncover deep insights even in noisy and complex signals, particularly relevant for identifying exoplanets.

We leverage the wealth of Kepler light curve data and employ meticulous data collection and preprocessing techniques to utilize this multi-model regression approach. Our analysis of the KIC 8462852 dataset, a potential exoplanet host, demonstrates the effectiveness of our method in unveiling the complex interplay of periodic and non-periodic phenomena, providing valuable insights for exoplanet detection. This groundbreaking approach empowers us to decode the mysteries of light curves, paving the way for transformative insights into exoplanets and the search for habitable worlds.

Session

Division B Facilities, Technologies and Data Science

1332

30 years of improving VLBI - technology developments at JIVE

Mrs Marjolein Verkouter

Joint Institute for VLBI ERIC

Abstract

The Very Long Baseline Interferometry (VLBI) radio astronomical observing technique is booming. Due to massive technological improvements and cost reduction in digital equipment this techique is increasingly popular and able to address unique science questions such as imaging the shadows of black holes or localising Fast Radio Bursts within their host galaxies.

The Joint Institute for VLBI European Research Infrastructure Consortium (JIVE) celebrates is 30th birthday this year. JIVE, and its Technical Operations and R&D department's, core mission states "improve the VLBI technique in the widest sense". Over the institute's life time so far, many tools, products, and algorithms were developed that not only benefit the European VLBI Network, but have found application in other VLBI arrays, communities, or into the Common Astronomical Software Applications (CASA) standard radio data reduction package.

In this talk I would like to introduce some of those technological developments potentially relevant to current, and future instruments such as the SKA, from a software VLBI correlator providing unique science opportunities to global high-speed data recording and transmission tools (the EVN is the only VLBI array offering real-time correlation as standard observing mode), Jupyter-notebook based radio data processing with CASA, and supporting radio data (including raw visibilities) in the International Virtual Observatory, demonstrated by the inclusion of the EVN Archive in the VO. To address future scalability in data rates and volumes, currently developments include porting the correlator's algorithm to a TensorCore-based GPU platform and the fringe fit algorithm to the Python Dask framework.

Session

Division B Facilities, Technologies and Data Science

1367

Machine Learning Approaches to Study Star Formation and Black Hole Accretion in the MeerKAT/MIGHTEE Survey

Mr Walter Silima

The Inter-University Institute for data intensive astronomy (IDIA), University of Cape Town

Abstract

Galaxy formation and evolution are driven by two main physical processes: star formation and black hole accretion. Both processes can be traced via the synchrotron emission at radio wavelengths. However, a reliable classification of radio sources as star-formation-dominated sources (or Star-Forming Galaxies, SFGs) and black-hole-accretion-dominated sources (or Active Galactic Nuclei, AGN) is non-trivial and often requires extensive use of multi-wavelength data. Although significant effort has been put into classifying radio sources as SFGs or AGN over the decades, the rapid growth of radio data available from facilities such as the South African MeerKAT telescope, the Australian Square Kilometre Array Pathfinder (ASKAP), and eventually the Square Kilometre Array (SKA) requires the development of efficient and reliable automated classification techniques. In this study, we develop, optimise and compare supervised machine learning (ML) models such as Logistic Regression (LR), Support Vector Machine (SVM), K-Nearest Neighbour (*k*NN), Random Forest (RF) and Extreme Gradient Boosting (XGB) to classify radio sources detected in the MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE)–COSMOS survey as SFGs and AGN. We found that supervised ML models perform very well in classifying SFGs and AGN detected in radio continuum surveys. All models performed well with accuracies greater than 90%, even when only 20% of the data was used to train models.

Session

Division B Facilities, Technologies and Data Science

1391

codeSMT – An Integrated Modelling tool for Segmented Mirror Telescopes.

Dr Prasanna Deshmukh

Indian Institute of Astrophysics

Abstract

Segmented mirror technology is slowly becoming a natural choice for upcoming telescopes of mid to large sizes. The challenge with the segmented primary mirror telescope (SMT) is to maintain the alignment of mirror segments against gravity, thermal and wind induced disturbances. This is achieved through an active control system using three actuators and six intersegment edge sensors. The conversion of sensor positions to required displacement in the actuator is carried out using a primary mirror control system (M1CS), which utilizes an interaction control matrix. As telescope size increases, control of segmented mirror telescope becomes more and more challenging due to its complexity and the presence of a high order system. So, the use of an Integrated model of the telescope becomes a necessity in the early design phase of the telescope for parameter selection and optimisation. A generic Integrated Modelling tool (codeSMT) for the design and analysis of a Segmented Mirror Telescope is developed at IIA. The codeSMT tool is built based on the state-space model of a soft actuator with Multiple-Input Multiple-Output (MIMO) capability to incorporate dynamic wind disturbance and vibration effects. A detailed error multiplier analysis can be performed numerically using this tool. A parameter sensitivity analysis can be performed to fine-tune the primary mirror control system variables. In this paper, I will present features and applications of the codeSMT tool along with a case study of the National Large Optical Telescope (NLOT) under design and development at the Indian Institute of Astrophysics.

Session

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1407

MAGIC: a focal reducer for the study of active galactic nuclei

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Abstract

We present the universal focal reducer MAGIC (Monitoring of Active Galaxies by Investigation of their Cores), which will be commissioned on the Russian 1-meter telescope in 2020. Three observing modes are currently implemented: photometry, polarization, and long-slit spectroscopy. MAGIC provides a wide field of view for photometry and a slit height for spectroscopy of ~12', and a field of view of ~6'.4 for polarization with a quadrupole Wollaston prism. This feature provides an efficient way to study extended nebulae and galaxies. The spectral mode in the range 4200-7000 AA provides a spectral resolution of R ~1000; for stellar objects up to 14 mag in mid-band filters with 1'' image quality over a 20 minute exposure, the photometric accuracy is better than 0.01 mag and the polarization accuracy is better than 0.6%. We will also highlight the current status and prospects of the project.

Session

Division B Facilities, Technologies and Data Science

1506

Scalable visualisation of large distributed data sets enabled by Virtual Observatory standards and tools.

Mark Allen

Centre de Données astronomique de Strasbourg. Strasbourg astronomical observatory, UMR 7550

Abstract

Surveys of the sky with current and future astronomical instruments will lead to very large volumes of data that are distributed in archives around the world. In the context of the international Virtual Observatory, hierarchical approaches have been developed to enable data-access and visualisation of very large data sets. This is based on the computation of multi-resolution representations of sky survey data, using the HEALPix indexation, and international agreement on the Hiearchical Progressive Survey (HiPS) standard of the IVOA. A network of ~20 'HiPS nodes' has been established, which provides access to ~1200 HiPS data sets, and a number of tools and services have been developed for visualisation of these data. I will present the capabilities of this open network using the example of the CDS Aladin service and the integration of Aladin Lite into various science portals. I will also highlight how the multi-resolution approach enables collections of pointed observations to be treated in the same systems as very large wide area surveys, and the new innovative scientific capabilities that are being built to exploit these rich data sets including cut-out services, and use the of time and frequency dimensions of the data.

Session

Division B Facilities, Technologies and Data Science

1528

EARTH'S PROTOTYPE, MOON'S FUTURE: MACHINE LEARNING FOR SMART AND SUSTAINABLE LUNAR CITIES

Mr Marc Crampe[1,2,3], Ms Fatemeh Fazel[3,2,4], Mr Jack Laffey[5,3,2], Ms Caitlin Robertson[5,3,2], Ms Molly Balfe[5,3,2], Dr Bernard FOING[3,2]

[1]IPSA Paris. [2]EuroMoonMars. [3]EuroSpaceHubAcademy. [4]Leiden University. [5]TE Dublin

Abstract

With the moon emerging as the next significant milestone in space colonization, it's crucial to learn from Earth's development and prioritize sustainability for lunar habitation. Using Earth as a blueprint, with its centuries of civilization and vast dataset is the best way to get ready for the next step.

What we have managed from now is using machine learning (ML) and Earth observation (EO) technologies to analyze urban organization and assist cities in expanding sustainably and strategically. We are now seeking to integrate insights from Fatemeh Fazel's work on ML with exoplanets and Molly Balfe and Caitlin Robertson's research on lunar mapping to develop a model for optimal organization of future moon villages and cities.

Recognizing that moon colonization will be an ongoing process requiring adaptability, our primary objective is to create an ML model, employing techniques such as Random Forest (RF) and Convolutional Neural Networks (CNN), to enable Moon urban mapping. This model will segment lunar areas based on key characteristics such as altitude, soil composition, and mineral deposits, while also considering the strategic placement of infrastructure elements as features which are crucial for city organization.

In conclusion, this comprehensive strategy offers Moon investors guidance in selecting the most suitable locations for infrastructure investment, fostering collaborative efforts towards lunar exploration and settlement in a sustainable way.

Session

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1533

Supercharging transient science in the Rubin Observatory era

Prof. Renee Hlozek[1,2], Dr. Rob Knop[3], Prof. Gautham Narayan[4], The ELAsTiCC Team[5]

[1]Dunlap Institute of Astronomy and Astrophysics, University of Toronto. [2]Department of Astronomy and Astrophysics, University of Toronto. [3]Lawrence Berkeley National Laboratory. [4]University of Illinois at Urbana-Champaign. [5]LSST Dark Energy Science Collaboration

Abstract

Science with transients — objects that change in brightness over a given time frame in the optical sky — will be revolutionized by the Vera C. Rubin Observatory, which will see first light in 2025. The Rubin observatory will scan the entire sky visible from Chile every few nights in optical wavebands. Millions of 'alerts' that new objects have formed in the sky will be generated by the telescope each night, and several dedicated brokers will absorb those alerts, classify them into different categories and send them out into the community. These data will be stored and processed by data centres in the US and through International Data Access Centres (IDACS) provided by international partners.

I will describe the Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC), which challenged LSST broker teams to classify simulated Rubin alert streams in advance of the arrival of data. I will highlight how ELAsTiCC supported improvement of algorithms and methods in participant broker classification schemes, and how classification performance was evaluated in the challenge.

I will also describe the Canadian Data Intensive Astrophysics PLatform (CanDIAPL), a Canadian data centre under construction that will process and serve multi-wavelength data from Rubin and surveys at other wavelengths.

Session

Division B Facilities, Technologies and Data Science

1540

On-The-Fly interferometric imaging with the MeerKLASS survey

Dr. Suman Chatterjee

University of the Western Cape

Abstract

MeerKLASS, the MeerKAT Large Area Synoptic Survey, aims to survey large areas of the sky with MeerKAT in order to probe cosmology using the single dish HI intensity mapping technique, while producing continuum images with the interferometer. The target is to cover 10,000 deg2 on the UHF band with 25 uJy rms and 13'' resolution (a new survey in the L-band with the MeerKAT extension aiming at 5,000 deg2, 9 uJy rms and 5'' has also been proposed). The single dish survey requires a fast scanning mode at constant elevation in order to deal with systematics. This requires the use of the "On-The-Fly" (OTF) interferometric imaging technique to enable commensal observing for intensity mapping and interferometric imaging. In this work, we demonstrate that science-quality OTF interferometric continuum imaging with fast scanning speeds is possible with MeerKAT, using available MeerKLASS data. We develop a framework to transform MeerKLASS scan observations into OTF-format measurement sets and mitigate these issues. We use these measurement sets to produce OTF interferometric imaging snapshots and employ two different techniques to add multiple OTF snapshots. Till now we have processed OTF snapshots in L-band, that cover about 300 square degrees in the Southern sky and achieved an image sensitivity of ~140 uJy and we aim to reach about 30 uJy with the existing observations. In future, with many fold data acquisition by the MeerKLASS survey we expect to embark on the search for slow transient and deep imaging.

Session

Division B Facilities, Technologies and Data Science

1550

Enabling Future Breakthroughs in Time-Domain and Multi-Messenger Astronomy

Brad Cenko

NASA/GSFC

Abstract

Time-domain and multi-messenger astronomy (TDAMM) was highlighted as a frontier science pursuit in the coming decade by the 2020 Decadal Survey in Astronomy and Astrophysics in the United States. Given the rapid response and cross-facility coordination necessary to enable such science, well-defined standards play a critical role in this field reaching its full potential. I provide an overview of some of the most exciting scientific opportunities in the coming years in this science, and highlight the important role played by coordination in enabling those results.

Session

Division B Facilities, Technologies and Data Science

1704

3D Astronomical Visualization with Open Shading Language and Blender

Dr. Brian Kent

National Radio Astronomy Observatory

Abstract

Astronomical datasets now exhibit complexity that requires innovative displays of observational and theoretical data. We describe methods for using Open Shading Language (OSL) and Python to render 3D data in the software package Blender. The API allows control over camera angles, rendering, and GUI programming with the node compositor. Using OSL code and its C-like syntax with Blender allows for rendering and animating data. We show examples of all sky maps, 3D data cubes, and astronomical catalogs that can be examined in real time with a viewer, or with rendered output in high resolution.

Session

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1778

Precipitable water vapour measurements at the potential sitesfor the Africa Millimetre Telescope

Mr Lott Frans[1], Prof Michael Backes[1,2], Prof Heino Falcke[3], Dr Tiziana Venturi[4]

[1]Department of Physics, Chemistry & Material Science, University of Namibia. [2]Centre for Space Research, North-West University. [3]Department of Astrophysics, Institute for Mathematics, Astrophysics and Particle Physics (IMAPP), Radboud University. [4]Istituto di Radioastronomia, Instituto Nazionale di Astrofisica

Abstract

The Event Horizon Telescope (EHT) is a network of antennas across the globe that is used to image super-massive blackholes (SMBHs). These antennas observe together in very long baseline interferometry (VLBI) at a frequency of 230 GHz to produce a single image. Since the release of the first image of M87* in 2019 and, subsequently, the image of Sgr A* in 2022 by the EHT collaboration, the focus has shifted to dynamically imaging blackholes. This has led to a search for possible sites to extend and fill the gaps within the EHT network. The Khomas highlands of Namibia have been found to have optimal conditions for astronomy and thus have been identified as one such area to add an observatory. The Gamsberg Mountain and the H.E.S.S. site are both located within the Khomas highlands and have been identified as potential sites for the AMT observatory. Precipitable water vapour (PWV) in the atmosphere is the main source of opacity when observing at millimetre wavelengths and therefore this study aims to establish the PWV content at the potential sites. Preliminary results show the overall PWV conditions at the Gamsberg Mountain was lower than that at the H.E.S.S. site. The winter period at both sites offered relatively low PWV's whilst the EHT window had relatively higher PWV at both sites in 2023. Both sites have higher atmospheric transmission during the winter period at 86 GHz and 230 GHz, with the possibility of conducting observations at 345 GHz at the Gamsberg Mountain under the best possible conditions of the winter period.

Session

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1877

The next-generation Event Horizon Telescope

Dr. Sheperd Doeleman, Dr. Lindy Blackburn, Mr. Garret Fitzpatrick, Dr. Michael Johnson, Mr. Aaron Oppenheimer, Dr. Dominic Pesce, Dr. Jonathan Weintroub

Center for Astrophysics | Harvard & Smithsonian

Abstract

The next-generation Event Horizon Telescope (ngEHT) is project that will transform the EHT, creating an array that will be capable of making real-time and time-lapse movies of supermassive black holes on event horizon scales. These movies will resolve complex structure and dynamics in the immediate vicinity of the event horizon, bringing into focus not just the persistent strong-field gravity features predicted by General Relativity (GR), but details of active accretion and relativistic jet-launching that drive large scale structure in the Universe. This effort builds upon recent results by the Event Horizon Telescope (EHT): the first image of M87's supermassive black hole and its magnetic field structure, as well as resolved images of Sgr A*, the central black hole at the heart of the Milky Way.

These images, though scientifically rich, show that evolution of the EHT to a more capable array can address even deeper questions across physics and astronomy. The central concept behind the ngEHT is that the addition of many modest-diameter dishes at new geographic locations will enable high-dynamic-range imaging and time-resolved dynamical studies of the black hole boundary.

The central elements of the ngEHT include:

- Adding multiple 10-meter-class radio dishes in new geographic locations.
- Enabling tri-band (86, 230, 345 GHz) simultaneous observations to increase Fourier spatial frequency sampling and enable multi-frequency modeling and imaging.
- Increasing bandwidth for higher instantaneous sensitivity, moving to a per-station data capture rate of >256 Gbps.
- Developing a high-throughput data processing and analysis pipeline that speeds time to science.

Session

Division B Facilities, Technologies and Data Science

1879

Data Processing And Scientific Exploration of the Moon-Based Ultraviolet Telescope on the Chang'E-3 Lander

Dr. Gaurav Singh

National Astronomical Observatory of China

Abstract

We present the first results pipeline processed data observed from the Moon-based Ultraviolet Telescope (MUVT). The MUVT system is set up to perform multi-day observation activities that can monitor variables tars and active galaxies in the near ultraviolet band, which include variable stars, binaries, novae, quasars and blazers. MUVT is capable of detecting objects with a brightness down to magnitude 13. We will discuss the steps involved in processing the data and further analysis for the desired scientific usage. This includes the first results of the pipeline processed Level 2A and 2B data observed through MUVT over a decade.

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1905

A New Implementation of Convolutional Neural Networks for Astronomical Data

Faezeh Bidjarchian[1], Dr Mohamamd Akhlaghi[2]

[1]A freelance researcher. [2]CEFCA

Abstract

With the arrival of JWST, Euclid, LSST, J-PAS, and other whole sky surveys astronomers now have unprecedented access to massive amounts of data. However, processing and extracting knowledge from this data is a challenging task due to the enormous amounts of data. To enhance efficiency and functionality, software methods such as machine learning have gained significant attention in the physics research community in recent years. A deeper understanding of how these networks distinguish available objects and patterns to accurately predict new data is essential for their optimal usage.

In this talk, we have explored the limitations of current neural network architectures applied to astronomical data. Our research has revealed that the existing networks may not be well-suited for handling astronomical data and multiple issues can impact the performance of these networks. For example, our deep FITS images are 32-bit floating point and in many filters, so the conversion to 8-bit RGB JPEG format images causes the loss of valuable data early in the process. This is compounded by adding all filters together in inner layers, which may not fully capture the complexities of the data, and the presence of NaN values which are prevalent in astronomical data.

To address such and other limitations of current neural networks when applied to astronomical data, we are developing a dedicated program within GNU Astronomy Utilities (Gnuastro). Our implementation is designed to account for the such issues mentioned above problems.

Session

Division B Facilities, Technologies and Data Science

1986

LSST Discovery Alliance - Helping Scientists Use Rubin's Legacy Survey of Space and Time

Dr. Beth Willman

LSST Discovery Alliance

Abstract

LSST Discovery Alliance (LSST-DA) aims to maximize the impact of Rubin Observatory's Legacy Survey of Space and Time. On track to begin in 2025, this ground-based, optical survey will curate astronomical data at a scale never seen before, producing the ultimate map of our dynamic Universe. LSST-DA removes obstacles between Rubin LSST's data-intensive output and discovery by developing an ecosystem of bold programs that foster innovation, inclusion, and interdisciplinary collaboration. Through our programs, we can propel a revolution in humankind's understanding of the Universe while transforming the way we do science. This talk will highlight our approaches to lowering the barrier of engagement with data-intensive astrophysics experiments.

Session

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2085

Unveiling the Instrument Polarization: Insights from the INdian Spectroscopic and Imaging Space Telescope (INSIST)

Dr Vineeth Valsan[1], Dr Sriram S[1,2], Ms Lorraine Maria Thomas[1], Ms Raveena Khan[2], Ms Namita M Kinnal[1], Professor Maheswar Gopinathan[2], Professor Annapurni Subramaniam[2]

[1]Christ University. [2]Indian Institute of Astrophysics

Abstract

The INdian Spectroscopic and Imaging Space Telescope (INSIST), a proposed Ultraviolet (UV) mission, aims to explore the UV-Visible region, generating high-quality images akin to the Hubble Space Telescope. Operating within the range of 150 nm - 500 nm, INSIST boasts a large focal area and delivers medium-resolution images (R ~ 1000- 2000). Utilizing an off-axis TMA design with a one-meter primary mirror, the telescope introduces instrumental polarization (IP) due to its optical configuration, which needs to be studied in detail.

Some degree of polarization is expected from every astronomical object, ranging from solar system objects to AGNs. Thus, polarimetry and polarization studies provide unique and powerful ways to discern the geometry and physical conditions of a large class of astronomical objects. Polarimetry, especially in UV, is an unexplored area, and having a polarimetric capability will add value to the mission. However, including a polarimetric capability in the mission requires elaborate and precise calibration. Understanding instrumental polarization is a vital component to achieving that.

This study comprehensively characterizes the instrumental polarization of INSIST using the Polarization Ray Tracing method and Pupil maps. Our analysis estimates the extent of IP, cross talk, and depolarization, enabling the correction of potential polarisation measurement errors. The critical insights into INSIST's instrumental polarization are obtained through simulations, ensuring accurate and reliable polarization measurements of celestial sources.

Session

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2187

The Frequency Distribution System for the Mid-Frequency Square Kilometre Array radio telescope

Dr Michael Kriele[1,2,3], Mr Charles Gravestock[1,2], Dr Edward Gluszak[1,2], Mrs Neethu Thomas[1,2], Dr Eric Tyler[1,2], A/Prof Sascha Schediwy[1,2]

[1]University of Western Australia. [2]International Centre for Radio Astronomy Research (ICRAR). [3]Curtin University

Abstract

Phase-stabilized frequency distribution techniques, facilitated by optical fibre networks, serve as a basis for highly stable and precise frequency reference sources. These applications find significance in critical fields like atomic clock comparison, relativistic geodesy, and the phase-synchronization of radio telescope-based interferometric arrays. Notably, the largest frequency transfer networks cover distances of 2,200km and 4,800km, exhibiting residual instabilities between 10^{-16} and 10^{-19} with up to 94% uptime. The expansion of network reach involves combining fibre infrastructure and diverse technologies, necessitating the use of specialized equipment. An efficient design approach is required to expand these networks effectively, augmenting nodes and extending their total distance.

We present the Reference Frequency Distribution System for the Mid-frequency Square Kilometre Array telescope, with an emphasis on the Receiver Module (RM) performance. Generally, the system uses round-trip phase-stabilisation techniques to deliver a 3.96GHz clock signal to each of the 197 receptors. A novel configuration of Acousto-optical Modulators are used to achieve the actuation range required to suppress the phase fluctuations contributed by the overhead cables.

The RM functions as a precision low-phase noise, narrow-band microwave signal generator, synchronizing with phase-corrected optically transmitted frequencies. It ensures synchronous operation across all required frequencies, we demonstrate excellent stability and spectral purity through implementation of an innovative jitter-attenuating phase-lock loop design. The RM has >99.9% uptime, a maximum of 1% coherence loss >1000s, microwave-frequency signals with instability $<10^{-16}$, and a phase jitter performance of <100fs. Overall, the design presents a potential baseline for adaptation with other next-generation telescopes.

Session

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2245

Mercurial MeerKAT & Fast ATA: towards a near-real time radio interferometric transient and variable detection pipeline

Distinguished Prof Oleg Smirnov[1,2,3], Dr Ian Heywood[4,1,5,2]

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Abstract

The time domain is one of the last frontiers of radio astronomical imaging. Transient (and time-variable) astrophysical phenomena represent some of the most extreme physical processes in the Universe, and are also of extreme relevance to the ongoing search for SETI. Mercurial MeerKAT & Fast ATA (MM/FATA) is a joint initiative between Breakthrough Listen, Rhodes University, University of Oxford, and South African Radio Astronomy Observatory to develop a fast imaging backend for the MeerKAT and ATA telescopes. South Africa's MeerKAT is the most sensitive radio telescope in operation today, and initial (largely handcrafted) transient detection results point at a goldmine of hitherto unknown objects and new classes of objects waiting to be discovered. The recently upgraded Allen Telescope Array (ATA), on the other hand, has a very broad and agile frequency capability (1-12 GHz), and provides the capability to rapidly survey specific regions of interest. MM/FATA is a fast imaging pipeline that will be able to process imaging data in near real-time, perform transient detection, and extract lightcurves and dynamic spectra for objects of interest. Such a pipeline is made possible by a new generation of software tools developed at Rhodes, which are presented at this year's FM7 meeting. The eventual goal of the project is to deploy both (a) a fully commensal transient search backend operating on both telescopes in real time, and (b) an "archive mining" machine that can go back and mine the archives of existing data for these events.

Session

Division B Facilities, Technologies and Data Science

2328

Spanish Virtual Observatory: 20 years of public and community engagement

Dr J. Ricardo Rizzo[1,2], Dr Enrique Solano[1], Dr Francisco Jiménez Esteban[1], Dr Patricia Cruz[1], MSc Pedro Mas[1]

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Abstract

It is described how the Spanish Virtual Observatory (SVO) contributed to the knowledge and best use of the VO tools and archives in its 20 years of existence. Since the beginning, SVO was heavily involved in a number of innovative activities aimed to promote the use of VO tools and archives, involving graduate and post-graduate students, and also amateur astronomers.

Specifically, we focus on two different actions: (1) the organization of events within large conferences; and (2) the development of specific schools.

Among the events, we highlight the successful organization of a Special Session within the EAS 2023 meeting. It was dedicated to current VO tools and the progressive incorporation of new approaches such as Machine Learning, Data Mining, and Big Data. We also describe the organization of a symposium in the frame of the Spanish Astronomical Society 2024 Annual Meeting, mostly focused on successful science cases based primarily in VO results.

Another set of actions is the continuous organization of specific VO Schools at different levels. The schools are developed both in-person and remote, sometimes co-hosted by universities and amateur astronomical societies. They are based on a learning-by-doing approach and makes use of the most common VO tools (such as TOPCAT and Aladin) and languages (such as ADQL and python/pyVO).

Session

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2365

High-energy neutrino astrophysics and blazars

Dr. Paolo giommi

Center of Astronomy and Space Science (CASS), New York University Abu Dhabi. INAF-Osservatorio Astronomico di Brera. Institute for Advanced Study, Technical University, Munich

Abstract

In my presentation I will review some of the recent results on the identification of astronomical high-energy neutrinos with extragalactic cosmic sources.
I will particularly consider the class of blazars, which along with the more isolated case of the Seyfert galaxy NGC1068, constitute the most promising type of candidates counterparts.
I will report on the latest statistical correlation between the list of IceCube tracks reported so far as well as possible theoretical interpretation based on multi-wavelength data using novel methods.

Session

Division B Facilities, Technologies and Data Science

2419

European participation in the Habitable Worlds Observatory

Prof. Ana Inés Gómez de Castro

Universidad Complutense de Madrid

Abstract

Habitable Worlds Observatory (HWO) is a large infrared/optical/ultraviolet space telescope designed specifically to search for signs of life on planets orbiting other stars. The concept emerged from the recommendations of the National Academies of Science, Engineering and Medicine of the United States after the Decadal Survey on Astronomy and Astrophysics 2020. NASA funded four concept studies to aid the National Academies' decision that were participated by European Astronomers, most of them as representatives of their National Agencies. This participation included not only the participation in the science cases and science definition but also the design of specific instruments for the purpose. In this talk, I will address the progression of these activities.

Session

Division B Facilities, Technologies and Data Science

2422

Investigating the pupil dependence of the polarimetric sensitivity on SALT

Dr Danièl Groenewald[1,2], Prof Kenneth Nordsieck[3]

[1]SAAO. [2]SALT. [3]University of Wisconsin-Madison

Abstract

The Robert Stobie Spectrograph (RSS) is an imaging spectrograph designed to occupy the Prime Focus Instrument Package of the Southern African Large Telescope (SALT). Grating spectro-polarimetry, 3200 - 9000 Angstrom, with resolution R up to 10 000, is always available, using rotating half- and quarter waveplates near the telescope focal plane and a calcite mosaic beamsplitter in the collimated space. In this talk we describe improvements made to the polarimetric calibration to correct for an unexpected time-dependent position angle ``ripple'' vs wavelength which has been seen in high-precision RSS observations and appears to be due to variations in the pupil illumination during an observation. A new calibration technique, which explicitly models the pupil dependence of the polarimetric sensitivity, has been developed. The net spectral polarization sensitivity vs field of view position (X; Y) and wavelength are computed as the polarization pupil dependence, weighted by the pupil intensity illumination of the observation. For the polarization pupil dependence, degree P and position angle are well represented by a polynomial function of position in the pupil. A pupil intensity illumination model for SALT has been devised, calibrated by twilight observations through a pinhole slitmask grid, observed out of focus. The polarization pupil dependence model has been calibrated using observations of the full Moon through a similar mask, plus a polaroid. The final calibration has been checked using repeated observations of known highly polarized standard stars.

Session

Division B Facilities, Technologies and Data Science

2431

The Future of ALMA: Wideband Sensitivity Upgrade and Next-Generation Concepts

Dr. P. R. Jewell[1], Dr. C. L. Brogan[1], Dr. John M. Carpenter[2], Dr. Sean M. Dougherty[2], Dr. Misato Fukagawa[3], Dr. Alvaro Gonzalez[2], Dr. Bunyo Hatsukade[3], Dr. Elizabeth M. L. Humphreys[4], Dr. Norikazu Mizuno[2], Dr. Maria Diaz Trigo[4], Dr. Martin A. Zwaan[4]

[1]National Radio Astronomy Observatory (NRAO). [2]Joint ALMA Observatory (JAO). [3]National Astronomical Observatory of Japan (NAOJ). [4]European Southern Observatory (ESO)

Abstract

ALMA has made many outstanding scientific discoveries in its first decade of observations, ranging from the detection of galaxies in the very early universe, to unveiling star formation within molecular clouds, to imaging planet formation in circumstellar disks. To continue enabling transformative science, ALMA is undergoing the Wideband Sensitivity Upgrade (WSU), the highest priority in the ALMA 2030 Development Roadmap. This will initially double and ultimately quadruple the observing bandwidth and improve receiver sensitivity, with a profound impact in all science areas. This Partnership-wide initiative entails upgrade of most elements of the ALMA system – receivers, IF switch, digitizer, data transmission system, fiber optics, digital correlator and related infrastructure, data acquisition, data storage and processing software, and multiple control, operations, and user interface systems. The WSU system upgrades are currently scheduled for release in late 2029.

Here, we explore concepts for an ambitious follow-up to the WSU, one that aims to achieve a major increase in spectral line sensitivity through increased collecting area, and higher resolution with longer baselines (both recommendations of the ALMA Development Roadmap). Extraordinary science cases abound for an ALMA with such capabilities, including routine, kinematic detection of proto-planetary bodies and un-lensed observations of early galaxies. Technical implementation options are in the initial concept stage, but could involve larger-diameter antennas at fixed locations. Engineering concepts and science cases will be refined through a series of studies and workshops over the coming few years.

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2489

Deriving Star Formation Histories of Galaxies from Spectra with Simulation-based Inference

Patricia Iglesias-Navarro[1,2], Johan H. Knapen[1,2], Ignacio Martín-Navarro[1,2], Marc Huertas-Company[1,2], Emily Pernet[3]

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[3]Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, GU2 7XH, Guildford, United Kingdom

Abstract

High-resolution galaxy spectra encode information about the stellar populations within galaxies. The properties of the stars, such as their ages, masses, and metallicities, provide insights into the underlying physical processes that drive the growth and transformation of galaxies over cosmic time.

We explore an amortised implicit inference approach to estimate from optical absorption spectra the posterior distributions of metallicities and star formation histories (SFHs) of galaxies, i.e. star formation rate as a function of time. We generate a sample of synthetic spectra to train and test our model in a simulation-based inference workflow using the spectroscopic predictions of the MILES stellar population library and non-parametric SFHs.

We reliably estimate the mass assembly of an integrated stellar population with well-calibrated uncertainties. We then apply the pipeline to real observations of massive elliptical galaxies, recovering the well-known relationship between age and velocity dispersion, and show that the most massive galaxies build up to 90% of their total stellar masses 1 Gyr after the Big Bang. The measurements also agree with state-of-the-art inversion codes, but the inference is performed up to five orders of magnitude faster.

This machine learning-based implicit inference applied to full spectral fitting makes it possible to address large numbers of galaxies while performing a thick sampling of the posteriors. It allows to estimate both the deterministic trends and the inherent uncertainties of the highly degenerate inversion problem, so far inaccessible, dealing with the size and complexity of upcoming spectroscopic surveys such as DESI, WEAVE or 4MOST.

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2571

Evaluation of South African Candidate Millimetre Sites for Participation in the Event Horizon Telescope

Mr Senkhosi Simelane[1], Professor Roger Deane[1,2], Professor Athol Kemball[3,1]

[1]University of the Witwatersrand. [2]University of Pretoria. [3]University of Illinois at Urbana-Champaign

Abstract

A significant expansion of the Event Horizon Telescope (EHT) will see the strategic addition of antennas at new geographical locations that will transform the sensitivity and imaging fidelity of this ground-breaking ~ 1 mm interferometric array, particularly for snapshot imaging of Sgr A*. A South African EHT station stands out as a promising geographical candidate, well aligned with the scientific requirements of ngEHT and offering strong synergies with the Africa Millimetre Telescope (AMT) in Namibia by adding a crucial, comparatively short ~1000 km baseline for reliably imaging larger-scale (~200 as) features. We assessed three South African candidate millimetre sites with existing infrastructure using climatological simulations, examining millimetre observing conditions over the past decade. Interferometric simulations of hypothetical future EHT arrays were performed for each candidate site under simulated atmospheric conditions, and evaluated using both observation quality metrics and static and dynamical imaging performance. We find that South Africa has at least two promising sites during the typical April EHT observing window. The model suggests these sites outperform some existing EHT stations for the majority of an average year, especially over the June-August period. This will assist the EHT goal of shadow-resolved imaging of M87* with a monthly rather than annual cadence. The results of the climatological and interferometric simulations collectively underscore the sizable, positive impact of a strategically placed South African EHT station on future EHT scientific objectives, which would build on South Africa's past hardware and software contributions to the EHT Collaboration.

Session

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2572

Adaptive optics simulations and test bed alignment for MOAO systems.

Dr. Archita Rai, Dr. Kyohoon Ahn, Dr. Jae Joon Lee

Korea Astronomy & Space Science Institute

Abstract

Adaptive optics (AO) technique has been utilised to improve the astronomical seeing, experienced by the ground based telescopes. The system compensates for the wavefront distortions present due to the Earth's atmospheric turbulence. It is an inevitable part of the standard instrumentation suite for all the leading large optical/IR telescope observatories. A set of deformable mirrors, wavefront sensors, phase screens and detectors are used to restore the image quality to diffraction limited performance. Adaptive optics has slowly emerged itself into a full zoo ranging as, MOAO, MCAO, GLAO, LTAO, eXAO and LGSAO, to cite the main ones utilised at different telescope facilities. These variations arise from the limitations to achieve a perfect image (Strehl ratio : 100%) over a varied field of view.
Simulating the AO system helps us in understanding the performance of the different components and the resultant outcome dependency over each parameter. Adaptive optics simulation includes the simulation for atmospheric turbulence, deformable mirrors, wavefronts, wavefront sensors etc and finally these individual components interact to help us in closing the loop, hence, estimating the image quality PSF iteratively. A test bench of optically aligned components in a proper set up is utilised to validate the different aspects of the AO system. This work shall present the simulation results and test bench set up in detail, leading to a conclusive interpretation.

Session

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2580

Mechanical design for the cold optics of NOTT, a nulling interferometer for VLTI

György Medgyesi[1], Andras Peter Joo[1], György Mező[1], Alexandra Mazzolli[2], Colin Dandumont[2], Jérôme Loicq[2], Gert Raskin[3], Marc-Antoine Martinod[3], Romain Laugier[3], Germain Garreau[3], Denis Defrère[3]

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Abstract

ESO's Very Large Telescope Interferometer (VLTI) has long been at the forefront of astrophysical research and instrumentation. Its new visitor instrument suite, Asgard, representing a leap forward in capabilities, will offer high angular resolution and high contrast imaging. Among its four natively collaborating instruments is NOTT, a nulling interferometer dedicated to imaging nearby young giant exoplanets in the L' band (3.5-4.0 microns), with its cold optics designed to operate at 90K. In this study, we present the first stage of mechanical design for NOTT's cold optics, encompassing the mounting for collimation, polarization, and imaging, along with a preliminary mount design for the detector. One of its main challenges is to ensure optimal alignment at the operating temperature and achieve precise focus at the detector plane. A critical requirement is to avoid stress on optical elements during and after the cooling process, to maintain their geometry within tolerances. Our devised system exerts minimal force to maintain axial alignment of the optics while facilitating necessary adjustments to achieve focal precision at the detector plane.

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2607

The Past, Present, and Future of the Submillimeter Array

Dr. Jonathan Weintroub

Center for Astrophysics | Harvard & Smithsonian

Abstract

The Submillimeter Array (SMA) is an 8 element radio interferometer on Maunakea in Hawai'i covering the semi-transparent atmospheric windows between 183 and 420 GHz corresponding to short radio wavelengths above and below ~1 mm. SMA was commissioned in 2003 as the first radio interferometer in this band, a pathfinder for later facilities. The eight 6 meter dishes are reconfigurable on baselines from 8 to 508 meters, corresponding to a finest angular resolution of 0.3 arcseconds. A singularly wide instantaneous bandwidth of 48 GHz is correlated to uniform-across-the band spectral resolution of 140 kHz or 0.12 km/s in the 345 GHz band. SMA observations have been published in over 1000 peer-reviewed papers in science areas ranging from high- and low-mass star formation, astrochemistry, supermassive black holes, evolved stars, planets, protoplanetary disks, nearby/high-redshift galaxies, clusters, and time-domain observation of gamma-ray bursts, supernovae, and tidal disruption events. As an early participant in Event Horizon Telescope (EHT) observations SMA pioneered 1 mm phased array beamformer VLBI processing, and become key to the black hole images of M87 and SgrA* published between 2019 and 2022. The SMA plans to upgrade to still wider bandwidths, implementing simultaneous observation in additional frequency bands, and to add solar robustness for direct observations of the Sun's chromosphere. I will discuss the history of the SMA, its current status, and its bright panchromatic future.

Presented on behalf of the Submillimeter Array Team.

Session

Division B Facilities, Technologies and Data Science

2611

MeerKAT: A Giant African Eye and Ear on the Universe

Prof Roger Deane

University of the Witwatersrand / University of Pretoria

Abstract

The 64-antenna MeerKAT radio interferometer, a precursor to the Square Kilometre Array, has amassed a broad range of world-leading results in a short space of time. The coherent confluence of a strategic vision, engineering excellence, and a pioneering human capacity development programme has delivered a state-of-the-art telescope and a diverse community of young African scientists to unlock its full potential. I will give an overview of some of the scientific highlights achieved thus far, from a transformed view of the centre of our Milky Way to the deepest extragalactic radio fields at ~1 GHz; lifting the veil on a diverse population of neutron stars to galaxy clusters; mapping out never-before-seen morphological features in nearby galaxies, relativistic jets from Galactic and extragalactic black holes, to detecting the most distant HI sources and OH megamasers known. MeerKAT's sensitivity and novel backend design have rendered a facility particularly adept at a wide range of time-domain research, which includes the ongoing characterisation of the stochastic gravitational wave background and the search for intelligent life beyond Earth. MeerKAT is demonstrably a transformative facility with an already rich scientific legacy ahead of its incorporation into the Square Kilometre Array, which will also serve as a nucleus for cm-wavelength long-baseline interferometry on the African continent, and beyond.

Session

Division B Facilities, Technologies and Data Science

2627

Status of the Lunar International Observatory

Steve Durst

ILOA

Abstract

The International Lunar Observatory Association (ILOA) is an interglobal enterprise incorporated in Hawaii as a non-profit in 2007, to help realize the multifunctional International Lunar Observatory for long-term astronomy, science and exploration at the Moon South Pole, and to participate in human lunar base. At the time of writing this abstract, ILOA has received the first moon surface and lunar descent images from ILO-X. The ILO-X payload includes a miniaturized dual-camera wide and narrow field-of-view lunar imaging suite. In this contribution the status of ILO-X and ILOA plans for the future will be presented.

Session

Division B Facilities, Technologies and Data Science

2630

Geospatial modeling of a 132kv electricity lines along Alaska_karoi

Geospatial modeling of 132kv electricity line along Alaska_Karoi Tapiwa wallace Gara

Chinhoyi University of Technology

Abstract

This study contributes to the knowledge gap that exists on the use of 3D GIS in transmission line design and electrification. GIS techniques enable the design of a power line in three dimension format and mapping of the existing demand of electricity and. The study also aims to identify the effectiveness of the technique in reducing costs that will be incurred to carry out the project, by identifying optimal routes after considering several factors simultaneously for example land cover and slope , geological characteristics of an area and vegetation cover. In this study we compared GIS with the drawing office techniques and deduce most effective and efficient method. Due to the due to the use of traditional methods of planning and monitoring electricity power lines which results in increased project operation time and more resources , 3D GIS represent viable alternative to meet the increasing demand for energy in the future attaining sustainable development goal number 7.

Poor work efficiency and the ease to optimize a line route continues to be not only a technical issue but a social issue.The motive of this study is that there is need for improvement of the management of the distribution grid and the development of the technique we also realize the limitation of the old distribution grid management systems Therefore, a 3D model for route optimization as a geographic model must be implemented where the terrain and elevation are accurately reproduced

Session

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2636

Direction-Dependent Continuum Subtraction in the uv-plane

Dr Sphesihle Makhathini

University of the Witwatersrand. Rhodes University

Abstract

In radio interferometry, {\it continuum subtraction} involves the estimation of the residual continuum emission not captured in the final self-calibration sky model. In the uv-plane, this is done by fitting a smooth function along the frequency axis for each baseline. This approach works very well close to the phase tracking centre (PTC) but gets increasingly inaccurate with increasing distance from the PTC due to chromatic aberration. This work employs a direction-dependent approach to estimate the baseline spectra for multiple directions (or PTCs). Our approach comes in two flavours. The first, segments the field into a regular grid with the directions corresponding to the centres of each segment (akin to image faceting). The second approach uses a brightness-based Voronoi tesselation to determine the segments and directions. In both approaches, the residual visibilities from a given set of directions are combined using appropriate weights to form a final continuum subtracted visibility data set. Preliminary results show an improvement of $\approx60\%$ at the edge of the MeerKAT field of view (Primary beam FWHM) compared to traditional methods ({\tt CASA's mstranform} tool).

Session

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2670

FiberPol-6D: Spectropolarimetric Integral Field mode for SAAO 1.9 m Telescope using fibers

Dr Siddharth Maharana[1], Dr Sabyasachi Chattopadhyay[1], Prof Matthew Bershady[2]

[1]South African Astronomical Observatory. [2]Univ. of Wisconsin-Madison

Abstract

Optical spectropolarimeters built to date operate as long-slit instruments, and inefficient for observations of extended objects such as galaxies. 2D spectropolarimetry is a major challenge in astronomical polarimetry .

At SAAO's FiberLab, we are developing a spectropolarimetry capable Integral Field front end called FiberPol(-6D) for the existing SpUpNIC spectrograph on the SAAO's 1.9 m telescope. SpUpNIC is a general purpose 2 arc-minute long-slit spectrograph with a grating suite covering the wavelength range from 350 to 1000 nm and at spectral resolutions between 500 and 6000. FiberPol generates 6D observational data: x-y, wavelength, and the three linear Stokes parameters I, q and u.

FiberPol is a low-cost technology demonstrator (< 10,000 USD), and the entire system predominantly employs small size (1 inch or less), commercial off-the-shelve optics and optomechanical components. FiberPol can be modified for use on any existing spectrograph, especially on bigger telescopes like the 10 m South African Large Telescope (SALT) and the upcoming 30 m class telescopes. Polarimetry is often relinquished on large telescopes due to the requirements of large, expensive and fragile optics, and challenging optical designs. FiberPol opens up the possibility of using relatively small, inexpensive fibre-fed polarimetric units, mitigating all the above mentioned hassle.

The instrument design has been completed. The lab assembly and characterization is ongoing and is expected to be completed by July 2024 with subsequent on-sky commissioning in second half of 2024. In this talk, we will present the scientific goals of FiberPol, its overall design and results from the lab characterization experiments.

Session

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2689

A MeerKAT+ and SKA-MID interferometric simulator

Mr Galefang Allycan Mapunda[1], Professor Roger Deane[1,2], Doctor Sphesihle Makhathini[1]

[1]University of the Witwatersrand. [2]University of Pretoria

Abstract

The development of interferometric algorithms and software tools becomes increasingly important with ever larger arrays with increased complexity. These tools aid in the design, and simulation of interferometric arrays as well as data reduction. Despite significant advancements in interferometric data processing techniques, challenges persist in processing data from wide-bandwidth heterogeneous arrays, exemplified by the transition from MeerKAT to MeerKAT+ and then the Square Kilometre Array mid-frequency array. This project will build an end-to-end interferometry simulation software tool and calibration pipeline for heterogeneous arrays such as MeerKAT+ and SKA-MID. Application of this tool include sensitivity calculations, source confusion estimations via synthetic radio source population simulation, as well as to optimise potential sub-array, or the sequential commissioning of receivers within the larger SKA1-MID array configuration. This approach enables the prediction and evaluation of array performance metrics such as; uv-coverage, dynamic range, imaging fidelity, and sensitivity and aid in maximising the scientific utility of future heterogeneous arrays. Additionally, I aim to incorporate VLBI simulations with new stations in African partner countries to assist the expansion of VLBI on the continent.

Session

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2692

PASIPHAE: Large optical polarization sky survey for dust cloud & magnetic field tomography using WALOP instruments

Dr Siddharth Maharana[1], Prof Konstantinos Tassis[2], Prof Ramaprakash Anamprambu N.[3]

[1]South African Astronomical Observatory. [2]Institute of Astrophysics, FORTH, Greece. [3]Inter-University Center for Astronomy and Astrophysics

Abstract

PASIPHAE (Polar-Areas Stellar Imaging in Polarization High Accuracy Experiment) project, scheduled to start in late 2024, aims to create the first large stellar polarization map of the sky, spanning thousands of square degrees in the galactic polar regions. This new catalog will enable creation of magnetic field and dust cloud tomography map of the galactic polar regions using stellar polarimetry and GAIA stellar distances as tools. Two WALOP (Wide-Area Linear Optical Polarimeter) instruments, to be mounted on 1 m class telescopes in South Africa and Greece are being developed to measure the linear polarization of stars up to 16 magnitude in SDSS-r broadband with 0.1 % accuracy.

WALOPs have been designed to operate with the combined capabilities of one-shot linear polarimetry, low polarization systematic (< 0.05%) and a large field of view of 35× 35 arc-minutes, making it a unique astronomical instrument. In a single measurement, WALOPs can measure the linear Stokes parameters I, q and u in the SDSS-r broadband and narrowband filters between 500- 700nm. For each exposure, four images of the full field corresponding to polarization angles of 0, 45,90 and 135 degrees will be generated and by carrying out differential photometry on these images, the Stokes parameters can be obtained.

The unique goals of the instrument place very stringent systems engineering goals, including on the optical, polarimetric, optomechanical, and electronic subsystems, all of which have been met.

In this talk, we will present an overview of the PASIPHAE survey, the WALOP instruments and the their current status.

Session

Division B Facilities, Technologies and Data Science

2699

Big Data and Open Science and Engagement in Radio Astronomy

Professor Russ Taylor

University of Cape Town. University of the Western Cape. Inter-University Institute for Data Intensive Astronomy

Abstract

Current and next generation radio telescopes on the pathway to the SKA are driving a tremendous challenge of big data in astronomy and changing the sociology of the scientific enterprise. Key science programs generating massive data sets are being executed by large internationally distributed collaborations. A prime example is the South African MeerKAT large survey projects, which dedicate thousands of hours of time undertaking high priority science programs by teams of senior researchers, postdoctoral fellows and graduate students from across Africa and the globe. This mode of science presents challenges for distributed collaborative research, data access, data analytics, data visualization, and interoperability with distributed multi-wavelength data archives.

Deployment of data intensive cloud systems along with the Virtual Observatory services offers a mechanism to address these challenges. Such platforms also provide outstanding opportunities for outreach and training to disadvantaged regions where access to data and resources is limited. I will discuss the nature of these challenge and approaches under development at the South African Ilifu data intensive research cloud facility developed and operated by the Inter-University Institute for Data Intensive Astronomy.

Session

Division B Facilities, Technologies and Data Science

2726

Future Egyptian 6.5 meter multi modes Telescope: basic design, scientific goals and accessories

Prof Nasser Ahmed

National Research Institute of Astronomy and Geophysics (NRIAG), Egypt

Abstract

Future Egyptian 6.5 M optical Telescopes is a new project instead of old Kottamia observatory (1.8 M, 1962). It will be multi-modes Telescope for a broad range of scientific applications. One mode for photometry, spectroscopic and polarimetry of any stellar objects. Anther mode is corrected focus 1º-3º field of view, for wide field applications such as survey and near earth objects studies.
The basic optical design is Gregorian Nasmyth focus with adaptive optics secondary. The telescope primary mirror is an **f/1.25 honeycomb** of borosilicate glass similarly to MMT and Magellan telescopes. The new telescope will be provided with powerful scientific instruments for high resolution and multi-slits spectrographs.
Polarimetric imaging and spectroscopic will be considered also.
Finally, we are welcome with any astronomical community suggestions.

Session

Division B Facilities, Technologies and Data Science

2737

NRT: observing the transient Universe with the world's largest robotic telescope

DR. Carlos Gutierrez

Instituto de Astrofísica de Canarias. University of La Laguna

Abstract

The New Robotic Telescope (NRT) is an international initiative to build a 4-metre robotic telescope. With a primary mirror consisting of 18 segmented hexagonal mirrors and a control system that will allow fully autonomous operation, NRT will be the world's largest robotic telescope. This, together with a response time of less than 30 seconds, a suite of simultaneously mounted instruments covering the usual modes of photometry and spectroscopy in the optical and near-infrared ranges, and the exceptional conditions at the Roque de los Muchachos observatory (La Palma, Spain) will make NRT a key astronomical facility in the field of time-domain astronomy. The project is in the final stages of design. In this contribution we present an overview of the project and the plans for its construction and operation.

Session

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2779

ASTRONOMY AND SPACE SCIENCE FROM THE MOON : PAST EXPERIMENTS AND CURRENT PROSPECTS

Prof Bernard Foing

CEO LUNEX, EuroSpaceHub, Prof Leiden Observatory

Abstract

The Moon is a special platform for astrophysics and cosmology (Foing et al 1993) .

From the Moon one can conduct observation of Earth and environment , as well as planets and solar system objects, in a large range of wavelengths.

Solar observations can be conducted in optical, UV, X-rays, radio, plasma sensors to monitor activity, flares and coronal mass ejections. We shall show some solar measurements from SMART1 and recent missions, and will discuss what could be done from networks on surface and orbit, and peaks of eternal light.

The Moon can host as well small telescopes (including simple transit telescopes scanning the sky over a lunar rotation) to monitor multiwavelength variability of stars and cosmic objects.

Larger telescopes can be used for diverse galactic and extragalactic research, and liquid mirror telescopes can be deployed with a sensitivity beyond JWST.

Interferometric telescopes can also be installed and operated thanks to the high stability and low seismicity of the Moon.

Networks of radio telescopes can be deployed on lunar farside for galactic and extragalactic studies, and cosmology of the dark ages.

The Moon surface can be used also for ultra high energy physics and astrophysics, with the possibility to detect cosmic rays, but also Cerenkov radiation of from subsurface soil of particles up to 10E20 eV .

We performed some precursor tests of lunar telescopes or radio antenna with analogue astronauts during LUNEX EuroMoonMars field campaigns . We deployed a network Low Frequency radio antenna during Etna DLR/ESA ARCHES campaign in June 2022.

Session

Division B Facilities, Technologies and Data Science

2793

From Barriers to Blastoff: Democratizing Space Education in Ethiopia with ESSS Learning

Mr. Lealem Kinfe

Ethiopian Space Science Society

Abstract

ESSS Learning emerges as a pioneering initiative by the Ethiopian Space Science Society (ESSS), destined to redefine the landscape of space science education in Ethiopia. Positioned as a beacon of knowledge, accessible at learn.ethiosss.org, this platform represents a transformative leap for students, instructors, and administrators.

The unique significance of ESSS Learning lies in its mission to democratize space education in Ethiopia. Notably absent from elementary and high school curricula, space science has been a privilege for a select few. As the project manager, my vision is to bridge this educational gap, making space science accessible to every corner of Ethiopia.

By leveraging ESSS Learning, students across the country will gain entry into a realm of knowledge previously reserved for a limited audience. This platform acts as a catalyst for inclusivity, ensuring that space science education is not confined to the privileged, but becomes a shared asset for all. In navigating the intricacies of project management, my aim is to create a user-friendly, intuitive interface that transcends barriers, making it seamlessly available to learners regardless of their geographical or socio-economic background.

As we progress towards the project's completion, the goal is not merely the creation of an educational platform but the empowerment of an entire nation through the democratization of space science knowledge. ESSS Learning aspires to be a catalyst for change, fostering a culture of curiosity, scientific exploration, and inclusivity in the pursuit of knowledge about the cosmos.

Session

Division B Facilities, Technologies and Data Science

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Open Science at NASA

Dr. Steven Crawford

NASA

Abstract

Open Science is the principle and practice of making research products and processes available to all, while respecting diverse cultures, maintaining security and privacy, and fostering collaborations, reproducibility, and equity. NASA has long embraced open science in its mission and openly sharing its scientific discoveries with the world. With the Open Source Science Initiative, NASA is implementing the ambitious, open science vision outlined in the NASA Science Mission Directorate's "Strategy for Data Management and Computing for Groundbreaking Science 2019-2024." OSSI includes the recently updated Scientific Information Policy (SPD-41a) that includes updated requirements, compliant with the recent OSTP memo on " Ensuring Free, Immediate, and Equitable Access to Federally Funded Research", for sharing data, publications, and software produced from SMD's research activities. The Initiative further aims to increase accessibility, inclusion, and reproducibility in Earth and Space Sciences through a range of activities including training in open science, development of Open Science technologies, and grants to support Open Science. NASA's Transform to Open Science, a program to train 20,000 scientists over the next 5 years in Open Science and broaden participation from historically excluded groups, kicked off with the US Federal Year of Open Science in 2023. The latest developments include a range of new infrastructure to support open science including the Science Discovery Engine, the Science Explorer, and new capabilities in machine learning and science platforms. These efforts will ensure the next discoveries from NASA science is even more accessible, inclusive, and reproducible.

Session

Division B Facilities, Technologies and Data Science

2822

Incorporating Ionospheric TEC predictions as sensory information for MeerKAT

Ms Lebogang Lekganyane

Rhodes University

Abstract

The ionosphere represents a region in Earth's upper atmosphere characterized by charged particles. Total Electron Content (TEC) gauges the concentration of these particles within a vertical atmospheric column. This project concentrates on incorporating TEC forecasts as sensor information to mitigate the effects of disruptions caused by the ionosphere on radio signals.

Meerkat heavily relies on radio signals for its observations, but the ionosphere can modify their polarization, posing challenges to data precision. To comprehend the ionosphere's impact, the initiative leverages Meerkat's capacity to analyze Radio Interference Data Exchange Format (RINEX) data obtained from on-site servers. A distinctive method involves using the Moon as a calibration tool, exploiting its consistently linear polarization unaffected by the ionosphere. Examining the Moon's radiation refracted through its surface allows for the isolation of ionospheric effects.

The primary objective of the project is to evaluate the accuracy of vertical TEC (vTEC) predictions. These predictions hold promise as corrections for Meerkat's polarimetric observations. A crucial step involves comparing vTEC measurements with data from the Global Navigation Satellite System (GNSS). This forms the foundation for a dependable RINEX-file processing system, offering precise rotation corrections for the astronomy community.

Session

Division B Facilities, Technologies and Data Science

2855

Calibrating the clock of JWST to sub-second accuracy

Aarran Shaw

Butler University

Abstract

JWST, despite not being designed for observing high time-resolution phenomena, can be an unparalleled tool for such studies, opening wide the sub-second infrared timescale regime, if timing systematics can be controlled. Rapid time-domain studies, such as lag measurements in accreting sources and Solar System occultations, require both precise inter-frame timing and knowing when a time series begins to an absolute accuracy significantly below 0.5 s

We present here results from our JWST clock calibration program. We observed ZTF J153932.16+502738.8 - a double white dwarf system that eclipses on a period of 6.91 minutes - over two ~9hr epochs with JWST's NIRCam. The well-known ephemeris of ZTF J1539 allows us to compare the expected time of the eclipses with the actual eclipse times as measured by JWST, providing us with strong constraints on the accuracy of JWST's clock.

Session

Division B Facilities, Technologies and Data Science

2948

Examining Cyber-relevant Cognitive Vulnerabilities and Their Impacts on Protecting Space Systems from Cyber Attacks

Professor Lori Coombs

Marymount University. (NASA) National Space and Aeronautics Administation. University of Arizona Global Campus. WWCM. WWCM Academy. U.S. Senate

Abstract

This focuses on emerging enabling technologies that implicate cybersecurity by identifying the impacts of cyber-relevant cognitive vulnerabilities to develop Cyberpsychology-informed Defenses (CyphiDs) to enhance design processes, harden space systems and increase cybersecurity posture against cyber-attacks. Research may lead to a quantum mechanics approach to support understanding human behavior for developing probability-based decision models that produce Adaptive Psychological-informed Defenses (APhiDs) which can automate the CyphiD sequences. Cyber deception is a defensive technique that considers human factors and the components of a cyber-attack. Deception aims to make it more difficult for bad actors. Experiments will be conducted in a three-phase approach that creates a new cyber research dataset for shared use that can support new human-focused research for the academic and science communities. The Theory Planned Behavior approach will be leveraged on understanding human factors that determine behaviors and decision-making processes. The Grounded Theory approach used to create cyber-specific computational cognitive models (C3M) that reflect and predict attacker behavior based on grounded data that has been systematically collected and analyzed to develop CyphiDs. CyphiD research data developed from open science info shall provide solutions for the evolution of the digital roll-out that considers software sustainment that has evolved to incorporate continuous engineering, which lies at the intersection of fixing problems and providing new capabilities made possible by new hardware and/or new threats that demand new functionality for space systems. The goal is to understand the cognitive vulnerabilities and behavior to advance the science of cyberpsychology and research to support astronomy assets.

Session

Division B Facilities, Technologies and Data Science

2949

Extending the Event Horizon Telescope to Space: The Black Hole Explorer

Dr Jonathan Weintroub

Center for Astrophysics | Harvard & Smithsonian

Abstract

The Black Hole Explorer (BHEX) is a space mission aiming to discover and measure a black hole's photon rings. BHEX captures light that has circled a black hole anywhere from half an orbit to multiple complete orbits. A series of ever sharper photon rings, produced from light that has orbited the black hole increasingly more times before escaping, lie under the Event Horizon Telescope (EHT) ring images. Photon rings require extremely fine angular resolution that can only be achieved by extending the EHT array into space. The physical properties of the black hole are imprinted on the size and shape of the photon ring, creating a new window into relativistic physics. This talk will summarize the primary BHEX science goals and discuss the technology and instrumentation being developed to make the mission a reality within the next decade.

This talk is presented on behalf of all the members of the Black Hole Explorer Team.

Session

Division B Facilities, Technologies and Data Science

2981

The Next Generation Transient Follow-Up Ecosystem

Prof. Andy Howell

Las Cumbres Observatory. University of California, Santa Barbara

Abstract

I will talk about a set of tools to enable rapid follow-up of transients, especially in the multimessenger domain. These include the Target and Observation Manager (TOM) Toolkit, the Hopskotch/HERMES messaging system, and the Treasure Map. The TOM Toolkit lets users trigger telescopes from a web interface. The system also reduces and manages data, and displays it for a collaboration, allowing them to comment on it and manipulate it. Hopskotch is a Kafka-based messaging system that allows uses to send machine- and human-readable messages rapidly and robustly. It is used by the LIGO/Virgo/Kagra collaboration (and others) to send alerts. HERMES is a web-based front-end for Hopskotch, which can submit and receive messages, and provides standards for machine readability. Finally, Treasure Map is a database, API, and visualization that allows users to submit planned and executed telescope pointings for gravitational wave follow-up localization. Users can see these telescope pointings on a visualization overlaid on sky survey data, and adjust their follow-up prioritization based on what others are doing. All of these tools interoperate, so that, for example, users may use their TOM to share send their telescope pointings to the Treasure Map. Or they may share data with the click of a button via Hopskotch, which automatically appears on anther user's TOM. I will discuss current capabilities, but also future needs of this transient follow-up ecosystem.

Session

Division B Facilities, Technologies and Data Science

3002

21cm global spectrum measurement on the lunar orbit and Antarctic ice sheet

Dr Fengquan Wu, Professor Xuelei Chen

National Astronomical Observatory, Beijing, China

Abstract

In this talk, I will focus on the recent development of 21cm global spectrum instrument in National Astronomical observatory, Beijing, China, and the effect to unveil the mystery of Cosmic Dark Age and Cosmic Dawn. First instrument is High-frequency spectrometer-the payload of Hongmeng project and its ground testing. Hongmeng project aims to launch satellite array on the lunar orbit to image the whole sky below 30MHz, and obtain global spectrum at 30-120MHz. Second instrument is the global spectrum instrument on Antarctica ice sheet.

Session

Division B Facilities, Technologies and Data Science

3008

The CANDLE Mission: an absolute flux calibration standard stars

Dr. Susana Deustua

National Institute of Standards and Technology

Abstract

Today's networks of standard stars, in principle, trace their calibration to Vega, often using a "daisy chain" approach. Even when these systems have high internal precision, the true uncertainties are dominated by the uncertainty in the historical absolute flux measurements of Vega resulting in a cascade of systematic uncertainty between 100 nm to 2500 nm (and beyond).

The CANDLE Mission is a proposed space observatory that will provide for the first times, hundreds of spectrophotometric standard stars around the sky whose fluxes are directly traceable to the International System of Units meaning there is "...an unbroken chain of calibrations to specified reference standards... "and "... that the uncertainty associated with a measured value or calibration be sufficiently small to satisfy a particular measurement need". I will describe a concept for a space-based project consisting of twin satellites, each consisting of a telescope and a calibrated artificial star, that can be deployed to establish an all-sky network of high accuracy, absolute flux standard stars. With NIST calibrated instruments and artificial stars above the earth's atmosphere, we aim to achieve total uncertainties of less than 0.5%, a factor of 5 to 10 times better than the current uncertaties over the VIS/NIR range for stars with a range of spectral types and brightness.

Session

Division B Facilities, Technologies and Data Science

Poster upload

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3023

Leveraging Large Language Models for Enhancing Accessibility and Efficiency of Research Discovery in Astrophysics

Rohan Rahatgaonkar

Pontifica Universidad de Catolica

Abstract

Given the amount of new papers are uploaded on Arxiv, it can be hard to keep up with new research in your field or even specific topics.To enhance the accessibility of astronomy and stay up-to-date with the latest advancements, we are introducing an AI-based astronomy newsletter tailored to your specific field of interest. This service provides concise, understandable, and insightful summaries, key takeaways, and links to related articles. Our aim is to promote accessibility to current AI tools available for researchers. Consequently, we also curate a list of services and resources for understanding, analyzing, and discovering scientific literature relevant to your field of interest.

Session

Division B Facilities, Technologies and Data Science

3024

DSA-2000: A novel approach to radio interferometry

Mr Francois Kapp

Caltech

Abstract

The DSA-2000 will be a radio survey telescope and multi-messenger discovery engine. The array will consist of 2000 × 5m dishes, instantaneously covering the 0.7 - 2 GHz frequency range, and span an area of 19 km × 15 km. The instrument will use a radio camera processing system to enable real time imaging, and also be capable of transient search and processing at a wide range of cadences. This approach is enabled by two key technologies, i) low-cost, high performance antennas with an ambient temperature receivers, and ii) a novel digital back-end - the radio camera - that outputs image data in real time. The project requires an industrialized approach to construct and commission 2000 antennas in a remote valley in Nevada, shielded by mountains from terrestrial radio frequency interference. Prototype antennas have been built and tested at Caltech's Owens Valley Radio Observatory as the team prepares for construction.

Session

Division B Facilities, Technologies and Data Science

3038

The Hubble Space Telescope: A New Era of Discovery

Dr. Jennifer Wiseman

NASA Goddard Space Flight Center

Abstract

The Hubble Space Telescope has served as the world's preeminent flagship space observatory for 34 years. Hubble is even now at the peak of its scientific power and demand, thanks to innovative uses and multiple astronaut upgrade missions. What is Hubble's role now, as we enter a new era of international astrophysical facilities and priorities? This overview talk will emphasize the unique future role of Hubble in terms of its *capabilities, complementarity,* and *scientific priorities. Capabilities:* The Hubble Space Telescope will serve as a critical and unique UV and optical space platform in the coming years. The outlook for its technical health will be discussed. *Complementarity:* The new confluence of flagship space telescopes together spanning wavelengths from gamma-ray to mid-IR, including e.g. Webb, Roman and GAIA, with precision ground-based platforms like ALMA, SKA, ELTs, and gravity wave detectors, and with solar system probes, will enable powerful new complementary investigations with Hubble in all fields of astrophysics. *Scientific Priorities*: Hubble's future observing program will emphasize its unique role in the highest priority science areas, including time domain and multi-messenger (TDAMM) astrophysics, exoplanet characterization, and the impacts of dark matter and dark energy in cosmic evolution. Hubble's robust archive is also enabling study of transient phenomena that span decades. Hubble will continue to pioneer processes that increase fairness and inclusion in observing proposal solicitations and selections, empowering science for the mission and its worldwide users. Hubble is a direct precursor mission to the Habitable Worlds Observatory, in terms of wavelength bands, science, and user community.

Session

Division B Facilities, Technologies and Data Science

3115

Development of Wideband Antennas

Dr. Hideki Ujihara, Dr. Hideyuki Nosaka

Ritsumeikan University

Abstract

After development of 3.2 - 16 GHz wideband feed for NICT Kashima wideband VLBI project Gala-V which used Kashima 34 m antenna and two portable VLBI 2.4 m stations, development of 16 - 64 GHz wideband antennas and feed systems was started. That can measure water vapor distribution with fine time and spacial resolutions and enable simultaneous VLBI observation. This system has larger bandwidth than conventional water vapor radiometers and can observe Oxygen and cloud emissions to reduce errors in estimation of water vapor in the atmosphere. The system will be tested as a wideband feed system of large radio telescopes, portable 900 mm or 2.4 m stations. Thus the feed can have wide variation of its beam width, from narrow beam for Nobeyama 45 m to wide beam for VGOS or SKA optics. Also they can make flat beam in some frequency range. Development of this system and other technical challenges such as high frequency phased array feed for 100 GHz or more will be presented. These developments are also useful for 6G communications. These works are supported by JSPS KAKENHI grant 21H04524, 23H00221 and NICT fund JPJ012368C04901.

Session

Division B Facilities, Technologies and Data Science

3126

Application of anomaly detection to MeerKAT radio data using machine learning techniques

Dr. Hanwool Koo, Dr. Michelle Lochner

University of the Western Cape

Abstract

As a mid-frequency Square Kilometre Array precursor, the MeerKAT radio telescope is a promising source of large sets of radio data. Developing an automated method for anomaly detection is becoming essential to discover more unknown phenomena for astrophysics or cosmology from the data with such an enormous volume. To do this, we explore anomaly detection techniques for time-frequency dynamic spectra of the radio data. We apply unsupervised machine learning techniques, coupled with active learning, for anomaly detection and evaluate our method using the simulated Single-dish PARKES data sets for finding the uneXpected (SPARKESX). We use these simulations to test anomaly detection methods that will be applied to real, unlabeled MeerKAT data. We also examine the possibility of detecting and removing anomalous radio frequency interference, which acts as the primary contaminant when hunting for genuine anomalies. We expect that applying machine learning methods will be a more efficient and reliable way to detect anomalous astrophysical signals with higher accuracy and in a shorter time than the classical methods.

Session

Division B Facilities, Technologies and Data Science

3139

65 years of Radio Astronomy in South Africa: from The Shack to SKA-Mid

Justin L. Jonas[1], George D. Nicolson[2], Pontsho Maruping[2]

[1]SKAO/Rhodes University/SARAO. [2]SARAO

Abstract

There has been an exponential growth in Radio Astronomy in South Africa over the past two decades, driven primarily by participation in the international Square Kilometre Array (SKA) project. In this paper we present the genesis and development of Radio Astronomy in South Africa (and the African continent) since its origin in the 1950s. The path from humble beginnings to becoming a major contributor to, and participant in, global Radio Astronomy has various enablers, including serendipity, opportunity and strategy. The hosting of the SKA-Mid telescope and the success of the MeerKAT precursor telescope are the most prominent landmarks on this path, but these outcomes were predicated on the foundation provided by the existing modest (but niche) Radio Astronomy activities at the Hartebeesthoek Radio Astronomy Observatory (HartRAO) and some South African universities over many decades. More recently, the expansion has been underpinned by programmes to grow a young and diverse cohort of scientists, engineers and technicians, to recruit industry as technology development partners, and to extend the footprint of Radio Astronomy into the larger African continent. We present a succinct narrative of this history of Radio Astronomy in (South) Africa, from the first observations of Solar radio emission made at Rhodes University in 1958 through to the unprecedented scientific results that MeerKAT is delivering today. We explore this history via the themes of socio-political context, strategy, science, technology and human capital development.

Session

Division B Facilities, Technologies and Data Science

3163

Artificial Intelligence in Astronomy: Unraveling variable stars with machine learning and the NASA Kepler and TESS space missions

Dr Jeroen Audenaert

MIT Kavli Institute for Astrophysics & Space Research, Massachusetts Institute of Technology, Cambridge, MA, USA

Abstract

Astronomy is entering the era of big data through the continuous delivery of millions of observations by both ground- and space-based observatories each day. These massive data sets provide us with a unique opportunity to probe the Universe on an unprecedented scale. The brightness observations of stars delivered by space missions contain a wealth of information for stellar variability, exoplanet and asteroseismology studies. We therefore developed an automated machine learning framework to classify the stars that are being observed by NASA's Transiting Exoplanet Survey Satellite (TESS) according to their stellar variability types, and in preparation for the upcoming ESA PLAnetary Transits and Oscillations of stars (PLATO) mission. Our classifications will form the basis to select the large samples of asteroseismic pulsators required to constrain stellar structure and evolution models. The photometric observations of these large samples of pulsating stars can be then coupled with their spectroscopic observations from ground-based surveys to start unraveling the interior physics of stars with machine learning.

Session

Division B Facilities, Technologies and Data Science

Final category: Division C Education, Outreach and Heritage

63

Cultivating Local Wisdom in Astronomical Education for Inclusive Cosmic Exploration- Policy Review in South African Higher Education

Dr Zukiswa Roboji

Walter Sisulu University

Abstract

Global integration of astronomical knowledge fosters cross-cultural understanding, and universal education accessibility, environmental awareness for sustainability. The African continent's situation varies widely across its diverse countries and regions. In the expansive realm of South Africa's higher educational cosmos, astronomical policies face intricate challenges. Within the astronomical educational cosmos, a critical void persists, marked by a lack of inclusivity in existing policies. The problem at hand lies in the failure of current educational frameworks to transcend language barriers, acknowledge diverse cultural perspectives, and cater to the accessibility requirements of differently-abled individuals. This gaping cosmic rift inhibits the full participation and engagement of aspiring astronomers from varied backgrounds. This paper delves into the specific celestial dynamics of South Africa's higher educational system, probing the efficacy of existing astronomical policies in addressing issues of linguistic diversity, cultural resonance, and accessibility for differently-abled learners. By adopting the literature review, the research aims to bridge the gap between traditional astronomical knowledge and formal education, fostering a harmonious and inclusive approach to cosmic exploration within local communities. Cross-referencing information from different sources will be adopted to ensure a well-rounded understanding of the current situation. This review will unearth insights that propel South African higher education toward fostering a more inclusive and culturally resonant cosmic exploration for aspiring astronomers.

Session

Division C Education, Outreach and Heritage

66

Cultural Astronomy in Uganda - Perspectives of Major and Minor Ethnic Groups

Dr Bosco Oruru

Makerere University

Abstract

Uganda has a long history of organized ethnic groups and cultures. Cultural astronomy in the country has been explored very recently. At least twelve ethnic groups have been explored, covering all the four broad linguistic categories of Bantu, Luo, Ateker and Sudanic people. The exploration of cultural astronomy with major and minor ethnic groups, gives a wide range of perspectives in the subject and sets a baseline for exploring cultural astronomy in other African countries. A qualitative research design was adopted, and data were collected with mutual consent by the respondents, who were purposively sampled because they had relevant information. The respondents were mainly those aged 40 years and above. The commonly known visible celestial objects, considered unique in characteristics, have been identified. Most natural phenomena involving celestial objects are considered mysterious, yet ethnic groups have attempted to explain them in their own ways. Some phenomena are thought to be caused by the actions of the gods. The results show that cultural astronomy can be a prerequisite for modern astronomy in most African countries.

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Division C Education, Outreach and Heritage

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Authors & Presenters DOROTHY MLAMBO Authors' emails dorrymlambo@gmail.com Authors' contacts +27609656117 Organization: CHRISTOPH MEYER MATHS & SCIENCE CENTRE Title of submission "Empowering Disadvantaged Communities through Astronomical Education: A Journey Beyond Boundaries"

Ms Dorothy Mlambo

SAASTA. SAASTEC. DSI

Abstract

This abstract digs into the transformative impact of astronomical education facilitated by the Christoph Meyer Maths and Science Center within the disadvantaged communities of the Umkhanyakude district in rural KwaZulu-Natal province, South Africa. The science center serves as a beacon of hope, offering a unique educational experience that transcends socioeconomic barriers and opens new horizons for individuals facing adversity. The narrative unfolds as a journey beyond boundaries, exploring how the cosmic wonders presented at the science center inspire curiosity, foster critical thinking, and ignite a sense of wonder among learners in a region where educational resources are limited. Through tailored astronomical education programs, the center aims to empower individuals, particularly children and youth, providing them with opportunities to dream beyond the challenges of their immediate environment. The Science Center's initiatives, emphasizes the potential to not only impart scientific knowledge but to instill passion for learning and discovery. Its overarching goal is to contribute to the holistic development of disadvantaged communities, fostering a generation of thinkers, dreamers, and innovators who can transcend their circumstances and contribute meaningfully to the broader scientific community. As we explore this journey, the abstract advocates for collaborative efforts to expand the reach of astronomical education initiatives, ensuring that all communities, regardless of their Geo socioeconomic status, can partake in the empowerment that comes from understanding the cosmos. The Science Center stands as a model for inclusive and transformative education, demonstrating how astronomy can serve as a catalyst for positive change in most underserved regions.

Session

Division C Education, Outreach and Heritage

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Responsible Telescope Siting: Environment, Community, and Science

Dr Ann Thresher[1], Dr Daniel Palumbo[2]

[1]Stanford University. [2]Harvard University

Abstract

Telescope siting has historically relied entirely upon ensuring sites meet the technical specifications required for observation including weather, atmospheric clarity, accessibility, and cost of developing the site. However, astrophysicists have obligations beyond merely the technical. As the field is becoming increasingly aware, telescopes exist within a broader social context, and the choice of site needs to be responsive to ethical, cultural and environmental specifications just as much as technical ones. We need look no further than the ongoing conflict surrounding the Thirty-Meter Telescope on Mauna Kea or the Square Kilometre Array in South Africa to see the importance of this lesson. In recognition of these challenges, the next-generation Event Horizon Telescope (ngEHT) has founded an interdisciplinary Responsible Siting working group that is integrated into the site selection process. This talk will present a formal overview of the ethical challenges of telescope siting, as well as discuss the work being done by the responsible siting group for a proposed site in Wyoming where the ngEHT has been working with local tribes, governmental organisations, and the university of Wyoming to build mutually productive partnerships. This talk also looks at lessons we can learn from parallel scientific fields including synthetic biology, palaeontology, and conservation in order to advance a set of ethical best-practices for astronomy, and consider the fundamental philosophical challenges of building large-scale scientific experiments, particularly in areas of the world with a history of colonial, environmental, and scientific exploitation.

Session

Division C Education, Outreach and Heritage

85

Identification of Ancient Astronomical records in North India.

Professor Naseer Iqbal

Department of Physics University of Kashmir Srinagar India.

Abstract

The subject of Astronomy and Astrophysics explores the understanding of evolutionary histories of the astronomical events happening in day-to-day universe. Starting from the identification of earlier astronomical records up to now the detection of Gravitational waves the subject of astronomy has revolutionized our view of understanding the universe. The study becomes very fascinating when as a present observer we through a light on the past astronomy and come up with exciting results which helps us to discuss the broader view of different kinds of past records like identification of ancient supernova of a star, identification of Kepler's supernova, impact of falling meteorite and having its significant impact on earth. The identification of earlier supernova records and having a survey of many such records worldwide it becomes quite noticeable that the subject of astronomy has really contributed to bringing considerable discoveries in the modern cosmology.

In my talk I will discuss the following:

Earlier astronomical findings / records in North India.

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Division C Education, Outreach and Heritage

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Opening mathematical astronomy by searching for orbital constant that hidden in variable star cylinder on Earth .

Mr. Mulugeta Markos, Mr. Abduselam Mohammed

Dambi Dollo

Abstract

ABSTRACT The study of astronomy is needed to integrate variable star with mathematics and science education. The scope of this study is the mathematical astronomy. The main objective of this project is to find the cylindrical constant of the variable star astrophysics that hidden in the formula of the volume of any spherical objects on the earth: in a case of western Ethiopia. A cylinder is a solid surface generated by a line moving parallel to a fixed line, while its end describes a closed figure in a plane. If r is the radius of the base, h is the height and d is the diameter of the base, then since cylinder is the limiting form of prism, therefore volume and surface area of the cylinder is also calculated by the same formula of prism. In this study we examined the cylinder constant hidden in the formula of the volume of any circular cylinder. Volume of the cylinder = Area of the base x height. $V=\pi r^2 h$. V = CDh/4.The volume of a right circular cylinder is directly proportional to the square of the radius. Generally, the constant is significant in the circular cylinder formula. This Study and digging out the mystery part of a cylindrical coordinate system needed to understand the origin and the nature of celestial (Astronomical) coordinate system that allows Oromo Educators to calculate Oromo Calendar and register it on UNESCO. Keywords: cylinder, height, diameter, circumference, volume, variable constan

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Carnarvon Astro Guides: Developing Astro Tourism programs using Indigenous Knowledge systems as a basis.

Dr Anton Binneman

NRF|SARAO. University of Johannesburg

Abstract

This talk will reflect on the Carnarvon Astro Guide Training project that assumes a pivotal role in positively contributing towards the socio-economic landscape of the Northern Cape where the SKA Project is currently being constructed. Crafted with a dual purpose, this initiative

not only seeks to advance Astro-tourism but also serves as a complementary effort to bolster the upcoming Science Exploratorium that will be constructed in Carnarvon. Through a comprehensive approach, the project has successfully achieved all its defined deliverables, albeit with varying degrees of success. Initial insights derived from formal evaluations have already demonstrated a commendable positive influence on the Carnarvon community's development trajectory.

By synergising the allure of Astro-tourism with Local Indigenous Astronomy, and the developmental potential of the region, this project aims to create a sustainable platform that enhances local livelihoods and enriches the cultural fabric. The integration of Astro-tourism with the Science Exploratorium amplifies its importance, forming a holistic engagement model that bridges science, education, and community empowerment. The project's success is underpinned by the achievement of all outlined deliverables, underscoring the commitment to the endeavour’s realisation. While each deliverable has been met, an iterative evaluation process has indicated that further interventions can catalyse and optimise outcomes. These insights underscore the adaptable and evolving nature of the initiative, positioning it for continuous enhancement and enduring impact.

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Context and challenges of Astronomy didactics at high school in Cameroon: an approach through the analysis of curricula and activities implemented by CASRO.CASRO (Cameroon Astronomy and Space Research Organization).CASRO link: https://web.facebook.com/profile.php?id=100069872782126

Dr William Christian Tchaptchet Tchaptchet[1,2,3,4], Mr Roland Ndunge[5], Dr Colette Njiki Chatue[5]

[1]MINESEC (Ministry of Secondary Education). [2]CASRO (Cameroon Astronomy and Space Research Organization).and NEAC Cameroon. [3]Member of AfAS (African Astronomical Society).. [4]WAROAD (West African Regional Office of Astronomy for Development) Coordinator. [5]CASRO (Cameroon Astronomy and Space Research Organization)

Abstract

The recent implementation of the Competency-Based Approach in Cameroon's academic systems has led to ongoing changes in curricula. Some disciplines (Mathematics, Physics, Biology, Computer Science, Geology, Geography) are clearly presented in the curricula. However, others, such as Astronomy, are subtly evoked in the curricula or presented by teachers of other disciplines when they address concepts (gravity, Planet Earth and the Solar System, the satellite in robotics/computing, etc.) that are directly linked to them.

Technological developments must inspire the design and implementation of educational programs to encourage learners to take a greater interest in STEM. In Cameroon, the relationship between STEM and Astronomy is still in its embryonic stages. It is influenced by several parameters: teachers' knowledge, pedagogical approaches, students' knowledge and/or conceptions, available materials, scientific approaches and the socio-cultural context. To raise awareness among communities and learners of the importance of STEM for their development, an urgent look needs to be taken at interdisciplinary and practical subjects such as: Earth Sciences, Geography, Astronomy.

The aim of this work is to evaluate the possibilities and advantages of involving Astronomy in Cameroon's high school curricula. Analyses will be carried out in two stages:

1- Present the high school curricula that deal with Astronomy concepts.

2- Propose pedagogical, scientific and cultural approaches and/or conceptions that can enable the evolution of Astronomy paradigm shifts in the high school academic system. An overview of the current implementation challenges of astronomical activities in certain academic and professional institutions will be presented.

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Finding the Origin of Circle constant that can open the connection between Ayyaana Observation in the Ayyaantuu's African cosmology and Borena Calendar

Mr. Abduselam Mohammed Yasin[1,2], Mr. Mulugeta Marikos Tediso[1], Dr. Habtamu Fekadu[3]

[1]Dambi Dollo University, Dambi Dollo, Ethiopia. [2]Ethiopian Space Science Society Dambi Dollo Branch, Dambi Dollo, Ethiopia. [3]Walter Sisulu University, Mthatha, South Africa

Abstract

Astronomical STEAMP team of Dambi Dollo University has been investigating variable device of orbital physics (elements) like Namoratonga pillar to interpret the light message of variable stars like Borena Calendar star and Kepler star, since 2020. The team invented variable ring as circle constant device to solve its memorization method problem in present Ethiopian science education. But not published. The educational research report of Yus and Beti (2021) confirmed the presence of the same issue in Indonesia. The modern astronomical research of Borena Calendar revealed that Ayyaantuu is an expert who computes Borena calendar. The uniqueness of the present work is that we investigated the mathematical astronomy of Ayyaana Observation (Success observation) and Borena variable star. The role of Ayyaantuu is not only computing the calendar. Ayyaantuu also forecasts the future opportunity of an interested person by making a proper observation of some materials like a cup of coffee. However, the connection between the astronomy of Namoratonga pillar and the cosmological prediction device was not studied. In this work we have identified that we can also read a circle constant from coffee cup. we measured the circumference and diameter of cups of coffee and orbital ring. The ratio of the first parameter to the second was computed and the contribution of the constant in the mathematics of Borena calendar was discovered. The new finding of this work shows that the indigenous cosmology in Borena calendar allows people to integrate physics and astronomy. Consequently, we will contribute a critical presentation on this issue.

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Developing Indigenous astrophysics of Borena astronomy to Open Indigenous Knowledge in The Astronomical Heritages of Ancient World

Mr. Abduselam Mohammed Yasin

Dambi Dollo University, Dambi Dollo, Ethiopia

Abstract

As John Percy reminded us in 2007, when he published his book titled understanding variable star, astronomy sparred the developments of logarithm, calculus and trigonometry in the history of natural science. Due to people sometimes forget such important contribution of astronomy, most of indigenous people in the world missed to develop indigenous terms. We have developed Afaan Oromoo terms for the six important terms of trigonometry using Hammachiisa (Ayyaantuu's Indigenous inclusive method) of Borena Community in the Borena Calendar. Consequently, we contribute presentation regarding this issue and forward necessary recommendation needed to expand such translation over the world.

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The linkage of Fichee Chambalala Festival with celestial body.

Mr. Mulugeta Markos Tediso

Department of Physics ,Dambi Dollo University, Dambi Dollo, Ethiopia.

Abstract

The fichee Chambalala Festival, a celebration of culture and community,intricately intertwines with the captivating allure of celestial bodies, creating a unique and enchanting experience for attendees.Thefestival's astronomicalcomponent embraces celestial bodies as a profound source of inspiration, providing a platform for stargazing, cosmic storytelling, and astronomicaleducation.By integrating star gazing sessions, celestial photography workshops,and cosmic-themed performances, the festival not only immerses attendees in the wonder of the night sky but also nurtures an appreciation for the interconnectedness of humanity and the cosmos. the festival's celestial linkage extends beyond mere observation, as it serves as an educational window to celestial phenomena, celestial navigation, and indigenous astronomical knowledge. Through the fusion of scientific insights with cultural narratives, the festival honors historicastronomical traditions, offering a unique opportunity to bridge ancient wisdom with modern scientific understanding the Festival's connection with celestial bodies inspires a deeper contemplation of environmental stewardship, as it emphasizes the themes of celestial harmony, cosmic interconnectedness, and the need for preserving natural darkness. This ethos not only underlines the festival's commitment to sustainability but also kindles a sense of responsibility for nurturing both cultural and natural heritage.hence,the Chambalala Festival's meaningful linkage with celestial bodies transcends mere observation, offering a profound celebration of astronomy,cultural diversity, and communal harmony.

Keywords ; fiche chambalala, Festival, celestial body.

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After a Decade of Astronomy In Ghana

Dr Naomi Asabre Frimpong[1,2], Dr Theophilus Ansah-Narh[1], Dr Benedicta Woode[1], Dr Emmanuel Proven-Adziri[3], Dr Joseph Tandoh[1]

[1]Ghana Space Science and Technology Institute. [2]African Astronomical Society. [3]Ghana Space Science and Technology Institute/ Ghana Radio Astronomy Observatory

Abstract

Ghana, in collaboration with the Ghana Space Science and Technology Institute, has been an active participant in SKA-SA since 2012. A decade subsequent to the introduction of astronomy in Ghana through the SKA and the conversion of the 32-meter telecommunication satellite into a radio astronomy observatory, it is imperative to assess how Ghana has effectively utilized this remarkable equipment to address the human capacity gap and foster socio-economic development. An examination of the initiatives and activities implemented during the past ten years of astronomy in Ghana offers insights into this transformative journey.

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Informal learning programs as a way to enhance astronomic knowledge. Example from Tunisian experience.

Dr Slimene Sedrette, Dr Slimene Sedrette

Ministry of Higer Education and Scientific Research / Monastir Science Palace

Abstract

Nocturnal beauty of the sky and the universe has captivated the imagination of humans since the dawn of time, making it an excellent springboard to interest people in astronomy. While, the lack of astronomy subjects in primary and secondary school curricula still remains a contributing factor to common misconceptions about what are considered fundamental concepts of astronomy.

This contribution focused on the effectiveness of the informal learning programs to enhance astronomical knowledge.

Science centers have played a significant role and still constitute a very significant informal learning sources in astronomy for large public. This public institutions contribute also to improving astronomy education teacher through training programs in order to develop their performance on the one hand, and to create an environment conducive to interactive learning in their own schools, on the other hand.

The astronomical observations and the mobile scientific program which reach poor and needy regions contribute to the dissemination of scientific culture and give remote schools and associations the opportunity to familiarize themselves with the concepts and learning tools of astronomy.

Science Festival and competitions provide an opportunity to show innovations and creations, in order to achieve the desired communication between the various scientific structures and different segments of society.

The existence today of a large number of astronomy associations and clubs in educational establishments, as well as the growing number of students interested in astronomical research areas in Tunisia, could be the result of informal astronomy learning programs that have been operating for almost 30 years.

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Urban Astronomy : What can modern space telescopes teach us about the distribution of light in cities ?

Mr Sukuma Mkhize

SKA SA

Abstract

Modern astronomy has evolved far away from developed cities as a result of the city lights that interfere with observations and prevent us from making pristine measurements of the cosmos, what is often referred to as light pollution. The emergence of some of the most spectacular night time-city light images lately with the advent of the international space station should come as a surprise then, since by convention telescopes are meant to be pointed as far away as possible from the city night sky. Almost as surprising is how these images reveal a logic and a labrynth that is ironically only accessible from space using the most precise instruments to pull out individual city light details as well as cover the span of an entire city. Some of the most popular ones to surface from the ISS are those of London, New York, Melbourne, Berlin Johannesburg & Cape Town and will form the basis of the presentation, the question being can we use these images to identify "dark spots" as possible sites for miniature observatories ? Once identified, can some of these dark spots be earmarked and conserved to promote astronomy activities within South African cities ? In this presentation I will also highlight initiatives that are being carried out by the Dark Sky Organisation and similar networks and what lessons can be derived for further promoting astronomy in cities within the South African context.

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How Outreach Helped Mozambique Building an Astronomy Community

Prof. Cláudio Paulo

Universidade Eduardo Mondlane, Faculdade de Ciências, Departamento de Física, Grupo de Astrofísica, Ciências Espaciais e Inteligência Artificial

Abstract

Mozambique is one of the African countries partnering with South Africa for the implementation of the Square Kilometre Array (SKA) Initiative in Africa. Since 2004, an effort has been made by a local scientist to introduce Astronomy in the country where outreach played a very good role. Here, we share the struggles and happiness of conducting outreach in a country with limited resources and present the successful results and future aspirations which can be used as a model for Africa Astronomy Development. By using amateur telescopes in public places, schools and universities for almost 20 years it was possible to motivate young people to pursue their careers in Astronomy which brought us some people with PhD Degrees, MSc and PhD students abroad, as well as, a Post Doctoral Fellow in the country which opened a new environment at Eduardo Mondlane University (UEM). The approach itself was vital to attracting external funding (e.g. from the DSI in South Africa, IAU, DARA, and DOPPLER) which was used for the establishment of the Computer Laboratory for Astronomy, Space Science and Artificial Intelligence at the UEM and the High-Performance Computing Facility at a Park of Science and Technology which are being used as the core for the future SKA in the country. Everything done led to the production of a roadmap which outlines the future of the field in the country and enriched the motivational letter to support the Introduction of an Honours Degree in Astronomy at the Department of Physics at the UEM.

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2020 Solar Eclipse and the discovery of new single rock building in Africa

Mr. Abduselam Mohammed Yasin

Dambi Dollo University, Dambi Dollo, Ethiopia

Abstract

2020 Solar Eclipse and the discovery of new single rock building in Africa

Abstract

Every new outcome is hidden in the beginning. We have investigated 684 Delta Scuti Kepler Pulsating variable stars, in 2018 at Ethiopian Space Science and Technology Inistitute (the present Space Science and Geospecial Inistitute). Using time delay method called Binarogram we have identified that 106 of them have single companion and 4 of them have two companions which implies that they are a member of the binary and triple star systems respectively. Two years later, in 2020, a solar eclipse happened in many parts of Ethiopia like Lalibela, Korem and Begi. We have observed a total solar eclipse at Lalibela where 11 single-rock building exists. This empowered us to investigate where a partial solar eclipse occurred, called Begi, though Begi community missed visiting it. Fortunately, we have discovered ancient single-rock building and we have offered a scientific name called Keppler Bollo so that it integrates the study of Kepler stars and the 2020 solar eclipse. Dambi Dollo University was also started astronomical research at Kepler Bollo, based on the submitted report of the newly discovered building of ancient World.

Key Words: Solar Eclipse; time-delay; single-rock building; Kepler star; Kepler Bollo

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Advancing Astronomy Education in Africa: A Decade of Impact and Future Horizons

Ms Olayinka Fagbemiro

Nigerian Space Agency. Astronomers Without Borders (AWB) Nigeria

Abstract

This paper presents a comprehensive overview of a decade-long initiative dedicated to advancing astronomy education in Africa, with a focus on Nigeria. As an amateur astronomer and longstanding staff of the Nigerian Space Agency, I have been actively involved in spearheading Astronomers Without Borders (AWB) in Nigeria. Our organization, documented at awbnigeria.org, has been at the forefront of creating astronomical awareness and fostering education among diverse audiences, including young people, school children, and out-of-school children.

The outreach efforts detailed in this presentation highlight the innovative approaches employed by AWB Nigeria to engage communities and schools, utilizing the passion of volunteer amateur astronomers. Through a series of workshops, stargazing events, and collaborative projects, we have successfully nurtured a burgeoning interest in astronomy across the nation. The paper will showcase specific instances of impactful initiatives and their outcomes, emphasizing the importance of accessibility, inclusivity, and sustainability in our educational endeavors.

In conclusion, the paper will outline our vision for the future, emphasizing the importance of continued collaboration, technology integration, and policy advocacy to sustain and expand the reach of astronomy education in Africa. As the IAU GA 2024 marks a historic moment on the African continent, this presentation seeks to contribute to the broader discourse on making astronomical science accessible, impactful, and environmentally sustainable in the pursuit of a brighter astronomical future for the continent and its people.

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Amateur activities and public Outreach in Nepal by Takshashila Astronomy Club

Professor Jayanta Acharya

Balmikee Campus. Takshashila Astronomy Club founder

Abstract

Takshashila Astronomy Club (TAC) has been dedicated to promoting astronomy in Nepal. The presentation provided an overview of the club's amateur activities and the outreach initiatives undertaken by TAC. Noteworthy events include star parties featuring the participation of the first president of Nepal, as well as regular Sunday sessions where solar observations are conducted using Japanese solar eclipse glasses, involving numerous students.

This paper explain into the methodologies employed by TAC in organizing such activities and sheds light on the challenges faced in Nepal. It aims to showcase the efforts made by the club to popularize astronomy and engage the public, as well as to address the unique obstacles encountered in the pursuit of these goals within the Nepalese context.

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Astrotourism in Nepal

Professor Jayanta Acharya

Balmikee Campus

Abstract

Nepal is a small, landlocked country situated in South Asia, positioned between India and China. Renowned for its breathtaking Himalayan mountain ranges, including the world's highest peak, Mount Everest, Nepal also boasts a rich history and cultural heritage, with numerous temples and monuments dating back to the medieval period.

In an effort to foster public awareness and interest in astronomy, as well as to support astronomical research in Nepal, various activities are organized. These include public lectures, workshops, and sky observation sessions, all aimed at promoting the field of astronomy within the country.

Recently, an astrotourism project has been initiated in Nepal with the objective of linking scientific knowledge and information technology with the tourism industry. This paper elucidates some of the distinctive cultural activities associated with astronomy in the context of Nepal.

Key words; Astrotourism, Mountain, Research, Science

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Challenges of Astronomy communications in rural communities and academic institutions in Cameroon: an approach through the activities implemented by CASRO.

Dr William Christian Tchaptchet Tchaptchet[1,2,3,4], Mr Roland Ndunge[5], Dr Colette Njiki Chatue[5]

[1]MINESEC (Ministry of Secondary Education). [2]CASRO (Cameroon Astronomy and Space Research Organization) and NEAC Cameroon. [3]Member of AfAS (African Astronomical Society).. [4]WAROAD (West African Regional Office of Astronomy for Development) Coordinator. [5]CASRO (Cameroon Astronomy and Space Research Organization)

Abstract

This work deals with the challenges of astronomical awareness in three rural areas (Dschang in the West, Missolé on the Littiral and Yagoua in the Far North) of Cameroon (a developing country), where communication contexts differ from one area to another and must respect cultural values. The geographical location of these areas has made astronomic communication highly complex. Indeed, these areas have been exposed to rural migration. Over the last 05 years, they have welcomed refugees from crisis zones in Cameroon. This phenomenon has already generated a cultural intermixing that has fragilized many of their traditional cultural values, including the traditional norms of communication that they have long preserved. A serious challenge remains in the cultural acceptability of these rural areas to both modern and international communication standards.

The question is therefore how to find a suitable communication medium that will respect the culture of these communities by showing the importance of Astronomy for their development and accessibility to quality education for all (gender equality and STEM). In this work, we aim to (1) show the importance of Astronomy in Cameroon's education system (in the particular case of secondary school curricula analysis). (2) Highlight the role of academic institutions (teaching staff and learners) and local associations in supporting Astronomy communication. (3) to present the activities carried out by CASRO (Cameroon and Astronomy Space Research Organization) in these regions from 2021 to the present.

Key words: Cameroon; Astronomical communication; Rural area; Developing Countries; Quality education for all; CASRO.

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How (not) to write a popular astronomy book

Mr. Govert Schilling

Self-employed

Abstract

Despite the rise of online media, old-fashioned books still constitute an important channel of astronomy communication for a wide variety of target groups, from young children and curious amateur astronomers to highly interested seniors. Many professional astronomers and astronomy popularizers or educators would love to write their own book at some point, but finding the right topic, approach, style and - last but not least - publisher can be hard. Acclaimed and prize-winning Dutch astronomy writer Govert Schilling, who wrote almost 100 books over the past 40 years, shares his personal experiences, provides insight in the market for popular astronomy books, and tells you about the challenges, opportunities and potential pitfalls.

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The cultural heritage of the African Arc of the 30th Meridian(Invited Talk Commission C3)

Dr Christiaan Sterken

University of Brussels

Abstract

The African Arc of the 30th Meridian is a chain of survey triangulations stretching from Cairo in Egypt to the southern tip of the African continent, over more than 9000 kilometer through Botswana, Mozambique, Zimbabwe, Zambia, Tanzania, Burundi, Uganda, the Democratic Republic of Congo and Sudan.

The project was initiated in 1874–1876 by Sir David Gill who was in Cairo for the Survey of Egypt, where he, in his own words, "measured a very very accurate kilometre, established the latitude and longitude of the Great Pyramid, and measured the sides and height of the Great Pyramid to ± 1 millim., and their exact azimuths by a triangulation" (1916). Gill's short base line was below and to the south-east of the Sphinx. The material Africa-wide heritage consists of survey beacons, several of which have been declared as national monuments.

The Arc is an outstanding example of a technological ensemble that helped in the establishment of the size and shape of the Earth. It was also an extraordinary example for interchange of human values in the form of scientific collaboration among scientists and political representatives from different countries, and it supplied the natural control for the surveys of Eastern Central Africa. The 30th Arc of the Meridian was 75 years in the making and its implementation was severely hampered by political conflicts and situations of war.

This presentation formulates a case for the Arc of the Thirtieth Meridian as a World Heritage Monument to be submitted to UNESCO for consideration.

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Citizen Science: A Tool for Astronomy Education, Dark Sky Protection Awareness, Astro-Tourism Development and SETI

Timothy Egbuim, Dr Bonaventure Okere, Dr Nnaemeka Onyeuwaoma

West African Regional Office of Astronomy for Development (WAROAD), Centre for Basic Space Science and Astronomy (NASRDA), Nigeria

Abstract

The engagement of non-professional astronomers in science through citizen science is a thriving practice that produces new knowledge for science and society. The application of citizen science to astronomy education, dark sky protection awareness, astro-tourism development, and SETI through Vanishing and Appearing Sources during a Century of Observations (VASCO) has been instrumental in space science development in Nigeria. Globally, light pollution of the night sky by artificial light sources has led to a significant loss of the natural skies, which can be attributed to urbanization. To curb the menace of light pollution and promote astro-tourism across Nigeria, this project engages space enthusiasts, space scientists, students, teachers, and scientific groups through workshops, experiments, and group projects. The dark sky protection projects thus far include the use of sky quality meters to estimate brightness levels in various environments, the use of the Globe at Night application to measure night sky brightness, and the use of the Anecdata application, which uses smartphone astrophotography to report light pollution in different communities. Through citizen science, astro-tourism is publicized using formal and informal approaches, especially the need for investments in cultural astronomy, astro-archaeology, and planetariums. The Search for Extraterrestrial Intelligence (SETI) through VASCO citizen science has led to the discovery of various artefacts, galaxies, and meteors. These projects have shown over 70% increased interest in STEM among participants. The scientific gains of citizen science cannot be overemphasized, as it is essential in the evolving world of science. Through these projects, the United Nations SDGs are achieved.

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Astronomy for Astronomical Numbers

Professor Chris Impey

University of Arizona

Abstract

The design and implantation of five massive open online classes, or MOOCs, are discussed. These online classes are offered through Coursera and Udemy and they are reaching astronomical numbers of informal, lifelong learners. Over 420,000 people have enrolled from 180 countries. Over 6 million minutes of astronomy video content have been consumed. Two MOOCs are on general astronomy, one is on astrobiology, one covers Biosphere 2 as a model for living off-Earth, and one is on the history and philosophy of astronomy. Online courses for informal lifelong learners address the challenge of delivering engaging astronomy content online to large numbers of people and reaching them in poor or developing countries. Design principles that allow MOOCs to inform and inspire are covered. Challenges include increasing interactivity, which can improve the typically low completion rates. Enrollment surged by a factor of ten during the pandemic and remains well above pre-pandemic levels. MOOCs are centered on a core of video lectures, but to maintain active engagement other elements are recommended, like quizzes, writing assignments, and citizen science projects. Short writing assignments are subject to peer review and recently we have used large language models to grade student assignments and create rubrics. GPT-4 can grade more reliably than peers and it approaches the reliability of an instructor. Live Q&A sessions attract over a hundred participants and thousands of views afterward on YouTube. The broad reach of MOOCs lets them reach relatively isolated and underserved populations.

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Digitization and Study of the Ancient Egyptian Astronomical Texts: A Research Project featuring the Lore of African Skies

Dr Dr Alicia Maravelia

Hellenic Institute of Egyptology. Centre for Life-Long Learning-Hellenic Open University

Abstract

DCSAEAT (= *Digitization and Complete Study of the Ancient Egyptian Astronomical Texts*) is one of the Research Projects of the Hellenic Institute of Egyptology, aiming to safeguard, promote and study in depth the pharaonic astronomical and cosmographic lore, pertaining to ancient Northern African Skies. It is performed internationally [Partners: the Institute (Alicia Maravelia) and the Writing & Scripts Centre of Bibliotheca Alexandrina (Ahmed Mansour)], in (voluntary) collaboration with several colleagues and graduate students from Greece, Egypt, New Zealand, Poland and Italy. The AEAT is a corpus of antique and interesting testimonies about the astronomical heritage and knowledge of ancient Egyptian culture, imbued with a strong metaphysical and religious background of cosmic metaphors/allegories, through which important pre– or proto–scientific knowledge was presented and ancient skyscapes were described. Since the eras of the most ancient funerary texts and the «Books of the Hereafter», the Diagonal and Ramesside Star Clocks, various astronomical ceilings in royal and private tombs and temples, zodiacs, calendars, astronomical instruments (including: typical «kits» of ancient priests–astronomers with mrxt and bay n imy-wnwt; clepsydrae; sundials), the accumulation and development of astronomical and cosmographic lore was continuous. The Project aims at the complete and methodological study of all extant AEAT and artefacts, extending the outstanding but outdated work by Neugebauer & Parker [*EAT*], collecting/classifying all modern literature and knowledge, building interactive Database(s), digitizing/reproducing/documenting/cataloging/exhibiting the most important texts, publishing a Series of splendid volumes with rich iconography, and training students to study ancient Egyptian/African sky–lore and heritage.

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ASTRONOMY OUTREACHES IN PRIMARY AND SECONDARY SCHOOLS IN TANZANIA

Mr. ELINEEMA NASSARI

Mount Meru Astronomical Observatory

Abstract

INTRODUCTION

Astronomy in Tanzania is not an independent Subject in the curriculum, it just a topic and in some subject is just a subtopic. Some subjects such as Geography and Physics have topics which talks about Astronomy but challenges is that teachers who teaches those subjects are not aware about astronomy at all since they just learn it partially since there is no good foundation of astronomy in the country.

MOUNT MERU ASTRONOMICAL OBSERVATORY

This is a Non Government Organization (N.G.O) Its main function is to inspire students and teachers in Astronomy. MMAO have been able to receive grants from IAU OAD on 2023 for Teachers Training workshop which was tremendously succeeded.

Mount Meru Astronomical Observatory is receiving students and teachers from different schools who visits the observatory for learning purposes. Geography students and teachers came to learn all about solar system by watching different videos about the solar system. This helps student to understand easily their subject.

Astronomy clubs, are groups of students who have been inspired with astronomy. They used their extra time to learn astronomy at their schools and they used also visit other students from different schools to inspire them as well. They usually conduct astronomy exhibition at their schools during graduation and during talent days.

MMAO with ambassadors conducts outreaches to different schools inspiring students and teachers about astronomy and establish new astronomy clubs. Students are so exited with astronomy and loves the subjects since it helped them to ask many questions about the universe.

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Unearthing Rich Cultural Astronomy in Ghana

Dr Emmanuel Proven-Adzri[1], Mr Steven, O. Sottie[1], Dr Cyril, D. Boateng[2], Dr Linus,K. Labik[2], Mr Samuel, O. Quarm[2]

[1]Ghana Space Science and Technology Institute. [2]Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract

Ghana has a rich and diverse cultural history that spans ancient civilization, colonialism, and independence. Due to the diverse cultural composition of Ghana, many cultures have indigenous traditional practices or observations about astronomy. This project was undertaken to dig out this indigenous knowledge of astronomy and how it affected the daily lives of people in Ghana. Eleven sites were visited across Ghana with remarkable discoveries. The findings point to how astronomy helped the locals to undertake daily activities, including those that are related to their livelihoods. According to these discoveries, hunters, for instance, rely on the direction of Venus to return home when they stray too far when they are out hunting at night. The crescent moon curved upwards may indicate early rains for farmers. The emergence of certain stars on the horizon is a prelude to the harvest of certain fish in the sea. When the Milky Way is spotted sometime in July, it indicates the major rainy season is about to end. In some communities, widowhood rites only occur when the new moon is sighted. The project has interlaced the traditional beliefs of the indigenous people about the cosmos concerning their religion, folklore, fishing, farming and hunting, and art as contrasted to modern astronomy.

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Students' International Network for Astronomy and its projects for sustainable development

Mahdi Rokni[1,2], Akihiko Tomita[3]

[1]Associate of IAU Commission C1 WG Astronomy Education Research & Methods. [2]Manager of Students' International Network for Astronomy (SINA). [3]University of Wakayama

Abstract

This network has been established by students in a small city in the south of Iran. It was a desire to globalize all the activities and plans that they have been carrying out in Mehr observatory. Some of these activities contain a lot of social skills and different methods for students to do. The main aims of this network involve students in astronomical programs and projects, preparing a reliable structure for students around the world to meet each other using astronomy as a link, using the methods of sustainable development to teach students about the global environmental concerns and world peace, letting students make friends with each other without limitation and introducing their own culture.

After a long journey with so many students, teachers and astronomers from all over the world specially from Iran, Japan, Thailand, Romania, Bulgaria and Spain. SINA's main activities have been through cultural relations with astronomy and those aspects which contain people lifestyles, such as Persian solstices and equinoxes' celebrations and introducing some scientific projects in order to inform the society about the importance of dark sky protection.

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Sensibility of Planetary Defense: Involving Africa in Global Initiatives

Dr. Youssef Moulane

Mohammed VI Polytechnic University

Abstract

The increasing recognition of potential threats posed by near-Earth objects (NEOs) has led to a growing global interest in Planetary Defense initiatives. These efforts aim to identify, track, and mitigate the impact risk of asteroids and comets that could potentially collide with Earth. While this field has traditionally been dominated by space agencies and institutions from developed nations, there is a growing awareness of the need for a more inclusive and collaborative approach, particularly involving regions that have been underrepresented.

This talk explores the sensibility of involving Africa in Planetary Defense efforts, emphasizing the continent's unique contributions and challenges. Africa's diverse geographical locations provide valuable observational perspectives, enhancing the global network for NEO detection and tracking. Furthermore, Africa's burgeoning scientific community can actively contribute to the research and development of technologies for planetary defense.

This talk underlines the need for international collaboration and the establishment of partnerships between African space agencies, research institutions, and their global counterparts. By fostering a sense of shared responsibility in Planetary Defense, Africa can play a crucial role in the collective efforts to safeguard the Earth from potential celestial threats.

Finally, I will advocate for a more inclusive and globally collaborative approach to Planetary Defense, with Africa serving as a significant partner in enhancing our collective capability to detect, monitor, and respond to potential impact threats from space.

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Pan-African Citizen Science e-Lab: An Emerging Online Platform for Astronomy Research, Education and Outreach in Africa.

Mr Miracle Chibuzor Marcel

Pan African Citizen Science e-Lab

Abstract

The Pan-African Citizen Science e-Lab (PACS e-Lab) is the leading platform in Africa for engaging the public in citizen science projects related to astronomy. Our activities promote hands-on astronomy activities in Africa to enhance Africans' knowledge and skills in this field. We are a very inclusive and diverse community with a network throughout Africa and beyond. We provide opportunities for African teachers, students, and astronomy enthusiasts to engage in cutting-edge research. The different research activities are:

Asteroid hunting: This activity involves searching and discovering new asteroids from datasets observed with telescopes such as the Pan-STARRS and the Catalina Sky survey. This project also contributes to the planetary defense efforts. Our African teams have made over 30 provisional asteroid discoveries, awaiting further study by the Minor Planet Center and astronomers worldwide.

Exoplanet research: This project is about observing and performing photometry on exoplanets that have already been discovered by the TESS and Kepler missions to refine their Mid Transit Time. This supports upcoming missions like the JWST and the Nancy Grace Roman Space Telescope. We use web telescopes such as the LCO and Micro Observatory for this purpose.

Astronomy Research Writing: This involves conducting research and writing research papers on double stars, variable stars, etc. Our participants are trained on how to use the LCO for data acquisition and different programs to process the data.

Astro Photo Visual Development: this project equips our participants with the skills to process deep-space images from JWST, HST, and the LCO to produce beautiful visuals.

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Education in IKI

Andrei Sadovski

Space Research Institute (IKI)

Abstract

The issues of history and organization of interaction between IKI RAS universities and schools are considered. It is worth noting that a scientific organization in Russia is not a university, it has no opportunities to organize teaching.

As for the students the Department of Space Physics of the LFI (Landau School of Physics and Technology) of the Moscow Institute of Physics and Technology (MIPT) exists at IKI. The task of the Department is to train highly qualified specialists engaged in space research using rocket probes, Earth and planetary satellites, and interplanetary spacecraft. For more than 50 years of its existence, the Department of Space Physics has trained more than 400 graduates, of whom more than 150 people work at IKI RAS. In 2016, the Chair of Space Physics was organized at the Faculty of Physics of the National Research University Higher School of Economics. The Chair specializes in training specialists in three main areas: high-energy astrophysics, space plasma physics and solar physics. Around the same time the Department of Remote Sensing Technologies was established at the Faculty of Space Research of Lomonosov Moscow State University. Somewhat later, the educational program "Studies of the Moon and Planets" appeared.

We considered problems and future of such student and pupils training.

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World Heritage and Astronomy – Inscriptions and Progress

Professor Michael Burton

Armagh Observatory and Planetarium

Abstract

UNESCO, the United Nations Educational, Scientific and Cultural Organisation, may inscribe sites that are recognised to have "outstanding universal value" world heritage status. Such sites belong to all peoples of the world, irrespective of the territory on which they are located.

Over a dozen sites with an astronomical connection now have such a status. Perhaps the most famous example is Stonehenge, with alignments of rising of the Sun at solstices illustrating humanity's early awareness of celestial and seasonal cycles. The inscription of Jodrell Bank radio observatory in 2019 marked a sea-change in the recognition of world heritage with the inclusion of a modern scientific facility in the list. The heritage being recognised here was the development of radio astronomy itself and the extant examples of this still present at Jodrell.

Since the last IAUGA six further sites with an astronomical connection have been added to the UNESCO list. This presentation will discuss these inscriptions, for instance the Chankillo archaeo-astronomical complex in Peru that functioned as a calendrical instrument, the Paseo del Prado in Spain in which the Royal Astronomical Observatory is sited, and the Eise Eisinga Planetarium in the Netherlands with a mechanical scale model of the Solar System dating from 1774. UNESCO candidature is also being actively pursued for several other sites, notably in Germany, Argentina and Ireland.

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Astronomy as a tool for peace on the post-conflict island of Cyprus: the case of the Columba-Hypatia project

Dr Francesca Fragkoudi

Durham University. GalileoMobile

Abstract

The "Columba-Hypatia: Astronomy for Peace"" Project is a cross-disciplinary collaboration between Science Communicators (GalileoMobile) and Peace Educators (Association for Historical Dialogue and Research) in which astronomy is used as a tool for peace and diplomacy on the divided, post-conflict island of Cyprus. The project aims to inspire young people, through astronomy, to be curious about science and the cosmos, while also using astronomy as a tool for promoting meaningful communication and a Culture of Peace and Non-violence. The project brought together the various communities of Cyprus “under the same sky” to look beyond borders and inspire a sense of global citizenship, by promoting meaningful communication and interactions between its participants. To this aim, we conducted "bi-communal" educational astronomy activities in schools as well as in the United Nations-controlled "Buffer Zone" as well as astronomy nights and events for the general public. I will share the experiences and lessons learnt from using astronomy as a tool for diplomacy and for promoting peace and co-existence in a post-conflict region, such as Cyprus.

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Outreach at the Pierre Auger Observatory: Agile methodology for communicating astroparticle physics with the public

Dr Beatriz Garcia[1,2], Dr. Karen Caballero[3]

[1]Universidad Tecnológica Nacional, Faculty Mendoza. [2]CONICET. [3]Universidad Autónoma de Chiapas

Abstract

The Pierre Auger Observatory has developed its activities in the field of education and dissemination of astrophysics and high-energy astroparticle physics following the iterative Agile methodology. In this sense, a permanent improvement of the tools used has been achieved. The innovations are of two kinds: externally, in terms of the offering for visitors, which are renewed approximately every five years ; but also internally, through continuous training and evaluation of the capabilities of the personnel. The link between the outreach office and the members of the Collaboration who contribute to the task is also permanent and has been reinforced. In this presentation, the improvements in the last twenty years of contact between the Observatory and the community, focusing on the new proposals will be shown. This includes the open data policy, master classes for middle-level students and teachers, the design of innovative activities that involve the community, and the presence of the Observatory in special events with the participation of students. It is worth mentioning that the evaluation of all this work and of the social impact of the Observatory allows a redesigning of strategies for improving communication with the public, taking into account social responsibility and projecting a vision for the next decade.

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Commission C5 Cultural Astronomy: A new asset for Cultural Astronomy support throughout the IAU

Dr Steven Gullberg[1], Dr Alejandro Lopez[2]

[1]University of Oklahoma. [2]University of Buenos Aires

Abstract

Cultural Astronomy deals with the astronomy of past cultures, present Indigenous cultures, and as well other aspects of contemporary astronomy in culture.

Cultural Astronomy has evolved into a robust field of study that fills a distinct need for cultural understanding. The activities of the WG Astronomy in Culture have broadened far beyond what is typical for a working group considering its number of members, its association with multiple commissions, and as well the support it is providing to other organizations. Future contributions of Cultural Astronomy will now be even better accomplished by work as a regular commission of the IAU.

This new commission embraces all goals of the IAU Strategic Plan 2020-2030 and will especially be well poised to enhance efforts with Goals 4 and 5 as Cultural Astronomy is very much an attention-getter for the public and is also a fascinating way to introduce students to astronomy education.

The Commission will be the IAU's focal point for Cultural Astronomy and how it relates to other branches of astronomy, for research in the field, and for educating the public regarding examples of how astronomy is being and has been used in culture throughout world history. As such the commission will exist to support any part of the IAU desiring such assistance. The commission will build solid relationships with the OAD, OAE, OAO, and OYA.

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Artificial intelligence and its role in enhancing the teaching and learning of astronomy and cosmology across the various stages of education

Prof. Abd El Fady Morcos

National Research Institute of Astronomy and Geophysics. Acadmy of Scientific Researchs and Technology

Abstract

Artificial intelligence (AI) is revolutionizing education, particularly in astronomy and cosmology, by enhancing teaching and learning experiences across different educational levels. The expected techniques in how AI technologies can personalize learning, create immersive experiences, and deepen understanding of complex astronomical concepts have been disused for different educational levels. AI capabilities like machine learning, natural language processing, and virtual reality offer interactive simulations and adaptive learning platforms to solve some of challenges in current astronomy education. It is also submitting the need for teacher training. Emphasizing ethical considerations, it highlights the importance of educators in designing AI-enabled learning environments that prioritize student well-being and academic integrity. Finally we can say that AI's potential to transform astronomy and cosmology education by inspiring curiosity, enabling deeper exploration of the universe, and nurturing scientifically literate individuals for future cosmic challenges.

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Astronomy and the Ongoing Conflict in Sudan

Tamador Khalil[1], Hassan Abdalla[2,3,4]

[1]Affiliation. [2]IPARCOS and Department of EMFTEL, Universidad Complutense de Madrid, E-28040 Madrid, Spain. [3]Department of Astronomy and Meteorology, Omdurman Islamic University, Omdurman 382, Sudan. [4]Centre for Space Research, North-West University, Potchefstroom 2520, South Africa

Abstract

In this talk, I will discuss the impact of the ongoing war in Sudan on the recent development and growth of astronomy within the country. Despite the challenges posed by difficult times, we remain inspired by the enduring brightness of the stars, representing hope. Our goal is to build human skills that will serve as the foundation for re-establishing a strong astronomical research community. This community aims to make significant contributions to the global effort in understanding the cosmos.

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10 years of the Pan-African School for Emerging Astronomers (PASEA)

Dr. Linda Strubbe[1], Dr. Bonaventure Okere[2,3,4], Prof. James Chibueze[5], Dr. Jielai Zhang[6,7]

[1]Strubbe Educational Consulting. [2]Centre for Basic Space Sciences, Nsukka, Nigeria. [3]National Space Research & Development Agency. [4]West African Office of Astronomy for Development - Regional Node. [5]University of South Africa, Department of Mathematical Sciences. [6]Swinburne University of Technology. [7]ARC CoE for Gravitational Wave Discovery

Abstract

The Pan-African School for Emerging Astronomers (PASEA) is a short course in astronomy for university students and teachers from across Africa, designed and taught by an international collaboration of astronomers from Africa and around the world. Founded in 2013, PASEA's vision is to build a critical mass of astronomers in Africa, and exchange teaching ideas across continents. Drawing from educational research principles, PASEA is designed to inspire students' interest in astronomy, develop their scientific practices, support their scientific identities, and offer career guidance.

The biennial school was held four times in Nigeria and Ghana. In 2022, PASEA became Pan-African, holding our first school in Southern Africa in Zambia; we also held our first online program on remote observing. PASEA 2024 will be our first school in Northern Africa, in Tunisia.

We will highlight four unique aspects of PASEA: (1) our innovative inquiry-based curriculum, in which students ask and investigate their own mini-research questions in small teams; (2) "paired-teaching," in which international partners co-teach to learn new teaching strategies; (3) our alumni community; and (4) our evaluations of student learning.

Over 10 years, PASEA has created positive educational impacts in Africa and beyond. We have almost 300 alumni from 20 African countries. Almost all continue in STEM, and 90% say PASEA was very influential for their choice of career or studies. We are thrilled that five of our alumni have returned to PASEA as instructors. We will share PASEA's accomplishments over the last decade, and plans for the decade to come.

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How History Touches the Sky: Historical Instruments, Archives, and Observatories, and Why History Is Vital to Modern Astronomical Research

Dr. Sara Schechner

Harvard University

Abstract

As a science that studies distant celestial objects, astronomy deals with few things that can be touched directly. And yet, astronomy has many tangible things—scientific instruments, logbooks, and observatories, for example—which link the past to the present. There is little question about maintaining things still valuable for scientific research purposes, but why should we care about documenting and preserving the old and obsolete? One answer is that material things, when closely examined, enhance our knowledge of astronomy's history in ways that written texts alone cannot do. A second answer is that learning about the past helps us live critically in the present. Indeed, historical astronomical objects, when thoughtfully examined and analyzed, are useful to modern scientists because they offer insight into why things are the way they are, why we believe what we believe, and perhaps how we can change them.

By way of example, this talk will briefly examine some historical, tangible things that have lessons for modern astronomy. It will also highlight Commission C3's work in promoting the preservation and study of astronomy's material objects as keys to understanding the history of astronomy and astrophysics and communicating this history to the public.

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Motivating school students towards astronomy through competitions

Prof. Aniket Sule

Homi Bhabha Centre for Science Education (HBCSE-TIFR), Mumbai, India. IAU OAE Center India

Abstract

IAU has adopted a multi-pronged approach to inspire school students towards astronomy. In this talk, I would like to put spotlight on one approach often overlooked by astronomy educators. Amongst student cohorts in many developing countries, astronomy themed competitions prove to be a key motivator. Competitions, by nature, are designed to reach a large number of students, something which cannot be achieved by other education efforts such as workshops and summer schools. The global competitions, if channeled in a constructive way, can motivate students to learn and research latest developments in the field, can set benchmarks for educators and kick start curricular reforms in countries where curriculum has remained static for long periods. The competitions can take many forms from art based competitions and project based competitions to problem solving competitions like Olympiads. I will discuss these competition formats through examples and propose future paths for IAU to explore in order to make further progress on its mission to bring larger sections of population in the fold of astronomy.

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Diversity of knowledge on stars in indigenous communities of India and South Africa

Dr SHYLAJA B S

Jawaharlal Nehru Planetarium, Bangalore, India

Abstract

Stars have fascinated the inquisitive indigenous peoples who attempted to project their own stories to the sky. While the civilised societies recorded the heavens systematically with concepts like the coordinate system, the world views of the underprivileged are not known very well.

In a vast continent like Africa, a diverse system of nomenclature is quite apparent. The subcontinent of India (South East Asia – may be a better definition) is no exception. The most popular is the 27-star system instead of the 12-zodiac constellations, which is popular in China and South East Asia, with names of common origin and local touch, an effect of the advent of early sea-farers . Canopus is discussed in all astronomy texts for its visibility from different latitudes. There are many other stars outside the zodiac and have names based on a similar flow of thoughts. The use of stars for navigation is suggested by very simple names coined by sea farers. Pleiades has the largest variety of names and directly relates to the lifestyle of natives. It has a special place in the names of the months as well. The proverbs and stories associated with it are in use even today. Here we discuss the star names and associated celestial / terrestrial phenomena as they evolved and stayed on in the tongues of the native people. While exploring the diversity as will be narrated with many illustrative examples, we also note that the continents separated by the vast sea have some commonness in the naming of stars.

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A comparative study of the prehistoric megalithic structures in India and South Africa

Dr SHYLAJA B S

Jawaharlal Nehru Planetarium, Bangalore, India

Abstract

Megalithic stone alignments and rock art structures have been reckoned as the earliest attempts to comprehend the complicated motion of the celestial bodies. Several such structures have been identified all over the globe including India, dating back to 8 to 10000BP. In spite of the man-made and natural disturbances, some structures have remained intact. The astronomical alignments of several such structures have been studied in great detail in the last couple of decades. More recent (5000BP) alignments have been identified in several excavations. The astronomical significance is verified from field work and associated solstice and equinox measurements. It is interesting that similar structures in Africa have been brought to light in recent decades. Here I propose to make a comparative study of them with those in India to arrive at common time frame of evolution of thoughts. The study is based on the field studies by British archaeologists in the last century and subsequent efforts (of Vahia et al, Menon et al, Rao et al) in India and the work initiated (by Ruggles and Wade) in South Africa. The understanding of the solar motion appears to have been achieved without any ambiguity and the attempts on lunar motion can be traced in both places. The evolution of the luni-solar calendar prevalent in Bantu communities also is probably influenced by such studies as in India. Similar studies on the rock paintings offer very astonishing results, especially in a 'double star' pattern dated to earlier than 5000BP.

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The Influence of Kilimanjaro Mobile Planetarium and Telescopes on education outreach to boost Interest in Science and increase the number of Scientists in underserved regions of Tanzania.

Engineer Musa Mishamo

Kilimanjaro Planetarium

Abstract

Since its inception in 2022, the Kilimanjaro Planetarium has pioneered astronomy outreach education in Tanzania, successfully engaging over 20,000 students across diverse regions of the country. This program uses space science and astronomy concepts as catalysts to kindle students' passion for science and inspire them to pursue ambitious careers in Science. One of its distinctive features is the strategic targeting of remote regions in Tanzania, where the program conducts school visits, introducing students to stargazing and planetarium experience for the first time.

Through the innovative use of the Kilimanjaro mobile planetarium, the program creates a transformative experience for participants, offering them the sensation of voyaging through space. This immersive approach allows individuals in these remote areas to gaze upon celestial bodies such as the moon, stars, planets, and galaxies, fostering a profound interest in science. The tangible impact of the program is evident in the remarkable results and heightened enthusiasm witnessed since its inception. Notably, more than 13,000 students have expressed aspirations to pursue careers as astronauts, space engineers, astronomers, pilots, engineers, and various other scientific disciplines.

The Kilimanjaro Planetarium stands as a beacon of educational outreach, bridging the gap between underprivileged regions and the awe-inspiring realms of space science. By fostering a love for science and nurturing dreams of significant scientific careers, this initiative is contributing to the emergence of a new generation of scientists and ambitious individuals in Tanzania. The program aims to attract more youth to get into Science, Technology, and Innovation.

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Title: The role of space technology for sustainable tourism development in Zululand, KwaZulu-Natal, South AfricaAuthor: Thabani Mazibuko*, PhD candidate at Durban University of Technology, South AfricaSupervisor: Professor Renitha Rampersad, Assistant Dean, Cape Peninsula University of TechnologyKeywords: *Space technology, sustainable tourism development, South Africa, Zululand Space technology and sustainable tourism.*

Mr THABANI MAZIBUKO

Group on earth observation

Abstract

Space technology has a huge potential to provide valuable support through applications and satellite communication, reliable data and accurate information for informed decision making with respect to sustainable tourism especially around fragile world heritage sites and ecotourism potential. Earth observation from space is a cost-effective way of obtaining unbiased and essential data on the physical world and will allow decision makers to use this information to understand trends, evaluate needs, and create sustainable development policies and programmes for society.

The aim of this study is to assess the contribution of space technology as a potential to provide support for sustainable tourism development in Zululand, Kwa Zulu-Natal.

A qualitative and a quantitative research paradigm adapting a mixed method approach through the use of surveys and interviews is utilised. The sample was drawn from 150 key role-players and stakeholders from the Zululand district, KwaZulu-Natal, South Africa.

Literature focuses on Global outlook, Africa and South Africa as well as local frameworks and policies in space technology and sustainable development. It engages multi-disciplinary approach to space technology approaches, with lessons learned towards interventions of space technology mechanisms for sustainable tourism development.

It will add to the body of literature on the potential of space technology through the development of an integrated model for the tourism sector that could assist Governmental agencies and private sector in developing countries to understand better and support space innovation initiatives to create the sustainable tourism sector.

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Spreading the Stars! Astronomy Education and Outreach at UNIZULU Science Centre

Dr Derek Fish, Prof Aroonkumar Beesham

University of Zululand

Abstract

The University of Zululand has run an exciting Science Centre (USC) in Richards Bay, South Africa for almost 40 years, working mostly with pupils from pre-school to Grade 12, but also the general public. While not a dedicated astronomy or space science centre, USC has found these topics ideal to engage pupils and public and to introduce them to many aspects of science.

Programmes run over the past 30 years will be presented, compared and contrasted and their relative impact and effectiveness discussed. Resources for all these will be freely shared with delegates. These have included:

- a mobile planetarium (a Starlab which later became digital)
- interactive science shows which present various aspects of space
    1. Spinning in Space – on the solar system
    2. Our Spectacular Spectrum – on the spectrum and multi-wavelength astronomy as well as SKA
    3. The Wide World of Webb – on the James Webb Space Telescope
    4. In Living Colour – on light, waves and colour
    5. Astrology – comparing and contrasting astrology with astronomy
- telescope viewing evenings
- an analemmatic sundial at the USC which has also been reproduced at schools
- “Stars on Zoom” – a weekly Zoom webinar on astronomy during Covid
- “Power Planets” – a “trump” card game about the solar system
- A large, portable, outdoor scale model of the solar system

USC has presented programmes in the Centre, at Universities, in schools, public libraries, churches, on fields and on the beach at night. Valuable lessons have been learned and will be shared about effective outreach and education programmes.

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Development of astronomy in Ethiopia and its future prospects

Dr Solomon Tessema

Entoto Observatory and Research Center, Space Science and Geospatial Institute. Ministry of Innovation and Technology

Abstract

Ethiopia's geographic location and astronomical legacy make it a prime candidate for astronomical observatory sites. Since 2004, astronomy in Ethiopia has expanded in terms of scientific research, human resources, infrastructural development, and linkages with other countries and continents. In this study, we provide an overview of the trajectory of astronomy development in Ethiopia, including its obstacles and future prospects at the national and international levels, as well as its impact on socio-economic development and research, education, and outreach.

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Results from a recent review of 2089 astronomy education research articles from 1898 to 2022.

Dr. Saeed Salimpour[1,2], Dr. Michael Fitzgerald[3,1], Prof. Urban Eriksson[4]

[1]Deakin University. [2]IAU Office of Astronomy for Education. [3]Las Cumbres Observatory. [4]Uppsala University

Abstract

Using a mixed-methods approach to textual analysis considering 2089 publications in the field, an order of magnitude larger than the previous largest reviews of the field, this study paints a rich picture of the landscape of AER over the timespan of a century from 1898 to 2022. The 2022 cutoff was decided so that the publication record was relatively "complete" at that stage.

In this presentation, we provide a broad overview of the history of publications in Astronomy Education Research, particularly around it's modern genesis in the 1970s and it's skyrocketing growth during the 1990s. Initially this was dominated by the United States but, in recent years, this has been shifting to a situation where most recent AER research has taken place outside the USA.

We present what types of content are heavily focussed on (e.g. Celestial Motion) and areas that are fairly neglected (e.g. Galactic topics), what types of constructs are heavily focussed on (e.g. Content Knowledge) and which are not (e.g. Affective or Theoretical research).

This overview, with the publication abstracts input to an online database (istardb.org), provides a resource to researchers, educators, and other interested stakeholders allowing efficient ascertainment of previous research. This supports both researchers, allowing them to develop research questions at the cutting edge of the field, as well as practitioners, to inform their pragmatic approach based on latest research findings. We also present a set of recommendations and future outlook of the field of Astronomy Education Research.

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Pearl Sky Girl Mentorship Program

Ms Mavyline Motari

University of Nairobi

Abstract

The Pearl Sky Girl is a mentorship program founded on the principles of guidance, support and inspiration to empower girls to uptake and excel in STEM disciplines. Mentors are primarily composed of accomplished women in STEM professions who can offer insights into their field and share their personal experiences and provide guidance on educational pathways and career opportunities. We facilitate hands-on activities, workshops, symposiums and discussions tailored to enhance girl's understanding and appreciation of STEM concepts with a keen interest in Physics. We seek to impart essential skills such as critical thinking, problem-solving and teamwork spirit. We intend to evaluate the effectiveness of the mentorship program using qualitative and quantitative measures. This includes the use of pre and post-program surveys, academic performance metrics, and qualitative feedback from participants on the program's impact. This mentorship program aims to break the barriers and stereotypes that hinder girls' participation in STEM fields and ensure that the girls stay through school and get to access tertiary and university education. We aspire to foster a supportive community and provide targeted guidance and resources that will empower the girls to confidently pursue and excel in STEM disciplines, thereby contributing to a more diverse and innovative future workforce.

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Ancient celebrations and climate changing

Hassan Baghbani[1,2], Alireza Dosti[1], Fatemeh Jamali[3]

[1]ITAU. [2]Education service. [3]Boushehr astronomy group

Abstract

Although religion has brought together different ethnicities,
But different religions have caused the most violent and longest wars between different ethnic groups.
But the events and celebrations have always been the cause of convergence and better understanding of nations, they have built friendship and convergence. The permanence of the ancient civilization of Persia, along with the preservation of its traditions, is an example of it. The selection of four astronomical events for the great celebrations of the Persian civilization has made it long lasting.
The basis of the four Persian festivals is based on four astrological events, so these festivals are universal .
The main question: why should these four events be introduced as four global events.
Answer: To help the planet earth to solve the biggest challenge in human history (climate changes), and environmental challenges.
The festival of Tirgan (summer solstice) ,Nowruz (march equinox) Mehrgan(September equinox) Yalda(December solstice). four celebrations for planet earth , that shows how we can use sieson changing to understand the planet earth and do many helpful things for our planet. These four festivals have been so effective that the passage of several thousands years has not been able to destroy them and now they are held simultaneously in every corner of Iran and some neighboring countries.
The official registration of these four festivals and events with the cooperation of UNESCO and IAU can be a great contribution to the global convergence to solve the problem of climate change and environmental problems

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STEAM in Action: NASE-UNESCO Bridges between Cultures

Dr Rosa M. Ros[1], Dr Beatriz García[2], Eng. Ricardo Moreno[3], Dr Ederlinda Viñuales[4]

[1]Polytechnical University of Catalonia. [2]National Technological University, Mendoza, Argentina. [3]Colegio Retamar, Madrid, Spain. [4]Zaragoza University, Zaragoza, Spain

Abstract

Astronomy marks our lives in diverse ways. The approach to the starry sky was important from a ritual and daily ceremonial point of view. Although we have fragments of the knowledge of the people of the past, we know that astronomy allowed us to establish patterns that became part of universal culture; intangible heritage of humanity, according to the UNESCO declaration of 2007, the starry sky connects us as human beings, establishing the link between the terrestrial and celestial landscapes, deploying a bridge that goes beyond the borders imposed on the planet. *Bridges Between Cultures* and *Seminaries N+*, are the annual proposals of the Network for Astronomy Education in Schools (NASE) associated with the UNESCO call for May 16 – IDL. These activities aim, hand in hand with universal astronomical themes, discoveries of the modern era and great challenges of science dedicated to the study of the "light" that comes from the cosmos, to reestablish the links that identify us as a species.

In this presentation we will show the topics addressed from the beginning of the proposal, which covers challenging topics in Astronomy, Astrophysics, Astrobiology and Astroculture. The indicators that allow us to evaluate the impact of the carry out these activities and plan new ones, the testimonies of participants who constitute diverse audiences who risk developing astronomical topics in the classroom and beyond it, in many cases for the first time, will be presented in order to show the power of the discipline in the public communication of science.

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Astronomy in a National Marine Park in Iran as a Model for Using Astronomy for Sustainable Development

Hassan Baghbani[1], Mohammad reza Fooladi[2], Sahar Sahhafizade[2]

[1]ITAU. [2]Nakhilo sustainable development school

Abstract

The Iranian Teachers Astronomy ' Union has been making efforts for over twenty years to play a significant role in environmental protection and sustainable development by educating teachers and the local community through the allure of celestial knowledge. This model, as a successful one, can be utilized in other countries as well. An example being the comprehensive management of the Nakhiloo Marine National Park in the northeastern part of the Persian Gulf. Previously, one of the major sources of income for the local people in this area was logging, illegal hunting, smuggling, and out-of-season fishing, The efforts of environmental protection organizations in this area didn't be successful . Therefore, the only way to protect this area was local community activities.

ITAU , by using on past experiences, initially gained credibility among the local community by organizing astronomy workshops for teachers and students. Subsequently, by establishing a Sustainable Development School in suitable part of the national park, they focused on educating and empowering the local community and on the other side, by combining the natural attractions with the dark skies and involving the local community, they built a large astronomical complex comprising an observatory, planetarium, conference hall, accommodation facilities, and a restaurant. Thousands of tourists visit this complex annually, and their numbers are increasing each year. Other valuable educational activities have also been carried out, such as teaching watershed management and proper planting of native trees, which have played a vital role in land sustainability

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Using Zooniverse to Enhance Classroom and Group Engagement with a Suite of New Educational Tools

Lindsay House[1], Laura Trouille[2,3], Cliff Johnson[2,4,3], Samantha Blickhan[2,3], Chris Lintott[5,3], Lucy Fortson[6,3]

[1]University of Texas at Austin. [2]Adler Planetarium. [3]Zooniverse. [4]Northwestern University. [5]Oxford University. [6]University of Minnesota

Abstract

Zooniverse has launched over 450 participatory research projects engaging over 2.7 million registered participants. The projects cover a diverse range of disciplines, from astronomy to cancer research to zoology. Zooniverse has become essential in the researcher's toolkit. And by engaging the public meaningfully in scientific research, Zooniverse advances the IAU's mission of impact and accessibility through fostering community growth and global collaboration while providing inclusive, family-friendly public engagement.

In addition to individual participants classifying on projects and engaging in the discussion forums, Zooniverse is used by thousands of groups in formal and informal learning settings such as schools, museums, and libraries. Classroom.zooniverse.org provides resources and support for these efforts. However, a common request has been better tools to track group-based collaborative effort on the platform. In response, in 2024 Zooniverse released a suite of new features to share individual and collective impact. Whether it's for an after-school club, corporate volunteering program, or a friend/family group, these new features provide new avenues for fostering community and collaboration. For example, educators can use these new tools to tailor classification challenges (and rewards) for their students, further motivating and integrating participatory science experiences into their curriculum. In this Talk we share pathways and lessons learned from leveraging participant data to celebrate impact and further motivate engagement. And we welcome feedback and collaborations to refine these features so that they are most useful to our diverse audiences.

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PLOAD special days and its non-formal education activities in virtual mode

Joana Latas[1,2], Patrícia Figueiró Spinelli[3], Joana Marques[4], Joana Silva[1], Rosa Doran[1]

[1]NUCLIO. [2]Center for Research in Education and Psychology of the University of Évora (CIEP-UE), Portugal. [3]Museum of Astronomy and Related Sciences, Brazil. [4]Institute of Astrophysics and Space Sciences (IA), University of Coimbra, Portugal

Abstract

Portuguese Language Office of Astronomy for Development (PLOAD) promotes the use of astronomy as a tool for development in Portuguese-speaking countries and communities, supporting the strategic plan of the International Astronomical Union (IAU). PLOAD aims to promote scientific literacy through accessible resources for all Portuguese-speaking countries and to contribute to their active participation in the field of Astronomy and Space Sciences. This is achieved by providing access to cutting-edge resources, establishing partnerships with the educational community, and highlighting the cultural importance of sky observation in the language and history of these countries. The diversity within the PLOAD network presents unique challenges and opportunities for scientific, technological, and educational development. Moreover, being represented on four continents, PLOAD faces additional geographical challenges. To overcome these challenges, digital communication is being a central tool in our actions, allowing PLOAD to achieve greater community engagement in the activities, bridging the gap between science and society.

This poster focuses on the non-formal education activities virtually and promoted in three Special Days related with PLOAD's mission: World Science Day for Peace and Development (November 10), International Day of Women and Girls in Science (February 11), and World Portuguese Language Day (May 5). During these celebrations, a joint program with a global online component and a local face-to-face one was organized, which will be presented. These diverse activities allowed participants, mainly young people, to share the Portuguese language and science curiosity through meaningful interactions.

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The Impact of the International Astronomical Union in Bolivia, through the work of the National Coordination of Diffusion and Education office since 2019.

Natieonal Outreach Coordinator Paola Daniela Ochoa Paniagua.

National Outreach Coordinator Bolivia - IUA. CEO - ANDRÓMEDA Company.

Abstract

In 2019, the year of celebration of the 100 years of the IAU, Bolivia has its first NOC, with this the IAU begins to gain popularity in the national territory. The IAU's Global activities are carried out for the first time with the support of amateur groups of professors and professionals in astronomy.
The diffusion office, acquired a first-hand role, was established independent of any other institution, which gives it the advantage of carrying out activities without highlighting the local institution, but rather the IAU itself with its global activities.
We named the first exoworld for Bolivia, we held national astronomy meetings and astronomical camps, “Telescopes for All” campaigns, “100 Hours of Astronomy”, “World Lunar Observation Day” “Girls and women in Science” workshops for teachers, students and amateur people, etcc. From these activities, astronomical communities grew more both in urban and rural areas.
All these activities are the result of the work of associations, clubs, professional and amateur teachers, who, motivated by the presence of the IAU, made it possible. Without a doubt, having the support of the IAU has been highly positive for our country and we continue working so that the institution has more presence in our country.

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Astronomy Day in Schools: Commonality and diversity of cultural astronomy and collaboration of research projects

Dr. Akihiko Tomita

Wakayama University

Abstract

The Astronomy Day in Schools project organizes the online program on the occasion of equinoxes and solstices. Students and teachers from various countries introduce each other not only their astronomy activities, but also their local cultural events and traditions and their relevance to astronomy. In the astronomy activities, the students have started the night sky photography project to raise awareness of light pollution issue. Cultural events and traditions are diverse from region to region, but at the same time very similar in some aspects. One reason for this may be that the yearly cycle of the landscape and people is related to the yearly cycle of the heavens, and another is the commonality in the way people react to the cycle. There are also presentations on ancient architectures and examples of how astronomy was incorporated into daily life at that time. As school materials, apart from the direction of developing advanced astronomy and STEM contents, applications to geography, history, art, music, and moral classes are examples of cross-disciplinary materials related to astronomy which are appealing to teachers and students who are not necessarily so astronomy-oriented. The teachers sometimes learn about local traditions only after hearing the students' presentations. In this talk, I will introduce some of the above examples in previous programs and feedback from teachers and students. The continents of the participating countries are so far mostly Eurasia and Latin America, and we would like to expand to other areas in the future.

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ASTRONOMY EDUCATION IN TANZANIA

Mr. George Kato

Afrikagera Geological Center

Abstract

Astronomy activities in Tanzania are at a minimum level, despite the potential advantages space science comes with in our societies. Research and education in space is vital for various sectors like agriculture, transportation, health, mining, geology technology and many others. Having a satellite in space means getting well prepared for the heavy rains, discovering potential mineral resources, building resilience to geohazards and exploring the universe. It is with this that astronomy education is important in several levels of education for the development of the people and the Nation. This presentation examines existing curriculum structures, educational resources and the level of integration of astronomy in schools. It also highlights initiatives that promote astronomy awareness among students and communities at large.

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Designing urban elements and the identity of cities with an astronomical approach

Mr Hossein Khezri[1,2], Ms Maryam Papari[3,1]

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Abstract

The presence of elemental elements in addition to beauty improves the quality of space, and this quality affects the human mind

and affects the sense of place and collective memories of citizens. Urban planners should use urban elements that promote the

transfer of urban identity to the city, which helps citizens to be satisfied and improve the quality of urban environments. Urban

elements play an important role in fostering urban identity and empowering citizens, and should be designed in such a way that

their readability is consistent with the events and events of the citizens and their plans are coordinated.

By strengthening citizen science, especially astronomy, people's view of their surroundings will change and in the long run it can have a significant impact on the development of astronomy in other societies.

These symbols include astronomical elements, solar calendars and sundials, etc.

Session

Division C Education, Outreach and Heritage

1074

Ethiopian Amateur Astronomy Community at the Ethiopian Space Science Society: Achievements, Challenges, and Future Prospects

Kirubel Menberu Alemu

Ethiopian Space Science Society (ESSS). Space Science and Geospatial Institute (SSGI). Office for Astronomy Outreach (OAO)

Abstract

The Ethiopian Space Science Society (ESSS) serves as a hub for astronomy enthusiasts, nurturing a vibrant community dedicated to science communication. One of the key initiative of ESSS is the development of an amateur astronomy community with access to telescopes and maintenance capabilities. This presentation showcases the achievements, challenges, and prospects of the Ethiopian Amateur Astronomy Community at ESSS.

ESSS has significantly contributed to promoting astronomy awareness and education across Ethiopia. Through outreach programs like public lectures, school visits, and stargazing events, the community has engaged a diverse audience, igniting a passion for astronomy among students, teachers, and the public. The community's interest in stargazing has also expanded to include astrophotography and live streaming of astronomical events.

Despite successes, the community faces challenges such as limited resources and infrastructure, hampering outreach efforts. Purchasing telescopes in Ethiopia is challenging due to the lack of vendors and cumbersome customs procedures. ESSS has resorted to DIY maintenance for telescopes and accessories due to these challenges. However, the growing interest in astro-tourism could lead to policy changes to improve access.

Looking ahead, the Ethiopian Amateur Astronomy Community at ESSS aims to overcome these challenges and expand its impact by including telescope training, technical support for telescope owners, and furthermore enhancing collaboration with international partners, and advocating for increased support for amateur astronomy in Ethiopia.

This presentation provides a comprehensive overview of the Ethiopian Amateur Astronomy Community's journey at ESSS, highlighting achievements, challenges, and future aspirations in advancing astronomy education and outreach in Ethiopia.

Session

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1076

Gender Sterotypes and Difficulty in Promoting Girl-Child Education in Nigeria: The way out

Chioma Okany, Timothy Egbuim, Francis Obieti, Evelyn Sam-Ngwu, Dr Chukwujekwu Ofodum, Dr Bonventure Okere

NASRDA-Centre for Basic Space Science ans Astronomy, Nsukka

Abstract

One area that seems to have not been well explored by researchers is the issue of gender sterotypes and girl-child education improvement in STEM, especially in Astronomy Education in Nigeria.

According to the United Nations (SDGs) 5, gender equality is the bedrock of an inclusive society. Girl-child participation in Astronomy education in Nigeria has been limited due to political, societal, and religious beliefs. Truly, this sterotype is a cankerworm that needs complete eradication in our society. Due to the broad ethnic and religious diversity, most cultures and religions frown at girl-child active participation in Astronomy/STEM activities. In some regions of Nigeria, tradition entails that the girl-child is relegated to house chores and child-bearing. A quantitative survey on willingness and possibility of activating Astronomy inclusion in Nigeria revealed that most girls shy away from participation in Astronomy/STEM-related activities. Incidentally, these problems were attributed mainly to religion and ethnicity. The Astro_girl child project aimed to encourage girl-child education in STEM/Astronomy-related courses in Nigeria. Inspite of all these efforts aimed at improving STEM education since 1859, the benefits of scientific and technological development have been unevenly distributed gender-wise. In other words, girl-child participation in Astronomy and STEM-related activities cannot be compared in any way with that of their male counterpart in this modern age. In light of the above, there is a need for active sensitization among boys, girls, and parents in all parts of Nigeria, for the effective realization of UN SDG-5 in Nigeria using education as a tool.

Session

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1165

Advancing STEM Education and Community Engagement: The Giant Magellan Telescope Approach

Valerie Hirschberg

Giant Magellan Telescope

Abstract

This oral presentation will provide a comprehensive overview of the Giant Magellan Telescope's approach to the design, development, and implementation of its education, public outreach, and community engagement programs all guided by our mission to foster interest, literacy, diverse participation and sustainability in STEM fields. We will explore our methodology, current initiatives, outcomes, key learnings for the astronomy community, and future directions.

Our commitment to education, outreach and engagement is deeply rooted in the conviction that collaboration and partnership are catalysts for change. Recognizing that advancing STEM interest, literacy, and participation requires a collective effort, we actively seek collaborations with experts and community stakeholders. This approach ensures the active involvement of our intended audiences and communities, with a profound emphasis on prioritizing community voices and needs. The presentation commences with an overview of our existing programs, their tangible impact, and lessons learned. We will provide the profession and community key insights into our approach and processes to developing initiatives that are rooted in a community-astronomy model. Finally, we'll provide a glimpse into our future education, outreach and community engagement endeavors and strategic directions.

Session

Division C Education, Outreach and Heritage

1200

A new approach to teach astronomy

Prof. Sun Kwok

University of British Columbia. University of Hong Kong

Abstract

In our education system, science is often presented to our students as a series of facts. In fact, science is about the process of rational thinking and creativity. What we consider to be the truth is constantly evolving and has certainly changed greatly over the history of humankind. The essence of science is not so much about the current view of our world, but how we changed from one set of views to another. In a course designed for the Common Core program of the University of Hong Kong, I use the historical development of astronomy to illustrate the process of rational reasoning and its effect on philosophy, religion, and society. I begin with a description of basic observations, summarize the patterns observed and the problems they pose, and discuss the suggested theories and their implications. The pros and cons of these theories are evaluated alongside alternate theories. This approach differs from typical science textbooks, which usually take an axiomatic approach by first stating the correct theory and deriving the deductions before comparing them with experimental results. With this historical approach, students can better understand the scientific process and learn from this process when they tackle real-life problems in their careers.

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Session

Division C Education, Outreach and Heritage

1222

Bringing Astronomer to Empowering Astronomy Club at Secondary School: Experience in Malaysia

Dr Raihana Abdul Wahab

University of Malaya

Abstract

The Astronomy Club at Secondary School plays a very important role for nurturing student's curiosity about astronomical sciences and fostering their scientific inquiry through the theoretical knowledge and practical applications. However, due to factors like a lack of experience and a deviation from complete, organised theoretical and practical training that can be translated into student-led hands-on activities, these club members are unable to fulfil this role. Hence, the goal of this project is to strengthen the function of the secondary school astronomy club by combining theoretical and practical instruction under the supervision and direction of qualified astronomers. As a result, this project creates a simple module in Malay Language named "Modul Celik Falak" that serves as curriculum direction for an astronomy club. Consequently, this project is being carried out to allow members of the astronomy club to share their knowledge with other students and the local community. This project was warmly received by both the teachers and the students who attended the training. The response clearly demonstrates that the majority of club members believe the astronomy club has a positive impact on capturing students' curiosity, encouraging lifelong learning, and developing the next wave of astronomers and the universe enthusiasts.

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1227

KNOWLEDGE AND PERCEPTION OF ASTRONOMICAL EVENTS AMONG STUDENTS OF HASSAN USMAN KATSINA POLYTECHNIC, KATSINA KATSINA STATE, NORTHERN NIGERIA

Mr. Suleiman Iguda Ladan

Hassan Usman Katsina Polytechnic, Katsina Katsina State, Nigeria

Abstract

ABSTRACT

Over the years astronomical events such as lunar eclipse, solar eclipse and the falling of meteorites etc have been occurring in different parts of the world and how such events are viewed depend largely on the knowledge and perception among the citizens. This paper examines knowledge and perception of astronomical events with particular reference to the Friday 27th July 2018 lunar eclipse, among students of Hassan Usman Katsina Polytechnic, Katsina Katsina State. The sampling of a Polytechnic for the study is apt as the Polytechnics are science and technology based institutions that play a critical role in the technological advancement of the country. Data for the research were generated using structured questionnaire survey conducted on two sets of students studying National Diploma Science Laboratory Technology and National Diploma Mass Communication numbering one hundred (100).The results have shown a varying degrees of knowledge of the lunar eclipse as the Mass Communication students depict an average while the Science Laboratory Technology students depict above average knowledge. In terms of the perception of the event only a small percentage of the students perceive the event as a normal astronomical event that occurs from time to time. It is therefore recommended that efforts should be made towards improving the student's knowledge of astronomical events and right perception of the event as experienced in Nigeria.

Key words: Knowledge, perception, astronomical events, students, Katsina.

Session

Division C Education, Outreach and Heritage

1298

From Analog Roots to Digital Frontiers: Investigating the Modern Planetarium in Astronomy Education

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[1]University of Cape Town. [2]Inter-University Institute for Data Intensive Astronomy

Abstract

The modern planetarium, blending digital immersion with its traditional analog roots, still serves as an important educational tool in astronomy. This study investigated the role of the digital planetarium in teaching and learning through two main inquiries: a) examining student engagement with the digital planetarium, and b) identifying factors influencing the teaching and learning space within the planetarium. Data for these inquiries were derived from both student responses and observational data, analyzed using the Grounded Theory Method. Responses were collected from university students during two visits to a digital planetarium, integrated into their introductory astronomy course. An instrument was created to assess their overall experiences and educational content engagement. Analysis of individual student responses revealed key ideas grouped into categories, forming a localized mid-level model of student engagement. The concept of a "spectrum of attentiveness" emerged, influencing student engagement levels, along with an optimal level for relevant engagement affected by coincident distractions. Detailed observations, gathered during multiple visits to the planetarium, also contributed to constructing categories for a second localized mid-level model. This model outlined key contextual factors shaping the planetarium's teaching and learning space. To expand on the initial inquiries, these two localized models were integrated with broader cognitive theory, specifically Working Memory (WM) and Cognitive Load Theory (CLT). The synthesis of these models culminated in the development of a comprehensive Model for Curriculum Design in the Planetarium (MCDiP), aimed at systematically enhancing the digital planetarium as an effective teaching and learning space.

Session

Division C Education, Outreach and Heritage

1358

Micrometeorites Project in Iran, Inspiring Discovery and Learning Journey

Seyedeh Fatemeh Hasheminasab[1], Hosan Fadaei Yekata Kaldehi[1], Rahimeh Foroughi[2]

[1]Thaqeb Astronomical Association. [2]Znjan University

Abstract

This is a scientific report about the international Micrometeorites project based on NASE's proposal for the International Day of Light, which was held in Iran by the Thaqib Astronomical Association.

It would describe our experience coordinating and conducting a special program on micrometeorites in Iran. At the end of this project, 212 students and 38 teachers from nine provinces in Iran actively participated. Our aim was to make space exploration captivating and accessible for Iranian students. The micrometeorite project empowered teachers across the country to bring the wonders of the universe into their classrooms. Students not only observed the night sky but also had the tangible experience of handling actual pieces of space debris, enriching their understanding of astronomy.

Session

Division C Education, Outreach and Heritage

1375

Hack4dev Data Science Hackathons

Dr Nikhita Madhanpall[1,2], Mr Eslam Hussein[3]

[1]Wits Centre for Astrophysics. [2]Development in Africa with Radio Astronomy (DARA). [3]Inter-University Institute for Data Intensive Astronomy (IDIA)

Abstract

Since 2018, Data Science Hackathons have been conducted in collaboration with DARA Big Data, a sister project to DARA (Development in Africa with Radio Astronomy), the Inter-University Institute for Data Intensive Astronomy (IDIA), and the Office of Astronomy for Development (OAD). The primary goal is to enhance data science capacity across the eight SKA African partner countries forming the African VLBI Network (AVN).

Between 2020 and 2023, the programme hosted 3-4 hackathons annually, featuring virtual events accessible to participants across Africa and benefiting around 300 individuals from 14 countries. These hackathons provided hands-on exposure to data science and machine learning, engaging a diverse participant pool, including undergraduates, postgraduates, and young professionals in STEM fields. This active involvement in real-world projects instilled confidence for future pursuits in industry or research. Each 3-day event comprised training and ideation segments, where participants delved into data science concepts using Jupyter Notebooks within IDIA's ilifu cloud computing system.

In 2022, the initiative evolved into the Hack4dev project led by IDIA in collaboration with the OAD, African Astronomical Society (AfAS), and BRICS Astronomy. The Hack4dev Data Science Hackathon programme now follows a new framework for sustainability and scalability. This involves an annual global call for individuals or groups interested in organising hackathons. Selected organisers undergo comprehensive in-person training to execute successful 2-3 day Data Science Hackathons in their respective countries. Additionally, hackathon projects, based on current research, offer participants the opportunity to generate new solutions with the potential for publication.

Session

Division C Education, Outreach and Heritage

1379

Embracing the Night Sky: Astro-Tourism Potential in Botswana

Mr Onkabetse Sengate

Botswana International University of Science and Technology. University of Kwazulu-Natal

Abstract

Botswana, with its vast expanses of pristine wilderness and remarkably low light pollution levels, presents a unique opportunity for astro-tourism enthusiasts to explore the wonders of the cosmos. This poster highlights the potential and challenges of astro-tourism in Botswana, offering insights into the socio-economic and environmental impacts of this emerging niche within the country's tourism sector. By examining the factors driving the growth of astro-tourism in Botswana and the strategies for sustainable development, this presentation aims to shed light on how Botswana can leverage its celestial assets to promote economic growth, cultural exchange, and scientific discovery while preserving its natural heritage. Join us as we journey through Botswana's enchanting night sky and discover the limitless possibilities of astro-tourism in this captivating poster presentation.

Session

Division C Education, Outreach and Heritage

1417

Perspectives on Decolonising Astronomy Towards An Inclusive Environment

Assistant Professor / Director of Communications Thilina Heenatigala

Earth-Life Science Institute (ELSI)

Abstract

A form of colonisation exists in scientific academia, education and outreach. It is identified through the imbalance of power and wealth between academia in developed and developing countries, Global North and Global South, and Western to East. Also recognised as 'parachute science' wherein experts from formerly mentioned regions would go into under-developed or Global Southern areas for one-off activities without collaboration with local expertise or long-term plans. The issue of 'colonial science' is reflected in astronomy research, development, education and outreach. These colonial structures continue to shape astronomy efforts, which could work against the development of underdeveloped communities. As a community of astronomy experts, it is essential to consider how resources such as expertise, guidance, and materials are shared among the communities. And collaborations that go hand-in-hand with local experts and address local needs. This talk will address the growing concern of 'parachute science' or 'colonial science' in astronomy and move towards an inclusive environment.

Session

Division C Education, Outreach and Heritage

1446

Office of Astronomy for Development. Flagship 2: Astronomy for Mental Health Overview

Mr Dominic Vertue, Dr Joyful Mdhluli, Mrs Mampho Ledimo

OAD

Abstract

The Office of Astronomy for Development's flagship program, Astronomy for Mental Health, harnesses the power of astronomy and the night sky to improve mental health and well-being.

I will share the work of the Office of Astronomy for Development (OAD) in integrating astronomy and mental health. Our work builds on research that shows engaging with astronomy can inspire awe, spark curiosity, and relieve anxiety and depression.

In this presentation, I will discuss the origins of this program, including supporting literature on astronomy's benefits for mental health. I will outline the challenges we faced in bringing psychology and astronomy together and the barriers that still need to be overcome to firmly establish astronomy as a mental health support tool, sharing lessons learned and best practices from our mental health astronomy initiatives along the way.

Session

Division C Education, Outreach and Heritage

1449

Can James Webb Telescope discoveries inspire the next Albert Einstein to come?- How to make Astronomy Accessible to the AfricanYouth?

Ms Basia Nasiorowska

AfAS

Abstract

This paper discusses and explores the idea of promoting Astronomy to the youth of Africa in conjunction with the James Web Telescope discoveries.

The JWST's new images are beautiful and at the same time scientifically valuable. Currently they are known only to a selected group of scientists, astronomers, amateur astronomers and all other knowledgeable enthusiast. How can an African youth be exposed to and then inspired by the JWST imagery and become a journalist, astronomer, astrophysicist or an Astronaut?

The surrounding cosmos has captured the imaginations of generations and is inspiring technological innovations and artistic expressions. JWST showcasing galaxies across the universe and other cosmic imagery can inspire the youth of Africa as long as it is made known and accessible.

Observatories such as Meer KAT radio telescope in South Africa would be a good starting point to be an introduction to the projects to better understand how galaxies are born and exist by observing the stars.

The interest can be born from star gazing initiatives by communities outreach projects through to

competitions such as **"From Star Gazing through the Galaxies to Living on Mars and Moon Competition".** Participants can express the beauty of Space as imaginative works of art such as paintings, drawings or digital forms inspired by JWST.

Competitions can be the engine to drive entrepreneurial spirit and form future African startups in Astronomy and Space Technologies.

The African youth is motivated and excited to be part of the discoveries and experience the fruits of such amazing tools as James Web Telescope.

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1451

GLOBAL ONLINE TEACHING AND RESEARCH TRAINING IN ATOMIC ASTROPHYSICS

Prof Sultana Nahar

The Ohio State University

Abstract

With realization of globalization of knowledge can bring scientific advances faster, one important objective in all areas of STEM has been globalize education and research. I found that objective was served most efficiently by teaching and training research online through zoom platform during COVID-19 pandemic. I have been delivering the 3-weeks long research training course "Atomic Astrophysics and Spectroscopy with Computational Workshops on R-matrix and SUPERSTRUCTURE codes" in-person internationally since 2013. It took a pause due to COVID-19. However, guiding students and researchers on the zoom in 2019, I realized the potential of zoom and transformed my course for virtual presentation, and offered it successfully to 75 participants organized by Choaib Doukkali University of Morocco in 2020. The following year, I expanded it to over 100 participants from 11 countries, from USA, Africa, Middle East to Asia, joining at the same time, afternoon in Mexico to early morning in Bangladesh. Interestingly and fortunately, the participants were enthusiastic with the subject materials with no complain on the time zones. The staff of my partner Ohio Supercomputer Center for facilitating high performance computers for the computational workshops provided all technical help patiently to the non-English speaking participants. The other best part was forming a what's app group of the participants who would help each other with projects and running programs, and ended in forming a wonderful bond among them. A news article of it was published on the front page of American Physical Society Newsletter Vol 31, No. 6, page 1 (2022).

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1469

Astronomy Outreach and Education in Ugandan Secondary Schools

Dr Cosmos Dumba[1,2], Dr Benard Nsamba[3,4]

[1]Mbarara University of Science & Technology, Uganda. [2]Thuringa Landessternwarte, Tautenburg, Germany. [3]Max Planck Institute for Astrophysics, Garching. [4]Mbarara University of Science & Technology

Abstract

Astronomy education in Uganda is on the rise as more public universities have included Astronomy in their curricula. This has lead to an increase in the necessity of Astronomy awareness in Secondary schools, which feed the universities with science students, and to the general public. To this end, we embark on a nationwide program, visiting secondary schools (high schools), conducting Astronomy outreach activities. These activities are designed to fit with the newly designed secondary school curriculum that is learner centered.

We report the outcome from the outreach visits to secondary schools from the East, North, West, South West and Central regions of Uganda. We also show that such programs highly motivate the learners to take on Science and Engineering based higher education courses. It is however noted too that in regions that are further away from the cities, the knowledge on Astronomy is still low and therefore more awareness has to be done to widen the scope.

Session

Division C Education, Outreach and Heritage

1499

Practice of Stargazing Tour on a Ship as a Astro-Tourism

Dr. Shio Kawagoe[1], Dr. Nobuhiko Kusakabe[2,3]

[1]The University of Tokyo. [2]Astrobiology Center, NINS. [3]National Astronomical Observatory of Japan

Abstract

Recently, astro-tourism, in which people leave residences to look up at beautiful starry skies, has attracted people. The main sites chosen as fields for astro-tourism research are those with international observatories and those accredited by the International Dark Sky Association (IDA). Astro-tourism is becoming popular in Japan. However, there is a paucity of academic research on astro-tourism.

This study implemented a tour to observe the Geminids meteor shower on a ferry as a case study of astro-tourism in Japan. In this tour, the participants boarded the Tokyo-Kyushu Ferry instead of observing at a specific location as certified by IDA. They observed from the ferry's deck as it traveled over the Pacific Ocean. Before observing, the author lectured on the Geminids meteor shower. After the lecture, we surveyed 27 tour participants.

It rained on the tour day in December 2023, and the Geminids meteor shower could not be observed. However, about 80% of the participants answered "very good" or "good." About 90% of the respondents said they would like to participate in future tours with astronomy as a theme. The results also suggest that tours with astronomy as a theme have the potential to attract a wide range of participants, regardless of their background in the humanities or sciences.

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1513

Investigating learners' experiences and attitudes towards astronomy in the New curriculum of Uganda: A case study of Kabale Municipality

Dr Isaac Habumugisha

Kabale University, Department of Physics

Abstract

Astronomy as natural science, is magnificently rich in concept. It is embedded in the various fields of modern 21st century; Science, Technology, Engineering and Mathematics (STEM). Slightly before the onset of Covid-19 pandemic (February 2020) in Uganda, the government rolled out the new lower secondary education curriculum (LSC). The aim of LSC was to equip learners with an enhancement skills training as opposed to the old curriculum, which was designed on colonial system. Interestingly, concepts on astronomy for beginners were included in the New LSC, but do learners have any experience in the content and how interested are they towards it. That is why this study investigated the learners' experience and attitudes towards Astronomy concepts. A total of 160 students from six secondary schools in Kabale Municipality (St. Marys' College-Rushoroza, Ndorwa Secondary School, Trinity College, Kabale Brainstorm High School, Rock High School, and Kigezi College-Butobere) were randomly sampled. A questionnaire-with carefully chosen set of questions was administered. Majority of the learners (67%) were found to have heard basic knowledge on astronomy, with 33% not conversant with astronomical concepts when first introduced in class. 81% of them were highly interested in Astronomy. Additionally, learners stated that they heard about astronomy from various sources like T.V programs, YouTube videos, among others. However, majority of the teachers were not trained about astronomy concepts. Thus thorough facilitation in teaching of Astronomy and Astrophysics is required. It is recommended that Physics teachers be given refresher courses and the scope of astronomy and astrophysics expanded.

Session

Division C Education, Outreach and Heritage

1517

Awareness, Interest and Challenges of Studying Astronomy among Students in Nigerian Universities

Dr Emmanuel Eseyin

Nigerian Institute of Social and Economic Research

Abstract

Never in the history of Africa has there been the need to better understand the way forward out of the social, cultural, economic and political crises bedeviling the continent than now and Nigeria is not excluded. Deep interest in astronomy can serve as a way out of this quagmire but this interest can only begin from attracting the interest of students who eventually become astronomers. This study hence focused on assessing the level of awareness, interest and challenges of students in embracing astronomy in Nigerian Universities. The survey sampled respondents from first generation Nigerian Universities. The Universities selected are University of Ibadan in the South and Ahmadu Bello University in the North. Purposive sampling technique was used to select 104 astronomy students in their first and final year in these Universities. These respondents responded to a structured questionnaire which was analyzed using descriptive statistics. The result of the study indicated that the level of awareness and interest of students in astronomy is low in the Universities. Some of the students offering the course had no option after failing to get their first choice courses. The challenges in embracing astronomy included parental career influence, low career prospects and the absence of human and material resources for the programmes in Nigerian Universities. It was recommended that increased funding and political will need to be channeled to this area for Nigeria's socio-economic stability

Session

Division C Education, Outreach and Heritage

1597

The IAU Office of Astronomy for Education – what members of Division C might want to know

Dr Marks Pössel

IAU Office of Astronomy for Education. Haus der Astronomie. Max Planck Institute for Astronomy

Abstract

Division C, and more specifically Commission C1, and the IAU Office of Astronomy for Education (OAE) have similar outlooks. This poster gives a brief introduction of the OAE and its activities, with a particular eye towards what Division C members should be aware of, and where there are possible opportunities for collaboration.

Session

Division C Education, Outreach and Heritage

1608

Astronomy as a conflict zone

Dr. Alejandro M. López

Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Instituto de Ciencias Antropológicas, Universidad de Buenos Aires

Abstract

The title of one of the axes of the Division C Days is "Astronomy in conflict zones." This expression could be understood as a reflection on how the work of academic astronomers residing in conflict zones is carried out and can be sustained. Also the expression could be linked to a reflection on the role that astronomy can play in reducing tensions and conflicts in a troubled world.

In this work I maintain that another, an essential, sense of the expression is a critical analysis of how the practice of professional astronomy has contributed to the generation of different conflicts. To do this I will use a cultural astronomy perspective, analyzing cases coming from my experience of 25 years of ethnographic fieldwork on the astronomy of indigenous peoples, and from my experience as chair of the WG on "Astronomical Heritage in Danger", and as part of the Joint Committee on Culturally Sensitive Sites (CSS) –of the IAU, RAS, AAS, ISAAC, and SIAC–. I will analyze these cases not as isolated situations, but looking at the panorama as a whole and seeking to understand its structural characteristics. To do this, I put them within its broader social framework, with the aid of social sciences. I will also critically study some of the strategies deployed in recent times to try to overcome these tensions. Finally, I will propose possible lines of action to address these problems in our individual and collective professional practice.

Session

Division C Education, Outreach and Heritage

1619

The development of Astronomy in Botswana through Outreach

Dr Kushatha Ntwaetsile

Botswana International University of science and technology

Abstract

Astronomy as a field in Botswana is still in its infancy and developing interests in Astronomy is crucial for the development of Astronomy. Schools outreach can be used to increase the interest of the teachers and students in Astronomy and also enhance the interest of young people in appreciating and studying Astronomy-related courses at University. Outreach is an important tool for reaffirming the critical importance of science. This presentation will center on previous and ongoing outreach initiatives designed to involve the students in astronomical exploration. In the last eight months, the Botswana team, in collaboration with the Botswana International University of Science and Technology, has organized diverse astronomy outreach events, encompassing teacher training, school visits, stargazing sessions, and more.

Session

Division C Education, Outreach and Heritage

1644

SPACE OUTREACH PROGRAMS IN KENYAN UNIVERSITIES.

Mr. Kimani Nyoike[1], Mr. Samuel Nyangi[1,2], Ms. Olyvia Gatwiri[3]

[1]Leo Sky Africa. [2]University of Nairobi. [3]Kenyatta University

Abstract

Over the past year, Leo Sky Africa has engaged in extensive outreach initiatives with Kenyan universities, particularly through collaborations with the University of Nairobi and Kenyatta University. Our efforts have included organizing Astro-nights and workshops at the University of Nairobi, covering diverse topics ranging from computer science to black holes, alongside sessions dedicated to highlighting the role of women in astronomy. Complementing these educational endeavours were public star-gazing events and captivating planetarium shows. Additionally, our partnership with Kenyatta University facilitated practical workshops focusing on drones and satellite technology, providing students with invaluable industry exposure. During World Space Week 2023, we further expanded our reach by joining forces with the Kenya Space Agency, Technical University of Kenya, Jomo Kenyatta University of Agriculture and Technology and Kenyatta University to address the four thematic areas of Astronomy and space science, earth observation, space and satellite technology, and space systems engineering. Through these collaborative efforts, we have strived to foster a deeper appreciation for space exploration and technological innovation within the Kenyan academic community. In this presentation, we present the work done in a bid to continuously build capacity and a community around space science education in Kenyan Universities, while creating a platform for students to engage with the ever-growing space industry.

Session

Division C Education, Outreach and Heritage

1647

The Astronomy Education Journal: A vehicle for publishing your practice and research

Professor Urban Eriksson[1], Dr. Saeed Salimpour[2]

[1]Dept. of Physics and Astronomy, Uppsala University, Uppsala, Sweden. [2]Deakin University, Melbourne, Australia

Abstract

In 2019, following the inaugural AstroEdu Conference in 2019, Garching, at the ESO Supernova, the international Astronomy Education Journal (AEJ, astroedjournal.org) was founded by Prof. Urban Eriksson and the late Prof. Paulo S. Bretones.

AEJ aims to meet the needs of the astronomy education community by providing a location for all manner of practical, newsworthy and scholarly publications involving developments in the field. In a sense, the journal tries to capture the original spirit whilst taking on board the important lessons from the, now out-of-print, Astronomy Education Review. By focusing on building community collaboration, disseminating important news and opinions, while also maintaining a section on formal, technical, Astronomy Education Research (AER). This research section intends to offer to you a compliment to the current scholarly discipline-based work undertaken by Latin-American Journal of Astronomy Education (RELEA), the Journal of Astronomy & Earth Sciences Education (JAESE) and, recently, the acceptance of AER articles into Physical Review Physics Education Research (PRPER).

There are also a less formal, peer-reviewed, but edited and curated section that contains other relevant material, such as, news, resources, correspondences, classroom and astronomical activities, to help circulate information among the community.

In this talk I will present the successful journey of the journal from its inauguration till today, where three volumes with very excellent articles has been published out of the many manuscripts that has been submitted to the journal. I will describe the width and breadth of articles and also discuss AEJ future directions.

Session

Division C Education, Outreach and Heritage

1648

Introductory Astronomy students' reasoning about astrophysical phenomena within their observational experience

Mr Chad Leukes, Professor Saalih Allie, Associate Professor Dale Taylor, Associate Professor Sarah Blyth

University of Cape Town

Abstract

The present contribution forms a broader programme of research aimed at understanding how students reason when engaging with astronomy concepts. To this end an instrument consisting of 4 questions was designed in order to probe student thinking by eliciting detailed written responses. The questions required explanations that students (a) would be expected to know from prior teaching and (b) had not been taught formally. The latter thus required students to come up with their own explanatory ideas. The instrument was administered to group of 87 introductory astronomy students.

This poster presents details of the instrument and selected results from the analysis of student writing. The analysis indicated that the central idea(s) the students used to underpin the reasoning for the phenomena they had been previously taught were largely in agreement with the accepted astronomical explanations. However, the way in which the students expressed these central idea(s) was surprisingly diverse. This highlighted the fact that diversity of thinking amongst a student cohort is masked when the focus is placed only on the summative outcome. With regard to the questions that probed areas that had not been formally taught, the key observation was that the majority of students drew on ideas that were plausible. Additionally, even where the ideas expressed did not coincide with the concepts that are central to the canonical explanation, it was clear that “sensemaking” was driving student reasoning.

Session

Division C Education, Outreach and Heritage

1766

The Impact of Astronomical Based Outreach for Inspiring Young Minds in Debre Berhan, Ethiopia.Abel T. Sisaye, Gizaw B. Yitayew, Abubeker S. Ali, Awoke Tadesse, and Getachew Tesfaye

Mr. Abel T. Sisaye

Debre Berhan University, Ethiopia

Abstract

The Ethiopian Space Science Society (ESSS) - Debre Berhan University (DBU) Branch is one of the earliest established branches of ESSS. For the past 15 years, the branch has conducted remarkable outreach activities. These activities aim to ignite a passion for Astronomy and Space Science among DBU and local high school students through a variety of engaging methods, such as Q&A contests, creativity and innovation contests, stargazing sessions, public talks, documentary screenings, lecture series, and hands-on workshops on rocket and satellite model building, and celestial photography. The goal of these efforts is to inspire young minds and foster a love and respect for science in Ethiopia. This initiative was deemed necessary due to the observed trend among Ethiopian youths, and globally, where students in high schools and universities show limited interest in science, particularly physics. Using astronomy as a tool for inspiration, although not new, has proven effective again here in our society, thanks to the substantial efforts of the society's executive committee. The results of these efforts have been profoundly encouraging: a significant number of DBU students from diverse academic backgrounds have developed an appreciation for science in general, with a notable increase in interest in pursuing advanced studies in Astronomy and Astrophysics. Furthermore, high school members of the society have shown a marked increase in their enthusiasm for science, demonstrating the program's effectiveness in fostering a culture of curiosity and innovation.

Session

Division C Education, Outreach and Heritage

1772

25 Years Thaqeb astronomy community activists

Presenter Hosna Fadaei yekta kaldehi

Thaqeb astronomy community

Abstract

This is a scientific report about the Thaqib Gilan Astronomy Association Acitites for 25 years in Iran. The Thaqib Gilan Astronomy Association began its journey, aiming to spread excitement about space in Iran's Gilan province. Back then, there wasn't much focus on teaching astronomy, so this association stepped up to fill the gap, especially in areas where learning resources were scarce.

The association made sure everyone could join in, not just students and teachers but anyone interested in stars and planets. They wanted to create a friendly space where people could learn and have fun together.

Their goal was clear: to change how people learn, with the help of enthusiastic folks. They believed in working together, planning carefully, and keeping the excitement going. Even before they officially started, they were already making waves with their activities.

The Thaqib Gilan Astronomy Association marked the beginning of a big change in education. Over the past 25 years, they've made a real difference. More students and everyday folks are interested in astronomy now.

Session

Division C Education, Outreach and Heritage

1895

Exploring Indigenous Astronomy: The Kargahe Setare Project's Use of Iran's Cultural Heritage for Astronomy Education

Shahrzad Mirsoltani

Director and Astronomy Educator at Kargahe Setare Project. Member of Zaferanieh Educational Observatory. Writer and Educator at Nojum Magazine. Member of the Specialized Science Group of the Children's Book Council of Iran. Writer and Member of Astronomy Group of Experts of Iranian Encyclopedia for Young People and Children. Expert and Podcaster at SpaceStation Podcast

Abstract

Astronomy stands out as one of the oldest sciences cultivated by humanity. Iran, as one of the most ancient countries, holds a rich heritage that has been globally recognized for centuries. Throughout history, people have gazed upon the night sky, and the reflection of their astronomical observations can be seen in various formats. These celestial objects, such as the moon, sun, and stars, have manifested in different ways in Iran's heritage, such as pottery, coins, manuscripts, and instruments. Indigenous astronomy has emerged as an important issue in the field of astronomy education and outreach in today's world. To address this issue, the Kargahe Setare Project undertook extensive research to explore the visualization of the heavens in Iran. By gathering objects from Iran's heritage and creating a database, the project utilized the visualization of the heavens to produce novel educational astronomy content for younger generations. This project offers a compelling example of how ancient heritage from different countries can be employed to create educational resources. By leveraging this heritage to disseminate knowledge about astronomy, history, culture, and art, we can transfer the legacy of our past to the present and future generations.This work can inspire researchers, Educators, Science Promoters and Scientists worldwide to explore their own country's cultural heritage in astronomy, history, culture, and art. By examining these fields together, we can gain a deeper understanding of our shared human experience.

Session

Division C Education, Outreach and Heritage

1919

Empowering Namibian Astronomy: Students Driving Outreach, Research, and Innovation

Mr Hiiko Katjaita

University of Namibia

Abstract

This abstract offers a unique perspective on Namibia's astronomy landscape, emphasizing students' significant contributions while addressing inclusivity, accessibility, research excellence, and international collaboration. The University of Namibia's student-operated mobile planetarium program, recipient of the Annie Maunder Medal from the Royal Astronomical Society, led inclusively with undergraduate students from diverse academic backgrounds, has engaged over 12,500 individuals, primarily school children, bolstering national science education and sparking public interest in astronomy across Namibia and Africa. Undergraduate students have also led publications such as an article on 'providing insights into running a student-driven mobile planetarium project in Africa' published in the “Communicating Astronomy with the Public Journal”. Additionally, students, including undergraduates, actively contribute to cutting-edge research and telescope operations at facilities like H.E.S.S., particularly during times of limited international access like the COVID-19 pandemic, strengthening global research resilience. Furthermore, students play a key role in the development of the AMT, focusing on site selection, future capabilities simulations, and observational strategies, and raising public awareness through the mobile planetarium, fostering future workforce development. Moreover, students support astro-tourism efforts by participating and helping the Namibian Academy for Tourism and Hospitality host programs aimed at equipping tour-guides and the public with astronomy knowledge and assisting in stargazing activities, promoting astronomy appreciation among locals and visitors. Recognizing the role of students in astronomy development, this work promotes an inclusive and collaborative future for the field, showcasing the pivotal role that Namibian students play in the development of astronomy not only in Namibia but also across Africa.

Session

Division C Education, Outreach and Heritage

1933

A didactic experience in the study of the proper motion of stars in the classroom

Mr. Rafael Girola Schneider

Universidad Nacional de Teews de febrero. Planetario Galileo Galilei

Abstract

The proper motion of stars is a very important topic in an Astronomy course. In principle, it allows us to measure the spatial speed of the stars in relation to the Sun and, from this, determine distances and other stellar parameters, allowing us to probe the proximities of the solar neighborhood and the speed of the local stars in the galaxy. That is why a work carried out by the Physics teachers in the subject of Astronomy II of the “Héctor Medici” Institute is presented. The work unifies a historical view of how and what was interpreted in the year 1718 when Edmund Halley found that the stars Sirius, Arthur and Aldebaran moved in the sky more than half a degree since the observations made by Hipparcos, along with a didactic sequence. That is, where students, through actions, link their knowledge and previous experiences, with some question that comes from reality and with information about an object of knowledge, managing to differentiate the improper movements of the stars, in which the coordinates stars are affected to the same extent by the movement of precession, nutation and aberration of light, deducing that only the proper movement corresponds to the real movement of the stars. One of the examples that has been highlighted in class is the proper motion of Barnard's Star moving 10.2 00/year. One of the tools on which the work is based is the information from the Tycho catalog, as well as measurements made by Hipparcos and Gaia satellites.

Session

Division C Education, Outreach and Heritage

1964

The Role of SAT Astronomy Learning Center in the Development of Astronomy Education and Outreach in Southern Thailand

Ms. Nareemas Chehlaeh[1], Ms. Nusreen Masae[2]

[1]Faculty pf Science and Technology, Prince of Songkla University. [2]Kathu district Office, Phuket

Abstract

This article aims to present the role and importance of an astronomy learning center in the development of astronomy education and outreach in southern Thailand. The Science and Technology (SAT) Astronomy Learning Center was established at the Prince of Songkla University (PSU), one of the oldest universities in southern Thailand. The SAT Astronomy Learning Center has been continuously maintained and managed by the Faculty of Science and Technology since 2019. The initial purpose of constructing this center was to commemorate the Faculty of Science and Technology's hosting of the 2017 International Astronomy Olympiad. The center is divided into three parts, consisting of a planetarium room, an exhibition room, and a telescope room on the rooftop. The center has provided academic services, training, astronomy camps, monthly stargazing events, and crescent moon sighting activities to students, teachers, and the public. Fortunately, our astronomical activities were supported by Songkhla Regional Observatory for Public, which is under the National Astronomical Research Institute of Thailand (NARIT). The observatory provides academic services for the local communities and supports the implementation of astronomical curricula in schools and universities. It also serves as another astro-tourism landmark in southern Thailand. We argue that the role of the SAT Astronomy Learning Center will mainly support learning astronomy to enlighten all students and youths in science literacy. In addition, we mention the significance of astronomy as a part of the integration of science, technology, local culture, and life.

Session

Division C Education, Outreach and Heritage

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2012

PopER Stand Up Científico: Between Science and Comedy.

Dr Juliana Saponara[1], Dr Aramburu Roxana[2], Dr Javier Garcia de souza[2]

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Abstract

PopER Stand Up Científico is the first Latin American stand-up comedy group dedicated to scientific outreach. The group includes students, graduates, postgraduates, and scientific researchers, covering various disciplines such as biology, chemistry, biochemistry, biotechnology, **astronomy**, palaeontology, physics, and mathematics. The group originated from the first scientific stand-up comedy course, an initiative by Argentina's Ministry of Science, Technology, and Productive Innovation in 2015.

We developed individual and group materials to use stand-up comedy to demystify the stereotypical image of a strict scientist in lab coats and glasses. We focus on the personal lives of scientist and their relationship with their work. Simultaneously, we strive to communicate science by entertainingly presenting scientific concepts and ideas. Our goal is to captivate those who approach us, arouse curiosity in those unfamiliar with science, and echo with those already part of our community. The invitation is to laugh with us and at ourselves.

Our show is suitable for all audiences, and since 2015, we have consistently presented our performance in various venues in America, mainly in Argentina, including scientific meetings, planetariums, bars, and cultural centres. We were also in Ecuador and Uruguay and participated in online scientific conferences in Chile and México.

Session

Division C Education, Outreach and Heritage

2017

Comparison of Attitudes in Astrobiology and Science/Technology/Astronomy in Japan

Dr. Nobuhiko Kusakabe[1,2], Dr. Naohiro Takanashi[3], Dr. Masaaki Hiramatsu[2,4], Dr. Shio Kawagoe[3], Mr. Koki Sawada[5], Mr. Harufumi Tamazawa[3]

[1]Astrobiology Center, NINS. [2]National Astronomical Observatory of Japan. [3]The University of Tokyo. [4]The Graduate University for Advanced Studies, SOKENDAI. [5]University of Wakayama

Abstract

We surveyed the Japanese public's attitudes toward Astronomy (Takanashi 2023) and Astrobiology. This survey was conducted via an online questionnaire, and responses were received from 2000 general public people. Respondents were people aged 20–69, selected from monitors registered with the survey firm, and were assigned according to the demographic and regional distribution of Japan.

The survey items consist of sociodemographic variables and questionnaire items. The sociodemographic variables are AGE, GENDER (male, female, and other), LOCATION (prefecture), MARRIAGE (married or not), CHILDREN (have a child or not), EDUCATION (educational background), and OCCUPATION. Fifteen of the questionnaire items were related to the attitude of Science, Technology, and Astronomy. The other six items were related to the attitude of Astrobiology.

The first three items are prepared for measuring the degree of interest in science and technology based on the Victorian Segmentation method (Quantum Market Research 2008), which classifies the general public and discusses their properties at a higher resolution. The next twelve items are prepared for measuring the degree of interest in astronomy from several different point of views. The last six items were prepared for measuring the degree of recognition in astrobiology from some interdisciplinary topics. Many of these questionnaire items were newly proposed for this survey from the point of view of comparing with prior surveys and researches.

This poster will present the results of a comparison of Science, Technology and Astronomy interest groups and their attitudes of Astrobiology.

Session

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2021

Astronomy Outreach Activities within the Context ofPLOAD (Mozambique Node)

Mr Edson Jequecene[1,2], Dr Valente Cuambe[3]

[1]Detetives do Cosmos - Amateur astronomy Group. [2]PLOAD (Portuguese Language Office of Astronomy for Development). [3]Department of Physics, Eduardo Mondlane University

Abstract

The Portuguese Language Office of Astronomy for Development (PLOAD) was established in August 2015 by the International Astronomical Union's Office of Astronomy for Development (IAU-OAD). In Mozambique, initial activities were primarily concentrated at Eduardo Mondlane University (UEM). During its initial phase, the program was supported by merely three volunteer researchers with specialised astronomy training. Among various projects undertaken, the Galileo Teacher Training Program (GTTP) was notable for its focus on primary education teacher training. Subsequently, UEM incorporated an introductory course on Astronomy into its Physics and Meteorology curricula, which catalysed several projects that significantly boosted interest in Astronomy within the country. Presently, numerous teams of science communication enthusiasts are spread across Mozambique, promoting Astronomy through lectures in schools, public spaces, and social media platforms. However, extending these educational and outreach activities to remote areas beyond urban centres remains a challenge due to resource limitations, with the capital predominantly benefiting from in-person activities. Moreover, securing funding for acquiring or constructing a planetarium, which would greatly enhance the dissemination of Astronomy and STEM (Science, Technology, Engineering, and

Mathematics) education in general, continues to be a significant hurdle for the organisation.

This work aims to present the progress of activities in Mozambique to

the international community.

Session

Division C Education, Outreach and Heritage

2034

The Monumental replica of the Antikythera Mechanism in Hermosillo

Dr. Julio Saucedo Morales[1], Dr Xenophon Moussas[2], Dr. Ezequiel Rodríguez-Jauregui[1], Eng Alfredo Carmona Martinez[3], Eng Jesús Clemente Olvera Trejo[3], Dr. Raúl Perez-Enriquez[1], Dr. Armando Ayala Corona[1], Dr. Alma Ayala Moreno[1]

[1]Universidad de Sonora. [2]University of Athens. [3]Relojes Olvera III Generación

Abstract

The Antikythera Mechanism (AM) was built by Greeks in the second century BC, lost to the sea around 70 BC and found near Antikythera in 1901. Motivated by the results of 120 years of research, scientists from Universidad de Sonora, University of Athens and *Relojes Olvera III Generación* (ROIIIG), embarked on a project to build two replicas of the AM (1:1 and 10:1) incorporating all known results. The 1:1 replica was presented in 2022. Thanks to the Sonoran Government on February 8, 2024, the 10:1 Monumental Antikythera Mechanism for Hermosillo (MAMH) was inaugurated, after 3 years of collaboration. MAMH (3.1 m in height, made of brass) is unique in the world. It is moved by a monumental clock built and donated by ROIIIG. In the front it presents in real time fairly correct positions of the Sun, the Moon (with its phase) and the 5 visible planets. In the back, the Saros spiral for the prediction of eclipses is below, whereas above is the Metonic spiral. Other small dials are also included. Though based on a geocentric model MAMH makes good astronomical predictions reinforcing the idea that the AM is an analogous computer, perhaps the first in history. MAMH is in the *Antikythera Plazoleta* at Universidad de Sonora. The aims of the MAMH project are Astronomy Education and Outreach. School groups of all levels, families, and public are welcome. People around the world will also be able to see the predictions via Internet thanks to cameras pointing at MAMH.

Session

Division C Education, Outreach and Heritage

2066

It's not just money: The Economic Barriers to Amateur Astronomy

Dr Pamela Gay[1], Dr Sanlyn Buxner[2]

[1]Planetary Science Institute. [2]University of Arizona

Abstract

We examine what economic factors prevent participation in amateur astronomy through survey data. It is anecdotally understood that amateur astronomers in the United States are typically affluent men. While this is often considered the result of both the high cost of telescopes, and the challenges in implementing demographic change, it is unclear what else is at play, and what specifically needs to change to make amateur astronomy open to a larger and more diverse set of demographics.

This research will look at both at-home engagement and remote astronomy. We define at-home engagement as amateur astronomers having equipment on hand to use in the vicinity of their home, or to take with them for in-person use. Remote astronomy is defined as using equipment, either rented or owned, that is at a fixed remote location and can only be accessed via the Internet.

In the first part of the survey, we will ask about what kinds of amateur astronomy the survey participant would want to learn and do if financial constraints (including factors such as working multiple jobs or providing child or elder care) were no barrier.

In the latter half of the study we explore what are the possible time and monetary outlays that people can spend on astronomy-related activities and how these compare with their perceived costs of astronomy.

We will also ask survey respondents about their local sky conditions, their access to the sky, and basic demographics, such as state, age within bins, pronouns, and areas of work.

Session

Division C Education, Outreach and Heritage

2074

Survivors Guide to New Media: Reaching audiences across multiple platforms

Dr Pamela Gay[1], Avivah Yamani[1,2]

[1]Planetary Science Institute. [2]Langitselatan

Abstract

A key factor in public outreach is going where the public goes. This means, as new technologies take hold, astronomy communicators must step forward as early adopters to make sure we can stake out our place to take about the stars in a landscape of memes, news, and too often hate. We are, with our science, a safe island in a sea of social media.

We will highlight the differences in platforms, review the literature on how people are using these platforms to communicate to massive online audiences, and we will discuss new results from a survey that looks at the distribution of our audiences across content platforms. With this data in hand, we present on the tools that can be used to make reaching all the different audiences as straight-forward as possible. This includes the ethical use of AI to add in content editing and repurposing.

Session

Division C Education, Outreach and Heritage

2083

Rethinking astronomy in conflict contexts and war anxiety

Dr. Mirjana Povic

Space Science and Geospatial Institute (SSGI), Ethiopia

Abstract

We are facing difficult times in which heavy wars and conflicts are affecting different parts of our planet and are putting into question our morality and what we have learned as humanity from the past and from our previous mistakes. Many countries in Africa are not excluded from political instability, conflicts or wars, and violence that has become normalized. Under such conditions, education and science are strongly affected. We rarely talk openly about how, under conditions of conflict and war anxiety, intense fear, constant stress, persistent worry, and hopelessness, astronomy research and education can be performed. Under such conditions, "What is the role of astronomy in making our world a better place?" becomes a real and challenging question that needs much rethinking. This talk aims to give more visibility to the challenges we face when we do research and teach astronomy in conflict contexts. It also aims to remind us that, in such contexts, astronomy must be used more than ever to constantly transmit the message that we all live under the same sky and to promote peace-building. This talk will also provide a list of recommendations on how we as a scientific community can support our colleagues and students working and living in conflict-affected areas, and will open the space to think about new initiatives by providing a list of suggestions.

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2184

Cultural Astronomy for Sustainable Development: A study on Indigenous San Communities in Botswana and Namibia

Ms. Tumo Fortunate Kedumele[1,2], Dr Auala Sisco[3], Ms. Maaike Perik[4,5], Ms. Keletso Bontle Dichaba[1,2]

[1]Botswana International University of Science and Technology. [2]Women in STEM-BW (WiS). [3]Namibia University of Science and Technology. [4]Radboud University. [5]University of Namibia

Abstract

This study explores the cultural astronomy knowledge of the Basarwa/San and Bangwato communities in the Central District of Botswana, as well as the Ju/'Hoansi San community in North-Eastern Namibia. The research was conducted in collaboration with the Central Botswana San community in Moralane village, the Bangwato in Serowe-Paje villages, and the Ju/'Hoansi community in Namibia. The San communities are widely recognized as the indigenous and native people of Southern Africa, possessing a wealth of raw and untouched knowledge of the history of astronomy within a Southern African context.

The primary objective of this study is to gain insight into how astronomy and the celestial realm influence the culture, history, and daily lives of these communities. Additionally, the study seeks to identify and establish connections and similarities between the Basarwa/San and Bangwato in Botswana and the Ju/'Hoansi community in Namibia.

The indigenous knowledge, along with folk stories collected during the first and second phases of this study, were meticulously recorded, interpreted, and subsequently compared and correlated with modern astronomy. The purpose of this knowledge-matching process was to establish a relationship between astronomy and modern astronomy, highlighting how both can contribute to the socio-economic development of these communities.

Session

Division C Education, Outreach and Heritage

2199

Astronomy Centre for Educators at IUCAA: An experiment to improve pedagogic processes in Indian colleges and universities

Professor Dhruba J Saikia

Inter-University Centre for Astronomy and Astrophysics (IUCAA)

Abstract

The Astronomy Centre for Educators at IUCAA was established in 2018 with the objectives of contributing to improving pedagogic processes in Indian colleges and universities. We have had a wide range of programs for the last six years which could be divided into five broad categories. Firstly we have emphasized development of expertise in astronomy-themed experiments, where we are building a repository of experiments with contributions from across the community. As an example of an experiment, faculty members have designed a horn antenna, made observations of neutral atomic hydrogen in our Galaxy, taken the equipment to their host institutions and done projects with these. Secondly, we have had courses with lectures, hands-on components, tutorials and assignments spread in the evenings over two to three months to enable faculty members to learn slowly while continuing to teach. Thirdly we have had focused short-term workshops emphasizing the hands-on components, and where teachers also share experiences and discuss how to teach a particular topic better and also make presentations on topics they are teaching or likely to teach. Then we are collaborating with the Maharashtra State Faculty Development Academy in India to conduct workshops in small towns on the theme of Astronomy, Science and Society to take the excitement of astronomy to faculty members across disciplines. Lastly we are focusing on orientation and sensitization programs for the new National Education Policy being implemented in India. This paper presents the results, our experiences and challenges.

Session

Division C Education, Outreach and Heritage

2204

Preserving the Past, Illuminating the Future: INAF Mission to Safeguard and Celebrate Italian Astronomical Heritage

Federico Di Giacomo[1], Antonella Gasperini[2], Ileana Chinnici[3], Manuela Coniglio[3], Giangiacomo Gandolfi[4], Mauro Gargano[5], Salvatore Guglielmino[6], Francesco Poppi[1], Valeria Zanini[7]

[1]INAF - Osservatorio di Astrofisica e Scienza dello Spazio di Bologna. [2]INAF - National Institute for Astrophysics. [3]INAF - Osservatorio Astronomico di Palermo. [4]INAF- Osservatorio Astronomico di Roma. [5]INAF - Osservatorio Astronomico di Capodimonte. [6]INAF - Osservatorio Astrofisico di Catania. [7]INAF- Osservatorio Astronomico di Padova

Abstract

One of the statutory missions of the National Institute for Astrophysics (INAF) in Italy is the protection, conservation, and enhancement of the huge historical heritage that is preserved in the astronomical Observatories. This important heritage offers unique opportunities to develop research in the History of Astronomy and foster interdisciplinary investigations in Cultural Astronomy. In this contribution, we aim to briefly describe the INAF historical collections, which consist of instruments, books, artworks and archives, mostly dating back to the 18th and 19th centuries. Thanks to the project “Polvere di Stelle” (Stardust), INAF has created a web portal (https://www.beniculturali.inaf.it/) dedicated to the Italian astronomical libraries, archives and museums. It offers various tools and databases designed to support astronomical research and increase the value of one of the richest astronomical heritages in the world. Most importantly, this project allows the connection of heritage from different observatories to tell a unified story.
We mention the recent "Touch Sky", a project including research, restoration and fruition of historical celestial atlases. Some bicentenaries of the birth/death of reputed astronomers, such as Secchi and Respighi, are also providing the opportunity to study and restore some instruments, books and archival documents related to their scientific research.

Looking forward to IAU GA 2027 in Rome, it is our hope that activities for the study and enhancement of the INAF astronomical heritage will encourage links with cultural astronomy activities in Italy and abroad; the “Seconda Stella a Destra” project, for instance, has developed “astrotourism” in historical Italian towns.

Session

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2207

'Astro Ecology': Exploring the Scientific and Social Interaction Between Celestial Bodies and Earth's Ecosystems, Astronomical Influence and Solutions to Combat the Negative Effects.

Ms. Anupama Rajya Shahi

Eco-Heart. Central Department Of Environmental Science, Tribhuvan University. Nepal Academy Of Science ans Technology (NAST)

Abstract

Astronomy has the power to restore harmony and vitality to our blue planet.

Astronomical instructions currently taught needs to be swiftly and significantly revised.

Numerous challenges, such as climate change, ecological disruption, imbalances in flora and fauna, inadequate food production with inconsistent nutritional values, health risk, bacterial-viral alternations beset us in our everyday lives and must be addressed with seriousness.

More practical teaching like harnessing energy, its proper utility, astronomical effects on earth and finding solutions to problems vexing us that bear interactive relations to our Sun, Moon along with all the planets in our Solar System and Galaxies.

Promoting interactions with contemporary technical instruments by leveraging digital and AI applications with reliable internet helps to reduce the conflict and unhappiness that permeate our scientific and social environment. More team efforts, young generation engagement, adequate financing responsibly by all of us together for all these efforts essentially needed to unravel the secretive enigmas and mysteries bestowed by nature that bear charismatically arcane relations with astronomy.

Participations in Space explorations should be encouraged to all interested members and citizens of our planet. Astronomers and astronauts could attempt to establish strong networking-bond among humans upholding positive supportive values of humanity to respect and learn from each other for surmounting any problems in efficient and elegant manner. Impending hazards and lurking dangers from space could be identified for mitigating and avoiding them. Interactions with academic institutions in research, applications should be even more facilitated and strengthened.

Session

Division C Education, Outreach and Heritage

2209

Short stories - *A Collection of African Astronomy Tales.*

Dr Ann Njeri[1], Tabitha Alango[2]

[1]Newcastle University. [2]Masai Mara University

Abstract

In many places in Africa (particularly in rural Africa), Astronomy is seen as an exotic science belonging to the West. To address this misconception and make Astronomy more relatable, Elimisha Msichana Elimisha
Jamii na Astronomia (EMEJA) organised a workshop in Kitale, Kenya, targeting high school teachers and the locals. The objective was to discuss and document Astronomy application and stories in the African context from back in time. For example, what were the cultural beliefs with regards to creation of the Universe? Different communities in Kenya have different ideas and beliefs on how the Universe, the earth, the sun, stars and moon were created. Our target audience were diverse and coming from different communities, and therefore provided diverse Astronomy-related tales that were nicely documented. Here, I will share some of these tales. For example, the Kikuyus believed that all the demons were sent to irima iruku (Kikuyu for a bottomless hole) where they could never escape. This being a likely reference to a black hole. The aim was to build upon these reflections and to use the ideas generated to effectively deliver Astronomy-related content in classrooms as part of the curriculumn for secondary education in Kenya. Overall, we aimed to spur interest in and appreciation of Astronomy across the whole community.

Session

Division C Education, Outreach and Heritage

2214

Enhancing Astronomy engagement: AfAS Strategies and Outcomes

Ms Zodwa Tiki

African Astronomical Society (AfAS)

Abstract

At the International Astronomical Union General Assembly (IAU-GA2024), it is crucial to recognise the complexity of public communication, where the audience is expected not only to comprehend astronomical concepts but also to actively participate in discussions and dialogues. The African Astronomical Society (AfAS) strives for effective communication with a focus on information sharing, knowledge transfer, and education, which are the primary objectives. Publications, including newsletters featuring compelling articles on astronomy and AfAS conferences and workshops, serve as key platforms for disseminating information and fostering community involvement.

The Newsletters have had a tangible impact on the public as they serve as a bridge between the astronomical community and the wider public, fostering understanding and interest in astronomy-related topics. Recognising the importance of online visibility, AfAS has invested in enhancing its website's user experience and regularly updates its content to provide valuable resources and information. Our efforts on social media have also yielded promising results, significantly expanding AfAS's outreach with notable increases in engagement metrics.

Moreover, AfAS actively participates in conferences, meetings, and oral communication to reach wider audiences and facilitate dialogue within the astronomical community and beyond. These gatherings serve as invaluable platforms for exchanging knowledge, fostering collaboration, and advancing scientific understanding. In essence, the strategies implemented by the AfAS Communications Committee foster dialogue and engagement, ensuring that the public not only comprehends astronomy but also becomes empowered to participate in meaningful discussions.

Session

Division C Education, Outreach and Heritage

2220

Formal education of Astronomy at School and College level as an extra curricular activity through Public Private Funding

Dr. Mukund Kurtadikar

Department of Physics, J.E.S.College, Jalna 431 203, India

Abstract

At present there is no formal channel for providing formal education of Astronomy at School and College level. However, somewhat similar work is being done through various activities of NGOs of amateur astronomers and outreach programmes conducted by various National Institutes, not in a well organised manner. Therefore there is a need to provide a channel for providing formal education of Astronomy at School and College level with a view to create general awareness as well as Human Resource. This can be achieved through dedicated efforts for this purpose though Public - Private Funding .

Formal education of Astronomy of various levels like proficiency, certificate and diploma level could be imparted by the schools and colleges as an 'extra curricular activity' run by a club formed for this purpose, in the scools and colleges. However, curriculum for this purpose be formulated by academic organisations /institutions and implemented by the 'clubs' in their schools and colleges. The clubs would be affiliated to the 'Outreach Departments' of the academic organisations /institutions in the country. Each school /college participating in this scheme should procure small observing telescopes through PPF i. e. donations and the activities run by the club so that the curriculum could be implemented more effectively. Moreover, the observing facilities could be used for dedicated 'amateur activities' of professional level by contributing their observations in 'observing campaigns' run by international organisations. In fact contributions of such observations could enrich the campaigns, which is also the need of the time.

Session

Division C Education, Outreach and Heritage

2244

The TART workshops: Building an African Education and Outreach Network of Radio Telescopes

Dr Tim Molteno[1,2], Dr Ben Hugo[3], Professor Oleg Smirnov[4,3], Dr Nadeem Oozeer[3], Dr Max Scheel[2]

[1]University of Otago, Dunedin New Zealand. [2]Electronics Research Foundation, New Zealand. [3]South African Radio Astronomy Observatory. [4]Rhodes University, Makhanda, South Africa

Abstract

The Transient Array Radio Telescope (TART) is an open-source, low-cost, compact imaging radio telescope developed by a dedicated community of volunteers from both the general public and the radio astronomy community. In Africa, South African Radio Astronomy Observatory (SARAO) and the TART project have developed the idea of building a self-sustaining outreach and education network through TART workshops: week-long workshops, in which volunteers from the TART project teach the fundamentals of radio astronomy in the mornings, and build a functioning radio telescope in the afternoons. The TART telescope remains at the host institution, and becomes a focus for outreach within that community, and also a common platform for collaboration in teaching and research between members of the TART network. Attendees can then present at future workshops, bringing their unique perspectives, developing links between communities and building awareness of the radio sky.

TART workshops in 2023-25 include South Africa, Botswana, Namibia, Zambia, Ghana, Mozambique, Mauritius and Madagascar and Morocco, and in the near future, the TART network will expand out of Africa, with workshops planned in Iran, Malta, and the USA.

Session

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2254

INVESTIGATION OF BANGWEULU BASIN AS A POSSIBLE CANDIDATE FOR A METEOR IMPACT, ZAMBIA

Mr Omogolo Keobokile, Dr Prospery Simpemba, Dr Edward Chisakulo, Dr Moola Mutondo

The Copperbelt University

Abstract

The Bangweulu Basin in north Zambia has previously been proposed as the site of a large (150km diameter) impact structure on Zambia's Bangweulu Block (centered at 11°10'S, 29°54'E). The Bangweulu Swamps, Lake Bangweulu (85km long), and Kampolombo (20km long) are all located at about 1148m above sea level (a.s.l). The Bangweulu Basin is a centripetal drainage system, with one outlet in the south, the Luapula River and the other outlet in the southwest is Luasenshi River. The Bangweulu Basin is largely aseismic and unconnected to rifting, in contrast to all the other significant lakes in Zambia and the neighboring regions (Mweru, Tanganyika, Rukwa, Malawi, and Kariba), which are located in seismically active rift structures. In addition to a magnetic anomaly density high over the center of the Bangweulu Basin, which is encircled by a concentric low, there is a positive aeromagnetic intensity anomaly over the central Bangweulu depression. Lake Bangweulu is in the middle of a nearly spherical anomaly of the local Bouguer gravity field, which is bounded by an arcuate high south of the Luongo Fold Belt and defined by the -140mgal contour. Lake Bangweulu's genesis is still unknown, some scholars proposed that it was by a meteorite impact, Master (1993). This is an ongoing research which is aimed to be concluded by June 2024, ground search has been conducted and rocks samples have been conducted. Laboratory analysis is ongoing and after conclusion will be made on whether to prove or disprove that this as a carter.

Session

Division C Education, Outreach and Heritage

2255

Review of Astronomy and Space science Developments in Zambia

Mr Ashley Nyamandi[1], Mr Prospery Simpemba[2], Dr Saul Phirii[3]

[1]The Copperbellt University. [2]The Copperbelelt University. [3]Copperbelelt University

Abstract

Zambia has made remarkable progress in the area development of astronomy, human capital development and strengthening of academic and learning programmes at institutions of higher learning. Several activities have been implemented in this process. In this talk, we highlight key developments that have taken place and forecast the future of astronomy and space science in the country. We touch on new learning programmes that have been developed, the training activities including but not limited to Development in Africa with Radio Astronomy (DARA), starlight in the university lab (ASTROLAB), Network for Astronomy School Education (NASE) and several other astronomy workshops done over the years. The country has been doing several outreach programmes to inform the public about astronomy's importance and the benefits of hosting an observatory of the Square Kilometre Array (SKA) project at Kasempa, now called the Kasempa Radio Astronomy Observatory (KASERAO).

Session

Division C Education, Outreach and Heritage

2261

Taking the universe to the community

Miss Tshepiso Maroga

Sci-Enza Science Centre, University of Pretoria

Abstract

Everyone should have the chance to acquire astronomy knowledge, a valuable heritage that should be accessible to all. Sci-Enza is committed to providing astronomy education to individuals from underprivileged backgrounds, those encountering socio-economic obstacles, and those with special learning requirements, without any limitations.

To ensure broad access to astronomy, we align our astronomy programme with the National Curriculum and Assessment Policy Statement (CAPS). We offer educational support in local schools and share general knowledge with the public through talks, planetarium shows, and workshops. National initiatives such as National Science Week and Programmatic Support Grant further enhance our astronomy outreach endeavors.

In this paper, we will share our experiences, successes, challenges, and recommendations in the astronomy outreach

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2271

Engarium: Empowering Astronomy Outreach in Iran

Mr. Mohammad Hadi Tabatabaei Yazdi

Engarium Planetarium. Ferdowsi University of Mashhad

Abstract

Engarium, a groundbreaking initiative in Mashhad, Iran, stands as a testament to the transformative power of grassroots efforts in advancing astronomy education and outreach. In this abstract, we present a concise overview of Engarium's journey, focusing on its pivotal role in promoting scientific curiosity and literacy within the region. Despite facing formidable challenges such as economic constraints and governmental restrictions, Engarium has emerged as a beacon of hope, offering a low-cost yet high-impact platform for engaging with the wonders of the universe.

Through strategic fundraising endeavors and innovative architectural design, Engarium has defied conventional limitations to create a truly immersive planetarium experience. Key features such as the imposing meridian gnomon and the subterranean construction underscore Engarium's commitment to pushing the boundaries of traditional planetarium design.

Engarium's success is not merely measured in numbers but in its profound impact on the community. With over 100,000 visitors and a robust membership base of 14,000, Engarium has become a focal point for science popularization in the east of Iran. By democratizing access to scientific knowledge and nurturing a culture of curiosity, Engarium serves as a catalyst for social change and intellectual empowerment.

In this lecture, we reflect on the lessons learned from Engarium's journey, highlighting the resilience, creativity, and collaborative spirit that have fueled its success. As we look towards the future, we envision Engarium as a model for sustainable and inclusive astronomy outreach, inspiring similar initiatives worldwide and paving the way for a more scientifically literate society.

Session

Division C Education, Outreach and Heritage

2276

Song Lines to the SKAO: Listening Beyond the Darkness

Prof Deborah Kala Perkins

Ubiquity University. AAS, COSPAR

Abstract

As SKAO touches “First Light”, it is shape-shifting on lands of Earth’s most ancient cultures, like the Aboriginal Rainbow Serpent naming all creatures and creations of our Earth. Might not secrets the SKAO has to reveal shed light on mysteries of life’s emergence? This presentation explores root cultural heritage around the journey into darkness, from Australia and South African cultures, and our astronomical science. Southern cultures share appreciation of Milky Way’s “dark constellations”, and *sky rivers of stars*. We also explore the Hindu cosmologies of Great Darkness, beyond the days and nights – Manvantaras and Pralayas – of cosmic cycles. Scientific American Magazine began its 2024 issue with the story of Cosmic Voids. What are the roles and significance of darkness in these cultures where the SKAO is employing the longest radio frequencies to peer into our cosmic origins beyond the visible? How is SKAO’s journey into the darkness mirrored in the cultural stories; *Song Lines*, the undulations of the Rainbow Serpent’s sky music singing Earth and stars to life? We explore astronomical and cultural resonances, proposing a series of multimedia performances and artworks, - theater, dance, storytelling, painting, sculpture - sharing SKAO’s astronomical emergence, destiny and legacy with the peoples and cultures where it is embarking on its journey into infinity. This syncretic emergence is a cultural weaving at the curvature of SKAO’s awakening with ancient cultures in which it is located. Do scattered clusters of SKAO antennae reflect star clusters and galaxies, the space they are designed to fathom? We co-create.

Session

Division C Education, Outreach and Heritage

2288

Desertification and global warming

Hassan Baghbani[1], Fatemeh Baghbani[2]

[1]ITAU. [2]Boushehr astronomy community

Abstract

Our research and findings, in the mountains of Southwest and Central part of Asia,North and Northeast part of Africa, and the Andes Mountains, in South America, show that, since thousands years ago, peoples by making billions of water dams (traces farming)and planting trees, they have had mead the biggest desertification, and by planting trees in millions of square kilometers, they created suitable vegetation and sufficient humidity that caused decrease the weather temperature .
Why this mechanism was very useful ? Because

1-The roots of the Trees have also made the dams stable. 2-The roots of the trees, penetrating into the ground, have created enough space for water to sink into the ground.
3- every year, with the fall of leaves, the quality of the soil has improved and cover the soil
4- the trees shadow on the ground, have prevented the soil and stones from heating up,
5- the leaves of the trees have caught the sun's rays, and stored them in the trees body,
So controled the temperature.
This great work has been in the form of a holy job.
Unfortunately, in recent centuries, with the industrialization of societies, these dams have been abandoned, which has resulted in severe soil erosion, and a decrease in vegetation, a severe decrease in vegetation, and the desertification of a large part of the land, one of the The important factors are global warming

Session

Division C Education, Outreach and Heritage

2303

Astronomy outreach roadmap for Zambian

Mr Chidi Joseph Nicholas, Mr Prospery Simpemba, Dr Saul Paul Phiri

The Copperbelt University, Department of Physics, P.O. Box 21692, Kitwe, Zambia

Abstract

Outreach activities have been instrumental in creating awareness about astronomy in Zambia. Many activities have been conducted, including but not limited to, sensitization for safe viewing of solar eclipses, science festivals, targeted school visits, naming of exoworlds, among other public engagements. The country launched the national outreach programme on 8th December 2023 which will see an intensified but strategic public engagement. The roadmap rides on other projects that have been identified and which render high potential to reach out to a wider public.The National Outreach Committee (NOC) has been reinforced by incorporating new volunteers to the existing team, among them postgraduate students. This presentation will highlight new ways and best practices in which public engagement will be carried out in Zambia.

Session

Division C Education, Outreach and Heritage

2307

The Cosmos as a Classroom: Reducing Anxiety through Astronomical Wonder

MR Dominic Vertue, Dr Joyful Mdhluli, Mrs Mampho Ledimo

OAD

Abstract

In this exploration, we propose to utilize the captivating appeal of the cosmos as an innovative educational framework for reducing anxiety, particularly among young learners. By integrating astronomical content into learning environments in a way that emphasizes curiosity, wonder, and the joy of discovery, we aim to create a more engaging and less stressful educational experience. We will examine the link between the natural human fascination with the stars and the potential for such interest to alleviate feelings of academic pressure and anxiety. The theory supporting our approach suggests that engagement with awe-inspiring subjects like astronomy can elicit positive emotions that counteract stress and anxiety, thereby fostering a more relaxed and conducive atmosphere for learning. Through this initiative, we seek to demonstrate how the vastness of the universe can offer a comforting perspective on personal challenges, making the educational journey a more inspiring and less daunting experience.

Session

Division C Education, Outreach and Heritage

2319

Astronomy, Space Science and Technology Education at the African Regional Centre for Space Science and Technology Education

Prof Babatunde Rabiu[1], Dr Bonaventure I. Okere[2]

[1]United Nations African Regional Centre for Space Science Technology and Education - English, (UN-ARCSSTE-E), Obafemi Awolowo University Campus, Ile-Ife, Nigeria. [2]Centre for Basic Space Science, National Space Research and Development Agency, Nsukka, Nigeria

Abstract

In line with the implementation of the United Nations General Assembly Resolution 45/72 of 1990 and 50/27 of 1995, The African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E) was inaugurated in Nigeria on 24th November 1998. The Centre has continued to implement its mandates particularly in the building of African indigenous capacities for the development and utilization of Space Science and Technology through its postgraduate programmes, short term trainings, outreach and research activities. From inception in 1998 to date, ARCSSTE-E has graduated six hundred and twenty four (624) Postgraduate Diploma (PGD) participants from nineteen (19) Anglo-phone countries in the following application areas namely; Remote Sensing/GIS, Satellite Communication, Basic Space and Atmospheric Science, Satellite Meteorology, Global Navigation Satellite System (GNSS) and Space Law. Astronomy is taught as a course to students with interest in Space and Atmospheric Science. The Centre is presented as model for postgraduate training in Astronomy. A call is made for collaboration and support from organisations with interest in capacity development on Space Science and Technology Education in the developing countries.

Session

Division C Education, Outreach and Heritage

2336

Development and Testing An Android-Based Virtual and Augmented Reality: A Platform for Teaching Abstract Astrophysics, Concepts and Experiments.

Mr. Gabriel Paul

University of Nairobi. Development in Africa with Radio Astronomy- DARA

Abstract

As a result of the paradigm shift and transitions in teaching and learning, it is of necessity to incorporate information technology as an essential tool in education. Worldwide, Institutions of higher learning are applying the digital e-learning tools and mechanisms to enhance teaching aids for educational purposes, due to the fundamental change into the fourth industrial revolution. Therefore, it calls for a prompt response and action, through STEM implementation, to counteract the significant problems faced by educators in the teaching and learning environment. Consequently, the digital practical concepts that are visually presented to learners using digital media devices and computer-based interactive platforms come in handy to salvage these problems. These platforms include; Virtual Reality (VR), Mixed Reality (MR), Augmented Reality (AR) and Extended Reality (XR). This paper focuses on the development process and final output of an android mobile VR and AR application that is relevant to Science, Technology, Engineering and Mathematics (STEM) education, fit for purpose. Not long ago, Higher Education Institutions (HEIs) have been exploiting virtual and augmented reality technological avenues to convey abstract concepts via this flawless approach, thereby enhancing the learning process. A virtual and augmented reality platform was developed. Students interact with the VR and AR multi user and 3-Dimensional (3-D) virtual rooms that looks like they're in real life-virtual environment. As a recommendation therefore, the infinite possibilities of virtual and augmented reality may be explored by educators, due to the comprehension of imagined concepts of its seamless-enabled simulations, and specifically in STEM education.

Session

Division C Education, Outreach and Heritage

2437

Teaching Indigenous astronomy in Ethiopia

Dr Getinet Ayane

Kotebe University of Education. Ethiopian Indigenous Knowledge Education and Research Center

Abstract

The cultural astronomy is among the least investigated in Ethiopia. Even though modern astronomy in Ethiopia is a recent history, astronomy cannot be entirely new in the country. Ancient agricultural practices, myths, calendars, alphabets, etc are quiet rich in astronomy. In the distant past the knowledge of astronomy was abundant. Ancient Books such as the book of Enoch, Bahire Hasab, Metsehafe Hasabe Berehan and Abu Shaker are devoted to this knowledge. The country has its own calendar, which is a witness for the existence of indigenous knowledge in astronomy.

There is a need to unearth indigenous astronomy in the country and to bridge the gap between cultural and modern astronomy. This abstract highlights the current status of indigenous knowledge of astronomy in Ethiopia, specifically some of the work I have started by publishing books on Ethiopian indigenous astronomy, the effort I did to reach the community through different media including television and the need for incorporating it in the modern curriculum.

Session

Division C Education, Outreach and Heritage

2452

Astronomy Education and Outreach using Mobile Planetarium at CBSS-NASRDA, Nigeria

Mr. Peter Okagu, Dr. Bonaventure Okere, Dr. Nnaemeka Onyeuwaoma, Mr. Timothy Egbuim

Centre for Basic Space Science and Astronomy (National Space Research and Development Agency) Nigeria.

Abstract

Planetariums are an essential tool in astronomy outreach, and their importance can never be overemphasized. The use of planetariums in astronomy and space science outreach has played a significant role in space science awareness. The Centre for Basic Space Science and Astronomy (NASRDA), Nigeria, has used its mobile planetarium over time to host educational outreaches to the awe of the participants. In the series of these events was the Astro-Christmas outreach for kids under the age of 15 years old. The event had 120 participants, with a gender classification of 70 girls and 50 boys. The content of the event includes outdoor lectures on the solar system, rockets, and women in space science. Inside the planetarium, space movies were played on solar system planets and their various distances, the moons, space travel, and a view of the International Space Station. The outcomes of the project were accessed using pre- and post-test surveys, which showed a significant increase of over 50% in the knowledge of space science and astronomy at the end of the event. Also, the qualitative assessment showed increased interest in space science and a willingness for increased participation in Science, Technology, Engineering, and Mathematics (STEM). Over time, the use of planetariums for space science and astronomy outreach has helped answer a lot of participants' questions. The planetarium at CBSS-NASRDA has been a point of attraction in the country, as schools, religious institutions, tourists, and enthusiasts are always eager to visit and satisfy their curiosity about its content.

Session

Division C Education, Outreach and Heritage

2453

Astronomy Education Concept Inventories: A Comprehensive Review

Dr Tshiamiso Makwela

IAU Office of Astronomy for Education. Max-Planck Institute of Astronomy / Haus der Astronomie. University of Cape Town

Abstract

This paper reviews astronomy concept inventories that have been developed and used in astronomy education. Concept inventories are tools that have been developed to measure students' conceptual understanding of concepts in astronomy and physics. These tools have been able to assist astronomy and physics lecturers and teachers in understanding their students better, thus creating learning materials that may help students develop more concrete learning experiences and knowledge gains. In most cases, these have been used as pre-test and post-test, where instructors are able to measure students' prior knowledge as they take the class and their learning gains at the end of the class/ course. Considering that most of these concept inventories have been developed and framed for entry-level undergraduates at universities, it is difficult to use these in primary and secondary schools. Since the content presented and learning outcomes of these widely differ, we need to find a way to tailor these concept inventories for primary and secondary schools. Additionally, while concept inventories provide good summative perspectives of what students know, they are also limitations such as the context, content, and their framing.

Session

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2464

Analysis of the Practice of A Flipped Classroom Designed with ICE Model At A Japanese University Using Digital Diamond Mandala Matrix

Dr. Seiichiro Aoki[1], Mr. Shinzo Kobayashi[2], Mr. Takahiko Naraki[3], Dr. Hoichi Tsuchimochi[1]

[1]The Kyoto College of Graduate Studies for Informatics. [2]CCC-TIES. [3]GREEN-COLLOR

Abstract

We offer a course on the fundamentals of space and the universe for undergraduate students at a Japanese university. We will explain the practice of the course and its results of analyzing the students' summarized thoughts throughout the course to capture their stage in the learning process. We designed the course based on the ICE model developed in Canada. To facilitate their thought to transition from I (ideas) to C (Connections) and E (Extensions) in the ICE model, the classes consist of group work, group presentations, and discussions. We prepared course materials (e.g., PDFs and videos) so the students could learn in the flipped classroom. As the preparatory work, the students learn and gain knowledge from the materials(equivalent to I in the ICE model) and summarize their thoughts individually on the designated topic (e.g., habitation in the Moon) before participating in the group work. In the class, group members summarize their opinions as a group thought based on their thoughts prepared in the preparatory work, present them, and discuss them. After the class, they reconsider and recapitulate their thoughts on the same topic based on the in-class presentations and discussions. They used our digital Diamond Mandala Matrix (dDMM) to summarize thoughts. We compared the text data of their thoughts input before and after the class. Statistically, we analyzed them with the KH Coder to trace the transition in the learning process from I to C and E using verbs according to the ICE model.

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2501

PhD-level training on the interface of astronomy and computer science

Johan H. Knapen

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Departamento de Astrofísica, Universidad de La Laguna, 38200 La Laguna, Tenerife, Spain

Abstract

Modern developments in fields like astronomy imply the need for advanced computational approaches to handle large data sets. However, most recent and current PhDs in astronomy have received little or no formal training in important areas including computer science, computational methods, software and algorithm design, or project management.

We will report on a number of scientific advances on the interface of extragalactic astronomy and computer science that have resulted from our EU-funded Initital Training Network SUNDIAL, in which 15 PhD candidates were trained. We will then discuss how these results will be built upon and expanded in a new Marie-Sklodowska Curie Doctoral Network called EDUCADO (Exploring the Deep Universe by Computational Analysis of Data from Observations). We will train 11 Doctoral Candidates in the development of a variety of high-quality methods needed to address the formation of the faintest observed structures in the nearby Universe, including novel object detection algorithms and object recognition and parameter distribution analyses of complex datasets. We aim to detect unprecedented numbers of the faintest observable galaxies from new large-area surveys. We will study the morphology, populations, and distribution of large samples of various classes of dwarf galaxies, compare dwarf galaxy populations and properties across different environments, and confront the results with cosmological models of galaxy formation and evolution. Finally, we will perform detailed simulations and observations of the Milky Way and the Local Group to compare with dwarf galaxies in other environments. Our interdisciplinary training tools, methods and materials will be made publicly available.

Session

Division C Education, Outreach and Heritage

2538

Breaking barriers to STEM careers through astronomy outreach and education activities

Dr Priscilla Muheki, Assoc Prof. Edward Jurua

Mbarara University of Science and Technology

Abstract

Education contributes greatly to science, technology, and innovation which are very vital in making societies a better place to live in.
Astronomy is known to be a powerful tool that can be used to promote education and science. In addition to that, it is one field of science that is envisioned to be a channel for technological developments, innovation and ultimately a tool to achieve the United Nations sustainable development goals especially for Africa. This is majorly facilitated by the significant growth of astronomy in Africa over the past years. This talk will summarise how we use astronomy during outreach activities to promote the love for school and education, science subjects and opt for STEM careers among primary and secondary school pupils in different schools in western Uganda through the support of the International Science Programme at Uppsala University. The biggest focus is on girls' schools as we hope to also break the myths surrounding girls excelling in science but we also include mixed schools and one boys primary school. I will also briefly talk about our efforts in training teacher trainees to teach astronomical concepts to their classes in secondary schools.

Session

Division C Education, Outreach and Heritage

2554

Transforming Access to Astronomy Heritage: Reorganizing and Automating Library and Archives Heritage Collections at Kodaikanal Solar Observatory

Dr. Arumugam Pitchai

Indian Institute of Astrophysics, Bangalore, India

Abstract

This research article presents a comprehensive approach to revitalizing access to the Astronomy Heritage collections at the Kodaikanal Solar Observatory (KSO) through reorganization and automation. The collection, consisting of books, journals, manuscripts, and observatory publications, holds significant historical value for Indian Science, with materials dating back to the 17th and early 19th centuries. The project aims to enhance the searchability and utilization of these resources by implementing modern cataloging techniques and automation tools. The study outlines the methodology and processes involved in reorganizing the library and archives collections, which includes leveraging advanced technologies for cataloging and metadata enrichment. The cataloging process entails creating detailed records for each item, incorporating descriptive metadata such as titles, authors, and subjects. Furthermore, the study highlights the use of automation tools like ATOM for Online Finding Aids and Koha for Library Automation to streamline processes such as indexing, classification, and retrieval of materials. The outcomes of this research contribute significantly to preserving and promoting the rich heritage of astronomy at KSO, ensuring that these collections remain accessible and relevant for future generations of researchers and enthusiasts. By employing modern cataloging techniques and automation tools, the project exemplifies a sustainable approach to managing and preserving valuable heritage collections, ensuring their continued significance in the field of astronomy and beyond.

Session

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2563

LUIGI LILIO AUTHOR OF THE GREGORIAN REFORM OF THE CALENDAR

Prof. Sandra Savaglio[1], Prof. Francesco Vizza[2]

[1]University of Calabria. [2]Istituto di Chimica dei Composti Organometallici del Consiglio Nazionale delle Ricerche

Abstract

In the second half of the 16th century, the Julian calendar then in use since 46 BC marked March 21st as the day of the vernal equinox, but astronomically it fell on March 11th, about 10 days earlier. This was a serious problem for the Church which had linked the spring equinox to the fundamental mystical event of Christianity: the celebration of the Easter of Resurrection. It was in fact established that the Easter of Resurrection should be celebrated on the Sunday following the 14th Moon following the spring equinox. It was therefore necessary to correct the Julian calendar and prevent the spring equinox from falling behind the civil calendar, as had happened over the centuries. Luigi Lilio, Italian doctor, astronomer and mathematician, using old astronomical data contained in the Alfonsine tables, formulated a new idea: he eliminated ten days from the Julian calendar, synchronized the solar cycle with the lunar cycle and drew up a table of ultra-millennial validity (Cycle of the Epacts) which allowed the dates of Easter to be determined without uncertainty. The proposal was accepted by Pope Gregory XIII and since then, it was the year 1582, this has become the well-known universally accepted Gregorian calendar. This talk will be about a rather mysterious story that has almost disappeared nowadays due to the limited documents that have come down to us.

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2600

Introductory Astronomy students' notion of astronomical scales from a cognitive perspective offered by embodied cognition

Dr Tshiamiso Makwela[1,2,3], Professor Saalih Allie[3], Assoc Professor Dale Taylor[4,5], Assoc Professor Sarah Blyth[3]

[1]IAU Office of Astronomy for Education. [2]Max Planck Institute for Astronomy/ Haus de Astronomie. [3]University of Cape Town. [4]Department of Physics, University of Cape Town. [5]University of Cape Town, Center of Higher Education and Development

Abstract

Previous studies in astronomy education research in both South Africa and Norway indicated that students perform poorly on questions regarding astronomical scales. Despite the marked educational, language, and science education differences, the results for both were similar, which suggests that there is a possibility of deeper cognitive issues that impede the conceptualization of scales that lie beyond immediate human experience. We carried out an exploratory study using the grounded theory method, where we probed students' engagement with distances that vary from tangible (meters) to intangible (astronomical units, light years, parsec). We developed a short questionnaire that prompted written explanations regarding a specific distance category from the given distance spectrum and administered it to astronomy introductory students. A grounded analysis of the student's responses was done, and categories emerged, that showed students operating in different domains of thinking when dealing with distances. Moreso, the emergent categories showed to be consistent with other cognitive perspectives offered by embodied cognition. In this talk/poster, we will explore how embodied cognition can be used to frame aspects of astronomical scales.

Session

Division C Education, Outreach and Heritage

2635

Twenty Years of Advancing Astronomy Education, Outreach, and Development in Ethiopia: A Journey of Advancement and Collaboration

Mr. Biruk Terefe Getu

Ethiopian Space Science Society. Addis Ababa University

Abstract

As the Managing Director of the Ethiopian Space Science Society (ESSS), I am honored to present our organization's journey of two decades dedicated to the advancement of Astronomy in Ethiopia. Our efforts have been deeply rooted in the realm of Education, Outreach, and running developmental programs and projects. Over the past twenty years, the ESSS has tirelessly worked towards fostering a culture of scientific curiosity and exploration across Ethiopia. Our educational initiatives have spanned in all levels, encompassing both formal and informal education methodologies. We have collaborated with local educational institutions, governmental bodies, and international partners to develop Astronomy, established the Entoto Observatory and Research Center, and we are currently finalizing our site testing project at Lalibella in which we will build the biggest observatory in our region.

Through our outreach programs, we have endeavored to engage the wider public in the wonders of the universe. Utilizing diverse media and formats, we have brought astronomy closer to communities across Ethiopia, inspiring interest and appreciation for the cosmos. Our efforts in astro-tourism have promoted economic development, our training programs equipped our generation with the proper scientific background, and through our proactive engagement we made more than 1500 members and 30 branch associations. As we reflect on our achievements, we remain committed to advancing astronomy education, outreach, and development. During my presentation, I will illuminate the extensive efforts we've undertaken, the profound impacts we've generated, the significant milestones

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2639

Evaluating the Impact of Astronomy Programmes for Education, Outreach and Development

Dr Sophie Bartlett

IAU Office of Astronomy for Education. Cardiff University

Abstract

There is a myriad of initiatives in the field of astronomy that are promoting astronomy, outreach, and development across the world, however, the impact of such projects often remains largely anecdotal or is based on limited feedback data from audiences and stakeholders. To further the field, we must work towards systematically evaluating the outcomes and impacts of such initiatives to allow us to work more efficiently and direct our efforts in a focused and effective manner.

This poster presentation will provide a visual guide to developing an evaluation framework for initiatives in astronomy education, outreach, and development. It will provide a step-by-step overview of the importance of evaluation, the process of setting meaningful objectives that will aid practitioners in capturing relevant evidence from which meaningful inferences can be made; creating a logic model or theory of change to identify the context surrounding an initiative, the resources that feed into it, the outputs that will be produced, and the expected outcomes and impacts of the initiative. The presentation will also detail the importance of identifying who is best placed to provide data and feedback in relation to an initiative and when is the best time to capture this. There will also be a summary of different tools and techniques for collecting evaluation data.

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2643

Asserting Achievements in Astronomy in Tanzania

Dr Noorali Jiwaji, Dr Said Ally

Open University of Tanzania

Abstract

Though there has been concern about professional level achievements in Astronomy in Tanzania we present clear gains through decades of persistent effort through many ways and methods and challenges. Among the achievements that present is increasing of public interest thousandfold, through articles in English and Kiswahili language articles about novel and exciting Astronomy phenomena and events and using major astronomical events such as the International Year of Astronomy, IYA 2009, and Annular eclipse of 2016 to increase public attention thousandfold across schools, students and public to want to know more about the sky. Particular focus has been given to creating Kiswahili lexicon for basic 3,000 space related terminologies. Another area is in in-service teacher training in Astronomy through the IAU Commission 46 NASE program that encourages hands on activities using locally available materials and creating training through training of tutors. A project to build simple telescopes locally using local material has been effective. An economic impact for the nations is expected from Astrotourism development with dark conducive skies in serene vast national reserves. An Astrotourgouides training curriculum is also in the offing. In research we have achieved Masters level training in Astrophysics with supervision by international experts with local co-supervision for research. Further research is not ongoing for international collaboration in Radioastronomy and a study of science readiness of the Kilimanjaro Saddle area for telescope installation is being undertaken

Session

Division C Education, Outreach and Heritage

2655

Survivors Guide to New Media: Engaging Audiences with Bite-Sized Science

Avivah Yamani[1,2], Dr. Pamela L. Gay[2]

[1]langitselatan. [2]Planetary Science Institute

Abstract

The way people look and grab information has shifted. They no longer have time and ability to focus on in-depth science content, but have shifted to content in short, digestible formats.

Short-form video content has easily captivated younger audiences and this bite-sized content has become their resource of choice for information. With content designed to be addictive and easily consumable, users will find themselves scrolling content endlessly. It can not be denied that compressing scientific concepts into engaging, bite-sized content allows the audience to grasp key points quickly and efficiently, without feeling overwhelmed by lengthy explanations.

And here is where communicators should step in and adopt the platform so we can engage with younger demographics. By doing so we are not only providing bite-sized information but also building our brand as a trustworthy resource in Astronomy.

However, simply creating short videos is not enough. To effectively utilize these platforms for science communication, we will explore how to build a trustworthy brand by utilizing short-form video.

Session

Division C Education, Outreach and Heritage

2668

Astronomy's role in shaping trade and culture in Bushehr province

Parham Eisvandi Dehnoei

Mehr observatory of Bushehr, Iran. Associate of Inter-Commission C1-C2-C3-C4 WG Astronomy in Culture (WGAC). Associate of Commission C1 WG Astronomy Education Research & Methods

Abstract

For thousands of years, Bushehr Province has been a lively trading hub along the coast, connecting with faraway places like India and East Africa. People here didn't just trade goods; they shared stories, ideas, and knowledge. Astronomy became a common interest, bringing people together across cultures. With similar skies and landscapes, Bushehr became a meeting point for sailors, and farmers alike. This shared fascination with the stars led to new discoveries in shipbuilding, navigation, and agriculture, enriching both trade and culture. In Bushehr, the legacy of this cosmic exchange is felt in everyday life, reminding us of the enduring bonds forged through curiosity and mutual learning.

Session

Division C Education, Outreach and Heritage

2688

Bringing Cosmos to Classroom: Astronomy Outreach Practice in Pakistan

Ms Yumna Majeed

Exploration - Cosmos to Pakistan

Abstract

In Pakistan's Space sector, a lack of awareness was observed in educational institutions and among the public, *from* outdated curricula in schools that made science uninteresting for students to the militarization of space agencies that led to no jobs in the country's space sector. Furthermore, there were no public observatories, planetariums or science museums to visit, nor role models or space-career counselling centres where students could progress their professional space careers.

In 2016, a space outreach campaign was initiated which turned into an organisation two years later. *Exploration* was created as a volunteer-run organisation with Ms Yumna Majeed as an Ambassador/NOC for global space NGO's. The mission was to raise awareness about Astronomy among Pakistan's public and promote Astronomy as a subject and career among students. The target audience was narrowed down to primary and secondary schools.

Since Astronomy is an observational science, using art mediums to engage students in themed activities proved to be a useful technique. Teaching methods included presentation-based STEM lectures, observation sessions via telescope, hands-on activities, space-art and storytelling sessions. To build sustainability and keep the outreach inclusive and diverse, private schools were charged to cover the material cost, subsequent funding enabling the same sessions to be conducted at low-income schools, trusts and orphanages for free.

Currently, there's high demand for space workshops, and *Exploration* reached over 110 schools and more than 14,0000 children. Schools started to celebrate World Space Week, universities initiated Space Clubs and authorities and the national space agency started to address space as part of the course curriculum.

Session

Division C Education, Outreach and Heritage

2693

A Multilingual Q&A Platform for Demystifying Apophis: A Collaborative World Wide Effort

Mrs. Luisa Fernanda Zambrano-Marin[1,2], Dr. Sean E Marshall[1], Dr. Julie Brisset[1], Mr. Robert J. Christian[3], Dr. Mike Nolan[4], Dr. Ellen Howell[4], Dr. Flavianne Venditi[1], Mrs Gina Morales[5]

[1]Florida Space Institute (University of Central Florida). [2]Universidad de Granada, Escuela Internacional de Posgrado. [3]DRM3 Labs Corp. [4]Lunar and Planetary Laboratory, University of Arizona. [5]Puerto Rico Space Foundation

Abstract

We are developing an online platform called "Ask About Apophis"; this web-based initiative aims to empower the global public with accurate and accessible knowledge about near-Earth object (NEO) Apophis, which will make its close approach to Earth in 2029. The Florida Space Institute, in collaboration with industry leaders in data management, is launching this initiative seeking not only to address public concerns regarding the absence of an impact threat but also to foster international collaboration and scientific understanding.

This platform goes beyond simply disseminating information; it aspires to become a trusted repository for the media to invoke and utilize as a source for accurate information. In today's world of AI-generated content, fidelity of data is imperative, and "Ask About Apophis" aims to establish itself as a reliable source for Apophis related information.

The heart of this program lies in a user-friendly platform specifically designed for multilingual Q&A. By harnessing the collective knowledge of citizen scientists and scientific experts, we aim to create a comprehensive understanding of Apophis and its upcoming encounter with Earth.

We are actively seeking input from the international community in two crucial ways. We invite astronomers and educators to volunteer their expertise.

By providing answers within their field of knowledge, they will directly contribute to public understanding and global collaboration in demystifying Apophis. We seek citizen scientists to submit questions about Apophis through the platform and embark on a collaborative journey of discovery, one question at a time.

Session

Division C Education, Outreach and Heritage

2715

An earth and beyond journey : reflections from supporting teacher development and support workshops in South Africa

MR Sivuyile Manxoyi

SAAO

Abstract

The South African National curriculum requires natural science teachers to each astronomy , geology and space science based content organized in a theme called Earth and Beyond and teachers are also encouraged to teach physics and mathematics using astronomy a a context. One of the challenges is that a majority of the teachers are usually uncomfortable teaching this section due to lack of training or exposure . The South African Astronomical Observatory has been facilitating teacher development and support workshops in collaboration with the provincial departments of education, science centres and universities . This presentation will evaluate the interventions implemented , detail the challenges and lessons and recommend best practices to handle and clarify the various misconceptions.

Session

Division C Education, Outreach and Heritage

2723

Cosmovisions of the Pacific: Advancing Indigenous - non-Indigenous Collaboration with Integrity (Cosmovisions)

Sr. STEM Education Specialist Yasmin Catricheo[1], Staff Associate for Facilities Planning and Management Tim Spuck[2]

[1]Associated Universities Inc. (AUI). [2]U.S. National Science Foundation

Abstract

Cosmovisions will be a gathering of approximately 100 Indigenous knowledge holders and non-Indigenous researchers and educators in STEM from the Pacific and Pacific Rim nations, and others from around the world who will continue and expand the work initiated by the Cosmovisions of the Pacific Phase 1 Gathering that took place in January 13 - 15, 2023, at the Northwest Indian College in Bellingham, WA, at the Lummi Nation. During phase 1, 30 Indigenous knowledge holders and non-Indigenous researchers and educators in STEM from the Pacific and Pacific Rim nations came together to walk the middle ground together, building new knowledge and relationships across cultures and sharing different ways of knowing our universe. Cosmovisions will create a safe space where individuals can comfortably share what is shareable, carry on and enrich the Cosmovisions of the Pacific report from Phase 1 that identifies key areas of future collaborative research between indigenous and non-indigenous investigators and practitioners. The objectives for of the proposed gathering are to expand and strength the previous exploratory work done by Cosmovisions of the Pacific Phase 1, but are not limited to: Establish a network of Indigenous and non-Indigenous researchers, educators, knowledge holders and others who are committed to collaboration across cultures and ways of knowing, Identify opportunities, in particular in high-need areas, for Indigenous - non-Indigenous Collaboration, Develop a guide for successful Indigenous and non-Indigenous collaboration. This presentation will detail the activities of Cosmovision to date and share information on the upcoming Cosmovisions phase 2.

Session

Division C Education, Outreach and Heritage

2753

Mobile Planetarium as a Tool for Astronomy Education in Namibia

Ms Hélène Honsbein[1], Prof. Michael Backes[2], Mr Zandré Duvenhage[3], Mr Hans-Werner Matthaei[3], Ms Queen Delight Namene[2], Mr Lott Frans[2], Mr Francisco Macucule[4], Mrs Sigrid Shilunga[2], Mrs Amanda Schut[3], Prof. Marc Klein Wolt[3], Ms Maaike Pierik[3], Prof. Joanna Holt[5], Mr Hiiko Katjaita[2], Ms Emilia Iiyambo[2], Ms Namasiku Simasiku[2], Ms Victoria Nakafingo[6], Dr. Eli Kasai[2], Prof. Heino Falcke[3], Prof. Sera Markoff[7], Prof. Rob Fender[8], Prof. Elina Lindfors[9], Prof. James Chibueze[4]

[1]University of Vienna. [2]University of Namibia. [3]Radboud University. [4]University of South Africa. [5]Netherlands Research School for Astronomy. [6]University of Stellenbosch. [7]University of Amsterdam. [8]University of Oxford. [9]University of Turku

Abstract

The Africa Millimetre Telescope (AMT) program successfully facilitates a mobile planetarium in Namibia as part of its educational and outreach projects. The idea for the project arose in the early stages of exploring the possibility of building the telescope in Namibia. However, the lack of locally qualified and experienced technical and scientific personnel to run the operations phase became evident as a risk to the sustainable exploitation of the telescope. The mobile planetarium enables us to simultaneously teach and reach out to local talent with an eye towards the future of AMT.

To that end, we adapted an existing mobile planetarium project, run by the Netherlands Research School for Astronomy (NOVA). A unique opportunity arose to set up a sister project in Namibia. Since 2022, more than 12,500 people, mostly schoolchildren, have visited the mobile planetarium. The innovative approach to astronomy outreach - and possibilities for educational purposes - recognized by the Royal Astronomical Society with the 2024 Annie Maunder Medal for Outreach. The IAU Office for Astronomy Education provided seed funding to create training material for student presenters. The project is now gaining such traction in Namibian society that many local businesses support the team with financial or in-kind support.

This contribution explores the best practices of a mobile planetarium for astronomy education, showcases differences and similarities in running this project in the Netherlands and Namibia, and explores the reasons why the feeling of ownership of the project in Namibia is so strong.

Session

Division C Education, Outreach and Heritage

2790

Teaching astronomy to students through Heritage and Archeoastronomy of Iran and the world

Director of Mehr Observatory Maryam Papari[1,2,3,4,5], Fatemeh Salimi[6,7], Coordinator of Mehr Observatory Anahita Zadsar[8], Researcher Hossein Khezri[9]

[1]Director of Mehr Observatory/ Ministry of Education, Iran. [2]Associate of Commission C1 WG Astronomy Education Research & Methods. [3]Associate of commission C1-C2-C3-C4 WG Astronomy in Culture (WGAC). [4]NAEC of Iran. [5]LOC of NASE (network for astronomy schools education) in Iran. [6]Biology teacher. [7]Deputy director of Khormuj research institute/ministry of education, Iran. [8]Coordinator of Mehr Observatory. [9]Researcher

Abstract

Students' familiarity with astronomy can be started in different ways, and one of these ways is to teach students about Heritage and Archeoastronomy. Mehr Observatory, as a center under the supervision of the Ministry of Education of Iran, has started the project of teaching heritage and archeoastronomy to Iranian students. In this way, schools officials, families and teachers, also accompany the students in the process of learning. In this presentation, we will explain the programs, workshops held, observations in astronomical sites that have a history of thousands of years, and also about the formation of groups of teachers and students in different cities of Iran with the aim of promoting and teaching astronomy to students.

Session

Division C Education, Outreach and Heritage

2800

Fostering STEM Interest through Practical Astronomy Education: The Astronomy in Ghana Project

Mr Joshua Kalognia[1], Mr Albert Forson[2], Miss Sarah Abotsi-Masters[2], Dr Emmanuel Prven-Adzri[3], Dr Naomi Asabre Frimpong[3], Miss Christiana Adorkor Kpakpo[2], Mr Stephen Ofoe Sottie[2]

[1]PRAGSAC/University of Cape Coast. [2]PRAGSAC. [3]GSSTI/PRAGSAC

Abstract

The Astronomy in Ghana project has successfully pioneered practical astronomy education in six schools across three southern regions of Ghana. With a focus on promoting problem-solving skills and cultivating STEM interest, the initiative began with a comprehensive 2-day preparation workshop, meticulously crafting an astronomy curriculum and teaching materials.

Emphasizing the significance of astronomy, the team conducted school visits, encouraging active participation in newly formed astronomy clubs among both students and teachers. To ensure long-term sustainability, a dedicated 2-day patrons' workshop equipped club leaders with the necessary knowledge and skills, complemented by a Teacher Training handout containing astronomy topics and activity materials.

Club progress was monitored through evaluation sessions, featuring pre and post astronomy questions to gauge students' understanding. Results indicated a significant enhancement in students' knowledge of various astronomy subjects. Enriching the educational experience, astronomy clubs visited the Ghana Radio Astronomy Observatory, gaining practical insights into a 32 m radio telescope and its operation.

The project concluded with an inter-school astronomy quiz competition, showcasing the acquired knowledge, with St. Martha’s Catholic Basic “B” School emerging as the winners. Overall, the Astronomy in Ghana project has effectively introduced practical astronomy topics, hands-on activities, and astronomy clubs to Ghanaian schools, significantly enhancing STEM interest and playing a pivotal role in guiding informed academic and career choices.

Session

Division C Education, Outreach and Heritage

2802

Engaging Minds, Empowering Action: Interactive Learning Materials for Effective Science Outreach

Mr. Lealem Kinfe

Ethiopian Space Science Society

Abstract

"Engaging Minds, Empowering Action" recounts a journey of impactful science outreach, where innovative learning materials become catalysts for change. Drawing from my background in computer engineering and a deep commitment to bridging educational divides, I've crafted interactive tools – flyers, brochures, digital posters, PDFs, engaging question cards about space science, and stickers – tailored for outreach programs in regions with limited educational resources.

The materials transcend traditional barriers, transforming complex astronomical concepts into digestible, visual narratives. Through interactive sessions, I witnessed students in the countryside grasp even the simplest astronomy principles, sparking a newfound fascination for the cosmos.

In the war-affected northern part of Ethiopia, the power of stickers as a reward system became evident. By distributing stickers to students answering questions, we not only encouraged active participation but also offered a momentary escape from the challenges they faced. These tangible rewards transcended the realm of education, providing a source of joy and motivation in the midst of adversity.

This abstract encapsulates not just a commitment to education but a narrative of empowerment and resilience. The proposed materials aim to kindle curiosity, making science an accessible and enjoyable journey for students in challenging circumstances. This story-driven approach underscores the transformative impact of tailored learning tools, turning outreach programs into beacons of hope and inspiration. I look forward to sharing these experiences, offering a glimpse into the profound change that science outreach can bring to underprivileged communities.

Session

Division C Education, Outreach and Heritage

2827

Empowering Through Astronomy: Girls in the Museum of Astronomy

Dr. Patricia F Spinelli[1], Dr Alejandra Irina Eismann[1], Claudia Sá Rego Matos[2]

[1]Museum of Astronomu and Related Sciences. [2]Observatorio Nacional

Abstract

The goal of science outreach is to diminish barriers between the academic realm and society, making scientific knowledge more accessible to diverse audiences. However, when it comes to informal education activities, experts recognize that it can be more expansive than mere dissemination: knowledge should be used to empower individuals and transform society.

The third edition of the project “Girls in the Museum of Astronomy” promoted activities to 35 girls aged 11-15, residents of Rio de Janeiro’s favelas. The project’s primary objective was to encourage these girls to experience science in the context of school clubs.

To achieve our goal and considering the harsh societal context of the participants, we have strived to move beyond the conventional approach of exclusively sharing astronomy content. This departure was also motivated by the mission of the project's hosting institution, a museum, where history and heritage must not be overlooked.

In this talk, we will present how astronomy activities can be conducted broadly and tailored to the interests of the audience while addressing cultural, philosophical, aesthetic, creative, and emotional dimensions. Specifically, we will showcase examples around the theme ‘Light Pollution’ explored by project's participants in various ways. Their findings were presented at prestigious events, transforming into astronomy ambassadors, earning awards in Olympiads and state fairs. However, the most significant outcomes are immeasurable — a noticeable shift in the girls' attitudes towards science and in their communities, manifested in various meaningful ways

Session

Division C Education, Outreach and Heritage

2842

Mandate of Heaven: an epistemological study on the astronomical thought in Ancient China

Mx Jun Nakayama

Federal University of Rio de Janeiro

Abstract

The history of astronomical advancements has always been told from an European viewpoint, using Western rulers to measure the quality and merit of discoveries. However, History of Science can't be separated from decolonial discussions and isn't exempt from bias. While the timeline for the evolution of the cosmological perspective was drawn from Western sources, from Ionians to Galileo, other ways of interpreting the sky were being developed independently from these European influences and those aren't unworthy of mention. The study of the Heavens was a science of cardinal importance for ancient Chinese society, with an almost symbiotic relationship between Man and the Cosmos. Despite its uniqueness and remarkable advances made by early astronomers, the Western narrative usually paints ancient Chinese astronomical knowledge as primitive, underdeveloped and poor in theory, but it's not possible to study completely different civilisations using the same cultural lenses. The aim of this work is to showcase the characteristics of astronomical thought in Ancient China between the Zhou and the Han dynasties (1045 BCE - 220 ACE), in an attempt to distance it from the Western context's bias, emphasising how the social and cultural connection to the Heavens in this period contributed to significant developments in Astronomy.

Session

Division C Education, Outreach and Heritage

2850

Heritage and Culture as Tools for Teaching Astronomy

Prof Somaya Saad, Miss Ola Ali

National Research Institute of Astronomy and Geophysics, NRIAG

Abstract

The Astronomical heritage is an integral part of the global human cultural heritage, and extends deep into the human conscience. Ancient man in all civilizations was interested in observing the sky and the stars shining in the sky and recording their sunrise and sunset. The sun and its movement in the sky during the day meant a lot to humans. In addition to spreading warm light that represented safety and renewal of daily life, it helped determine time and days.

Time was recognized and divided into parts as years, months, days, and hours. This has been a huge part of the work and ongoing efforts. Whereas, in more advanced stages, man made tools to help him calculate time, such as the hourglass and the water clock, and used the sun's shadow, which lengthens and shortens during the day, to tell the time.

With the knowledge of writing, man began to write down and record these notes in lists, maps, and manuscripts, which represent a great wealth and heritage accumulated over time.

Here we will review the Egyptian astronomical heritage, which was built on scientific foundations and precise knowledge of astronomy, and we will use these concepts as a good and effective means to teach students many astronomical lessons in an interactive and tangible way. We will focus on how astronomical heritage can be used as an ideal tool for teaching astronomy, and will orient pupils and the public to the importance of preserving their history and culture through astronomy education.

Session

Division C Education, Outreach and Heritage

2852

Human Capital Development and Research Capacity Building for the MeerKAT and SKA projects.

Dr Mthuthuzeli Zamxaka

South African Radio Astronomy Observatory (SARAO)

Abstract

The South African Radio Astronomy's human capital development programme (SARAO-HCD) was established to ensure that a sustainable and demographically representative workforce of highly skilled engineers, scientists, technicians and artisans would be available to build, operate and use the SKA, MeerKAT and AVN radio telescope facilities, as well as other local radio astronomy experiments.

Since its inception in 2005, SARAO HCD has successfully grown – from a very small pool - a diverse, interactive, globally recognised and transformed radio astronomy community in South Africa. This community participates and exploits the scientific and technical research opportunities that have been made available through South Africa's strategic investments in radio astronomy, particularly the MeerKAT and SKA projects, and thereby continues to secure the country's return on its investment. It has enabled the growth of SARAO's social license to operate with local communities, and is a critical success factor in ensuring the long-term strategic objectives for radio astronomy investment in South Africa is attained.

When South Africa submitted its expression of interest to host the SKA in 2003, there were less than five radio astronomers in South Africa. Since then, over 1400 grants to postdoctoral fellows, postgraduate and undergraduate students doing science and engineering degrees and research at universities, and universities of technology, and students training to be artisans, have been awarded by SARAO - a significant return on South Africa's investment in the international SKA effort, and the construction and operation of MeerKAT.

Session

Division C Education, Outreach and Heritage

2854

ASTRO ACCEL for Advancing Astronomy Education, Development, and Cultural Understanding

Tiffany Stone Wolbrecht[1], Kelly Blumenthal[2], Nic Bonne[3], Yasmin Catricheo[1], Anica Miller-Rushing[1], Saeed Salimpour[4], Tim Spuck[5], Gretchen Stahlman[6]

[1]Associated Universities, Inc. [2]IAU Office for Astronomy for Outreach. [3]Univeristy of Portsmouth. [4]IAU Office for Astronomy for Education. [5]U.S. National Science Foundation. [6]Florida State University

Abstract

Learn more about the ASTRO ACCEL initiative, a global collaborative effort dedicated to promoting research and leveraging expertise in astronomy education for development and cultural enrichment. Comprising 13 interconnected networks, including prominent contributions from the International Astronomical Union (IAU), ASTRO ACCEL spans continents to accelerate the exchange of resources, ideas, and practices in culture, communications, education, and public engagement within the realm of astronomy. By uniting researchers and practitioners and supporting early career researchers, ASTRO ACCEL aims to cultivate a vibrant community where collaborative priorities are established, innovative strategies are shared, and significant strides are taken toward enhancing astronomy education and fostering cross-cultural understanding.

Session

Division C Education, Outreach and Heritage

2879

Armenian Activities on Astronomy-related Inter- and Multi- Disciplinary Studies

Gayane Baleyan, Areg Mickaelian

Byurakan Astrophysical Observatory

Abstract

All sciences in the world, especially the natural ones, move toward each other creating both Interdisciplinary (ID) and Multidisciplinary (MD) fields. Astronomy is probably the leader in this tendency, as data coming from the Space serve for and develop many natural and also social sciences: The Byurakan Astrophysical Observatory (BAO) and later on, the IAU South West and Central Asian Regional Office of Astronomy for Development (SWCA ROAD) have been very active in promoting such fields. In 2012, an Archaeo-astronomical Conference *"Astronomical Heritage in the National Culture"* was organized in Byurakan. Then one of the first meetings on Astronomy as the leader in ID and MD sciences was held, *"Relation of Astronomy to other Sciences, Culture and Society"* (RASCS, 2014) and a similar meeting *"Astronomy in the Crossroads of Interdisciplinary and Multidisciplinary Sciences"* was held in 2021. In addition, one of our Byurakan International Summer Schools (BISS) had a title *"Astronomy as the leader of Natural Sciences"* (2022). As in 2014, RASCS topic will have the Armenian Astronomical Society (ArAS) 25th anniversary meeting in 2024. The most prominent meeting was probably the UNESCO Regional Conference in 2017 on *"Astronomical Heritage of the Middle East"*. BAO actively collaborates with related international organizations: International Virtual Observatory Alliance (IVOA; VOs, Astroinformatics), International Planetary Data Alliance (IPDA; Planetology), ISC World Data System (WDS; Data Science), COmmittee on SPAace Research (COSPAR; Space Sciences and Technologies), IAU Working Group on Archaeoastronomy and Astronomy in Culture (WGAAC), European Society for Astronomy in Culture (SEAC) and others.

Session

Division C Education, Outreach and Heritage

2899

Astronomy Outreach in Nigerian High Schools

Ms Barivure Popnwin

North-West University

Abstract

Astronomy, as a field of scientific inquiry, stands as a beacon of exploration. Throughout history, astronomy has not only deepened our comprehension of cosmic phenomena but also provided profound insights into our place in the cosmos. In Nigeria, the accessibility of astronomy and space science remains a challenge. The absence of educational institutions offering space science curriculum poses a significant barrier to students' exposure to astronomy, a scarcity extending across the nation with only a handful of universities offering astronomy programs. Despite these challenges, I seized opportunities to engage with high school students during my one-year community service in Nigeria. Through presentations at schools like The Nigerian Air Force High School in Akwa Ibom State and Premiere Academy in Lugbe, Abuja, I endeavoured to instill a sense of curiosity about space science and astronomy among young learners. Witnessing their enthusiasm reaffirmed the belief in the crucial role of Astronomy outreach in bridging educational disparities, while the road to advancing astronomy education in Nigeria may be fraught with challenges, the potential impact on inspiring future generations of scientists makes it a journey worth undertaking. Through concerted efforts in outreach and education, we can cultivate a new generation of astronomers who will contribute to the global pursuit of knowledge about the universe.

Session

Division C Education, Outreach and Heritage

2908

Advancing Astronomy Education: Innovative Outreach Projects to Inspire Future Astronomers

Gayane Baleyan

Byurakan Astrophysical Observatory

Abstract

In the pursuit of fostering a deeper understanding and appreciation for the cosmos, the Byurakan Astrophysical Observatory (BAO) has been at the forefront of organizing diverse Outreach and Educational events. As we prepare to engage with esteemed colleagues at the International Astronomical Union General Assembly, we present a comprehensive talk outlining our vision and initiatives aimed at advancing astronomy education and cultivating a passion for the celestial sciences.

At BAO, we recognize that effective astronomy education transcends traditional classroom settings and necessitates innovative outreach strategies that captivate the imagination of learners of all ages and backgrounds. Our educational projects are designed not only to disseminate astronomical knowledge but also to instill a sense of wonder and curiosity about the universe.

Key components of our outreach initiatives include:

- **Public Stargazing Events**: Leveraging our state-of-the-art telescopes, we organize regular stargazing sessions open to the public.
- **Virtual Astronomy Workshops:** Through interactive sessions, we cover a range of topics, from basic astronomical concepts to cutting-edge research developments, fostering a global community of astronomy enthusiasts.
- **School Outreach Programs:** We collaborate with local schools to develop tailored astronomy curriculum supplements and conduct engaging workshops and demonstrations on-site.
- **Citizen Science Initiatives**: We involve enthusiasts in data collection and analysis projects. By democratizing the scientific process, we not only advance our understanding of the cosmos but also foster a sense of ownership and pride among participants.
- **Art and Astronomy Fusion Events**: We organize events that explore the intersection of astronomy and various art forms.

Session

Division C Education, Outreach and Heritage

2913

Evaluating Astronomy Education in Uganda and Africa through Vlogging

MR. TERRY MARK TUKAMUSABA

KYAMBOGO UNIVERSITY,UGANDA

Abstract

Abstract:

This proposal outlines a pioneering initiative aimed at transforming astronomy education in Uganda and across Africa through the innovative use of vlogging. Recognizing the importance of accessible and engaging educational content, this project seeks to leverage the popularity of online video platforms to inspire a new generation of astronomers, foster scientific curiosity, and bridge the cosmic gap that often exists in regions with limited access to traditional educational resources.

The primary objective of this project is to create a dynamic ,scientific and culturally relevant vlogging series that delivers astronomy content in an engaging and accessible manner. The aim is to demystify Astronomy by developing content that simplifies complex astronomical concepts, making them accessible to a wide audience with varying levels of scientific background, integrating local cultures, folk tales, and indigenous knowledge into astronomy lessons, fostering a sense of connection between the cosmic realm (particularly stellar pulsations in low mass stars initially) and everyday life. Promoting diversity while showcasing diverse role models and professionals in astronomy, emphasizing inclusivity and encouraging underrepresented groups, particularly women, to pursue careers in STEM fields is also essential alongside community engagement to establish a feedback loop through online platforms, encouraging audience participation, and tailoring content to address specific questions and interests of the viewers in the various areas separated by language differences.

The project will employ content creation ,platform utilization and community Outreach.

Session

Division C Education, Outreach and Heritage

2930

The development of astronomy public-outreach activities in Bratislava in Slovakia

Doctor Patrik Čechvala[1], Doctor Juraj Kubica[2]

[1]Comenius University in Bratislava, Slovakia. [2]Slovak planetaria, residents association

Abstract

Although, Bratislava, capital of Slovakia, is the agglomeration with more than half of million of inhabitants and the place where the biggest slovak university is located, we have been struggling with the support and the development astronomy-related outreach activities in this region for several years. This was most visible when Park of Culture and Relaxation was closed also with its Astronomy office around 20 years ago. Since then, Bratislava is missing any type of official public-outreach institution for astronomy. However, there are nowadays several activities to change this status. There is an initiative to build a planetarium after long decades of waiting. Also the new observatory is currently being built at the high school in Bratislava. We would like to briefly summarize different current astronomy-related outreach acitivities in our capital city.

Session

Division C Education, Outreach and Heritage

2933

Digital Astronomy Festivals - Bridging Enthusiast Communities and the General Public. An Analysis of Results and Challenges

Pr Andres David Torres Cañas[1,2], Dr Camilo Delgado-Correal[3,4,5], Mag Carlos Molina[6,7]

[1]Metropolitan Technological Institute (Medellín - Colombia). [2]NOC Outreach Astronomy Office (Colombia). [3]Francisco José de Caldas District University of (Bogotá-Colombia). [4]Geographic Institute Agustín Codazzi - IGAC (Colombia). [5]ViceNOC Outreach Astronomy Office (Colombia). [6]Planetarium of Bogotá (Colombia). [7]Inmerdome S.A.S

Abstract

In 2020, during the quarantine prompted by the covid-19 pandemic, the Office for the Outreach of Astronomy of the International Astronomical Union in Colombia (IAU-OAO Colombia) proposed a strategy to maintain the connection between the community of enthusiasts and the general public interested in astronomy: the creation of a Digital Astronomy Festival (AstroFest) . In these event, astronomy groups offered lectures, workshops, panels, and discussions on topics previously defined by the OAO's expert committee. The festival took place for one day, usually during the September equinox week, and has already had three editions, each per year. In the third festival, more than 200 people participated by connecting to the Zoom platform, and additional viewers tuned in for the 12-hour live broadcast on the OAO's YouTube channel. This work aims to present the results obtained in all editions of the festivals and explore the possibility of expanding this format to other regions of the world and by using other platforms like Tik Tok and Virtual Reality environments.

Session

Division C Education, Outreach and Heritage

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2937

The Sun at a Glance: An International Infographic Competition to Teach Science at School

Luis Bellot rubio[1], Mariarita Murabito[2]

[1]Instituto de Astrofisica de Andalucia (IAA-CSIC). [2]INAF-Osservatorio Astronomico di Capodimonte

Abstract

Innovative activities are needed to promote STEM vocations among young students. The Sun, as an object that can be studied from many different perspectives, offers an excellent opportunity to accomplish this goal. In 2021, the European Solar Telescope (EST) project organized the international competition “The Sun at a glance” to show the potential of the Sun for teaching science at school. Here we describe the philosophy, the main organizational aspects, and the results of this activity.

The competition was designed to encourage students in the age ranges 14-15 and 15-16 to research about the Sun and present their results in the form of an infographic. The students worked in small teams of 4 people, led by a teacher. The prizes included a visit to Teide Observatory (Tenerife, Spain) for the two teams producing the best designs. A dedicated website (www.est-east.eu/contest) was set up to provide the participants with the rules, the announcement poster, and other general information. The names of all the students and their teachers were also listed on the website in real time.

This activity raised extraordinary interest in the European education community. A total of 2,859 students and 303 teachers from 242 schools signed up for the competition, representing 16 European countries. The infographics they submitted were used to build the EST Solarpedia, a comprehensive solar encyclopedia hosted on the EST website. This unique educational resource, open to both the teaching community and the general public, is a legacy that will stand for years to come.

Session

Division C Education, Outreach and Heritage

2946

CHASING THE STARS NAKED EYE The Benin Tofin fishermen challenging modern telescopes in daily navigation

Prudence AYIVI[1], Dr Aimé SEGLA[2], Jean-Eudes MISSIKEY[2]

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Abstract

Where do Indigenous knowledge holders and their astronomical knowledge sit in the modern techno scientific future of astrophysics? The present project revolves around the research among the indigenous peoples of the Tofin, a West African people living mainly in southern Benin, Nigeria, Togo and Ghana and attempts to address the question. Our methodology consists on collecting, using the Tofin local language, concepts in links with astronomy. It is indeed scientifically interesting to find out how, for example, the local sky knowledge influences the culture and the local knowledge of procedural boat building technologies. It appears during our fields work those meanings are aligned on the knowledge of the stars. Furthermore, we seek to document the knowledge of the sky as guidance in daily navigation for fishing on the sea, lake and lagoons, as basis for the organization of social and cultural life, and for more: the cycle of the stars is used to define the harvest periods; stars are used as guides during extensive marine navigation, etc. During on-site expeditions, we organize evening observations with modern telescopes to verify the accuracy of peoples' empirical knowledge with modern theoretical models, thus allowing local people to better connect with future technological innovations. In conclusion, the Tofin fishermen propositions to the Benin Government, based on their secular experiences, are substantial for the improvement of fishing economy and for the development of the urban coastal areas in southern Benin Republic.

Key words: Astrophysics; indigenous-knowledge; Tofin (Benin); cultural astronomy; innovation-studies.

Session

Division C Education, Outreach and Heritage

2959

AstroSounds - Listen to the Stars

Professor Katrien Kolenberg

KU Leuven. University of Antwerp. Free University of Brussels

Abstract

Our Universe is full of sound. In the depths of space, planets of all flavors crackle and roar, stars are ringing like giant bells, and merging black holes occasionally send ripples through the fabric of spacetime. And this is just the tip of the cosmic iceberg…

Within the vast field of Astrophysics, the study of variable stars is expansive and inclusive. Groundbreaking discoveries can be made with modest instrumentation and small telescopes, also by amateurs, and treasure troves of new unexplored data are available to the scientific community and the public. Therefore, this field lends itself perfectly to involving more people in astronomical research, sharing a cosmic perspective on our human scientific endeavors, and using it as a "hook" for STEAM education.

AstroSounds is a citizen science project investigating the extent to which the human ear can distinguish the timbre of different pulsating star types. At the same time, it is an educational project, inspired by the research field of asteroseismology, naturally linking different STEAM curriculum topics, such as physics, mathematics, biology, chemistry and music education. The multimodal exploration of data, including the auditory channel, opens the field of astronomy to people with visual impairments.

Session

Division C Education, Outreach and Heritage

2960

Astronomical education in the Democratic Republic of Congo, a challenge for primary and secondary education

Professor Nsiami Catherine Mabiala

Coordination pour l'éducation astronomique en RDCongo

Abstract

Education in general, and astronomical education in particular, is a major challenge for the Democratic Republic of Congo, in a context of war and poverty. Priorities are often clear, but they are far from astronomical. This challenge becomes that of national coordination, which relies on the few amateur astronomers and on the advice of the only professional Congolese astronomer living outside the country. The main question is how to give astronomy a face so that it attracts the attention of primary and secondary school-age children? The awareness-raising activities organised with the means at hand seem to be bearing fruit, but they are insignificant given the size of the country. This paper takes stock of what is being done and presents the vision of the national coordination for astronomy education in the DRC.

Session

Division C Education, Outreach and Heritage

2972

Bridging Scientific Expertise to Underserved Communities: Initiating and Sustaining Local STEM Outreach

Tania Anderson

Space Telescope Science Institute

Abstract

This session will feature effective outreach strategies used to recruit, engage, and sustain student involvement from underserved communities in out-of-school informal science outreach programs. Resources to build such programs from the ground will be discussed. Join us to learn more about how you can initiate and sustain a STEM based program in your local community.

Session

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2986

Ingredients for New Discoveries: Sun, Solar Eclipse, Earth's Atmosphere, and the Local Community.

Dr Juie Shetye

New Mexico State University

Abstract

The annular solar eclipse of October 14, 2023, catalysed collaborative research efforts between academic institutions, a barn, and over 200 local enthusiasts. Through partnerships with NASA, Montana State University, and the New Mexico Space Grant Consortium, the project aimed to investigate the atmospheric impacts of the eclipse. Methodologies involved deploying high-altitude balloons equipped with radiosondes to collect essential atmospheric data.

These experiments discovered over 30 eclipse-driven atmospheric gravity waves, observed for the first time during an annular solar eclipse.

The icing on the cake was the public photographs that captured the formation of these waves in clouds created at the locations, thus providing a unique means to make scientific discoveries and visually confirm our results.

The presentation underscores the significance of experiencing totality in a specific location and highlights the broader impact of the eclipse on both scientific understanding and public engagement with astronomy.

Session

Division C Education, Outreach and Heritage

2989

Poster Presentation: Girls in Astro-Space Science The Workforce of the Future

Ms Buzani Khumalo

South African Astronomical Observatory

Abstract

This poster is a presentation of the activities that SAAO Education Outreach has undertaken for high school girls to continue the effort to bridge the gender gap in the area of Astronomy and Space Science that sparked a stronger desire to pursue careers in astronomy and space science. The gender inequality in Astronomy and Space Science is still prevalent in South Africa. The poster will showcase various activities that have been implemented to inspire high school girls in astronomy and space science.

Session

Division C Education, Outreach and Heritage

2991

Telescopes and Libraries as Tools for Cultural Astronomy and Dark Skies

L.Fís. Durruty Jesús de Alba Martínez[1], MGDC. Mónica Martínez Borrayo[2,3]

[1]Universidad de Guadalajara. [2]Secretaría de Cultura del Estado de Jalisco. [3]Universidad de Guadalajara, Doctorado en Ciudad, Territorio y Sustentabilidad

Abstract

In this talk we describe our experiences through travels to several towns and cities in whose libraries, cultural centers and even main squares where developed activities concerning Astronomy, Cultural Astronomy and care of dark skyes; each one of this journeys had a diverse way to be concreted, we review from these wich will be the best way to perform a succesful activity, we introduced there organizations such *Network for Astronomy School Education* and their different courses for teachers, as well activities from popularization and outreach area from *Instituto de Astronomía y Meteorología* at *Universidad de Guadalajara* as a form to develop consciousness of their Astronomical Heritage and the preservation of dark skyes.

Session

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3022

Junior Astroclub - An educational project for interactive teaching of astronomy.

Simon Anghel[1,2], Diana Chirita[3], Andra Stoica[3]

[1]Astronomical Institute of the Romanian Academy. [2]IMCCE - Paris Observatory. [3]Space Club

Abstract

Astronomy sparks a natural curiosity and passion in many from an early age, making learning feel effortless. Despite its potential to boost critical thinking and scientific reasoning, it's often overlooked in school curriculums. Thus, in 2018, a group of amateur astronomers from Romania initiated the “Junior Astroclub” project, with a dedication to teach astronomy to children from diverse communities through engaging activities.

The club's initiatives include practical and interactive projects like courses, crafting homemade planetariums, comets, space elevators, drawing celestial bodies etc. These activities are designed to be educational yet captivating, ensuring the kids not only learn but also enjoy the process. As the project is not linked with an external funding scheme, we rely on a minor support from the parents, which is invested in teaching materials. This small fee for the online courses also incentivised the parents to ensure that the kids never miss a workshop.

The project was a great success, participants eagerly awaiting future workshops and other activities. Thanks to the online workshops, Romanian children across all Europe could join in, overcoming geographical barriers. The absence of mandatory homework hasn't hindered learning, confirming that the peak of the learning process resides at the intersection of passion and creative educational activities.

The team: A. Stoica, D. Chiriță, S. Anghel, E. Anton, B. Arion, M. Barbu, M. Boicescu, M. Crețu, Ș. Mirică, M. Naiman, A. Neaga, A. Nichiforov, C. Palade, O. Pănoiu, A. Perrota, S. Roșu, A. Soare, M. Sinca, C. Stancu, G. Stratulat, C. Șulea, V. Vasile

Session

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3059

'Ale Lau Loa: Indigenous Culture-based Learning

Dr Yuko Kakazu[1,2], Dr Fengchuan Liu[1]

[1]TMT International Observatory. [2]National Astronomical Observatory of Japan

Abstract

The Thirty Meter Telescope (TMT) International Observatory is dedicated to an inclusive community model of astronomy that upholds the values of respect, inclusion, and community stewardship. Under new management and a Hawai'i-based team, TMT actively engages in grassroots dialogues with community members, especially with Native Hawaiians. Through community input, diverse programs in education, workforce development, culture-based learning, and environmental conservation are co-created and community-reviewed.

This presentation introduces the 'Ale Lau Loa: Indigenous Culture Exchange Program, symbolizing the profound and enduring histories of indigenous cultures. Developed in collaboration with the Hawai'i County Sister City program, TMT, and guided by cultural practitioners and wayfinders, this community-driven program fosters cultural exchange between Hawai'i Island high school students and global peers, emphasizing indigenous traditions and their deep connections to the sky and the ocean.

Session

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3063

Sky Machines: Manufacturing and prototyping of educational materials on astronomical topics for non-specialized audiences. Cintia Durán. Tlaloque. HackerGarage.

Cintia Duran

Tlaloque. HackerGarage

Abstract

An important problem we share in astronomy outreach is the limited tools we have for establishing common ideas with society. There is a wide range of communication strategies designed without much room for the public to experiment and learn by themselves. All this under guidelines and practices of international models, overlooking the specific needs of each country. This project gives a sample of the work we have done in the city of Guadalajara, Mexico in collaboration with HackerGarage, a citizen technology lab, for the design and prototyping of didactic materials that can be used by the public and responding to the specific challenges of the communities that use them.

Our main focus is the mix of industrial design and other technologies that can be used to complement outreach/education practices while giving the user a sense of participation in the construction of their own devices. Once we select a topic, and the scientific research is well structured, we start to transform that content into a tangible object, that can transmit complex concepts, and meet the needs of the user without an intermediary or prior knowledge of science.

From our experience, in a Latin American country, where social problems exceed academic needs, we saw in industrial design and DIY culture, a powerful, affordable, and inclusive tool, that can be used in the manufacture of educational products and a way to approach complex issues reinforcing a positive relationship with science, positioning it as something familiar in their day to day life.

Session

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3069

A sun that never sets. Outreach techniques through language, and the importance of oral tradition in astronomy studies.

Cintia Duran[1], Dr. Kelly Blumenthal[2]

[1]Tlaloque. [2]IAU

Abstract

A sun that never sets proposes a linguistic analysis, whose basis is built on the research of different languages of native communities in four regions of the world, to design astronomy outreach strategies specific to each community. We take as a starting point concepts from the Systematic Functional Grammar studies, where it is established that the structure of language that each society develops dictates roles, behaviors, and ways of learning. All this to explore the relationship that different indigenous cultures have established with the earth and the cosmos, and in consequence modify concepts and practices of astronomy communication that can be used by different communities.

Giving relevance to the language of each community can be a solid tool for the development of a new stage in the relationship that astronomy has with society, creating the foundations for new multidisciplinary research from astronomy for the benefit of humanity.

We start with the importance of **making evident the differences between languages** and forms of communication in each country because by honoring these differences we can understand the history and customs of a people, as well as their way of thinking and expressing themselves. **It is in the recognition of the community that we can modify and add new concepts in the teaching** and communication of scientific topics.

Session

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3077

Implementing the Cascade Outreach Model in Astronomy Engagement during national Science Week 2023

Ms Duduzile Kubheka

African Astronomical Society. BRICS Astronomy. South African Astronomical Observatory. Stellenbosch University

Abstract

Our project during National Science Week 2023 in South Africa epitomized a collaborative endeavor aimed at igniting curiosity and nurturing a passion for astronomy, particularly among youth, while also spotlighting potential career paths in STEM fields. Through strategic partnerships with local education departments and the enthusiastic participation of dedicated outreach ambassadors, mainly comprised of astronomy postgraduate students, we extended the initiative's reach across multiple regions in South Africa, covering over six provinces. A pivotal innovation was the introduction of the "cascade outreach" model, inspired by the exemplary work of Carolina Odman, facilitating the dissemination of astronomical knowledge while championing diversity, inclusivity, and leadership in science communication. Targeting learners in townships and remote areas, we broke geographic and socioeconomic barriers, bringing astronomy directly to those with limited exposure. The engagement was both informative and inspirational, fostering interaction with relatable ambassadors and igniting curiosity among participants. Moreover, the project significantly impacted participating ambassadors, equipping them with valuable communication skills and nurturing a sense of social responsibility. This collective action exemplifies the transformative potential of promoting science awareness and capacity-building in African communities, fostering a legacy of scientific curiosity and empowerment.

Session

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3082

DIY Radio Telescopes for Education and Outreach in Developing Countries

Dr Ikechukwu Obi, Mr Ike James, Mr Williams Onyinyechi, Dr Bonaventure Okere

Centre for Basic Space Science & Astronomy (CBSS)

Abstract

Outreach and educational activities in astronomy in developing countries have over the years focused on optical astronomy with little or no activities were carried out in the radio counterpart despite it's feasibility of daytime observations which in turn allows for it's easy inclusion in the curriculum activities of schools. This is mainly due to the unavailability of ready-made expensive radio telescopes or lack of expertise to build low cost ones. On the other hand, professional radio telescopes can not be easily accessed by students for teaching purposes due to it's high demand. We present various designs and performances of some affordable but effective mobile and portable DIY radio telescopes that will serve as an indispensable tool for outreach, education and training in radio astronomy at all levels.

Session

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3090

Inspiration through space science: exoplanet themed education activities for secondary students

Sandor Kruk[1], Kate Isaak[1], Catia Cardoso[2], Maximilian Guenther[1], Davide Gandolfi[3], Sandra Benitez Herrera[1], Monica Talevi[1], Clara Cruz Niggebrugge[1]

[1]European Space Agency. [2]Aurora Technology B. V. for ESA. [3]University of Turin

Abstract

The topic of exoplanets is connected directly to the simple and profound question of whether we are alone in the Universe, capturing the imagination of scientists and the public alike. As such, it provides an excellent means through which to engage school students in some of the thrills of science and, critically, to teach science, technology, engineering and mathematics (STEM) core skills.

In this contribution we give an overview of a collection of exoplanet inspired classroom activities and resources that have been developed through a collaboration between ESA Education and scientists working in ESA Science and beyond. The emphasis of the activities has been on transit photometry and more specifically ESA's CHEOPS mission, with the underlying theme of using in-flight CHEOPS observations to engage young people. A highlight is the 'Hack an Exoplanet' (https://hackanexoplanet.esa.int/) challenge, in which student teams engage in the analysis of several exoplanets observed by CHEOPS for this educational purpose. Through these initiatives, we demonstrate the power of using real scientific missions' data to inspire the next generation of scientists and engineers, underscoring the critical role of hands-on, practical experiences in STEM education.

Session

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3107

Communicating Astronomy: The IDP Experience

Engr Onuche Ogu

AWBNigeria/NASRDA

Abstract

My submission will address a wide range of challenges in communicating astronomy. The IDP-CAO Project target audience is children below the age of 18. The target audience have been through the traumatizing effects of violence and displacements from their homes due to ethno-religious conflicts. The results of cognitive behavioral therapy assessments show that a huge percentage of the target audience suffer from anxiety disorders. The target audience have little to no knowledge of astronomy and science. The target audience have become familiar with folklore and myths concerning the wonders of the sky.

The presentation will address the multifaceted challenge of communicating astronomy to children that have experienced violence and dealing with the effects mentally. Also, the challenge of demystifying common folklore that have become all familiar to the target audience.

Participants will learn the following from my submission:

1. Inter-disciplinary approach to astronomy communication.

2. The use of multimedia in communicating astronomy to children.

3. The importance of gaining trust before embarking on astronomy communication

This project employed interdisciplinary approach to holistically achieve it aims and objectives by using a team of professional counsellors to conduct cognitive behavioral therapy assessments. This approach was done to gain insight on the state of the mental health of the children and to gain their trust. Data from the psycho-social therapy assessments and the impact of the project have been analyzed.

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3133

Paths to promote inclusive Astronomy learning environments: from teacher trainings to multisensory resources

Ms. Mariana Gomes

FIOCRUZ. Museum of Astronomy and Related Sciences

Abstract

In the vastness of human knowledge, Astronomy becomes a window for contemplating the Universe, playing a vital role in acknowledging our role as global citizens. That said, the construction of a teaching and learning process of Astronomy concepts demand an exhaustive exercise of optimism. However, outlining educational paths in Astronomy necessitates a careful analysis of challenges faced by both protagonists in the classroom – teachers and students. In this work, an offshoot from the production of multisensory resources to teach about the Moon for visually impaired students at the Universo Acessível project, our discussion underscores the potentials of using multisensory resources inside the classrooms and the emergent need of teacher trainings to instill confidence in teaching Astronomy and effectively leveraging such resources, by showing a panorama from the Astronomy education in Brazil, from a qualitative research study targeting Brazilian teachers in the field of Natural Sciences, where they were asked about realities faced in the Astronomy teaching inside classrooms. We expect to discuss how promoting an inclusive learning environment can engage students and teachers from the beginning and create a good environment for Astronomy teaching and learning, emphasizing the need to spotlight teachers as key players in the Astronomy Education process. Our aim is to explore how fostering an inclusive learning environment can captivate both students and teachers from the outset, establishing a conducive atmosphere for Astronomy education. This discussion reinforces the potential for initiatives that interconnect astronomers, educators, and students collaboratively, guiding the learning process of astronomical concepts while solidifying teacher training in this field.

Session

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3146

The Role of the African Astronomical Society in Shaping Astronomy in Africa

Dr Naomi Asabre Frimpong

African Astronomical Society (AfAS)/ Ghana Space Science and Technology Institute (GSSTI)

Abstract

Since its relaunch in 2019, the African Astronomical Society (AfAS) has made notable strides towards contributing to advancing the field of astronomy within Africa, with a focus on education, research, and public engagement. This presentation aims to show AfAS's different initiatives, including comprehensive capacity-building efforts through workshops, astronomy schools, grant programs, and extensive outreach activities that have aimed to increase public access to astronomy. Furthermore, the society's commitment to fostering research and facilitating international collaborations has elevated the global presence of astronomy in Africa. The presentation will also address society's contribution to supporting infrastructural development and policy advocacy, underscoring its dedication to the sustained growth of astronomy across the continent. By reviewing AfAS's accomplishments, challenges faced, and prospective goals, this talk intends to provide a thorough overview of the society's role in enriching the African astronomical landscape.

Session

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3147

Remembering Paulo S. Bretones: A passionate Astronomy Educator and Researcher

Professor, Dr Urban Eriksson

Division of Physics Education Research, Dept. of Physics and Astronomy, Uppsala University, Uppsala, Sweden

Abstract

I met Paulo S. Bretones for the first time in Vienna 2018 at the International Astronomical Union (IAU) General Assembly. This was the beginning of a very fruitful collaboration that led to us organizing two international AstroEdu conferences, and start the international Astronomy Education Journal. The conferences have been very successful in bringing together astronomy educators and astronomy education researcher where we have a forum to discuss with our peers and colleagues on interesting and intricate matters concerning astronomy education and research. Paulo was a driving force to make these conferences happened. The situation was similar with the AEJ, launched at the AstroEdu conference in 2019, where Paulo and I saw a great need for astronomy educators and researchers to publish their work. At the time, and now, there is no other journal that meets these needs. Paulo was pushing me forwards as new editor together with him, and I learned so, so, much from him. He was also involved in the initiative Astronomy Days in Schools.

It was with great sadness that I, during the end of 2022 understood that Paulo was unwell and by the beginning of 2023 our otherwise weekly meetings ceased; Paulo could not continue the fantastic work he had done.

We have all lost a very good and appreciated colleague. Paulo, we miss you deeply and will always remember you. Thank you for all we have learned from you and all the laughter over the years.

May you rest in peace among the stars.

Session

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3155

DIDACTICS OF TEACHING ASTRONOMY AND ASTROPHYSICS

Dr Afrodita Liliana Boldea

National Institute for R&D in Physics and Nuclear Engineering, Bucharest, Romania. University of Craiova, Romania

Abstract

Education has a purpose that by the terms in which it is formulated has the purpose of forming the profile of the human personality.

In education it is operated with purposes that are related to the dimensions of education, of each level of schooling, the curricular cycles. In the didactic activity, in order to carry out the teaching-learning process the teacher uses different methods, depending on the specific and framework of the topics. The introduction in the educational environment, in Astronomy and Astrophysics discipline, of the information technologies of online communication, of type e-learning, along with the traditional teaching methods according to the principles of didactics, had a major impact on the didactic strategies and the forms of organization of training in the education process.

This work aims to present a didactic project for teaching a lesson in Astronomy and Astrophysics discipline and the implementation of a modern teaching method, as efficient, through the e-Learning Moodle platform, to teach an Astronomy and Astrophysics course, for students. The composition of the didactic project regarding the process of teaching-learning-evaluation to Astronomy and Astrophysics was carried out together with the students from University of Craiova, Faculty of Sciences, during the participation at the course of Didactics of the domain and development in specialization didactics, Master, I year . The experimental part of the lesson taught is represented by the processing with the Astrometrica software, a image package of asteroids, taken with the INT telescope, Isaac Newton Telescope, from La Palma, Spain.

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What Does Moroccan Astronomy Owe to the Oukaimeden Observatory and What Are the Future Perspectives?

Zouhair Benkhaldoun

Oukaimeden Observatory, Cadi Ayyad University, Morocco

Abstract

Morocco's journey in advancing astronomy commenced in the late 1980s with the formation of a group of astrophysicists within the National Center for Scientific and Technical Research (CNRST) in Rabat. These researchers, educated abroad, established the Laboratory of Astronomy and Geophysics (LAG), marking Morocco's trajectory towards a comprehensive research center. Despite initial hurdles, the Laboratory of High Energy Physics and Astrophysics (LPHEA) emerged in 1999, attaining the status of the leading research center at Cadi Ayyad University by 2009. Their dedication led to the formal recognition of the Oukaimeden Astronomical Observatory as a research center in 2009. Subsequently, the Oukaimeden Observatory ascended as one of Africa's premier astrophysical research infrastructures, with international collaborations augmenting research endeavors.

In this contribution, I will present advancements achieved by our team in diverse areas of astrophysics. These include site qualification, exoplanet observation, high-resolution interferometry, solar physics, planetary sciences, and small solar system bodies research, wherein our team excelled.

Looking ahead, Moroccan astronomers aim to expand into space sciences, particularly in Space Situational Awareness (SSA) and Space Weather. These themes promise advancements in understanding celestial phenomena and their impacts on Earth. With ongoing international collaborations and a focus on research and innovation, Morocco's astronomical pursuits are poised to continue flourishing globally.

Session

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3168

Research on access, use and effective exploration of astronomical data from sonification

Johanna Casado

Instituto de Bioingeniería, Facultad de Ingeniería, Universidad de Mendoza

Abstract

Data analysis in space sciences has been performed exclusively visually for years, despite the fact that the largest amount of data belongs to non-visible portions of the electromagnetic spectrum. This, on the one hand, limits the study of the unknown to the current resolution possibilities of the screens, and on the other hand, it excludes a group of people who present some type of visual disability. Taking into account the aforementioned, and the barriers that people with disability face to achieve academic studies and stable jobs, the present investigation focuses on new modalities of access to the data, but taking into account the accessibility and inclusion from the beginning. It has been shown that multimodal perception (use of more than one sense) can be a good complement to visual exploration and understanding of complex scientific data. This is especially true for astrophysical data, composed of a sum of different oscillatory modes resulting in the final complex data array. This proposal focuses on the human ability to adapt to data and interaction with sound, in order to analyze data sets and produce an application aimed at leveling the possibilities of access to information in the field of physics and astronomy for people with disabilities. In addition, it proposes the study of scientific and technological capacities for the generation of tools with a novel approach, focused on the user and oriented to: a specific social problem, the use of free programming languages and the design of infrastructure to improve inclusion.

Session

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3174

SciAccess: Best Practices for Accessibility in Astronomy Education and Outreach

Anna Voelker[1], Caitlin O'Brien[2]

[1]SciAccess, Inc. [2]SciAccess, Inc. | The Ohio State University

Abstract

SciAccess is an award-winning nonprofit dedicated to advancing disability inclusion and equity in STEM education, research, and outreach. This poster will showcase accessible astronomy best practices that have been discovered through the following:

(1) The SciAccess Conference, an annual international conference bringing together STEM educators, astronomers, disability advocates, and students to design and disseminate best practices in STEM accessibility.

(2) The Zenith Mentorship program, which provides blind high schoolers with astronomy mentorship and the opportunity to engage in experiential learning through tactile 3D models, sensory astronomical graphs, and data sonification.

(3) AstroAccess, which works with disabled individuals to research universal design in space architecture, making concrete advancements in access to space exploration.

(4) Solstice, which uses a state-of-the-art portable planetarium system to bring immersive, engaging astronomy outreach in the form of planetarium shows to underserved communities.

This poster will highlight key takeaways from the above programs, offering concrete guidance on accessible astronomy best practices and outreach strategies. This will include an overview of accessible astronomy resources, where attendees will be invited to interact with 3D printed models of astronomical bodies to demonstrate that tactile resources designed for blind users can improve comprehension for all people. Participants will leave with a new understanding of astronomy accessibility and the resources and connections they need to play a part in engaging the next generation of diverse scientists and researchers.

Session

Division C Education, Outreach and Heritage

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The Africa Radio Astronomy Programme

Mrs Carla Mitchell

South African Radio Astronomy Observatory

Abstract

The new Africa Radio Astronomy Programme (ARAP) is broader than the original African VLBI Nework (AVN) and, although it still incorporates VLBI implementation activities, it also aims to capitalise on the achievements to date while reflecting on the challenges encountered in order to design a coherent programme that will accelerate the SKA Africa partnership objectives. The new Africa Radio Astronomy Programme strategy was approved in June 2023. Implementation will be customised to the basic needs and agendas of each Africa Partner Country (APC) towards technology, industry and academic advancement. The vision of the programme is for the sustainable establishment of African science and technology networks and skills, and growth of science and technology capacity in the SKA APCs. Next steps include the roll out of the TART training instruments, to be distributed to each APC during 2024, high performance computing and data intensive analytics implementations and training, and the 3-metre interferometer dishes will be designed, manufactured and installed in each country through the period from 2024 to 2026. These instruments will be used for interferometry and single-dish science and a 5 stage training programme will be implemented in partnership with DARA. These and other activities and partnerships are based on three main pillars: Human Capital Development, Research and Technology Infrastructure; and Funding, Governance and Partnerships. Each pillar is centred around specific and intentional activities, that are aimed at solidifying the impact of the strategy on the development of astronomy and its resultant socio-economic impacts in the partner countries.

Session

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3181

Unlocking the African Sky: Strategies for maximizing the socio-economic development

Mr Takalani Nemaungani

Department of Science & Innovation

Abstract

Africa boasts a rich astronomical heritage and some of the darkest skies on Earth, offering unparalleled potential for astronomy education, outreach, and economic development. This presentation explores a multifaceted approach to unlocking Africa's astronomical potential, highlighting the vital work of organisations like SAAO, SARAO, and the Astro-Tourism Strategy by the Department of Science and Innovation and Department of Tourism.

Astronomy is contributing to skills development, technological development through local innovations, job creation, improvement of educational outcomes and outreach. Online resources and digital learning platforms further democratize access to astronomy education, and initiatives like SARAO's robotics program and school bursaries provide crucial support to the next generation of scientists and astronomers.

Public engagement is fostered through a variety of initiatives. SAAO's Open Nights allow citizens to directly experience the cosmos. Further bridging the gap, SARAO's "Mission MeerKAT" cartoon series makes radio astronomy accessible and engaging through a fun and informative format. Initiatives like the SALT Collateral Benefits Programme leverage SAAO's resources to develop educational materials and support local communities, fostering a deeper public engagement with astronomy.

Astro-tourism aims to go beyond simply viewing the night sky by integrating traditional African starlore and cultural knowledge into astro-tourism experiences creating a unique and meaningful connection for visitors. The Astro-Tourism Strategy provides a framework for developing sustainable astro-tourism projects that benefit local economies while preserving Africa's unique astronomical heritage.

The success of these initiatives hinges on collaboration between government departments, research institutions, and local communities.

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Astro-Reach in Kenyan Schools

Mr Kenneth Monjero

Fun and Education Global Network

Abstract

Astro-Reach is an astronomy outreach program tailored for primary schools in Kenya, aiming to stimulate curiosity and empower learners through practical engagement with celestial phenomena. By employing interactive exhibits, hands-on activities, and captivating demonstrations, Astro-Reach provides students with immersive experiences that demystify the cosmos and inspire a passion for space exploration. Central to its approach are locally designed space suits, representing cultural diversity and inclusivity in STEM fields. Through Astro-Reach, students not only gain knowledge of astronomy but also develop a deeper appreciation for scientific inquiry and the wonders of the universe, fostering a new generation of curious and empowered learners.

Session

Division C Education, Outreach and Heritage

3211

11 CAP Conferences strong – C2 updates from the largest international conference forastronomy communication

Marieke Baan[1], Oana Sandu Barbulete[2], Sylvie Vauclair[3]

[1]NOVA, University of Amsterdam. [2]President Commission C2. [3]Vice-president Commission C2

Abstract

The Communicating Astronomy with the Public (CAP) Conference is the only large-scale, international conference for astronomy communication. The conference is targeted towards professionals from science communication, informal education, planetaria and science centres, as well as professional and amateur astronomers, journalists and creative personalities. This year's CAP2024 in Toulouse, France, was the 11th in the series of conferences organised by the International Astronomical Union (IAU), through Commission C2 Communicating Astronomy with the Public, and the IAU Office for Astronomy Outreach (OAO). Since 2003, CAP conferences have facilitated the exchange of ideas and best practices. The conference helps strengthen the local community of professionals by connecting them to the global network. In this talk, we will present an overview of the conference and how it has evolved over the years.

Session

Division C Education, Outreach and Heritage

3214

The present state of Higher Education in the Gaza strip and the West Bank with a focus on astronomy

Jamal Mimouni

Department of Physics, University of Constantine1, Algeria

Abstract

This presentation will highlight the severe challenges faced by the academic community in conflict zones, with a specific focus on the Palestinian occupied territories. The ongoing conflict in the Gaza Strip and the West Bank has had profound implications on various aspects of life, including higher education. In the Gaza Strip, most of the educational infrastructure has been devastated, and universities and institutions of higher learning have been systematically destroyed. A stark example of this devastation is the fate of the "UNESCO Palestine Chair in Astronomy, Astrophysics & Space Sciences," which we personally inaugurated in 2012 in Gaza alongside UNESCO chair holder Prof. Suleiman Baraka. The center was obliterated in the recent events, along with Gaza Islamic University, where it was located, and Al-Aqsa University, where the classes were held. All the students working at the center had their academic lives disrupted as they became refugees, and many were tragically killed. This presentation underscores the necessity of sanctuarizing academic institutions, much like hospitals and other vital facilities, to protect them from the ravages of conflict. The dire situation faced by the inhabitants of the Gaza Strip and the West Bank. It also highlights the urgent need for international support and solidarity to rebuild educational infrastructure in these regions.

Session

Division C Education, Outreach and Heritage

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Government and science engagement sector contribution in astronomy

Shadrack Mkansi

NRF-SAASTA. ASSA Jhb Central. Beijing Global Network of Science Festivals (BGNSF). ICORSA. SAASTEC Ex-Officio

Abstract

Astronomy is an easily accessible scientific area with a naturally accessible resource. The science engagement sector, majority of whom are science centres, are one of the great contributors to the communication of astronomy in the country. Science centres are found in all nine (9) provinces of the country. They are easily accessible to most community members because they are found within various economic levels of communities. Through science centres and other science engagement community astronomy has been communicated widely in most communities in all 52 municipalities in the country. This paper will show the landscape of the science engagement sector in the country and then give a special focus on the distribution of science centres. We will look at the impact this has in the astronomy subject area. There are resourcing challenges but this paper will show how the government resources were able to provide capacity for science engagement community to communicate astronomy. The impact of the types of resources provided by government and other sectors in astronomy awareness will be covered. Lastly we will look at how resources can be maximised to ensure that we have a continuous astronomy engagement throughout the country in all municipalities and all communities. The paper will show how government support changed the level of astronomy awareness to be where it is today.

Session

Division C Education, Outreach and Heritage

Final category: Division D High Energy Phenomena and Fundamental Physics

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Acceleration of Ultra-high-energy Cosmic Rays in Relativistic Jets of Giant Radio Galaxies

Prof Hyesung Kang[1], Prof Dongsu Ryu[2], Dr. Jeongbhin Seo[3]

[1]Pusan National University. [2]Ulsan National Institute of Science and Technology. [3]Los Alamos National Laboratory

Abstract

In this study, we investigate cosmic ray (CR) acceleration processes within FR-I and FR-II radio galaxies through a series of relativistic hydrodynamic simulations, encompassing relativistic jets characterized by varying powers and bulk Lorentz factors. Monte Carlo simulations are subsequently employed to model the transport, scattering, and energy changes of CR particles, facilitating the calculation of particle acceleration within the simulated jet-induced flows. Our results indicate that diffusive shock acceleration in the jet-spine and backflow energizes CRs up to approximately 1 EeV. At higher energies, however, relativistic shear acceleration across the jet-backflow interface becomes more significant. The time-asymptotic energy spectrum of CR particles escaping from the jet system can be represented by a double power law with an extended exponential cutoff. We demonstrate that the charge-dependent break energy is primarily governed by the jet power, but with weak dependencies on the jet size and background density. Notably, the conventional exponential cutoff is extended through the energy boost achieved via non-gradual shear acceleration, proportional to the square of the mean Lorentz factor of the jet. Our analysis demonstrates that more relativistic jets with higher bulk Lorentz factors can generate energy spectra extending to higher energies, resulting in elevated particle flux and a lighter mass composition at the high-energy tail. These findings provide valuable insights into the acceleration of ultra-high-energy cosmic rays within giant radio galaxies.

Session

Division D High Energy Phenomena and Fundamental Physics

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X-Ray Polarization Variability of High Spectral Peak BL Lacertaes: Cases of 1ES 1959+650 and PKS 2155--304

Dr. Jin Zhang

Beijing Institute of Technology

Abstract

The high-energy-peaked BL Lacertae objects (HBLs) are the main targets of the Imaging X-ray Polarimetry Explorer (IXPE) for investigating the mechanisms of radiation and particle acceleration in jets. In this paper, we report the first IXPE observations of two HBLs, 1ES 1959+650 and PKS 2155--304. Both sources exhibit X-ray polarization with a confidence level exceeding 99%, as well as significant variability in polarization across different time intervals and energy ranges. Notably, PKS 2155--304 demonstrates the highest X-ray polarization among all blazars detected by IXPE within its entire energy band (2--8 keV), with a polarization degree of Π_X=21.9%±1.9% (MDP_{99}=6.0%). An even higher polarization is observed in the 3--4 keV band, reaching Π_X=28.6%±2.7 (MDP_{99}=8.1%) with a confidence level of 10.8σ. Furthermore, no polarization is detected above 5 keV energy band. For 1ES 1959+650, the highest detected polarization degree in the 2--8 keV band is Π_X=12.4%±0.7% (MDP_{99}=2.2%), with an electric vector position angle (EVPA) of Ψ_X=19.7°±1.6°. The X-ray polarization of 1ES 1959+650 exhibits evident variability, accompanied by the variations of Ψ_X, flux, spectrum, and energy bin. We discuss possible implications of these observational findings, including the variability in polarization, rotation of EVPA, and transition between synchrotron and synchrotron-self-Compton. We speculate that the X-rays observed during different IXPE observations originate from distinct regions in the jet and may involve diverse mechanisms for particle acceleration.

Session

Division D High Energy Phenomena and Fundamental Physics

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A Comprehensive Multi-Frequency Analysis of the Radio Phoenix in the Abell 85 Cluster

Ramij Raja[1], Majidul Rahaman[2], Prof. Abhirup Datta[3], Prof. Oleg Smirnov[1,4]

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Abstract

Radio phoenixes are intricate and filamentary diffuse radio sources discovered in both merging and relaxed clusters. It has been suggested that these sources form due to the adiabatic compression of aged Active Galactic Nucleus (AGN) plasma within shock waves. Previous studies on these sources primarily focused on integrated spectral indices, which were found to be steep and exhibited a curved spectrum. In this study, we conducted a multi-frequency investigation of the radio phoenix in the Abell 85 cluster. Utilizing sensitive high-resolution observations, we identified finer filamentary structures that had previously gone unnoticed. Resolved spectral index maps of the radio phoenix were generated across frequencies ranging from 148 to 1280 MHz. Analysis of filament orientation and spectral index gradient suggests a potential direction of shock motion from northeast to southwest. The integrated spectral index of the radio phoenix was notably steep, with a break observed around 700 MHz, indicating recent re-energization of fossil electrons. Furthermore, filament spectral indices were found to be less steep compared to non-filamentary regions, suggesting higher energy injection in the filaments. These findings support the adiabatic shock compression mechanism as the likely explanation for the observed features in the radio phoenix in the Abell 85 cluster.

Session

Division D High Energy Phenomena and Fundamental Physics

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White dwarfs in Gaia survey to constrain the fine-structure constant

Dr. Surajit Kalita[1], Mr. Akhil Uniyal[2], Prof. Sayan Chakrabarti[3]

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Abstract

This abstract is primarily based on MNRAS 527 (2024) 232 and ApJ 949 (2023) 62. Understanding various physical mechanisms requires an understanding of fundamental constants, however, measurements of these constants are subject to error due to experimental constraints. Researchers have proposed several bounds on fundamental constants based on a variety of experiments and observations. These constraints are different primarily because of the energy scale of the systems used in the studies. We investigate the impact of system temperature and the effect of the underlying theory of gravity on these uncertainties using white dwarfs observed in the Gaia data survey. In my talk, using the structures of these white dwarfs, I will show that variations in temperature as well as the underlying theory of gravity can affect the accuracy of measurements for fundamental constants such as the fine-structure constant and the proton-to-electron mass ratio. This exploration emphasizes the importance of considering the energy of a system when putting bounds on fundamental parameters.

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Energy-dependent polarization of Gamma-Ray Bursts' prompt emission with the POLAR and POLAR-2 instruments

Nicolas De Angelis

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Abstract

Gamma-ray bursts (GRBs) are among the most powerful and violent events in the Universe. Despite half a century of observations of these transient sources, many open questions remain about their nature and the physical emission mechanisms at play. Polarization measurements of the GRB prompt emission have long been theorized to be able to answer most of these questions.

To characterize the polarization of these prompt emissions, a compact Compton polarimeter, called POLAR, has been operated for 6 months on the Tiangong-2 space lab starting September 2016. The instrument detected 55 GRBs as well as several pulsars. Time-integrated polarization analysis of the POLAR GRB catalog has shown that the prompt emission is lowly polarized or fully unpolarized. However, time-resolved analysis depicted strong hints of an evolving polarization angle within single pulses, washing out the polarization degree in time-integrated analyses.

Here we will present the first energy-resolved polarization measurements of GRB prompt emission. The novel analysis, performed on several GRBs using the POLAR data, will provide new insights and alter our understanding of GRB polarization. The analysis was performed using the 3ML framework to fit the polarization parameters as a function of the energy in parallel to the spectral parameters. Although limited by statistics, the results could provide a very relevant input to disentangle between existing theoretical models. The presentation will conclude with prospects for energy-resolved polarization measurements using the upcoming POLAR-2 mission.

Session

Division D High Energy Phenomena and Fundamental Physics

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A polarized view of the pulsar wind nebulae with IXPE

Dr. Fei Xie

Guangxi University, China

Abstract

Pulsar wind nebulae (PWNe) are powerful sources of non-thermal X-ray radiation, which is intrinsically polarized due to synchrotron emission. The magnetic field strength and structure in these sources play a crucial role in shaping their dynamics, energetics and evolution, as well as in accelerating particles to very high energies. X-ray polarimetry can provide unique insights into understanding the local orientation and degree of order of the magnetic field, as well as the distribution and spectrum of the emitting particles. In this talk, I will review the current status and future prospects of X-ray polarimetry applied to extended source PWN, with a focus on the Imaging X-ray Polarimetry Explorer (IXPE) mission, which is a NASA/ASI explorer launched in December 2021.

Session

Division D High Energy Phenomena and Fundamental Physics

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A study of the polarization and RM of pulsars in globular clusters with MeerKAT and FAST

Dr Lei Zhang

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

Magnetic fields are found in astronomical objects of all scales. One class of objects where magnetic fields have been very hard to observe and study is globular cluster (GC). There is very limited evidence of intracluster medium within GCs. For this reason traditional techniques to detect magnetic fields like synchrotron emission or rotation measure (RM) from the gas are not effective. The limited number of studies that have focused on the magnetic fields towards GCs used information derived from pulsars. In the last few years, the total known population of GC pulsars has increased dramatically, jumping from about 150 objects known in 2018, to more than 300 known today. Such a surge in new discoveries and the consequent "renaissance" of the field has been possible mainly thanks to two major radio facilities that have recently been built: the FAST radio telescope in the northern hemisphere and the MeerKAT radio telescope in the southern hemisphere. In the talk, I will present a study of the polarization and RM of pulsars in globular clusters with MeerKAT and FAST. The goal, among others, is to study the magnetic field in the clusters and small scale magnetic field in the Galactic disk and halo.

Session

Division D High Energy Phenomena and Fundamental Physics

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An Evolutionary Picture of Fast Radio Bursts

Dr. Di Li

NAOC

Abstract

The Five-hundred-meter Aperture Spherical radio Telescope (FAST) has been in operation for four years. Based on a novel high-cadence CAL injection technique, we have designed the Commensal Radio Astronomy FAST Survey (CRAFTS), which realizes, for the first time at any major facility, simultaneous data recording of pulsar search, HI imaging, HI galaxies, and transients (FRB and SETI). CRAFTS has discovered ~200 pulsars, ~10 FRBs including the only persistently active repeater FRB 20190520B, and ~5000 d^2 HI images with 1% calibration consistency, 5-10 times better than what is available from Arecibo. I will discuss FAST's science highlights regarding FRBs, particularly a new evolutionary picture. Critical pieces of evidence include a 10% drop of FRB 121102's DM on a decade time scale, the frequency evolution of active repeaters well described by a single physical parameter sigma_RM, the B field reversal around 190520B, and the intriguing correlation of sigma_RM with PRS. We are starting to reveal a likely explosive event associated with FRBs' origin and their changing complex plasma environments.

Session

Division D High Energy Phenomena and Fundamental Physics

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A spectral and timing study of MAXI J1820+070 during itsoutburst

Mr. Kyle Solomons[1,2], Dr. Sunil Chandra[2,3]

[1]University of Cape Town. [2]South African Astronomical observatory. [3]North-West University

Abstract

This study investigates the spectral and timing characteristics of MAXI J1820+070, a Black Hole X-ray binary, during its 2018 outburst utilizing data from NuSTAR, NICER, and Swift-XRT. Our findings reveal valuable insights into spectral properties, including a power-law index of ~1.6 and an inner disk temperature peaking at 0.8 keV. Furthermore, we identify quasi-periodic oscillations (QPOs) and provide evidence supporting their origin in the corona. Additionally, dynamic hard and soft time lags are observed, indicating a vertically expanding and contracting corona at different stages of the outburst. Notably, we detect potential absorption features between 6.9-7.3 keV, suggesting the presence of outflows. Our comprehensive analysis tracks the evolution of temporal and spectral parameters throughout the outburst, contributing to a deeper understanding of the system's behaviour."

Session

Division D High Energy Phenomena and Fundamental Physics

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Polarized X-ray Signals from Neutron Star Surfaces

Dr. Matthew Baring[1], Dr. Hoa Dinh[1], Dr. George Younes[2], Dr. Kun Hu[3]

[1]Rice University, Department of Physics and Astronomy, Houston, TX 77005, USA. [2]NASA's Goddard Space Flight Center and University of Maryland, Baltimore County, USA. [3]Physics Department, Washington University, St. Louis, MO 63130, USA

Abstract

The intense magnetic fields of neutron stars generate strong anisotropy and polarization of radiation emanating from their surfaces. These emission properties are sensitive to the magnetic field orientation relative to the local zenith, and thus on the hot spot position on the surface. Therefore, phase-resolved intensities and polarizations depend on the angle between the magnetic and spin axes of a star, and an observer's viewing direction. In this talk, we present results from a Monte Carlo simulation of neutron star atmospheres that uses a complex electric field vector formalism to treat polarized radiative transfer due to magnetic Thomson scattering. The atmospheres possess temperature gradients via their hydrostatic equilibrium. General relativistic and QED vacuum birefringence influences on the propagation of light from the stellar surface to a distant observer are taken into account. We outline a range of theoretical predictions for pulse profiles at different X-ray energies, focusing on magnetars and also neutron stars of lower magnetization. A general anti-correlation between intensity and polarization degree is observed, which is naturally connected to the scattering cross section physics. By comparing these models with observed intensity and IXPE polarization pulse profiles for select magnetars, and light curves for other isolated neutron stars, we obtain constraints on the stellar geometry angles and the size and location of the hot spots. For magnetars, we outline how polarization measures might inform us about the level of toroidal twist in the magnetospheric field.

Session

Division D High Energy Phenomena and Fundamental Physics

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Revealing Blazar Jets: A Review of High-Energy Polarimetry of Jets

Ms Lenté Dreyer, Prof. Markus Böttcher

North-West University

Abstract

This presentation will explore the critical role of high-energy polarimetry in our current understanding of blazar jets. The Imaging X-ray Polarimetry Explorer (IXPE), launched in 2021, elucidated high-energy polarimetry. The detection of high degrees of polarization in X-rays suggests ordered magnetic fields and indicates that particle acceleration in blazar jets may proceed through coherent processes like shocks rather than diffusively. IXPE's capability, combined with simultaneous multiwavelength polarization measurements, provides insights into the magnetic topology and the physical processes driving jet dynamics. For instance, the orphan optical polarization swing seen in PG 1553+113 and its different polarization degrees in the X-ray, radio, and optical bands point to emission regions that are either entirely separate or only partially overlapping. A rotation of the polarization angle in the X-rays seen in Markarian 421 supports the idea that helical magnetic fields exist in blazar jets. The presentation will conclude by examining the prospective advancements in jet polarimetry, considering the contributions expected from IXPE, forthcoming instruments, and the ongoing application of Monte Carlo methods to investigate high-energy polarization due to anisotropic Compton scattering, thereby offering pivotal insights into the complex mechanisms operating within blazar jets.

Session

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Turbulence induced fast magnetic reconnection: high resolution 3D MHD simulations of self-sustained turbulent current sheets

Giovani Heinzen Vicentin[1,2], Dr. Grzegorz Kowal[1], Dr. Elisabete de Gouveia Dal Pino[1], Dr. Alex Lazarian[3]

[1]Universidade de São Paulo. [2]Princeton University. [3]University of Wisconsin–Madison

Abstract

Magnetic reconnection plays a crucial role in converting magnetic energy into kinetic and thermal energy in the plasma, being a powerful mechanism to explain solar, pulsar nebulae and AGN flares, heating and particle acceleration. In this work (Vicentin et al. 2024), we study the properties of turbulence induced reconnection using very-high-resolution 3D MHD simulations for a vast parametric space, reaching Lundquist numbers of 10^6. We demonstrate that an initial perturbation in the current sheet drives self-sustained turbulence in the domain of our simulations, providing fast reconnection rates of V_{rec} ~ 0.03-0.08 V_A, where V_A is the Alfvén velocity. These reconnection rates are larger and grow faster than the ones generated solely by resistive tearing mode (plasmoid) instability measured from 2D and 3D PIC/MHD simulations (Huang and Bhattacharjee, 2010, 2016). Notably, the reconnection rates obtained in this work are compatible to the ones obtained in local classical 3D MHD simulations of current sheets (Kowal et al. 2009, 2017, for lower Lundquist numbers) and in 3D (GR)MHD simulations of turbulent accretion flows and relativistic jets (Kadowaki et al. 2018, 2021; Medina-Torrejon et al. 2021, 2023), where no evidence of plasmoid formation was found. In our simulations the reconnection rate reaches a steady state at the same time that turbulence is fully developed. They evidence the independence of the reconnection rate on the Lundquist number, as first proposed by Lazarian and Vishniac (1999), and a weak dependence of V_{rec} on the plasma-beta (the ratio between thermal and magnetic pressure in the plasma).

Session

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Machine-Learning Enhanced Photometric Analysis of the Extremely Bright GRB 210822A

Ms. Camila Angulo-Valdez[1], Dr. Rosa Becerra[2], Dr. Margarita Pereyra[3]

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Abstract

In this talk, I will present analytical and numerical models of the bright long GRB 210822A at z=1.736. The intrinsic extreme brightness exhibited in the optical, which is very similar to other bright GRBs (e.g., GRBs 080319B, 130427A, 160625A 190114C, and 221009A), makes GRB 210822A an ideal case for studying the evolution of this particular kind of GRB.

We use optical data from the RATIR instrument, as well as Swift/UVOT, and X-ray data from the Swift/XRT instrument. The temporal profiles and spectral properties during the late stages align consistently with the conventional forward shock model, complemented by a reverse shock element that dominates optical emissions during the initial phases (T<300 s). We observe a break in the light curve at T=80000 s that we interpreted as evidence of a jet break, which constrains the opening angle to be about θ_j = (3-5) degrees.

Finally, we apply a machine-learning technique to model the multi-wavelength light curve of GRB 210822A using the AFTERGLOWPy library. We estimate the angle of sight θobs=(6.4 ± 0.1) × 10-1 degrees, the energy E_o= (7.9 ± 1.6)× 10^{53} ergs, the electron index p=2.54 ± 0.10, the thermal energy fraction in electrons ε_e = (4.63 ±0.91) × 10^{-5} and in the magnetic field ε_B= (8.66 ± 1.01) × 10^{-6}, the efficiency χ = 0.89 ± 0.01, and the density of the surrounding medium n_o = 0.85 ± 0.01 cm^{-3}.

Session

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Deciphering Blazar Emission Zones through Polarisation and Spectral Energy Distribution Studies

Ms. Hester Schutte[1], Prof. Markus Böttcher[1], Amanpreet Kaur[2], Abe Falcone[2], Joleen Barnard[3], Justin Cooper[3], Brian van Soelen[3], Anton Dmytriiev[4], Haocheng Zhang[5], David Buckley[3,6]

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Abstract

Blazars emit strongly polarised (nonthermal) synchrotron emission detected in the radio through optical-UV/X-ray observations. The dusty torus, broad line region, accretion disk and host galaxy radiate unpolarised thermal emission. Their presence is usually visible in the total polarisation degree observed, because they dilute the synchrotron polarisation. However, in some observations a polarisation decrease is also discernible towards longer wavelengths. This can be described by partially ordered magnetic fields downstream from a shock in the jet. We present co-ordinated observations from the SALT, H.E.S.S., *Fermi* -LAT, *Swift*-XRT, ATOM and LCO. From this, we deduce the presence of different emission zones (one, two and multiple domains) required to simultaneously model the polarisation degree and multi-wavelength spectral energy distributions.

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Division D High Energy Phenomena and Fundamental Physics

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Joint Gamma-Ray Burst Spectro-Polarimetric Analysis with AstroSat-CZTI and POLAR

Mr. Utkarsh Pathak[1], Dr. Nicolas De Angelis[2], Dr. Hancheng Li[3], Dr. Merlin Kole[4], Prof. Varun Bhalerao[1], Dr. Tanmoy Chattopadhyay[5], Dr. Sujay Mate[6], Ms. Ana Bacelj[7], Prof. Dipanker Bhattacharya[8,9], Prof. Gulab Dewangan[9], Prof. Jochen Greiner[7], Dr. J. Michael Burgess[10], Mr. Mithun NPS[11], Mr. Navaneeth PK[9], Dr. Nicolas Produit[3], Prof. Santosh Vadawale[11]

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Abstract

Gamma-ray Bursts (GRBs) are produced by highly relativistic beamed jets powered by a compact central engine. The nature of the central engine and the role of magnetic fields are still open questions to be addressed by high energy polarimetry of the prompt emission, which is widely believed to be the key to disentangling jet outflow composition, emission mechanisms, and energy dissipation. Each physical process gives different degrees of polarized light - low in thermal radiation, and high in synchrotron radiation with a structured magnetic field in the jet. In the past few years, high-energy X-ray polarimeters, AstroSat CZTI (100-600 keV), and POLAR (50-500 keV) have measured the polarization of more than 32 GRBs. Two bursts - namely GRB 170202B and GRB 161218B - were detected by both CZTI and POLAR. We undertake joint analysis of these two GRBs with PolPy, a universal tool developed on the 3ML framework. We forward-fold the model using Bayesian time-integrated analysis, and perform joint spectral fit from various missions, cross-calibrating the polarization using CZTI and POLAR. In this talk, I will showcase the results of our joint spectro-polarimetric fit, and discuss implications for emission models of GRBs.

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Exploring AGN coronae through X-ray polarimetry: insights from IXPE observations

Mr. Daniele Tagliacozzo

Università degli Studi Roma Tre

Abstract

The Imaging X-ray Polarimetry Explorer (IXPE) observed three unobscured radio-quiet AGN during its initial two years of operation (NGC4151, IC 4329A and MCG-05-23-16), retrieving two detections and one tight upper limit. Here we present the results of the X-ray polarimetric analyses of these sources, together with simultaneous XMM-Newton and NuSTAR data. The synergy between these instruments has been fundamental to constrain the physical properties of the hot corona and to assess its geometry, which may hold clues to its physical origin. The outcomes of extensive Monte Carlo simulations will also be presented, exploring insights gained through comparison with real data. Present and future polarimetric observations remain pivotal for understanding the nature of AGN coronae.

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Early Evolution of Long Gamma-Ray Burst Jets: Ultra-Relativistic Hydrodynamic Simulations

Professor Dongsu Ryu, Mr. Seonho Kim, Professor Kyujin Kwak

UNIST (Ulsan National Institute of Science and Technology), South Korea

Abstract

Gamma-ray bursts (GRBs), one of the most energetic phenomena in the universe, involve ultra-relativistic jets with Lorentz factors reaching several hundred. With such large Lorentz factors, simulation studies of these jets require robust codes that can properly handle ultra-relativistic flows. Using a newly developed relativistic hydrodynamic code of high accuracy, we perform three-dimensional simulations of ultra-relativistic jets with Lorentz factors up to ~ 100, to explore the early evolution and structure of long GRB (LGRB). Our simulations incorporate realistic LGRB environments and investigate models with varying jet Lorentz factor, opening angle, density, and pressure, as well as varying ambient medium properties. In the simulations, we identify four distinct regions: the spine, the shocked spine, the shocked ambient medium, and the ambient medium from the interior of the jet outwards. We find that the structure of GRB jets differs from that of the relativistic jets in radio galaxies. Notably, the larger Lorentz factors and non-zero opening angles of GRB jets lead to wider spines. Additionally, instead of the back-flow cocoon, the shocked spine with forward moving flow develops. We analyze shocks, shear, and vorticity in the simulations, quantifying physical properties such as the probability distribution functions of shocks and relativistic shear and the energy dissipation due to shocks and turbulence. Our analysis indicates that shocks and shear predominantly develop within the shocked spine, suggesting that particle acceleration within LGRBs would occur primarily in this region.

Session

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Exploring the Properties of the Black Hole in GRB 220101 Fatemeh Rastegarniaa,1,3 , Rahim Moradib,1,2,4,5 , Shahrzad Sheikhi3 , Samaneh Norouzi3 1 ICRANet, Piazza della Repubblica 10, I-65122 Pescara, Italy 2CAS Key Laboratory for Research in Galaxies and Cosmology, Department of Astronomy, University of Science and Technology of China, Hefei 230026, China 3Department of Physics,Faculty of Physics and Chemistry, Alzahra University, Tehran, Iran 4 ICRA, Dipartimento di Fisica, Universita di Roma "La Sapienza", Piazzale Aldo Moro 5, I-00185 Roma, Italy ` 5 INAF – Osservatorio Astronomico d'Abruzzo, Via M. Maggini snc, I-64100, Teramo, Italy

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Abstract

The recent confirmation of black hole births in GRB 130427A and GRB 190114C, coupled with parallels drawn from GRB 180720B, provides a robust foundation for studying the properties of the black hole in GRB 220101A. In our approach we consider the "inner engine" as a rotating Kerr BH of mass M and dimensionless spin parameter α, a magnetic field of strength B0 aligned and parallel to the rotation axis, and a very low-density ionized plasma. We show that in GRB 220101A the BH mass M = 6.15M⊙, α = 0.95, Mirr = 4.98M⊙ and B0 ≈ 109G can lead to a high-energy (≥ GeV) luminosity of 10^51ergs−1 .
Keywords gamma-ray-burst · black hole physics · magnetic fields

Session

Division D High Energy Phenomena and Fundamental Physics

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Understanding the nature of the Partially screened Gap in Pulsars from radio observations.

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Abstract

The single pulse sequence from pulsars is dynamic in nature and shows a number of interesting phenomena like subpulse drifting, mode changing, nulling, periodic intensity modulation, periodic nulling, etc. A non-stationary outflow of plasma is setup along the open magnetic field line region of pulsars due to sparking discharges above the polar cap. The sparking process is thermally regulated due to discharge of ions from the heated polar cap surface forming a partially screened gap (PSG). The magnetic field near the pulsar surface are highly non-dipolar in nature. The sparks undergo variable **E✕B** drift in the PSG that gives rise to subpulse drifting.

In this talk we present the results of our observations, primarily using the GMRT, of the single pulse behaviour from more than 200 pulsars. We have characterised the nature of subpulse drifting, nulling and emission mode changing seen in a large fraction of these sources. We have also demonstrated that periodic intensity modulations and periodic nulling are a new class of emission feature in pulsars with a distinct physical origin than subpulse drifting. The measurements of subpulse drifting features can be be used to constrain the sparking process in PSG. Nulling, mode changing and periodic modulations require rapid transitions between different emission states. Hall and thermoelectric oscillations can perturb the heated polar cap magnetic field to alter the sparking process in the PSG, resulting in the observed transitions of the radio emission states.

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IXPE observation confirms a high spin value in the accreting black hole 4U 1957+115.

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Abstract

X-ray binaries are key sources for understanding the accretion and ejection processes around compact objects. Multiwavelength monitoring of these sources showed that the X-ray emission comes from the inner regions of the accretion disk. Parallely, optical spectroscopy gives valuable information about the companion star parameters. Resolving the intricate geometry of X-ray binaries requires precise measurements of the polarimetric properties of the source. Since the launch of the Imaging X-ray Polarimetry Explorer (IXPE) in 2021, constraining the shape of the corona around stellar-mass black holes is now possible. We present the first X-ray polarimetric observation of the low-mass X-ray binary 4U 1957+115 in its persistent high/soft spectral state, performed with IXPE in May 2023. These unique measurements enabled estimates of the BH spin and the inclination of the system.

Session

Division D High Energy Phenomena and Fundamental Physics

1112

X-ray polarization properties across black-hole accretion states

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Abstract

Accreting black holes represent unique laboratories to study physics under extreme gravity. The X-ray polarization measurements put constraints on the geometry of accretion flow and may also provide independent estimates of the black hole spin when the matter accretes in the form of a thin accretion disk. A recently launched Imaging X-ray Polarimetry Explorer has observed about a dozen accreting stellar-mass black holes in various accretion states. In my talk, I will discuss how the X-ray polarization properties depend on the accretion state and which observational constraints we got from the observations.

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1134

The culprit for the termination of Mars'magnetic field: Dark Matter

Ms Javeria Makda, Dr Geoff Beck

University of the Witwatersrand

Abstract

In this work we derive limits on the WIMP-nucleon scattering cross-section by comparing the potential heat flow within the Earth from Dark Matter capture and subsequent annihilation to the observational value. This effect has been argued previously in the literature to provide a potential link to mass extinction phenomena on Earth. However, we focus on whether additional heat-flux from dark matter annihilations within the Martian core could have affected the decay of its geodynamo, and thus precipitated its magnetic field loss. We determine that Xenon1T limits on the WIMP nucleon cross-sections do not allow sufficient heating to significantly affect either Earth or Mars. We then use this to determine the local dark matter density and the density of a dark matter sub-halo that would support a significant effect given these limits. In addition, we have extended previous work on this topic by including resonant collisional effects, considering the impact of Xenon1T limits, and by considering possible effects on the evolution of the Martian geodynamo. We have lastly presented the possibility of Mars coming into contact with such a sub-halo.

Session

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PolPy: A universal tool for X-/gamma-ray polarimetry using common data format standards

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Abstract

Over the past few years, X-/gamma-ray polarimetry has witnessed a boom with great results from missions like *POLAR*, *AstroSat*/CZTI, *IXPE* and *XPoSat*/POLIX. Furthermore, the numerous missions in the pipeline (e.g. *POLAR-2, COSI*, *LEAP*, *Daksha*, *eXTP*, etc.) that are dedicated or are capable of measuring X-/gamma-ray polarisation indicate coming-of-age for the field. Hence, going forward it is important to set standards for effective use of the data generated by current and future missions. We present *PolPy*, a universal tool that can be used for multi-instrument spectro-polarimetric analysis of data from current and future space-based X-/gamma-ray missions using common data format standards. We have defined the standards in consultation with several mission teams, and they are based on the well-established OGIP standards for spectroscopy. In its present format, *PolPy* utilises the Multi-Mission Maximum Likelihood (3ML) framework as the backend to fit spectro-polarimetric parameters; however, it can be easily extended to incorporate any other data analysis framework. The tool is instrument-agnostic and hence can be easily used for cross-instrument joint analysis if the data and response standards are followed. In this talk, I will present the common data and response standards which we have developed for X-/gamma-ray polarimetry, the *PolPy* package, and results of polarisation analysis using *PolPy* for two GRBs from *POLAR* and *AstroSat*/CZTI as an example.

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Evolution of QPOs and other timing-spectral parameters of Swift J1727.8-1613 during the 2023 outburst observed with NICER and NuSTAR

Dr. Ramanshu P. Singh

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Abstract

Several *NICER* and one *NuSTAR* observation have been analyzed for QPOs and other time-lag parameters of the newly discovered LMXB Swift J1727.8-1613 since it underwent into an outburst in mid-2023. Using *GHATS*, we observed the presence of type-C LFQPOs with varying centroid frequency in range 0.35-1.45 Hz. With the light-curves from NICER observation, hardness parameter has also been computed in 0.3-2.0 keV, 2.0-4.0 keV and 4.0-10.0 keV to trace the transition states. Further, we also analyzed the time-lag properties with *pyLag* and the results suggest that during the hard to soft transitioning state, the reverberation lags become wider and prominent at lower Fourier frequency. A model fit of const*tbabs*plabs(diskbb+relxillcp+cutoffpl) for the energy spectra in XSPEC suggests the inclination angle to be ~39.87 degree and spin to be ~0.978.

Session

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1392

Adding Gamma-Ray Polarimetry to the Multi-Messenger Era

Merlin Kole[1,2], Nicolas Produit[1], Francesco Iacovelli[1], Michele Mancarella[3]

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Abstract

Many open questions remain regarding the emission from the high energy transient events known as Gamma-Ray Bursts (GRBs). Studies of the spectral and timing properties of both their bright prompt gamma-ray component as well as the longer lasting afterglow have taught us much about these extreme events. However, questions regarding the origin of the prompt gamma-rays as well as the structure of the jets in which they are thought to be emitted remain unanswered to this day. This can soon change thanks to the emergence of two novel measurement types: Gravitational Wave (GW) astronomy and high energy polarimetry. Here we explore how these two can complement one another. The polarization degree (PD) of the gamma-ray emission has long been thought to hold vital information regarding the emission mechanism. The polarization angle (PA), however, cannot be easily used as the orientation of the progenitor is not known. GW measurements can, in the near future, however measure this orientation. We will show here how information from GW measurements will improve model discrimination when combining it with the PD. Furthermore we will show how GW measurements will enable the PA to be used in this analysis. Furthermore, we will discus how, in addition, measurements with radio and optical can further complement such studies. Finally, the number of anticipated joint detections between current GW detectors and upcoming polarimetry missions such as POLAR-2, Daksha and LEAP will also be presented.

Session

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1400

Relativistic viscous accretion flow model for BH-ULX sources with XMM–Newton observations

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Abstract

We develop a model formalism to study the structure of a relativistic, viscous, optically thin, advective accretion flow around a rotating black hole in presence of radiative coolings. We use this model to examine the physical parameters of four black hole Ultra-luminous X-ray sources (BH-ULXs), namely mass ($M_{\rm BH}$), spin ($a_{\rm k}$) and accretion rate (${\dot m}$), respectively. While doing this, we adopt a recently developed effective potential to mimic the spacetime geometry around the rotating black holes. We solve the governing equations to obtain the shock induced global accretion solutions in terms of ${\dot m}$ and viscosity parameter (α). Using shock properties, we compute the Quasi-periodic Oscillation (QPO) frequency ($\nu_{\rm QPO}$) of the post-shock matter pragmatically, when the shock front exhibits Quasi-periodic variations. We also calculate the bolometric luminosity ($L_{\rm bol}$) of the entire disc for these shock solutions. Utilizing $\nu_{\rm QPO}$ and $L_{\rm bol}$, we constrain BH-ULXs mass by varying their spin ($a_{\rm k}$) and accretion rate ($\dot m$). We find that NGC6946 X$-$1 and NGC5408 X$-$1 seem to accrete at sub-Eddington accretion rate provided their central sources are rapidly rotating, whereas IC342 X$-$1 and NGC1313 X$-$1 can accrete in sub/super-Eddington limit irrespective to their spin values.

Session

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Unrevealing pulsar radio beam shape.

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Abstract

Pulsar radio emission originates around 50-100 stellar radii above the surface, with the plasma responsible for the emission formed due to sparking in an inner acceleration region above the polar cap. The radio emission originates from the region of the open dipolar magnetic field lines that can be broadly considered as an emission beam. The most widely accepted model of the average emission beam consists of a central core component surrounded by two concentric rings of conal components. We have found the average emission beam to show evolution with pulsar parameters, particularly rate of the rotational energy loss, dE/dt. The traditional model seems to be more more applicable for older pulsars with lower dE/dt. Deviation from the above emission beam model occurs for younger pulsars, in higher dE/dt range. Interestingly other emission features like subpulse drifting and degree of polarisation also show dependence on dE/dt.

Our aim is to establish the average emission beam of the pulsar population using the publicly available databases from telescopes like MEERKAT, FAST, Parkes, etc. We have compiled the largest dataset of fully polarised average profiles (approx. 1800 pulsars), over a wide frequency range between 100 MHz and 5 GHz. These studies covers detailed characterisation of the average profile properties like profile classification, measurement of the profile as well as individual components widths, estimating the line-of-sight geometry, etc. This will enable us to estimate the average emission beam and study their evolution with different parameters like observing frequency, dE/dt, etc.

Session

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Studying the geometry of the emitting region in X-ray binaries using optical and X-ray polarimetry

Prof Juri Poutanen

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Abstract

The launch of the Imaging X-ray Polarimetry Explorer (IXPE) in Dec 2021 opened a new era in the study of compact astrophysical objects. For unresolved sources, polarimetry is the only way to learn about the source geometry. In this talk, I will highlight the progress made thanks to IXPE in understanding the geometry and physics of emitting regions in accreting black holes and neutron stars. High-precision optical polarimetry complements these studies by adding information about the orientation of binary systems in the sky.

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1515

Radio Pulsars with gigahertz-peaked spectra

Jaroslaw Kijak

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Abstract

The discovery of gigahertz-peaked spectra pulsars (GPS) revealed new aspects inthe field of pulsar spectra. Until today we know of more than 30 objects that show high-frequency turnover in the spectrum, between 0.5 and 2.0 GHz, and in the case of radiomagnetars the peak frequencies are above 2 GHz. The GPS phenomenon in pulsars is most likely a result of thermal free-free absorption of the pulsar flux in specialized environments along the line of sight. The appearance of the GPS in these pulsars is often related to the environments these objects reside in, such as pulsar wind nebulae (PWN), supernova remnant (SNR) nebulae, or H II regions.

The spectral nature in these objects were studied using the thermal free–free absorption model. The results of the fits were then used to estimate the physical properties of the absorbing electron gas: its density, temperature, and possible sizes of the absorber. In the summary we present and discuss the properties of the entire GPS pulsar population.

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1523

Wide-Band Observations of Pulsar Radio Emission

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Abstract

Pulsar radio emission is currently poorly understood, especially the wide-band coherent emission process. To arrive at a consistent theory which explains all observed emission features, other phenomena such as moding, nulling, and profile evolution must be examined in the wide-band context. For this purpose a radio receiver capable of receiving wide-band radio signals such as the Ultra-BroadBand receiver (UBB) is needed. The UBB is a novel receiver on the Effelsberg 100 meter radio telescope. The UBB is capable of detecting radio emission in the frequency ranges from 1.3 GHz to 6 GHz. This bandwidth is larger than typical receivers which is particularly interesting for studies which analyze properties that vary in frequency. Understanding the frequency dependent properties will not only help in understanding emission mechanisms of pulsars but can also lead to better timing precision for pulsar timing array experiments such as the European Pulsar Timing Array.

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1583

Quasi-two-dimenstionality of three-dimensional, magnetically dominated, decaying turbulence

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Abstract

Decaying magnetohydrodynamic (MHD) turbulence is important in various astrophysical contexts, including early universe magnetic fields, star formation, turbulence in galaxy clusters, magnetospheres and solar corona. Of particular interest are systems that are not driven by external agencies, i.e., are freely decaying and are magnetically dominated. An example in focus is the magnetic fields in the intergalactic medium, which are thought to be of primordial origin. Previously known in the nonhelical case, we show that magnetic reconnection is important also in the fully helical case and is likely the agent responsible for the inverse transfer of energy. Again, in the fully helical case, we find that there is a similarity in power law decay exponents in both 2.5D and 3D simulations. To understand this intriguing similarity, we investigate the possible quasi-two dimensionalization of the 3D system. We perform Minkowski functional analysis and find that the characteristic length scales of a typical magnetic structure in the system are widely different, suggesting the existence of local anisotropies. Finally, we provide a quasi-two-dimensional hierarchical merger model which recovers the relevant power law scaling. In the nonhelical case, we show that a helicity-based invariant cannot constrain the system, and the best candidate is still anastrophy or vector potential squared, which is consistent with the quasi-two-dimensionalization of the system. Studying the decay properties of these systems is vital to estimating the evolution of the strength and scale of cosmological magnetic fields. Thus, our findings could have far-reaching implications for the physics of the early universe.

Session

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1613

Polarization signatures from blazars: A key observable for high energy emission mechanism

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Abstract

The distinctive low-energy hump observed in the broadband spectral energy distribution (SED) of blazars is a result of synchrotron radiation from relativistic particles in their jets. In the case of high synchrotron peaked (HSP) blazars, the observed X-ray emission falls within the high-energy tail of the synchrotron portion of the SED, allowing X-ray polarization measurements to provide constraints on the mechanisms governing particle acceleration in their jets. We present results on the X-ray polarization measurements of 1ES 1959+650, PKS 2155-304, Mrk 421 and 3C 454.3 based on observations carried out by the Imaging X-ray Polarimetry Explorer (IXPE). Also, we carried out model fits to the broad band SED of all the IXPE observed sources in order to understand the high energy emission processes. We found that sources with detectable X-ray polarization are all HSP blazars and their SEDs are well fit by leptonic models. Details of the results will be presented.

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Multi-Screen scattering in Fast Radio Bursts

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Max Planck Institute for Radio Astronomy

Abstract

Fast Radio Bursts (FRBs) are known for their scintillation and scattering phenomena, often attributed to multiple screens within the interstellar medium (ISM). These plasma screens, spanning from 1-100 AU in scale, cause multipath propagation and angular broadening of single pulses. When two screens appear "pointlike" to each other, they scintillate on both small and large scales, aiding in constraining scattering to FRB host galaxies.In this study, we use simulations to explore this regime, revealing that when one screen resolves the other, it quenches Milky Way scintillations.

We introduce a new theoretical framework to study multi-screen scattering of single pulses, considering the cosmological nature of FRBs and the screens involved. Our primary goal is to understand how pulses appear when screens resolve each other, allowing us to distinguish such systems.

Simulations show that changes in the scintillation pattern over time in the dynamic spectra of the pulse I(t,v) is the key. Moreover, we propose an updated formula for locating the host galaxy screen from the FRB source, giving insights into probing extragalactic ISM structures at AU scales. This approach also opens up avenues in calculating the velocities of such plasma screens, particularly when a sufficient number of bursts allows for the analysis of secondary spectra.

An intriguing prospect is the use of such screens as cosmic lenses to constrain emission region sizes from pulsars, FRBs, and other coherent emissions from neutron stars. Through simulation studies, we have devised a novel observational technique for this purpose.

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1674

Exploring possible effects of the dark sector on neutron stars

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Abstract

The potential relationship between the baryonic and the dark sector of the universe is investigated in order to explore the possible effects of dark energy and dark matter in the structure of neutron stars. In our approach, a fraction of the dark components depend on the energy density of the baryonic matter. It is also discussed how the equation of state of dark energy, $p_{de} = \omega \rho_{de}$, affects the convergence of the mass-radius relation for constant and variable ω. As expected, the results are heavily dependent on the proportion of each component present in the interacting scenario. When the dark fluids interact and the amount of dark energy exceeds that of dark matter, there is an increase in mass and radius (although less apparent) in comparison to the baryonic case. This outcome is consistent with recent observations, which indicate increasingly higher masses.

Session

Division D High Energy Phenomena and Fundamental Physics

1693

Radio pulsars: a polarized perspective

Dr Lucy Oswald

University of Oxford

Abstract

Polarimetry of the radio emission from pulsars is a unique probe of the structure and evolution of the neutron star magnetosphere. In 1969, Radhakrishnan and Cooke proposed the "rotating vector model" as an explanation of the linear polarization angle properties of radio emission from the Vela pulsar, and in doing so opened up a wealth of possibility for mapping neutron star magnetic field geometries. With more polarimetric observations came the discovery of orthogonal polarization modes of pulsar radio emission, and further investigation, both observational and theoretical, revealed additional complexity in terms of orthogonal and non-orthogonal behaviour, circular polarization, and the relationship of these observations to the birefringent properties of the pulsar magnetosphere. With modern telescopes we can now probe pulsar radio polarimetry with greater sensitivity and frequency resolution than ever before, revealing insights into how the neutron star magnetic field structure evolves over its lifetime. In this talk, I will review the development of polarimetric studies of radio pulsars over the last half-century, explain what pulsar polarization reveals to us about the neutron star magnetosphere, and look forward to future possibilities in our new era of multi-wavelength polarimetry.

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1807

Spectro-timing Insights into the Neutron Star Low mass X-ray binary GX 340+0

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Abstract

Persistent neutron star low-mass X-ray binaries are a few of the enigmatic sources in the X-ray sky. These sources have been extensively observed with various X-ray missions and still are feebly understood due to their complex evolution. One of the subset of these sources includes Z-sources which trace a peculiar Z-shaped track on the Hardness-Intensity diagram. Z-sources are accrete close to the Eddington limit and trace the HID over a timescale of a few days. In this talk, I will discuss the spectral and timing properties of one of the prominent Z-source GX 340+0 which has been extensively observed with AstroSat. The wideband coverage with AstroSat has proved to be paramount to disentangling the spectral components and the fast time resolution and large effective area of LAXPC provide a unique timing view of the source to constrain the evolving components in the source. I will also discuss some prospects in the X-ray polarisation emission from this source in the context of the recently launched IXPE and XPoSat mission.

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1853

ACCRETION FLOW CHARACTERISTICS OF A BLACK HOLE CANDIDATE; MAXI J1535-571

mr Ambrose EZE[1,2], Prof Romanus EZE[3], Prof Augustine CHUKWUDE[3]

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Abstract

MAXI J1535-571 outburst was an episodic phase of enhanced dramatic changes/disruptions of the accretion disk. These lead to the ejection of optically thick (Keplerian) and optically thin (sub-keplerian) plasma/flow. The emergent thermal (multi-color black body) and non-thermal (power-law) X-radiations originate from the individual manifestations of components of the accretion flow. Hard X-rays are produced when soft photons are thermally or inverse comptonized by high-temperature electrons in the Compton cloud/post-shock region. The variations/fluctuations of components of the accretion flow create propagating oscillatory shocks/humps (Quasi-periodic oscillations) when the resonance condition is satisfied. Mass accretion rates are intrinsic properties of the accretion flow, and their variations/fluctuations seem to regulate other accretion flow characteristics. In this study, spectral analysis of MAXI J1535-571 data observed by the three X-ray missions (*MAXI/GSC, Swift/BAT*, and *NuSTAR*) during the hard-intermediate state was carried out using HEASoft version 6.26.1 and its software packages, and standard pipeline product of each detector. Spectral fittings/modeling data was done in XSPEC version 12.10.1f using a combination of selected XSPEC and TCAF models. These models gave a statistically acceptable fit with a reduced Chi-squared value of ≤ 1.0. The accretion flow characteristics were constrained, and their correlation with one another suggests that the saturation effect and variations/fluctuations of other accretion flow characteristics, intermittent/flickering behavior, and origin of photon index–QPO frequency (Γ–νQPO) relation are tied to the variations/fluctuations of the mass accretion flow rates.

Keywords; MAXI J1535-571, outburst evolution, hard X-rays, accretion flow characteristics; mass accretion rates.

Session

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1910

A GPU-accelerated approach for realistic radiative cooling in black hole X-ray binary simulations

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Abstract

Observational evidence of low-mass black hole X-ray binary systems (XRBs) reveals significant spectral changes over short periods, often associated with state transitions and accompanied by substantial alterations in the accretion flow. There is a great effort in simulating these systems using general relativistic magnetohydrodynamic (GRMHD) codes because the intricate interplay of magnetic topology, thermodynamics, and radiative processes imposes challenges. The cooling involved in these systems is not trivial to implement and can increase the computational cost considerably. In this paper, we propose an approach to address this challenge by incorporating a realistic cooling prescription, such as bremsstrahlung, synchrotron, and inverse Compton effects, in the GPU-accelerated code H-AMR leveraging the capabilities of GPU's texture memory. We observe a considerable speed enhancement, being approximately 10,000 times faster compared to resolving the equations on the fly. This method can be effective in the studying of the dynamic evolution of these systems, shedding light on the intricate processes involved.

Session

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1985

Polarization of magnetars with high energy instruments

Zorawar Wadiasingh

University of Maryland College Park. NASA Goddard Space Flight Center

Abstract

In this talk I will review the physics of magnetars and recent polarization results of magnetars from high energy instruments such as IXPE. I will also highlight what future polarization measurements may reveal and how quantum electrodynamics could be revealed and tested.

Session

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1987

Blazar physics through broadband radio polarization monitoring

Dr. Ioannis Myserlis[1,2], Prof. Alan Marscher[3], Dr. Svetlana Jorstad[3], Dr. Ramprasad Rao[4]

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Abstract

Blazars, the subclass of jetted AGN with their outflow axes closely aligned to our line of sight, comprise one of the most energetic, long-lived phenomena in the Universe. They are among the main constituents of the high-energy sky, especially in gamma-rays and up to TeV energies, and one of possible sources of astrophysical neutrinos. The low-energy part of their SEDs is understood as incoherent synchrotron emission from their jets, which spans from radio to optical, UV or even X-rays and is both linearly and circularly polarized. On top of their persistent broadband emission, blazar jets often show pronounced variability across the electromagnetic spectrum with timescales from days/months down to minutes.

In this presentation, I will demonstrate our efforts to capture the complex phenomenology of blazar jets through dedicated multi-wavelength polarization monitoring programs using several large radio facilities operating at mm and cm wavelengths. Our observations, which cover two decades of frequency (2.6 GHz — 230 GHz), are used to follow the flux density and polarization variations of our blazar sample with a ~3-week cadence. The linear and circular polarization parameters and their variability are used to constrain the jet physical conditions, such as the magnetic field strength and topology, the particle density and the plasma composition and study their dynamics. In addition, we coordinate with multi-wavelength campaigns, including IXPE or MAGIC, to identify the high-energy emission mechanism of blazar jets based on the expected multi-band polarization characteristics.

Session

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2059

ZWCL 1856.8 : A rare double radio relic system captured within NuSTAR and Chandra field of view

Dr. Aysegul Tumer

MIT Kavli Institute

Abstract

Observations of galaxy cluster mergers provide insights on the particle acceleration and heating mechanisms taking place within the intracluster medium. Mergers form shocks that propagate through the plasma, which result in shock/cold fronts in the X-ray, and radio halos and/or relics in the radio regime. The connection between these tracers and the mechanisms driving non-thermal processes, such as inverse Compton, are not well understood. ZWCL 1856.8 is one of the few known double radio relic systems that originate from nearly head-on collisions observed close to the plane of the sky. For the first time, we study NuSTAR and Chandra observations of such a system that enclose both relics within their field of view. The spectro-imaging analyses of the system provide evidence for a shock front coinciding with the northern relic (M = 1.8), and suggestions of inverse Compton emission at both relic sites.

Session

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Prospects of measuring gamma-ray burst polarization with the Daksha mission

Dr Suman Bala[1,2], Dr Sujay Mate[3], Divita Saraogi[2], Prof Varun Bhalerao[2], Prof. Dipankar Bhattacharya[4], Advait Mehla[2], Parth Sastry[2,5], Dr. N. P. S Mithun[6], Dr. Sourav Palit[2,7], Mehul Chanda[2], C. S. Vaishnava[6], Gaurav Waratkar[2], Prof Shriharsh Tendulkar[3], Prof Santosh Vadawale[6]

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Abstract

The proposed Daksha mission comprises of a pair of highly sensitive space telescopes for detecting and characterizing high-energy transients, such as electromagnetic counterparts of gravitational wave events and gamma-ray bursts (GRBs). Along with spectral and timing analysis, Daksha can also undertake polarization studies of these transients, providing data crucial for understanding the source geometry and physical processes governing high-energy emission. Each Daksha satellite will have 340 pixelated cadmium zinc telluride (CZT) detectors arranged in a quasi-hemispherical configuration without any field-of-view collimation (open detectors). These CZT detectors are good polarimeters in the energy range 100 to 400 keV, and their ability to measure polarization has been successfully demonstrated by the cadmium zinc telluride imager onboard AstroSat. Here, we demonstrate the hard x-ray polarization measurement capabilities of Daksha and estimate the polarization measurement sensitivity (in terms of the minimum detectable polarization: MDP) using extensive simulations. We find that Daksha will have MDP of 30% for a fluence threshold of 10^{-4} erg cm^{-2} (in 10 to 1000 keV). We estimate that with this sensitivity, if GRBs are highly polarized, Daksha can measure the polarization of about five GRBs per year.

Session

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Electron scattering in an extended reprocessing envelope around optical Tidal Disruption Events

Dr. Giorgos Leloudas

DTU Space, Technical University of Denmark

Abstract

Tidal disruption events (TDEs) are panchromatic transient phenomena involving the violent disruption of stars by supermassive black holes, yet the precise origin of their optical luminosity is still debated. Here, we present insights from a sample of TDEs observed in polarized light, primarily with the VLT, incorporating both published (Leloudas et al. 2023) and new data. The analysis of both continuum and line polarization suggests an origin in electron scattering, indicating the presence of an extended reprocessing envelope encircling the accretion disk. Our modeling, utilizing the radiative transfer code POSSIS and different TDE models, including a super-Eddington accretion disk with outflows, produces predictions that align overall with the observed data. Observations of a rare relativistic TDE are consistent with a pole-on view, assuming axial symmetry.

Session

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Localisation of Gamma Ray Bursts using AstroSat Mass Model

Ms. DIVITA SARAOGI[1], Mr. Aditya J Venkata[2], Dr. Varun Bhalerao[1], Mr. Suman Bala[3,1], Mr. Arvind Balasubramanian[4], Mr. Sujay Mate[4], Mr. Tanmoy Chattopadhyay[5], Ms. Soumya Gupta[6], Mr. Vipul Prasad[7], Mr. Gaurav Waratkar[1], Mr. Navneeth P K[7], Mr. Rahul Gopalakrishnan[7], Mr. Dipankar Bhattacharya[8], Mr. Gulab Dewangan[7], Mr. Santosh Vadawale[9]

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Abstract

The Cadmium Zinc Telluride Imager (CZTI) on the AstroSat satellite exhibits strong sensitivity to Gamma Ray Bursts (GRBs), having detected nearly 600 of them, including approximately 50 that went unnoticed by other missions. Nonetheless, CZTI was not originally designed for GRB monitoring and lacks the capability to localise them. In this study, we introduce an innovative approach for GRB localisation based on the "shadows" created on the CZTI detector plane through the absorption and scattering caused by components and instruments on the satellite. By comparing the observed distribution of counts on the detector plane with simulated distributions using GEANT4 simulations with the AstroSat Mass Model, we can determine the sky coordinates of GRBs. Our localisation accuracy is characterized by a two-component model, featuring a narrow Gaussian component that encompasses nearly 50% probability of containing the source and a broader Gaussian component that accounts for the remaining spread. The localisation radius scales inversely with the number of counts detected. To validate this model, we apply the method to GRBs with known positions, and our findings show excellent agreement between the model and actual observations. This newfound capability enhances the CZTI's versatility in the exploration of GRBs and other fast high-energy transient events.

Session

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2228

Exploring Energy-Dependent Temporal Variability in the Black Hole Binary GRS 1915+105

Ms Ruchika Dhaka

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Abstract

We conducted a comprehensive analysis of the black hole X-ray binary source GRS 1915+105 by simultaneously observing it with AstroSat and NICER in 2017. Our study employed a wide-range X-ray spectral-timing approach to gain a deeper understanding of the source's behaviour. The power density spectra from LAXPC and NICER revealed a broad prominent feature at 2 Hz and the component's fraction r.m.s increased with energy, while the time-lag was found to be soft. We found that the energy dependence of the fractional r.m.s and time-lag cannot be explained by variations of coronal spectral parameters only. Instead, a model where the coronal heating rate varies first and induces a change in the disk temperature and inner radius can explain the variation.

Session

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2239

Where do neutron stars get their mass from?

Dr Marisa Geyer[1], Dr Vivek Krishnan[2], Dr Daniel Reardon[3], Dr Hagatiana Andrianomena[4]

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Abstract

And how did the MeerKAT get its stripes? As in a children's book, observing intriguing phenomena such as large ranges in neutron star (NS) masses, is the easier part of a discovery. Understanding how such phenomena came to be, is far more ambiguous.

The Meertime Relativistic Binary programme running on the MeerKAT telescope in South Africa, is actively weighing neutron stars across many relativistic binary systems that contain a pulsating neutron star (or pulsar) and a white dwarf or main sequence companion. Optimal results through high precision pulsar timing are achieved by conducting dedicated orbital campaigns during superior conjunction at UHF and L-band frequencies.

I will highlight the results of studying a set of relativistic binaries and their implications for NS masses, including PSRs J1933-6211, J1614-2230 and J1902-5105. PSR J1902-5105, analysed as part of a student project collaboration, is the most massive NS yet found in MeerKAT data, and at the edge of challenging NS formation theories and the physics of their interiors.

PSR J1933-6211 is a relatively rare system where the analysis of both its kinematic and relativistic orbital parameters, allowed us to fully map its 3D orbital geometry and to obtain accurate mass estimates of both the pulsar and its companion. These measurements solved the mystery of the nature of PSR J1933-6211's companion, and in analogy to the PSR J1644-2230 binary strengthens the case for NS being massive not through accreting matter but *because, just like how the MeerKAT got its stripes, they were born that way.*

Session

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2247

Polarization Measurements of the Gamma-Ray Burst Prompt emission with POLAR and prospects for POLAR-2

Hancheng Li, Merlin Kole, Nicolas de Angelis

University of Geneva

Abstract

Gamma-Ray Bursts (GRBs) are the most powerful electro-magnetic events in the Universe. Even after thousands of spectral measurements of these transient events, how and where the gamma-ray emission is produced remains poorly understood. Polarization measurements have long been theorized to be capable of breaking this stalemate. The POLAR detector was developed for this purpose. The data this dedicated gamma-ray polarimeter collected after its launch in 2016 allowed for polarization measurements of 14 GRBs in the 50-500 keV energy range. The results of POLAR indicate that the polarization level is low which is in agreement with the majority of the emission models. In addition, the data provides strong hints for temporal evolution of the polarization angle during the GRB, something which is not explained by any existing model. To probe the polarization properties more deeply the POLAR-2 project was initiated in 2019 and is currently planned to be launched towards the Chinese Space Station in 2027. The detector will have an effective area approximately 1 order of magnitude larger than POLAR and, as recently shown through calibration of the first prototype, is sensitive to polarization down to 30 keV. In addition, its effective area of over 2000 cm^2, access to an onboard GPU and a near real time communication to ground, will allow it to send detailed transient alerts within seconds. In this talk we will present a detailed overview of the results of POLAR along with a discussion on the impact POLAR-2 can have on the field.

Session

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2262

Early results from the Indian X-ray Polarimeter (POLIX)

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Abstract

POLIX is the main scientific payload on XPoSat (X-ray Polarimeter Satellite), a dedicated X-ray polarimetry mission of the Indian Space Research Organisation, launched on 01st January 2024. Measuring polarization in celestial X-ray sources is a new frontier in X-ray astronomy, providing crucial insights into emission mechanisms in X-ray sources. POLIX is based on the anisotropic Thomson scattering of polarized X-rays from a low atomic mass scatterer (Beryllium) and their subsequent detection in X-ray proportional counters. The spinning of the satellite around the viewing axis of POLIX during source observations enables the polarization measurements by measuring the distribution of scattered X-ray photons. It is sensitive to X-ray polarization in the 8-30 keV range, which complements NASA's Imaging X-ray Polarimetry Explorer (IXPE), sensitive to polarization in the 2-8 keV energy range. POLIX is set to provide polarization measurements in this unexplored energy band, enabling in-depth investigations of astrophysical processes in neutron stars and black hole sources. The in-flight performance of the POLIX instrument and some early results will be presented.

Session

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2265

Unveiling the Polarization Signature of Quasi-periodic Oscillations in Swift J1727.8-1613: Insights from IXPE Observations

Han-Cheng Li[1], Qing-Chang Zhao[2,3], Lian Tao[2], Shuang-Nan Zhang[2], Hua Feng[4], Ming-Yu Ge[2], Long Ji[5], Ya-Nan Wang[6], Yue Huang[2], Xiang Ma[2], Liang Zhang[2], Jin-Lu Qu[2], Yan-Jun Xu[2], Shu Zhang[2], Qian-Qing Ying[2], Qing-Cang Shui[2,3], Rui-Can Ma[2,3], Shu-Jie Zhao[2,3], Pan-Ping Li[2,3], Zi-Xu Yang[7], He-Xin Liu[2,3], Wei Yu[2,3]

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Abstract

The origin of low-frequency Quasi-periodic Oscillations (QPOs) in black hole binaries remains a subject of intense debate, with a polarimetric perspective offering crucial insights. Utilizing the Hilbert-Huang transform method applied to Imaging X-ray Polarimetry Explorer (IXPE) observations of Swift J1727.8-1613 during its remarkable outburst, we conducted the first phase-resolved spectropolarimetric analysis on the QPO cycle. On average, the polarization degree (PD) and polarization angle (PA) were measured at 4.28% ± 0.20% and 1°.9 ± 1°.4, respectively. Furthermore, our phase-resolved analysis revealed a clear modulation of the photon index with the QPO phase, while no significant modulations in PD and PA were discernible. The observed polarization signatures present discrepancies with prevailing model expectations, which require further investigation to understand the underlying physics governing QPOs' origin.

Session

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2341

Further Constraining on the Geometry of Hercules X-1: A Comprehensive Analysis Using IXPE and NuSTAR Data

Han-Cheng Li[1], Qing-Chang Zhao[2,3], Lian Tao[2], Hua Feng[4], Shuang-Nan Zhang[2], Roland Walter[1], Ming-Yu Ge[2], Hao Tong[5], Long Ji[6], Liang Zhang[2], Jin-Lu Qu[2], Yue Huang[2], Xiang Ma[2], Shu Zhang[2], Qian-Qing Yin[2], Hong-Xing Yin[7], Rui-Can Ma[2,3], Shu-Jie Zhao[2,3], Pan-Ping Li[2,3], Zi-Xu Yang[8], He-Xin Liu[2,3], Wei Yu[2,3], Yi-Ming Huang[2,3], Ze-Xi Li[2,3], Ya-Jun Li[2,3], Jing-Yu Xiao[2,3], Kang Zhao[2,3]

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Abstract

Recent observations by the Imaging X-ray Polarimetry Explorer (IXPE) provide a robust view of Her X-1, shedding light on its geometry and system precession. We present our latest analysis, integrating IXPE and NuSTAR data, to reevaluate Her X-1 geometric characteristics. Our time-resolved study reveals negative linear correlations for total flux versus polarization degree (PD) and pulse fraction versus PD. By fitting phase-resolved modulations of the Cyclotron Resonance Scattering Feature (CRSF) and polarization angle (PA), using respectively a simple dipole model and a Rotating Vector Model, we consistently constrain geometric parameters. Variations in χp (the position angle of the pulsar's spin axis) across Main-on observations hint at forced neutron star crust precession. A linear relationship between CRSF energy and PA suggests a dominant dipole magnetic field, with their modulations likely arising from viewing angle effects.

Session

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2393

Deciphering Gamma-Ray Burst Secrets Through Polarized Lenses

Dr Michela Negro

Louisiana State University

Abstract

Gamma-ray bursts (GRBs) stand as one of the most enigmatic and energetic phenomena in the universe, yet their underlying mechanisms remain elusive. In this talk, I will review recent polarimetric findings and provide prospects enabled by upcoming instruments. From probing the magnetic fields in the ultra relativistic outflows to unveiling the structure of the jets, polarimetry offers unprecedented insights into the physics behind GRBs.

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Testing the Rigidity Dependence of Galactic Cosmic Ray Intensity Variation using Algorithm Selected Forbush Decreases

Testing the Rigidity Dependence of Galactic Cosmic Ray Intensity Variation using Algorithm-Selected Forbush Decreases Sam Samuneti

University of Nigeria Nsukka

Abstract

Galactic cosmic rays (GCRs) are high energy particles originating from outside our solar system. In this study, we investigate the rigidity dependence of GCR intensity variations using algorithm-selected Forbush decrease (FD) data from daily averaged CR count stored at Apatity (APTY) and Haleakala (HLEA) neutron monitor (NM) stations between 1996 and 2008. The average FD magnitude respectively for APTY and HLEA are -8.04% and -4.00%. The magnitude of the mean values of the FDs reflects the different in their geomagnetic cutoff rigidities which is 0.57 GV and 13.30 GV respectively. We discover that the mean value of FD at APTY is greater than that at HLEA. This is thought to be caused by geomagnetic cutoff rigidities (R) at the two NM stations with R at HLEA being greater than that at APTY. The respective altitudes of APTY and HLEA are 177m and 3052m above sea level. It is predicted that NM with low R will record more FDs and larger sizes of CR flux intensity reductions than NM with higher values. This prediction is supported by the results in this submission. Additionally, the association between the FDs at the two stations and the corresponding solar wind disturbance parameters were tested using regression analysis which showed that interplanetary magnetic field (IMF), solar wind speed (SWS), disturbance storm time index (Dst) and geomagnetic index (ap) explain a portion of variability in CR flux intensity at the time of FD. All the results are statistically significant at 95% confidence level.

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Poster upload

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2441

Neutron Star to Quark Star Conversion: The Catastrophic and Gradual Mechanism

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Abstract

The existence of quark stars is an open problem in astrophysics, and the quest to find such stars has attained much focus in recent years. According to QCD theory, the extreme densities found in neutron star core could trigger a transition from hadronic matter to a more stable quark matter, leading to the formation of hybrid/quark stars. We explored both catastrophic and gradual conversion scenarios. Using general relativistic hydrodynamics simulations, we examined the shock-induced deconfinement, where a propagating shock wave triggers the conversion of the entire star within a mere 30-50 microseconds. The gravitational wave produced in this is a burst-type signal with frequency of about 100 kilohertz and holds promise for detection by future high-frequency detectors. The aftermath of deconfinement is 2-flavour quark matter (u,d) to 3-flavour quark matter (u,d,s) conversion and distinct emissions can originate from it. The time scale and energy budget available indicate that short gamma-ray bursts and fast radio bursts could arise in phase transition events. Further, we have addressed the spin-down driven phase transition scenario, a gradual conversion wherein magnetic braking drives neutron stars from their birth (Keplerian rotation) to later stages of life (slow spin). The rise in density during spin-down can lead to the formation of a quark core or the growth of an existing quark core. Persistent signals can emerge in this (braking index changes, GWs from excited oscillation modes, neutrino bursts). Detecting these multi-messenger signals and their sky localization may help find the quark/hybrid stars.

Session

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2447

Towards an understanding of the pulsar radio emission mechanism.

Prof. Giorgi Melikidze[1,2], Dr. Dipanjan Mitra[3,1], Dr Rahul Basu[1], Dr Jaroslaw Kijak[1]

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Abstract

We present the results of recent pulsar observations that limit the nature of the possible radio emission mechanism. The study of the single pulse polarisation properties provides crucial insights into the features of the mechanism. The behaviour of the polarisation positional angle of time samples with high levels of linear polarisation reproduces the S-shaped curves that closely resemble the rotating vector model for the two eigenmodes of the relativistic electron-positron plasma: ordinary and extraordinary modes. The polarisations of these modes are mutually perpendicular. Moreover, certain observations showed that the detected polarisation vector must be directed either orthogonally or along the plane in which the curved dipole field lies. These observations greatly limit the number of possible mechanisms, as the successful mechanism should be sensitive to the direction of the curved magnetic field plane. This feature is an inherent property of the coherent curvature radiation mechanism.

We also address two essential requirements for any model of pulsar radio emission: the escape of radio waves from the pulsar magnetosphere and the level of circular polarisation. According to the standard model of the pulsar magnetosphere, the radio emission should detach from the plasma at heights less than 10% of the light cylinder radius, a phenomenon that is supported by observations. We show that within the partially screened gap model of the inner acceleration region, a nonstationary plasma flow is setup due to the sparking process. The nonstationary plasma flow naturally fulfils the observed properties of the radio emission without any additional assumptions.

Session

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2505

The InterPlanetary Network

Eric Burns

Louisiana State University

Abstract

The InterPlanetary Network is a half-century old consortium of high-energy survey instruments focused on the detection and localization of short-duration transients. It is key to the discovery and characterization of gamma-ray bursts, flares from magnetars, and monitoring other Galactic sources. The IPN is undergoing modernization efforts to automate its procedure in the new era of time-domain and multimessenger astronomy. We will discuss past results, the current status, and near-future plans.

Session

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2540

Inferring Properties of Plasma in a Curved Spacetime

Daniel Palumbo

Black Hole Initiative at Harvard University

Abstract

Advances in sub-millimeter very-long baseline interferometry (VLBI) have brought the event horizons of supermassive black holes into focus. For the first time, we have direct access to synchrotron emission from plasma embedded in the strongly curved spacetime near a black hole. This region imposes additional structure on emission from magnetized plasma relating to deep symmetries of the spacetime. In this talk, I will outline how the Event Horizon Telescope infers basic properties of plasma from images, and how future VLBI observations can probe fundamental physics using the polarization of light. These techniques will allow space-VLBI missions like the Black Hole Explorer to separate light in the strongly lensed photon ring from the background emission. Lastly, I will detail fundamental limits on the inference of plasma properties under conditions of limited frequency access, viewing angles, polarization, and unknown electron distribution function. These results show that due to the strong lensing around black holes, degeneracies in plasma parameters are broken as multiple viewing angles on the same emitting material provide unique information to the observer.

Session

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Particle Acceleration in the Heliosphere and in Supernova Remnants

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Abstract

Cosmic rays are charged particles that permeate astrophysical environments with energies much higher than the ambient thermal particles. The bulk of the galactic cosmic-ray protons and heavier nucleus, with energies up to PeV, are most probably energized in shocks resulting from supernova remnants (SNR) expansion in the interstellar medium, although the process is not yet fully understood. In the interplanetary medium, directly detected ions with energies in the tens of MeV range are correlated with shock fronts.

This research aims to develop a one-dimensional model to study the confinement and injection of energized protons in the heliosphere, using magnetohydrodynamic (MHD) simulations. Furthermore, this modified model, including a kinetic representation of the relativistic particles (Particle-In-Cell-MHD), was applied in SNR scenarios.

Our models were able to reproduce the evolution of shock events observed in the heliosphere, in accordance with previous MHD models in the literature, with the advantage of providing the energy distribution of the energetic particles, which can be used to better constrain the acceleration and diffusion processes. In the SNR case, our simulations produced the instabilities believed to regulate the self-confinement of the particles which affect the acceleration efficiency. In the future, we intend to apply it to construct non-thermal emission models of SNR that can be compared to observations.

This approach will contribute to the understanding of the cosmic ray acceleration process, as certain open questions, such as the development of instabilities near the shock, can be tested in the interplanetary medium, where direct observations are available.

Session

Division D High Energy Phenomena and Fundamental Physics

2839

Multi-wavelength observations of GRS 1915+105 during its unusual low state

Aarran Shaw

Butler University

Abstract

The black hole X-ray binary GRS 1915+105 has been in outburst since its 1992 and is famous for exhibiting a diverse range of accretion-related phenomena such as distinct variability classes, outflows such as jets and winds, and drastic changes in luminosity. In 2018, GRS 1915+105 began to transition to a new low-flux phase, where it has since remained. In 2023, we commenced an ambitious multi-wavelength observing campaign of GRS 1915+105 to study the temporal and spectral properties of the source during this phase. Observations spanned the electromagnetic spectrum from radio to hard X-rays, and utilized a variety of observatories including, but not limited to, JWST, ALMA, VLA and NuSTAR. We present here results from this campaign, focusing specifically on flux variations seen at X-ray energies and drawing comparisons with the variability seen at other wavelengths, in particular mid-infrared as observed by JWST.

Session

Division D High Energy Phenomena and Fundamental Physics

2918

Modelling of the irradiation of Knyahinya meteorite by galactic cosmic-ray protons

Doctor Patrik Čechvala, Associate Professor Robert Breier, Professor Jozef Masarik

Comenius University in Bratislava, Slovakia

Abstract

The extraterrestrial material in Solar system is exposed to the bombardment of cosmic-ray particles. Reaching sufficient energies, the interactions result in the generation of cosmogenic nuclides. Studying the production rates of different cosmogenic isotopes, it is possible to obtain valuable information about the exposition history or the original dimension of the extraterrestrial material. For this purpose, we have created model based on Monte Carlo simulation software Geant4 capable to simulate the irradiation of specific material, defined by user, by cosmic-ray particles. The model was tested in case of Knyahinya meteorite for which also experimental measurements of production rates of several cosmogenic nuclides are available. We would like to present the results of our model for chosen cosmogenic nuclides.

Session

Division D High Energy Phenomena and Fundamental Physics

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Highly collimated microquasar jets as efficient cosmic-ray sources

Dr. Gaston Escobar[1,2], Dr. Leonardo Pellizza[3]

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Abstract

Supernova remnants are currently believed to be the main sources from which Galactic cosmic rays originate. This scenario, however, fails to explain some of the features in the observed cosmic-ray spectrum, such as the spectral indices or the breaks (i.e. knee and ankle). Microquasars have been proposed as complementary candidates, because their non-thermal emission indicates the existence of efficient particle acceleration mechanisms in their jets. Some jets, such as that of SS 433, have been observed to have hadronic content. In these cases, the production of neutrons is an inescapable consequence of hadronic interactions. Given that neutrons cannot be magnetically confined, they escape from the jet and then decay, providing a way for charged particles to escape the system becoming cosmic rays. In this talk I will discuss neutron-driven cosmic-ray production in microquasar jets. I will show that this mechanism renders the most collimated, luminous, and compact microquasar jets as serious candidates for cosmic-ray sources. These jets provide a non-negligible proton cosmic-ray power, with a spectrum capable of producing the features observed at energies below the knee. I will also discuss the contribution of this mechanism to Galactic and extragalactic cosmic-ray production, especially at the Cosmic Dawn, when cosmic rays may have had an important role regarding the heating and reionization of the intergalactic medium.

Session

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Abstract Title: A series of NICER Thermonuclear Bursts from UCXB M15 XA series of NICER Thermonuclear Bursts from UCXB M15 X-2

María Alejandra Díaz[1,2], Prof. Juri Poutanen[1], Dr. Jari Kajava[3]

[1]University of Turku. [2]Nordic Optical Telescope. [3]European Space Astronomy Centre (ESAC)

Abstract

This poster provides the initial findings of a study focused on Type I X-ray bursts observed in the ultracompact X-ray binary 4U 2129+12, located in the globular cluster M15. Investigating ultracompact X-ray binaries (UCXBs) with hydrogen-poor companions offers valuable insights into accretion environments and neutron star atmospheres during bursts. Following the detection of an X-ray burst in September 2022, the Neutron Star Interior Composition Explorer (NICER) diligently monitored the 2022 outburst of this source. After analyzing the data from these subsequent observations, we have identified a total of 5 additional X-ray bursts. Performing time-resolved spectroscopy, we observed deviations from a blackbody in the spectra of all bursts. We significantly improved the fit by taking into account the enhanced persistent emission and have compared the results to those obtained through neutron star atmosphere models. Moreover, our examination of the fuel composition, indicating helium bursts, has refined our understanding of the companion's characteristics.

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Session

Division D High Energy Phenomena and Fundamental Physics

3070

Detection of QPOs and other Timing-Spectral properties of GX 339-4 during the 2021 and 2023-2024 outbursts: a comparative study

Dr. Ramanshu P. Singh

Department of Physics, Prof. Rajendra Singh (Rajju Bhaiya) Institute of Physical Sciences for Study and Research, Veer Bahadur Singh Purvanchal University, Jaunpur UP India

Abstract

By undergoing an outburst at the end of the 2023, low mass x-ray binary GX 339-4 has again attracted astronomers' attention. Here, we present a comparative study on the timing-spectral properties of GX 339-4 during the 2021 and 2023-2024 outburst using NuSTAR and NICER observations. Using GHATS, we detected mutiple LFQPOs. QPOs with centroid ~0.08 Hz and ~0.35 are present in both cases, but we also detected a qpo with centroid 2.645 Hz in 2021 outburst while in 2023-2024 case, there is a QPO of centroid ~4.6 Hz with a signature of a harmonic at ~9.0 Hz. We have also calculated the hardness parameter using the NICER light-curves and also computed the time lag properties using pyLag to further correlated timing-spectral parameters at various phases of the outburst.

Session

Division D High Energy Phenomena and Fundamental Physics

3116

Unveiling the Most Promising Formation Channel of FRBs Using Local Universe Bursts

Dr Mohit Bhardwaj

Carnegie Mellon University

Abstract

The origin of fast radio bursts (FRBs) remains an enduring enigma in contemporary astronomy, even after 17 years since their serendipitous discovery. A plethora of models has been proposed to shed light on their origins, encompassing both cataclysmic and non-cataclysmic formation channels. Within the non-cataclysmic category, the debate persists on whether the majority of FRBs are promptly formed after the death of their progenitor main sequence star or arise from recycled compact objects. In this talk, I leverage currently available observational data to address three pivotal questions: (1) What are the prospects of detecting FRBs originating from proposed cataclysmic channels? (2) Is there a single dominant FRB formation channel, governing these enigmatic bursts? And if a dominant channel does exist, can it explain the observed diversity among FRB host galaxies and their local environments? To address these probing questions, I use a sample of two dozen local Universe FRBs ($z < 0.1$), many of which have been detected by the Canadian Hydrogen Intensity Mapping Experiment Fast Radio Burst (CHIME/FRB) Project. Our analysis provides compelling evidence that core collapse supernovae are likely the dominant formation channel of FRB sources. Additionally, I discuss our targeted search campaign of FRBs at the sites of pre-2005 Type II supernovae, which offers novel constraints on the age of the FRB sources. Finally, both of these findings carry considerable implications for multi-wavelength follow-up studies of FRBs, which I also discuss in this talk.

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The CATCH Space Mission and Its Polarimetry Pathfinder

Dr. Qian-Qing Yin, Dr. Lian Tao, Dr. Xiangyang Wen, Dr. Zhengwei Li

Institute of High Energy Physics, Chinese Academy of Sciences

Abstract

The Chasing All Transients Constellation Hunters (CATCH) space mission, proposed in 2019, aims to bring about significant changes in X-ray astronomical observation by deploying an intelligent constellation of 126 microsatellites. These satellites, categorized into three types (Type-A, -B, and -C), will work in tandem to monitor the X-ray emissions of all-sky, multi-wavelength, multi-messenger transients. The primary objective of the mission is to provide a dynamic and comprehensive view of the universe through imaging, spectral, timing, and polarization measurements.

The mission will predominantly consist of 108 Type-A satellites, which will focus on monitoring the timing of transients detected by other survey telescopes. Subsequently, Type-B and -C satellites will conduct imaging-spectral-timing and polarization observations of the most intriguing transients based on the initial findings from Type-A satellites. The seamless coordination and collaboration of these satellites, facilitated by artificial intelligence, will establish a time-domain astronomical network for transients.

To validate the relevant technologies for Type-A satellites, the first pathfinder (CATCH-1) is expected to be launched in June 2024. This pathfinder will carry a Micro Pore Optics (MPO) and a 4-pixel Silicon Drift Detector (SDD) array. Following this, a polarimetry pathfinder (CATCH-2) for Type-C satellites will be developed and is expected to be launched around 2027. Equipped with a lightweight Wolter-I focusing mirror and a Gas Micro Plate Detector (GMPD) system, CATCH-2 will conduct rapid follow-up, high-sensitivity polarization measurements in the 2-10 keV energy range. It will also collaborate with other missions such as EP and SVOM to enhance its observational capabilities.

Session

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Metric type II radio bursts and associated space weather phenomena during solar cycle 24

Dr. Ramesh Chandra[1], Dr. Rositsa Miteva[2], Ms. Pooja Devi[1], Dr. Bendict Lawrance[3], Dr. Kostadinka Koleva[4]

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Abstract

We compile a catalog of metric type II radio bursts using Radio Solar Telescope Network (RSTN), to study the occurrence, associations, and properties of the emission and their parent solar activity phenomena. We analysed RSTN data in solar cycle 24 (2009–2019) from four worldwide stations: Learmonth, Sanvito, Sagamore Hills and Palehua. Through careful visual inspection, we have collected all major metric type II bursts detected in the range of 25–180 MHz. The relationships between these bursts and solar and their associated space weather (SW) phenomena, namely, solar flares (SFs), sunspot (SN) configurations, coronal mass ejections (CMEs), their interplanetary (IP) counterparts (ICMEs) and shocks, filaments, in situ detected particles and geomagnetic storms (GSs) are presented and discussed. The data of the associated phenomena is collected from various space-based satellites, ground-based observatories or public catalogs. We complement the m-II results with m+IP IIs where the IP IIs are identified from the Wind/WAVES spacecraft. Occurrence rates are calculated and presented as a function of the strength of the specific SW event type: higher rates are obtained with CMEs, SFs, and SN configurations, whereas a much weaker relationship is found with ICMEs, IP shocks, energetic particles, and GSs. The obtained relationships can be utilized in empirical or physics-based models for SW forecasting.

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An investigation of the relation between CME cores and the near-surface prominence eruptions

Pooja Devi[1], Dr. Nat Gopalswamy[2], Dr. Seiji Yashiro[2,3], Dr. Sachiko Akiyama[2,3], Dr. Ramesh Chandra[1], Dr. Kostadinka Koleva[2,3,4]

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Abstract

It is known that eruptive prominences are the near-surface manifestations of the core of the associated coronal mass ejections (CMEs). Previous studies have shown that the speed of the eruptive prominence is less than the associated CME core speed. This is because the prominences continue to accelerate before reaching the coronagraph field of view and hence the core speed is higher. However, we found a few exceptions in which the CME core speed is lower that the near-surface prominence speed: 11 May 2011, 01 October 2011, 7 June 2012, and 21 April 2014. We analysed these events using data of the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) together with coronagraph images from the Large Angle and Spectrometric Coronagraph (LASCO) onboard Solar and Heliospheric Observatory (SOHO) spacecraft. We discuss the situations that result in the higher prominence speed relative to the corresponding CME core speed.

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Wave-particle interaction acceleration of proton and 3He/4He ions in impulsive flares with fractal turbulence reconnection model via 3D RHPIC-LBM simulations

Professor Boring Zhu

Yunnan Observatories of Chinese Academy of Sciences, Kunming, 650216, China. Center of Astronomical Mega-Science, Chinese Academy of Sciences, Beijing, 100012, China. State Key Laboratory of Space Weather, National Space Science Center, Chinese Academy of Sciences, Beijing, 100190,China. Earth and Planetary College & School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing, 100049, China

Abstract

The high-energy solar energetic particles (SEPs) are the fundamental reason for SEPs-induced space weather disasters, especially for the GeV level flare/CME cases. However, due to the complex acceleration process (e.g., different species, different abundances, different isotopes, and different ionization), the acceleration mechanism and source & origin are still an open, challenging topic. Based on the statistical plasma treatment, this work investigates the wave-particle interaction acceleration mechanism on the supercomputer platform (e.g., Tianhe-series Homogeneous CPU and heterogeneous CPU-GPU systems) with relativistic hybrid particle-in-cell & lattice-boltzmann (RHPIC-LBM) code. The results show that wave-particle-interaction acceleration is a new independent turbulence acceleration mechanism that is different from the present turbulence acceleration mechanism (shock wave acceleration including 1st and 2nd fermi acceleration) and more efficient in high-energy level (e.g., GeV level) that shock wave acceleration mechanism.

IAU_Abstract.pdf Cloud disk link：https://pan.cstcloud.cn/s/hrGck8nmQ98

Session

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Geomagnetic jerks observed in geomagnetic observatory data over Southern Africa between 2017 and 2023

Mr Sanele Khanyile

South African National Space Agency. University of KwaZulu Natal

Abstract

Geomagnetic jerks are jumps observed in the second derivative of the main magnetic field that occur on annual to decadal timescales. Understanding these jerks is crucial as they provide valuable insights into the complex dynamics of the Earth's outer liquid core. In this study, we investigate the occurrence of geomagnetic jerks in geomagnetic observatory data collected at southern African magnetic observatories, Hermanus (HER), Tsumeb (TSU), Hartebeesthoek (HBK) and Keetmanshoop (KMH) between 2017 and 2023. The observatory data was processed and analysed by retaining quiet night-time data recorded during quiet geomagnetic activities with the help of Kp, Dst and ring current RC indices. Results confirm the occurrence of 2018 and 2020 geomagnetic jerks in the region, and the recent 2021 jerk detected with V-shaped secular variation changes in X and Z components at all four observatories. The highest estimated 2021 jerk secular acceleration amplitudes in X and Z components were found at HBK, 12.7 nT/year^2 and 19. 1 nT/year^2, respectively. Notably, the global CHAOS-7 model aptly identifies this 2021 jerk in the Z component at all magnetic observatories in the region.

Keywords: Geomagnetic jerks, secular variation, magnetic observatory data, South Atlantic Anomaly

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On the Magnetic Parameters of an Active Region Producing Flares and Confined Eruptions

Dr. Cristina Mandrini, Dr. Marcelo López-Fuentes, Dr. Mariano Poisson

Instituto de Astronomía y Física de Espacio - IAFE

Abstract

Active region (AR) NOAA 11476 produced a series of surge-type eruptions accompanied by GOES X-ray class M flares between 9 and 10 May 2012. Using force-free models and observations in several wavelengths, we studied the evolution of the eruptions and we associated them to the AR magnetic topology and suggest a reconnection scheme at their origin. The eruptions were due to the ejection of mini-filaments that were recurrently ejected and reformed at the polarity inversion line of a bipole that emerged in the middle of the positive main AR magnetic polarity. The bipole was observed to rotate for several tens of hours before the events. In this work, we analyze the evolution of a series of magnetic parameters for the full AR and the rotating bipole using the Helioseismic and Magnetic Imager (HMI) vector magnetograms. This analysis is combined with estimations of the injection of magnetic energy and helicity obtained using the Differential Affine Velocity Estimator for Vector Magnetograms (DAVE4VM) method. Our results let us conclude that the rotation of the bipole was the main driver providing the magnetic energy and helicity necessary for the mini-filament destabilizations and ejections.

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Solar photospheric spectrum microvariability: Relations to magnetic activity and radial-velocity modulation

Prof Dainis Dravins[1], Dr. Hans-Günter Ludwig[2]

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Abstract

Searches for exoplanets around solar-type stars are limited by jittering of apparent radial velocities. To trace their origins, solar spectra were assembled from time-dependent 3D-hydrodynamics. Synthetic spectra were computed during numerous instances of the simulation sequences, producing movies of high-resolution solar spectral atlases.

The behavior was monitored for different classes of lines. The jittering scales to ~2 m/s for the full solar disk. Most photospheric lines vary in phase but amplitudes differ. Radial-velocity excursions are greater for stronger and for ionized lines, decreasing at longer wavelengths.

Extreme precision radial-velocity spectrometers enable extreme precision stellar spectroscopy. From three years of HARPS-N observations of the Sun-as-a-star, 1000 low-noise spectra were examined. Systematic line-strength variability largely shadows the solar-cycle evolution of Ca II H&K emission, but with much smaller amounts. Among iron lines, greatest amplitudes are for Fe II in the blue, while trends change sign among lines in the green Mg I triplet and between Balmer lines. Variations in the G-band core are greater than of the full G-band, in line with theoretical predictions. No variation is seen in the semi-forbidden Mg I 457 nm.

Microvariability in the photospheric spectrum thus measures something different than the Ca II H&K chromospheric index while still reflecting an influence from magnetic regions. A modelling with magnetic and nonmagnetic regions should be able to both reproduce solar-cycle changes in line-strengths and the ensuing changes in the apparent radial velocities of the Sun seen as a star.

Astron.Astrophys. 679, A3 (2023); Astron.Astrophys. (2024)

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Magnetic Detonation in Solar Flares

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Abstract

The emergence of solar flares and the development of coronal mass ejections (CMEs) and their relationships have been investigated for a very long time. However, the solution is very far from its completion. We developed a qualitative model for the emergence of CMEs as a result of multiple reconnection events and describe it as analogous to the process of detonation — magnetic detonation.

By such process we mean the propagation of multiple magnetic reconnection with a supersonic speed in eruptive flares and following acceleration of the CME. We found the limiting speeds of CME and proton acceleration time scale for CME.

Our model can be realized in in long flares in the presence of CMEs and particle acceleration but is not realized in short impulsive flares. We considered the possible expansion of the soft X-ray source, calculated its size and expansion speeds under the assumption that the plasma density in the source corresponds to the plasma frequency.

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The Nature of the Solar Spicule Forest

Dr Piyali Chatterjee[1], Dr. Sahel Dey[2], Dr. Murthy O V S N[3], Prof Robertus Erdelyi[4], Dr. Jiajia Liu[5]

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Abstract

At any given time, it is estimated that millions of spicules are present on the solar surface. We find an intriguing parallel between the simulated spicular forest in a solar-like atmosphere and the numerous jets of polymeric fluid in the laboratory when both are subjected to harmonic forcing. In our radiative (both 2D and 3D) MHD simulations with sub-surface convection, the solar surface oscillations are excited similarly to those harmonic vibrations. A forest of spicules are formed in our simulations with heights ranging between 6 and 20 Mm, bearing substantially closer resemblance to clusters of jets observed in the solar atmosphere. Taken together, the numerical simulations of the Sun and the laboratory fluid dynamics experiments provide insights into the mechanism underlying the ubiquity of jets. Our 3D numerical simulations further indicate an interesting relationship between spicules and what we refer to as "coronal swirling conduits" or CoSCos. In contrast to spicules that fall back to the solar chromosphere, the CoSCos form by drawing energy from the thermal and magnetic energy reservoir of the chromospheric plasma. These CoSCos have the potential to carry the rotational energy pulses further upward at Alfven speeds than the typical lengths of spicules seen in the Si IV emission lines even when spicules are falling sun-ward.

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Solar Close Observation and Proximity Experiments (SCOPE) Mission Concept

Professor Jun Lin

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Abstract

The region close to the Sun is a totally unknown world to us, many important processes and phenomena occurring there are completely imperceptible on the Earth, and it is still an “uninhabited zone” for the deep space mission. This work is to introduce an unprecedented deep space mission that will enter the “uninhabited zone”, solving the puzzles that have challenged the solar physics society for around a century. These puzzles are related to the mechanisms for the solar eruption, detection of the coronal magnetic field, as well as the mechanism of the corona heating. The spacecraft will reach to the location closer to the Sun than the Parker Solar Probe would reach on an orbit of larger inclination to the ecliptic plane than the Solar Orbiter. The associated scientific goals include: 1. Entering the central structure of the energy release driving the solar eruption, performing in situ measurements of physical properties of the structure, and solving the problem of mechanisms of solar eruptions; 2. Acquiring the true thickness of the reconnecting current sheet connecting a coronal mass ejection to the associated solar flare, and renovating the classical theory and the physical scenario regarding the large-scale of magnetic reconnection; 3. Acquiring the coronal magnetic field via in situ measurement, obtaining unique evidence for identifying mechanisms of the corona heating, observing closely the polar magnetic field and plasma, revealing the role of the polar magnetic field and plasma in governing the global behavior of the solar activity.

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Observations and 3D MHD simulations of turbulent reconnection within CME-flare current sheet

Xin Cheng

Nanjing University

Abstract

Magnetic reconnection is a fundamental physical process in various astrophysical, space, and laboratory environments. In solar physics, it is even believed to be a key mechanism to heat/accelerate plasmas and drive the eruption of large-scale magnetic field, giving rise to coronal mass ejections and flares, as well as solar energetic particles. High-cadence and high-resolution observations recently show that magnetic reconnection always presents an intermittency as characterised by the appearance of magnetic islands of different scales, which can be well understood in the framework of turbulent reconnection theory. In this talk, I will present observational evidence for turbulent reconnection within the current sheet in the wake of erupting coronal mass ejections and during a very tiny 3D magnetic null-point in the corona. We also implemented a 3D high-resolution MHD simulation of magnetic reconnection in a realistic flare configuration in order to explore the origin and property of turbulent reconnection, as well as its physical links to large-scale flare dynamics.

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Toward Commissioning Solar Observations with MeerKAT: Opening a New Frontier in Solar Radio Physics

Dr. Devojyoti Kansabanik[1,2,3], Mr. Marcel Gouws[4], Prof. Divya Oberoi[3], Sarah Buchner[4], Dr. Surajit Mondal[5]

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Abstract

Solar radio emissions provide several unique diagnostics tools of the solar corona, which are otherwise inaccessible. However, imaging the very dynamic coronal emissions spanning a large range of angular scales at radio wavelengths is extremely challenging. Due to large numbers of antennas, at GHz frequencies, MeerKAT radio telescope is possibly globally the best-suited instrument at present for providing high-fidelity spectroscopic snapshot solar images. At GHz frequencies, the Sun has a much higher flux-density than any other astronomical source in the sky. Hence, observing the Sun with sensitive radio telescopes like MeerKAT requires one to attenuate solar signals suitably for optimum operation of the instrument. We embarked on our voyage of MeerKAT solar observation using the sidelobes of the primary beam. The images show extremely good morphological similarities with the EUV images as well as the simulated radio images at MeerKAT frequencies demonstrating the high fidelity of these images. Although this approach was successful, it is naturally better to observe the Sun in the main lobe of the primary beam using suitable attenuation in the signal chain to keep the system in the linear regime. We have been working towards this and will present the current status of our efforts toward commissioning solar observations with the MeerKAT. Once commissioned, this will enable a host of novel studies, open the door to a large unexplored phase space with significant discovery potential, and also pave the way for solar science with the upcoming Square Kilometre Array-Mid telescope, for which MeerKAT is a precursor.

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How have modern observations changed our understanding of small-scale bursts in the solar atmosphere?

Dr Chris Nelson

European Space Agency

Abstract

Small-scale bursts are prevalent throughout the solar atmosphere, from the photosphere to the corona. These events are often attributed to being the observational signatures of the physical process known as magnetic reconnection, the energetic restructuring of the local magnetic field from a high-energy state to a lower-energy state. As their name would suggest, the analysis of small-scale bursts relies heavily on high-resolution (in terms of both spatial and temporal capabilities) observations, with the definition of 'high-resolution' having evolved significantly with the development of larger and larger telescopes. Rapid advances in instrumentation over the past decade mean that we can now sample the solar atmosphere down to scales of tens of kilometres across a range of thermal windows. Combining these datasets together allows us to gain an insight into the heating and cooling process taking place in different regions of the solar atmosphere at any given time. In this talk, we will explore a range of small-scale bursts that have been identified in the transition region and corona of the solar atmosphere, as well as linkages between them. Specifically, this will include discussions of the new 'campfire' phenomena identified in coronal imaging data sampled by the Extreme Ultraviolet Imager onboard Solar Orbiter. The frequency and apparent temperatures of campfires make them potentially relevant as contributors to the long-standing open puzzle known as coronal heating. Finally, we will present a brief discussion about how data from the Daniel K. Inouye Solar Telescope will help to better understand small-scale bursts in the future,

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Investigating Campfires and Their Relationship to Transition Region Explosive Events

Dr. Yajie Chen[1], Prof. Hardi Peter[1], Dr. Damien Przybylski[1], Dr. Hui Tian[2]

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Abstract

Recent observations by the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter have revealed prevalent small-scale transient brightenings in the quiet solar corona termed "campfires". To understand the generation mechanism of these coronal brightenings, we constructed a self-consistent and time-dependent quiet-Sun model extending from the upper convection zone to the lower corona using a realistic three-dimensional radiation magnetohydrodynamic simulation. From the model we have synthesized the coronal emission in the EUI 174 A passband. We identified several transient coronal brightenings similar to those in EUI observations (lifetime, size, aspect ratio, etc). By examining the magnetic field structures before and after the occurrence of brightenings, we concluded that these coronal brightenings are generated by component magnetic reconnection between interacting bundles of magnetic field lines or neighboring field lines within highly twisted flux ropes. These transient coronal brightenings may play an important role in the heating of the local coronal plasma. Furthermore, we synthesize spectral profiles of the Si IV 1394 A lines from the model. All seven campfires in our model show enhanced Si IV emissions, and most of them exhibit non-Gaussian Si IV line profiles. On the other hand, many explosive events do not show any coronal signature in the synthesized EUI 174 A images. Therefore, campfires often occur together with transition region explosive events, but the released energy around most explosive events is insufficient to heat the plasma there to 1 MK.

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The Power of Ground-based Coronagraphs

Sarah Gibson, Ben Berkey, Joan Burkepile, Giuliana de Toma, Alfred de Wijn, Michael Galloy, Holly Gilbert, Maurice Wilson

NCAR/HAO

Abstract

For decades, we have observed the low and middle corona with instruments from the Mauna Loa Solar Observatory, including the white light K-Coronagraph (K-Cor) and the Coronal Multichannel Polarimeter (CoMP) and Upgraded CoMP (UCoMP). These instruments have demonstrated the crucial benefits of coronagraphs with small occulting disks (relative to space-based coronagraphs) for characterizing the nature of coronal mass ejection (CME) source regions and providing early warnings of CME launches, an advantage compounded by the extremely high cadence/latency possible with ground-based observations. In this presentation, we will discuss the particular advantages of ground-based white-light and visible-infrared coronagraphs, which enable unique measurements of coronal mass and magnetism. We will discuss the advantages gained by global networks of coronagraphs and by large aperture coronagraphs (e.g., COSMO), and the critical importance of global (full-Sun) synoptic observations for studying the processes of magnetic storage and release in the solar corona.

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Solar Radio Type V Burst: Scattering, Trapping, and Emission Process of a Dense Electron Beam

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Abstract

Solar type V radio bursts are associated with type III bursts. Several processes have been proposed to interpret the association, the electron velocity distribution, and the emission. We present the observation of a unique type V event observed by e-CALLISTO on 2121/05/07. The type V radio emission follows a group of U bursts. Its polarisation is opposite to the type III burst and its front edge has a U-shape. The observations conform to a scenario where a dense electron beam first saturates its two-stream instability (causing type III emission) and then becomes unstable to another instability, such as the electron firehose instability. This second instability scatters some beam electrons into velocities perpendicular to the magnetic field and produces a trapped distribution prone to electron cyclotron masering (ECM). A reduction in beaming is predicted for electron beams continuing to interplanetary space, observable for Parker Probe and Solar Orbiter.

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The Origins of Coronal Mass Ejections and their Initial Stages: An ObservationalAccount

Prof. SPIROS PATSOURAKOS

Department of Physics, University of Ioannina, Greece

Abstract

The chance discovery of Coronal Mass Ejections (CMEs) in the early 70's turned out to be a major milestone in solar physics and the Sun-Earth and Sun-stellar connections. Our understanding of these fascinating and important phenomena keeps making important strides thanks to advances in both observational and modelling/theory fronts. With this presentation, we attempt to supply an observational account of recent advances and challenges about the origins and initial stages of CMEs. We will feature topics including: 1) the pre-eruptive magnetic configuration of CMEs; 2) CME evolution in the low corona; 3) the search of physical parameters/regimes with the potential to identify regions which could spawn CMEs. We will conclude by discussing outstanding open questions in CME research and how observations from existing and upcoming instrumentation may accommodate them.

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Preliminary prediction of solar active region evolution using deep learning

Dr. Harim Lee[1], Dr. Eunsu Park[2], Dr. Yong-Jae Moon[1], Dr. Jihyeon Son[1]

[1]Kyung Hee University. [2]Korea Astronomy and Space Science Institute

Abstract

Solar active regions are important for solar physics research and have been used as an input for various space weather forecasting models. In this study, we are developing a prediction model for solar active region evolution using video prediction methods based on deep learning. For the dataset, we use magnetograms observed by Solar Dynamics Observatory (SDO) / Helioseismic and Magnetic Imager (HMI). For magnetograms we use the Cylindrical Equal Area (CEA) projected HMI Active Region Patches (HARPs) data provided by JSOC, which have an advantage that they have the same area per pixel, without any additional data pre-processing. We consider 720 HARPs within ±30 degrees of the solar central meridian and with HARPs of 512x512 size from May 2010 to May 2023 (about 1 million images at 12 minute intervals). For the deep learning models, we consider several spatiotemporal prediction models, such as ConvLSTM and Top-tier video prediction models. Our models are designed to predict the change of active regions over the next 24 hours. Our study is a new attempt to predict the evolution of solar active regions using deep learning and is meaningful in providing useful information on solar activity forecasts.

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Solar radius variability over the solar cycle.

Dr Jan Louis Raath, Dr Martin Snow

South African National Space Agency

Abstract

We study the variability of the solar radius between 2017 and the present. This period of time includes solar activity levels ranging from minimum to approximately maximum conditions. We make use of solar spectral irradiance observations, as measured by the GOES-16 satellite in the ultraviolet and visible spectral ranges. The observations are made during lunar transits of the Sun, as observed from the spacecraft. During these transits, the ratio of the solar to lunar radius can be obtained and, since the lunar radius is well known, we can obtain an absolute value for the solar radius. By obtaining such values for each of the lunar transits, we can achieve valuable insights as to the variability of the solar radius on the time scale of the solar activity cycle.

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Space Weather at Mars: A Solar Cycle of Space Radiation Measurements on the Surface of Mars with RAD on the Mars Science Laboratory

Dr. Donald M. Hassler[1], Dr. Cary Zeitlin[2], Dr. Bent Ehresmann[1], Dr. Robert Wimmer-Schweingruber[3]

[1]Southwest Research Institute. [2]NASA. [3]CAU/Kiel

Abstract

The Radiation Assessment Detector (RAD) on the Mars Rover Curiosity has been effectively serving as a space weather monitor on the surface of Mars since Curiosity landed on the red planet in 2012. RAD has measured the impact of more than a dozen solar storms, with the frequency of events increasing as the Sun approaches solar maximum. Two recent relatively large events (Sept. 10, 2017 and Oct. 28, 2021) were observed as Ground Level Events (GLEs) at both Earth and Mars, separated by 180 degrees in longitude. We will discuss these events and their implications for space weather predictions, as well as the need for heliosphere-wide space weather monitoring to support future human exploration to Mars and beyond.

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Solar Cycle Prediction at NOAA's Space Weather Prediction Center

Mark Miesch

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Abstract

In 2019 the US National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the International Space Environment Services (ISES) convened an international panel to predict the amplitude and timing of Solar Cycle 25. We now believe that Solar Cycle 25 is likely to be stronger and to peak sooner than predicted in 2019. In order to address this, NOAA's Space Weather Prediction Center (SWPC) has deployed a new experimental product for predicting the amplitude and timing of Solar Cycle 25. This product remains faithful to the NOAA/NASA/ISES panel but provides more reliable practical guidance for SWPC customers. It is based on nonlinear curve fits applied to monthly sunspot and F10.7 cm radio flux observations and is updated every month as new observations become available. Error bars are estimated by applying the same method at the same point in past cycles and computing residuals. As of February 2024 the new method predicts a maximum sunspot number of 136-169 to occur sometime between February 2024 and February 2025. This prediction method provides a robust benchmark by which other more sophisticated solar cycle prediction methods can be evaluated. In this presentation I will describe the experimental product, including its methodology and validation, and I will demonstrate how to access it on NOAA/SWPC's new Space Weather Prediction Testbed website. I will also review the motivation and history of SWPC's solar cycle prediction products and describe a preliminary forecast method for Solar Cycle 26.

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Analysis of the Occurrence of the First Most Intense Geomagnetic Storm (G4) to Hit the Earth in Solar Cycle 25

Dr Hammed Adeniyi Lawal[1], Mr Muhammed Itopa Mukhtar[2,3]

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Abstract

A study of the occurrence of the first intense Geomagnetic storm (G4) to hit the Earth since the start of the Solar Cycle 25 is carried out. This study analyzed the Geomagnetic Storm that occurred between the 28th of October and the 7th of November 2021. The values of the Disturbance storm time (Dst) index of the storm reach -115 nT (G4) which occurred on the 4th of November at 1300UT. The storm is the first intense magnetic storm that occurred in the solar cycle 25. It is also a multiple-step storm with moderate two-step storm occurrence which occurred on the 5th and 6th of November at 1500UT and 0600UT respectively towards the recovery phase after the intense storm. The interplanetary magnetic field (IMF)Bz (nT) during these storm events decreases. Our analysis shows that the rise in solar wind speed, temperature and the enhancement of pressure plays a significant role in the occurrence of the first intense Geomagnetic storm of Solar Cycle 25

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Pixel-to-pixel translation of SDO/AIA EUV images for DEMs by deep learning

Eunsu Park[1], Harim Lee[2], Yong-Jae Moon[2], Seonghwan Choi[1]

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Abstract

We suggest a pixel-to-pixel image translation method among similar types of filtergrams such as solar extreme-ultraviolet (EUV) images. For this, we consider a deep-learning model based on a fully connected network in which all pixels of solar EUV images are independent of one another. We use six-EUV-channel data from the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO), of which three channels (17.1, 19.3, and 21.1 nm) are used as the input data and the remaining three channels (9.4, 13.1, and 33.5 nm) as the target data. We apply our model to representative solar structures (coronal loops inside of the solar disk and above the limb, coronal bright point, and coronal hole) in SDO/AIA data and then determine differential emission measures (DEMs). Our results from this study are as follows. First, our model generates three EUV channels (9.4, 13.1, and 33.5 nm) with average correlation coefficient values of 0.78, 0.89, and 0.85, respectively. Second, our model generates the solar EUV data with no boundary effects and clearer identification of small structures when compared to a convolutional neural network–based deep-learning model. Third, the estimated DEMs from AI- generated data by our model are consistent with those using only SDO/AIA channel data. Fourth, for a region in the coronal hole, the estimated DEMs from AI-generated data by our model are more consistent with those from the 50 frames stacked SDO/AIA data than those from the single-frame SDO/AIA data.

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Solar Coronal Jets and Jet-like Features: Their Nature, and Their Possible Implications for the Solar Wind

Dr. Alphonse Sterling[1], Dr. Ronald Moore[2,1], Dr. Navdeep Panesar[3,4]

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Abstract

The Sun's hot (~1 MK) outer atmosphere, the corona, can be seen from the ground in its full glory for only a few minutes during total solar eclipses. From space, however, it can be seen continuously with EUV and X-ray telescopes. In recent decades, such high-resolution (a few arcseconds or less) and high-time-cadence (a few minutes down to seconds) observations have shown the corona to be dynamic on the time scale of a few minutes. Solar "coronal jets" are one such prominent dynamic feature: They resemble long narrow geysers that shoot out from near the Sun's surface and reach far out into the corona, sometimes extending out to about 50,000 km with a width of only about 10,000 km or less, over a lifetime of tens of minutes. Recent observations indicate that coronal jets usually (if not always) result from eruptions near the solar surface of “minifilaments.” These minifilaments are small-scale versions (size ~10,000 km) of typical large-scale filaments (~30,000 --- 100,000 km) that have long been known to erupt and produce typical solar flares and coronal mass ejections (CMEs). Smaller scale "jet-like features" in the solar atmosphere, such as "jetlets," and spicules, are even more common than jets, and might work the same way as jets. Small-scale erupting minifilaments (or more specifically, the erupting small-scale magnetic flux ropes that often carry chromospheric-temperature minifilament material) that produce these events plausibly could power the solar wind and evolve to form the magnetic "switchbacks" commonly observed by the Parker Solar Probe satellite.

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An expansion-driven Alfvén wave dynamo generates mean magnetic field in the solar wind

Prof Stuart Bale

University of California, Berkeley

Abstract

The global solar magnetic field arises from dynamo processes associated with convective plasma motion in the outer envelope of the Sun. The solar wind, escaping from coronal holes, entrains this magnetic field and transports it out into the heliosphere to become the global heliospheric magnetic field (HMF). The HMF is predominantly radial in the inner heliosphere and becomes structured as a large-scale Archimedean spiral (the so-called Parker Spiral) at larger distances in the Ecliptic plane. The HMF is also punctuated by transient shocks and pileup where fast and slow wind streams meet (corotating interaction regions). Conservation of magnetic flux requires that the radial component of the HMF scale as $1/r^2$ becoming accordingly weaker at high altitudes. Here we report in situ measurements demonstrating that the radial component and magnitude of the global HMF *increase* beyond the expectations of flux conservation over a range of altitudes in the inner heliosphere. This growth of the mean field is associated with the generation and evolution of large-amplitude $\delta B/B \sim 1$ spherically-polarized Alfvén waves (termed 'switchbacks'). Alfvén waves generated at low altitudes are amplified by combined wind expansion and wave action conservation to grow to large amplitudes. As wave growth saturates and plasma motions begin to dominate, the Alfvén waves evolve to MHD turbulence and the underlying HMF is amplified. Our results may address, in part, the 'missing flux' problem.

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The JAXA's next solar mission SOLAR-C: mission status update

Prof. Toshifumi Shimizu

ISAS/JAXA

Abstract

As a next observatory on orbit for high resolution solar physics, Japan Aerospace eXploration Agency (JAXA) has launched the SOLAR-C project team toward a launch target in Japanese fiscal year 2028. The SOLAR-C mission is a JAXA international mission in collaboration with US and European countries. High resolution observations allow us to investigate MHD fundamental processes acting in solar outer atmosphere and to take great contributions to revealing the mechanisms responsible for the heating of the upper atmosphere and explosions there. New imaging spectroscopic observations in EUV are eagerly awaited as the highest priority in latter half of 2020s. The SOLAR-C will carry the EUV high-throughput Spectroscopic Telescope (EUVST), which is a state-of-the-art EUV imaging spectrometer with slit-jaw imaging system, that will, for the first time, carry out simultaneous observations of the solar atmosphere from the photosphere/chromosphere up to the corona with seamless temperature coverage, high spatial resolution (0.4"), and with high throughput for achieving 0.5 sec high temporal cadence. The Phase-B development for the EUVST is on-going and preliminary design review (PDR) will be completed by the time of the IAU GA symposium. The EUVST observations are expected to be deeply coordinated with NASA's MUSE mission, other space missions, and ground-based facilities, to enhance synergies that are expected from such coordinated observations. This presentation will report on the latest status of the mission to be shared with the meeting participants, with reviewing scientific capabilities and expected performance of the mission.

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The Cosmic-on-Air citizen science project: flight-based observations of cosmic rays and solar flares

Prof Andy Buffler[1], Dr Carine Briand[2], Dr Tanya Hutton[1], Dr Gael Patton[3], Dr Francois Trompier[4]

[1]University of Cape Town. [2]Observatoire de Paris-PSL. [3]Icohup. [4]Institut de Radioprotection et de Sûreté Nucléaire

Abstract

The Earth is constantly being bombarded by energetic charged particles associated with both Galactic Cosmic Rays (GCRs) and Solar Particle Events (SPEs). The Earth's atmosphere and magnetic field provide a natural barrier to this radiation at ground level, but this protection is less effective with increasing altitude which impacts the radiation exposure of aircraft crew and passengers. For example, the dose rate at a typical aircraft cruising altitude of 11 km is about 10 micro-sieverts per hour, approximately two orders of magnitude higher than at sea level.

Dosimetry of aircrew is routinely achieved using numerical approaches validated by measurements made on board aircraft. However, in cases of randomly occurring solar eruptive phenomena, which can produce a burst of sufficiently energetic SEPs to be classified as a Ground Level Event (GLE), the dose rates at flight altitudes can be significantly increased. Current dosimetry models for GLEs cannot be easily validated due to the very few on-board measurements during such phenomena.

We present Cosmic-on-Air, a citizen science project, which aims to increase coverage of measurements of cosmic radiation on board aircraft in the search of solar eruptive phenomena. A series of low-cost, compact, and connected radiation monitors are available to the public for purchase, and the data measured during flights are uploaded to an open data repository for analysis. We discuss the science that is possible from these measurements, the impact on dosimetry models for aircrew, the development of next-generation detectors, and the science outreach which is catalysed through the program.

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Solar small-scale magnetic fields and their effect on convection and activity

Matthias Rempel

NSF NCAR, High Altitude Observatory

Abstract

The Sun is a unique star in the sense that we can observe it at high resolution and study phenomena with a detail that is hidden in stellar observations. This applies specifically to small-scale magnetic fields that are organized on the stellar surface on scales of granulation and smaller. Observations have shown that these small-scale magnetic fields are ubiquitous in the solar atmosphere and appear to be mostly independent of the solar sunspot cycle, which provides strong support for a small-scale magnetic dynamo. In this talk I will provide an overview of developments over the past 10-20 years. Recent research has clarified the role of the magnetic Prandtl number for small-scale dynamo action during both kinematic and saturated phase of dynamo operation and demonstrated that the low Pm found in stellar convection zones does not prevent small-scale dynamo operation as thought earlier. Simulations of strongly stratified convection point to a small-scale dynamo that operates over a wide range of scales in the solar convection zone and produces a magnetic field of a large enough strength to have a dynamical impact on convection. I summarize findings from simulations in terms of spatial distribution of magnetic energy, anisotropy of magnetic field throughout the atmosphere, effects on irradiance, the energetics of the dynamo and overall contributions to heating of the quiet Sun solar corona. Recent findings indicate that the small-scale dynamo may also influence convective power on the largest scales and play a critical role in establishing the solar differential rotation.

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Heliopsheric and Magnetospheric modulation of cosmic rays during the St. Patrick day storms of 2013 and 2015.

Dr Kingsley Okpala

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Abstract

The heliospheric and magnetospheric conditions from cosmic ray observations during the March 16-17, 2013 storm and March 17, 2015 super storm is studied. Data from the OMNI database and cosmic ray data measurements at the Geostationary Operational Environmental Satellite (GOES) and from global network of neutron monitors were employed. The interplanetary magnetic field (IMF), proton density, coronal mass (CME) speed and the, heliospheric current sheet (HCS) were investigated. The magnetospheric conditions were deduced from the disturbance storm time index. The principal component analysis from the scores of the PC1 of the Cosmic rays during these storms reveal that the IMF and HCS accounts for the greatest variance (>74%) of the cosmic rays during the storms. Both storms reveal a small but significant contribution from the ring current during the main phase of the storm. These results have important implications for the present understanding of the modulation of cosmic rays during energetic events in the heliosphere.

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Magnetic Loop breakout during a X5.0 Class Flare

Xiaofan Zhang[1,2], Prof. Guiping Zhou[1,2]

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Abstract

We newly report a magnetic loop breakout process during a GOES X5.0 class flare initiating at 21:36 UT on December 31, 2023. The breakout of the magnetic loop was triggered by the eruption of a magnetic flux rope (MFR) below, which was situated above the polarity inversion line (PIL) of AR 13536 with two footpoints located in the positive and negative polarities, respectively. Especially, both the studied magnetic loop and the MFR below share their west footpoints in the same positive magnetic patch of a sunspot with strong magnetic fields. The MFR showed instability since 20:47 UT that manifested as intermittent brightenings of its two footpoints based on EUV observations from the Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA). The MFR was identified as a high-temperature magnetic-channel structure in 131 Å. It erupted with two flare ribbons along the PIL. Its ejecting material first interacted with the nearest magnetic loops, but caused none of topologic changes. When the ejecting MFR kept reaching the studied magnetic loop that shared the same west magnetic footpoints, this magnetic loop occurred magnetic breakout phenomenon. An associated EUV wave was observed to propagate through a coronal hole nearby at the southeast. The intensity variation of the coronal hole was analyzed to relate to the dynamic process of the EUV wave. It discusses that the strong magnetic interactions in the PIL near the sunspot destabilized the MFR. The eruption of the MFR modified the magnetic fields of its west footpoint, which was also beared the instability of the studied magnetic loop. This should be the reason that the magnetic loop can happen magnetic breakout. Our findings provide insights into the new physical mechanisms of solar eruptions by uncovering the magnetic breakout process of a magnetic loop that was triggered by the ejecting MFR.

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A multi-wavelength investigation into the photospheric effects of a solar flare on 1 July 2012 using Swedish Solar Telescope observations

Dr Ruhann Steyn[1], Dr Gert Botha[2], Prof Eamon Scullion[2]

[1]North-West University. [2]Northumbria University

Abstract

The solar flare event of 1 July 2012 13:08 UTC was observed in multiple wavelengths by the Swedish Solar Telescope (SST), providing information about the state of the photosphere, chromosphere and corona. In this study, focus is placed on the changes in sheared photospheric flow pre and post flare. Two pores and several bright points inside the flow pattern are tracked using the Local Correlation Tracking software package YAFTA. The border between two counter flows and the location of a polarity inversion line are identified, while the distance between two pores over time is monitored for the changes in magnetic field line tension. The velocity flow vectors show the degree of shearing before and after the solar flare and the Poynting flux quantifies the magnetic energy evolution before and after the flare. The SST results are combined with results from the Solar Dynamics Observatory (SDO), the Geostationary Orbital Environmental Satellite (GOES) and the FERMI Gamma-Ray Space Telescope providing a multi-wavelength evolution of this event.

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Investigating the relationship between photospheric differential rotation and sunspot area using the Solar Observing Optical Network and terrestrial solar observations from the North-West University solar telescope

Ms Calmay Lee, Dr Ruhann Steyn

North-West University

Abstract

The North-West University in Potchefstroom, South Africa, commissioned a dedicated solar telescope observatory in 2021. Since its inception several postgraduate projects have been completed using the solar telescope. This study focuses on the latitudinal dependence of the photospheric differential rotation rate of sunspots and its relationship to sunspot area. The rotation rates and areas are experimentally determined by using a dedicated hydrogen alpha solar telescope by tracking sunspots across the solar disk for several months. The results are compared with the Solar Observing Optical Network observations extracted from their daily Solar Region Summary. Our results confirm the previously reported underestimation of sunspot areas, and we discuss its relationship with the differential rotation rates.

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Features of photoionization of Fe XVII, XVIII, Fe XIX impacting solar opacity

Prof Sultana Nahar

The Ohio State University

Abstract

Iron is the dominant heavy element that plays an important role in radiation transport in stellar interiors. Owing to its abundance and large number of bound levels and transitions, iron ions determine the opacity more than any other abundant element. A few iron ions constitute the abundance and opacity of iron at the base of the convection zone (BCZ) at the boundary between the solar convection and radiative zones, and are the focus of the present study. Together, Fe xvii , Fe xviii and Fe xix contribute 85% of iron ion fractions 20%, 39% and 26% respectively, at the BCZ physical conditions of temperature T $\sim 2.11 \times 10^6$K and electron density Ne = 3.1×10^{22}cc. We report heretofore the most extensive R-matrix atomic calculations for these ions for bound-bound and bound-free transitions, the two main processes of radiation absorption. We chose large wavefunction expansions which includes core ion excitation to n=2,3,4 complexes enable accuracy, convergence of photoionization cross sections, and inclusion of high lying resonances. The resulting datasets include 454 bound levels for Fe xvii, 1,174 levels for Fe xviii, and 1,626 for Fe xix up to n ≤ 10 and l=0 - 9. Corresponding datasets of oscillator strengths for photoabsorption are: 20,951 transitions for Fe xvii , 141,869 for Fe xviii , and 289,291 for Fe xix . Photoionization cross sections have obtained for all bound fine structure levels of Fe xvii and Fe xviii , and for 900 bound LS states of Fe xix. Selected results demonstrating prominent characteristic features of photoionization are presented, particularly the strong Seaton PEC (photoexcitation-of-core) resonances formed via high-lying core excitation with Δn = 1 that significantly impact bound-free opacity.

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Temperature profiles of coronal streamers and pseudostreamers during the full solar cycle

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Abstract

Both coronal streamers and pseudostreamers are long lived structures of the solar corona, and are very important source of slow solar wind. We have analyzed 200+ coronal streamers and pseudostreamers observed by AIA/SDO, from 2011 to 2023. For each streamers we applied a Differential Emission Measure method to obtain both a temperature distribution and a value of average temperature as well as it's change with height above photosphere. We find that streamers and pseudostreamers are filled with plasma with temperatures in the range of 1.2-2.0 MK, but height-temperature profiles of both streamer types differ slightly. Additionally the average temperatures of streamers vary with the solar cycle, and the temperature difference of ~0.7 MK is consistent with slow wind temperature variation.

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Advances and Future Directions in Modeling Total and Spectral Solar Irradiance

Dr. Serena Criscuoli

National Solar Observatory

Abstract

Variations of the electromagnetic radiation emitted by the Sun affects life on Earth. Similarly, the spectral energy distribution of stars and its variability affect the habitability of exoplanets and their detectability. In this contribution I will give a review of models of Total (TSI) and Spectral Solar (SSI) irradiance, developed to model variability of the solar electromagnetic spectrum at different temporal scales. I will focus on the advancements in radiative transfer models and techniques that are needed to improve our capability to reproduce and predict spectral irradiance variability, especially in the UV and chromospheric lines, and will describe the crucial role that new and future facilities will play in improving solar and stellar irradiance models.

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Lessons learned From The Magnetic Flux Rope Modeling

Dr. Teresa Nieves-Chinchilla[1], Dr. Andreas Weiss[2], Dr. Sanchita Pal[2], Ayris Narock[2,3]

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Abstract

Magnetic Flux Ropes (MFRs) are very common structures in the Heliosphere and traditionally associated with Coronal Mass Ejections (CMEs). Inferred from the in-situ observations and sometimes remotely observed, the internal structure of CMEs is assumed to be an organized bundle of magnetic field lines, twisting around a common axis, confining plasma, and dragging away a large part of the Sun's or a planet's atmosphere. Thus, MFRs dominate the transport of energy, mass, and helicity from the Sun to the heliosphere and from the heliosphere to the planets' local environment and determine the impact of space weather activity. The three-dimensional characterization of magnetic flux-ropes observed in the heliosphere has been a challenging task for decades. This is mainly due to the limitation to infer the 3D global topology and the physical properties from the 1D time series from any spacecraft, the gap of information to reconcile with the in situ measurements with remote sensing observations and the limitations imposed by currently available measurements and techniques.

To advance our understanding of magnetic flux-ropes, here we will present the efforts to development of more realistic 3D flux-rope physical modeling that allow us to reconnect the local observations with the global structure. This effort is combined with artificial intelligence technique to automatically detect FRs in solar wind data and additionally determine their geoeffective/non-geoeffective characteristics.

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Sunspot inclination of leading and tail magnetic field polarity

Mrs. Kseniia Tlatova, Mr. Andrey Tlatov

Kislovodsk Mountain Astronomical Station GAO RAS

Abstract

We investigated the inclination of sunspots a relative to the vertical. To determine the deviation angle a, a method was used to search for differences at different distances of sunspots from the central meridian, in the eastern and western hemispheres of the Sun. Particular attention is paid to the difference in angles a for spots of leading and tail polarity of the magnetic field. It has been established that the angles of deviation of sunspot umbra from the vertical depend on the logarithm of the area, but have opposite signs for leading sunspot umbra's and for umbra's tail polarity. When the magnetic field is Bmx~1500 G, the deviation angle a is approximately equal to zero. The found dependencies indicate the ascent of U-shaped force tubes.

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Multi-scale structure of Interplanetary Coronal Mass Ejections

Emilia Kilpua

Univeristy of Helsinki

Abstract

Interplanetary Coronal Mass Ejections (ICMEs) are macroscale structures in the heliosphere that drive intense space weather disturbances at the Earth and other planets of the solar system. A typical ICME consists of a leading fast forward shock wave, turbulent and compressed sheath region and a magnetic obstacle (magnetic cloud or a flux rope, or a more complex ejecta). This presentation will give an overview of the multi-scale structure of ICMEs. Sheaths and magnetic obstacles behind them are macroscale structures with radial widths of a significant fraction of an astronomical unit. Both however feature significant internal structuring, for example sheath regions have frequently mesoscale structures embedded such as small flux ropes and reconnection exhausts. These smaller scale structures have an importance for driving magnetospheric disturbances and accelerating charged particles. Turbulent properties, including level of magnetic field fluctuations, intermittency, cross-helicity, residual energy and magnetic helicity will be also discussed.

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Are there local dynamos acting in sunspot regions?

Dr. Chunlan Jin

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

A long lonely question in solar physics is whether or not there are local dynamo or dynamos acting in sunspot regions. Here we present an observed pattern of magnetic evolution implying a type of local dynamo does make the sunspots alive with ample complexity and energy. The unusual pattern is shown by peculiar bipolar magnetic emergences (BMEs) surrounding a mature unipolar sunspot with the following characteristics: (1) BMEs persistently appear beyond the penumbra, encircling the sunspot in end-to-end connection; (2) each BME gradually grows and separates its two polarities along an arc trajectory centered on sunspot; (3) a circular brightening belt is manifested in the ultraviolent/extreme-ultraviolent radiations during the BMEs'evolution; (4) often the sunspot regions with such flux emergence have vigorous solar activity, e.g., homogeneous major flares. Seven active regions (ARs) are definitively identified to host the above typical evolving pattern, which suggests a local twisted-reconnection dynamo operating in these sunspot regions.

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Helioseismic Diagnostics of Emerging Active Regions and Their Flaring Activity

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Abstract

We investigate the evolution of subsurface flows during the emergence and the active phase of sunspot regions using the time-distance helioseismology analysis of the full-disk Dopplergrams from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO). We present an analysis of emerging active regions of various types, including delta-type active regions with high flaring activity and regions with the reverse polarity order (`anti-Hale active regions'). The results reveal strong vortical and shearing flows during the emergence of magnetic flux, as well as large-scale converging flow patterns around developing active regions, predominantly in the top 4 Mm deep layers. The delta-type and anti-Hale active regions, which originated from the interaction of new emerging flux with the previously formed sunspots in our case studies, were associated with complex subsurface flow patterns. Our analysis revealed a significant correlation between the flow divergence and helicity in the active regions with their flaring activity. The strongest Kendall's tau rank correlation coefficients of the flow descriptors (the total divergence, vorticity, and helicity averaged over the 30x30-degree patches) with the flare productivity within the next 24-hour window, were found for subsurface flows at 1-3 Mm depth. This work shows the potential for using subsurface flow measurements to improve flare forecasting.

Session

Division E Sun and Heliosphere

2093

The Swift Solar Activity X-ray Imager (SSAXI-Rocket) onboard Hi-C Flare Rocket for the Flare Campaign

Dr. Christopher Moore[1], Dr. Leon Golub[1], Dr. Laura Hayes[2], Dr. Johnny Ho[1], Dr. Jae Sub Hong[1], Dr. Andrew Inglis[3], Dr. Almus Kenter[1], Dr. Adam Kobelski[4], Dr. Jeffrey Reep[5], Sophia Sánchez-Maes[1], Dr. Sabrina Savage[4], Dr. Amy Winebarger[4]

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Abstract

In April 2024, the High Resolution Coronal Imager (Hi-C Flare) and the Focusing Optics X-ray Solar Imager (FOXSI-4) rockets are planned to launch sequentially during the soft X-ray flux raising phase of a large solar flare. This NASA sounding rocket Flare Campaign is designed for a coordinated solar flare observation with the latest EUV and X-ray instrumentation. A ride-along instrument to the Hi-C Flare payload is the Swift Solar Activity X-ray Imager (SSAXI-Rocket. In the short 5-minute rocket flight, SSAXI-Rocket will measure the soft X-ray near-peak emission phase of a GOES C-class or greater solar flare. The SSAXI-Rocket instrument has peak sensitivity to 10 MK solar plasma, similar to the current Hi-C flare instruments, providing the exploration of the variability in heating and energy transport of Solar flares. SSAXI-Rocket combines small X-ray focusing optics with on-axis imaging resolution of 10 arcseconds or better and high speed readout detector, to image the flare soft X-rays at 5 hertz or faster, with minimized image saturation and pixel signal blooming. These high time cadence measurements can help uncover the soft X-ray intensity variations which can provide constraints on the intermittent heating processes in the magnetic loops.

Session

Division E Sun and Heliosphere

2141

The dust-heliosphere connection

Dr. Veerle Sterken

ETH Zürich

Abstract

Interstellar and interplanetary dust in the solar system acquire a surface charge as they are irradiated by the Sun and move through the heliospheric plasma. In situ spacecraft with dedicated dust instruments or with plasma wave antennas can measure these dust fluxes and in some cases the surface charges of cosmic dust. Several dust-heliosphere interactions are known from previous missions. For instance, interstellar dust focuses and de-focuses with respect to the solar equatorial plane depending on the 22-year Hale-cycle due to Lorentz forces. This was measured by a.o. the Ulysses and Galileo dust instruments and the Wind and STEREO plasma wave antennas. Also, the measurement of Jovian dust streams consisting of nanometers-sized dust particles are known to be correlated with transient structures in the solar wind.

In this talk we review the latest results and the prospects concerning dust-heliosphere interaction processes. In particular, we emphasize the current knowledge concerning the interstellar dust modulation by the heliosphere and the heliosheath. We highlight unique in situ measurement opportunities in the 2030 dust focusing phase - and beyond. Such measurements can happen at 1 AU with "local" spacecraft or, e.g. with a dust instrument on the Lunar Gateway - and across the heliosphere with an Interstellar Probe. We report on the discovery of a solar rotation frequency in the dust data, measured by plasma wave antennas, and elaborate on its possible causes. Finally, we argue that future missions with joint plasma and dust instrumentation are needed to foster synergies between dust and heliospheric sciences.

Session

Division E Sun and Heliosphere

2145

The non-thermal emission from the quiet Sun

Elena Orlando

University of Trieste and INFN

Abstract

The observed electromagnetic spectrum of the Sun in its non-flaring state extends from radio up to hundreds of GeV. In fact, the Sun is a recently-known gamma-ray source also in its quiet state. This high-energy emission is supposed to originate from interactions of Galactic cosmic rays with the solar surface and its surroundings.
We provide an overview of our current theoretical expectations and of present observations of the steady emission from the Sun from gamma rays to radio produced by galactic cosmic rays. We discuss how observations impact our knowledge of the solar environment and on galactic cosmic rays.

Session

Division E Sun and Heliosphere

2174

Photometric Calibration and Spectral validation of SUIT onboard Aditya-L1

Mr. Janmejoy Sarkar[1,2], Mr. Soumya Roy[1], Mr. Rushikesh Deogaonkar[1], Prof. A. N. Ramaprakash[1], Prof. Durgesh Tripathi[1], Dr. Sreejith Padinhatteeri[3], Mr. Anurag Tyagi[4], Mr. Ghanshyam Kumar[4]

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Abstract

The Solar Ultraviolet Imaging Telescope (SUIT) onboard India's Aditya-L1 mission takes spatially resolved full-disk images of the Sun in the 200-400 nm wavelength band. With eleven bandpasses, SUIT can explore various altitudes of the solar atmosphere and study the mass and energy transfer mechanisms.

SUIT aims to observe dynamic solar features like flares and jets and magnetic phenomena like plages, active regions, and network regions, spanning diverse scales in the solar atmosphere. Solar emission in this wavelength range is also highly significant for understanding the Ozone-Oxygen chemistry and the Sun-Earth climatic connection, making SUIT a unique addition to the existing instruments.

The scientific goals of SUIT require reliable photometric calibration to derive the associated absolute radiative energies. The instrument throughput is modeled using sun-as-a-star solar spectra from SOLSTICE and SOLSPEC for all science filters. This is validated by measuring the radiometric response of the instrument in the lab. The payload is loaded in a contamination-controlled vacuum chamber, and monochromatic light of known energy and wavelength is collimated and fed into the chamber. The measured counts are compared with the modeled values, revealing >85% coherence.

This presentation demonstrates the experimental setup, precautions, complete methodology, and related test results. The ratio of modeled data numbers to measured values is close to 1, while the spectral response of the payload isseen to closely match the model. The technology and methods employed are anticipated to be significant to the calibration of ground and space-based instruments in the future.

Session

Division E Sun and Heliosphere

2206

Electron-Scale Electric Field Turbulence in the Solar Wind: Clues to understanding energy dissipation

Dr Chadi Salem[1], Dr John Bonnell[1], Dr Kristopher Klein[2], Dr Luca Franci[3], Dr Vadim Roytershteyn[4]

[1]University of California Berkeley, USA. [2]University of Arizona Tucson, USA. [3]Northumbria University, Newcastle, UK. [4]Space Science Institute, Colorado, USA

Abstract

Recent works on solar wind turbulence and dissipation suggest that kinetic-scale fluctuations are both heating and isotropizing the solar wind during transit to 1 AU. The nature of these fluctuations and associated heating processes are poorly understood. The Electric Field is key to understanding the nature of the dissipative processes (Landau damping, cyclotron damping, stochastic heating, or energization through coherent structures) that link fields and particles.

The dissipation due to the fluctuations depends intimately upon the temporal/spatial variations of those fluctuations in the plasma frame. In order to derive that distribution in the plasma frame, one must also use magnetic field and density fluctuations, in addition to electric field fluctuations, as measured in the spacecraft frame (s/c) to help constrain the type of fluctuation and dissipation mechanisms that are at play.

We present an analysis of electromagnetic fluctuations in the solar wind from MHD scales down to electron scales using data from the Artemis spacecraft at 1 AU. We analyze magnetic and electric field, and density fluctuations from the 0.01 Hz up to 1 kHz. We compute electric to magnetic field ratio, magnetic compressibility, magnetic helicity, compressibility and other relevant quantities in order to diagnose the nature of the fluctuations at those scales, extracting information on the dominant modes composing the fluctuations, and compare to expectations from linear theory. These results are supplemented by analysis of fully nonlinear kinetic simulations of decaying turbulence at small scales.

Session

Division E Sun and Heliosphere

2378

Evolution of Ratio of Mg II Intensities During Solar Flares

Soumya Roy, Durgesh Tripathi

The Inter-University Center for Astronomy and Astrophysics

Abstract

The ratios of Mg II k & h line intensities offer a valuable means to explore plasma properties within the solar atmosphere. In this investigation, we analyse observations obtained by the Interface Region Imaging Spectrometer (IRIS) to examine how the Mg II k & h intensity ratio varies across the evolution of three different flares: X-class, M-class, and C-class. Additionally, we investigate the relationship between the k-to-h intensity ratio and the magnetic flux density derived from line-of-sight magnetograms captured by the Helioseismic and Magnetic Imager (HMI) aboard the Solar Dynamics Observatory (SDO). Our findings demonstrate that although the intensity ratios remain unaffected by magnetic flux density, they undergo significant changes during the progression of C-class and M-class flares. Specifically, these ratios begin to rise at the onset of the flare, reaching a peak during the impulsive phase before the flare reaches its maximum, followed by a rapid decline after that. During the peak and decline phases of the flare, the ratios plummet even below their pre-flare levels. These observations shed light on plasma's localised heating and cooling, thus adding valuable insights to our understanding of flare physics.

Session

Division E Sun and Heliosphere

2424

Estimating magnetospheric current systems during geomagnetic storms: Comparison of Inner-Magnetosphere and Ionosphere modeling with ground and space-based magnetic field observations

Dr Ephrem Tesfaye Desta[1,2], Dr Mei-ching Fok[3], Prof Mark B. Moldwin[4], Prof Tigistu Haile Eritro[5]

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Abstract

During geomagnetic storms, solar wind energy is coupled into the magnetosphere, creating and amplifying the global magnetospheric current system. Rapid plasma transport, ULF wave propagation, and enhanced pressure gradients through the magnetosphere intensifies high-latitude field aligned currents (FACs) and equatorial current systems, respectively. We report the effect of solar wind dynamic pressure and particle density enhancements on the FAC, Ring Current (RC), RC energy injection and associated magnetic fluctuations by multipoint magnetic observations from ground and space in the equatorial plane. In this study,(1) the solar wind dynamic pressure, particle density, and IMF B_z during geomagnetic storms are examined; (2) magnetic data from four geomagnetic equatorial stations measuring ground magnetic disturbances across a wide range of geomagnetic equatorial longitudes for the storm periods 17 March 2013, 31 May-01 June 2013, and 05-08 July 2013 are analyzed; (3) using ground magnetometer data, the magnetic field disturbance (dH) across the equator and the Dst index, ring current and ring current energy content are estimated at r = 4.5 R_e; and (4) for corresponding geomagnetic storm periods using the Van Allen Probes and THEMIS spacecraft data, the FACs were estimated. (5) Inner magnetosphere (CIMI) and lower ionosphere model (SAMI2) also used for the event analysis. Our results show that the sudden enhancement of solar wind pressure, proton density and strong southward reversal orientation of IMF B_z lead to strong geomagnetic storm that increases ring current asymmetry over geomagnetic equator and rapid peak variations in FAC. The results also show that when geomagnetic storms persist longer, variations in equatorward Field-Aligned Currents (FAC) last longer as well

Session

Division E Sun and Heliosphere

2582

Investigating the response of the topside ionosphere to space weather and solar activity using Global Navigation Satellite System positioning

Dr Joseph Omojola

North-West University

Abstract

This study investigates the response of the ionosphere to space weather events and solar activity by single-point post-processing analysis of the Global Navigation Satellite Systems (GNSS) archival data from the International GNSS Service (IGS) over Addis Ababa with station ID ADIS and Sutherland with Station ID SUTV in the African sector. The data were selected during the solar minimum and maximum of solar cycle 24, during the geomagnetic storm that occurred on 16-18 March 2015 and the quiet days on 6-8 January 2010. The storm began with a sudden commencement at 5:00 UT on 17 March 2015, reaching the main phase on the same day with a minimum SYM-H index of -234 nT at 22:47 UT. The X-Ray Telescope (XRT) onboard Hinode also show an X-ray irradiance with several active regions and coronal holes on the solar disk during this period. The observation of the solar disk by Hinode on the 7th and 8th of January 2010 is interesting, during which the development of the active region and the coronal holes can be easily observed, and its signature was detected prominently at SUTV, a mid-latitude station. The results indicate that GNSS positioning is very sensitive to solar activity and can be useful in studying solar-terrestrial interactions.

Session

Division E Sun and Heliosphere

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2584

Signature of self-absorption in the Si IV emission lines from a solar surge

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VIT Bhopal University

Abstract

Interface Region Imaging Spectrograph (IRIS) has observed a surge that occurred at the periphery of an active region (AR) on October 17, 2023. The multi-wavelength images from Atmospheric Imaging Assembly (AIA) revealed that the jet is visible only in the cool temperature filters, with no hot jet signature. The projected propagation speed of the jet, deduced from the time-distance analysis, is around 200 km/s in the cool temperature filters. The spectroscopic diagnostic shows that the base of the surge is highly red-shifted while the spire of the jet is blue-shifted. Most importantly, some Si IV spectral profiles from the base and spire of the surge have a dip at the central wavelength, which is the signature of self-absorption. Here, we emphasize that this is the first observational evidence of self-absorption in the jet-like structure. Then, we estimated the Si iv line ratio (1393.755 Å/1402.70 Å) and found that most of the locations in the base and the spire of the surge have ratio values less than the theoretical value of 2.0. This supports that the Si IV spectral lines are forming under optically thick conditions. Further, the electron density is estimated using the O IV spectral lines (1393.78 Å and 1401.16 Å) and the CHIANTI atomic database. The mean electron density at the base is log 10.82 and at the spire of the surge is log 9.93. The observational evidence (e.g., anemone shape, and brightening at the base) supports that this particular surge is triggered by magnetic reconnection.

Session

Division E Sun and Heliosphere

2746

Observational Validation of the Modeling and Simulation of a CME using a Deep Neural Network

Dr Diego Lloveras[1], Dr. Hebe Cremades[1], Dr. Francisco Iglesias[1], Florencia Cisterna[1], Dr. Alberto Vasquez[2], Dr Federico Nuevo[2], Dr Ward Manchester IV[3], Dr Nishtha Sachdeva[3]

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Abstract

Coronal mass ejections (CMEs), huge structures of plasma and magnetic field that are expelled from the solar corona into the solar wind, play a determining role in the evolution of space weather and climate. A detailed understanding of the physical mechanisms that govern CME dynamics requires the combination of observations with theoretical modeling and numerical simulation. In this work, we use the three-dimensional (3D) magnetohydrodynamic Alfvén Wave Solar Model to simulate the background corona and solar wind. To simulate the CMEs, we use the Eruptive Event Generator Gibson-Low module (EEGGL), which provides an initial flux-rope type magnetic configuration that is allowed to evolve into the interplanetary medium. We use a Deep Neural Network to identify and segment the outer envelope of CMEs in a time series of single images provided by
SOHO/LASCO-C2, and STEREO/COR2, which allows us to calculate CME parameters (such as angular width and central position angle) using the segmentation masks. We used the parameters obtained from the real image segmentation to validate the simulated synthetic images from the CME. In this presentation, we show the analysis applied to a selected event, whose observations are used to validate the simulation's ability to successfully model this CME.

Session

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2771

The Sun's differential rotation is controlled by baroclinically-unstable high-latitude inertial modes

Dr. Yuto Bekki[1], Dr. Robert Cameron[1], Prof. Dr. Laurent Gizon[1,2]

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Abstract

Global p-mode helioseismology has revealed that the Sun’s differential rotation substantially deviates from the well-known Taylor-Proudman theorem. It has been postulated that this deviation is due to the poles being warmer than the equator by a few degrees. However, this latitudinal temperature difference is too small to be directly measured. Recently, various inertial modes have been observed and identified on the Sun, including modes at high latitudes. These high-latitude inertial modes are baroclinically unstable and thus quite sensitive to the latitudinal temperature difference in the Sun. In this talk, using 3D nonlinear numerical simulations, we show that the pole-to-equator temperature difference in the Sun is limited to less than 7 K due to the nonlinear feedback of the high-latitude modes. It is also found that these inertial modes control the Sun's differential rotation by transporting heat equatorward and driving the meridional circulation to redistribute the angular momentum. The observed amplitudes of these inertial modes indicate that the Sun's latitudinal differential rotation is near its maximum allowed value.

Session

Division E Sun and Heliosphere

2773

First detailed polarimetric study of a type-II solar radio burst with the Murchison Widefield Array

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Abstract

Type II solar radio bursts are plasma emissions generated by magnetohydrodynamic shocks that are predominantly associated with the more energetic and fast coronal mass ejections (CMEs). These CMEs are expected to drive shocks in the coronal medium and play a dominant role in giving rise to energetic particles which are the biggest concern for Space Weather. The evolution and geo-effectiveness of these eruptions are governed by their magnetic fields and interaction with the coronal magnetized plasma; hence, crucial to understand. Polarimetric properties of type-IIs provide promising diagnostics for measuring and understanding the magnetic field strength, and topology at the CME-shocks. In the literature, their polarization properties have been reported to vary from being unpolarized to very strongly circularly polarized, and no linear polarization has ever been reported. The vast majority of these studies rely on dynamic spectra which can only provide spatially integrated information. Instruments like the Murchison Widefield Array (MWA) and robust spectropolarimetric snapshot solar imaging pipeline, P-AIRCARS, (Kansabanik et al., 2022a, 2022b, 2023) have enabled high-fidelity and high-dynamic range solar radio imaging with good temporal, spectral and reasonable angular resolution. Benefiting from these, we have used this capability to carry out a detailed imaging polarimetric study of a type-II solar radio burst. We have also characterized the structures of the sources in both the total intensity and polarized emissions, meticulously investigating their temporal and spectral evolutions. Our study marks the start of the use of polarimetric imaging observations to further the understanding of type-II radio bursts and coronal propagation.

Session

Division E Sun and Heliosphere

2775

ICME deformation rate in their propagation to 1 AU

Lic Franco Manini[1], Dr Hebe Cremades[1], Dr Teresa Nieves-Chinchilla[2], Dr Diego Lloveras[1], Dr Francisco Iglesias[1], Dr Fernando Lopez[1]

[1]Universidad de Mendoza - CONICET - Argentina. [2]NASA Goddard Space Flight Center

Abstract

The 3D shape and internal structure of heliospheric flux ropes is still mostly unknown. Therefore, there is a need to
investigate the interplanetary evolution of Coronal Mass Ejections in the inner heliosphere, mainly due to their impact on Earth and spacecrafts orbiting the Sun and other planets.
In this work we built a list of Earth-directed ICMEs during the years 2010 to 2012. We used the Heliospheric Imagers (HI) aboard the STEREO spacecrafts to identify 366 ICMEs in the FOV of the HI-1 telescopes.
For 28 events, we were able to follow the CMEs from their source region in the Sun and in coronographic images from COR2 and C2 instruments, with their respective interplanetary counterparts using the Heliospheric Imagers HI-1 and HI-2, up to the in situ
plasma measurements made with the WIND and ACE spacecrafts, in the vicinity of Earth. We selected 3 events with their flux rope seen horizontally in HI-1 instruments, to apply different distortion functions using the General Distorted-toroidal flux-rope model, and measure the deformation rate
of the cross section in the different stages of propagation in the FOV. This work is an intent to characterize the changes in the ICMEs complexity as they propagate from the Sun to 1 AU.

Session

Division E Sun and Heliosphere

2788

Solar coronal structure in the Maunder Minimum and the Dalton Minimum: Archival investigations

Dr Hisashi Hayakawa

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Abstract

This presentation contrasts the coronal structures in the Maunder Minimum (1645 -- 1715) with those in the modern regular solar cycles, the Dalton Minimum, and the immediate aftermath of the Maunder Minimum. The Maunder Minimum was typically considered as the only grand minimum within the coverage of the direct instrumental solar observations in the last 4 centuries. The solar magnetic activity was far calmer than that of the regular solar cycles in the space age -- and probably so than that of the Dalton Minimum (1790s -- 1820s), whereas it is not immediately clear how quiet the solar magnetic activity was. This is because we have limited access to the contemporaneous sunspot observations. In contrast, total solar eclipses in history have occasionally left graphical records. They are especially helpful to understand the solar coronal structure and indirectly visualize the large-scale solar magnetic activity back in the past. This presentation reviews such graphical records for historical total solar eclipses, contesting the solar coronal structures in the Maunder Minimum with those of the modern solar cycles, the Dalton Minimum, and the immediate aftermath of the Maunder Minimum, including developments from Hayakawa et al. (2021, JSWSC, 11, 1). These results strikingly contrast the Maunder Minimum with the modern solar cycles, the Dalton Minimum, and the immediate aftermath of the Maunder Minimum, to emphasize how unique the Maunder Minimum was.

Session

Division E Sun and Heliosphere

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Solar X-ray Irradiance Observations from the Miniature X-ray Solar Spectrometer (MinXSS) CubeSats

Crisel Suarez[1,2], Christopher S. Moore[2], Amir Caspi[3], Phil Chamberlin[4], Brendan D'Aquino[2], Anant Kumar[5], James Mason[6], Bennet Schwab[4], Robert Sewell[4], Tom Woods[4]

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Abstract

The Miniature X-ray Solar Spectrometer (MinXSS) CubeSats were the first solar science-oriented CubeSat mission flown for the NASA Science Mission Directorate, with the main objective of measuring the absolute radiometrically calibrated energy distribution of solar soft X-ray emission over a large spectral bandpass at a moderate spectral resolution (nominal 0.15 keV energy resolution at 5.9 keV). The MinXSS Cuebsats were successful in measuring the solar soft X-ray irradiance in the energy range of 0.8 - 12 keV. The first of the twin CubeSats, MinXSS-1, has observed over 30 solar flares from June 2016 to May 2017 over its 1-year mission lifetime. MinXSS-2 observed the quiescent Sun during December 2018-January 2019. Since February 2022, the next generation MinXSS, the Dual Aperture X-ray Solar Spectrometer (DAXSS), has been conducting higher sensitivity and higher spectral resolution measurements. The spectral measurements and unique energy resolution at the time, provided by MinXSS can constrain solar flare and active region temperature structure, emission measure, and abundances of Fe, Ca, Si, and, S. We present the science results of the MinXSS-1 and MinXSS-2 measurements for flares and the quiescent Sun. These results have proven to be consistent with numerous solar observations from other satellites, and provide constraints in modeling and understanding solar phenomena, therefore proving the scientific capabilities of CubeSats.

Session

Division E Sun and Heliosphere

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Opening New Frontiers in Solar Radio Physics Using High-fidelity Imaging Observations with Square Kilometre Array Precursors

Dr DEVOJYOTI KANSABANIK

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Abstract

Solar radio emissions and their polarization properties provide the means to remotely measure plasma parameters including magnetic fields of the solar atmosphere as well as different eruptive phenomena like flares and coronal mass ejections (CMEs). However, observing radio emissions from all of them is intrinsically challenging. These emissions show morphological structures ranging from a few arcseconds to a few solar radii. Additionally, their brightness spans more than ten orders of magnitude and shows dramatic variation in both spectral and temporal dimensions. Hence, one requires high dynamic-range (DR) spectropolarimetric snapshot imaging to observe them in detail. We have developed the state-of-the-art polarimetric calibration and imaging pipeline (P-AIRCARS; Kansabanik et al., 2022, 2023) over the last few years. P-AIRCARS now routinely provides high DR spectropolarimetric meter-wavelength solar images using observations from the Murchison Widefield Array (MWA), the precursor of the low-frequency telescope of Square Kilometer Array Observatory (SKAO). These high DR images have led to several new results – quiet Sun magnetic field estimation using measurements of low levels circular polarization, spectropolarimetric modeling of faint gyrosynchrotron (GS) emission from CMEs providing robust estimations of its plasma parameters. Alongside, we have recently started solar observations at GHz frequencies with MeerKAT, the mid-frequency precursor of the SKAO. Comparing the very first MeerKAT solar images with simulation, we demonstrated its capability to produce high-fidelity solar images at GHz frequencies. This talk will give glimpses of new results from both of these instruments establishing the ability of SKAO to open up new frontiers in solar radio physics.

Session

Division E Sun and Heliosphere

3182

Frontiers of Artificial Intelligence in Solar Physics

Robert Jarolim[1,2], Astrid Veronig[2,3], Benoit Trembaly[1], Julia Thalmann[2], Matthias Rempel[1], Momchil Molnar[1], Tatiana Podladchikova[3]

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Abstract

Artificial intelligence (AI) has enabled ground-breaking results across scientific domains. With the rapid increase in data volume and computational complexity, astrophysics can directly profit from the most recent breakthrough methods of artificial intelligence. In this presentation we give an overview of the six research papers that comprise the thesis and that address recent frontiers of artificial intelligence in solar physics. Leveraging cutting-edge AI techniques, these studies are key to extract unprecedented information from large data sets, spanning the applications from precise detection of coronal hole boundaries to transformative imaging translation and real-time magnetic field extrapolations. By bridging historical observations, enhancing data accessibility, and unlocking new dimensions of the structure of the solar corona, these advancements mark a significant step forward in our ability to comprehend the complexities of the Sun and its dynamic behavior.

In this talk, we specifically focus on the transformative role of physics-informed neural networks (PINNs) for modeling of the solar corona, where we use photospheric and chromospheric magnetic field measurements to estimate the magnetic topology in the upper solar atmosphere.

With this we underscore the remarkable addition and synergy that artificial intelligence brings to solar physics.

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How to deflect a solar eruption

Abril Sahade[1], Mariana Cécere[2,3]

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Abstract

Understanding the properties, evolution, and geoeffectiveness of coronal mass ejections (CMEs) is of utmost importance for space weather forecasting. CMEs originate from an erupting magnetic flux rope (MFR), and are usually related with erupting filaments and flares. Not all CMEs evolve radially, and deviations in the trajectory are mainly attributed to interactions with magnetic structures surrounding the eruption source region, coupling between successive events, and asymmetric detachment of the MFR. However, the extent to which each process influences the MFR deflection is still under investigation. The research conducted in this work focuses on understanding how the interaction between the erupting MFR and the magnetic environment of the source region leads to a deflection. In particular we investigated the role of coronal holes and pseudostreamers using magnetohydrodynamic (MHD) 2.5 simulations and compared them with observational cases. We conclude that null points play a key role in deviating erupting flux ropes. By identifying the null point location, hierarchy and the environment topology we may improve our understanding of the early development and trajectory of solar eruptions.

Session

Division E Sun and Heliosphere

Final category: Division F Planetary Systems and Astrobiology

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An Earth-sized Exoplanet Orbiting an M2 Star

Mr Francis Zong Lang, Professor Brice-Olivier Demory

University of Bern

Abstract

The population of rocky exoplanets are abundant and cool
stars such as M-dwarfs provide a unique opportunity to detect these objects
with possible implications for the study of Astrobiology.

SAINT-EX (Searching And characterisINg Transiting EXoplanets) consists of a
one-meter telescope optimized to obtain high-precision light curves of transiting
planets orbiting ultra-cool stars. The two main objectives of SAINT-EX are:
-The search of terrestrial exoplanets orbiting ultra-cool stars and
-To give ground-based support to the ESA CHEOPS mission.

TOI4616, a system with a planet of size 1.22R$\oplus$ and an orbital period of 1.554
days has been detected by the NASA TESS mission and later characterized
with the SAINT-EX telescope. We study this system in order to characterise
the properties of the planet and its host star and use transit photometry to con-
strain critical parameters of the planet such as its mass and orbital dynamics.
By employing a series of aperture and PSF photometry methods to determine
the crowding metric and the flux fraction to compute an accurate transit depth
obtained from the SAINT-EX light curves and constrain the necessary plane-
tary parameters.

The validation of the orbital period of 1.554 days reinforces our understand-
ing of rocky exoplanets around low-mass stars. We expect TOI4616 to be a
rocky exoplanet with the possibility of hosting an atmosphere. Analysis through
transmission spectroscopy might offer insights into the exoplanet's atmosphere,
revealing potential molecular constituents. Investigating the planet's stability
in this system would reveal potential interactions with other bodies and the system's long-term stability.

Session

Division F Planetary Systems and Astrobiology

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The Dynamical Evolution of Planets Orbiting Interacting Binaries

Dr Santiago Torres

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Abstract

15% of solar-type stars are in such close binaries that interaction is bound to occur as the stars evolve and swell. Around 20 circumbinary planets have been detected orbiting binary systems. This suggests that dynamical processes play a key role in the evolution of circumbinary planetary systems. Understing the interaction between the bodies in such complex systems is important for planet formation and binary evolution. The tightest orbit binaries should host the most stable and, therefore, long-lived circumbinary planetary systems. Still, they are also the systems that are expected to experience mass transfer, common envelope evolution, or stellar mergers. Subdwarfs are one of the most common types of products resulting from binary evolution. They are both long-lived and easy to recognize. In order to disentangle the dynamic evolution of planets around evolved and interacting binaries, we developed an integration framework that seamlessly integrates the binary evolution data from the stellar evolution code MESA into a detailed N-body simulation code REBOUND. To ensure numerical robustness, we constructed a binary star model and introduced a recalibration method to mitigate errors from updates of binary properties during dynamical computations. We reveal that the nearest stable orbital separation for circumbinary planets is roughly 2.5 times the binary separation after mass transfer. In this talk, I will present our new method, model and latest results of the evolution of planets whose host binary evolves into a subdwarf system.

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The demographics of small transiting exoplanets

Dr Rafael Luque

The University of Chicago

Abstract

The diversity of the exoplanet population is beyond our imagination. The more than 5000 known exoplanets vastly differ in mass, size, orbital period, dynamics, and host type. Demographic studies, however, aim to find patterns in the population that inform us about their origin, composition, and evolution. Among these features, perhaps the most surprising is the abundance of planets with no analog in the solar system, also known as sub-Neptunes. In this talk, I will review the state-of-the-art regarding the detection and characterization of such planets and what we know today about their enigmatic nature. A definitive answer, however, seems within reach during this decade thanks to the game-changing observations that will be provided by JWST, PLATO, and ARIEL.

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A new ARM-based CPU implementation of the RHPIC-LBM code

Professor Bojing Zhu

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Abstract

We present a new version of the RHPIC-LBM code, applied to investigating the GeV-level-SEPs-induced extreme space weather disasters with a plasma statistical physics theoretical model.

This new implementation, which we have named RHPIC-LBM-Phyton, uses ARM architecture to allow the code execution on the Embedded Central Processing Unit (Phyton E3000 CPU). The Phyton version is an unofficial, modified SUGON version of the RHPIC-LBM code previously designed for the X86 architecture heterogeneous system (CPU-DCU).

We perform numerical simulations based on the previous SUGON version and its Phyton CPU counterpart to conduct performance analysis, including execution time, precision differences, and accuracy. We narrowed our tests and analysis only to double-precision floating point operations and a spherical domain with a 12000 Km fine-structure test (turbulence magnetic fields change around the below and above the loop in the top of the 3D circular flaring coronal loop arcade).

Our comparison shows that results are similar for both versions of the code, confirming the correctness of our ARM-based implementation. Our tests reveal that the RHPIC-LBM Phyton version code can be four times faster than the SUGON version.

Cloud disk link： https://pan.cstcloud.cn/s/ddoxPrdHSBU

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Radioactivity of Saturn's D-Ring

Dr James Welsh[1,2], Dr Andrew Karam[3]

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Abstract

Saturn's rings are the most recognizable feature in our Solar System. Given the extent of Saturn's magnetosphere and radiation belts, it is natural to wonder if the radiation might induce radioactivity in the ring fragments. We have systematically examined activation of the D-ring by considering the following:

1. Radiation flux and energy spectrum
2. Radiation species
3. Elemental composition of the rings
4. Potential nuclear activation channels
5. Interaction cross sections
6. Activation product half-lives

Saturn's rings are 99.9% water ice with traces of organic and silicate impurities. Hence, ^{1}H and ^{16}O are the principal nuclides available for induced activation. Other nuclides include ^{2}H, ^{17}O, and ^{18}O. Minute quantities of tholins and silicates introduce targets of ^{12}C, ^{13}C, ^{14}N, ^{15}N, and ^{28}Si, ^{29}Si, and ^{30}Si. CRAND protons are the most likely source of radiation in the inner radiation belt. We reviewed multiple potential proton capture channels involving the available nuclides; possibilities include:

- High interaction probability, but the products are not radioactive.
- Low activation probability.
- Low abundance of parent isotopes for producing radioactive products
- High activation probability, but only for low energy radiation.
- High activation probability at the energies available.

We conclude that the most likely activation products in the D-ring are ^{11}C, ^{15}C, ^{13}N, ^{14}O, ^{15}O, ^{17}F, ^{18}F, with traces of ^{7}Be, ^{28}Al, ^{14}C, and ^{16}N. As many of these radionuclides are positron emitters, their presence should be readily detectable via characteristic 511 keV annihilation gamma photons.

We note that the ring systems of other planets are amenable to similar analysis.

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A FAMILY OF ASTEROIDS WITH COMET-LIKE ORBITS ASSOCIATED WITH THE DELTA-CANCRIDS METEOROID STREAM

Dr. Gulchehra Kokhirova[1], Dr. Zhang Ming[2,3,4], Dr. Xing-Gui Li[2,5], Dr. Umed Khamroev[1], Dr. Abdullo Zhonmuhammadi[1], Dr. Manuchehr Latipov[1]

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Abstract

The *d*-Cancrid meteoroid stream produces 4 meteor showers active on the Earth annually during January-February and August-September. A certain parent comet of the stream is not found. We performed a search for near-Earth asteroids (NEAs) associated with this stream. On the base of calculation of orbital evolution of a sample of NEAs and determination of theoretical features of related showers a search for observable active showers close to theoretically predicted ones was carried out in published databases. As a result, the predicted showers of 13 NEAs were identified with active showers producing by the *d*-Cancrid meteoroid stream. Revealed association points to a common cometary origin of NEAs that are moving within the stream and very likely are extinct fragments of a larger comet-progenitor of the Cancrid asteroid-meteoroid complex.

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The depletion of the asteroid belt and the impact history of the terrestrial planets

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Abstract

The asteroid belt has been by far the main source of projectiles that collide with the Earth and the other terrestrial planets. We have analyzed the different escape routes of material from the asteroid belt. Asteroid fragments that do not escape from the belt are ground down by mutual collisions to dust. We find that the asteroid belt is currently losing a fraction of about 7×10^{-5} Myr^{-1} of its mass, about 25% as macroscopic bodies, and 75% as dust particles that feed the zodiacal dust cloud. The computed relative contributions depend on what fraction of zodiacal dust is of asteroidal origin. Estimates can vary between less than 0.1 to about 0.3. Extrapolation of the current mass loss rate to the past suggests only a modest increase of the asteroid belt mass and the mass loss rate (about a factor of 1.3 and 2 respectively) in the last 3.5 Gyr. This should correlate with a modest variation of the impact rate of the terrestrial planets. Yet, should the computed current asteroid mass loss rate be greater than our canonical value, owing to different uncertainties, the extrapolation to the past would lead to quite different results. For instance, an increase by a factor of three in the current asteroid mass loss rate would lead to an exponential increase of the asteroid mass about 3.5 Gyr ago, which would be consistent with models predicting the existence of a primordial massive asteroid belt that decayed on a time scale of 1 Gyr.

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The MUIWAST Space telescope, Its instruments and The Omega Super Telescopes Project This is an 25 meter telescope successors to JWST and NRGST telescopes An General Infrared Observatory has a full infrared wavelength spectrum under the the Omega Super Telescopes Project Like MUIWAST 25 meter telescope and OAMUIWAST a 30 meters telescope and UVAOAMUIWAST a 35 meters telescope and Grand planetary Observatory a 4 699.3 meters bigger than E-ELT the biggest telescope todayAuthor by Albert Michael E Pacupac Independent Author

The MUIWAST Space telescope, its Instruments and The Omega Super Telescopes Albert Michael Pacupac

Rizal high school

Abstract

This is an 25 meter telescope successors to JWST, NRGST, OST and Luvoir telescopes An General Infrared Observatory has a full infrared wavelength spectrum under the the Omega Super Telescopes Project Like MUIWAST 25 meter telescope and OAMUIWAST a 30 meters telescope and UVAOAMUIWAST a 35 meters telescope and Grand planetary Observatory a 4 699.3 meters bigger than E-ELT the biggest telescope today

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Dust growth and pebble formation in the initial stages of protoplanetary disk evolution

Dr. Vardan Elbakyan[1], Dr. Eduard Vorobyov[2], Dr. Prof. Anders Johansen[3], Dr. Michiel Lambrechts[3], Aleksandr Skliarevskii[4], Dr. Vitaly Akimkin[5], Dr. Igor Kulikov[6], James McKevitt[2], Dr. Prof. Manuel Güdel[2]

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Abstract

We study the dust growth and pebble formation in a protoplanetary disk that is still accreting from a parental cloud core using 3D numerical hydrodynamics code with nested meshes. We found that the dust growth from ∼1 μm to 1–10 mm already occurs in the initial few thousand years of disk evolution. The ratio of the dust-to-gas vertical scale heights remains rather modest, 0.2–0.5. The dust-to-gas mass ratio in the disk midplane is highly non-homogeneous throughout the disk extent and is in general enhanced by a factor of several compared to the fiducial 1:100 value. Low St hinders strong dust accumulation in the spiral arms compared to the rest of the disk, and the non-steady nature of the spirals is also an obstacle. The spatial distribution of pebbles in the disk midplane exhibits a highly non-homogeneous and patchy character. The total mass of pebbles in the disk increases with time and reaches a few tens of Earth masses after a few tens of thousands of years of disk evolution. Hence, young disks with an age ≤20 kyr can already be ripe for the planet formation process to start.

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Lightcurves and colors of 11 small Near-Earth Asteroids

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Abstract

We conducted observations of several small near-Earth asteroids (NEA) starting in 2023 using the Vatican Advanced Technology Telescope (VATT) 1.8-m telescope on Mount Graham in southern Arizona. Observations were made for each asteroid in multiple broadband color filters. A long series of V-band images were collected to ensure that the entire lightcurve was covered. In order to compute the color of the asteroid, we also collected images in B, R, and I filters. Petr Pravec's Asteroid Lightcurve (ALC) software was used to compute the lightcurve and determine color indices (V-R, B-V, and V-I) for each asteroid. We use the following methods to determine the asteroid's taxonomy and meteorite classification. The first method consisted of making two-color plots (B-V vs . V-R and V-I vs. V-R) to compare the colors against those of other asteroids. For the second method, we computed the relative reflectance of the NEA, which we compared with the observed asteroid spectra in the SMASS/SMASSII database (Bus and Binzel 2002a,b). The final method consists of a comparison between the relative reflectance of the NEA and the laboratory spectra of meteorites from the Brown University Reflectance Experiment Laboratory (RELAB).

2020 BV14, a H=23.4 Apollo asteroid, is a fast rotator with a rotation of 0.17460+/-0.00006 h. The color indices of B-V=0.781+/-0.029, V-R=0.441+/-0.031, and V-I=0.826+/-0.026 suggest 2020 BV14 belongs to the X-complex of asteroids.

The results for the 11 observed NEAs are shown in Tables 1 (Kikwaya Eluo & Hergenrother, 2023) and 2 ((Kikwaya Eluo & Hergenrother, 2024).

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The Vatican Observation Meteor Research Program (VOMRP)

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Abstract

The Vatican Observatory Meteor Research Program is collaborating with three meteor and fireball video detection networks. The first collaboration is with cameras operated in Italy as part of Fripon (Fireball Recovery and InterPlanetary Observation Network). The Vatican Observatory's contribution consists of a camera installed in 2022 at Castel Gandolfo. Fripon gathers data on meteors brighter than -4 magnitude with a clear objective of meteorite recovery. The Castel Gandolfo camera has observed more than 20 fireballs since 2022 though none produced meteorites. The goal is to observe fireballs capable of producing meteorites that would then be studied at the Vatican Observatory's meteorite laboratory to determine physical characteristics (density, porosity, heat conductivity, etc.).

The second system operates near Tucson, Arizona, USA, in collaboration with the NASA Asgard All Sky Fireball Network, observing meteors brighter than 3rd magnitude. The Vatican Observatory collaboration includes 3 cameras installed around Tucson on Mount Lemmon, Mount Hopkins and Kitt Peak. Each night, meteors are detected, analyzed, published online by NASA (e.g. https://fireballs.ndc.nasa.gov/). For each meteor, the time of observation, velocity, beginning and ending height, Tisserand parameter, and orbital elements are available.

The third system also operates in southeastern Arizona but focuses on the detection of faint meteors (fainter than 3rd magnitude). This collaboration is with the GMN (Global Meteor Network), which provides information on the radiant, orbital elements, brightness, and mass of each detected meteor. The results are public and available at https://globalmeteornetwork.org/data/plots/. The Vatican Observatory contributes 3 cameras installed in parallel with the Asgard system.

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Constraining the Gas Mass of Protoplanetary Disks: From CO to Multi-Molecular Approaches

Miss Amina Diop[1], Dr. Ilse Cleeves[1], Dr. Dana Anderson[2], Dr. Jamila Pegues[3], Dr. Adele Plunkett[4]

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Abstract

Thousands of planetary systems have been discovered, each characterized by unique orbital patterns and chemical compositions. The next logical step is to investigate how the birthplace of planets, protoplanetary disks, evolve into these diverse systems. However, the gas mass of disks, one of the most important properties determining the outcome of planet formation, remains poorly constrained due to the difficulty in detecting H2, the main gas constituent. CO has been often used as a mass proxy, but its chemistry is very sensitive to the disk physical conditions. I will first present the results of our study where we developed a novel approach combining chemical modeling and machine learning to understand how physical conditions, i.e., gas temperature, UV field, cosmic ray and X-ray ionization rates, gas density impact CO chemistry. Our findings reveal a complex interplay between CO and disk conditions, suggesting a tendency toward CO depletion and highlighting its unreliability as a gas-mass tracer. These findings agree with previous more modeling intensive and computationally expensive studies, demonstrating the usefulness of machine learning in efficiently unraveling complex chemical processes. Additionally, I will share results from our ongoing efforts to constrain gas masses using multi-molecular approaches, recently proven to be more robust than single-molecule attempts. These efforts utilize the rich molecular data collected by the largest ALMA disk chemical survey, the Disk-Exoplanet C/Onnection (DECO) in tandem with machine learning techniques and physical-chemical disk models to identify the best molecular combinations tracing gas masses.

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Simulation of the Planetary Mass-Radius Relation Using Machine Learning

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Abstract

The objective of this study is to develop an appropriate model for estimating the radius of planets using the fewest features possible from spectroscopic observations. Investigations on the mass-radius relationship using various methods have been published. Our intention is to provide an optimal model for the mass-radius relationship, regardless of the type of planet. We created a sample in machine learning studies of the planetary mass-radius relation with 792 planets, including exoplanets, eight solar system planets, and Pluto, for this study. A number of different features were tested, and four features that showed the most impact on the model, including planetary mass, equilibrium temperature of the planet, host star's radius, and stellar mass, were selected. Considering that different machine learning models were used in previous studies, we tried the 19 most common regression models. According to the metrics, eXtreme Gradient BOOSting (XGBoost) and Random Forest (RF) produced the best results. We selected some exoplanets to examine in the model, including gaseous planets and an exosolar system with Earth-like planets. The radius estimation in the model of this study was compared with the radii declared or calculated by other studies and methods, which shows that the model performs well. The model described in this study is more appropriate for estimating the radius of planets since it has a greater number of samples, fewer features, reduced errors, and performs across the entire range of planet radii.

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A possible mechanism for the origin of the dwarf planets in the Kuiper belt

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Abstract

The distributions of the orbital elements of most of bodies of the “hot” component in the Kuiper belt (KB) were analyzed. The distributions’ shapes indicate that all those bodies (including four dwarf planets) could have arisen as a result of the destruction of one massive body (the Kuiper belt planet, KBP). The separation velocities of the fragments were determined mainly by the linear velocities of the parts of the KBP at different depths and latitudes. The maximum separation velocity corresponded to the linear velocity on the surface of the KBP near the equator and could be 2.4 km/s. The spin axis of the KBP was tilted at a little angle to the ecliptic plane and at the destruction moment it was directed towards the Sun. The performed model calculations of the KBP destruction show that the resulting distributions of the model fragment orbits almost completely correspond to the distributions of the real orbits of the KB bodies.

This model predicts, then the spin axes of the fragments should be inclined at small angles to the planes of their orbits. The fragments with not large orbit inclinations may be inclined at small angles to the ecliptic plane. The spin axes of the dwarf planets Pluto (i = 17°) and Haumea (i = 28°) are inclined to the ecliptic plane at angles of 23° and 10°, respectively. The spin axis of the dwarf planet Eris (i = 44°) is inclined to the plane of it orbit at an angle of 12°.

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Variations in Background Radiation over Earth's History

Dr James Welsh[1,2], Dr Andrew Karam[3]

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Abstract

Our radioactive Earth is incessantly irradiated by space radiation. But this cosmic bombardment has been inconstant, and Earth's inherent radioactivity has decreased over geologic time. Here, we analyze varying sources of natural background radiation:

1. Primordial radionuclides
2. Cosmogenic radionuclides
3. Cosmic rays plus extraterrestrial gamma rays

As lithophilic elements, uranium, thorium and potassium-40 were partitioned into Earth's earliest felsic continental crust. The activity of these primordial radionuclides (and their progeny) has decreased monotonically over time. Dose from biospheric ^{14}C varies slightly and irregularly over time. Dose from cosmic rays and cosmogenic radioisotopes is relatively consistent but varies with changes in atmospheric chemistry/thickness, solar activity, geomagnetic field strength and galactic cosmic ray flux. Earth has also been intermittently irradiated through gamma ray bursts and other sporadic astrophysical incidents. Such infrequent events may have briefly escalated dose by a few orders of magnitude and transiently depleted stratospheric ozone. Episodic geophysical and solar events such geomagnetic excursions/reversals, grand solar minima, and Miyake events have also intermittently increased the biosphere's background dose. Furthermore, through fixation of radiogenic damage, the rise in free molecular oxygen after the Great Oxidation Event dramatically increased the radiobiological effectiveness of low-LET environmental radiation.

Life arose in the Archean when background radiation was >10x higher than today. Multicellular organisms evolved in a high radiation background and now possess effective means of coping with radiogenic molecular damage though the DNA damage response. Earth's long, variable radiation history is reflected in life's effective molecular means of managing radiation damage.

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Equivalence between simple multilayered and homogeneous laboratory-based rheological models in planetary science

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Abstract

We investigate under which circumstances the tidal response of a stratified body can be approximated by that of a homogeneous body. We show that any multilayered planet model can be approximated by a homogeneous body, with the same dissipation of tidal energy as a function of the excitation frequency, as long as the rheology of the homogeneous model is sufficiently complex. These results highlight the fact that the two models cannot be distinguished from each other only by the measurement of the second degree tidal Love number and quality factor, and that we do not need the complexity of the multilayer planet model in order to estimate its tidal dissipation. The methodology promises a great simplification of the treatment of multilayered bodies in numerical simulations because the treatment of a homogeneous body – even with a complex rheological model – can be computationally better handled than that of a multilayered planet.

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Ethanolamine stability in simulated space conditions

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Abstract

Laboratory experiments on the interactions between complex organic molecules, interstellar dust and UV radiation are crucial to understand the physico-chemical mechanisms that lead to the synthesis of organic molecules, and to search for new species not yet observed in the interstellar medium ISM gas phase. Ethanolamine ($NH_2CH_2CH_2OH$) is an organic molecule of great astrobiological interest, proposed as a precursor of phospholipids, the main constituents of cell membranes, and of glycine, the simplest amino acid. This molecule, already detected in the Almahata Sitta meteorite, has recently been observed in the ISM in the molecular cloud G+0.693-0.027. Its presence in the gas phase suggests that ethanolamine, once formed on dust grains, is involved in solid-state chemistry. The aim of this work was to study in the laboratory the physico-chemical properties of ethanolamine in simulated astrophysical condition, in order to understand its stability and role in surface chemistry in the ISM. We irradiated the icy sample at 10 K *in situ* with the UV-enhanced Xenon lamp, simulating the radiation of solar-type stars, and also the secondary UV emission due to cosmic rays inside dense molecular clouds. We performed the analyses by adsorbing the molecules onto nanometric fluffy grains of amorphous olivine, to study their catalytic role of dust. Our results provide support for understanding existing observational data and indicate possible targets for future observations. Furthermore, they improve our knowledge of the role of the grain surface in the enrichment of chemistry in space.

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Exploration of habitable worlds in the solar system

Dr Athena Coustenis

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Abstract

Besides Mars, currently under extensive exploration (Mars Express, ExoMars, Hope, Mars2020/Perseverance, Tianwen-1 etc) and remains an object with many unknowns about its past [1], the satellites of the gas giants Jupiter and Saturn, situated beyond the snow-line and the traditional "habitability zone" [2], have been revealed as potential habitats by missions like Galileo, Cassini-Huygens and Juno, presenting promising conditions for habitability [3]. Jupiter's Europa and Ganymede show indications of harboring internal liquid water oceans while Europa may be in direct contact with a silicate mantle floor and kept warm through time by tidally generated heat [4]. Around Saturn, Titan, Mimas and Enceladus, were found to possess internal liquid water oceans and sometimes organic chemistry [3]. The icy satellites provide a conceptual basis for new theories of habitability.

These bodies will be further investigated in the future by missions to the red planet (such as ExoMars 2028 and Mars Sample Return) but also by exploring the icy moons around the giant planets. Future exploration of the Galilean satellites includes missions like ESA's JUICE, [4] (launched in 2023, arrival in 2030) and NASA's Europa Clipper [5] to launch in 2024. For Titan, NASA selected the Dragonfly mission [6].

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Evolution of Carbonaceous Asteroids as a Factory of Prebiotic Molecules

Shogo Tachibana

University of Tokyo

Abstract

The JAXA's Hayabusa2 spacecraft returned about 5 grams of surface materials from C-type near-Earth asteroid (162173) Ryugu in December 2020 (Tachibana et al. 2022).

The Ryugu samples show close relations with CI chondrites chemically, isotopically, mineralogically, and petrologically (e.g., Yokoyama et al. 2022; Nakamura T. et al. 2022; Okazaki et al. 2022; Noguchi et al. 2023; Yabuta et al. 2023; Naraoka et al. 2023). Among more than 20000 organic molecules, prebiotic molecules such as amino acids, uracil, and nicotinic acid have been identified (e.g., Naraoka et al. 2023; Parker et al. 2023; Oba et al. 2023). The presence of CO2-bearing fluid inclusions in pyrrhotite indicates that Ryugu's parent planetesimal formed in the outer region of the Sun's protoplanetary disk (Nakamura T. et al. 2022). Because the main belt is dominated by C-type asteroids, Ryugu-like planetesimals were likely to have been transported from the outer to the inner Solar System, and Ryugu's siblings may have brought water and organics to the early Earth (e.g., Yabuta et al. 2023; Naraoka et al. 2023).

In this presentation, we will discuss what we have learned from Ryugu about its formation and evolution of Ryugu as a factory of prebiotic molecules.

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Rogue worlds and black holes in the era of Roman

William DeRocco

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Abstract

During the chaotic early stages of system formation, gravitational scattering is expected to efficiently eject a large number of planets and planetesimals over a wide range of masses. In the terrestrial-mass range, these ejecta constitute "free-floating planets" (FFPs) and are expected to outnumber their bound counterparts. Despite the large abundance, FFPs are a difficult target for observation. The only existing observational technique sensitive to these objects is gravitational microlensing. While ground-based observatories have produced tantalizing hints of this population, our understanding of these worlds will be transformed with the launch of the Roman Space Telescope in 2026, whose Galactic Bulge Time Domain Survey will usher in a new era of discovery through microlensing. In this talk, I will discuss how by leveraging the high-statistics observations that Roman will make, we will be able to make our first direct measurement of the mass function of this enigmatic population, as well as its unique implications for models of planetary system formation and, potentially, for our understanding of dark matter and the early universe. Furthermore, I will discuss how we are engaging the broader astronomical community at all career stages on becoming involved in microlensing analysis in advance Roman's launch.

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A Dynamical Synthesis of Planetary Systems

Prof. Malena Rice

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Abstract

Over recent decades, complementary lines of evidence have each offered independent constraints on the underlying mechanisms shaping planetary system architectures. My dissertation progresses at the intersection of subfields, drawing from both solar system and exoplanet studies to develop a cohesive picture of planetary system evolution. My work leverages dynamics to synthesize the joint imprints of planetary evolution on stars, planets, and minor planets. First, I demonstrated that stellar occultation events can provide sufficiently precise positional measurements of solar system asteroids to constrain the presence of neighboring masses, including the predicted “Planet Nine” in the distant solar system. I then developed a novel algorithm to directly search for distant solar system objects using NASA’s Transiting Exoplanet Survey Satellite, demonstrating a new use case for the survey. In parallel, I showed that the long-period Neptune-sized exoplanet population suggested by protoplanetary disk images can efficiently eject neighboring minor planets, accounting for the high rate of observed interstellar objects passing through the solar system. Lastly, I spearheaded the SOLES survey to extend the sample of measured stellar obliquities in long-period exoplanet systems. My analysis of the stellar obliquity distribution provided evidence that hot Jupiter systems are largely shaped by post-disk dynamical interactions.

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The search for Planets around LkCa 15

MR SWASTIK CHOWBAY[1], Dr. Zahed Wahhaj[2], Dr Myriam Benisty[3], Mr. Saksham Arora[4], Dr Bin B Ren[5], Dr Christian Ginski[6], Dr Rob de Rosa[2], Dr Ravinder K Banyal[1]

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Abstract

In this study, we present K-band imaging and polarimetry of the young disk system, LkCa 15. Leveraging near-simultaneous reference star difference imaging,or "star-hopping," we unveil the true intensity of the disk without the interference of self-subtraction effects for the first time. Our primary objectives are to identify potential new giant planets beyond 0.1'' separations and to analyze the disk's morphology to understand its interactions with the existing planets. Through radiative transfer modeling, we align the near-infrared imaging with polarimetric data and further integrate sub-millimeter imaging data from ALMA. We model our LkCa 15-protoplanetary disk using three grain components consisting of submicron, micron, and sub-millimeter sized grains. Our results indicate a highly flared region in the inner part of the disk with notable features with a very strong forward scattering.We also analysed the K-band inverse polarimetric map, no new planets were found outside of a 12 au separation.However, based on contrast curve estimates, we have established an upper mass limit for potential companions that might be present in LkCa 15. In conclusion, we are able to constrain the disk morphology using the three component radiative transfer modelling and also estimate the upper limits for the companion mass that might be present in this system at different separations from the host star.

Session

Division F Planetary Systems and Astrobiology

922

UV photo-degradation of the secondary lichen substance parietin: a multi-spectroscopic analysis in astrobiology perspective

Mr. Christian Lorenz[1,2], PhD Elisabetta Bianchi[3], Mr. Andrew Alberini[1], PhD Giovanni Poggiali[1,4], Prof. Renato Benesperi[3], Prof. Alessio Papini[3], Prof. John Robert Brucato[1]

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Abstract

The anthraquinone pigment parietin is a secondary lichen substance providing UV-shielding properties that is produced by several lichen species. In our study, we extracted the secondary metabolite from air-dried thalli of *Xanthoria parietina*. The objectives of this work were to analyse the absorbance of parietin using UV-VIS spectrophotometry and its photodegradability under UV radiation thought *in situ* reflectance FTIR spectroscopy. This analysis aims to determine the extent to which parietin may provide photoprotection. This enables us to relate parietin photo-degradability and the lichen UV tolerance in its native terrestrial habitats, as well as in extreme environments relevant to astrobiology, such as Mars. Crystals were UV irradiated for 5.59 hours under N_2 flux. Then, we evaluated significant degradations in the bands at 1614, 1227, 1202, 1160, and 755 cm^{-1}. Considering *Xanthoria parietina* resilience in extreme environments like space and Mars-simulated ones, we emphasize the UV photo-resistance of parietin and its significance in astrobiology as a protective substance against UV radiation and potentially being a bio-hint.

Session

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The Aligned Orbit of TOI-2533 b, a Transiting Brown Dwarf Orbiting an F8-type Star

Thiago Ferreira dos Santos[1], Malena Rice[1], Xian-Yu Wang[2], Songhu Wang[2]

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Abstract

Brown dwarfs comprise an intermediate class of objects between the giant planet and low-mass star regimes. As such, the orbital orientations of brown dwarfs orbiting stellar hosts provide insights into the formation channels that delineate these neighbouring classes of astronomical objects. We present an analysis of the Rossiter-McLaughlin (RM) effect across the transit of TOI-2533 b, a brown dwarf on a moderately eccentric ($e = 0.2476 \pm 0.0090$) and wide-separation ($a/R_* = 13.34 \pm 0.30$) orbit around an F8-type star, using data from the NEID/WIYN spectrograph in combination with archival photometry and radial velocity observations. Spin-orbit analyses of brown dwarfs are relatively rare, and TOI-2533 stands out as the fifth brown dwarf system with a measured stellar obliquity. We derive a sky-projected stellar obliquity ($\lambda = -7 \pm 14$ deg) for TOI-2533 b, consistent with alignment. Our joint model also indicates that TOI-2533 b falls within the minimum mass range for sub-stellar objects undergoing hydrogen-burning ($M_b = 74.9 \pm 5.3\ M_{Jup}$), and considering its equilibrium temperature ($T_{eq,b} = 1095 \pm 17$ K), we propose that it qualifies as a T-type brown dwarf. We conclude that TOI-2533 b is fully consistent with formation in a spin-orbit aligned disk without primordial misalignment, potentially during the second collapse phase of a molecular cloud's fragmentation.

Session

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Graph Algorithmic Thinking for the Waw! Signal. The first contact.

Graph Algorithmic Thinking for the Waw! Signal. The First Contact. Gizo Vashakidze

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Abstract

A novel feature of the present work consists of a unique approach. When considering the Wow! signal, not only the 6 radio signals received on channel #2 are taken into account, but also the total content of the 12 high-intensity signals received on six different channels, as a result of which we got an infographic image. (New encoding method) The infographic shows a brief description of the solar system. Also, the distance from the sun to the star is also recorded—about 20 light-years. There are several stars at this distance from the Sun. The researchers from the Big Ear radio telescope report that at the moment of picking up the signal, the scanning of the sky took place towards the constellation Sagittarius. The binary pair, J. Herschel 5173 AB, is located at approximately the same distance. According to the calculations of astronomers, the mentioned binary pair of stars and the Sun are approaching each other (Bobylev, 2010). The infographic representation of the radio signal displays the same information. The stellar convergence can be considered the motivation for beginning written communication. The radio signal displays an image of a man and a woman. The outlines of both pictures are similar to the „Profile Picture" template that you often see on the Internet. In 1973, humans did the same; a picture of a man and a woman was sent into space. (Pioneer plaques) Also, neighboring civilization propose an agreement for two-way communication using the coding method present in the Wow! signal.

Session

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Ice on comets : Lessons learned from the Rosetta mission

Prof. Sonia Fornasier

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Abstract

Ice is one of the main constituents of cometary nuclei but it is rarely observed exposed on their surfaces, as evidenced by images from Giotto, Deep Space 1, Stardust, Deep Impact-Epoxy and Rosetta, the missions dedicated to in-situ cometary investigation. ESA's Rosetta mission, which orbited comet 67P/Churyumov-Gerasimenko (hereafter 67P) for more than two years, provided a unique opportunity to study the morphology, composition and activity of 67P's nucleus, and their evolution over time at different heliocentric distances.

A dedicated analysis of exposed water ice revealed that it represents only 0.1% of the total surface of 67P, confirming that cometary nuclei are dominated by refractory dark terrains. The vast majority of identified ice exposures on 67P are typically on the order of a meter or sub-meter in size, demonstrating the need for high spatial resolution to identify ice on cometary nuclei. Although rarely exposed, several lines of evidence indicate that ices are abundant just below the surface: cliffs collapse or outbursts often exposed subsurface layers enriched in water ice, with local water ice abundances up to 75%; spectacular diurnal and seasonal color variations have been observed on 67P nucleus, associated with the sublimation and recondensation cycle of water ice with varying temperature over day-night/seasons. The main findings on the 67P nucleus composition, especially in terms of volatiles, and the lessons learned from the Rosetta mission on ice detection, size distribution, and lifetime will be presented.

Session

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1066

Recent results of NEO space missions and perspectives

Dr. Patrick Michel

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Abstract

The past years have produced a large number of new results and science advances in the field of NEO studies thanks to space missions that returned samples (JAXA Hayabusa2, NASA OSIRIS-REx) or performed a deflection test (NASA DART). They also revealed the complex geology of these objects and their counter-intuitive behavior in their low-gravity environment. So far, NEOs showed us the behavior of bodies having a very weak cohesion, while solid rocks are present on the surface and numerical models indicate that they are sensitive to unexpected low cohesion levels of the order of 0.1 Pa. These bodies are thus more complex than we could anticipate, showing the high value of space missions visiting them. The ESA Hera mission will allow checking the simulation predictions of the DART impact outcome. In April 2029, nature offers us a laboratory to explore the response of small asteroids to external forces, with the close passage of Apophis to Earth. NASA APEX will visit Apophis a few days after this close passage and mission studies are ongoing to visit the asteroid before and during this passage, offering a great synergy with APEX. The Hayabusa2# mission will also rendezvous with a 30 m-size fast rotator NEO in 2031, allowing us to investigate the properties of an object, whose size is similar to that of the bolide that exploded over Tunguska in 1908. Thanks to these missions and possibly other ones, our understanding will again improve drastically, since so far, all missions challenged our knowledge.

Session

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Potential detections of M-dwarf rocky planet atmospheres and a trend in atmosphere occurrence

Dr. Megan Weiner Mansfield[1,2], Dr. Jacob Bean[3], Jegug Ih[4], Dr. Eliza Kempton[4], Dr. Edwin Kite[3], Qiao Xue[3], Dr. Michael Zhang[3]

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Abstract

One of the most exciting opportunities enabled by JWST is the characterization of atmospheres on terrestrial planets orbiting M dwarfs (M-Earths). However, transmission spectroscopy of M-Earths with JWST has been ambiguous due to challenges such as stellar contamination. We discuss the technique of thermal emission observations during secondary eclipse, which is a rapid way to detect M-Earth atmospheres with JWST without encountering issues of stellar contamination.

We present thermal emission observations of three hot M-Earths (GJ 367b, Gl 486b, and GJ 1132b) observed with JWST/MIRI+LRS between 5-12 microns. A phase curve of GJ 367b, the hottest planet in this sample, shows a maximally hot dayside and zero heat redistribution, consistent with an airless body. However, secondary eclipses of the cooler planets Gl 486b and GJ 1132b show colder daysides than expected for a bare rock. These detections represent the strongest evidence yet of M-Earth atmospheres. When combined with other JWST M-Earth results, we find a trend suggesting that planets at irradiation temperatures below 800 K retain atmospheres, while hotter planets are airless.

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Multi-interferometric Investigation of Outer Planets Magneto-bremsstrahlung Radiation in Support of Planetary Exploration

Daniel Santos-Costa[1], Bryan Butler[2], Imke de Pater[3], R.J. Sault[4], Oleg Smirnov[5], Hajime Kita[6], Anil Bhardwaj[7], J.N. Girard[8], Laurent Lamy[8], Philippe Zarka[8], Nicolas André[9], Fuminori Tsuchiya[10], Mykola Ivchenko[11], Lorenz Roth[11]

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Abstract

The interaction of the solar wind with planetary magnetic field creates a magnetic cavity called the magnetosphere. Deep inside this magnetic structure, the trapping of 10's of keV up to 10's (100's) of MeV electrons (ions) forms the radiation belts. Radiation belts exist at Jupiter, Saturn, Uranus and Neptune. At Jupiter, the electron belt is the source of a strong magneto-bremsstrahlung emission at frequencies of ~0.05 - 8 GHz. Although the detection of this radio emission presented the first evidence of a harsh radiation environment at Jupiter in the late 1950s, its spatio-temporal variations on different timescales remain unexplained more than 60 years later. We present our on-going multi-frequency investigation of Jupiter's electron-belt emission from multiple interferometers (VLA, MeerKAT, GMRT, ATCA, LOFAR). We demonstrate how multi-data-set analyses at 0.05 - 8 GHz reveal the contribution of trans-to-ultra-relativistic electrons trapped in different magnetospheric regions to Jupiter's radio spectrum. We emphasize how our improved understanding of the dynamical response of energetic electrons to magnetospheric and heliospheric environments can provide new interpretations of on-going remote sensing observations at Jupiter, while yielding new information on the radiation environment that JUICE and Europa Clipper will encounter at larger distances. We finally discuss our computational effort to model the electron-belt emission at Saturn, Uranus and Neptune and subsequent implications for future missions at the ice giant planets.

Session

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Juno Results on the Origin and Evolution of Jupiter

Dr Scott Bolton[1], Juno Science Team[2]

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Abstract

Results from the Juno investigation of Jupiter has challenged our understanding of Jupiter origin and evolution. As the archetype of giant planets, the study of Jupiter provides knowledge needed to understand the origin of our own solar system and the planetary systems being discovered around other stars. No other object in the solar system can tell us more about the origin of planets than Jupiter. The mass of Jupiter's solid core and the abundance of heavy elements in the atmosphere discriminate among models for giant planet formation. Measurements by Juno of Jupiter's gravity field suggest Jupiter's core is diffuse, extended and contains compositional gradients. These new results require new models of Jupiter's formation and evolution. The gravity science results on the measurement of J4 coupled to current estimates on the Hydrogen and Helium equation of state suggests Jupiter's interior composition has very low metallicity, potentially solar or even sub-solar. This is inconsistent with measurements of the atmosphere by both Juno and the Galileo probe which indicate the atmospheric composition is of higher metallicity (3-4x solar). The combined results from Juno provide new constraints on theories of Jupiter's formation and evolution and giant planets in general. A summary of Juno's results relevant to Jupiter's formation and evolution will be presented along with a discussion of theoretical implications on Jupiter, and giant planets both within our solar system and beyond.

Session

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Beyond the Stars: Revolutionizing Exoplanet Detection with Vision Transformers in Time-Series DataA. Choudhary[1], S. Bandari[2], and B.S. Kushvah[31,3] Department of Mathematics and Computing, IIT(ISM), Dhanbad [2] Department of Electronics Engineering, IIT(ISM), Dhanbad

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Abstract

The planets outside of our solar system are known as exoplanets. Finding exoplanets is a major area of research in the hopes of discovering a habitable, earth-like planet. There are various analytical methods related to the detection process, Like the radial velocity method, the transit method, etc. Initially, people use these methods to classify exoplanets, but it is a time-consuming process. As things are done manually, there is an issue related to accuracy. The merging of machine learning (ML) and neural network techniques has significantly advanced the area of exoplanet discovery in recent years. Researchers and space agencies are working with TESS, K2, and Kepler data and applying that to convolution neural network models. The accuracy of the suggested model is being enhanced through multiple adjustments and tuning of hyperparameters. In this area, several AI models have already been generated. So, we have used the powerful Transformer model to handle time series data due to its ability to capture long-term dependencies, combining that with the recurrence plot technique. The model was applied to massive data, resulting in an impressive accuracy rate of 95.85% and a precision rate of 94.92%. This impressive accuracy indicates the model's reliability in classifying cases and distinguishing between exoplanets and non-exoplanet objects. It also has a precision rate of 94.92%, indicating its ability to accurately predict exoplanet presence.

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Juno's exploration of Jupiter's moons, ring system, and dark side with its Stellar Reference Unit camera

Heidi Becker[1], Paul Schenk[2], Rosaly Lopes[1], Alessandro Mura[3], Federico Tosi[3], Meghan Florence[1], Martin Brennan[1], Jonathan Lunine[4], Candice Hansen[5], Yasmina Martos[6,7], Mike Wong[8], Scott Bolton[9], James Alexander[1]

[1]Jet Propulsion Laboratory, California Institute of Technology. [2]Lunar and Planetary Institute. [3]INAF/IAPS. [4]Cornell University, Department of Astronomy. [5]Planetary Science Institute. [6]NASA Goddard Space Flight Center. [7]University of Maryland. [8]Carl Sagan Center for Research, SETI Institute. [9]Southwest Research Institute

Abstract

Juno's use of its low-light Stellar Reference Unit (SRU) star camera as a high-resolution visible wavelength science imager has opened unprecedented opportunities for exploration of Jupiter's enigmatic ring system and a search for lightning on Jupiter's dark side. SRU imaging of Europa's night side (illuminated by Jupiter-shine) in 2022 yielded the Mission's highest resolution image of the icy moon, enabling significant improvements to the geomorphologic mapping of the surface and revealing sites of potential present day surface activity (providing high quality baselines for the upcoming Europa Clipper and JUICE missions). Juno's recent flybys of Io in December 2023 and February 2024 presented additional opportunities for low-light high-resolution SRU imaging of the night side of this highly volcanic moon. Our presentation will discuss the latest results from Juno's innovative SRU imaging campaigns.

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Results of Observations of the Jovian System by Juno and a Network of Earth-Based Astronomical Observing Stations

Glenn Orton[1], Scott Bolton[2], Stephen Levin[1], Thomas Momary[1], Shawn Brueshaber[3], Emma Dahl[1], Juno Science Team[2]

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Abstract

The Juno mission to the Jupiter system has promoted and coordinated a network of Earth-based astronomical observations, both Earth-proximal and ground-based facilities, to extend and enhance its own observations. The spectral region and timeline of all of these observations are summarized in the web site: https://www.missionjuno.swri.edu/planned-observations. These include Juno's approach phase, e.g. observation of Jovian auroral phenomena and measurements of Jovian synchrotron radiation from the Earth simultaneously with the measurement of properties of the upstream solar wind. Observations of significance to the magnetosphere measure the mass loading from Io by tracking its volcanic activity and its torus opacity. Measurements of Jupiter's neutral atmosphere include observations of reflected sunlight from the near-ultraviolet through the near-infrared and thermal emission from 5 μm through the radio region. These measurements relate properties of the deep atmosphere, a major focus of Juno, to the state of much higher atmospheric levels. These observations access spectral regions not covered by Juno, expand Juno's spatial range, and track the evolution of features measured only once by Juno. We summarize the results of observations made by Juno and the supporting campaign during the primary and extended missions. Observations in the extended mission include support for close encounters of Juno with the Galilean satellites. Besides a global network of professional astronomers, the Juno mission also benefited from the enlistment of a network of dedicated amateur astronomers who provided a nearly continuous survey of the evolution of features observed by Juno's instruments.

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The Development of a Superconducting MKID High Resolution Multi-Object Spectrometer Testbed for the Detection and Characterization of Exoplanets.

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Abstract

Conventional high-resolution spectrographs are typically designed to take detailed spectra of single targets or of a very limited field of view. On the other hand, multi-object spectrographs are designed to acquire spectra of multiple targets simultaneously at the expense of spectral resolution, wavelength coverage, and/or instrument cost. The inherent energy resolution of superconducting microwave kinetic inductance detectors (MKIDs) can be used to eliminate the need for a cross-dispersing element in a high-resolution spectrograph, freeing up valuable detector space that can be allocated to the spectra of multiple objects. This work lays the foundation for the development of a new class of high-resolution multi-object spectrographs (HRMOS) without the need to compromise resolution or coverage. A future, fiber-fed MKID HRMOS for the extremely large class of telescopes will be able to sample a comprehensive region around a star with an R~100,000 to simultaneously detect and characterize exoplanet atmospheres using high-dispersion coronagraphy.

Session

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1229

A survey of comets in the vicinity of Jupiter

Gonzalo Tancredi[1], Mario Hierro[1,2], Silvia Martino[1], Martín Cavarozzi[1], Ernesto Elenter[1], José Furtado[1], Mariana Gutiérrez[1], Silvia Hernández[1], Mateo Muñoz[1], Nicolás Pan[1], Juan Roberto Varela[1], Miguel Alarcón[3], Javier Licandro[3], Antonio Maudes[2], Miquel Serra-Ricart[2,3]

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Abstract

Based on our dynamic analysis of Jupiter Family Comets (JFCs) in 1991, it was proposed that Jupiter's vicinity presents the highest likelihood of encountering a comet (Tancredi & Lindgren 1992). A survey to detect comets approaching Jupiter was recommended. Following this advice, the Shoemaker-Levy team directed their NEO survey telescope near Jupiter for the first time in March 1993 and discovered the renowned P/Shoemaker-Levy 9, which was undergoing a temporary capture by the planet. Concurrently, we also observed it during our survey around the same time (Tancredi & Lindgren 1994).

It has been 20 years since then, and survey technologies have significantly advanced. In November 2023, Jupiter was at opposition and near perihelion, providing an excellent opportunity to replicate the survey using the 80cm Light Bridges' telescope equipped with a large-format CCD (151 Mpx). We covered a sky area of 7.6degx6.6deg (50 deg^2) across 143 fields. Each field was captured in sequences of four images with an interval of ~5 minutes between shots, and these sequences were repeated on subsequent nights. By aligning the images based on Jupiter's motion, we enhanced detection capabilities. In December 2023, we acquired a new set of images for follow-up, yielding sufficient data to identify and calculate the orbits of new objects.

In this report, we share the preliminary findings of our survey. Despite not identifying any new objects approaching Jupiter, we will be able to establish an upper threshold for the JFC population and investigate the potential progenitors of recent impact flashes on Jupiter.

Session

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Subglacial Habitability from the Solar System to Exoplanets

Prof Amri Wandel

The Hebrew University of Jerusalem

Abstract

The Habitable Zone (HZ) is defined as the circumstellar region where liquid water can exist on a planetary surface. This definition of habitability may however turn out too strict, as even on Earth life strives under the ice cover of the north polar cap. Large quantities of liquid water are present under a relatively thin ice cover on bodies in our Solar System like Enceladus and Europa. Similarly, subglacial liquid water may be expected in exoplanets orbiting their host star outside of the HZ. Considering subglacial liquid water Wandel (2023) showed that the conservative HZ can be significantly extended. Exoplanets and satellites with geothermal heat sources can maintain liquid water outside of the conservative HZ under an ice cover, although their surface temperature is well below freezing. The HZ may be extended inwards for tidally locked planets, where the atmospheric water vapor can be transported to the night-side and condense as lakes (for intermediate atmospheric heat transport between the day and night sides) or as ice sheets (for low heat transport). In the latter case, the inner boundary of the extended HZ strongly depends on the degree of heat transport.

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Session

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1538

Exotic Red Flare on the Stars as Exo-Asteroid Manifestations

Dr Mansur Ibrahimov

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Abstract

Exo-world population is currently presented by 2 type of objects – exo-planets and exo-comets. To the date, more than 5000 exo-planets were discovered using spectroscopy (wobbling effect) and photometry (transiting effect), and more than 500 exo-comet observed as so called FEB-events (Falling Evaporating Body lines observed only spectroscopically). A question is: could exo-asteriods, the 3rd type of population, be discovered using existing observational methods ? A talk's answer is: yes, they can be discovered and they'd already been observed using IR/optic photometry. It is argued that a manifestation of an exo-asteriod activity is so called "red flare" on a star. For the first time, the talk brings together and presents practically all the observed red flares in IR/optic photometry. Exotic red flares are interpreted as collisional interaction and subsequent disintegration of the exo-asteroids accompanied by a huge (up to 10^{39} erg in optic) and long timescale (about of hours) energy production emitted mostly in IR and a red part of optical spectra. In contrast to well-studied "blue flares" on M dwarfs (flares on UV Cet-type stars), the red flares exhibit a red maximum in magnitude, red colors in optic, and a "red" distribution of flare amplitudes. So far, the red flares had already been observed in space IR missions (2 events), in several normal stars (6 events), in several systems with compact objects (tens of events), and in available star-flare statistical studies (hundreds of events). All the mentioned red flare events are briefly compared and analyzed in the talk.

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Probing the Origins of Biomolecular Handedness with SKA Surveys for Sugar and Amino Acid Enantiomers

Miss Pallavi Kajrekar

Royal Astronomical Society. The University of Edinburgh

Abstract

The sugars and amino acids that make up terrestrial life exhibit exclusive handedness, with only D-sugars and L-amino acids incorporated into biology. The origins of this selective chirality remain unknown. As the world's largest radio telescope, the Square Kilometer Array (SKA) is set to provide unrivaled sensitivity for interstellar molecular surveys; this project will exploit SKA's capabilities for sensitive, wide-bandwidth observations to search for enantiomeric excesses in the simplest sugar (glyceraldehyde) and amino acid (alanine/glycine) toward galactic center clouds. The detection of both enantiomeric forms in interstellar space would demonstrate that abiotic synthesis yields racemic mixtures, implicating further chiral selection on planetary surfaces. Null detections may indicate asymmetric interstellar chemistry, providing astrophysical insight into the intriguing origins of biomolecular homochirality.Flux ratios of D- over L-enantiomers can further quantify any asymmetry, distinguishing interstellar versus planetary origins of chiral asymmetry essential for terrestrial biology.

Session

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Detection of Complex Organic Molecules in the protoplanetary disk of V883 Ori

Mr. Abubakar Fadul, Dr. Kamber Schwarz

Max Planck Institute for Astronomy

Abstract

The study of protoplanetary disks provides invaluable insights into the processes governing planetary formation and the chemistry of early solar systems. Here, I present observations of the protoplanetary disk surrounding the young stellar object V883 Ori, revealing the presence of complex organic molecules (COMs). V883 Ori is an FUor object in the Orion A L1641 molecular cloud. Given that the COMs were frozen out on the dust grains, we took advantage of the sudden increase in disk temperature caused by the outburst due to an increased accretion rate to detect these molecules. Previous studies have already detected COMs in this source, but our spectral scan covers more lines, allowing us to place better constraints on the emitting temperature, and by extension, the abundance, of these species.

Utilizing high-resolution spectroscopy of Atacama Large Millimeter/submillimeter Array (ALMA) Band 7, we detect a rich molecular inventory encompassing species such as methanol (CH3OH), acetone (CH3COCH3), and acetaldehyde (CH3CHO), among others. The detection of these COMs in the disk of the V883 Ori protoplanetary disk suggests the existence of efficient chemical pathways even in the early stages of planetary system formation. Furthermore, the abundance and distribution of COMs in this environment may serve as crucial precursors for prebiotic chemistry, potentially influencing the emergence of life on nascent planets. Our findings underscore the significance of investigating the chemical complexity of protoplanetary disks and contribute to a broader understanding of the chemical evolution of protoplanetary disks and the conditions necessary for the emergence of life-bearing planets.

Session

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New candidate planetary companion to the radial velocity standard star HIP10301

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Abstract

HIP10301 is a K2V star listed in the catalogue of radial velocity (RV) standard stars used in wavelength calibration of the Radial Velocity Spectrograph (RVS) on board of Gaia satellite. Two planets orbiting this star with periods of 14.18 and 53.75 days have been confirmed (Ahrer et al., 2021). This study aims to search for new companions to this target. To this end, we employed the minimum distance algorithm to derive the star's RVs. This method, as described in Boulkaboul et al. 2022, entails matching observed spectra from the HARPS instrument with theoretical templates of MARCS-AMBER atmosphere models. Applying the Zechmeister and Kürster (2009) periodogram to the RV dataset, measured from the 1-D barycentric-corrected and orders-combined spectra, unveiled the presence of the two confirmed planets, alongside a long-period signal of 3169 ± 330 d attributed to the star's magnetic cycle. This assumption is confirmed by similar detections in stellar activity indicators, such as the S-index (3228 ± 80 d) and Bisector Inverse Slope (2395 ± 442 d). Furthermore, another periodic signal with a period of 18.986 ± 0.019 days was identified. It is noteworthy that this period did not emerge in the RV dataset derived from the 2-D spectra, which lack barycentric correction, and instead yielded a yearly period, despite the final RVs being corrected to the barycenter. Conversely, correcting the spectra to the barycenter before RV measurement led to the disappearance of the yearly signal and the appearance of a peak at 18 days, rendering the hypothesis of this signal being planetary more plausible.

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1834

ADVANCES IN CULTURE OF MARINE TARDIGRADES: AN ASTROBIOLOGICAL MODEL FOR OTHER OCEANIC WORLDS

Cintia Cabada[1,2], Ana Ulla-Miguel[1,3,4], Marcos Rubal[5], Daniel Rey[2], Yara Meleán[2], Milagrosa Aldana[6]

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Abstract

Most hypotheses locate the origin of life in an aquatic environment, emphasizing the importance of oceanic celestial bodies like Enceladus, Europa, and exoplanets in the search for extraterrestrial life. Thus, investigating analogous Earth's habitats is essential. One of them is tidal zones, an extreme environment where conditions of desiccation and exposure to ultraviolet radiation are common. These areas harbor marine tardigrades, known for their extreme resilience. Despite extensive study in various habitats, marine tardigrades remain relatively unexplored. Our research aims to improve the current level of knowledge through the study of marine tardigrades as models of extraterrestrial habitability, particularly concerning oceanic celestial bodies.

In this study, we collected several samples of *Caloplaca*, *Lichina pygmaea* and macroalgae of the genus *Ulva* at Portiño Beach (Galicia, NW Spain). After isolating individuals, six genera were identified: *Ramazzottius*, *Macrobiotus*, *Milnesium*, *Echiniscoides*, *Styraconyx* and *Batillipes*. Individuals of different ages as well as eggs were isolated. Morphological differences were also observed between taxa and between females and males in some genera. Individuals of *Echiniscoides* and *Ramazzottius* were selected to establish long-term cultures under laboratory conditions. We will present the results obtained, including observations on life cycles and resistance mechanisms.

Our study also aims to gather information on the response of marine tardigrades in active or resistant states to different stress conditions. In particular, we are investigating the influence of hypomagnetic conditions on this taxon, for which there are very few studies. To do this, we will compare the results obtained in the genera *Echiniscoides* and *Ramazzottius*.

Session

Division F Planetary Systems and Astrobiology

1845

"What If Earth Orbited TRAPPIST-1?

Prof. William Welsh, Mr. Jospeh Soliz

San Diego State University

Abstract

It took ~700 million years between the origin of oxygenic photosynthesis in cyanobacteria and the rise of oxygen in our atmosphere (the "Great Oxidation Event" or GOE). Oxygenic photosynthesis requires light in the "PAR" (Photosynthetically Active Radiation) wavelength range: 400-700 nm. TRAPPIST-1 is an M dwarf with Teff of only 2560 K. If Earth orbited TRAPPIST-1 at the same distance as TRAPPIST-1e, it would be in the habitable zone but the number of PAR photons would be 0.9% of what it receives from the Sun. If the rate of oxygen production is proportional to the number of PAR photons, it would take ~60-75 billion years for a GOE. But the linear assumption is poor: photoinhibition decreases photosynthesis at high incident flux and this reduces the timescale by a factor of ~2. Tidal locking provides another factor of 2. Extending the upper wavelength limit of the PAR out to just 750 nm doubles the number of photons. These factors lead to a timescale between the origin of oxygenic photosynthesis and a GOE of ~4-7 Gyrs; a Cambrian explosion would take ~15-26 Gyrs. However, non-oxygenic photosynthetic bacteria can use light out to 1100 nm, and for TRAPPIST-1 this provides over 50 times as many photons! Such bacteria would have a huge advantage and thus dominate over oxygen-producing cyanobacteria. We speculate that on such a hypothetical planet, a GOE would never occur, let alone a Cambrian explosion. Complex macro-cellular animal life would not exist. The real TRAPPIST-1e may have this same fate.

Session

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1855

Dust in the solar system measured by the Juno spacecraft en route to Jupiter

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Abstract

A star camera aboard the Juno spacecraft traveling from Earth to Jupiter serendipitously recorded the impact of interplanetary dust particles (IDPs) by imaging bits of the spacecraft ejected from the IDP impact sites. In essence, the Juno spacecraft, with its expansive ~60 m^2 of solar arrays, served as a dust detector with orders of magnitude more aperture than dedicated dust detectors specifically designed and flown to detect dust impacts. Consequently, Juno recorded many impacts by the larger (few to tens of micro-meters) and less numerous IDPs that populate the inner solar system, establishing for the first time their distribution and source (Jorgensen et al., 2020). This dust population, of the size responsible for the Zodiacal light, resides between the orbit of Earth and the 4:1 mean motion resonance with Jupiter, and explains the variation of Zodiacal light with ecliptic latitude if the dust introduced into the solar system with the inclination and eccentricity of the planet Mars. This surprising result might properly encourage critical examination of the usual assumptions regarding dust populations about stars – e.g., that they are replenished by comets in eccentric orbits or that they are remnants of planet formation.

Session

Division F Planetary Systems and Astrobiology

1953

Proposed Follow-up to IAU Resolution B5 (2006) "Definition of a Planet in the Solar System"

Prof. Jean-Luc Margot[1], Prof. Brett Gladman[2]

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Abstract

The current IAU definition of "planet" is problematic both because it is not quantitative and because it excludes exoplanets. We submitted a proposed resolution (https://bit.ly/IAUproposal) to IAU Commission F2 (Dec. 22, 2023 and Feb. 13, 2024) and IAU Division F (Jan. 17, 2024 and Feb. 13, 2024) with the goal of clarifying the definition and extending it to exoplanets. A proposed improvement is to replace "is in orbit around the Sun" with "orbits one or more stars, brown dwarfs, or stellar remnants". Another proposed improvement is to replace "has cleared the neighbourhood around its orbit" – an impossible standard to meet – with "has sufficient mass to dynamically dominate the neighborhood around its orbit", which can be quantified with measurements of stellar mass, planet mass, and orbital period. This change replaces the “cleared” requirement, which is difficult to evaluate without a complete inventory of a planetary system down to very small sizes, with the ability to dynamically dominate, which can be evaluated with easily measurable properties of the star-planet system.

IAU Resolution B5 is problematic and the problems will not go away on their own. A reasonable approach to astronomical nomenclature is to use physical principles to establish a meaningful threshold, and then adhere to this threshold for definitional purposes. We argue that physically motivated thresholds, even if imperfect, are superior to definitional voids or ambiguities. We encourage community feedback to improve the draft proposal.

Reference: J. L. Margot. A Quantitative Criterion for Defining Planets. *Astronomical Journal* **150**, 185, 2015. http://doi.org/10.1088/0004-6256/150/6/185

Session

Division F Planetary Systems and Astrobiology

1973

From giant planet to brown dwarf: evidence for deuterium burning in old age?

Dr Jan Subjak

Center for Astrophysics | Harvard & Smithsonian. Astronomical Institute, Czech Academy of Sciences

Abstract

The question of distinguishing between planets and brown dwarfs has been the subject of extensive debate in academic circles. While using the deuterium reactions that occur within brown dwarf interiors to differentiate between these groups is a straightforward approach, it may not be the most fundamental method. In some cases, this approach can even lead to intriguing consequences, such as the transition of objects between these groups during late evolutionary stages. The discovery of BD-14 3065b (TOI-4987b) is an example of such a case. This object has a mass that is near the deuterium burning boundary and an extremely inflated radius. The investigation of potential processes that could be responsible for the inflated radius suggests that deuterium burning is a plausible explanation resulting from the heating of BD-14 3065b's interior due to irradiation from its evolving host star.

Session

Division F Planetary Systems and Astrobiology

2016

High Precision Astrometry: Not just for exoplanets!

Mr Conaire Deagan

University of New South Wales

Abstract

One of the goals of the exoplanet community is to find and characterise Earth twins. One upcoming mission - the TOLIMAN space telescope - is designed with innovative optics to achieve high-precision astrometry to detect the presence of an Earth-twin around either Alpha Cen A or B. This level of precision - better than 1 micro arcsecond - has opened new opportunities in stellar physics. By detecting magnetic surface features, such as starspots, we can infer properties of the host stars. These properties include relative inclination between the stars equator and the orbital plane of any planets, the magnitude and frequency of starspots, differential rotation curves, and potentially the presence (or absence) of a Sun-like dynamo. From simulations of the expected performance of TOLIMAN, if it hosts a Sun-like dynamo we expect to be able to measure the inclination of Alpha Cen A to better than 5 degrees. These insights will provide information regarding the stellar environment and habitability of any exoplanets present. Understanding the host star in detail is crucial, as things such as the stellar wind, the frequency and intensity of stellar flares, and the topology of the stellar magnetosphere directly impact the sustainability of biospheres in the surrounding environment.

Session

Division F Planetary Systems and Astrobiology

2018

From Bacteria to Exoplanets: a pioneering approach to biosignature detection

Valeska Molina[1,2], Professor Jeremy Tregloan-Reed[1], Professor Pablo Aguilar[2], Professor Cristina Dorador[2]

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Abstract

Exoplanetary atmospheric characterization plays a pivotal role in unraveling planetary formation, evolution, and potential habitability. Carbon monoxide (CO), wielding a dual role in both biology and astronomy, stands out as a potential biosignature due to its distinct spectral features. Microbial communities thriving in extreme environments, like the Chilean salt flats, serve as valuable analogues for early Earth and potentially for exoplanets. These communities harbor anoxygenic phototrophic bacteria, such as Roseovarius, capable of oxidizing CO.

This study bridges the gap between terrestrial microbial signatures and exoplanetary atmospheres by investigating CO-dependent enzymes (CO-CODH) within Roseovarius sp. isolated from the Atacama Desert's Salar de Llamara. We employed Raman and infrared spectroscopy to identify unique vibrational modes associated with various cellular components. The obtained spectra revealed distinct signatures: Molybdenum active site, FAD (770-776 nm, 1300-1400 cm^{-1}), Fe/S clusters (715-718 nm, 300-350 cm^{-1}), and CO presence (814 nm, 2000 cm^{-1}). These findings support the feasibility of detecting CO-CODH in the atmospheres of Earth-like and super-Earth exoplanets, potentially around ultracool dwarf stars (M7 and later), where the search for habitable transiting exoplanets hold promise. Additionally, atmospheric models were generated to simulate Earth-like planets, enabling a comparative analysis with the acquired spectra. This pioneering approach establishes a crucial link between the microbial ecology of extreme environments and potential biosignatures in exoplanetary atmospheres, advancing our understanding of habitability beyond Earth.

Session

Division F Planetary Systems and Astrobiology

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Non-linear stability analysis for perturbed non-collinear equilibrium point in non-resonance case

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Abstract

Normalization of Hamiltonian for the non-linear stability analysis of a dynamical system is a key task to study the dynamics in the vicinity of an invariant objects. In the present study, normalization of the Hamiltonian and analysis of non-linear stability in non-resonance case for the Chermnykh-like problem with power-law density profile under the influence of perturbations is performed. Initially, quadratic part of the Hamiltonian is normalized near the non-collinear equilibrium point and then fourth order normalized Hamiltonian is obtained with the help of Lie transforms. In non-resonance case, non-linear stability test is performed using the Arnold–Moser theorem, followed by effects assumed perturbation such as radiation pressure, oblateness and the presence of the disc are analyzed separately and it is observed that in the absence as well as presence of perturbing parameters, non-collinear equilibrium point is unstable in the non-linear sense within the stability range due to failure of the Arnold–Moser theorem.

Session

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2198

Detection of sulphur cycle in Enceladus using latest technology advancements

Mrs Aruna Devi TM

International Space University

Abstract

1. Enceladus is the next target in search of life which has almost all the potential biomarkers. Sulphur is one of the most important biosignature found. This sulphur is obtained by various sources. To find the source of sulphur we use latest technological advancement using Artificial intelligence. Using this knowledge we try to find the source of sulphur. By knowing the source whether it is obtained from biotic we could conclude that what organisms to look for in the environment.This further helps us to make our search easier.

Session

Division F Planetary Systems and Astrobiology

2339

Korea's Pre-Earth Encounter Fly-by Mission to Apophis

Young-Jun Choi, Youngmin JeongAhn, Hong-Kyu Moon, Myung-Jin Kim, Dukhang Lee, Bongkon Moon, Minsup Jeong, Chae Kyung Sim, Hee-Jae Lee

Korea Astronomy and Space Science Institute

Abstract

The Korea Astronomy and Space Science Institute (KASI) is preparing a fly-by mission to observe asteroid 99942 Apophis with a multi-wavelength optical camera before its close approach to Earth in 2029. This mission, uniquely timed, will fill a crucial observational gap by providing pre-encounter imagery for comparative analysis with post-encounter data collected by the forthcoming OSIRIS-APEX mission. Our scientific goal is to detect surface changes on Apophis through color variations, which may arise from movements of regolith due to the influence of Earth's tidal torque. This endeavor will not only enable us to observe pre- and post-encounter changes but also enhance our understanding of the surface changes and dynamics of near-Earth objects (NEOs), thereby contributing to planetary defense strategies. International collaboration is crucial for this mission, and we anticipate providing more detailed progress updates during our presentation.

Session

Division F Planetary Systems and Astrobiology

2391

Observation, Behavior and Origin Tracing of Fireballs by PMO-SU Fireball Network

Zhijian Xu[1], Ye Li[1], Nawaz Mahomed[2], Bin Li[1], Shiyong Liao[1], Tinglei Zhu[1], Chen Zhang[1], Haibin Zhao[1]

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Abstract

Outer space objects undergo complex physical and chemical processes during entering the Earth's atmosphere, which could deposit energy and cause damage to human life and property. To effectively monitor such events, the establishment of an expansive monitoring network is imperative. A prototype fireball observation network has been established in eastern China, utilizing a combination of cameras and fisheye lens for video recording at each station. Based on the prototype network, five more stations are being built in South Africa and China, respectively. The PMO-SU Fireball Network (Purple Mountain Observatory-Stellenbosch University Fireball Network) aims to span approximately 200,000 square kilometers, anticipated to record over 12,000 meteors per year, primarily targeting those with an absolute magnitude brighter than -2.5. The network is expected to record roughly 140 fireballs annually. Furthermore, each station will be equipped with a spectrum observation camera for obtaining compositional information. By leveraging a fusion of dynamical differential equations and the Markov Chain Monte Carlo (MCMC) method, the network will be capable of calculating the dynamics, trajectories, and orbits of descending objects. The identification of an object's orbital classification will facilitate the distinction between natural and man-made entities and enable the tracing of the origins of natural objects.

Session

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2420

Photometric Follow-up for the PLATO Space Mission - an Opportunity for Southern-Hemisphere Observers

Dr. Hans Deeg, Dr. Roi Alonso

Instituto de Astrofísica de Canarias

Abstract

The detection of transiting planets by the PLATO space mission poses a risk of false positives due to contaminating eclipsing binaries. Therefore, a ground-based program is being established for the photometric follow-up of planet candidates. This program will acquire time-series data of planet candidates and adjacent stars during expected transits. This undertaking is part of the broader PLATO Ground-Based Observations Programme, which includes spectroscopy and imaging. The photometric follow-up encompasses work packages for standard and multi-colour follow-up observations, secondary eclipse observations, the definition of analysis tools, the reprocessing of archival photometry, and contributions from amateur astronomers and citizen scientists. Currently, the program's main effort is organizing its observational resources and developing strategies for data collection and reporting, with benchmark observations soon to follow. After PLATO's launch in late 2026, the program's focus will shift to coordinating the observations, analyzing and ensuring their quality, and inserting valid observations into the PLATO follow-up database. The field for the first 2-year-long pointing by PLATO will be a large area, centered at a declination of -48 degrees. Therefore, the photometric follow-up for PLATO provides an excellent opportunity for observers in the Southern Hemisphere to contribute to the PLATO mission, with moderate requirements on observing resources.

Session

Division F Planetary Systems and Astrobiology

2456

Simulation of potentially habitable environments on the surface of exoplanets.

Paola Cunha[1], Luan Ghezzi[1], Douglas Galante[2], Evandro Silva[2], Fabio Rodrigues[2], Ana Carolina Carvalho[2], Junia Schultz[3], Alexandre Rosado[3], Amanda Bendia[2]

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Abstract

M-dwarfs comprise 75% of the stars in the Milky Way and also host a large fraction of the potentially habitable exoplanets. However, the high levels of stellar activity are a challenge in a biological conext. They exhibit frequent and intense flares, exposing their planets to high levels of ultraviolet (UV) radiation. This radiation is crucial for biological systems, but excessive exposure can cause damage to important cell structures. Thus, the aim of this work is to investigate whether life could withstand the environmental conditions of planets orbiting M-dwarfs. For our analysis, we choose, Proxima Centauri b, an exoplanet discovered in 2016 and recently confirmed. It has 1.17 times the mass of Earth and is located in the habitable zone of the system, which is a favorable characteristic for life as we know it. To obtain the results, we performed irradiation experiments with the yeast Rhodotorula collected in Diamantina, MG. The first experiment was performed with a tubular lamp that covers only the UVC region. The second experiment was conducted with a continuous spectrum lamp that covers the entire UV range. The results showed that irradiations using the continuous spectrum lamp are more lethal than the tubular lamp. Additionally, we observed that cells resisted to a fluence of 60000 J/m^2 for the UVC lamp. Assuming an average flux value for the flares on Proxima b (7 W/m^2), this fluence would be reached in about 2.38 hours. Our results provide important data to guide studies searching for biosignatures on exoplanets.

Session

Division F Planetary Systems and Astrobiology

2632

Which stars can form planets: Planetesimal formation at low metallicities

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Abstract

The host star and the disc metallicity play a crucial role in the exoplanet diversity. The initial stages of planet formation by core accretion paradigm require the growth of dust material from micrometre size to planetesimal size bodies before core accretion kick-starts. It is still poorly understood how planetesimal formation and, hence, planet formation takes place in low metallicity stellar environments. We explore planetesimal formation in low metallicity stellar environments. We performed global 1D viscous disc simulations, including grain growth, evaporation and condensation of chemical species at the ice lines. We followed planetesimal formation during disc evolution and tested different metallicities, disc sizes and turbulent viscosities. We find that, at solar and sub-solar metallicities, the midplane dust-to-gas ratios increase significantly at the ice lines. However, this leads to planetesimal formation only at the water ice line. In our simulations, [Fe/H] = -0.6 is the lowest metallicity limit for planetesimal formation where a few Earth masses of planetesimals could form. For such extreme disc environments, large discs are more conducive than small discs for planetesimal formation at a given metallicity because pebble flux can be maintained for a longer time, resulting in a longer and more efficient planetesimal formation phase. At lower metallicities, planetesimal formation is less supported in quiescent discs compared to turbulent discs because the pebble flux lasts longer. The amount of planetesimals formed at sub-solar metallicities in our simulations places a limit on core sizes that could only result in the formation of super-Earths.

Session

Division F Planetary Systems and Astrobiology

2694

ExtremeLifeLab: A Toolbox for Field-based Astrobiology Research in Resource-Poor Contexts

Dr Moola Mutondo[1,2], Ms Annette Lombe[1], Ms Salome Mulikita[1]

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Abstract

Astrobiology is a multidisciplinary field of study that appeals to curious young minds with a fascination for space and its endless possibilities. Astrobiology can also be a gateway science to other fields in astronomy. This paper addresses the astrobiological research theme concerned with the limits of life here on Earth as a stepping stone to understand how life could exist in similar conditions found elsewhere in the solar system and beyond. The ExtremeLifeLab, developed with funding from National Geographic Society, allows the chemical and biological investigation of sites with extreme conditions such extreme pH, temperature, or metal concentration. The presence or absence of keystone extremophiles or keystone extremophilic groups, (especially microalgae for ease of handling) can be verified in situ, using phenotypic characteristics, phylogenetic and functional marker genes (16S, 18S rRNA genes; nifH genes). Reference DNA for 4 Zambian extremophilic sites was made from isolates previously cultured from each site. Data collected by 2 postgraduate researchers and 8 undergraduate students using ExtremLifeLab from two thermophilic sites (Gwisho Hot Springs and Kapisha Hot Springs) will be presented. We show how financially accessible Astrobiology research can be. We hope that many more researchers in resource-poor contexts can exploit local extremophilic sites using ExtremeLifeLab and bring new insights about the limits of life and the interplay between extreme conditions and biology.

Session

Division F Planetary Systems and Astrobiology

2708

The Ophiuchus Disk Survey Employing ALMA (ODISEA): project updates

Lucas Cieza[1,2], Camilo Gonzalez-Ruilova[1,2], Trisha Bhowmik[1,2], Prachi Chavan[1,2], Grace Batalla[1], Dary Ruiz-Rodriguez[3], Anibal Sierra[4]

[1]Universidad Diego Portales (UDP). [2]Millennium Nucleus on Young Exoplanets and their Moons (YEMS). [3]Joint ALMA Observatory (JAO). [4]Universidad de Chile

Abstract

The Ophiuchus Molecular Cloud hosts the largest population of protoplanetary disks within 200 pc and a significant number of embedded young stellar objects (Class I and Flat Spectrum sources), making it an ideal region for the study of disk evolution and planet formation. ODISEA is the largest ALMA survey of nearby molecular clouds and currently involves observations at five different ALMA bands (3, 4, 6, 8, and 10) at resolutions ranging from 50 mas to 1.0". Here we present recent results from ODISEA, including the identification of molecular outflows in young brown dwarfs, a multi-frequency analysis of the ~50 brightest targets, the full size distribution of the ~100 brightest disks in the cloud and the discovery of substructures in several compact disks.

Session

Division F Planetary Systems and Astrobiology

2821

X-rays in the Prime of Life

Dr. Scott Wolk[1], Dr. Bradford Wargelin[1], Dr. Vinay Kashyap[1], Dr. Ignazio Pillitteri[2]

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Abstract

We discuss the current state of our analysis of the X-ray fluence experienced by 38 planets. Assuming hydrodynamic equilibrium we estimated the mass loss rates of these planets and found 85% of them exceed the mass escape rate of the Earth. At least 3 planets have an estimated mass escape rate of over 1 million times that of the Earth. We specifically examine Two systems, Proxima Cen, Wolf 359, and HD 189733 for which we have over 10 epochs of observations that determine the different environments these planets have experienced over the past 2 decades. In addition, we focus on GJ 273 b TRAPPIST d, e, f, and g all of which have an Earth similarity index of > 0.5. We also examine the impact of individual flares and discuss the implications for like around M stars.

Session

Division F Planetary Systems and Astrobiology

2862

Report from the Division A & F Working Group on Cartographic Coordinates and Rotational Elements

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Abstract

We report here on the activities of the Working Group (WG) on Cartographic Coordinates and Rotational Elements. Our main work is publishing reports that include recommendations regarding the creation and maintenance of cartographic planetary coordinates.

Our most recent report was published in 2018. After many delays we are beginning to compile the next version of that report. We expect routine updates to recommended orientation and size models resulting from processing or reprocessing of various planetary datasets. These include the models for various bodies, such as Mercury, Venus, Jupiter, Saturn, the Saturnian satellites, Ceres, Comet-67P, Arrokoth, Bennu, and Ryugu.

During 2023–2024, we have largely been considering issues arising after several groups have proposed making a major change in lunar coordinates (https://journees2023.sciencesconf.org/490324). Our presentation will highlight those issues and related WG publications.

Changes to improve the orientation model for Mars are also under consideration.

Our presentation will describe the membership and operation of the WG, numerous types of community requests that we respond to, and our increasing cooperation with other groups.

The WG has concerns that it is becoming over-extended. Input on that and on our recommendations themselves is welcome. In the meantime, the WG has continued to make its efforts and activities known via its website (https://www.usgs.gov/centers/astrogeology-science-center/science/iau-wgccre) and by various publications and presentations. Further information on the WG is given in our activities reports to the IAU, available from the main IAU WG website (https://www.iau.org/science/scientific_bodies/working_groups/100/).

Session

Division F Planetary Systems and Astrobiology

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Investigating Links Between Mechanical Properties, Petrography, and Geochemistry of Meteoritic Materials to Comment on the Early Breakup of Meteoritic Materials on Atmospheric Entry

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[1]Department of Earth Sciences, Stellenbosch University. [2]Department of Mechanical and Mechatronic Engineering, Stellenbosch University

Abstract

This project aims to investigate the petrography and geochemistry of meteoritic materials in an effort to explore the relationship between the geological makeup of meteorites and their mechanical properties, shedding light on their behaviours during atmospheric entry, in particular, the early breakup of meteoroids at relatively low compressive stress. The project aligns with the initiative "Research on the Observation, Behaviour, and Origin Tracing of Outer Space Objects Entering the Atmosphere," which includes the investigation of factors contributing to early meteoritic breakup.

Comprehensive analysis of meteoritic materials, ranging from iron meteorites to chondrites, will be undertaken, including thin section petrography, SEM, XRF, LA-ICP-MS, CT scanning, and statistical analyses. Specific focus will, among others, be on the minerals present, their proportions and makeup, the elemental and mineral compositions, and how it may relate to macro- and microstructural features such as porosity within the samples. The expected results can be used, in combination with studies relating to mechanical strength, for the effective quantification of material composition, structural properties, and material behaviour.

The larger integrated research study investigates the influence of shock waves, drag, ablation and fragmentation on meteoritic body mechanical properties, considering factors such as permeability, porosity, and phase transformations during atmospheric entry. This interdisciplinary approach aims to provide valuable insights into the complex behaviours of meteoritic materials, contributing to our understanding of their origins and behaviours in the solar system.

Session

Division F Planetary Systems and Astrobiology

2920

Orbital and physical characterization of asteroid Dimorphos following the DART impact

Steven R. Chesley[1], Shantanu P. Naidu[1], Nicholas Moskovitz[2], Cristina Thomas[3], Alex J. Meyer[4], Peter Pravec[5], Peter Scheirich[5], Davide Farnocchia[1], Daniel J. Scheeres[4], Marina Brozovic[1], Lance A.M. Benner[1], Andrew S. Rivkin[6], Nancy L. Chabot[6]

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Abstract

The Double Asteroid Redirection Test (DART) mission impacted Dimorphos, the satellite of binary near-Earth asteroid (65803) Didymos, on 2022 September 26 UTC. We estimate the changes in the orbital and physical properties of the system due to the impact using ground-based photometric and radar observations, as well as DART camera observations. We estimate that the DART impact instantaneously changed the along-track velocity of Dimorphos by −2.63 ± 0.06 mm s^{-1}. Initially, after the impact, Dimorphos's orbital period had changed by −32.7 minutes ± 16 s to 11.377±0.004 h. We find that over the subsequent several weeks the orbital period changed by an additional 34 ± 15 s, eventually stabilizing at 11.3674 ± 0.0004 h. The total change in the orbital period was −33.25 minutes ± 1.5 s. The post-impact orbit exhibits an apsidal precession rate of 6.7 ± 0.2 deg day^{-1}. Under our model, this rate is driven by the oblateness parameter of Didymos, J_2, as well as the spherical harmonics coefficients, C_{20} and C_{22}, of Dimorphos's gravity. Under the assumption that Dimorphos is a triaxial ellipsoid with a uniform density, its C_{20} and C_{22} estimates imply axial ratios, a/b and a/c, of about 1.3 and 1.6 respectively. Pre-impact images from DART indicate Dimorphos's shape was close to that of an oblate spheroid, and thus our results indicate that the DART impact significantly altered the shape of Dimorphos.

Session

Division F Planetary Systems and Astrobiology

Final category: Division G Stars and Stellar Physics

60

Searching for globular clusters in the inner halo of the Circinus galaxy

Dr Casmir Obasi[1], Professor Matias Gomez[2], Professor Dante Minniti[2], Professor Maria Alonso[3], Dr Laura Baravalle[3], Dr Bonaventure Okere[1]

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Abstract

In this study, we search for Globular Clusters (GCs) in the inner halo of the Circinus galaxy using a combination of observational data. Our dataset includes observations from the VISTA Variables in the Vía Láctea Extended Survey (VVVX), optical data from Gaia Release 3 (DR3), and observations from the Dark Energy Camera (DECam). These multiple data sources provide a comprehensive basis for our analysis. Our search was concentrated within a 50 kpc radius from the centre, leading to the identification of 93 sources that met our established criteria. To ensure the reliability of our findings, we conducted multiple examinations for sample contamination. These examinations incorporated tests based on Gaia Astrometric Excess Noise (AEN), the Blue Photometer (BP)/Red Photometer (RP) Excess Factor (BRexcess), as well as comparisons with stellar evolution models. This analysis confidently classified 41 sources as genuine GCs, as they successfully passed both the 3σ Gaia AEN and BRexcess tests. We used the ISHAPE program to determine the structural parameters (half-light radii) of the GC candidates, with a peak effective radius of 4$\pm$ 0.5 pc. The catalogue mainly consists of bright GCs. Relationships between colour, size, and distance were found in the GC candidates, alongside confirmation of bi-modality in colour distributions.

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Four new eclipsing accreting ultracompact white dwarf binaries found with the Zwicky Transient Facility

Ms Jasmine Khalil

University of Amsterdam

Abstract

Context. Accreting ultracompact binaries contain a white dwarf that is accreting from a degenerate object and have orbital periods shorter than 65 minutes.

Aims. The aims of this work are to report the discovery and the orbital period of four new eclipsing accreting ultracompact binaries found using the Zwicky Transient Facility, and to discuss their photometric properties.

Methods. We searched through a list of 4171 dwarf novae compiled using the Zwicky Transient Facility and used the Box Least Square method to search for periodic signals in the data.

Results. We found four eclipsing new eclipsing accreting ultracompact binaries with orbital periods between 25.9–56 minutes, one of which is previously published as an AM CVn, while the other three systems are new discoveries. The other two shorter period systems are likely also AM CVn systems, while the longest period system (P=56 minutes) shows multiple super-outbursts observed in a short amount of time which might be more consistent with it being a Helium-CV

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Violent dynamics around the Galactic center.

Professor Roberto Capuzzo Dolcetta

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Abstract

The center of our Galaxy hosts a massive compact object, claimed to be a super massive black hole of about 4 million Solar masses. This result is coming mainly bu the accurate determination of the movement of a set of stars (so called S-stars) revolving around the massive object at distances above 1500 times the Schwarzschild radius of the alleged massive black hole. The situation is around the threshold between the region of very strong gravitational field, where relativistic effects should be taken into account thoroughly, and that where an approximated Post newtonian treatment suffices. In this presentation I will describe recent results about the expected precession, gravitational red shift, etc., for stars plunging very close to the Galactic center that would be likely needed to investigate the innermost dynamical physics of our Galaxy. This work has a clear feedback on checking validity of the General Theory of Relativity in strong field regime.

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Observation and data analysis of the newly discovered δ−Scuti variable, 1SWASP J193127.17+465809.1

Dr mohamed Adel Sabour

National Research Institute of Astronomy and Geophysics

Abstract

CCD photometric *observations with BVRI* filters on 2016, 2017, 2021, and 2023 by using the 1.88 m telescope of Kottamia Astronomical Observatory (KAO) (Egypt) revealed that the star V2855 Cyg is low-amplitude (Δm<0.3 mag) δ Scuti star. the star was lassied as an Eclipsing binary variable, released later as a high-amplitude Delta Scuti (HADS) star .The peak-to-peak amplitudes is 0.0478 mag(V), one mode present (f_1 =10.1184414±0.0027 c/d). The frequency suggests that the star is non-radial pulsator. during ten nights from August 2016 to 2022, observations , we predect that the possibility of a third body being present in this system. our observations clearly show that V2855 Cyg is not an EB, as reported by Qian S.-B. et al (2017). By using the empirical relations for V2855 Cyg, we determined the global physical parameters. Also Stellar global physical parameters of our system in the instability strip of the Hertzsprung Russell diagram and stellar evolution are presented.

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The Radio Emission from Young Massive Stars

Mr. Solomon Appekey, Dr. Stuart Lumsden, Professor Melvin Hoare

University of Leeds

Abstract

Studying young massive stars or young stellar objects (YSOs) at radio wavelengths together with complementary millimetre wavelength data is very important for understanding the complete process of the formation and evolution (especially the mechanism behind the production of jets and outflows) of these objects. In this study, we investigate a sample of 20 YSOs which form the IRAM Northern Extended Millimeter Array (NOEMA) CORE large program sample. These targets are luminous ($L > 104L\odot$), close by ($d < 6$ kpc) and well-studied young massive stars in the northern hemisphere. We have studied 8 of these targets that did not have any previous Karl G. Jansky Very Large Array (JVLA) data prior to this work. This study was performed in JVLA's A-configuration at 6 GHz and at a resolution of 0.33 arcseconds. For our targets, we detected radio continuum emission from 7 of these objects including the detection of 2 jets. Additionally, we found evidence of variability among 2 of our targets. For the entire sample, we performed a comprehensive radio and millimetre study where we found and associated observed millimetre cores with radio detections (including jets, jet lobes and HII regions) using results from this work and literature. One of the goals of this study is to investigate the orientation of jets to their respective millimetre emission and or discs (if present). We found evidence of a perpendicular orientation of the detected jet to the millimetre emission for the target NGC 7538S. Also, 2 of our targets show a perpendicular disc-jet orientation (using information from literature). Our sample also show divergence from low-mass stars and HII regions in radio luminosity and bolometric luminosity parameter space which indicates that young massive stars are likely to be formed through a scaled up version of their low-mass counterparts. We also find a strong correlation between sample and core masses which may suggest that larger global or sample masses tend to lead to larger core masses.

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The death of stars in binary systems as seen by SPHERE/VLT

PhD Aymard BADOLO[1,2], Eric LAGADEC[2], Sié Zacharie KAM[1], Mamadou N'DIAYE[2], Jean KOULIDIATI[1]

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Abstract

During the late stages of their evolution, low- and intermediate-mass stars reach the asymptotic giant branch (AGB), where they expel their gas, enriched with newly transformed elements, into the interstellar medium (ISM). This mass-loss process is the main driver of the late evolution of these stars and one of the main sources of ISM enrichment, but it's not yet understoud well. For decades, the description of the mass loss of these stars has assumed that AGB stars are unique. A growing body of work clearly shows that this is not the case, such as the recent paper by Decin et al. (2020) in Science, which shows that binaries shape the gas flows of most AGB stars. Studying the distribution of dust near the surface of these stars is therefore key to understanding how binaries can affect their mass loss. We performed a polarimetric survey of the dust around a sample of 53 nearby AGB and RGB stars, mainly symbiotic stars, using the SPHERE (specially ZIMPOL) extreme adaptive optics instrument installed on the VLT in Chile. This allowed us to map the dust distribution around the AGB stars with an angular resolution of 20 milliarcsec. We thus made circumstellar envelop models using RADMC-3D in order to determine ceratains parameters of theses stars and to better understand the phenomenon of their loss of mass , with a particular focus on binarity.

Key words: s*tars: mass loss – stars: symbiotic, binarity – stars: polarimetry*

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A Study of the Mechanism for X-ray Emission from Symbiotic Stars

Prof Romanus Nwachukwu Eze

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Abstract

We propose to address the mystery surrounding the genesis of X-ray emission from Symbiotic Stars (SySts), a broad class composed of interacting binary systems formed from the combination of a red giant or supergiant that transfers mass to a much hotter primary, either a white dwarf (WD) or neutron star. A century ago, it was identified the first such system in the odd variable star, R Aqr, appeared to have an optical spectrum typical of an M dwarf but with bright [O III] lines, a much higher ionization state than expected from a cool star. Decades later SySts were detected in X-rays, but this has not simplified the situation. Researchers have differing perspectives on the genesis of X-ray emission, resulting in four major classifications of X-ray emitting SySts with potentially four separate origins or perhaps simply different variants of the same mechanism. However, in many cases, the exact processes and physics responsible for X-ray emission remain unknown, in part because their distances are either poorly determined or simply unavailable. To estimate the genuine X-ray luminosities and spectra of SySts, We will combine newly available data on distances to X-rays-emitting SySts from ESA's GAIA mission with archival X-ray data from the Chandra, XMM-Newton, and Swift satellites. This can be done with improved and expanded catalogs of SySts and the new all-sky eRosita survey data. Comparing this significantly enhanced data set to the various postulated categories will enable a better grasp of the physics and origins of these strange systems.

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Strange stars and their formation mechanism

Dr Mohamad alassiry

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Abstract

the energy based on the quantum chromodynamic theory is less than the energy needed to obtain a nucleus Neutron stars, but we need a mass between 2 to 2.5 of the mass of the sun M⊙and with a radius of less than 10 km, from which we can conclude that the heavier neutron stars may turn into strange stars after the supernova stage, where the supernova either forms a neutron star or turns into a quark nova forming a strange star.And the quarks can become free if the temperature is very high in addition to that the baryonic density is sufficient, but so far the necessary confirmation for this has not been obtained, especially the transition from the state of the hadron gas to the state of the quark-gallon plasma, which is the expression the athlete reports on the conditions for forming a strange star.But in the laboratory,we can get the strange quark by switching between the upper and lower quarks that form hadrons,and it is also possible to obtain even with a small probability of electrons.Although the strange stars are not new,the technological and scientific development recently has brought this topic back to the fore,especially the follow-up techniques are developing, because what is required is to follow some neutron stars and observe the signals coming from them that prove or deny their transformation into strange stars, and some technologies have come to believe that and the difference between neutron stars can be monitored.And strange.

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High Resolution Spectra of the Galactic Binary Pulsar 4U 1907+09

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Abstract

The accreting pulsar 4U1907-09 is one of ~35 high-mass X-ray binaries with known high magnetic field strengths. A detected cyclotron resonance scattering feature (CRSF) at ~19 keV leads to a field strength of around 2E12 G. The system consists of a slowly-rotating (~440 s) X-ray pulsar accreting from the stellar wind of an O8/9 supergiant. The X-ray pulsar is in a close (~8.37 d) elliptical orbit (e ~ 0.28) around its donor.

We conducted an analysis of four High Energy Transmission Grating observations with the Chandra X-ray Observatory for a total of ~140 ks and one NuSTAR observation for 78 ks, at different orbital phases, to probe the variation of the absorbing column around the orbit.

We measure line fluorescence at Fe K and possibly Si K and other lower Z elements to study dense clumps in the wind of the pulsar's companion star. The details of the NuSTAR observation are used to determine the higher energy continuum beyond 10 keV.

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Extracting the Physical Parameters of Platais 8 Open Cluster with GAIADR3

Elnaz Bakhshi

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Abstract

Using G, Bp, Rp photometry band and proper motion astrometry data from GAIA's latest version of DR3, we have successfully identified potential cluster members of the nearby open cluster Platais 8. These members were pinpointed within a 5-degree radius from the cluster's center, considering a distance modulus of (m − M)0 = 5.88 mag (which corresponds to approximately 150 pc). By establishing a new cluster center at α = 08h 55m 36s, δ = -58° 09' 30", we have gained valuable insights into the structure of Platais 8. Our calculations also reveal a total cluster mass of approximately 230 M⊙, as well as the 2D half-number and half-mass radii. Furthermore, we have determined the surface density of members within a 6-degree field and explored the dynamics of mass segregation within the cluster. Additionally, we have analyzed the mass function of cluster members using a power-law ξ(m) ∼ m-α, uncovering distinct slopes for high and low mas stars. Notably, our examination of the color-magnitude diagram of Platais 8 has led to the identification of a significant population of binary and triple systems, performing a series of Monte Carlo simulations, we obtained a binary fraction stars. Indicating that this open cluster contains a large population of unresolved binaries. Finally, we corrected the MF slopes for the effect of unresolved binaries and found low- and high-mass slopes.

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Calculation of the activity cycle of the star Proxima Centauri using the Hα Index

Rahimeh Foroughi[1,2], Fatemeh Azizi[2]

[1]Department of physics, Zanjan University, Iran.. [2]Department of physics, Payame Noor University, Tehran, Iran.

Abstract

we use the Hα index for spectroscopic data of Proxima Centauri for calculating the periodicity of this star.

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EXPLORING THE JET FORMATION IN BINARY SYSTEMS APPLYING 3D MHD SIMULATIONS

Mr. Mostafa Sepahvand

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Abstract

We conducted axisymmetric MHD simulations to investigate the formation of an ideal magnetized jet that originates from a disk acting as a boundary. Our simulations showed that the magnetized jet consistently launched and reached a stable state. To further our research, we extended the model setup to three dimensions and conducted 3D MHD simulations of the jet launched from a disk surface, achieving a stable and appropriate model setup. Furthermore, we expanded our study by including the companion star and examining the influence of the Roche potential on the jet material. Specifically, we investigated whether the inclusion of the companion star in the model significantly affects the dynamical evolution of the jet. Our findings indicate that the host accretion disk is responsible for the primary physical effects and characteristics of the outflow on a larger scale, whereas the direct tidal effects on the jet dynamics have a substantial impact, particularly in the vicinity of the Roche lobe and towards the secondary star.

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EXTREME MASS RATIO MAGNETIC SOLAR TYPE BINARIES, NSVS 6429576, GDS_J1139444-611732, GSC 0642 00195, TYC 2402 0643 1

Dr. Ronald Samec[1,2], Dr. Daniel Caton[3], Dr. Walter Van Hamme[4]

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Abstract

Short period solar-type binaries are strongly magnetic. As stellar winds leave the poles, this results in a loss of angular momentum, ultimately, decreasing the orbital periods. Extreme mass ratio binaries (EMRB's, $m_2/m_1 \lessapprox 0.2$) result from this process. Recently, our research group has observed the following EMRB's:

GSC06462-00195 is an ~F4V eclipsing binary with a period of 0.63348292d. The system has a mass ratio of q = 0.0937. Its fill-out is a high 66% with an inclination of ~82.5° with an eclipse duration ~109.5 minutes.

NSVS6429576 has a period of 0.5366686 d and a spectral type of ~F2.5. Despite

its low amplitude, DV=0.284 mags, the light curve shows a long total eclipse duration of 96.6 minutes. Its Roche lobe fill-out is found to be 40% along with a mass ratio of only 0.11 and its period appears to be decreasing. The inclination is 83.9˚. The third light was determined.

GDS_J1139444-611732 is a Southern solar type (T ~ 6250K), marginally overcontact, eclipsing binary. The amplitude of the light curves was 0.56 mags in V. A Wilson-Devinney Program solution gives a m_2/m_1=0.1790, a large component temperature difference of 780 K and a fill-out of only 4%. An eclipse duration of $\gtrsim$39 minutes was found.

TYC 2402 0643 1 was found to have a mass ratio q=0.207. Its Roche lobe fill-out is ~22%. It has a period of 0.39958073d. The inclination is high, 83.4±0.1˚ resulting in a total eclipse duration of 43 minutes. The temperature of the primary component ~5250K.

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Accretion bursts in high-mass protostars

Dr. Vardan Elbakyan[1], Dr. Prof. Sergei Nayakshin[2], Dr. Eduard Vorobyov[3], Dr. Dominique Meyer[4], Dr. Alessio Caratti o Garatti[5], Dr. Jochen Eislöffel[6]

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Abstract

Recent observations of high-mass young stellar objects (HMYSOs) with masses $M_*\geq 10\ M_\odot$ uncovered outbursts with accretion rates exceeding $\sim 10^{-3}\ M_\odot\ yr^{-1}$. We utilise 1D time-dependent models of protoplanetary discs around HMYSOs to study burst properties. We find that discs around HMYSOs are much hotter than those around their low-mass cousins. As a result, a much more extended region of the disc is prone to the thermal hydrogen ionisation and magnetorotational (MRI) activation instabilities. The outbursts triggered by these instabilities, however, always have too low accretion rates and are one to several orders of magnitude too long compared to those observed from HMYSOs to date. On the other hand, bursts generated by tidal disruptions of gaseous giant planets formed by the gravitational instability of the protoplanetary discs yield properties commensurate with observations, provided that the clumps are in the post-collapse configuration with planet radius $R_p\geq 10$ Jupiter radii.

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Pulsar glitch activities estimations: the spin parameters approach

Dr Innocent Eya

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Abstract

Glitch activity refers to the change in pulsar spin frequency per year due to rotational glitches. It is an important tool for studying the dynamics of super-nuclear matter using neutron star interiors as models. Glitch events are usually observed in the spin frequency and frequency derivative of pulsars. As a pulsar ages, the rate of occurrence of these glitches decreases. The activity parameter can be calculated by performing linear regression on the cumulative glitches of a given pulsar over a given period. However, this method is only practical for pulsars with multiple regular glitch events. Unfortunately, there are only a few pulsars with such records due to the scarcity of glitch events and the difficulty of monitoring all known pulsars. This makes it difficult to study neutron star interiors with multiple pulsars using the activity parameter. This analysis investigates the relationship between the glitch activity parameters and pulsar spin parameters (spin frequency, frequency derivatives and characteristic ages). We found that a quadratic function provides a better description of the relationship between the activity parameters and pulsar spin parameters than the commonly used linear functions. Using this information, we were able to estimate the activity parameters of other pulsars that do not have records of glitches. We observed that the relationship between the estimated activity parameters and pulsar spin parameters in the ensemble of pulsars is consistent with that of the observed.

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Radio emission from Massive Protostars in the SARAO MeerKAT Galactic Plane Survey

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[1]Technical University of Kenya. [2]University of South Africa. [3]University Leeds. [4]University of Leeds

Abstract

L-band radio emission from known massive young stellar objects (MYSOs) in the SARAO MeerKAT Galactic Plane Survey were studied to search for non-thermal radio emitters from the sample. A total of 398 massive protostars, identified from the RMS survey, lie within the region covered by the survey. One hundred and sixty four fields that host the protostars are isolated from nearby bright HII regions, and can be studied to establish the nature of the emission from any ionized jets in the fields. Seventy four of the fields have jets with five-sigma detections and above, corresponding to a detection rate of 45%. The MeerKAT fluxes of the detections and the upper limits of the non-detections, together with any other fluxes from previous observations, were used to estimate the spectral indices of the jets to search for the presence of non-thermal radiation. If a source manifests a single emission at a given observation but is resolved into multiple components in observations of higher resolutions, then the sum of the fluxes of the components were used in estimating the indices. The spectral energy distribution of some of the sources as well as as their radio-luminosities display evidence of non-thermal emission, especially from extended sources.

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Multiwavelength Study of Be/X-ray Binary Stars

Mr Thuto Ndlovu

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Abstract

Be/X-ray binary stars are the largest subclass of high-mass X-ray binaries which comprise a neutron star in an eccentric orbit around a massive B spectral type star. They undergo X-ray outbursts which come in two flavours: Type I and Type II. The origin of the outbursts is due to the complex interaction between the neutron star and circumstellar disc around the Be star. We perform a systematic study of circumstellar discs of Be/X-ray binaries to demonstrate observational signatures of the Kozai-Lidov mechanism. The results show that circumstellar discs undergo morphological variability which influences the mass accretion onto the neutron star.

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Fine Structure of the Hα Age-Chromospheric Activity Relation in Solar-Type Stars

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Abstract

Excess chromospheric emissions within deep photospheric lines are useful proxies of stellar magnetism for FGK stars. This emission decays with stellar age and is a potential determinant of this important stellar quantity. We report Hα chromospheric fluxes for 511 solar-type stars in a wide range of masses, [Fe/H], ages and stages of evolution, from high S/N, moderately high-resolution spectra and calibrated absolutely with model atmospheres. The comparison of Hα and H+K (Ca II) chromospheric fluxes reveals a strong metallicity bias affecting H+K fluxes thereby metal-rich stars with deep line profiles mimic low levels of chromospheric flux, the converse being true for metal-poor stars. This bias blurs the age-activity relation, precluding age determinations for old, inactive stars unless the relation is carefully calibrated with mass and [Fe/H] terms. Hα chromospheric losses do not suffer from significant metallicity biases and are competitive age indicators up to ages 6 Gyr. The Hα age-activity-mass-metallicity calibration fully satisfies the theoretical expectation that (other parameters being equal) more massive stars possess narrower convective zones and are less active than less massive stars, while more metal-rich stars have deeper convective zones and appear more active than metal-poorer stars.

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PRECISION ANALYSES OF THREE SOLAR TYPE BINARIES, AND THEIR THIRD COMPONENTS: V471, V1115 CASSIOPEIAE, AND V642 VIRGINIS

Dr. Ronald Samec[1], Dr. Walter Van Hamme[2], Dr. Marek Wolf[3]

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Abstract

Recently, BVR_cI_c light curve observations were taken of A type W UMa contact systems V471 and V1115 Cassiopeiae and the detached binary, V642 Virginis. They have undergone Wilson-Devinney (W-D) analyses. V1115 Cas is a totally eclipsing binary with a mean V magnitude of 14.32, an amplitude of DV=0.532 mags and a period of 0.32328d. V471 Cas has a period of 0.40101d and a magnitude range of 13.6-14.4. Both studies include extensive period studies with many new eclipse timings and a determination of the minimum masses of the third bodies. In an 82-year period study of V471 Cas, an analysis by Wolf, a sinusoidal oscillation results which yields a composite third body of mass 0.10 $M_\odot$. An analysis of the light curve reveals that the system has a mass ratio of q~0.89 (M_2/M_1). From our 19-year period study of V1115 Cas, the residuals form a sinusoidal curve. An analysis of this curve yields a third body of minimum mass, 0.50 $M_\odot$. The system has a somewhat extreme q=0.23. The inclination is high, 86.06° resulting in a total eclipse. V642 Vir is a polar spotted, well detached, UV Leo-type, low mass, ~K6V system. The O-C plots show a low amplitude oscillation of residuals which points an orbiting third body, a dwarf of minimum mass, 0.15 $M_\odot$ in an eccentric orbit (e=0.41), with an orbital period of 20 years. The odd light curves of V642 Virginis indicate that it has polar spots.

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Astrophysical Jets in Binary Systems; 2D

Mrs Leyla Karimi Akbarabadi

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Abstract

Our research investigates the formation and launch of magnetized jets from the inner regions of young stellar objects (YSOs), specifically protostellar disks. To achieve this, we used the PLUTO code to implement time-dependent magnetohydrodynamic equations. Our simulations were 2D and considered the accretion disk as a boundary. We varied physical parameters such as magnetic field intensity, mass injection ratio, and potential wells generated by a single central star or a binary system with different masses. We also added the gravitational potential of the companion star in the binary system to observe the direct effects of tidal forces on the jet structure. Our observations revealed that stronger magnetic fields result in faster but less dense jets. Additionally, mass injection leads to massive jets that further slow down the jet's speed. We also found that tidal forces have a significant impact on the jet structure, especially in areas close to the disk and the launching region. The effect of tidal forces directly on the jet structure is undeniable, with the most significant impact being on the transfer of tidal forces from the disk to the jet.

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RECENTLY OBSERVED MARGINALLY OVERCONTACT SOLAR TYPE BINARIES: TX CMI, DW CMI, SZ SCL, V590 CAM, and GDS_J1139444-61173

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Abstract

Marginally contact solar-type binaries occur when binary stars have recently come into contact or are undergoing Thermal Relaxation Oscillations. These systems have not come into thermal contact. Five recently observed systems are in this configuration.

GDS_J1139444-611732 is a solar-type (T ~ 6250K), overcontact, eclipsing binary. A Wilson-Devinney Program (WD) solution gives a m_2/m_1=0.1790, a large component temperature difference of 780 K is due to recent contact and a fill-out of only 4%. An eclipse duration of 39 minutes was found.

TX CMi: Fifty-five total times of minimum light are included in the 61-year period study (p=0.38d). From these we determined that the period is increasing. A W-D analysis reveals that the system is a W UMa binary with a mass ratio near unity. q~1.00. Its Roche Lobe fill-out is ~10%. One spot was needed in the modeling. The temperature difference of the components is only ~90 K, so the stars are nearly twins, with the secondary component as the slightly cooler one. The inclination is high, 86.9º.

DX CMi: Thirty-five total times of minimum light are included in this W-type W UMa's 19.3 year period study. The period is weakly decreasing with a quadratic term of $-1.9X10^{-11}$. A W-D analysis reveals that this W-type W UMa binary has a mass ratio near unity, q~1.1. Its Roche Lobe fill-out is ~10%. One weak spot was needed. The temperature difference of the components is ~260 K.

SZ Scl and V590 Cam (Roche Lobe fill-out is 7% and ~4%, respectfully) were also observed.

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Light Curve Analysis of Contact Binary Stars Using BSN Software

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Abstract

Light curve analysis of binary systems using existing programs and the Markov chain Monte Carlo (MCMC) method or Monte Carlo (MC) simulation is generally a time-consuming process. There were some suggestions for this issue, but they were challenging to implement by users. We introduce the BSN software, whose name is taken from the Binary Systems of South and North (BSN) project. This software is the PHysics Of Eclipsing BinariEs (PHOEBE) and the Wilson-Devinney (WD) codes based, and usable for the analysis of light curves of contact binary systems, which has the fastest MCMC speed compared to other existing programs. The BSN software offers more features and is easier to use for analyzing the light curve on ground- or space-based data, taking into consideration scientific principles. This software follows all the standard scientific requirements, the same as other programs, for light curve analysis of contact systems. We also used machine learning in this software to suggest the location of the star spot (if needed) to the user. The BSN software can estimate and display absolute parameters along with stellar evolution diagrams in different methods. Calculations and display of orbital period changes (O-C) of binary systems is one of the other parts of this software, which can be drawn using linear, parabolic and sinusoidal MCMC fits. Currently, the contact binaries section of this software is finished and can be presented.

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Global Parameters of Eight W UMa-type Binary Systems

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Abstract

Multiband photometric investigations for eight binary systems of the W Ursae Majoris (W UMa)-type are presented. Six systems are presented for the first time to analyze their light curves. All the analyzed systems have a temperature below 5000 K and an orbital period of less than 0.28 days. We extracted primary and secondary minima from the ground-based observations of these systems. According to a few observations reported in the literature, linear fits were considered in the O-C diagrams, and new ephemerides were presented. Light curve solutions were performed using the PHysics Of Eclipsing BinariEs (PHOEBE) code. The results of the mass ratio and fillout factor indicate that the systems are contact binary stars. Six of them showed the O'Connell effect, and a cold starspot on each companion was required for light curve solutions. Their absolute parameters were estimated and evaluated by two other methods. In this study, the empirical relationship between the orbital period and semi-major axis was updated using a sample consisting of 414 contact binary systems and the Monte Carlo Markov Chain (MCMC) approach. Also, using Machine Learning (ML) and the Artificial Neural Network (ANN) model, the relationship between P-T1-M1 was updated for a better estimation of the mass of the primary star.

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2D Parameter Relationships for W UMa-type Systems Revisited

Atila Poro[1,2], Ehsan Paki[2], Ailar Alizadehsabegh[3]

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Abstract

Reviewing the empirical and theoretical parameter relationships between various parameters is a good way to understand more about contact binary systems. In this investigation, two-dimensional (2D) relationships for P-M_V(system), P-L1,2, M1,2-L1,2, and q-L_ratio were revisited. The sample used is related to 118 contact binary systems with an orbital period shorter than 0.6 days whose absolute parameters were estimated based on the Gaia Data Release 3 (DR3) parallax. We reviewed previous studies on 2D relationships and updated six parameter relationships. Therefore, Markov chain Monte Carlo (MCMC) and machine learning methods were used, and the outcomes were compared. We selected 22 contact binary systems from eight previous studies for comparison, which had light curve solutions using spectroscopic data. The results show that the systems are in good agreement with the results of this study.

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Estimating the Absolute Parameters of W UMa-type Binary Stars Using Gaia DR3 Parallax: Limitations

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Abstract

W UMa-type systems are significant astrophysical tools for studying the formation, evolution, and structure of stars. It is possible to get insight into the evolution of stars by studying contact binary systems, including relationships between parameters and important stellar elements like mass, luminosity, and surface gravity. Deepest investigations are required to solve the numerous unanswered concerns and unsolved challenges regarding these systems in our current understanding. To obtain reliable results and overcome some challenges, it is necessary to measure accurately and use appropriate methods for computations and analysis. One of the issues is estimating absolute parameters after observation and data reduction processes, analysis of orbital period variations, and light curve solution. When just photometric data is available, there are several methods based on various parameter relationship equations that were presented through investigations. The use of Gaia DR3 parallax is one method that has been utilized recently to estimate the absolute parameters of contact binary systems we attempted to investigate different aspects of using this method to estimate absolute parameters.

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Period-Luminosity Relationship for Delta Scuti Stars Revisited

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Abstract

The Gaia DR3 parallax approach was used to estimate the absolute parameters of 2375 Delta Scuti stars from the ASAS catalog. The selected stars have a variety of observational characteristics, with a higher than 80% probability of being Delta Scuti stars. We have displayed all the stars in the Hertzsprung-Russell (H-R) diagram along with the Delta Scuti instability strip, the Zero Age Main Sequence (ZAMS), and the Terminal-Age Main Sequence (TAMS). Then, we determined which fundamental and overtone modes each star belongs to using pulsation constant (Q) calculations. In addition, we evaluated the parameters in the Q calculation equation using three machine learning methods, which showed that surface gravity and temperature have the greatest effect on its calculation. The Period-Luminosity (P-L) relationship of the Delta Scuti stars was also revisited. Eventually, using least squares linear regression, we made four linear fits for fundamental and overtone modes and updated their relationships.

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Making a HASH* of it: Strange Galactic alignments and solving the sulphur anomaly in Planetary Nebulae*HASH: The Hong Kong, AAO, Strasbourg H-alpha Planetary Nebulae database and reseaerch platform

Prof Quentin Parker

The University of Hong Kong

Abstract

Planetary Nebulae (PNe) are a relatively rare but powerful late-stage stellar population in terms of what we can learn about stellar evolution and the chemical enrichment process of entire Galaxies. Their ionised shells exhibit numerous and strong emission lines over a wide range of the electromagnetic spectrum. As such they represent highly useful “laboratories” for studying the plasma physics of these celestial objects. Because most radiation from PNe is emitted via their strong emission lines they can be found to enormous distances outside of our own Galaxy. Their rich variety of lines also enables estimation of elemental abundances, expansion velocity of the nebula and associated kinematic age. HASH (Hong Kong/AAO/Strasbourg H-alpha PN catalogue) is a PNe mutliwavelength database of all currently known Galactic and Magellanic Cloud PNe. It has provided a powerful online resource for the global community to study both PNe and their CSPN with over 1100 users in more than 60 countries.

In this talk I will present some key, recent results from various HKU based projects on PNe facilitated via our ESO VLT data and HASH. I will cover a recent, enigmatic 5-sigma PNe alignment result in the Galactic centre, our robust abundance determinations, resolution of the decades old “sulphur anomaly” problem and some recent work on PNe in Open Clusters.

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Probing the magnetic field orientation of low latitude dark clouds and it's correlation with galactic longitude

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Abstract

We perform the magnetic field morphology of selected Bok globules and Lynd's clouds situated at low latitudes within the galactic latitude (b) range of −10° to 10°. The polarimetric observations of four clouds, CB17, CB24, CB27, and CB188, were conducted using the 104-cm Sampurnanand Telescope located at ARIES, Manora Peak, Nainital, India, during 22-23 Dec. 2017 and 8th May 2019. The results obtained from the observed data are combined with 13 more low-latitude clouds (*viz.*, CB3, CB4, CB25, CB26, CB34, CB39, CB56, CB60, CB69, CB130, CB246, L1014, and L1415) available in literature. From the polarimetric analysis of 17 clouds, we obtained a correlation between the orientation of the local magnetic field with respect to the galactic plane and their galactic longitude ($\theta_{off} = (0.0020 \pm 0.0006)l^2 - (0.8380 \pm 0.1841)l + (90.5358 \pm 14.09)$, where θ_{off} is the offset between the orientation of local magnetic field of the cloud and the galactic plane) which signifies that the local magnetic field of clouds are oriented along the galactic plane for the clouds that are situated towards the galactic anti-center region and huge offsets are obtained in the clouds that are situated towards the galactic center region. Later, we performed the optical polarimetric analysis of two more low-latitude dark clouds L1495 and L1498, and found that the results fit well with our correlation. We also measured the dust column densities of L1495 and L1498 in both high-density as well as low-density regions of the clouds.

Key words: *polarization – (ISM:) dust – extinction – ISM: magnetic fields*

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Photometric Light Curve Analysis of Two Contact Binary Systems LS Del and V997 Cyg

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Abstract

The light curve analyses and orbital period variations for two W Ursae Majoris (W UMa) binary stars, LS Del and V997 Cyg, were presented in this work. We used TESS data for extracting times of minima and light curve analysis of the target systems. The O-C diagram for both systems displays a parabolic trend. LS Del and V997 Cyg's orbital periods are increasing at a rate of dP/dt= 7.20*10^{-08} d yr^{-1} and dP/dt= 2.54*10^{-08} d yr^{-1}, respectively. Therefore, it can be concluded that the mass is being transferred from the less massive star to the more massive component with a rate of dM/dt=-1.96*10^{-7} M_Sun yr^{-1} for LS Del system, and dM/dt=-3.83*10^{-7} M_Sun yr^{-1} for V997 Cyg. The parameters of the third possible object in the system were also considered. The PHOEBE Python code was used to analyze the light curves. The light curve solutions needed a cold starspot due to the asymmetry in the LS Del system's light curve maxima. The mass ratio, fill-out factor, and star temperature all indicate that both systems are contact binary types in this investigation. Two methods were used to estimate the absolute parameters of the systems: one method used the parallax of Gaia DR3, and the other used a P-M relationship.

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First Multiband Photometric Light Curve Analysis of Southern Hemisphere Contact Binary System: DM Cir

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Abstract

We present the first photometric analysis of DM Cir which is a short period in the Southern Hemisphere. Observations and analysis of this binary system were done in the form of the Binary Systems of South and North (BSN) Project. The ground-based observations were conducted with BVI_c filters. The times of minima of our observations and the TESS sectors' data were extracted, and a new ephemeris was presented. The O-C diagram shows a parabolic trend. According to our computation, the orbital period is increasing at a rate of dP/dt=5.83*10^{-07} d yr^{-1}. The increase of the orbit period can be explained by mass transfer from the less massive component to the more massive one as the mass transfer rate dM_2/dt=-1.01*10^{-6} M_Sun yr^{-1}. We performed a light curve analysis using the Phoebe program. So, the values of mass ratio 0.3932 and fillout factor 29% were obtained. A hot spot on the secondary star was required for the solution. The stars' temperatures indicate that they are a G5 spectral type. The a-P empirical relationship and the mass ratio were utilized for estimating the mass of each star in the system. The other absolute parameters were then computed using standard processes. The results show that DM Cir is an A-type contact binary system. We displayed stars' positions in the M-L and M-R diagrams. In addition, our findings indicate a good agreement with the P-L and q-L_{ratio} empirical relationships.

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Reanalyzing the Light Curves of 20 Contact Binary Stars Using TESS Data

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Abstract

We revised light curve solutions for 20 W Ursae Majoris (W UMa)-type contact binary systems. We used the latest available Transiting Exoplanet Survey Satellite (TESS) data for analysis. All the analyzed systems have an orbital period of less than 0.58 days and have been introduced as contact systems in previous studies. Light curve solutions were performed using the PHysics Of Eclipsing BinariEs (PHOEBE) Python code version 2.4.9. The results show that systems had various mass ratios from 0.149 to 3.915, and fillout factors from 0.072 to 0.566. The effective temperature of the stars was less than 7016 K, which was expected given the features of most contact binary stars. Twelve of the target systems' light curves were asymmetrical in the maxima, showing the O'Connell effect, and a starspot was required for light curve solutions. The estimation of the absolute parameters of the binary systems was presented using Gaia DR3 parallax. The orbital angular momentum of the systems was calculated. The positions of the systems were also depicted on the L-M, R-M, q-L_{ratio}, and logM_{tot}-logJ_0 diagrams.

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Thorne-Zytkow Objects

Professor Christopher Tout

University of Cambridge

Abstract

Thorne-Zytkow objects were envisaged in the 1970s as stars similar to red giants but with the electron degenerate core replaced by a neutron degenerate object. The much increased gravity at the surface of the core likely leads to stars powered by accretion but at temperatures that also support nuclear burning. Full detailed models were made in the 1990s and revealed that hydrogen burning can take place at the base of the star's deep convective envelope at very high temperatures. This allows for proton captures by much heavier charged nuclei. The convective removal of processed material interrupts the burning. In this way TZOs might be responsible for rare p-process isotopes. However the physics, particularly opacities and neutrino loss rates as well as the equation of state, used in these models has been significantly updated in the intervening years. The models also only included hydrogen burning so excluding helium and carbon burning shells and the possibility of thermal pulses. Thus new models are required with more realistic nucleosynthetic yields. It is comparison of abundances with observed giants that offers the best hope of observational identification of a TZO. However attempts to make such models recently have failed. We review the objects, the new physics and the modelling process and attempt to construct our own models.

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An Improved Photometric Mode identification Equation for the Light Variation in Non-Radially pulsating stars

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Abstract

In this talk, we introduce a new and improved photometric mode identification formula for pulsating stars. We begin our calculations from the radiative transfer equations. By considering appropriate physical conditions and mathematical formulations, we derive a formula that describes the effect of pulsations in the light output of pulsating stars. For this formulation, we took into

consideration the interaction of light with the different layers of the atmosphere of the star.

The calculation we did is to show the dependence of the variation in the observed luminosity on the surface area, surface normal and variation in temperature which is caused by nonradial pulsations.

By implementing the theories and principles introduced by Watson (1987, 1988), we investigated photometric mode identification and introduce an alternative way of deriving theoretical photometric mode identification. We also demonstrate the effect of pulsation in the light output of a pulsating star. Hence, the calculation we did show the dependence of the variation in the observed luminosity on the surface area, surface normal and variation in temperature caused by nonradial pulsation.

Key words: Mode identification; Photometry; Pulsating Stars; Radial and Nonradial Pulsation; Radiative transfer equations; Flux perturbations

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X-Shooting ULLYSES: Massive stars at low metallicity

Prof Jorick Vink

Armagh Observatory and Planetarium

Abstract

Observations of individual massive stars, super-luminous supernovae, gamma-ray bursts, and gravitational wave events involving spectacular black hole mergers indicate that the low-metallicity Universe is fundamentally different from our own Galaxy. Many transient phenomena will remain enigmatic until we achieve a firm understanding of the physics and evolution of massive stars at low metallicity (Z). The Hubble Space Telescope has devoted 500 orbits to observing ∼250 massive stars at low Z in the ultraviolet (UV) with the COS and STIS spectrographs under the ULLYSES programme. The complementary X-Shooting ULLYSES (XShootU) project provides an enhanced legacy value with high-quality optical and near-infrared spectra obtained with the wide-wavelength coverage X-shooter spectrograph at ESO's Very Large Telescope. We present an overview of the XShootU project, showing that combining ULLYSES UV and XShootU optical spectra is critical for the uniform determination of stellar parameters such as effective temperature, surface gravity, luminosity, and abundances, as well as wind properties such as mass-loss rates as a function of Z. As uncertainties in stellar and wind parameters percolate into many adjacent areas of astrophysics, the data and modelling of the XShootU project is expected to be a game changer for our physical understanding of massive stars at low Z. To be able to confidently interpret James Webb Space Telescope spectra of the first stellar generations, the individual spectra of low-Z stars need to be understood, which is exactly where XShootU can deliver.

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Massive Algols as whetstones for the progenitors of stripped-envelope supernovae and gravitational wave sources

Koushik Sen[1], Norbert Langer[2], Daniel Pauli[3], Goetz Gräfener[2], Abel Schootemeijer[2], Hugues Sana[4], Tomer Shenar[5], Laurent Mahy[6], Chen Wang[7]

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Abstract

All except one mass transfer episode in the isolated binary evolution channel occur at short timescales and, hence, are difficult to observe. This leads to many unconstrained assumptions in modelling mass transfer phases. The uncertainties percolate through our understanding of progenitors of stripped-envelope supernovae and gravitational wave mergers. As the only exception, the nuclear-timescale so-called 'slow Case A' mass transfer phase in short-period binaries has many Algol binaries as observational counterparts. Since a thermal timescale mass transfer precedes the slow Case A phase, in-situ constraints on stellar and binary physics assumptions, such as mass transfer efficiency, tidal strength and internal mixing, can be obtained through population synthesis studies of massive Algols. I will discuss the current state-of-the-art modelling and observations of these binaries and our identification of a novel outcome from this binary evolution channel, namely the 'reverse Algols'. We identified semi-detached binaries where the more massive star transfers mass to a less massive companion on a nuclear timescale. We also found that binary stripping can form Wolf-Rayet binaries on the main sequence with identified observational counterparts. Our population synthesis results predict ~5% of massive binaries (30-90 Msun) in the main sequence from the reverse Algol channel. We derived the predicted distribution of orbital periods, mass ratios, rotational velocities, and surface abundances of these binaries using a grid of ~100,000 detailed binary evolution models at a metallicity suitable for the Large Magellanic Cloud.

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BSN Project: First Light Curve Study of the Low Mass Contact Binary V0610 Vir

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Abstract

Photometric data were used to perform the first light curve analysis of the V0610 Vir binary system. Observations and analysis were done in the form of the Binary Systems of South and North (BSN) Project. We extracted the minima from our observations and compiled the literature, which was few. Therefore, we performed computations using the reference ephemeris and presented a new ephemeris and O-C diagram with a linear fit. Light curve analysis was performed using the PHOEBE Python code and the Markov chain Monte Carlo (MCMC) approach. The assumption of a hot starspot was required due to the asymmetry in the light curve's maxima. The analysis shows that V0610 Vir is a contact binary system with a fillout factor of 0.085, a mass ratio of 0.998, and an inclination of 70.65deg. The absolute parameters of the system were estimated based on the Gaia DR3 parallax method. The results show that the system is a low-mass contact binary with a total mass lower than 0.8(M_Sun). The location of the stars was shown in the M-L and M-R diagrams.

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Discovery of a Previously Unknown Population of Eruptive Class I YSOs, within Cygnus-X.

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Abstract

Eruptive variability is an important mechanism within the accretion history of YSOs. Stars can see accretion rates increase to the order of ~10^-4 solar masses per year during the larger FU Orionis (FUor) events, which can lead to a vast increase in luminosity for durations ranging from a decade to a century. Further understanding of the phenomenon, with particular regard to the frequency of such events, will be useful in constraining the timescales of star formation. It has been theorised (Audard+ 2014) that these events are more common at earlier phases of stellar formation, but this has been a challenge to observationally confirm. To that end, we undertook an examination of Spitzer selected YSOs within the Cygnus-X complex, comparing the time domain behaviour of both the Class I and Flat-spectrum/Class II stars. We report on 70 candidate eruptive variables within these groups, including 12 stars with eruptions longer than 10 years in duration, and 8 with characteristics that resemble the photometric behaviour of FUors. We find the candidate FUors to be an order of magnitude more common among the younger Class I systems than in flat-spectrum and Class II objects. The embedded systems also show MIR colour behaviour that is redder-when-brighter, which contrasts with traditional eruptive YSOs. Finally, we note the unusual long-term rising behaviours for ten Class I YSOs, with rising timescales longer than five years, which is far slower than ~6-12 month timescale for the historical FUor-type objects.

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Opportunities for Observing at the CHARA Array

Dr Christopher Farrington, Dr Gail Schaefer, Dr Douglas Gies, Dr Theo ten Brummelaar, Dr Edgar Ligon, Dr Nicolas Scott, Dr Cyprien Lanthermann, Dr Nils Turner, Dr Jeremy Jones, Dr Narsireddy Anugu, Dr Rainer Kohler, Dr Karolina Kubiak

Georgia State University - CHARA

Abstract

The CHARA Array located at Mount Wilson Observatory combines the light of six 1-meter telescopes at optical/infrared wavelengths to achieve milliarcsecond resolution. The Array is used to measure stellar diameters, image stellar surfaces, detect close binary companions, and resolve the structure of circumstellar disks. Recent and ongoing updates to our instrument suite will provide expanded access to imaging with all six telescopes in the V, H, and K-bands and improved sensitivity for fainter objects. Open access time at the CHARA Array is available through the NOIRLab call for proposals. CHARA staff provides assistance to new observers on developing science programs, planning and collecting observations, and reducing data.

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The Polstar FUV Spectropolarimetry Mission to Understand the Role of Rotation in Massive Star Evolution

Dr Paul Scowen

NASA Goddard Space Flight Center

Abstract

Polstar combines, for the first time, the complementary benefits of spectroscopy and polarimetry to provide insight into the impact and effect of rotation, mass loss and stellar environment on the evolution of massive stars. Furthermore, it leverages an innovative combination of effective area and time coverage, to reach the diversity of targets necessary to transform our understanding of how massive stars evolve. Detailed knowledge of these bright, yet distant objects, is crucial because massive stars underpin the Baryonic life cycle in galaxies and thereby dictate the return of energy and processed material to the ISM for subsequent generations of stars and planets. *Polstar* will map stellar wind and magnetospheric structures by uniting time domain, polarimetry and spectroscopy capability in the near- and far-UV (NUV and FUV) which is densely populated with high-opacity resonance lines encoding a rich array of diagnostic information. The instrument combines advances in high reflectivity UV coatings and delta-doped CCDs with high quantum efficiencies to provide dedicated FUV spectropolarimetry for the first time in 25 years. The instrument covers 122-320nm at resolution R~10k. The instrumental polarization stability is built to provide signal-to-noise ratios (SNR) for UV polarimetry precision of $1x10^{-3}$ per exposure per resolution element (resel). Precision can be further improved with spectral binning and/or stacking multiple exposures. *Polstar* spectral resolution is >10x better than WUPPE, with 10x better effective area, while reaching shorter wavelength than *WUPPE* to access strong lines of species like NIV and SiIV.

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Unraveling the Nature of the Protostellar Object G358.46–0.39 Using ALMA Data

Dr. Chukwuebuka Ugwu[1,2,3], Prof. James Chibueze[2,3,4], Mrs Jean-Marie Morgan[4], Dr. Timea Csengeri[5], Prof. Augustine Chukwude[3], Prof. Johan van Der Walt[4], Prof. Jibrin Alhassan[3]

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Abstract

In spite of the key role that high-mass stars play in the evolution of galaxy, their early formation processes remain poorly understood due to their complex environment. Dust continuum and molecular line emissions observed with ALMA provide better understanding of the earliest stages of massive star formation. The continuum and spectral lines archival ALMA data of G358.46−0.39 was analyzed using the CASA package in other to probe the gas kinematics and protostellar nature of the ongoing high-mass star formation. The dust continuum map reveals multiple dust continuum cores (MM1a, MM1b, MM1c and MM2) dominated by MM1a. MM1a is found to harbour a periodic methanol maser while MM2 hosts a non-periodic methanol maser and is associated with faint free-free emission. We calculated the masses and the column densities of the various objects (MM1a, MM1b, MM1c and MM2). A total of 33, 10, 10 and 9 molecular transitions are detected towards MM1a, MM1b, MM1c and MM2, respectively. The differences in the number of molecular lines detected towards each of the cores support different excitation conditions at different positions. We derived the kinetic temperature ranges of MM1a, MM1b, MM1c, and MM2 to be $\sim 96 - 118$, $96 - 114$, $72 - 74$, and $80 - 84$ K, respectively. A highly collimated bipolar outflow traced by CO emission is seen towards MM1a, with knots along the outflow lobes, which could be an indication of episodic ejection. The velocity field map of CH_3OH suggests the presence of a rotating structure, possibly a disc. These results are clear indication that MM1a is a massive young stellar object, with ongoing outflow activity.

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Binary stars from optical long-baseline interferometry

Dr Alexandre Gallenne

Universidad Andres Bello. French-Chilean Laboratory for Astronomy

Abstract

The most fundamental stellar parameter, the mass, is rarely available or has a low accuracy, providing poor constraints on the stellar structure and evolution. Observing binary stars by combining interferometry and spectroscopic measurements offers a unique opportunity to measure very precise dynamical masses. In addition, double-lined spectroscopic binaries provide independent distance measurements with an extreme accuracy, allowing to direclty test the Gaia parallaxes and the P-L relations of Cepheids. I will show that masses and distances as high as 0.05% accuraccy level can be obtained by combining interferometric and spectroscopic observations for different type of binary systems, i.e. binary Cepheids, eclipsing and normal binaries.

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PROBING STRUCTURAL PARAMETERS OF THE GLOBULAR CLUSTER M2 BY ELLIPSE FITTING OF ITS STELLAR DENSITY

PhD student Svetoslav Botev, Assoc. prof. Petko Nedialkov

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Abstract

The Globular cluster M2 is a suitable object for measuring structural parameters like its center's coordinates, ellipticity, and positional angle. Earlier we measured them by elllipse fitting of the 2D spatial distribution of cluster stars, selected within different color-magnitude ranges on HR-diagram. We used g&r photometry from Pan-STARRS Catalog DR1 (Chambers et al. 2016) with a limiting magnitude of V~21 mag. Recently we apply the same technique on of BV photometry of Lee et al. (1999) which goes deeper up to V~22.5 mag. Here we make use of the astrometric part of same data to produce a 100x100 px^2 stellar density map averaged over area of 12x12 $arcsec^2$ and apply elllipse fitting of isodensity pixels. Thus we were able to derive not only more precise estimates of the structural parameters themselves, but also their errors and their variance with the distance from the center of M2.

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Resolving the prestellar molecular clumps in the external galaxies

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Abstract

ABSTRACT

In the distribution of molecular mass across the Milky Way Galaxy, dense molecular clumps are the sites where the gas begins its gravitational collapse and produces new stars. We aimed to study the lifestyle of molecular clumps, the formation of clumps and clump masses, clump decomposition and viral theorem. In resolving the pre-stellar molecular clumps in the external galaxies, This method and observations were obtained with the Mopra1 radio telescope, including the configuration of the MOPSspectrometer, which collects data simultaneously on multiple transition within an 8-GHz segment of the 3-mm band is to obtained on resolving the molecular clumps in external galaxies, Mopra is used to collect data on several 'dense gas tracer' spectral lines in the 85–93 GHz range.

Session

Division G Stars and Stellar Physics

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The habitability of exoplanets based on the interaction of magnetized protostellar winds

Ms. Yasmmin Tamburus, Ms. Natalia Fernanda de Souza Andrade, Mrs. Vera Jatenco-Pereira

Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG, University of São Paulo, Brazil

Abstract

Strong magnetized stellar winds are observed in weak-lined T Tauris stars (wTTs), where, together with turbulence, can excite MHD modes, like Alfven waves. A possible mechanism for accelerating this wind is their damping. We aim to study the interaction of these magnetized winds with the magnetospheres of Earth-type planets in the habitable zones of their host stars, and verify if their magnetospheres can preserve the planetary atmospheres, acting as a shield. In our model, we assumed a simple constant damping and a non-linear damping. Finally, we obtained our preliminary results that some planets can sustain their atmospheres.

Session

Division G Stars and Stellar Physics

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Weird Binaries Under Surveillance: TU Tau and HD 5501

Christopher Corbally[1], Richard Gray[2]

[1]Vatican Observatory. [2]Appalachian State University

Abstract

While TU Tau was known to be a binary (Sanford 1944) with a C-N carbon star primary, it was not until a LAMOST 2013 spectrum was closely inspected by Gray that the companion was revealed as an A2 III-IV star with strong lines of Sr II, Ba II, and Y II. This suggested that it is a prime candidate for a barium giant progenitor. A Pro-Am group began tracking it with photometry and spectroscopy, only to find the companion dimmed irregularly and finally disappeared in April 2023. A trace of the A-giant star was seen in October 2023, so it is clearly serving as a probe of the outer atmosphere of the carbon star.

HD 5501 is an unusual eclipsing binary with a light curve that does not repeat exactly from one cycle to the next. The primary is an A0 II shell star. Photometry and spectroscopy contributed by the same Pro-Am group has detailed the variable emission at H-alpha through a complete phase. The working hypothesis is that the secondary is a B dwarf surrounded by an accretion disk. Mass is being transferred from the primary to the accretion disk, on which there is a hot spot where the mass stream from the primary collides with the disk. Modeling is underway to account more securely for the variations within a cycle and between cycles.

Session

Division G Stars and Stellar Physics

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Stellar Physics and General Relativity

Dr Shuichi Yokoyama

Ritsumeikan University

Abstract

As seen in most textbooks of astrophysics, most astronomical bodies such as main sequence stars have been investigated only by Newtonian gravity. This is presumably based on a belief that Newtonian physics could be sufficient to extract important physics of most astronomical bodies except compact stars and General Relativity would be too precise to analyze them.

In this talk, I will explain that this belief is not correct any more and General Relativity plays an important role in extracting new physics of luminous stars like the Sun.

I will explain it based on my recent work arXiv:2306.16647, in which I have investigated the relativistic extension of the classic stellar structure equations and proposed a closed set of differential equations as the basic structure equations for a relativistic hydrostatic equilibrium system with spherical symmetry.

The following characteristic results will be explained as much as possible within given time:

(i) The proposed structure equations are consistent with the expected local thermodynamic relation.

(ii) The exact forms of the relativistic Poisson equation and steady-state heat conduction equation were derived.

(iii) They were solved exactly or non-perturbatively in the Newton constant for a system consisting of an ideal gas of particles with their number conserved, and thermal observables were exactly determined to exhibit the power law behavior.

(iv) This power law behavior is expected also inside the Sun, which is in tension with results in textbooks.

(v) The conventional argument using the Newtonian approximation in coronal region is invalid.

Session

Division G Stars and Stellar Physics

1011

Ensemble analysis of main-sequence stars in the mass transition zone: impact of stellar model physics on the nature of stellar cores

Dr Benard Nsamba

Kyambogo University. Max Planck Institute for Astrophysics

Abstract

Main-sequence stars in the **mass transition region** where their cores may become convective offer an **excellent opportunity of testing our understanding of stellar model physics**. The treatment and implementation of stellar model physics *(such as convective core overshoot and atomic diffusion including gravitational settling)* in models with small cores has significant impact on the nature and size of stellar cores of stars in this region. In this talk, I showcase our findings which entail a **detail analysis of an ensemble of binary stars in the mass transition region**, with known orbital and stellar parameters (such as dynamical mass and radius). These parameters offer additional constraints on our optimisation routines, **allowing to isolate the effects** of convective core overshoot and atomic diffusion on the nature of stellar cores.

Session

Division G Stars and Stellar Physics

1017

The radio evolution of supernova in M82 Galaxy

Dr. Naftali Kimani

Kenyatta University

Abstract

This work report on multi-frequency Very Large Array (VLA) and Very Long Baseline Interferometry (VLBI) radio observations for a monitoring campaign of supernova SN 2008iz in the nearby irregular galaxy M82. The light curve evolution analysis show flux density flares at 970 and 1400 days which are a factor of 2 and 4 higher than the expected flux respectively. The spectral index analysis for frequencies 1.4 to 43 GHz for the period 430 to 2167 days after the explosion show no signs of evolution and remains steep at approximately -1. The high resolution 4.8 and 8.4 GHz VLBI images show supernova expansion start with shell like structure that gets more and more asymmetric, then breaks up in the later epochs with bright structures dominating the southern part of the ring. This structural evolution differs significantly from SN 1993J, which remains circularly symmetric over 4000 days after the explosion. From the energy equipartition between magnetic field and particles, we estimate the minimum total energy in relativistic particles and the magnetic fields during the supernova expansion and found the magnetic field amplification factor for SN 2008iz to be in the range of 55 to 400.

Session

Division G Stars and Stellar Physics

1049

Using Machine Learning algorithms to extract globular clusters in *Gaia* DR3

Mr Nhlengani Junior Baloyi

University of South Africa

Abstract

Star clusters are the building blocks of galaxies, the continued study of which will likely reveal key insights into the chemical, and kinematic properties of galaxies, stellar formation and evolution, as well as assist in applying constraints on dark matter and initial mass function models.

The automated search, spatial and kinematic characterisation of globular clusters (GCs) is carried out through the use of machine learning methods which employ high-precision astrometric and photometric data from Gaia DR3.

Two clustering algorithms, DBSCAN and HDBSCAN, were applied to 24 cone-searched regions containing known GCs. The resulting astrometric parameters were compared to those reported in the literature. The best-performing algorithm was applied to an expanded blind search. The classification of true physical clusters and spurious over-densities was done via a convolutional neural network.

HDBSCAN out-performed DBSCAN by recording a better re-detection rate. For most clusters, the derived astrometric parameters were in agreement with those in literature. The expanded search field contained 18 known GCs. 15 of them were detected, as well as 2 known OC and 57 potential candidates. The masses of GCs M72 and NGC 6397 were derived via a projected mass estimator.

While the methods used here require refinement, their applicability to this science case seems valid. Due to the dearth of GC mass measurements using Gaia data, there is an opportunity for such work to be done, and may assist in the search of the elusive class of intermediate mass black holes.

Session

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1105

BSN Project: Analysis of Orbital Period and Light Curve of the V801 And Contact System Using Ground-Based and TESS Observations (Poster)

Ata Narimani[1], Ailar Alizadehsabegh[2], Atila Poro[3], Coliac Jean francois[4]

[1]BSN Project, Tabriz, Iran. [2]Tabriz University, Tabriz, Iran. [3]Astronomy Department of the Raderon AI Lab., BC., Burnaby, Canada. [4]Société astronomique de France, Paris, France

Abstract

We performed the first photometric study of the V801 And W Ursae Majoris (WUMa)-type system based on ground-based and TESS observations. We extracted times of minima from the observations and proposed a linear ephemeris using a Markov chain Monte Carlo (MCMC) approach. The PHOEBE Python code and the MCMC approach were used for the light curve analysis. This binary system needs a cold starspot for the light curve analysis. We also estimated the absolute parameters of the system using the Gaia DR3 parallax method. Therefore, the masses, radii, and luminosities have been determined. The orbital angular momentum of the V801 And system indicated that this system is in a region of contact binaries. The positions of the primary and secondary components on the Hertzsprung-Russell (HR) diagram are depicted. The observations and analysis of V801 And were done in the form of the BSN Project.

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Introducing the BSN project in the field of binary star systems

Atila Poro[1], Mark G. Blackford[2], Edwin Budding[3]

[1]The Raderon AI Laboratory, Astronomy Department, BC., Burnaby, Canada. [2]Variable Stars South (VSS), Congarinni Observatory, Congarinni, NSW, 2447, Australia. [3]Carter Observatory, New Zealand

Abstract

Binary Systems of South and North (BSN) project started in 2021. The founders of this project were Atila Poro, Mark G. Blackford and Edwin Budding. So far, this project has collaborated online with 19 observatories in the southern and northern hemispheres for observations and 23 researcher for data analysis. During the last three years, this project focused on contact binary systems, and from 2024, other types have been added to the scope of this project's activities. We held our first meeting in Paris in November 2023 in collaboration with the French Astronomical Society. Perhaps one of the most important current activities of this project is the binary systems analysis software called BSN software. In this presentation, we will present the most important activities along with the introduction of our colleagues (observatories and analysis team). The BSN Project's website: https://bsnp.info/

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Investigating the Astrosphere of λ Cephei: Effects of Relative Velocity and ISM Magnetic Field Strength

Mr Douglas Moyeni

North West university center for space science

Abstract

Astrospheres are bullet-shaped structures resulting from the relative motion through the interstellar medium and comprise of three distinct features: a termination shock, astropause, and a bow shock. This work investigates the astrosphere of λ Cephei. λ Cephei is a bright runaway star. Previous 3D magnetohydrodynamic (MHD) simulations by Baalmann et al. (2021) showed the position of the termination shock (TS), astropause (AP), and bow shock (BS) of λ Cephei. A comparison between the simulations by Baalmann et al. (2021) is done using the Pen et al. (2003) model which shows similar results. Due to the Pen et al. (2003) model excluding the radiative cooling process also being solved on a Cartesian grid, the bow shock width is somewhat different compared to the Baalmann et al. (2021) model. Additionally, the study shows how variations in relative velocity and interstellar medium (ISM) magnetic field strength affect λ Cephei's astrosphere. Decreasing relative velocity from 80 km/s to 40 km/s leads to an enlarged astrosphere, particularly evident in bow shock regions. Investigation of ISM magnetic field effects shows that increasing field strength alters the astrosphere's structure, resulting in an asymmetry under high ISM magnetic field conditions.

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Massive and/or Magnetic : That is the question.

Dr. Atsuko Nitta[1,2], Prof. Kepler Oliveira[3], Dr. Kathleen Labrie[1], Dr. Scot Kleinman[4], Dr. Andre-Nicolas Chene[5]

[1]Gemini Observatory/NOIRLab. [2]Subaru Telescope, NOAJ. [3]Departmento de Astronomia do Instituto de Física da UFRGS, Brazil. [4]Astronomanger LLC, Hilo HI U.S.A.. [5]US Extremely Large Telescope Program/NOIRLab

Abstract

We seek to understand the origin of magnetic fields in white dwarf stars. One telling clue in this mystery is that spectroscopic mass determinations for magnetic white dwarf stars are consistently higher (averaging ~0.93 Msun) than for non-magnetic white dwarf stars (approximately 0.6 Msun). Since the effects of Stark pressure broadening, an indicator of log(g), or mass, and Zeeman-splitting, from magnetic fields, can mimic each other at low signal to noise, we need to explore this clue in more detail. Are magnetic white dwarf stars really more massive, or do they just appear so? Through our Sloan Digital Sky Survey white dwarf catalog, we identified over a thousand magnetic white dwarf stars over a wide range of field strength, mass, and temperature. The survey data often have low S/N spectra, leaving some uncertainty in our identifications of magnetic fields and hampering our ability to simultaneously measure both the Zeeman-splitting and the Stark pressure broadening in these stars. We therefore used Gemini Observatory's twin 8 meter telescopes to obtain new S/N>70 spectra of a sample of 25 low-field, massive magnetic white dwarf stars to test our low S/N determinations of mass and magnetic field strength. Our results help us understand if these magnetic fields are likely developed through the white dwarf stars' surface convection zones or inherited from massive Ap/Bp progenitors.

Session

Division G Stars and Stellar Physics

1256

Evolutionary models for the most massive stars known in the Universe

Dr Zsolt Keszthelyi

National Astronomical Observatory of Japan

Abstract

30 Doradus in the Large Magellanic Clouds hosts the presently known most massive stars, namely R136a1, R136a2, and R136a3. Spectroscopic studies allow for inferring current masses of the order of 200 - 300 Msun for these stars. Interestingly, close companions are not found around the objects, indicating that they are presently evolving as single stars. We utilize a recent spectroscopic study to adopt mass-loss rates that are constrained for the massive and very massive stars in 30 Doradus. We scrutinize the evolutionary models on the main sequence and beyond and make predictions on the expected supernova and long-duration gamma-ray bursts from various progenitor channels. We compare our new models with the observations of R136a1, a2, and a3 and find compatible single-star solutions. However, an interesting dichotomy emerges as we cannot rule out scenarios in which the initial mass is in the range of 400 - 800 Msun. Within 1 Myr, such stars would lose hundreds of solar masses and appear with similar characteristics as stars with initially 200 - 400 Msun. We conclude that despite their currently very high masses, R136a1, a2, and a3 are unlikely to produce exotic types of supernovae by the end of their evolution. Instead, they are predicted to become extremely hot stars (Teff ~ 100 kK) with final masses of the order of 20 - 40 Msun prior to their explosion.

Session

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1270

Search and Study of Variables in Open Clusters and Beyond

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

The determination and understanding of observable properties of stars of different masses and evolutionary stages, their time variability, the physical mechanisms that govern them still remain very relevant. In particular, the search and study of variable stars in star clusters is important not only for studying the variability nature, but also for understanding clusters' physics, kinematics and evolution. We present current results of long-term photometric monitoring campaign of 15 open clusters obtained under the international Uzbek-Indian research project during 2021-2023. Earlier the time series were also obtained for 7 clusters in 2003. Analyzing our data with *TESS* and *Gaia* ones, we discovered a large number of new variable stars as well as checked the few known variables in these clusters and determined their belonging to the cluster (membership), kinematics, distance, age and other parameters of the host cluster. Besides, we also conducted 4-5 hours patrol observations for 14 individual selected magnetic cataclysmic variables (MCVs) in different regions of the sky. In particular, the variables 1RXS J174320.1-042953 and YY Sex have been proven to be magnetic polars. Continuous monitoring of number of selected eclipsing binary stars and of the 2021 outburst of recurrent Nova RS Oph (about 4 months after maximum) were carried out too. The obtained observational database and the current results of its analysis in combination with *TESS* and other data is discussed. Processing and in-depth analysis of this data using original pipelines and existed *BigData* analysis software for *Gaia* and *TESS* is currently ongoing together with Indian partners.

Session

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1350

Estimating the maximum mass of an anisotropic star admitting modified Chaplygin gas EOS and prediction of radius of lighter object in GW190814 event

Dr. Pradip Kumar Chattopadhyay

Cooch Behar Panchanan Barma University

Abstract

A new class of model is proposed for relativistic compact stars considering anisotropic fluid distribution. Interior matter is assumed to be satisfy modified Chaplygin gas EOS, $p=H\rho-\frac{K}{\rho^{n}}$, where H, K and n are constants with $0<n\leq1$, and employing Buchdahl-I metric for g_{rr} component within the framework of GR stellar model is obtained. As softer EOS is unable to support massive stellar bodies, a constraint on the EOS must hold. Hence proper choice of EOS may reveal viable information which are consistent with the observational evidences. Recent observations show that observed maximum mass of lighter object in GW 190814 event is approximately $2.59^{+0.08}_{-0.09}~M_{\odot}$ till date. To find the maximum mass in this model, we have solved the TOV equations and noted that the mass of $3.72~M_{\odot}$ is achieved when $H=1.0$, $K=10^{-7}$ and $n=1$. This $3.72~M_{\odot}$ can hardly be obtained in general relativity considering fast rotation effects too. This model is suitable to describe the mass of pulsars PSR J2215+5135 and PSR J0952-0607 and the mass of the lighter component in the GW 190814 event. We consider the pulsar PSR J0740+6620 to study the relevant properties in this approach. All the properties of physical parameters namely, energy density, pressures, and pressure anisotropy etc. are satisfied in this model. To check the physical viability, we have opted for energy conditions and stability analysis. The model satisfies all the necessary criteria to be a physically realistic one.

Session

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The oldest stars in the Large Magellanic Cloud

Thomas Nordlander

Research School of Astronomy and Astrophysics, Australian National University

Abstract

The most metal-poor stars alive today carry the chemical fingerprints of ancient stars and supernovae. I will present a resent spectroscopic survey of metal-poor stars in the Large Magellanic Cloud that has uncovered seven of the most metal-poor stars known. Two of the stars are strongly r-process enhanced, with abundances matching the universal r-process pattern. The other five stars are not r-process enhanced, and therefore likely formed before the enhancement event (binary neutron star merger?) discovered by Reggiani et al. 2021, therefore clearly making them both the most metal-poor and oldest stars in this galaxy.

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Spectral classification of HD 73574

Dr. Edward JuruA[1], Dr. Otto Trust[1], Mr Gabriel Modo[2]

[1]Mbarara University of Science and Technology. [2]Busitema University

Abstract

Interesting phenomena such as pulsation, rotation, and spot induced variability, have been observed in normal A/F and Am/Fm stars. These phenomena seem to be connected with the chemical anomalies in chemically peculiar (CP) stars. However, the connection between such phenomena and chemical peculiarity still needs to be investigated. Using high resolution spectroscopic observations from Hanle Echelle Spectrograph (HESP), we performed spectral analysis and determined the fundamental atmospheric parameters such as effective temperature, surface gravity, projected rotational velocity, radial velocity, microtubulent velocity, and chemical abundances of HD 73574. From the spectral analysis and the chemical abundance patterns, we classify HD 73574 as Am (kA7hA8mK2) star

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1374

PHOTOMETRIC STUDY OF VARIABLE STARS IN AN OPEN CLUSTER NGC 7209Dorothy Museo Mwanzia[1,2*], Geoffrey. O. Okeng'o [1], Soumen Mondal[2], Sneh Lata[31]Department of Physics, Faculty of Science and Technology, University of Nairobi, Kenya[2]S. N. Bose National Centre for Basic Science, Department of Science and Technology, Kolkata, India[3]Aryabhatta Research Institute of Observational Sciences, Manora Peak-Nainital, India

Ms. Dorothy Museo[1,2], Dr. Geoffrey Okeng'o[1], Prof. Soumen Mondal[2], Dr. Sneh Lata[3]

[1]University of Nairobi. [2]S.N Bose National Center for Basic Sciences, India. [3]Aryabhatta Research Institute of Observational Sciences, Manora Peak-Nainital, India

Abstract

Photometric variability study provides a unique opportunity to investigate the interplay of processes governing stellar objects. This study presents a comprehensive survey of long-term photometric variability in the intermediate-age open cluster NGC 7209. We conducted V-band photometric observations on over 180 nights, utilizing two telescopes. Our analysis of these observations led to the discovery of more than 280 variable stars within the cluster. 21 of these periodic variables were confirmed as cluster members, while the remaining were classified as field variables. Among the periodic variables, some exhibited short periods (P < 1 day) and others displayed longer periods (P > 1 day). These variable stars demonstrated periodicity spanning from 3.1 hours to 27 days, with brightness ranging from V = 0.053 to 0.764 mag.

Key words: open clusters, variable stars, photometric observations.

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1431

Searching for signs of recent member loss events in open clusters of the Cyg-Cep-Lac region

Dr Dmitrij Semionov[1], Dr Justas Zdanavičius[1], Dr. Richard Boyle[2,3], dr Marius Maskoliūnas[1], dr. Algirdas Kazlauskas[1], Saulius Raudeliūnas[1], dr. Vytautas Čepas[1], dr Robert Janusz[3]

[1]Vilnius University. [2]University of Arizona. [3]Vatican Observatory

Abstract

Context. The dynamical evolution of an isolated star cluster is driven by internal, continuous and relatively low-rate mechanisms, and external, episodic and possibly periodic disruption mechanisms. The latter causes some members to detach from the rest of the cluster forming halos and tidal tails. Reconstructing this process should help to determine the main characteristics of the cluster population, such as the initial mass function, as well as refining the Galactic gravitational potential model.

Aims. To construct a set of observable key cluster parameters and interaction signatures that can be compared with dynamical evolution models computed using N-body problem-solving programs.

Methods. Using Gaia DR3 astrometry in combination with available Gaia DR3 broadband photometry and complemented by our observations in the Vilnius medium-band photometric system, we search for previously unrecognized members outside the Hill sphere of known star clusters in Perseus and the Local Arm region.

Results. We present a first sample of the star clusters we have studied, expanding their lists of likely members. Stellar classification using Vilnius photometry data allows us to update estimates of clusters key parameters, including age and extinction, while Gaia astrometry reveals signatures of their dynamical history, e.g. the most recent mass loss event.

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1438

Modelling concurrent processes of isolated open cluster disruption: relaxation vs. tidal forces

dr Justas Zdanavičius, Dr Dmitrij Semionov, Dr. Marius Maskoliūnas, Saulius Raudeliunas, Dr Vytautas Čepas

Vilnius University

Abstract

Context. Episodic mass losses in open clusters, due to passage through the Galactic plane or interactions with giant molecular cloud complexes, could significantly accelerate the dissolution of the cluster in the overall disk population, affecting the observed cluster mass function and parameters of the disk's evolution.

Aims. To obtain key parameters such as central concentration (density profile variation), Initial Mass Function and total bound mass by modelling spatial (projected) variation of the cluster mass distribution in the presence of a variable external gravitational potential.

Methods. Starting from a standard (Plummer profile) observed mass distribution, stellar clusters models are evolved up to an age of 1 Gyr using Nbody6 package with varying and constant external potential. Gravitational interaction simulation sets are iteratively adjusted to reproduce the observed spatial and kinematic distribution properties of intermediate-age (10 to 500 Myr) open clusters characteristic of Galactic inter-arm regions.

Results. We present an initial set of models replicating the different evolutionary paths of isolated medium- and low-mass open clusters.

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1466

Radiation Vs convection: revisiting the core behaviours of main-sequence stars in the mass transition zone

Ms MARION ASASIRA[1], Dr BENARD NSAMBA[1,2]

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Abstract

The evolution and interior structure of main-sequence stars significantly depends on their core properties. Main-sequence models in the mass range [1.1 -1.2] solar masses and constructed at solar metallicity may develop a convective core during their evolution. We revisit this mass transition zone taking into account the most relevant model physics which affects stellar core properties and chemical profiles, i.e. core overshoot, atomic diffusion including gravitational settling and metal abundance. Our preliminary findings demonstrate that core overshoot and metallicity has the greatest impact in sustaining small convective cores during the main-sequence evolution of stars in the mass transition zone.

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A grid-based machine learning tool for inferring exoplanet host-star parameters.

Mr. Juma Kamulali[1], Dr. Benard Nsamba[1,2,3]

[1]Kyambogo University. [2]Max Planck Institute for Astrophysics - Germany. [3]Institute of Astrophysics and Space Sciences - Portugal

Abstract

Uniform inference of exoplanet-host star parameters (such as mass, radius, and age) taking into account the relevant stellar physics is essential in the robust characterisation of planetary systems. This is attributed to the strong synergy between planets and their host-stars. In this poster, we present a machine learning tool which precisely and accurately infers exoplanet host-star parameters, based on available set of spectroscopic constraints. The tool rapidly trains on a set of theoretical model observables, delivering instant estimates of stellar parameters. The results from our machine learning tool are consistent with stellar properties of binary stars, thus can be adopted in uniformly deriving stellar properties of a catalogue of exoplanet-host stars.

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Dwarf Cepheids, Classical Cepheids and the PL relation

Dr Clifton D Laney

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Abstract

Various authors in the past have looked at the possibility that dwarf Cepheids (HADS) can be regarded as small analogues of classical Cepheids (Eggen 1979, Fernie 1992, Laney et al. 2003). It is apparent, however, that the period-luminosity relation for these stars is strongly metallicity dependent (McNamara 1997). I reanalyze the available data to obtain a correlation between metallicity and Stroemgren photometry specifically for dwarf Cepheids, and find that the relation appears to differ from that which applies to non-pulsating stars of similar temperature and luminosity. I then derive a new period-luminosity-metallicity relation for HADS, and compare the period-luminosity relation for solar metallicity to the PL relation for classical Cepheids, both in the visual and in the K-band, using Gaia parallaxes to derive distances. These are corrected for bias as needed (Lutz & Kelker 1973, Benedict et al. 2011, Bailer-Jones et al. 2021).

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1525

Re-visiting the masses of retired A type stars

Mr Selassie Karobwa, Dr. Cosmos Dumba

Mbarara University of Science and Technology

Abstract

The detection of planets around bright stars (A, F-type stars) along the main sequence is challenging. This is due to the larger stellar radius and the increased line broadening induced by the faster rotation of these stars. However, the brightness of these stars reduce as they evolve to their sub-giant and low luminosity red-giant phases increasing the detection probability. The characterisation of planets around stars requires robust mass estimates of the hosts. However, the mass estimates of the retired A-type stars using spectroscopic constraints are reported to be overestimated. In this poster, we present a detailed analysis of an ensemble of retired A-type stars while taking into account the available asteroseismic constraints.

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1526

Submillimeter observations of the white dwarf pulsar AR Sco

Dr. Paul Barrett[1], Dr. Mark Gurwell[2]

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Abstract

AR Sco contains a rapidly rotating magnetic white (WD, P_{spin} = 117.0564 s) accreting from a cool, red dwarf companion in a 3.56 hour orbit. It is a strong radio source (~tens mJy) with a positive spectral index between 1—1000 GHz that is indicative of synchrotron emission. We present the first submillimeter observations of AR Sco using the SubMillimeter Array (SMA). The average flux densities at 210 and 354 GHz are 114 and 86 mJy/bm, respectively. The lower than expected flux density at 354 GHz suggests a break in the synchrotron emission at ≈200 GHz. A periodogram analysis of the 210 GHz observations shows a modulation with an amplitude of ≈6% at a period of 58.5595 s or about twice the spin frequency of the WD. This implies that the synchrotron emission arises from interactions of the accreted matter with the WD's magnetic dipole and not from the photosphere of the donor star, which would be modulated at twice the beat frequency. We model the synchrotron emission using an assemble of fast and slow-cooling models and find that observations constrain the WD to have a weak magnetic moment (~10^{33} G cm^3), and not a strong magnetic moment (~10^{35} G cm^3) based on the spin-down power of the WD. A weak magnetic moment avoids the problem of how the WD spun-up to such a rapid rotation rate and then acquired a very strong magnetic field. We conclude that AR Sco is a *magnetic propeller* like AE Aqr.

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Grid-based tool for inferring stellar core properties

Mr Ronald Ssembatya[1], Dr Benard Nsamba[1,2]

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Abstract

Abstract: The proper description of stellar interior physics (such as core overshoot, atomic diffusion) necessities for the revision of the mass transition region where main sequence stars could develop convective cores. We developed a grid-based tool capable of ascertaining the nature (i.e convective or radiative) and properties (chemical abundances, masses, radii) of stellar cores. Our tool relies on comparing radiative and adiabatic temperature gradients in allocating the convective core boundaries. We also test the efficiency of our grid-based tool when the stellar interior physics capable of varying convective boundaries is included in stellar models. We present a revised mass transition region highlighting how each of the essential model physics impacts this region.

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Abundances of Bioessential Elements on Solar-type Stars Using High Resolution Spectra

MSc Ellen Costa-Almeida[1], Dr Luan Ghezzi[2], Dr Katia Cunha[3]

[1]National Observatory. [2]Valongo Observatory. [3]Steward Observatory

Abstract

The fast increase in the number of exoplanets detected, associated with an increasingly detailed characterization of exoplanets and their host stars, have expanded the frontiers of Astrobiology and allowed even more comprehensive studies on the formation and habitability of planets and the distribution of life in the Universe. When we think about life as we know it, we are naturally driven to think of the most frequent elements in the composition of organisms: the CHNOPS (carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur). Though they are bioessential elements for life on Earth, they are not widely explored in abundance studies in general due to challenges in their analyses. Thus, for a better understanding of the structures of planets, habitability and life, it is fundamental to have more homogeneous and precise abundances for these elements for a large number of stars. Therefore, in this work, we derived atmospheric parameters (Teff, [Fe/H] and logg) and abundances O using spectral synthesis and C and S using equivalent widths measured on high-quality spectra and the software MOOG, focusing on solar-type stars with detected exoplanets, in order to investigate the possible relation between these elements and the formation and habitability of planets, to contribute for a better understanding of the necessary conditions for life to emerge. We present homogeneous abundances of Fe, C, O and S for more than 500 solar-type stars and their relationships to the presence of planets.

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1656

The Absolute Age of Globular Clusters

Professor Brian Chaboyer[1], Jiaqi Martin Ying[1], Emily Boudreaux[1], Catherine Slaughter[1], Wenxin Du[2], Michael Boylan-Kolchin[3], Daniel Weisz[4]

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Abstract

A large set of theoretical isochrones were generated through Monte Carlo simulation using the Dartmouth Stellar Evolution Program. For each isochrone, a range of input physics used in the stellar evolution models, including opacities, nuclear reaction rates, diffusion coefficients, atmospheric boundary conditions, helium abundance, and treatment of convection were varied. Variations in the overall metallicity and α enhancement were also taken into account. These isochrones are used to to measure the absolute age of the galactic globular clusters. We generate simulated Hess diagrams around the main-sequence turn-off region from each set of isochrones and use a Voronoi binning method to fit the diagrams to HST ACS data taking into account uncertainties in the distance and reddening to each cluster. The age of the metal-poor globular cluster M92 ([Fe/H] = -2.2) is 13.8 ± 0.7 Gyr. A similar analysis for the somewhat more metal-rich cluster, NGC 3201 ([Fe/H] = -1.5) finds an age of 11.8 ± 0.9 Gyr. The age of NGC 3201 was also found using via a 2-D KS test in the Hess diagram, leading to a very similar age of 11.6 ± 0.8 Gyr. NGC 3201 hosts 3 eclipsing binaries and fitting the radius, luminosity and masses of these eclipsing binaries with the same set of Monte Carlo generated isochrones yields an age of 12.0 ± 0.6 Gyr. The good agreement of these independent age estimates using different observational datasets and fitting methods demonstrates the reliability of our ages. 11.76 ± 0.8911.76 ± 0.89

Session

Division G Stars and Stellar Physics

1657

Compact Stars with Non-Uniform Relativistic Polytrope

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Abstract

This paper presents new relativistic composite polytropic models for compact stars by solving Einstein field equations simultaneously with the polytropic equation of state to simulate the spherically symmetric, static matter distribution. Using a non-uniform polytropic index, we get the Tolman-Oppenheimer-Volkoff equation for the relativistic composite polytrope (CTOV). To analyze the star's structure, we numerically solve the CTOV equation and compute the Emden and mass functions for various relativistic parameters and polytropic indices appropriate for neutron stars. The calculation results show that, as the relativistic parameter approaches zero, we recover the well-known Lane-Emden equation from the Newtonian theory of polytropic stars; thus, testing the computational code by comparing composite Newtonian models to those in the literature yields good agreement. We compute composite relativistic models for the neutron star candidates Cen X-3, SAXJ1808.4-3658, and PSR J1614-22304. We shall compare the findings with various existing models in the literature. Based on the accepted models for PSR J1614-22304 and Cen X-3, the star's core radius is predicted to be between 50-60% percent of its total radius, while we found that the radius of the core of star SAXJ1808.4-3658 is around 30% of the total radius. Our findings show that the neutron's structure may be approximated by a composite relativistic polytrope, resulting in masses and radii that are quite consistent with observation.

Session

Division G Stars and Stellar Physics

1680

Characterization of the Young Stellar Clusters Collinder 205 and Ruprecht 709

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Abstract

Star clusters are characterized as a group of stars formed from the same cloud of gas and dust within the same period of time. For this reason, the stars in a cluster share common characteristics, making them essential objects for the study of stellar evolution. The evolution of clusters can be better understood based on the study of dynamic conditions of the gas associated with the parental molecular cloud, the clustering properties and by the evaluation of the effects due to the presence of ionization sources. In order to compare the characteristics of the cluster members with the conditions of the molecular gas in the cloud where the young stars are associated, our group conducted near-infrared imaging towards the young clusters Collinder 205 and Ruprecht 79, using the SOAR telescope and the Spartan camera. We aim to extract the sources detected in such images and correlate them with complementary data from public catalogs (optical and infrared), following the example of previous studies perfomed by our group in the CMa region and extended to clusters in different regions of the Galaxy. We conducted PSF photometry on the infrared images of the clusters acquired with the H2, Cont.3, and Brγ filters, and extracted their photometric data using the StarFinder software. In addition to the analysis of Spartan images and photometric extraction to create a catalog of detected sources, we are able to identify confirmed members belonging to the cluster through parallax and proper motion analysis, using data from the Gaia DR3 Catalog.

Session

Division G Stars and Stellar Physics

1714

The Role of External Pressure in Low Mass Star-Forming Cloud

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Abstract

This thesis explores the critical mass required for low-mass star formation within a self-gravitating cloud influenced by external pressure. The study delves into the molecular cloud's critical mass formation under the impact of external pressure, utilizing theoretical modeling to incorporate fundamental equations and assumptions. The research also investigates the external pressure's role in massive star formation processes, analyzing the star formation rate and efficiency of low-mass star-forming clouds subjected to external pressure. The findings indicate that external pressure can either induce cloud collapse or lead to cloud dispersion. The study concludes that external pressure can have a dual effect on low-mass star-forming clouds. When external pressure is present, clouds with a relatively minimal critical mass can collapse and form stars, whereas clouds with out external pressure require a larger critical mass for collapse. Ultimately, the research highlights the significant impact of external pressure on star-forming molecular clouds.

Session

Division G Stars and Stellar Physics

1750

Investigating Maia-like Physical Features in TESS Target TIC 202431888

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[1]Botswana International University of Science and Technology. [2]Institute of Astronomy with National Astronomical Observatory - Rozhen

Abstract

We present a comprehensive study of the Maia-type TESS target, TIC 202431888, to investigate its physical features. The study focuses on the Maia Phenomenon among B-type stars, which is characterized by multiple high frequencies between the red edge of the β Cephei and the blue edge of the δ Scuti instability strips. It is possible that the high frequencies observed in late B-type stars still lack an explanation based on current knowledge. In addition the current models do not take into account pulsations in either of these two categories, which even add complexity to pulsation models in the upper main sequence. Recent space missions such as Kepler/K2 and TESS play a pivotal role in accurately determining stellar parameters and solving the classification puzzle of Maia Phenomenon among B-type stars. The frequency content of the star was extracted using TESS photometry, yielding several genuine, harmonics, and combination frequencies. The highest peaks occurred at f_1=19.32 d^{-1} and f_2=22.10 d^{-1}. The atmospheric parameters, projected rotational velocity *v sin i,* and chemical abundance of selected elements of TIC 202431888 were determined using ground-based spectroscopic observations obtained with the 2-m RCC telescope at Rozhen Station of the Bulgarian National Astronomical Observatory. The findings indicate that TIC 202431888 complies with Maia-like physical features, except for having low Fe and Mg values compared to solar values.

Session

Division G Stars and Stellar Physics

1758

Observational properties of Short Period Low Mass EBs

Ms. Redait Basznew, Dr. Seblue Humne

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Abstract

In this work, we have determined the parameters of an eclipsing binary system using the observed parameters from the catalog of the original Kepler data. Also, we used this catalog to determine the evolution of stars in eclipsing binaries and to determine the orbital and physical characteristics of these within the stellar mass range of 0.302 M⊙ to 1.512 M⊙. The parameters that we have performed include the temperature, the primary and secondary luminosities, the total mass, the orbital period, the orbital angular momentum, and the Roche lobe radius of the donor star. We have also examined the internal stellar structure of stars in these systems between the theoretical models of the zero-age main sequence phase and the terminal-age main sequence phase, as well as beyond. The binary stellar evolution models and the observational data from the catalog of the original Kepler field have been used in these computations. We seek to improve our knowledge of stellar systems and the physical mechanisms influencing their behavior by examining and parameterizing the characteristics and evolution of eclipsing binaries. The study's findings will advance the science of stellar astrophysics and offer important new information on the genesis and development of the Eclipsing binary star system.

Session

Division G Stars and Stellar Physics

1762

Modeling the Formation of Thorne-Zytkow Objects: Hydrodynamical Simulations of Neutron Star-Main Sequence Mergers

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Abstract

Thorne-Zytkow Objects (TZOs) are hypothetical hybrid stars with a neutron star at the core of a large, diffuse envelope. TZOs may be formed when a newly formed neutron star is kicked by its supernova into its main-sequence companion. Using a moving-mesh hydrodynamics solver integrated into the parallel-code Charm N-body GrAvity solver (ChaNGa), we conduct a two-parameter study into these ”impact scenarios” focusing on stellar mass and periapsis. Our hydrodynamical simulations show that at sufficiently small periastrons, there is a successful merger of the massive companion and the neutron star, resulting in a dynamically stable TZO**.** The relevance of this work significantly progresses our limited understanding of the physics of the formation for TZOs, as well as setting important constraints on their relative abundance which aids in the observational search for TZO candidates.

Session

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1770

New Observational Insights into the Astrophysics of Extremely Metal-Poor O Stars

Grace Telford

Princeton University. Carnegie Observatories

Abstract

Low-metallicity massive stars produce energetic radiation and supernova explosions that shape the evolution of low-mass galaxies, both locally and in the early universe. Theory predicts that these stars drive weaker winds than their higher-metallicity counterparts, with important implications for their evolutionary pathways and endpoints. Yet, open questions remain about the physical driver of metallicity-dependent differences in the nature of the explosions that end massive stars' lives. A fundamental limitation is that very few observations of individual massive stars below 20% solar metallicity (Z_sun) exist to validate stellar models in the very low-metallicity regime. I will present Hubble Space Telescope FUV spectra of three O stars in nearby dwarf galaxies spanning 3-14% Z_sun, which reveal that the two most metal-poor stars are both fast rotators driving weak stellar winds. Combined with with Keck/KCWI optical spectra, these observations provide novel constraints on theoretical stellar mass-loss prescriptions below 20% Z_sun, a crucial ingredient in evolution models for metal-poor stars. I will then describe the Treasury of Extremely Metal-Poor O Stars (TEMPOS), a new Large Treasury HST program that is assembling a comprehensive FUV and optical spectral library across O-star parameter space at ~5-10% Z_sun. These observations will provide the community with a much-needed empirical benchmark for the stellar models necessary to understand stellar evolution and feedback in metal-poor galaxies.

Session

Division G Stars and Stellar Physics

1773

Investigating triggered star formation scenarios in Galactic star-forming regions

Mrs Annarien Headley, Professor James Chibueze

University of South Africa

Abstract

Highly energetic processes like the expansion of a HII region, explosion of a dying massive star can trigger the formation of a new generation of stars in its vicinity. Granted, the formation of every star in the Milky Way cannot be explained by adopting the triggered scenario. Some stars form spontaneously without the influence of an external force. A key probe of triggered star formation in a region is the distribution of the class 0, I, II and II young stellar objects (YSOs) around the region. A shell-like, “onion-layer” distribution of the different classes of YSOs are typical used as indicators of triggered star formation. In this paper, we revisited the case of the Monkey Head nebula using updated catalog of YSOs. We also investigated triggered star formation around the G06.14-0.63, and 2 others star-forming regions. We found clear evidence of triggered star formation in G06.14-0.63 and the presence of a high-energy gamma ray source at the center of the shell.

Session

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1816

The Physical Characteristics Based on The Photometric Study of The Close Binary Systems: KIC 2715417 and KIC 6050116

Mr. Mahmoud NegmEldin

Astronomy Department, Faculty of Science , Cairo University, Egypt

Abstract

We present and analyze the light curve data to determine the physical parameters of the two close binary systems: KIC 2715417 and KIC 6050116. The data obtained from the Kepler space telescope in wide band approaching to Johnson V filter. In order to study the variation due to the eclipsing without any effect of stellar activity, we selected the observed data for a short interval within about 10 days. We used the Wilson Devinney code inside the software PHOEBE (v 0.031a) packages to make the photometric analysis of our systems. The photometric mass ratio has been determined using the q-search method for each system owing to the unavailability of the spectroscopic data. Finally, we found the spectral type of each component of our binary systems from their effective temperatures according to the calibration of Morgan-Keenan (MK).

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1820

Investigating Star Formation Rates in Spiral Galaxies: Reducing Uncertainties in Key Indicators

Ms. Boitumelo Gaolape, Dr. Rhodri Evans

Botswana International University of Science and Technology

Abstract

Understanding the star formation process in galaxies is fundamental to unravelling the mysteries of galaxy evolution. Spiral galaxies, with their characteristic arms of stars and gas, offer an ideal setting for studying star formation due to their diverse morphologies and ongoing stellar birth. This study focuses on investigating the star formation rates (SFRs) of a sample of several hundred spiral galaxies, aiming to address major uncertainties in commonly used SFR indicators.

In this research, we aim to investigate the star formation rates (SFRs) of a sample of several hundred spiral galaxies, focusing on reducing uncertainties in three commonly used SFR indicators: ultraviolet (UV) emission, total far infrared (FIR) emission, and 1.4GHz non-thermal radio continuum (NTRC). We will utilize the CIGALE SED fitting model to analyze the complete FIR spectral energy distribution and compare the observed results and our models to Monte Carlo radiative transfer models of dust absorption, scattering, and emission.

This research work provides much better constraints on the fraction of the total FIR emission of galaxies due to star formation. Additionally, we will use this improved modelling of the FIR to gain a more precise understanding of how much UV radiation from hot young stars is lost to dust heating.

Session

Division G Stars and Stellar Physics

1823

Multi-wavelength Monitoring of Two Gamma-ray Binary Stars: 1FGLJ1018.6-5856 and LMC P3

Mr Masekamisha Andries Mathiba

University of Cape Town

Abstract

Gamma-ray binaries are a subclass of high-mass binary systems consisting of a compact object (neutron star/black hole) and an O- or B-type stellar companion. They emit across the electromagnetic spectrum, with a characteristic energy spectrum that peaks above 1 MeV. To date, there are only nine objects in this class.

1FGLJ1018.6-5856 and LMC P3 were discovered in 2011 and 2016, respectively. We are using observational radio data from *MeerKAT* and archival X-ray and Gamma-ray from *Swift* and *Fermi* space telescopes to study these two sources. The main objective of the study is to:
i) Conduct a radio analysis for these sources,
ii) Infer the localization of the multi-wavelength emission and whether it is produced by the same set of particles.

The results of the study will shed light on the dominant emission mechanism in the sources, which will provide evidence about the type of compact object in these binaries (i.e., whether we have a neutron star or black hole).

Session

Division G Stars and Stellar Physics

1844

Monitoring the large-scale magnetic field for active M dwarfs with SPIRou, ESPaDOnS and Narval: the case of AD Leo, CN Leo, DS Leo and EV Lac

Dr. Stefano Bellotti

Leiden Observatory (Leiden, NL). Institute de Recherche en Astrophysique et Planetologie (Toulouse, FR)

Abstract

One clear manifestation of dynamo action on the Sun is the 22-yr magnetic cycle which sees polarity reversals of the large-scale magnetic field. Despite we have some evidence of cycles on other sun-like stars, low-mass, cool M dwarfs are still an unexplored territory. With a long-term spectropolarimetric monitoring of active M dwarfs, we can trace the long-term evolution of their large-scale magnetic field and hunt for magnetic cycles. These observational constraints provide valuable information for dynamo theories and a better understanding of the processes that generate magnetic fields in the interior of stars. For instance, these observations feed back on the dichotomy of magnetic field topologies for fully-convective stars, potentially shedding more light on whether this phenomenon is due to dynamo bistability or the existence of magnetic cycles.
We analysed optical (ESPaDOnS and Narval) and near-infrared (SPIRou) spectropolarimetric data of four well-studied M dwarfs: AD Leo, CN Leo, DS Leo, and EV Lac. We used circularly polarised spectra collected over a baseline of 15 years and reconstructed the large-scale magnetic topology with tomographic inversion (Zeeman-Doppler Imaging). We found different long-term trends, that exhibit similarities or complementarities with the solar cycle, in the form of evolving poloidal-to-toroidal energy fraction, oscillating axisymmetry, and sinusoidal variations of the field strength. This potentially indicates a underlying variety of dynamo processes in action.

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1871

Time-series NIR spectroscopy of classical Cepheids

Scott Call[1], Eric Hintz[1], Steve Ardern[2], Victoria Scowcroft[2], Tim Morrell[1]

[1]Brigham Young University. [2]University of Bath

Abstract

Over 100 years ago, Henrietta Leavitt discovered that Cepheid variable stars followed a period-luminosity relation, and to this day, they play a crucial role in the cosmic distance ladder. At near-infrared (NIR) wavelengths, the Cepheid period-luminosity relation is tighter, and interstellar extinction has less impact. NIR data can still be obtained using ground-based observatories, making the NIR regime popular for the study of Cepheids.

In this study, we present time-series spectra for several classical Cepheid variable stars. The data were obtained using the Astrophysical Research Consortium (ARC) 3.5-m telescope and spectrograph, *TripleSpec*, located in New Mexico, USA. The targets range in pulsation period from less than 6 to more than 25 days. Our analyses focus on the molecular features CO (2.3-micron) and CN (1.1-micron) for the sample, specifically examining the dissociation and recombination of these simple molecules throughout the pulsation cycle. Additionally, we conducted static atmosphere fitting and determined NIR colors for the phased observations.

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1891

Towards the Understanding of the Largest White Dwarf Evolution Mystery, the DB Gap

Dr. Atsuko Nitta[1,2], Dr. Judi Provencal[3], Kaylee Grace[3], Zachery Savery[3], Dr. Scot Kleinman[4]

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Abstract

We present our analysis of Hubble Space Telescope (HST) spectra of two unique DB white dwarf stars to enhance our understanding of general white dwarf (WD) composition and evolution.

WDs, the most common end products of stellar evolution, offer crucial insights into the Milky Way's history via their distribution, structure, and composition. Post internal nuclear fusion, the dominant process in WD evolution is secular cooling. One of the variables that determine the cooling rate is their atmospheric composition. The majority of WDs have either essentially pure hydrogen (DA) or helium (DB) outer atmospheres and the ratio of DA to non-DA WDs varies with temperature, i.e. cooling time.

One outstanding mystery in WD research is the origin of the DB gap, a temperature range in which DBs are notably absent (~45,000 to 30,000K). WD structure and evolution models are heavily influenced by having to explain this gap. Although the Sloan Digital Sky Survey identified a few DBs within this gap, their properties remain poorly understood, and the gap remains at least a dearth if not an outright *gap*.

To explore the DB gap further, we obtained UV spectra of two DBs in the gap using the HST. We present our preliminary analysis of these spectra and what they provide on the physical properties and chemical abundances of these enigmatic objects. Ultimately, we hope to refine our understanding of WD formation and evolution, enhancing our grasp of the WD population and stellar end-stage processes through this and similar analyses.

Session

Division G Stars and Stellar Physics

1902

Statistical analysis of Algol-type eclipsing binaries with stable mass transfer

Dr Seblu Negu

Space Science and Geospatial Institute

Abstract

In this study, we have investigated the stellar parameters of Algol-type eclipsing binaries in the range of primary and secondary masses between 0.2 and 8 M⊙, which were obtained from the catalog of approximate photometric and absolute elements of eclipsing variable stars. We examined those parameters for classical Algols and hot semidetached binaries. We have made a statistical analysis of Algol-type eclipsing binaries' stellar parameters and constructed the mass–luminosity and mass–radius relations for the primary and secondary components of classical Algols and hot semidetached binaries.

Session

Division G Stars and Stellar Physics

1924

Classification techniques for high-mass interacting binary systems. Use of cross validation.

Mr. Rafael Girola Schneider

Universidad Nacional de Tres de Febrero. Planetario Galiuleo Galilei

Abstract

In high-mass interacting binary systems, one can find, for example, binary systems with a compact object (such as a black hole or a neutron star) and a giant star, where both orbit around each other in a very short period. generating intense radiation emissions, which include radio waves, X-rays, and gamma rays, in addition to producing relativistic jets. In this field, there is already an important classification. However, we can ask ourselves from the knowledge of the physical laws and interaction scenarios between the components, which other possible candidates could exist without having been resolved yet, using cross-validation. This technique designed to solve machine learning problems, through regression and prediction models, can be used to evaluate the results of a statistical analysis when the data set has been segmented into a training sample and a test sample. The classification problem involves modeling these systems using training data and then evaluating the model on a test sample. The comparison between the model results and real observations allows us to validate its performance in terms of error, through the hold-out process. The complement of the taxonomy of binary star systems must be self-consistent and logical in relation to what is already known. Therefore, there could be room to discover new classifications even in those cases that have not yet been identified. Continued exploration and detailed study of these systems will allow us to better understand their diversity and evolution.

Session

Division G Stars and Stellar Physics

1966

X-Raying a Be star disk — fundamental parameters of the eclipsing binary V 658 Carinae

Tajan de Amorim[1,2], Alex Carciofi[1], Jonathan Labadie-Bartz[3], Saul Rappaport[4], Ariane Silva[1], Felipe Navarete[5], Pamela Querido[1], COPA collaboration[6]

[1]IAG - University of São Paulo, Brazil. [2]University of Toledo, USA. [3]LESIA, Paris Observatory, Sorbonne University, France. [4]Massachusetts Institute of Technology, USA. [5]SOAR Telescope/NSF's NOIRLab, Chile. [6]Brazilian Astronomic Society, Brazil

Abstract

With its two stellar eclipses and two disk attenuations per binary orbit, V 658 Car stands out as a unique system. Using a new ray-tracing code, we have determined its status as the second known late-type Be + stripped star, occupying a unique niche in the rapidly rotating binary population. Such systems are most likely the sub-product of binary interactions, where the current stripped star has donated its outer layers to a previous normal B star companion. This process spins up the B star into a state of near-critical rotation, triggering mass loss and the subsequent build up of a gaseous circumstellar 'decretion' disks, thus turning it into a classical Be star. As radiation from the stripped star passes through the disk of the primary, the local disk properties are encoded in the observed spectrum. This offers the unique possibility of mapping the disk conditions, as well as the physical characteristics of the stars, with exquisite details. Our study allowed us to identify a series of interesting phenomena that can be attributed to binary interactions, e.g., spiral density waves in the primary disk and mass transfer into the secondary, with the clear detection of circumstellar matter in a disk-like configuration surrounding the stripped star. A full analysis promises to make this a benchmark system, with properties determined with far higher precision than what is typically possible.

Session

Division G Stars and Stellar Physics

2003

Unveiling Starspot Penumbra from Exoplanet Transit Photometry

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Abstract

While current methodologies map large-scale starspots on rapidly rotating active stars, investigation of active regions structure on slowly rotating, solar-like stars is challenging. For this, we introduce a novel analysis technique aimed at extracting the umbral and penumbral structure of starspots from exoplanet transit light curves. Our goal is to determine the constraints associated with penumbra detectability. Our method uses simulated transits of a solar active region to determine the resulting flux ratios of occulted umbra and penumbra. The detection of starspot penumbrae depends on their flux variations in transit light curves surpassing the photometric noise. This detection threshold is related to the apparent stellar magnitude, as noise predominates for all but the brightest stars. Thus, a large transit depth is crucial for detection, albeit the penumbra potentially becoming undetectable due to low contrast relative to the photosphere in the case of the coolest stars. For systems featuring a 2 or 3 R planet transiting an M or small K dwarf star, low-contrast (high-intensity) penumbrae may be discernible for stars with Mv ≤ 13. This shows the feasibility of detecting stellar umbrae and penumbrae with flux ratios similar to solar values (1.7 - 4.4). Consequently, we demonstrate that future space-based transit photometry may provide characterization

Session

Division G Stars and Stellar Physics

2039

Stellar Archeology of the Be + sdO Binaries

Dr. Geraldine Peters

University of Southern California

Abstract

Currently there is a consensus that at least 50% of the OB stars evolve as close binary systems. The recent discovery that many Be stars have an sdO companion reinforces the widely held perception that the classical Be stars acquired their fast rotation and resultant disk through mass transfer. The Be star has been spun up from the mass and angular momentum gained and the sdO object is the core of what remains of the mass loser. The details through which the Be star acquires and distributes its acquired mass and angular momentum are currently mostly speculative. We have embarked on an effort to identify proxies of the Be + sdO binaries in their earlier lives to gain an insight on their progenitors and information on the mass transfer process itself such as if it is conservative or if there are important epochs of non-conservative mass transfer. The data for this study are primarily archival high-resolution FUV spectra from the *IUE* and *FUSE* spacecraft. The procedure is to track the evolution of the mass gainer in the r-q Diagram (RQD). Massive Algol-type systems appear to be younger versions of the Be + sdO systems. Early results reveal that systemic mass loss is largest when the system is passing through Region 2 of the RQD, whereas mass and angular momentum transfer are mostly conservative in the upper part of Region 1. Details of the evolution of the mass flow structures (gas stream, disk, and mass outflow regions) are given in this presentation.

Session

Division G Stars and Stellar Physics

2077

A simple method using the derivatives of light curves for estimating the mass ratios of overcontact eclipsing binaries.

Shinjirou Kouzuma

Chukyo University

Abstract

The mass ratio is a key parameter in overcontact binary systems. A reliable mass ratio is derived from a radial velocity curve through spectroscopic observation. However, this requires relatively advanced instruments and repeated observations. Photometric mass ratios are estimated using light curves, usually obtained through light curve modeling. This method is more convenient compared to deriving spectroscopic mass ratios. A major downside of this method is that the derivation of photometric mass ratios requires an appropriate parameter setting and light curve modeling with an iterative method.

We propose a new method for estimating photometric mass ratios. Our approach primarily involves measuring the time interval between two local extrema found in the third derivative of a light curve, with no need of an iterative procedure. We validated the effectiveness of our method by comparing the mass ratios estimated by our method with their spectroscopic values. The comparison showed that our estimated mass ratios for ∼67 % of the samples agreed with their spectroscopic mass ratios within the estimated uncertainties, and the errors for 95% of them are within ±0.1. In the presentation, we also discuss the background of why the proposed method works and the influence of third light on our estimation.

Session

Division G Stars and Stellar Physics

2091

RR Lyrae stars as distance calibrator and as tracers of Galaxy kinematics and structure.

Dr Tesfaye Muhie

Washera Geospace and Radar Science Research Laboratory, Physics Department, Science Collage, Bahir Dar University, Bahir Dar, Ethiopia. Institute of Geophysics, Space Science and Astronomy, (IGSA), Addis Ababa University, Ethiopia

Abstract

By studying the multicomponent kinematic model of RR Lyrae stars(RRLs) in the Milky Way using the statistical parallax method, RRLs distance calibration can be improved and insight into the Galaxy structure and evolution can be gained. Though many authors have used the method to set the zero point of the period-luminosity-metallicity-(PLZ) relation of RRLs in differentt bands and to estimate the velocity distribution of the Galactic field RR Lyrae population since its first use; the uncertainties of the estimated parameters are still significant due to the reliant of the method on the sample size and the accuracy of the input observational data. Thus, this research is dedicated on improv the results of the method by increasing the sample size with accurate photometric and spectroscopic data. In the study, I obtained a number of new important results including original BVI photometric CCD observations of 197 RR Lyraes performed with the 1.0-m SAAO telescope and original low-resolution spectroscopic observations of 488 RR Lyraes performed with the 11-m Southern African Large Telescope (SALT). The photometric and spectroscopic results were combined with previously published data including the data from large-scale surveys, and properly homogenized, allowing me to significantly refine previous kinematic model of the Milky Way and their period-luminosity metallicity relationships based on the statistical-parallax method. My analysis actually narrows down the long-time distance calibration gap between the statistical parallaxes method and others. The other new result that was estimated is the Gaia DR2 parallax offset.

Session

Division G Stars and Stellar Physics

2108

10 years of optical spectroscopic monitoring of Be/X-ray binaries with the Southern African Large Telescope.

Dr Lee Townsend[1,2], Dr Julia Alfonso-Garzón[3], Dr Peter Kretschmar[4], Dr Enrico Kotze[5]

[1]South African Astronomical Observatory. [2]Southern African Large Telescope. [3]CAB. [4]ESA. [5]SAAO/SALT

Abstract

High-mass X-ray binaries (HMXB) are one of the most numerous class of interacting binary star systems. They offer the chance to observe extreme physics in high magnetic field and strong gravitational environments, as well as massive stellar and binary evolution, which may ultimately lead to double-degenerate systems. A large fraction of HMXBs comprise a neutron star and a Be star, which is characterised by an equatorial 'decretion' disc from which the neutron star periodically accretes. Studying the interaction between the Be star, disc and compact object is central to our understanding of the formation and evolution of these systems. Whilst X-ray all-sky monitors have built up excellent long-term light curves of the accretion events in HMXBs, our optical coverage, particularly spectroscopic, has been much sparser. We present here details of our 10 year Southern African Large Telescope (SALT) optical spectroscopic monitoring programme of the Be counterparts of Galactic and Magellanic HMXBs. The long baseline of these observations, along with good cadence, resolution & S/N make this one of the best available optical spectroscopic datasets in the field, and a valuable resource for observers and theoreticians alike. We discuss some of the science that our team is doing with this data, and our plans to release the full catalogue to the community.

Session

Division G Stars and Stellar Physics

2151

Spectroscopic properties of microlensing events alerted by Gaia

Pawel Zielinski[1], Etienne Bachelet[2], Mariusz Gromadzki[3], Lukasz Wyrzykowski[3]

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Abstract

The Gaia mission delivers enourmous amount of astrometric and photometric data. Based on Gaia light curves we are able to select a growing number of microlensing event candidates located mostly in the Galactic Plane. The majority of them must still be classified spectroscopically in order to distinguish genuine microlensing events from other types of outbursts and variables. Therefore, we use a wide range of world-class telescopes equipped with low- and high-resolution spectrographs to detect distinctive absorption and/or emission features and determine physical parameters as well as line-of-sight extinction for the sources in the microlensing events. Moreover, the spectroscopic analysis is important not only in constraining the microlensing model and the lens parameters, but also in distance estimation. From the comparison of spectroscopic distances with Gaia parallax/distance measurements we found that at least in some cases Gaia distances can not be trusted (probably due to blending or astrometric microlensing) and have to be used with caution. In additon, this seems to be reflected in the quality flags and parameters of astrometric signals given in the GaiaDR3 catalogue. I will present the status of the spectroscopic study of candidates for microlensing events alerted by Gaia with recent examples of interesting results.

Session

Division G Stars and Stellar Physics

2217

Deciphering Super-Metallicity, Lithium Depletion, and Radial Migration in the Vicinity of Our Solar Neighborhood

Dr. Maria Luiza L. Dantas[1,2,3], Prof. Rodolfo Smiljanic[3]

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Abstract

We present the discovery of a unique set of super-metal-rich dwarf stars exhibiting low eccentricity orbits, peaking in height from the Galactic plane at ~0.5-1.5 kpc. Utilizing data from the Gaia-ESO Survey, we analyze high-resolution observations of stars with abundances spanning over 18 elements. Employing hierarchical clustering on abundance data (excluding Li), and integrating orbits using Gaia astrometry and Gaia-ESO radial velocities, we estimate stellar ages through isochrone fitting and Bayesian methods. Our investigation reveals five distinct subgroups characterized by a median age of around 8 Gyr, near-solar [Mg/Fe] ratios, varying Galactic azimuthal heights, low eccentricities, and no discernible metallicity gradient with guiding radius. These findings suggest an origin in the inner Galaxy, with subsequent migration to the solar vicinity likely driven by interactions with the galactic bar and spiral arms. Furthermore, our analysis confirms previous observations of sub-benchmark lithium abundance in old metal-rich dwarf stars, challenging its utility as a proxy for interstellar medium lithium. Our study sheds light on the chemo-dynamical properties and origins of these stars, posing intriguing questions about Galactic evolution. For more details, see Dantas et al. (2023, A&A, 669, A96; 2022, A&A, 668, L7).

Session

Division G Stars and Stellar Physics

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From Birth to Orbit: Dissecting churn and blur in Galactic dynamics

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Abstract

As stars traverse the Galaxy, their orbits are influenced by various perturbations, leading to deviations from their original birth radii, which can be attributed to two main mechanisms: "churning," characterized by a change in angular momentum, and "blurring," characterized by a significant change in angular momentum. In Dantas et al. (in prep), we assess the motion of these stars within the context of theoretical chemical evolution models for the Milky Way, enhancing the precision of these models by generating finer grids and delving into the orbital characteristics of a diverse set of Gaia-ESO stars. We employ a Generalized Additive Model (GAM) to estimate birth radii for the stars and compare these predictions with calculated guiding, apocentric, and pericentric radii using the *galpy* in conjunction with Gaia parallaxes. Our analysis involves Hierarchical Clustering of 21 chemical abundances across 18 species to categorize the stellar dataset, quantifying and qualifying perturbations experienced by these stars. Our results reveal that metal-rich stars formed in the inner regions of the Milky Way seem to be moving outwards, and metal-poor counterparts formed in larger Galactocentric radii are moving inwards. We discuss the potential influence of the transient spiral arms and the central bar of the Galaxy. Furthermore, we attempt on quantifying the movement of each star, i.e. either blurring or churning. Finally, we compare our findings with simulations and provide insights into the potential causes of the migration, including the role of the central bar and spiral arms (Dantas et al. in prep.).

Session

Division G Stars and Stellar Physics

2240

HIGH RESOLUTION STUDIES OF THE C-BAND AND L-BANDRADIO CONTINUUM OF THE PERIODIC METHANOL MASERSOURCE G9.62 +-0.20E AND SURROUNDING SOURCES

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Abstract

High resolution observations of the C and L-band radio continuum of the hyper-compact HII region G9.62 +-0.20E conducted

with the e-MERLIN array are presented. A flux density of 2.25 +-0.20 mJy and an angular size of 127+-22 mas

were measured for the C-band continuum. At L-band, an upper limit of 162 micro Jy on the integrated flux density was calculated at

the position of the continuum. The surrounding sources C and D were detected at levels consistent with previous detections.

The results for source E shows that the upper limit for L-band is not consistent and reveals the spectrum falls off more

steepily from L-band as extrapolated from high frequencies. This can be explained with a truncated inverse square law

density distribution model. The calculated C-band peak brightness temperature of about 4000K, which translates to an optical

depth of 0.5, indicates that the continuum is optically thin at C-band and optically thick at L-band. These continuum results

therefore place firm constraints on models of the HII region in source E. In the context of the colliding wind binary (CWB) model

for the periodic maser it is very small changes in the the seed photons from the background HII region that are greatly

amplified by the maser that explains the maser variability. Hence, models of the H II region that match our observations

can be used to test the predictions of the CWB model in terms of the variability profiles of the 1.6GHz OH

and the 6.7 GHz methanol masers

Session

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Poster upload

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2263

physical properties of post common envelope binaries and their distribution

physical properties of post common envelope binaries and their distribution AYANA FEKADU

Space science and Geospatial Institute.. Addis Ababa University

Abstract

Post-common envelope binaries (PCEBs) represent a crucial phase in the evolution of binary star systems, characterized by the shedding of a common envelope during mass transfer between the two stars. Understanding the physical properties and distribution of PCEBs is essential for elucidating the common envelope phase, binary star evolution, and the formation of exotic objects such as cataclysmic variables and type Ia supernovae. In this study, we present an analysis of a large sample of PCEBs drawn from observational surveys and theoretical models. We investigate the distribution of key physical properties such as orbital parameters, component masses, spectral characteristics, and evolutionary histories. Our analysis reveals important insights into the demographics of PCEBs, including their mass ratio distribution, period distribution, and the incidence of various evolutionary outcomes. We discuss the implications of our findings for theories of binary star formation and evolution, as well as the potential role of PCEBs in the production of gravitational wave sources. Our results contribute to a comprehensive understanding of post-common envelope binaries and their significance in astrophysical contexts.

Session

Division G Stars and Stellar Physics

2310

A Multi-wavelength Study of the Galactic Point Sources in the SARAO MeerKAT Galactic Plane Survey with Gaia DR3

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Abstract

The SARAO MeerKAT Galactic Plane Survey is a radio continuum survey conducted in the *L* band (~1.3 GHz) in the Galactic plane, covering a wide range of galactic longitudes, and mostly within a latitude range of $|b| \leq 1.5$ degrees. In this study, we present our analysis of the Galactic stellar sources by cross-matching the radio point sources with the Gaia Data Release 3 (DR3) and the X-ray ROSAT catalogs. To refine our sample and mitigate spurious and extragalactic counterparts, we imposed a selection criterion based on multiple Gaia parameters such as proper motion and distances resulting in a few hundred sources. Leveraging the Gaia extinction measurements along the line of sight and the reddening parameter, we applied extinction corrections to the magnitudes and dereddened the colors of the optical counterpart candidates to produce a color-magnitude diagram (CMD). The CMD revealed a diverse population of stellar sources, ranging from massive OB binaries such as wolf-rayets, main-sequence RS CVn binaries, YSOs and dMe stars. Using distance estimates from Gaia, we calculated the radio-X-ray luminosities for 35 sources with ROSAT associations and obtained radio luminosities in the range of 10^{13} - 10^{17} erg s^{-1} Hz-1. A correlation exist between the radio-X-ray luminosities hence the stars follow the Gudel-Benz luminosity relationship indicating that gyro-synchrotron emission is responsible for the radio emission and as the non-thermal electrons travel through the stellar chromospheres, they lose energy in the process, thereby heating the stellar corona which gives rise to thermal X-ray emission.

Session

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2350

Results of a preliminary search for new hot sub-dwarf stars in binaries in TESS

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Abstract

Hot subdwarf B stars (sdB) are stellar objects at the late stage of their stellar evolution. These helium burning objects are the product of excessive loss of hydrogen envelope before the helium flash. The origins of these objects are believed to arise from binary interactions, with three primary formation channels proposed: common-envelope ejection (CEE), stable Roche-lobe overflow (RLOF) mechanism, and the merger of two low-mass white dwarfs (Han et al., 2002, 2003). These objects are crucial for studying the late stages of stellar evolution, binary interactions, and stellar interiors, particularly through the analysis of their pulsations. Current research indicates that approximately 60% of identified sdB stars are located within binary systems. Depending on the interactions between the sdB and its companion, these binaries are divided into two main groups, the systems with long orbital periods (longer than one year) produced in a stable RLOF, and the short period systems (order of hours) which evolved via the CEE.

Recently, we have published a catalog comprising over 300 variable sdBs (Uzundag et al., 2024). In this poster, we expand our investigation using the latest dataset from Transiting Exoplanet Survey Satellite (TESS) to identify newly discovered sdBs in binaries and pulsating sdB stars. We utilize a sample of approximately 3000 objects obtained from the Gaia EDR3 catalog of potential hot subdwarf candidates (Culpan et al., 2022), cross-matched with TESS data.

Session

Division G Stars and Stellar Physics

2364

Detection and Characterization of sdO companions of massive stars

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Abstract

The B emission-line stars are rapid rotators that were probably spun up by mass and angular momentum accretion through mass transfer in an interacting binary. Mass transfer will strip the donor star of its envelope to form a hot and faint subdwarf star. Here we present our past and present works on detecting and characterizing the hot sdO companions of rapidly rotating Be stars using spectroscopic observations from the International Ultraviolet Explorer and Hubble Space Telescope. Further analysis of such binaries yields the temperatures and radii of the hot sdO stars, a comparison of these measurements to evolutionary tracks indicates that the sdO stars occupy the relatively long-lived, helium core burning stage. By complementing the study with ground optical spectra analysis, we determined the orbital and physical properties of several Be+sdO binary systems and found that the sdO stars in a few of them could be progenitors of Type Ib and Ic supernovae. Continuing long-term monitoring of these Be+sdO binaries to determine their physical, atmospheric, and orbital parameters will provide insights into understanding the formation and evolution of massive stars.

Session

Division G Stars and Stellar Physics

2368

Herbig Ae/Be Stars: Bridging the Gap in Star Formation

Dr Blesson Mathew

Christ University

Abstract

Herbig Ae/Be stars are often considered as the crucial missing link in our understanding of star formation as their mass is intermediate to that of low-mass and high-mass pre-main sequence stars. A strategy to address this problem is to have a multi-wavelength approach, where one could study samples of Herbig Ae/Be stars in diverse environments using missions or survey programs such as Gaia, LAMOST, XShooter, Spitzer and Chandra. With the advent of the Gaia space mission, quite a number of interesting studies were published, where the focus was to evaluate the role of clustering in the immediate environment of Herbig Ae/Be stars. We will also discuss the exciting studies from spectroscopy, particularly with LAMOST, which was instrumental in understanding the accretion mechanisms in Herbig Ae/Be stars. The line profile studies from Xshooter spectra were very much useful to evaluate the dynamics of the circumstellar environment in these young stars. Thanks to missions such as JWST and Spitzer, the formation of molecules in the disk of Herbig Ae/Be stars is being understood in a better manner. We will highlight the astrochemistry studies from our group, particularly those stars with PAH emission and the recent discovery of fullerene molecules in the circumstellar medium of Herbig Ae/Be stars. Finally, we discuss the role of a low-mass companion in Herbig Ae/Be stars, as evident from the X-ray emission seen from Chandra observations.

Session

Division G Stars and Stellar Physics

2439

Accretion processes in cataclysmic variable stars: Insights from optical transient surveys

Miss Mokhine Motsoaledi[1,2], Prof. Patrick Woudt[1], Dr David Buckley[2]

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Abstract

Cataclysmic variable stars are binary stars mainly characterised by accretion from a main sequence donor star to a white dwarf star. This study focuses on two sub-classes of cataclysmic variables, namely AM CVn stars with helium accretion from a compact (semi-)degenerate donor star and magnetic cataclysmic variables with strong magnetic fields leading to magnetically-controlled accretion. I make use of optical transient surveys, primarily the Catalina Real-time Transient Survey (CRTS), for the identification of individual objects to follow up. I will present some of the spectroscopic and photometric results of individual cataclysmic variables using the 11-m Southern African Large Telescope and the 1.0/1.9-m telescopes situated at the South African Astronomical Observatory in Sutherland, South Africa. I also used the long-term light curves from CRTS to characterise the long-term photometric behavioural patterns of magnetic cataclysmic variables. A set of criteria was developed to quantify these characterisations and to systematically identify potential magnetic cataclysmic variables through their long-term light curves.

Session

Division G Stars and Stellar Physics

2440

Stacking radio stars in MIGHTEE

Francesco Cavallaro

INAF - Osservatorio Astrofisico di Catania

Abstract

The MIGHTEE (MeerKAT International GHz Tiered Extragalactic Exploration) survey has emerged as a groundbreaking initiative, leveraging the unprecedented capabilities of the MeerKAT radio telescope array to explore the depths of the radio sky. Even if its primary focus is on extragalactic sources, MIGHTEE can push forward the study of late-type stars through stacking techniques. .

Stars, typically associated with optical and infrared observations, have been relatively unexplored in the radio wavelength domain. MIGHTEE's unique sensitivity and high-resolution imaging provide an opportunity to revolutionize our understanding of stellar radio emission. By employing the innovative technique of stacking, we aggregate faint signals from individual stars, from the Gaia catalogue in the MIGHTEE region, thereby enhancing our ability to detect and characterize the radio emission from this stellar population.

The presentation will outline the methodology behind the stacking process, highlighting the challenges and advantages associated with probing the radio properties of stars in large-scale surveys. Preliminary results from the MIGHTEE survey will be presented, showcasing the collective radio signatures of stacked stars and providing insights into the underlying physical mechanisms responsible for their radio emission.

Session

Division G Stars and Stellar Physics

2477

Supernovae as reporting messengers about structure and properties of the surrounding universe

Dr. Petr Kurfürst

Masaryk University

Abstract

We study the interactions of expanding envelopes of supernovae (SN) with dense asymmetric circumstellar matter (CSM) of various shapes and profiles, forming a circumstellar disk, bipolar outflows, or slabs of colliding matter ejected in binaries. Various not well understood mechanisms can lead to non-stationary eruptions of huge amounts of matter from SN progenitors, which may be active over a long time or only shortly before the SN explosion. The propagation of a supernova shock wave through such an environment leads to a substantial increase in luminosity and duration of light curves which exhibit characteristic irregularities, including sudden brightenings or fluctuations. These effects can also manifest themselves in significant asymmetries in the spectra when observed from different directions. We have used multidimensional radiation-hydrodynamics codes to simulate the gas dynamics in shock wave regions and quantify the thermal energy of shock waves released during such interactions. Using a 3D radiative-transfer code, we determined the light curves and spectral profiles produced by such SN-CSM interactions, “seen” from different directions at different times. By comparing the calculated observables with the really observed ones, we estimate the amount and spatial distribution of the ejected mass before the explosion. This can further contribute to the description of the distribution of CSM and to the understanding of the mechanisms of violent outbursts or extremely violent eruptions by which this matter is ejected into space from stars approaching their death.

Session

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2487

Optical Light Curve and Spectral Analyses of Recurrent Nova RS Ophiuchi during the 2021 Outburst

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Abstract

The recurrent nova RS Ophiuchi (hereafter RS Oph) erupted again in August 2021, 15.5 years following the 2006 eruption. Regular monitoring of the eruption by amateur and professional observers, with numerous spectra taken covering a wide spectral range, including optical, UV, and X-rays.

This study analyzed the optical light curve and spectra during its outburst in August 2021 obtained from AAVSO [1] and ARAS [2] databases. The light curve analysis shows that the magnitude change of the RS Oph takes 102 days for the phase of initial rise (explosion) to the final declining phase with the dimmest magnitude of 12.3. The nova eruption period was separated into five main phases according to the light curve variation, in which the brightness increased from magnitude 9.1 to 4.78 within less than 24 hours during its initial rise phase.

From spectral analyses, the initial and maximum brightness phase spectra are dominated by hydrogen line (H-alpha), FeI and ArII in the P-Cygni profile. The expansion velocity of the H-alpha profile during the outburst phenomena rose from 5396.7 ± 2.3 km/s in the initial rise to 7066.3 ± 2.6 km/s a day after its maximum brightness. The P-Cygni profile starts to disappear at the end of the early decline and transition phases toward the final declining phase. Permitted-line phase Based on the element lines present during the phenomena, RS Oph is classified as a fast hybrid nova that evolved from Fe II to He/N class.

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Division G Stars and Stellar Physics

2518

Higher-order multipolar magnetic fields of corotating clouds of hot stars

Dr. Petr Kurfürst

Masaryk University

Abstract

We performed 3D magnetohydrodynamic simulations of magnetic fields and surrounding magnetospheres of massive, hot stars. Here, we considered not only the dipole configuration but also the possible higher polarities of these fields. The purpose of these simulations was to to investigate and assess in detail the influence of magnetic fields and stellar magnetospheres using dynamical, that is rotating and evolving over time, models on the abundance and geometric structure of the mass flowing out of these stars into the surrounding space. Determining the mass loss of these stars is crucial for studying the further evolution of both the surrounding environment supplied by this mass and the star itself. The latter, depending on the greater or lesser loss of its mass, may become the origin of cataclysmic objects and processes associated with supernova explosions, gamma-ray bursts or magnetars, leading ultimately to exotic phenomena such as kilonovae or direct collapses of stellar objects into black holes. Thus, the study of the magnetism of massive stars provides a key to better understanding and quantifying the evolution that leads to these phenomena.

Session

Division G Stars and Stellar Physics

2561

Synthetic stellar spectra to study multiple populations in globular clusters: an extended grid and the effects on the integrated light.

MSc Vinicius Branco

IAG/USP

Abstract

Most Galactic Globular Clusters (GCs) harbor multiple populations of stars (MPs), composed of at least two generations: the first characterized by a “standard” α-enhanced metal mixture, as observed in field halo stars of the Milky Way, and the second displaying anti-correlated CN-ONa chemical abundance pattern in combination with an enhanced helium fraction. Adequate collections of stellar spectra are needed to characterize the effect of such stellar abundance changes on the integrated light of GCs. Expanding on previous work, we present a grid of synthetic stellar spectra based on empirical stellar population data, covering the atmospheric parameters relevant to old stellar populations at four subsolar metallicities. Each population was computed} with abundance patterns representative of both a standard α-enhanced metal mixture and one with abundances typical of second-generations of stars in GCs. The spectra extend from 2900 to 10100Å. Using the stellar grid, we synthesized integrated spectra based on color-magnitude diagrams of Galactic GCs and studied the effect of the specific stellar surface abundances of multiple populations in terms of spectrophotometric indices. We find non-negligible effects of the MPs on spectroscopic indices sensitive to C, N, Ca, or Na, and on Balmer indices; we also describe how MPs modify specific regions in the near-UV and near-IR that can be measured with narrow or medium photometric passbands. The effects vary with metallicity. A number of these changes remain detectable even when accounting for the stochastic fluctuations due to the finite nature of the stellar population cluster

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2564

Stellar activity an important ingredient for planet habitability: the case of M stars

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Abstract

In the search for habitable exoplanets, it is important to consider the effects of energetic stellar events in the form of flares and Coronal Mass Ejections (CMEs) on potentially habitable planets. These phenomena can either lead to eroding off of planetary atmospheres or optimistically be a means of initiating prebiotic chemistry on planets. This is particularly important for planets orbiting M-stars, because these stars are very active and stay in this state for a long period of time. Here we present findings from the spectroscopic monitoring of two active M stars AD Leo and EV Lac. Using these data, the behaviour of the spectral lines Hα, Hβ, and He I 5876 was studied in detail and asymmetric features that might be Doppler signatures of CMEs investigated. Although several spectra showed asymmetries both in the blue and red, the velocities were much lower than the escape velocities of the stars. A possible erupting filament from a quiet region was also observed on EV Lac which largely suggests the great impact of the strong magnetic fields of these stars on preventing CMEs from escaping from the star. We will also briefly highlight on flaring as a function of age.

Session

Division G Stars and Stellar Physics

2588

Hot Subdwarf stars in the integrated light of old stellar populations

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Abstract

Observational evidence indicates that hot Horizontal Branch stars are the most likely candidates to account for the ultraviolet excess of old globular clusters and elliptical galaxies. These hot and evolved components are still missing in most of the libraries used in the synthesis of stellar populations. Due to this, some differences between models based on resolved and integrated light spectral fitting can translate into age differences of up to 50% in low metallicity globular clusters.

To address this problem, we first computed a detailed grid of non-LTE fully line-blanketed stellar atmosphere models for hot and moderately cool Horizontal Branch stars. This new library also provides high-resolution spectra and synthetic photometry in the range from 1,000 – 10,000 Å.

Secondly, this library was combined with others in the literature to model the integrated spectra of simple stellar populations based on the color-magnitude diagrams of NGC 2808 and NGC 7089. We propose modifying the CMD-based methodology in literature by directly matching each observed star to a synthetic spectrum in a ten-dimensional color plane, avoiding inaccuracies of current color-Teff relations. This allows us to quantify the impact of Blue/Extreme Horizontal Branches in the integrated flux of the far ultraviolet. This impact has been shown to vary across the blue part of the spectrum, contributing up to 100% in the far-ultraviolet, but still showing significant contributions in the near-ultraviolet of around 20%. These models show remarkable agreement with observations over a very long baseline, from 1,200 to 6,300 Å.

Session

Division G Stars and Stellar Physics

2634

ALPHA CENTAURI BINARY: A TEST BED FOR STELLAR CORE PROPERTIES

Ms Racheal Nabachwa[1], Dr. Benard Nsamba[2,3], Dr. Cosmos Dumba[1]

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Abstract

The mass of main-sequence stars plays an essential role in the determination of their evolution and interior structure. Main-sequence stars in the mass transition zone between convective and radiative cores offer an opportunity for testing the sensitivity of stellar core properties to the variations of stellar core physics, such as core overshoot, metallicity, atomic diffusion and gravitational settling. In this poster, we employ the Alpha Century binary as our benchmark star in the mass transition zone to unveil the impact of stellar model physics and different combination of observable constraints on the nature of stellar cores.

Session

Division G Stars and Stellar Physics

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Multiple Peaks and a Long Precursor in the Type IIn Supernova 2021qqp

Dr. Daichi Hiramatsu

Center for Astrophysics | Harvard & Smithsonian

Abstract

Type IIn supernovae (SNe IIn) show narrow hydrogen emission lines due to the strong interaction between the SN ejecta and massive circumstellar material (CSM) from progenitor mass-loss activities. In this talk, I present optical photometry and spectroscopy of SN IIn 2021qqp. Its unique light curve is marked by a ~300-day-long precursor and two distinct sharp peaks respectively at -19.5 and -17.3 mag separated by ~335 days. The spectra are dominated by Balmer lines with a complex morphology, indicating the velocity evolution of the CSM from ~1300 km/s (first peak) to ~2500 km/s (second peak) and the SN—CSM interaction shell from ~8500 km/s (first peak) to ~5600 km/s (second peak). Using the bolometric light curve and velocity evolution, we construct a flexible analytical model, finding two significant mass-loss episodes with peak mass-loss rates of ~10 Msun/yr and ~5 Msun/yr about 0.8 and 2 years before explosion, respectively, with a total CSM mass of ~2–4 Msun. The SN ejecta mass is constrained to be ~5–30 Msun for an explosion energy of ~3–10e51 erg. Finally, I discuss eruptive massive stars (luminous blue variable, pulsational pair instability) and an extreme stellar merger with a compact object as possible progenitor channels of for generating the energetic explosion in the complex CSM environment.

Session

Division G Stars and Stellar Physics

2662

Relativistic Magnetohydrodynamics for Amplification of Magnetic Fields during the Binary Neutron Stars Merger

Ms Magdeline Mohlao Seabi, Prof Azwinndini Muronga

Nelson Mandela University

Abstract

Binary neutron stars (BNSs) mergers are at the centre of observational targets for gravitational-wave detectors. BNSs mergers give insight into the state of hot dense matter generated under extreme conditions and also offer valuable information about the origins of heavy elements in the Universe and the formation of magnetars, etc. To understand the observations, solutions derived from general-relativistic equations are employed, to describe the dynamics of magnetic fields, and to further comprehend this phenomenon, a thorough investigation of relativistic magnetohydrodynamics (RMHD) studies is necessary. However, the equations within RMHD are highly non-linear and cannot be easily solved through analytical methods. The resolution of these equations requires numerical techniques within the framework of RMHD. To address substantial theoretical and technical challenges in discretizing RMHD equations, contemporary numerical relativity is employed to yield reliable results. Computational codes help model matter and magnetic field dynamics at pre-BNSs mergers to hundreds of milliseconds post-BNSs mergers. Our study focuses on relativistic magnetohydrodynamics simulations that explain the amplification of magnetic fields during the BNSs merger.

Session

Division G Stars and Stellar Physics

2700

Magnetic field maps and accretion properties of the young star GM Aurigae

Dr Bonnie Zaire

Universidade Federal de Minas Gerais (UFMG)

Abstract

The study of young accreting stars has been crucial in advancing our understanding of planet formation, evolution, and habitability, as their circumstellar discs are believed to be natural birthplaces for planets. Playing a central role in these systems are magnetic fields, which mediate the star-disc interaction, control the accretion process, and regulate the exchange of mass and angular momentum between the star and its environment. This talk aims to study the magnetic field and magnetospheric accretion process operative in the 2 Myr old protoplanetary system GM Aurigae. We present three large-scale magnetic field maps reconstructed from September 2021 to January 2023 using high-resolution near-infrared spectropolarimetry from SPIRou at CFHT. These maps reveal a predominantly axisymmetric poloidal field configuration, which places GM Aurigae close to other stars with similar internal structures. A dipole of about 700 G dominates the field configuration, while higher-order harmonics account for less than 35 per cent of the total energy. The main difference between the magnetic maps is due to a magnetic field excursion, wherein the dipole field changes its meridional and azimuthal tilts. Finally, we constrain the ratio between the corotation radius and magnetospheric truncation radius of GM Aurigae to 1.7 ± 0.4, which places the star near the boundary between stable and unstable accretion regimes ($\sim$1.4). Nonetheless, we conclude that the star was likely in a stable accretion regime due to the periodic variability of the redshifted absorption reported for the near-infrared hydrogen emission lines.

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Division G Stars and Stellar Physics

2764

Stellar Parameters on the Panchromatic Stellar Atlas (PaStA)

Morgan Camargo[1], Dr. Alessandro Ederoclite[2], Dr Ramachrisna Teixeira[1]

[1]Universidade de São Paulo. [2]Centro de Estudios de Física del Cosmos de Aragón

Abstract

Wide field surveys are powerful tools for astrophysical studies. These observations target a very large number of sources, building vast databases which can be used for studies which transcend the original goals of the projects. With the advance of technologies in the last decades, the storage and distribution of these databases have become much more accessible. The Sloan Digital Sky Survey and the Gaia mission are good examples of this change of paradigm.All surveys have strengths and weaknesses which are defined by their own primary science goals, like their limiting magnitudes or the wavelength coverage. For instance, Gaia focuses on optical light to derive position and velocities, whereas WISE only probes in infrared, and the GALEX All Sky Survey observed only the ultraviolet extragalactic sky.The Panchromatic Stellar Atlas (PaStA) has been developed to build up on the strengths of different surveys, joining these observations to create a database of stellar spectral energy distributions ranging from ultraviolet to infrared. Initially, we used PaStA to test stellar models and search for exotic objects. The Atlas is now evolving, there are now better corrections of interstellar extinction to be applied with recent publications, and with these important additions, we can further populate the catalogue with stellar atmospheric parameters for each object.

Session

Division G Stars and Stellar Physics

2785

Photometric binaries in Magellanic Cloud star clusters

Ms. Anjana Mohandasan

University of Padova

Abstract

Binaries are fascinating objects that hold a fundamental and significant position in stellar evolution studies. Being a dense environment, Globular clusters (GCs) host a substantial amount of binaries, many of them being primordial. By studying the binary fraction in GCs, we can not only accurately determine the various cluster parameters, such as age, luminosity function, radius, and mass, but also understand the formation scenarios of its various stellar populations.

Extra Galactic GCs, like the ones in Magellanic Clouds (MCs), are quite interesting due to the wide ranges of ages and densities they span. Yet, they are less explored compared to their Galactic counterparts due to resolution limitations. In this study, we have successfully explored the MS binaries in 20 MC GCs using high-precision astrometry and photometry obtained from Space Telescopes. Thus derived binary fraction is investigated for its monovarietal relations with the main structural parameters of the clusters, including age, metallicity, mass, dynamical age, and density. The behaviour of binary fractions with stellar parameters, such as the mass of the primary star, the mass ratio between the companion stars, and radial distances yield interesting results. The comparison of results obtained from young and intermediate-age MC clusters, with those from old Milky Way GCs, opens a window into understanding the influence of cluster age and environment on stellar evolution and cluster dynamics. Additionally, it gives valuable insights into the relationship between binaries and exotic objects, such as Blue Straggler Stars, which are often present in the exciting expanses of GCs.

Session

Division G Stars and Stellar Physics

2813

Stellar modelling with conformal symmetry

Dr Chevarra Hansraj, Prof Rituparno Goswami, Prof Sunil Maharaj

University of KwaZulu-Natal

Abstract

Solutions to Einstein's field equations (EFEs) are useful in describing compact stellar objects which have very strong gravitational fields and high densities. Different solutions depict different scenarios. For example, the Schwarzschild solution describes a compact stellar object with constant density in hydrostatic equilibrium. The Kerr solution describes a rotating uncharged axially symmetric black hole. Finding solutions to the EFEs is difficult in general because they are a system of complicated nonlinear partial differential equations. Ad hoc methods need to be employed to make them simpler to work with such as assuming a type of symmetry, for example, conformal symmetry. Pressure anisotropy is an important quantity which includes the difference in pressures that exist within relativistic bodies. Several situations occurring in stellar bodies can cause pressure anisotropy which influences the stability of stellar structures. We study the kinematical and dynamical properties of spacetimes that admit a conformal Killing vector (CKV) through spacetime decomposition. This provides new insights into the behaviour of physical quantities such as acceleration, expansion, shear and vorticity. The energy momentum tensor for an anisotropic fluid is decomposed which makes it possible to generate constraint equations that must be satisfied for a CKV to exist. We apply our results to the perfect fluid model and noteworthily we show that the conformal factor satisfies a damped wave equation. We further show that in the case of the pure null dust (or Vaidya) spacetime, a proper CKV cannot be admitted and briefly present the effects in rotating black hole geometry.

Session

Division G Stars and Stellar Physics

2825

Optimisation of stellar pulsation modelling of BL Her stars using MESA-RSP

Dr. Susmita Das

CSFK Konkoly Observatory

Abstract

We present new theoretical period-luminosity (*PL*), period-Wesenheit (*PW*) and period-radius (*PR*) relations at multiple wavelengths (Johnson-Cousin-Glass bands *UBVRIJHKLL'M* and Gaia passbands $GG_{BP}G_{RP}$) for a fine grid of convective BL Herculis models computed using the non-linear radial stellar pulsation tool MESA-RSP. The non-linear models were computed for periods typical for BL Her stars, i.e. 1≤P (days)≤4 covering a wide range of input parameters: metallicity (-2.0 dex≤ [Fe/H]≤ 0.0 dex), stellar mass ($0.5M_{\odot}$-$0.8M_{\odot}$), luminosity ($50L_{\odot}$-$300L_{\odot}$) and effective temperature (full extent of the instability strip; in steps of 50K). We investigate the impact of four sets of different convection parameters on multi-wavelength properties. Most empirical relations match well with the theoretical *PL*, *PW* and *PR* relations from the BL Her models computed using the four sets of convection parameters. However, *PL* slopes of the models with radiative cooling provide a better match to empirical relations for BL Her stars in the LMC in the *G*-band and the HK_S bands. No significant metallicity effects are seen in the *PR* relations. Another important result from our grid of BL Her models is that it supports the equivalence of the *PL* relations of RR Lyrae and T2Cs, thereby providing us the opportunity of adopting RRLs+T2Cs together as an alternative to classical Cepheids for the extragalactic distance scale calibration.

Session

Division G Stars and Stellar Physics

2829

An observational and theoretical view of the stellar photosphere-hydrogen ionization front interaction in classical pulsators

Dr. Susmita Das

CSFK Konkoly Observatory, Budapest

Abstract

The hydrodynamics of the outer envelope structure in classical pulsators can be studied using the period-colour relations at different pulsation phases. In this work, the hydrogen ionization front (HIF)-stellar photosphere interaction theory is probed from both the observational and theoretical aspects. Empirical period-colour (PC) relations for the classical pulsators exhibit flat/sloped PC relations for RRab stars at minimum/maximum light; sloped/flat PC results for W Vir stars and long-period (P >10d) classical Cepheids at min/max light and intermediate behaviour with a much smaller difference between the PC slopes at max/min light for BL Her stars and short-period (P < 10d) Cepheids. The theoretical aspect involves studying the HIF-stellar photosphere distances from stellar pulsation models computed using MESA-RSP. We found the results from the models to be generally consistent with this picture and thereby demonstrated that the theory holds true across a broad spectrum of variable stars in different evolutionary stages.

Session

Division G Stars and Stellar Physics

2837

The LADUMA CV: Multiwavelength study on an SU-UMa Type Dwarf Nova in the LADUMA field using MeerLICHT and MeerKAT

Miss Sumari Barocci-Faul

University of Cape Town. South African Astronomical Observatory

Abstract

I will report on the optical-radio study of the outbursting cataclysmic variable star CRTS J033349.8-282244 in the LADUMA field. The source has extensively been observed with multiple South African and international facilities. I will present the results from observations of the CV done with MeerLICHT, MeerKAT and SAAO telescopes throughout outbursts, super-outbursts and during quiescence. The LADUMA field is frequently observed by the MeerKAT radio array as well as MeerLICHT, which observes the field in multiple filters. This resulted in a unique dataset to study the colour evolution of this CV, specifically a Dwarf Nova, as a function of the outburst phase for many dwarf nova outbursts - a study that has never conclusively been done before.

Session

Division G Stars and Stellar Physics

2868

Spectroscopy of the HD68695 star using the Mahikeng Astronomical Telescope

Mr Lobone Nchoe

North-West University

Abstract

Through multi-wavelength observations, we anticipate strong infrared excess from HD 68695, these infrared excess are believed be caused by the presence of a proto-planetary disk as explained by Keller et al. (2019). The presence of this disk will mean that our candidate star according to Murphy et al. (2020) is a Herbig star. Studying these types of stars presents an opportunity to study planet formation as they form within proto-planetary disks. It should be noted however that that the presence of infrared excess does not squarely conclude the stellar type, as stated by Draper et al. (2015). Our study proposes to determine whether HD 68695 can be classified as a λ-Bootis star or Herbig Ae/Be star. We plan to achieve this by making spectroscopic observations of this star using the Mahikeng Astronomical Telescope attached to the eShel échelle spectrograph, as well as the HRS (High-Resolution Spectrograph) from the South African Large Telescope (see appendix), making a comparison between both data sets. This will allow us to perform an abundance analysis of this star. Based on the analysis we will determine if there is an under-abundance of iron peak elements, determine infrared excess using JHK (infrared excess filters) using existing observations of the star.

Session

Division G Stars and Stellar Physics

2885

The tango of the rotation and pulsations in KIC7756853: a *Kepler* Hybrid δ Sct-γ Dor binary system

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Abstract

Pulsating late A-F-type stars are characterized as intermediate to fast rotators. Kepler observations have revealed that due to their fast rotation γ Dor stars can have purely inertial and gravito-inertial pulsations. The advent of new-generation space missions, *Kepler* and TESS, has revealed hybrid stars exhibit pulsation frequencies falling within the range of 5-10 d^{-1}. KIC 7756853, a bright Kepler target of magnitude Kp = 8.96 mag, is a confirmed double-lined spectroscopic system following a comprehensive study based on high-resolution spectra. This system has an orbital period of 99.32 days, a mass ratio of 0.91, and consists of two A-type stars with projected rotational velocities = 31 and 51 km/s. From the Fourier analysis applied to the complete *Kepler* long-cadence data we detected δ Sct-type modes with frequencies ranging from 18.24 -28.28 d^{-1}. Two distinct regular frequency splittings were observed in both p and low-frequency modes, linking these pulsation modes to two of the most significant low frequencies, 0.8914 d^{-1} and 2.5258 d^{-1}. Significant low-frequency modes, indicative of inertial and gravito-inertial modes, were observed in the inertial (0.7 - 5.1 d^{-1}) and the super-inertial range (5.1 - 7. d^{-1}). The observed frequency splittings arise from the rotational effects of both primary and secondary components and allow us to deduce a core-to-surface rotation rate of 1.062 for the secondary. The coupling of rotation and pulsation in KIC 7756853 suggests the presence of a pair of (δ Sct – γ Dor) hybrid pulsators with intermediate to fast rotation.

Session

Division G Stars and Stellar Physics

2901

Rotational period determination of selected chemically peculiar stars.

Caiyun Xia, prof. Zdeněk Mikulášek, Dr. Jan Janík

Masaryk University, Czech Republic

Abstract

About 10% of stars on the upper main sequence of HR diagram show anomaly abundance of some chemical element on their surface layers. The appearance of light curves of magnetic chemically peculiar stars are the same even for decades. This is due to a strong global magnetic field which leads to originating of spots on stellar surface and decreasing of stellar flux. By analysing of these light curves, we are able to determine their rotational periods with high precision. We will analyse light curves from TESS mission for selected stars and determine their period of rotation.

Session

Division G Stars and Stellar Physics

2936

Binary Population Synthesis: a case for detailed binary models

Dr. Max Briel

University of Geneva

Abstract

Binary population synthesis (BPS) has emerged as a vital tool in astrophysics, particularly in the contexts of gravitational wave and supernova studies. Binary interactions lead to unique astrophysics objects, such as double compact object, novae, blue stragglers, and Type Ia supernovae, while complicating the already intricate landscape of single star evolution. BPS codes, often categorized into rapid and detailed codes, offer avenues for exploring uncertainties in interaction mechanisms and formation pathways of exotic objects.

While rapid BPS codes dominate due to computational efficiency, detailed BPS models provide unique insights into rare events despite their higher computational costs. This talk highlights two cases revealing distinctive binary evolution behaviors: the formation of binary black holes through stable mass transfer in the BPASS code, and the emergence of rapidly spinning gamma-ray burst progenitors via "reverse mass transfer" onto hydrogen-poor stars at high metallicity with POSYDON. Both these (semi-)detailed BPS codes provide an insight into these events due the usage of detailed stellar modelling. These examples underscore the essential role of detailed stellar physics, especially in understanding mass transfer stability and transients originating from binary populations.

Session

Division G Stars and Stellar Physics

2963

Hour-to-Decade+ Variability in Young Stellar Objects

Lynne A. Hillenbrand

California Institute of Technology

Abstract

Young (1-10 Myr old) stars are ubiquitous variables, in both continuum and spectral lines, over a wide range of wavelengths. YSO activity is driven by a combination of stellar physics and accretion/outflow physics, all viewed through a complex circumstellar dust geometry. The diversity of variability behavior in YSOs has been illustrated by the plethora of time domain surveys covering various parts of the wavelength, duration, and cadence parameter space. Our ability to classify lightcurves has grown more sophisticated and our understanding of the underlying phenomena driving the various forms of variability has improved. The presentation will provide an overview of YSO variability behavior on short to long timescales, and from low to high amplitudes. Special attention will be paid to the dramatic accretion outbursts signalling transition from ``low-state" to ``high-state" accretion phases of varying extremity.

Session

Division G Stars and Stellar Physics

2966

Recent observations of Supernova associated Gamma-Ray Burst

Prof. Xianggao Wang[1], Mr De-Feng Kong[1], Dr WeiKang Zheng[2], Prof. Enwei Liang[1], Prof. Alexei V. Filippenko[2]

[1]Guangxi University. [2]University of California, Berkeley

Abstract

We present recent observations of observations of supernova associated gamma-ray burst. Espically the GRB 221009A, in some respects the most extraordinary gamma-ray burst (GRB) ever observed. Good quality in the R-band light curve is obtained, covering 0.32--19.57 days since the Fermi-GBM trigger. We find that a weak bump emerges from the declining afterglow at about 11 days; a supernova (SN) may be responsible. We use a smooth broken power-law and Ni-56 model to fit the light curve. The best-fitting results reveal that the SN ejected a total mass of M_ej = 3.43 M_\odot$, a Ni-56 mass of M_Ni = 0.32 M_\odot$, and a kinetic energy of E_SN,K= 8.52 \times 10^{52} erg. We also compare GRB 221009A with other GRB-SN events based on a GRB-associated SN sample, and find that only SN 2003lw and SN 2011kl can be obviously revealed in the afterglow of GRB 221009A by setting these objects at its distance. This suggests that a supernova (SN 2022xiw) is possibly obscured by the brighter afterglow emission from GRB 221009A.

Session

Division G Stars and Stellar Physics

3036

Asteroseismology vs Binarity: the battle for the old red stars

Dr Kelly Hambleton

Villanova University

Abstract

For main sequence stars, the asteroseismic scaling relations have been shown to provide stellar radii and masses to accuracies of 5% and 10%, respectively. For red giants, however, the discrepancy is more significant, on the order of 10% and 15%, attributed to the non-linearity of the scaling relations alongside the use of the Sun for calibration. Extensive attempts have been made to calibrate the asteroseismic scaling relations for red giants, including the analysis of pulsating red giants in eclipsing binary systems (RGEBs). Through the analysis of RGEBs, a direct comparison can be made between the scaling relation-derived masses and radii, and those derived through binary modeling. The premise of such work is that the results from modeling eclipsing binary system are ground truth and that the asteroseismic results should be adjusted accordingly. The catch is that binary star results are contingent on the treatment of the trends in the data and the application of an appropriate model, especially when the stars are non-spherical. Here we provide updated binary star masses and radii, determined using a state-of-the-art binary star modeling code (PHOEBE 2) for a selection of RGEBs. We highlight the importance of using a model with Roche geometry for distorted stars. Finally, we provide a comparison between the updated binary results and those from the asteroseismic scaling relations.

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3072

A Very Large Program with Chandra: investigating the metallicity effect on the formation and evolution of young X-ray binaries

Dr. Vallia Antoniou[1,2], Andreas Zezas[3,4,2], Konstantinos Droudakis[1], Jeremy Drake[5], Frank Haberl[6], Jaesub Hong[2], Paul Plucinsky[2], Grigoris Maravelias[7], Manami Sasaki[8], Jeff Andrews[9], Ben Williams[10]

[1]Texas Tech University. [2]Center for Astrophysics | Harvard & Smithsonian, Cambridge, USA. [3]Uniiversity of Crete, Greece. [4]Institute of Astrophysics/FORTH, Greece. [5]Lockheed Martin. [6]Max-Planck-Institut fuer extraterrestrische Physik, Garching, Germany. [7]National Observatorv of Athens, Athens, Greece. [8]Universitat Erlangen-Nurnberg/Remeis-Sternwarte, Bamberg, Germany. [9]Universitv of Florida. Gainesville, USA. [10]University of Washington, Seattle, USA

Abstract

Our nearest star-forming galaxy, the Large Magellanic Cloud (LMC), has been largely neglected in X-ray binary (XRB) populations studies targeting quiescent luminosities. In Chandra Cycle 24, we were awarded a Very Large Program (1 Ms) to perform a comprehensive survey of sources brighter than ~2 x 10^{32} erg/s in 10 LMC fields dominated by young (10 - 100 Myr) stellar populations of different ages, matching those sampled in the similar survey of the Small Magellanic Cloud (SMC). This luminosity limit probes all active XRBs and reaches into the regime of quiescent binaries and X-ray emitting normal stars. This program will provide the deepest X-ray luminosity functions (XLFs) for XRBs ever recorded, and in combination with the SMC survey will allow us to directly measure their formation efficiency as a function of age and metallicity and address the XLF evolution in the 10 - 100 Myr range. Here we present the first promising results from the analysis of the first 400 ks.

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Division G Stars and Stellar Physics

3206

S-type and symbiotic Stars from LAMOST DR10: Classification and New Identifications

Dr Jing Chen[1,2], Prof A-Li Luo[2], Dr Yin-Bi Li[2], Dr Liang Wang[1], Dr Zi-Chong Zhang[1]

[1]Nanjing Institute of Astronomical Optics & Technology, Chinese Academy of Sciences.
[2]National Astronomical Observatories, Chinese Academy of Sciences

Abstract

S-type stars are cool giant stars with C/O ratios between 0.5 and 1.0. They have prominent ZrO molecular bands in their spectra and show an enrichment of s-process element. The largest catalog of S-type stars contained only slightly over one thousand stars, and there was no quantitative method to classify S-type stars suitable for large-scale photometric and spectroscopic surveys. We found 2939 S-type stars from LAMOST Data Release 10 using two machine-learning methods, and 2306 of them were reported for the first time. We divided S-type stars into intrinsic and extrinsic stars with photometric data and LAMOST spectra. Using infrared photometric data, the model trained by input features with 2MASS, AKARI, and IRAS data has the highest accuracy of 95.52%, and 381 intrinsic and 495 extrinsic stars were classified. Using these photometrically classified intrinsic and extrinsic stars, we retrained XGBoost model with medium-resolution spectra, and the 2939 stars were divided into 855 intrinsic and 2056 extrinsic stars with an accuracy of 94.82%. We also found four spectral regions of Zr I (6451.6 Å), Ne II (6539.6 Å), H alpha (6564.5 Å), and Fe I (6609.1 Å) & C I (6611.4 Å) are the most important features, which can reach an accuracy of 92.1% when using them to classify S-type stars. In addition, due to the possibility of symbiotic stars existing among the extrinsic S-type stars, we searched for symbiotic stars in the LAMOST spectra and found nine confirmed symbiotic stars, including two new discoveries.

Session

Division G Stars and Stellar Physics

3207

New Data Release of AST3-2 Photometric Survey from Dome A, Antarctica

Dr Liang Wang, Dr Jing-Jian Chen, Dr Xiao-Yan Li, Prof Zheng-Yang Li, Dr Zi-Chong Zhang, Dr Jing Chen

Nanjing Institute of Astronomical Optics & Technology, Chinese Academy of Sciences

Abstract

Dome A in Antarctica has proved to be one of the best astronomical sites on Earth. Since 2012, a group of wide-angle 0.5m telescopes AST3 has been placed in Dome A to conduct a time-domain optical sky survey. One of its key programs has a sky field that largely overlaps with the southern continuous Viewing Zone (CVZ) of TESS. Zhang et al. (2018) analyzed the photometric data of 10 fields scanned in 2016, and found 179 new variables and 116 new transiting planet candidates. We developed new image calibration methods and applied them to the photometric data from all 32 fields from 2016 to 2017. We presented light curves of ~140,000 stars, of which 7,297 periodic variables have been listed in VSX or Gaia DR3 catalogs. We also identified 42 new variables and updated periods of some known variables. As these fields were observed before TESS, this dataset is particularly valuable for confirming the eclipsing binaries and exoplanet candidates identified by TESS and searching for TTV and ETV signals.

Session

Division G Stars and Stellar Physics

3209

Search and study of young infrared stellar clusters

Naira Azatyan

Byurakan Astrophysical Observatory

Abstract

The Milky Way serves as a natural laboratory for astronomers, particularly for studying the origins and evolution of stars. The Galactic disc's "bricks" are giant molecular clouds, which are the birthplaces of stellar populations. Thus, there is a genetic connection between young stellar objects (YSOs) and their surrounding interstellar medium (ISM). Studying the ISM in conjunction with embedded YSOs is crucial for understanding the star formation process. This talk is dedicated to investigating star-forming regions, including determining the parameters of the ISM and YSOs. Among the 16 clusters we identified, we selected three star-forming regions for detailed study. It is likely that these three young stellar clusters were formed under different scenarios. The age spread of the IRAS05137+3919 and IRAS05168+3634 regions is much larger, leading us to conclude that their stellar populations formed as a result of independent condensations. In contrast, the age spread of the clusters' members in the third region, which comprises a pair of UCHIIs (G45.12+0.13 and G45.07+0.13), is small. We, therefore, concluded that their origin might be related to an external triggering shock. Moreover, high-mass YSOs were only found in the G45.07+0.13 and G45.12+0.13 UCHII regions, where the ISM's initial density was higher and star formation proceeded relatively quickly.

Session

Division G Stars and Stellar Physics

3210

Buoyant crystals give a second life to white dwarf stars

Dr Antoine Bédard

University of Warwick (UK)

Abstract

White dwarfs represent the final stage of the life cycle of more than 95% of all stars. These stellar remnants are essentially devoid of energy sources and are thus condemned to cool continuously over billions of years — or so we thought. A few years ago, the Gaia mission uncovered a population of white dwarfs that have maintained a constant temperature for over 8 Gyr, revealing the existence of a powerful yet unknown energy source in these objects. This staggering challenge to conventional stellar physics prompted a flurry of modeling efforts aiming to identify the nature of the mysterious energy source. In this talk, I will show that the solution to this puzzle is the occurrence of a solid-liquid distillation mechanism triggered by the crystallization of the dense white dwarf core. For certain core compositions, the crystals forming at the center are depleted in heavy neutron-rich impurities, which makes them lighter than the surrounding liquid. The crystals float and eventually melt, causing heavier liquid to be gradually displaced downward, which releases a large amount of gravitational energy and thus interrupts the cooling for about 10 Gyr. This phenomenon had never been observed in any type of stars before and challenges our very notion of white dwarfs as dead stars. It also has profound implications for the use of white dwarfs in dating stellar populations and reconstructing the formation history of the Milky Way.

Session

Division G Stars and Stellar Physics

Final category: Division H Interstellar Matter and Local Universe

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Large scale triggered star formation in the Milky Way

Mr. Moses Langa[1], Professor Mark Thompson[2], Professor Paul Baki[1], Professor James Chibueze[3], Dr. Andrew Rigby[2], Dr. Gwenllian Williams[4], Dr. Mubela Mutale[2], Dr. Willice Obonyo[1]

[1]Department of Astronomy and Space science, Technical University of Kenya. [2]School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT, UK. [3]University of South Africa. [4]Department of Physics, Aberystwyth University, Ceredigion, Cymru, SY23 3BZ, UK

Abstract

Massive stars release vast amounts of energy into the interstellar medium through their lifetime processes and supernova explosions, compressing nearby regions and triggering star formation. While triggering mechanisms have been studied on smaller scales, comprehensive analysis on a larger Milky Way scale has been hindered by the lack of high-quality radio imaging and the limited angular resolution of molecular mapping. The significance of triggered star formation across the Galactic disc is, therefore, not well understood. Access to data from the MeerKAT Galactic Plane Survey and the Structure, excitation, and dynamics of the inner Galactic interstellar medium (SEDIGISM) molecular mapping survey addresses these limitations. This research combines MeerKAT and SEDIGISM data to identify molecular clouds interacting with HII regions and supernovae. The study examines differences between clouds interacting with Supernova Remnants (SNRs) and HII regions, analyzing any associated star formation. The anticipated outcome is the creation of a comprehensive catalog of clouds interacting with HII regions and SNRs. Comparing these clouds to the sample of non-interacting clouds aims to deepen our understanding of galactic-scale triggered star formation processes, and allow us to constrain the significance of its contribution to global star formation across galactic discs.

Session

Division H Interstellar Matter and Local Universe

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Gaps in the Main Sequence of Star Clusters with Gaia DR3 data

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

The presence of gaps or regions of small numbers of stars in the main sequence of the Hertzsprung Russell Diagram (HRD) of star clusters has been reported in literature. This is interesting and significant as it could be related to star formation and/or rapid evolution or instabilities. In this paper, using Gaia DR3 photometry and confirmed membership data, we explore the HRD of nine open clusters with reported gaps, identify them and assess their importance and spectral types.

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Division H Interstellar Matter and Local Universe

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Mass segregation in the Gaia Era

Dr Priya Shah, Prof Syed Najamul Hasan

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In the present study, we used published membership data of 9 open star clusters as a training set to find new members from Gaia DR3 data using a supervised random forest model with a precision of around 90\%. The number of new members found is often double the published number.

We study mass segregation in a sample of clusters where mass segregaton has been reported. We find the mass function $\phi(M) = dN/dM \propto M^{-\alpha}$ in different regions of the clusters and tracing the variation in the value of α as a function of the parameter $\tau = t_{age}/t_{relax}$ (where t_{age} is the age of the cluster and t_{relax} is the relaxation time of the cluster). We explore relations of various parameters like Galactocentric distance, intracluster reddening (star formation efficiency (SFE)), age and size of the clusters to look for common defining features or signatures in them to help differentiate if the process is dynamical or related to their formation. Recent results supporting early dynamical mass segregation are discussed and attempts are made to critically assess the evidence of primordial mass segregation for the above sample.

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Dynamics of Mass Segregation in Open Star Clusters.

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

We use Gaia DR3 data to study mass segregation in a sample of nine star clusters. We use machine learning techniques Random Forest, Gaussia Mixture Model and DBSCAN to find members of these clusters. We use these resuts to compare the dynamical time-scales of these clusters with heir ages to assess if the mass segreagtion is primordial or dynamical. We study the orbits of the massive and low mass stars and find the differences in their parameters.

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From Collision to Creation: Origin of Hub-Filament Systems through Cloud-Cloud Collision

Mr. Arup Kumar Maity[1,2], Prof. Yasuo Fukui[3], Dr. Lokesh Dewangan[1]

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Abstract

The massive star-forming regions (MSFRs) are commonly associated with hub-filament systems (HFSs) and the sites of cloud-cloud collision (CCC). Recent observational studies on Galactic MSFRs, such as SDC13, W31 complex, W33 complex, and AFGL 5180 & 6366S, have revealed concurrent signatures of CCC and the presence of HFS. This suggests that CCC may lead to the formation of HFSs. To understand the connection between CCC and the formation of HFSs, we conducted a comprehensive examination of magneto-hydrodynamic simulation data from Inoue et al. (2018), 70(SP2), S53 (1-11). This simulation involves the collision of molecular clouds at a relative velocity of ∼10 km/s with a spatial resolution of about 2400 AU. The supersonic collision between the cloud components develops a shock-compressed layer at their interface. The width and density of the shock-compressed layer increase over time. Following the collision, the turbulent and non-uniform cloud undergoes shock compression, resulting in the rapid development of filamentary structures within the compressed interface. Mass accumulation is facilitated along magnetic fields, promoting the development of heavier and denser filaments oriented perpendicular to the magnetic field. Finally, filaments converge toward a common junction under the influence of gravity to form a HFS, hosting a massive core of about 15 Solar mass at its hub. Overall, in the case of CCC, the combined influence of turbulence, shock compression, magnetic fields, and gravity contributes to the formation of HFSs and, subsequently, the birth of massive stars. During this presentation, I will share these research outcomes.

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Exploring the complex nature of the intergalactic medium in Stephan's Quintet

Marina Arnaudova[1], Soumyadeep Das[1], Daniel Smith[1], Martin Hardcastle[1], Nina Hatch[2], Scott Trager[3]

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Abstract

Galaxy mergers and interactions are a cornerstone of our understanding of how galaxies form, but their precise role in driving galaxy evolution across cosmic time is still widely debated. Compact galaxy groups at low-redshift, such as Stephan's Quintet (SQ), however, give us the opportunity to study such processes in more detail. This galaxy group is at a unique dynamical stage where we are able to observe manifestations of both past and present interactions by examining its most distinguished feature: the large-scale shock front. This system contains a wealth of multi-wavelength information including radio observations from the LOFAR Two-metre Sky Survey (LoTSS) and targeted observations with the Very Large Array (VLA). Recently, the next generation spectroscopic facility on the 4.2m William Herschel telescope in La Palma - WEAVE, has contributed to this wealth of information with its first panoramic optical integral field unit (LIFU) observation. By harnessing this instrument's large field of view and high spectral resolution (R=10 000), we are able to study the physical characteristics of the ionized gas by performing robust spectral fitting of complex line profiles on an individual spaxel of 2.6 arcsec basis across the area of 90x78 arcsec^2. This combined with radio spectral index maps (between 144MHz, 1.7GHz and 4.8GHz) allows us to determine the ionisation mechanism, age, and thermodynamics of the particles populating the structure, and thus shed new light on the interplay between galaxy-galaxy and galaxy-intergalactic-medium interactions.

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Spectral Energy Distributions of Stellar Populations for a Broad Range of Galaxy Properties

Dr. Calum Hawcroft[1], Dr. Claus Leitherer[1], Dr. John Chisholm[2], Dr. Lucimara Martins[3], Dr. Georges Meynet[4], Dr. Andreas Sander[5], Dr. Aida Wofford[6]

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Abstract

Star-forming galaxies are host to significant populations of recently formed hot, massive stars, which give rise to strong stellar spectral features in the ultraviolet and provide the ionizing fluxes of the stellar population. The properties of massive stars become more extreme at low metallicity and, thanks to pioneering observations of young, metal-poor stellar populations, both locally with HST and at high redshifts with JWST, we are at a key moment to assess our understanding of these galaxies through stellar population synthesis. This poster showcases the latest progress in extending the capabilities of the stellar population synthesis code Starburst99 to lower metallicities (covering a range from super-solar to zero metallicity) and higher upper mass limits (up to 500 solar masses). Thanks to the recent advent of new evolutionary and atmosphere models of massive stars in these extreme regions of the parameter space, we are able to characterize the integrated properties of such populations.

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Interstellar dust in 3D at parsec-scale resolution out to 1.25 kiloparsecs in distance

Gordian Edenhofer

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Abstract

Interstellar dust traces the mass in the ISM and is a crucial catalyst for star formation. To study the structure of the ISM and the conditions for star formation, we need to study the distribution of dust in 3D. However, we only observe interstellar dust in 2D projections. In this talk I will discuss how we can use astrometic data namely distance and extinction information from Gaia to de-project our 2D view of the sky to 3D. I will present a 3D map of interstellar dust extending out to 1.25 kiloparsecs in distance from the Sun. The 3D map improves upon previous high resolution 3D maps in terms of covered volume and resolution. It reveals previously undiscovered faint molecular clouds at high latitudes and far away distances, and significantly improves the dynamic range with which we resolve nearby molecular clouds.

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The outskirts of M33: signatures of accretion or tidal interaction?

Dr. Edvige Corbelli

INAF- Osservatorio di Astrofisico di Arcetri

Abstract

By examining a variety of orbital initial conditions compatible with the Early Third Data Release of the Gaia mission and with mass estimates of Local Group spirals, we study the probability and the effects of a close pericenter passage of M33 around M31 in the past. A close encounter of M33 and M31 in the past has a low but non negligible probability. If the two galaxies had been closer in the past, their minimum distance was of the order of 100~kpc or larger, and this happened earlier than 3~Gyr ago. During this encounter 35-40% of the dark matter mass of M33 might have been removed from the halo due to tidal stripping. A detailed comparison of the results of test-particle simulations with the observed disk warp or with the spatial distribution of candidate dark satellites of M33 suggests that a closer passage of M33 around M31 cannot however be responsible for the observed morphological features. We suggest that more recent gas accretion events, possibly from a cosmic filament, might cause the misalignment of the outer disk of M33 after the rapid inner disk formation.

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Experimental evidence of high temperature formation of H_2 and solid water on PAH-like surfaces

Mr Francesco Grieco

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Abstract

H2 is the cooling agent regulating star-formation and it requires dust grains as catalysts to be formed. PAHs have been shown to increase the H2 formation rate, believed to be very efficient only below 20 K and becoming irrelevant above 100 K. Water represents instead the main component of the icy mantles on dust grains and its solid-phase formation route is essential to explain abundances in molecular clouds.

We report direct experimental QMS results through the interaction of hydrogen and (for water) oxygen atomic beams aimed towards the surface, connected to a cryostat, and analyzed with temperature desorption techniques.

H2 is efficiently formed through atomic recombination on coronene, PAH-like surface, up to 250 K while solid water is obtained up to 85 K, mimicking the conditions from dense to translucent regions where the ice mantle onset starts.

Our experimental results could have important implications for the location of the H/H2 photodissociation front and for the formation of H2 in high-redshift galaxies where dust temperatures are generally above 40 K. Icy mantles could form in less dense and warmer environments, explaining oxygen depletion in the ISM and the disappearance of PAHs in translucent regions.

Correctly accounting for H2 formation is key for its line emission in local PDRs and for JWST observations of PAHs that, if combined with H2O observations, could further support the warm temperature solid water formation on those surfaces. Both these experimental works show the catalytic nature of coronene and the role of chemisorption processes. [1, 2]

1.Grieco, F. et al. Nature Astronomy (2023).

2.Grieco, F. et al. MNRAS (2024).

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The JWST View of the Nearest Starbursts

Dr Alberto Bolatto[1], Dr. Rebecca Levy[2], Dr. Deanne Fisher[3], The JWST Starbursts Collaboration[4]

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Abstract

Starbursts are a rare phenomenon in the present day universe, but they represent the most common mode under which stars formed and galaxies grew during the z~1-2 peak of cosmic star formation activity. This mode of star formation is not a simple scaling of what happens in typical molecular clouds, but represents a much more efficient manner of converting gas into stars likely through the formation of massive clusters. The resulting feedback in the form of galaxy-scale outflows is, together with AGN, thought to be one of the main forms of regulation of galaxy growth. I will present recent imaging and spectroscopic JWST observations of two of the nearest starbursts, M 82 and NGC 253, and discuss the inferred properties of these starbursts and their dusty winds with particular emphasis on the feedback effects on the interstellar medium of these nearby galaxies. These images reveal the structure of the dust in the outflow on scales of a few parsecs, while the spectroscopy provides unique insights into the clusters at the extremely obscured core of the starburst.

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Affordable Multiple Aperture Spectroscopy Explorer

Dr. Sabyasachi Chattopadhyay

South African Astronomical Observatory

Abstract

Affordable Multiple Aperture Spectroscopy Explorer (AMASE) is an optical spectroscopic survey of the ionized gas in Milky Way and all Local Group star-forming galaxies at spatial scales of 0.1 to 100 pc and a spectral resolution of σ = 8.5 km s^-1. Key emission lines captured include Hα, Hβ, HeII, and strong emission lines of forbidden OI, OIII, NII, and SII in two windows between 4640-5092 Å and 6250-6850 Å. These data will be used to uncover the process driving outflows in star-forming regions, to calibrate the metallicity measurements and photoionization models, and to understand the origin of the diffuse ionized gas. AMASE will pair many identical multi-fibre spectrographs with an array of telephoto lenses to achieve integral field spectroscopy at half-arcminute resolution over large areas of the sky. This is enabled by a significant reduction in the cost of each spectrograph relative to typical astronomical spectrographs of comparable performance. Cost-reduction is achieved by fibre-coupling and reducing the beam size to match commercial photographic lenses and large-format, small-pixel CMOS detectors. High performance is achieved by recent advances in detectors, optical coatings and new grating technology (fused-silica etched gratings that outperform even volume phase holographic gratings). In this talk the speaker will discuss the scientific motivation and update on the instrument development progress.

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LightCube: A 3D Model of the Local UV Interstellar Radiation Field

Dr. Hannah Bish[1], Dr. Joshua Peek[1,2], Dr. Claire Murray[1], Dr. Karl Gordon[1], Dr. Catherine Zucker[3]

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Abstract

Traditionally, studies of the Milky Way and ISM have assumed a constant value for the interstellar radiation field (ISRF) in the nearby Galaxy. This is often the most reasonable assumption given the limited information we have. In reality, the ISRF varies depending on proximity to stars, dust extinction, and other factors, and these variations can greatly influence the properties of diffuse matter. Thanks to recent progress in the quality of local dust maps and distances to UV-bright stars, we are now able to calculate a detailed representation of the UV radiation background within 370 pc of the Sun - a data set we call LightCube. We present this data set, discuss our initial findings, and touch on potential uses of LightCube by the community.

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New Observations of the Fermi Bubbles: Tracing Nuclear Feedback and in-situ Conditions

Dhanesh Krishnarao

Colorado College

Abstract

The biconical gamma-ray lobes known as the Fermi Bubbles likely trace nuclear feedback and winds from the Galactic Center. These winds have been observed in several wavelengths, ranging from radio to UV to trace individual clouds outflowing from the CMZ region at large scales. These studies however have been limited to small regions near the galactic plane to find cold gas, or rely heavily on background quasars for UV absorption line studies for a bigger picture. Now, we have directly observed this outflowing gas using recombination line emission in the optical and radio wavelengths, providing a more holistic picture into the feedback effects and radiation field emerging from Galactic Center at large scales. Our discovery (Krishnarao et al. 2020a, ApJL; Krishnarao et al. 2020b, Science Advances) provides in-situ measurements of ionized gas density, temperature, and pressure, suggesting that the Fermi Bubbles may be creating an over-pressured zone of ionized gas within a few kpc of Galactic Center. The combination of optical/radio recombination line emission and UV absorption from the same Fermi Bubble gas allows us to directly constrain the escaping radiation field from the Galactic Center environment and indirectly model the underlying stellar population and distribution (Krishnarao, Cashman, & Fox. 2022, HST AR 17060). Soon, using the Wisconsin H-Alpha Mapper and Green Bank Telescope, we will be able to create the first, continuous, 4-Dimensional (position + velocity) maps of the Fermi Bubbles via emission lines.

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Peering into the MilkyWay by FAST: I. Exquisite HI structures in the inner Galactic disk from the piggyback line observations of the FAST GPPS survey

Dr. Tao Hong, Prof. Jinlin Han, Dr. Ligang Hou

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Abstract

Neutral hydrogen (HI) is the fundamental component of the interstellar medium. The Galactic Plane Pulsar Snapshot (GPPS) survey is designed for hunting pulsars by using the Five-hundred-meter Aperture Spherical radio Telescope (FAST) from the visible Galactic plane within $|b| \leq 10°$. The survey observations are conducted with the L-band 19-beam receivers in the frequency range of 1.0-1.5 GHz, and each pointing has an integration time of 5 min. The piggyback spectral data simultaneously recorded during the FAST GPPS survey are great resources for studies on the Galactic HI distribution and ionized gas. We process the piggyback HI data of the FAST GPPS survey in the region of $33° \leq l \leq 55°$ and $|b| \leq 2°$. The rms of the data cube is found to be approximately 40 mK at a velocity resolution of 0.1 km s^{-1}, placing it the most sensitive observations of the Galactic HI by far. The high velocity resolution and high sensitivity of the FAST GPPS HI data enable us to detect weak exquisite HI structures in the interstellar medium. HI absorption line with great details can be obtained against bright continuum sources.

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Asteroseismic ages for the development of chemical age determination methods

Prof. Grazina Tautvaisiene, Dr. Erika Pakstiene, Dr. Yuriy Chorniy, Dr. Carlos Viscasillas Vazquez, Dr. Arnas Drazdauskas, Dr. Sarunas Mikolaitis, Dr. Renata Minkeviciute, Dr. Edita Stonkute, Mr. Vilius Bagdonas, Dr. Carlos Viscasillas Vazquez

Vilnius University

Abstract

For the deeper understanding of the Galactic chemical evolution, three main parameters of stars have to be known – the detailed chemical composition, age, and the birth place. So far the stellar age determination has largest uncertainties. In this work, we use a unique opportunity to use the TESS Space Mission data for the asteroseismic age determination, the Gaia Space Mission data for more precise stellar birth-place determinations, and a detailed chemical composition of bright stars located in the northern TESS continuous viewing zone and 12 degrees around it. Among all stars of $V < 8$ mag, we found 238 stars with clear solar-type pulsations and determined their asteroseismic ages. This allowed to compare the isochronal and asteroseismic age determinations. Using [C/N] and [Y/Mg] abundance ratios, we also addressed the emerging chemical-clock method applicability for stars of the thin and thick discs in different Galactic radial distances.

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SMARTY: The mileS Moderate resolution neAr infRared sTellar librarY

Michele Bertoldo-Coêlho[1], Rogério Riffel[1,2], Marina Trevisan[1], Natacha Zanon Dametto[2,3], Luis Dahmer-Hahn[4], Paula Coelho[5], Lucimara Martins[6], Daniel Ruschel-Dutra[7], Alexandre Vazdekis[2,3], Tatiana Moura[5], Alberto Rodríguez-Ardila[8,9], Ana Chies-Santos[1], Rogemar A. Riffel[10], Francesco La Barbera[11], Ignacio Martín Navarro[2,3], Jesus Falcon Barroso[2,3]

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Abstract

We present a 0.35-2.4 µm stellar spectral library composed by 31 stars observed with the Gemini Near-IR Spectrograph (GNIRS) on the 8.1 m Gemini North telescope in Mauna Kea, Hawaii. These stars are present in the MILES library, and thus various parameters derived from the optical are available. Furthermore, out of those, 26 are presented for the first time in the NIR and 5 were used as control sample to check the spectra quality. The SMARTY library will be made available to the community.

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Overview of the ALMA Large Project FAUST

Dr. Yoko Oya[1], Dr. Cecilia Ceccarelli[2], Dr. Clare Chandler[3], Dr. Claudio Codella[4], Dr. Nami Sakai[5], Dr. Satoshi Yamamoto[6]

[1]Center for Gravitational Physics and Quantum Information, Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, 606-8502, Japan. [2]Universite Grenoble Alpes, CNRS, IPAG, France. [3]National Radio Astronomy Observatory, United States. [4]INAF, Osservatorio Astrofisico di Arcetri, Italy. [5]RIKEN, Japan. [6]SOKENDAI, Japan

Abstract

It has been recognized that protostellar cores show chemical diversity, especially in the composition of organic species. For instance, two distinct cases are well known; hot corino sources are rich in interstellar complex organic molecules, while warm carbon-chain chemistry sources are rich in unsaturated hydrocarbons. They are still unclear whether such a chemical diversity is seen in disk-forming regions and what kinds of molecular species are delivered into disks from envelope gas.
To tackle with the above problems, our ALMA large program 'FAUST (Fifty AU STudy of the chemistry in the disk/envelope system of Solar-like protostars)' focuses on the early stage of Solar-type protostars and their chemical diversity on a 50 au scale, where a planetary system is expected to be formed. The main goal of this project is to quantify molecular abundances of the disk/envelope system in relation to its physical structure and to reveal how different they are among sources. For this purpose, we observed thirteen young protostellar sources as representatives of the chemical diversity observed on larger scales to obtain a homogeneous database of thousands of images from different lines and species. The analysis of this huge database is in progress to disentangle the components of the 50-2000 au disk/envelope system, to characterize the organic complexity in each source, to delineate their distribution, and to probe their ionization structure. In this presentation, we especially focus on the chemical diversity among sources and the differences of the molecular distributions.

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Testing the Supermassive Star Scenario for Early Massive Cluster Evolution

Katarzyna Nowak

University of Hertfordshire

Abstract

For a long time, it was believed that globular clusters were simple structures consisting of only one population of stars that share the same chemical composition. However, recent extensive evidence shows that these old and massive stellar aggregates exhibit significant differences in lighter elements with the Na-O anticorrelation being the most prominent feature in most of them. Additionally, multiple sequences in the colour-magnitude diagram suggest a spread in helium abundance in most Galactic and extra-galactic globular clusters. The most likely explanation for the chemical peculiarities observed in globular cluster is self-enrichment, where specific stars pollute the surrounding gas with their yields. Supermassive stars (> 1000 Msun) are proposed candidates for polluters but at the present time it is very hard to observe them due to their location. The candidates forming massive clusters are located outside the Milky Way with very dense centers, where the hypothetical star would be obscured by gas and dust. The supermassive stars would form via runaway collisions, simultaneously with the cluster, hence their disc is perturbed by stellar flybys.

We use a 3D hydrodynamic simulations set up around a supermassive star to examine how its accretion disc reacts to frequent stellar encounters. We examine if the disc survives and remains dense enough to mase water lines. We then model kilomasers, which are generally associated with the forming super star cluster and compare it to an interesting candidate in the starburst galaxy NGC 253.

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Investigating Self-Enrichment in Young Massive Clusters through ^{26}Al Signatures

Katarzyna Nowak

University of Hertfordshire

Abstract

Self-enrichment is one of the leading explanations for chemical anomalies in globular clusters. In this scenario, a certain polluter star, enriches a forming cluster with its yields, likely ejecting radioactive 26Al into its surroundings. Detection of 26Al in young massive star clusters holds significant implications, potentially supporting the self-enrichment scenario if these clusters are indeed progenitors of globular clusters. Recent advancements in observational techniques, including detections of the 1.8 MeV and 511 keV 26Al decay gamma ray lines, as well as 26AlF molecules or positronium radio recombination lines, suggest promising avenues for detecting 26Al and maturing detection methods.

In this talk, I will focus on examining a sample of young massive star clusters in the nearby Universe, where self-enrichment could plausibly occur. Despite optimistic scenarios, detecting most sources remains challenging with some methods. However, we identify R136 in the Large Magellanic Cloud as a promising candidate for such investigations. Although the best-case scenario for detecting a 1.8 MeV signal may require several years with instruments like COSI, the feasibility of detecting 26AlF with the ALMA telescope in several candidate clusters offers encouraging prospects for further study and understanding of self-enrichment scenario in young massive star clusters.

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The Ratio of $^{12}C_2$ and $^{12}C^{13}C$ Column Densities in Diffuse Molecular Gas

Steven Federman[1], Adam Ritchey[1], Evelyne Roueff[2], Jacques Le Bourlot[2], David Lambert[3], Joe Ninan[4], Suvrath Mahadevan[5], Gregory Zeimann[3], Steven Janowiecki[3]

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Abstract

We describe a study yielding the $N(^{12}C_2)/N(^{12}C^{13}C)$ ratio with the Habitable-zone Planetary Finder (spectral resolution of 6 km s^{-1} and signal-to-noise per resolution element from 900 to 2000) on the Hobby-Eberly Telescope (HET) in West Texas. The sample comprises sight lines toward stars that are accessible to HET and have $^{12}C_2$ column densities greater than $7x10^{13}$ cm^{-2} in three or fewer velocity components. The focus is on absorption from the (1-0) band of the Phillips system ($A^1\Pi_u - X^1\Sigma_g^+$) near 1 micron toward the stars HD 28975, HD 29647, HD 169754, Cyg OB2 12, and HD 204827. These data are supplemented by results on the $N(^{12}CO)/N(^{13}CO)$ and $N(^{12}CN)/N(^{13}CN)$ ratios from absorption at infrared, visible, and ultraviolet wavelengths and radio emission. Q- and R-branch lines of $^{12}C^{13}C$ from J" = 0 to 3 are detected in all the stellar spectra except for HD 29647. Our findings to date reveal a $N(^{12}C_2)/N(^{12}C^{13}C)$ ratio of about 30, or an ambient $^{12}C/^{13}C$ ratio of ~60; such a value is consistent with expectations. However, toward HD 29647, only a lower limit for the $N(^{12}C_2)/N(^{12}C^{13}C)$ ratio of 100, or an ambient $^{12}C/^{13}C$ ratio greater than 200, is inferred. We are constructing models of chemical fractionation to interpret the range of column density ratios. Comparisons between observational results and model predictions will be presented.

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Spectral Mapping of Nearby Galaxies Utilizing Multi-wavelength Data and Machine Learning Algorithms

Dr. Ji Hoon Kim[1], Prof. Myungshin Im[1,2]

[1]Astronomy Research Center, Seoul National University. [2]Department of Physics and Astronomy, Seoul National University

Abstract

Spectral mapping of nearby galaxies provides immense information into their physical properties, encompassing stellar populations, chemical composition, dynamical characteristics, and more. While recent surveys like SAURON, MANGA, and SAMI have advanced the field using integrated-field units (IFUs), these surveys are limited in sample sizes due to the expensive nature of IFU observations. In this presentation, we are introducing a pilot study utilizing the commissioning data of the 7-Dimensional Telescope (7DT), a multi-telescope array of 20 50-cm telescopes with 40 medium-band filters of 25 nm FWHM, which will ultimately provide spectral cubes of a large number of nearby galaxies in the southern hemisphere in conjunction with SPHEREx. While operating in different platforms and wavelengths - ground-based and optical for 7DT and space-based and near-infrared for SPHREx - both facilities provide comparable data in terms of spectral resolutions and survey depths. Combining data from these facilities, we can generate spectral cubes for nearby galaxies spanning the wavelength range from 400nm to 50000nm. In our pilot study, we plan to train a deep learning (DL) algorithm on low-resolution spectra observed by 7DT and high-resolution spectra obtained by VLT-MUSE of nearby galaxies selected from the PHANGS survey to examine if the DL algorithm recovers high-resolution spectra. If successful, we will apply the algorithm to the Wide-Field Survey, one of 3 layers of the 7-Dimensional Sky Survey, and expand the method for SPHEREx and PHANGS-JWST. The synergy between 7DS and SPHEREx can provide a comprehensive dataset as a valuable legacy resource for prospective studies of nearby galaxies.

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Feedback and galaxy dynamics: A study of turbulence and star formation in 34 galaxies using the PHANGS survey

Dr. Bruce Elmegreen

NA

Abstract

To understand the effects of star formation feedback on ISM turbulence and future star formation, the relationship between molecular gas turbulent speed, sigma, and local star formation rate surface density, Sigma_SFR, is studied using CO observations of 17 strong-arm spiral galaxies and 17 weak-arm spiral galaxies in the PHANGS survey. Azimuthal fluctuations in sigma and Sigma_SFR correlate well, but apparently not because of feedback, because sigma depends on molecular surface density and cloud mass with the usual molecular cloud correlations, while Sigma_SFR increases with both of these quantities because of a nearly constant star formation efficiency per CO. Azimuthal variations of molecular pressure have a weaker correlation with Sigma_SFR than expected from the power-law correlation between these total quantities, suggesting slightly enhanced SFR efficiency per molecule in spiral arms. Dynamical equilibrium pressure, P_DE, and Sigma_SFR correlate well for the whole sample, both in total and with azimuthal fluctuations. Because of this close association even with young star formation, and because of the similarity between the components of P_DE and the Kennicutt-Schmidt and Extended KS laws, we suggest that P_DE should be viewed as both a precursor to star formation through its dependence on gas content and as a reaction to star formation through non-local feedback effects. Galactic dynamical processes are also studied. They all correlate well with Sigma_SFR, such that Sigma_SFR~(Sigma_gas x R)^{1.0+-0.3} for total gas surface density, Sigma_gas, and galactic dynamical rates, R, equal to either epicyclic frequency, shear rate, or orbital rate.

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X-rays from a Central "Exhaust Vent" of the Galactic Center Chimney

Scott Mackey[1,2], Mark Morris[2]

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Abstract

Using deep archival observations from the Chandra X-ray Observatory, we present an analysis of linear X-ray-emitting features located within the southern portion of the Galactic center chimney, and oriented orthogonal to the Galactic plane, centered at coordinates l = 0.08 deg, b = −1.42 deg. The surface brightness and hardness ratio patterns are suggestive of a cylindrical morphology which may have been produced by a plasma outflow channel extending from the Galactic center. Our fits of the feature's spectra favor a complex two-component model consisting of thermal and recombining plasma components, possibly a sign of shock compression or heating of the interstellar medium by outflowing material. Assuming a recombining plasma scenario, we further estimate the cooling timescale of this plasma to be on the order of a few hundred to thousands of years, leading us to speculate that a sequence of accretion events onto the Galactic Black Hole may be a plausible quasi-continuous energy source to sustain the observed morphology.

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Properties and structure of the local ISM obtained from HST ultraviolet spectra as prototypes for the Galactic ISM

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Abstract

High-resolution spectra obtained with the STIS instrument on the Hubble Space Telescope are providing line widths and velocities that characterize interstellar gas in the sightlines to several hundred stars located within 100 pc of the Sun. All of these sightlines show at least one interstellar velocity component with partially ionized hydrogen, and many sightlines show multiple velocity components. Line widths for elements with different masses permit the separation of thermal from non-thermal (turbulent) components. The identification of different velocity components that share a comment velocity vector allowed the identification of 15 individual clouds located within about 10 pc of the Sun. The Sun appears to be located in a mixed cloud region where the Local Interstellar Cloud and the G Cloud overlap. Within 4 pc of the Sun, the local ISM is completely filled with partially ionized warm gas clouds, but with increasing distance, the clouds become isolated and are surrounded by fully ionized hydrogen produced by supernovae explosions. The temperatures and densities of the partially ionized gas in the local clouds are very inhomogeneous on small distance scales. There appears to be total pressure balance between the heliosphere, the local warm clouds, and the surrounding Local Cavity (Bubble) with ram pressure playing an important role. There are several proposed explanations for the structure of the local ISM.

This work is supported by NASA grant 80NSSC20K0785.

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Mixed aromatic/aliphatic organic nanoparticles as possible carriers of the unidentified infrared emission bands

Prof. Sun Kwok[1,2], Dr. SeyedAbdolreza Sadjadi[2]

[1]University of British Columbia. [2]University of Hong Kong

Abstract

Circumstellar envelopes of evolved stars are prolific sites of molecular synthesis. Starting with acetylene, aromatic molecules such as benzene can form. Aliphatic side chains have been observed to form around islands of aromatic rings, leading to complex mixed aromatic/aliphatic organic nanoparticles (MAONs). From quantum chemistry calculations, we show that MAONs have spectral properties similar of the family of identified infrared emission (UIE) bands widely observed in the interstellar medium. Comparisons will be made with other models of possible carriers of the UIE bands.

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Characterising GRAO observations of 6.7-GHz methanol masers

Mr Stephen Sottie[1,2], Dr Emmanuel Proven-Adzri[2], Dr Theophilus Ansah-Narh[2]

[1]University of Ghana. [2]Ghana Space Science and Technology Institute, Ghana Atomic Energy Commission

Abstract

We developed a computational model that estimates the parameters that characterize GRAO masers. Three probability distribution functions (models), including Gaussian, Lorentzian, and Voigt models, were fitted onto the Maser data using Bayesian inference and Markov Chain Monte Carlo approaches. This estimated the fwhm, which determined the peak flux and central velocity of the Maser. For this work, the parameters for four Masers species (G9.62+0.20, G351.44+00.65, G328.277-00.530, and G339.884+1.259) were found. The Gaussian model fit for G9.62 + 0.20 (for instance) estimated the peak flux, central velocity, and FWHM values to be 998.920 Jy, 0.034 km/s, and 0.00079 km/s respectively. The Voigt model fits G339.
This tool does not only streamlines data analysis but also significantly contributes to astrophysical research in Ghana.

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Enrichment by Extragalactic First Stars in the Large Magellanic Cloud

Dr Anirudh Chiti[1,2], Dr Mohammad Mardini[3,4], Mr Guilherme Limberg[5], Dr Anna Frebel[6], Dr Alexander Ji[1,2], Dr Henrique Reggiani[7], Dr Peter Ferguson[8], Ms. Hillary Andales[6], Dr Kaley Brauer[9], Dr Ting Li[10,11], Dr Joshua Simon[12]

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Abstract

The Large Magellanic Cloud (LMC) is the most massive Milky Way satellite dwarf galaxy and is thought to have only recently (~2 Gyr ago) fallen into the Milky Way. This recent infall means that the LMC's lowest metallicity stars ([Fe/H] < -2.5) provide a unique opportunity to study chemical evolution and element production by the first stars in a formerly distant, extragalactic environment. We present the detection and detailed chemical abundances of 10 stars between -4.2 < [Fe/H] < -2.5 in the LMC, the lowest metallicity of which is significantly more metal-poor than any prior LMC star with detailed chemical abundances. This star, with [Fe/H] = -4.13, is the most metal-poor star known in any external galaxy, and is at sufficiently low metallicity to plausibly reflect enrichment from an individual supernova from an extragalactic first star. Intriguingly, this star is not a carbon-enhanced metal-poor star (CEMP; with [C/Fe] > 0.7), in contrast to the lowest metallicity Milky Way halo stars where ~90% of stars with [Fe/H] < -4.0 are classified as CEMP. This lack of carbon-enhancement is also seen in the rest of our low metallicity sample, in addition to several other trends that suggest that the early LMC may have experienced diverging enrichment processes from the early Milky Way. These results, along with other recent studies, demonstrate that the very lowest metallicity stars are detectable in the LMC, opening up possibilities for testing the universality of early enrichment and the properties of the first stars in diverse cosmic environments.

Session

Division H Interstellar Matter and Local Universe

1294

Unveiling the Dynamics of Open Clusters: Insights from External and Internal Perspectives.

Dr. Carlos Viscasillas Vázquez

Vilnius University

Abstract

Delving into the dynamical evolution of open clusters offers invaluable insights into Galactic disc properties. Leveraging Gaia DR3 data, our study explores the temporal evolution of kinematical and dynamical characteristics within the Galactic open cluster population. Our investigation adopts a dual approach, scrutinizing both external perturbations and internal kinematic evolution. Externally, we investigate the determinants of cluster survival, including factors such as mass, density, size, and galactic perturbations. Internally, we employ diverse metrics to track the evolution of intra-cluster member distances over time.
This poster presentation unveils the boundaries and potential of the oldest open clusters as crucial tools for deciphering the complexities of our Milky Way.

Session

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1327

Understanding circumnuclear environments in M31 and M81 with multi-wavelength, high-resolution observations

Dr. Zongnan Li

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

Galactic circumnuclear regions, where stars and supermassive black holes interact with the interstellar medium, are crucial for understanding black hole feeding, feedback, and galaxy co-evolution. However, the connection between black hole feedback and the surrounding interstellar medium remains elusive. We utilizes multiwavelength observations of nearby galaxies (M31 and M81) to investigate the interaction between the multiphase interstellar medium and supermassive black holes in circumnuclear regions. Millimeter and infrared observations reveal a deficiency of cold gas in the circumnuclear region of M31 compared to the Milky Way, but with higher temperatures possibly linked to past nuclear activity. Additionally, optical spectroscopic observations uncover a biconical ionized gas outflow structure located at around 200 pc from the center of M81, likely associated with the low luminosity active galactic nucleus. We also addresses the long-standing puzzle of the origin of low-ionization nuclear emission-line regions (LINERs) in both galaxies. Using the CLOUDY photoionization code, the model incorporating contributions from inactive nuclei and stellar populations fails to fully explain the observed radial distribution of emission-line intensity within 1 kpc. This discrepancy suggests the presence of additional mechanisms, such as shocks or previous nuclear activity, in the ionization processes of these nearest LINERs.

Session

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1338

MAUVE: Tracking the influence of the environment on the gas-star formation cycle of cluster galaxies during infall

Luca Cortese, Barbara Catinella

ICRAR-UWA

Abstract

I will present the first results from the MAUVE (MUSE and ALMA Unveiling the Virgo Environment) survey a multi-wavelength observational campaign combining VLT/MUSE, ALMA and HI observations of 40 galaxies in the Virgo cluster aimed at understanding the environmental impacts on the gas-star formation cycle in cluster galaxies during their infall. These data are allowing us to probe the distributions and kinematics of stars, ionized and molecular gas over the full extent of the inner galactic disks, at scales of a few hundred of parsecs, making it possible to investigate the link between cold gas and star formation when and where environmental processes are at play. Excitingly, these observations are starting to reveal unexpected cases of star formation driven outflows even in ram-pressure stripped and HI deficient galaxies, as well as providing new insights into how star formation proceeds after first pericentre passage. While still at the early stages, MAUVE is showing us how outflows may still play an important role in the full quenching of the star formation of satellite galaxies and highlight how a multi-phase mapping of the interstellar medium is critical to fully unveil the physical processes regulating the star formation cycle of galaxies.

Session

Division H Interstellar Matter and Local Universe

1341

Investigating the blue stellar clumps of the collisional ring galaxy Arp 142

Ms Lisa Seconna

University of Cape Town (UCT). South African Astronomical Observatory (SAAO)

Abstract

Star formation (SF) is a complex and dynamic process influenced by various factors including stellar feedback, gas dynamics, and environmental conditions. Formed through the head-on collision between a small galaxy companion and the rotation axis of a larger disk galaxy, collisional ring galaxies (CRGs) offer a unique laboratory that helps understand the origin of SF in clumpy systems. The collision is so intense that it triggers new episodes of starburst activities leading to the formation of blue stellar clumps. These objects represent the youngest and most massive (> 10^5 $M_\odot$) form of SF in nearby galaxies. In this work, we study a large sample of blue stellar clumps in the CRG Arp 142 using high-resolution HST multiband observations (PSF ~ 0.1''). By studying the photometric and physical properties of the stellar clump population, we aim to investigate the effects of the host environment on the cluster formation and evolution mechanisms. We find that clumps have approximate mass and age ranges of ~ 10^5 – 10^7 $M_\odot$ and ~ 10 – 500 Myr, respectively. Their spatial distribution suggests that their physical properties are likely influenced by the host environment.

Session

Division H Interstellar Matter and Local Universe

1357

The oldest stars in the Large Magellanic Cloud

Thomas Nordlander

Research School of Astronomy and Astrophysics, Australian National University

Abstract

The most metal-poor stars alive today carry the chemical fingerprints of ancient stars and supernovae. I will present a resent spectroscopic survey of metal-poor stars in the Large Magellanic Cloud that has uncovered seven of the most metal-poor stars known. Two of the stars are strongly r-process enhanced, with abundances matching the universal r-process pattern. The other five stars are not r-process enhanced, and therefore likely formed before the enhancement event (binary neutron star merger?) discovered by Reggiani et al. 2021, therefore clearly making them both the most metal-poor and oldest stars in this galaxy.

Session

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1410

Properties of molecular clumps in the nearby galaxy: M33

Dr Saul Paul Phiri[1,2], Dr Jason Kirk[2], Prof. Derek Ward-Thompson[2], Dr Anne E. Sansom[2], Dr George Bendo[3]

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Abstract

Resolving molecular clouds in external galaxies offers an opportunity to study the properties of molecular clouds from different environments and compare them to our own Galaxy the Milky Way (MW). It also offers an opportunity to study molecular clouds without worrying about materials obscuring our line of sight as it is mostly the case in the MW. We have resolved molecular clouds to clump level and created a catalog of clumps in M33 for the first time using ALMA archival data. The GMCs were traced by 12CO(2-1), 13CO(2-1) and C18O(2-1). We derived different properties of these clumps and compared them to those done in other Local Group of galaxies.The molecular clouds resolved are at different evolutionary stages, giving insights of environmental variation in our clumps and their properties.

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1413

A STUDY OF POST-AGB STARS IN THE LIGHT OF GAIA DR3 DATA

Minia Manteiga[1,2], Iker González-Santamaría[3,1,4], Arturo Manchado[5,6,7], Eva Villaver[5,8], Ana Ulla-Miguel[9,10], Carlos Dafonte[3,1]

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Abstract

Low and intermediate-mass stars evolve through the Post Asymptotic Giant Branch (post-AGB) phase before they reach the Planetary Nebulae stage. After leaving the Main Sequence, they undergo intense episodes of mass loss when in the Giant Branch and, then, they enter the post-AGB stage which is a rather puzzling stellar evolutionary phase . Also, it has a very short duration, of the order of a few thousand years at most, so the number of confirmed post-AGB objects is really small and, thus, our understanding of this elusive evolutionary stage is still very constrained. Post-AGB stars are characterized by infrared excesses and high luminosities. The publication of precise Gaia DR3 parallaxes made it possible to calculate accurate distances and to revise the derivation of luminosities for post-AGB candidates to discard objects outside the expected luminosity range. By identifying post-AGB stars or possible candidates from the literature, then searching for their Gaia DR3 counterparts and using available photometry, interstellar extinction, published spectroscopically derived temperatures or spectral types and parallax-based distances, we fitted their Spectral Energy Distributions (SED) and we estimated their luminosities and circumstellar extinctions. When compared to models, luminosity values allowed us to disclose objects that are likely post-AGB stars from other target types whose observational properties mimic those of post-AGB stars. The position of our selected sample on the Hertzsprung-Russell (HR) diagram allows direct comparison with updated post-AGB evolutionary tracks and an estimation of their masses and evolutionary ages. A summary of the so far obtained outcome will be here presented.

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1436

Trigonometric parallax and proper motion of Sagittarius A* measured by VERA using the new broad-band back-end system OCTAVE-DAS

Dr Tomoaki Oyama[1], Dr Takumi Nagayama[1], Dr Aya Yamauchi[1], Dr Daisuke Sakai[1], Prof Hiroshi Imai[2], Prof Mareki Honma[1], Yu Asakura[1], Dr Kazuhiro Hada[1], Prof Yoshiaki Hagiwara[3], Dr Tomoya Hirota[1], Dr Takaaki Jike[1], Dr Yusuke Kono[1], Syunsaku Suzuki[1], Prof Hideyuki Kobayashi[1], Prof Noriyuki Kawaguchi[1]

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Abstract

We successfully measured the trigonometric parallax of Sagittarius A* (Sgr A*) to be 117 ± 17 micro-arcseconds (μas) using the VLBI Exploration of Radio Astrometry (VERA) with the newly developed broad-band signal-processing system named "OCTAVE-DAS." The measured parallax corresponds to a Galactocentric distance at the Sun of $R_0 = 8.5^{+1.5}_{-1.1}$ kpc. By combining the astrometric results with VERA and the Very Long Baseline Array (VLBA) over a monitoring period of 25 years, the proper motion of Sgr A* is obtained to be $(\mu_\alpha, \mu_\delta) = (-3.133 \pm 0.003, -5.575 \pm 0.005)$ mas yr^{-1} in equatorial coordinates, corresponding to $(\mu_l, \mu_b) = (-6.391 \pm 0.005, -0.230 \pm 0.004)$ mas yr^{-1} in Galactic coordinates. This gives an angular orbital velocity of the Sun of $\Omega_\odot = 30.30 \pm 0.02$ km s^{-1} kpc^{-1} . We find upper limits to the core wander, $\Delta\theta < 0.20$ mas (1.6 AU), peculiar motion, $\Delta\mu < 0.10$ mas yr−1 (3.7 km s^{-1}), and acceleration, a < 2.6 μas yr^{-1} (0.10 km s^{-1} yr^{-1}) for Sgr A*. Thus, we obtained upper mass limits of $\approx 3 \times 10^4$ $M_\odot$ and $\approx 3 \times 10^3$ $M_\odot$ for the supposed intermediate-mass black holes at 0.1 and 0.01 pc from the Galactic center, respectively.

Session

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1437

Modeling open clusters in CMD: binaries, mass function, and dynamic effects

Dr Lu Li

Shanghai Astronomical Observatory, CAS

Abstract

As cradles of stars and building blocks of galaxies, open clusters (OCs) encode valuable information about star formation and galaxy evolution. Hence, precisely and robustly measuring the fundamental properties of OCs, including age, metallicity, distance, extinction, stellar mass function (MF), and binary properties, is of great importance. The field star contamination has long been a major obstacle. Here I will present a state-of-the-art Bayesian framework that models the color-magnitude diagram of an observed OC as a mixture of single stars, photometric unresolved binaries, and field stars. Its advanced statistics and comprehensive physical models enable the determination of all the OC properties simultaneously with unprecedented precision and permit exciting discoveries. This method enables us to build a comprehensive OC parameter catalog, in particular, including the MF and binary properties, which were unfeasible in conventional catalogs. Applying the method to Gaia data, we find clear evidence of dynamical evolution in OCs for the first time. Taking NGC3532 as the first example, we find that stars with smaller mass or in the inner region tend to have less low mass-ratio binaries. Using a larger OC sample, we unveil that the MF slope is evolving with cluster age: older OC has flatter MF (i.e., less low mass stars). This is because the dynamic encounters can destroy the low mass-ratio binaries (especially in the cluster center) and kick out low-mass stars. Finally, this method has a great potential to incorporate other stellar models or physical processes in OCs, such as stellar rotation or blue stragglers.

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1478

Machine Learning Approach for the Spectral Classification of Dusty Stellar Sources in the Magellanic Clouds

Sepideh Ghaziasgar[1], Mahdi Abdollahi[1], Dr. Atefeh Javadi[1], Dr. Jacco Th. van Loon[2], Dr. Iain McDonald[3], Amirhossein Masoudnezhad[4], Prof. Habib G. Khosroshahi[1], Dr. Bernard H. Foing[5], Dr. Fatemeh Fazel[5], Dr. Hamidreza Mahani[1]

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Abstract

Dusty stellar point sources contribute to stellar dust emissions and enrichment of galaxies such as the Magellanic Clouds (MCs). We applied supervised machine learning classifiers for dusty stellar point source classification in the MCs, including young stellar objects (YSOs) and evolved stars. We implemented typical algorithms to classify dusty stellar categories comprising YSOs, oxygen- and carbon-rich asymptotic giant branch stars (AGBs), red supergiants (RSGs), and post-AGB stars. In the following, we created synthetic samples based on the minority class using the Synthetic Minority Oversampling Technique (SMOTE) method to resolve the SAGE catalogs' imbalanced spectral counts. The classification accuracy of these sources, which include 619 spectral labeled counts, was assessed using infrared features and multiwavelength filters. Therefore, the Probabilistic Random Forest (PRF) classifier, a tuned Random Forest (RF), performed best among all the models applied before and after data augmentation with the SMOTE. We reached an accuracy of ~89 percent based on the recall metric for the spectral classification. In this study, using the SMOTE technique does not improve the accuracy of the best model for the CAGB, PAGB, and RSG classes; it stays at 100% and 88%, respectively. However, there are variations for the CAGB, OAGB, and YSO classes. We collected photometric labeled data with properties similar to the training dataset and classified them using the top four models with more than 87% accuracy. The labeled data is available for three dusty stellar types, YSOs, oxygen- and carbon-rich AGBs, due to the reliable accuracy we achieved for them in models.

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1505

The imprint of star-formation-driven outflows on the evolution of dwarf galaxies

Dr. Michael Romano

National Centre for Nuclear Research, Warsaw, Poland. INAF - Osservatorio Astronomico di Padova, Padova, Italy

Abstract

Feedback from stars and active galactic nuclei is one of the most important processes steering the baryon cycle in galaxies, i.e., the set of complex phenomena driving the interplay between gas, dust, and star formation in their interstellar medium (ISM). Such a feedback could be strong enough to produce galactic-scale outflows able to sweep the gas out of the galaxies, drastically shaping their evolution. We investigated the impact of star-formation-driven outflows in local, low-metallicity dwarf galaxies drawn from the Dwarf Galaxy Survey. We made use of Herschel observations to detect atomic outflowing gas in the high-velocity wings of [CII] 158 μm emission line profiles. We found that outflows are ubiquitous in these galaxies, with an average outflow efficiency of the order of unity, at odds with predictions from state-of-the-art chemical evolution models. We estimated that ~40% of the gas entrained by the outflows can be expelled from the ISM, significantly enriching the surrounding circumgalactic medium, and producing extended atomic gas and dust reservoirs around the galaxies. These results highlight the key role of stellar feedback in the baryon cycle of low-mass sources, and are crucial for calibrating cosmological simulations attempting to reproduce the processes ruling the evolution of these galaxies across cosmic time.

Session

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1509

The Rise of r-Process in Dwarf Galaxies

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Abstract

Multimessenger observations of gravitational wave event GW170817 of a neutron star merger (NSM), have confirmed that these sites are capable of producing copious amounts of heavy elements through the rapid neutron capture process (r-process). However, because NSMs are expected to be delayed by billions of years, it is unclear how much they can actually contribute to the chemical enrichment of galaxies. Prompt sources of r-process, such as exotic kinds of supernovae, are theoretically promising for producing heavy elements in the early universe, but observational evidence is lacking. One way to investigate which is the dominant source of r-process is to look at the chemical evolution of dwarf galaxies, which are relatively simple systems in comparison to the Milky Way. We studied the r-process signature in a disrupted dwarf galaxy in the form of a stellar stream in the Galactic halo, referred to as Wukong or LMS-1. Stars in Wukong/LMS-1 are much closer than classical surviving Milky Way satellites and are, hence, much brighter and amenable to high-resolution spectroscopy, which is necessary to detect the heaviest elements. We discovered that Wukong/LMS-1 is the first example of a galaxy that has been enriched in r-process elements predominantly by NSMs. This finding confirms that NSMs not only do happen, but are actually important contributors to the chemical evolution of galaxies. Future observations of additional disrupted and/or surviving dwarf galaxies will finally answer if NSMs alone contribute to all r-process across cosmic history of if prompt sources are also involved.

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1584

Mass-loss rates and dust production from cool evolved stars in the Local Group galaxies

Dr Atefeh Javadi[1], Dr Jacco van Loon[2]

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Abstract

The final stages of stellar evolution are critical for the evolution of galaxies because the processed matter is returned to the interstellar medium (ISM). Furthermore, the feedback from cool evolved stars is in the form of dust grains that play an important role in the temperature regulation of ISM, chemistry, and formation of planets. To begin, to understand the mass-loss mechanism we: [1] carried out a census of cool evolved stars in the majority of Local Group galaxies via long-term monitoring surveys in optical and near-IR wavelengths [2] performed accurate modeling of spectral energy distribution (SEDs) to measure the excess infrared emission from dust produced by these stars and to quantify the amount of matter they return to the interstellar medium. In this paper, I first present the mass-loss rates of cool evolved stars in a wide range of masses to see how mass loss mechanism acts in different populations (RGBs, AGBs (M-type or carbon stars) and RSGs) and to investigate whether it differs in different environments. Then, I will discuss the ISM replenishment by mass-loss via cool evolved stars in different galaxies.

Session

Division H Interstellar Matter and Local Universe

1624

Global insight into the properties of Infrared bright galaxies via panchromatic SED modeling

Subhrata Dey

Astronomical Observatory of Jagiellonian University

Abstract

We present the detailed spectral energy distribution (SED) modeling of 14 local (ultra)luminous infrared galaxies (U/LIRGs) with outstanding photometric data from the literature covering ultraviolet-far-infrared and radio bands (~50 MHz to ~30 GHz). We employ the CIGALE SED fitting code for ultraviolet--far-infrared--radio SED modeling. For radio-only SED modeling, we use the UltraNest package, leveraging its nested sampling algorithm. Combining results from our previous study on 11 LIRGs, we discuss the global astrophysical properties of a sample of 25 starburst galaxies ($z<0.5$). Their radio spectra are frequently characterized by bends and turnovers, with no indication of ULIRGs exhibiting more complicated SEDs than LIRGs despite showing more signs of interactions. Including radio measurements in CIGALE modeling constrained the dust luminosity and star formation rate (SFR) estimates by more than one order of magnitude better than previously reported for starburst galaxies. We show that total and nonthermal radio luminosity at 1.4 and 4.8 GHz frequencies can be good estimators of the recent SFR for all LIRGs and those ULIRGS with insignificant AGN influence. A weaker but still significant correlation is observed between radio SFR at 1.4 GHz and old (averaged over 100 Myr) SFR based on SED modeling, indicative of multiple episodes of starburst activity during their lifetime. The thermal radio luminosity at 4.8 GHz is a better tracer of recent star formation than the thermal luminosity at 1.4 GHz.

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1662

Multi-Screen scattering in Fast Radio Bursts to probe extragalactic ISM

Mr. Sachin Pradeep Etakkepravan Thulicheri

Max Planck Institute for Radio Astronomy

Abstract

Fast Radio Bursts (FRBs) are known for their scintillation and scattering phenomena, often attributed to multiple screens within the interstellar medium (ISM). These plasma screens, spanning from 1-100 AU in scale, cause multipath propagation and angular broadening of single pulses. When two screens appear "pointlike" to each other, they scintillate on both small and large scales, aiding in constraining scattering to FRB host galaxies.In this study, we use simulations to explore this regime, revealing that when one screen resolves the other, it quenches Milky Way scintillations.

We introduce a new theoretical framework to study multi-screen scattering of single pulses, considering the cosmological nature of FRBs and the screens involved. Our primary goal is to understand how pulses appear when screens resolve each other, allowing us to distinguish such systems.

Simulations show that changes in the scintillation pattern over time in the dynamic spectra of the pulse I(t,v) is the key. Moreover, we propose an updated formula for locating the host galaxy screen from the FRB source, giving insights into probing extragalactic ISM structures at AU scales. This approach also opens up avenues in calculating the velocities of such plasma screens, particularly when a sufficient number of bursts allows for the analysis of secondary spectra.

An intriguing prospect is the use of such screens as cosmic lenses to constrain emission region sizes from pulsars, FRBs, and other coherent emissions from neutron stars. Through simulation studies, we have devised a novel observational technique for this purpose.

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1800

New Candidate Proplyds in the Orion NGC 1977 and NGC 2024 Clusters

Dr. Ryan Boyden

University of Virginia. Space Science Institute

Abstract

I will present new results from my VLA programs that aim to constrain the photoevaporative mass-loss rates of protoplanetary disks in the Orion NGC 1977 and NGC 2024 clusters. Both clusters were recently found to host populations of externally evaporating disks (i.e., “proplyds”), but the HST observations used to discover these photoevaporating disks only targeted a small area of each cluster. My VLA programs have mapped all of NGC 1977 and NGC 2024 at high sensitivity and high angular resolution over multiple radio continuum bands, allowing for the first systematic search of photoevaporating disks in clustered star-forming regions with less extreme radiation environments than the Orion Nebula Cluster. We identify several-dozen new candidate proplyds in NGC 1977 and NGC 2024, as evidenced by their centimeter-wavelength morphologies and free-free emission spectra. We measure the photoevaporative mass-loss rates using the observed brightness of the free-free emission, and find typical mass-loss rates of ~10^(-8) Msun/yr. These mass-loss rates, combined with the discovery of additional proplyds in each region, indicate that disks in NGC 1977 and NGC 2024 are impacted by the external environment, but to a lesser degree than disks in the Orion Nebula Cluster. Overall, this study highlights the importance of external photoevaporation over a range of cluster conditions, and it lays the groundworks for future studies of disk photoevaporation that will be achievable in more distant, yet more typical, star-forming clusters with next-generation radio interferometeric facilities like SKA and, eventually, ngVLA.

Session

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1808

Comprehensive Compilation of Stellar Data in M33's Central Region: Unveiling the Final-Stage Evolution Through Near-Infrared Survey

ms Mina Alizadeh[1,2], Dr. Atefeh Javadi[2], Prof. Jacco Van Loon[3], Dr. Yousef Ali Abedini[1], Dr. Hedieh Abdollahi[2]

[1]University of Zanjan. [2]IPM (Institute for theoretical Physics and Mathematics). [3]Keele University

Abstract

We obtained data using three cameras at the UK InfraRed Telescope (UKIRT) between 2003 and 2007. The observations in the K-band were conducted by the UKIRT Fast-Track Imager (UFTI) over three consecutive nights in August 2005. The Wide Field Camera (WFCAM) data in the J and H bands were collected between 2005 and 2007. Additionally, UIST data in the K-band for the central region of M33 were gathered from 2003 to 2007.

Our focus was on stars in the final stage of their evolution, where luminosity is more directly related to birth mass. By combining data from multiple instruments and projects, we aim to identify long-period variables in the galaxy's central region, as this area provides the deepest and most comprehensive investigation of the galactic center due to the nature of the data. The identification of variables will involve photometry on the WFCAM data with PSF calibration followed by a re-examination of the data.

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1849

Novel Chemical Abundance Measurements with JWST MIRI/MRS

Dr. Noah Rogers[1], Dr. Evan Skillman[2], Dr. Danielle Berg[3], Dr. Rick Pogge[4], Dr. Karla Arellano-Cordova[5]

[1]CIERA, Northwestern University. [2]University of Minnesota - Twin Cities. [3]University of Texas at Austin. [4]The Ohio State University. [5]University of Edinburgh

Abstract

Gas-phase chemical abundances are powerful tracers of star formation and galactic evolutionary mechanisms. To constrain the overall metallicity of the interstellar medium, many prior galaxy surveys have relied on strong-line abundance diagnostics, which relate the emission of intense optical collisionally-excited lines to the O/H abundance in a nebula. However, these diagnostics have been shown to have large variation and discrepancies when calibrated on empirical or photoionization model data. One alternative is to utilize the IR fine-structure lines, which are insensitive to the electron temperature and reddening, and which accurately probe gas-phase abundances/ionization conditions. We present new JWST MIR observations of multiple extragalactic H II regions in the spiral galaxies M33 and M101 with prior direct T_e and abundance measurements from the CHAOS survey. We provide the first empirical calibration of Ne_{23}, a novel MIR abundance diagnostic that can infer O/H in high-metallicity or obscured environments from the MIR Ne fine-structure lines and H I recombination lines. We employ other intense fine-structure emission lines to directly calculate the gas-phase abundance of Ne, S, and Ar from all relevant ionization states. The total abundances of these alpha elements are compared to the optical abundance measurements to assess the validity of ionization correction factors that are commonly adopted for chemical abundance inferences in local and high-z galaxies.

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1850

Ages and metallicities of stellar clusters using S-PLUS narrow-band integrated photometry: the Small Magellanic Cloud

Gabriel Fabiano de Souza, Guilherme Limberg

Universidade de São Paulo

Abstract

The Magellanic Clouds are irregular dwarf-galaxies and are among the largest and closest of the Milky Way, with stars covering every age. This makes them an important laboratory for validating methods to understand the evolution of stellar populations and their star-formation processes, which can then be applied to more distant galaxies. In this work, the characterization of the populations of a set of stellar clusters of the Small Magellanic Cloud (SMC) is made, for the first time, using the Southern Photometric Local Universe survey (S-PLUS). Through its 7 narrow bands centered on important spectral lines, we can obtain more information about stellar populations, also counting on 5 broad bands similar to those of the Sloan Digital Sky Survey. Two methods were used to determine ages and metallicities. The first was done by adjusting S-PLUS observed colors to the colors of simple stellar population models. The second was BAGPIPES, which fits spectral energy distributions in a Bayesian framework. Both methods were validated to stellar clusters of the SMC whose parameters are well known and that have S-PLUS photometry and then applied to new determinations in the SMC.

Session

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2048

Galactic Supernova Candidates Discovered by MeerKAT

Dr. Loren Anderson

West Virginia University

Abstract

It is well-known that the census of Galactic supernova remnants (SNRs) is incomplete. This incompleteness is thought to arise from difficulties locating Galactic SNRs due to confusion (mainly with HII regions) and a lack of sensitivity. Recent works have shown that sensitive radio continuum data, when combined with data in the mid-infrared (MIR), can identify new SNR candidates. While thermally-emitting HII regions have strong MIR and radio continuum emission, non-thermally emitting SNRs are deficient in MIR emission. We here discuss our recent work with new 1.3 GHz South African Radio Astronomy Observatory (SARAO) MeerKAT Galactic Plane Survey continuum data to identify new SNR candidates in the inner Galaxy. The MeerKAT data boast an angular resolution of 8" and are sensitive to a wide range of size scales, making them ideal for SNR searches. We have identified nearly 200 new SNR candidates and objects of interest. SNR candidates identified using the MIR/radio continuum criterion require additional information to confirm that they are true SNRs, namely determination of negative spectral indices, detection of polarized radio continuum emission, or association with high-energy emission. If confirmed, these SNR candidates would increase the known Galactic SNR population by ~50%.

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2129

Constraining the icy origin of H_2CO in Protoplanetary Disks

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Abstract

Protoplanetary disks are considered a material reservoir for planetary assembly. Hence, resolving the spatial distribution of complex organic molecules (COMs) in protoplanetary disks is crucial in estimating the potential habitability of other worlds. Unfortunately, a significant portion of the organic inventory is thought to be locked on the surface of dust grains, mostly the O-bearing COMs. In this case, smaller but brighter tracers like formaldehyde (H_2CO) could be used. H_2CO is a small organic molecule considered a precursor of O-bearing COMs on the icy surfaces of dust grains, but gas-phase reactions can also form it. Since the specific contribution of each mechanism is poorly constrained, determining the dominant formation pathway of H_2CO is necessary for setting up its potential as a tracer of the cold reservoir in protoplanetary disks. In this context, we present spectrally and spatially resolved ALMA observations of several H_2CO lines toward the bright Herbig Ae protoplanetary disk HD 163296. We determined the excitation conditions of H_2CO as a function of disk radius and put constraints on the height of H_2CO emission to get clues about its formation. In contrast to TW Hya, a T Tauri disk where the cold gas-phase chemistry is expected to predominate, a significant contribution from dust-grain surface chemistry cannot be discarded in HD 163296. Additionally, to obtain more representative statistics of H_2CO formation, we complement our analysis with the early results from the DECO ALMA large program, thus adding an extensive sample of 80 protoplanetary disks with multiple H_2CO transitions.

Session

Division H Interstellar Matter and Local Universe

2146

Protostars and young disks with JWST

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Abstract

Understanding how stars and planets are built requires observations at long wavelengths in order to penetrate their dusty natal clouds. Webb is orders of magnitude more sensitive than previous missions and has subarcsec resolution in the infrared. Webb is therefore eminently suited to study the physical and chemical structure of embedded protostars and disks. In addition to jets and outflows, rich ice spectra are seen in the cold outer envelopes of protostars providing evidence for the presence of simple and complex molecules in ices, including salts. In addition, gaseous molecules such as CO, CO2 and water are seen in the mid-infrared spectra. These lines can be used to probe the composition of hot cores and young disks in the embedded stage and compare this with results found around T Tauri stars, whose rich spectra show many lines from gaseous molecules including surprising new hydrocarbon molecules. Together they point to a rich chemistry with a varying composition and C/O ratio that may be linked to stellar mass and to the physical structure of the system. Results from the first year of observations of the JOYS+ program will be presented. See miri.strw.leidenuniv.nl for more details.

Session

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Dust evolution across PDRs using JWST data

Dr Meriem Elyajouri

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Abstract

Using JWST spectro-imaging, we conducted a quantitative analysis of the observations from two photon-dominated regions (PDRs) with different physical conditions: The Orion Bar (ERS PDRs4All [1]) and Horsehead Nebula (GTO 1192, [2]).

Our analysis with the THEMIS dust model [3] and the SOC radiative transfer model [4] resolved, for the first time, the very strong density gradient and revealed unprecedented constraints on the properties of dust grains: depletion of nano-grains in the atomic region and variations in the hydrogenation of nano-grains in different regions of the PDRs [5].

These constraints truly challenge our understanding of the physics and chemistry of PDRs, given that nano-grains are responsible for the majority of UV radiation attenuation, gas heating via the photoelectric effect, and the formation of H2 on their surface. In conclusion, We showed that it is not possible to reproduce the observations in the PDRs using grains from the diffuse interstellar medium. Therefore, it is necessary to evolve the grains by altering their properties to understand the observations in PDRs.

[1] Berné *et al PASP* **134** 054301 (2022)

[2] Abergel et al. subm.

[3] Jones, A. P., Fanciullo, L., Köhler, M., et al., A&A, 558, A62 (2013)

[4] Juvela M., Astronomy and Astrophysics, 622, A79 (2019)

[5] Elyajouri et al., A&A, Forthcoming article (2023)

Session

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2208

On the Formation of Massive Stars in Filamentary Clouds: Importance of Edge Collapse Process

Dr. Naval Kishor Bhadari, Dr. Lokesh Kumar Dewangan

Physical Research Laboratory, Ahmedabad

Abstract

Recent studies, utilizing infrared and millimeter observations of the interstellar medium (ISM), have unveiled a complex network of dusty and gaseous filaments closely associated with star-forming regions. How these filaments play a role in star formation processes is one of the hot topics of debate in astronomy. Our recent investigations, utilizing multiwavelength data, have shed light on a rarely observed physical process in isolated filaments named "end-dominated collapse (EDC)," demonstrating its pivotal role in mass assembly for the formation of star clusters including massive stars. The EDC process, propelled solely by filament self-gravity, leads to the formation of dense clumps at the ends of the filament. Thus far, a handful of EDC filaments are observed and raised questions on the commonality of this process in filaments. We have identified three such potential filaments: Monoceros R1 (length ~14 pc, mass ~1465 Msun), a Giant molecular filament (GMF) G45.3+0.1 (length ~75 pc, mass ~1.1 × 10^6 Msun), and IC 5146 dark Streamer (length ~8 pc). Additionally, the configuration of multiple converging small-scale sub-filaments (~1-5 pc), known as hub-filament systems (HFSs), is primarily observed at the ends of the filament. Our study also unveils a new observational proxy of the EDC process as the bending of magnetic field lines at the end of filaments. This presentation provides a comprehensive overview of recent progress in this area and the importance of the EDC process along with HFSs in massive star formation.

Session

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2218

Role of Magnetic fields in Star-formation: New Insights into the Galactic 'Snake' IRDC G11.11-0.12

Mr Omkar Jadhav[1], Dr. Lokesh Kumar Dewangan[2]

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Abstract

Observational studies indicate Infrared Dark Clouds (IRDCs) are significant for understanding massive star and protostar formation, with magnetic fields playing a key role in their stability. However, their exact role in the early stages of star formation remains unclear. Our study focuses on the Galactic 'Snake' IRDC G11.11-0.12, using SOFIA HAWC+ 214 µm polarimetric data, allowing us to study the plane of the sky (POS) magnetic field (B-field) morphology. We observe perpendicular B-field orientations across the cloud G11, with a notable shift towards the center. We generated a POS B-field map using the Davis-Chandrasekhar-Fermi Method and computed mass-to-flux ratios, revealing both subcritical and supercritical regions in the cloud. The local gravitational field vectors are also calculated towards the cloud using the 214 µm intensity map. However, embedded protostars are found toward the entire cloud. Interestingly, dust condensations hosting previously known high-mass protostellar candidates p1 and p6 seem to be subcritical and supercritical, respectively. Our analysis of the cloud's Position-Position-Velocity map revealed large-scale periodic velocity oscillations. In comparison with the existing Gravitationally Induced (GI) core-collapse model, it was observed that the detected oscillations arise from a combination of the kinematics associated with the GI core collapse model and the oscillation of large-scale physical filaments. The existing JWST near-infrared images reveal a hub-filament configuration (below 10000 AU) around p1 and p6, where new embedded sources are investigated, which are not detected in the existing highly sensitive IR surveys. In this presentation, I will provide a more thorough analysis of our findings.

Session

Division H Interstellar Matter and Local Universe

2229

Dust distribution in the Galactic plane using interstellar polarimetry

Dr Namita Uppal, Prof Shashikiran Ganesh

Physical Research Laboratory, Ahmedabad, India

Abstract

Dust, despite constituting only 1% of the mass of the interstellar medium, has a profound effect on our view of the Galaxy. It is majorly confined within the disk of the Galaxy, making it an ideal candidate for investigating the Galactic structure, particularly the spiral arms. Interstellar dust emits thermal radiation primarily in the longer wavelengths, where the effect of extinction is minimized. Studying the three-dimensional dust distribution in the Galaxy at longer wavelengths may cause discrepancies due to distance ambiguity and assumptions of Galactic rotation models.

Instead of directly tracing dust at longer wavelengths, we aim to investigate the efficacy of the ISM polarization in combination with Gaia distances as an indirect probe for the line of sight dust distribution. We conducted the R-band polarization observation of fifteen Galactic open-clusters distributed roughly in three lines of sight. The clusters were selected at varying distances to infer the number of dust layers present along each line of sight. The observations were conducted using Imaging polarimeters, EMPOL (EMCCD-based POLarimeter) and AIMPOL (ARIES IMaging POLarimeter) available on 1.2m and 1.04m telescopes, respectively hosted by the Physical Research Laboratory and Aryabhatta Research Institute of Observational Science, India. Through careful observation strategies and meticulous data reduction, our study has revealed indications of local and global features, like spiral arms of the Galaxy. These findings highlight the significance of polarization observations for studying the Galactic structure and strongly justify the need for a dedicated polarisation survey to be carried out in the entire Galactic plane.

Session

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2253

A new insight on the dust properties of low surface brightness galaxies

Dr. Junais Junais

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Abstract

Low surface brightness galaxies (LSBs) contribute a large fraction to the number density of galaxies, but their properties are still poorly known. LSBs are often considered dust poor, based only on a few studies. We use, for the first time, a large sample of LSBs and high surface brightness galaxies (HSBs) with deep observational data to study their dust properties. Our sample consists of 1631 optically selected galaxies at z<0.1 from the North Ecliptic Pole (NEP) wide field. We use the large set of data available in this field, from UV to FIR. By performing a spectral energy distribution fitting, we found that the majority of LSBs in our sample have negligible dust attenuation (Av < 0.1 mag), except for about 4% of LSBs that show significant attenuation with a mean Av of 0.8 mag. We found that these LSBs also have a high r-band mass-to-light ratio (M/Lr>3 Msun/Lsun), and show similarity to the extreme giant LSBs from the literature. This work provides a large catalog of LSBs and HSBs with detailed measurements of their several optical and infrared physical properties. Our results suggest that the dust content of LSBs is more varied than previously thought, with some of them having significant attenuation making them fainter than their intrinsic value. This will have serious implications for the observation and analysis of LSBs with current/upcoming surveys like JWST and LSST.

Session

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2287

Cosmic-ray propagation and feedback in star-forming environments

Dr Lucia Armillotta[1], Prof. Eve Ostriker[1], Dr Yan-Fei Jiang[2]

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Abstract

In recent years, there has been a growing interest in understanding the role of cosmic rays (CRs) in shaping galaxy evolution. MHD galaxy simulations including CRs have demonstrated that they may significantly contribute to the dynamics of the interstellar medium (ISM), regulating the level of star formation and driving large-scale outflows. However, the degree to which CRs influence these phenomena is highly contingent upon the chosen CR transport prescription within the model. To address this issue, we have recently developed a transport prescription that is grounded in physical principles rather than empirical considerations, aiming for a more realistic representation of CR physics in ISM simulations. This novel prescription has been employed to compute the propagation of CRs in three different galactic environments typical of nearby disk galaxies reproduced by the TIGRESS simulations. Together, the three simulated environments cover a wide range of gas surface density, gravitational potential, and star formation rate (SFR). Our results show that in the disk region the CR pressure to gas pressure ratio decreases with increasing SFR. The dynamical impact of CRs is therefore expected to increase in environments with lower SFR. Predictions from the simulations suggest limited support against gravity for most of the ISM mass near the midplane, but notable impacts on extraplanar dynamics (i.e., galactic fountains/winds).

Session

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2291

Probing the star cluster population to trace the star formation history of Arp 147

Ms Miora Rakototafika[1], Mrs Zara Randriamanakoto[2]

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Abstract

Collisional ring galaxies (CRGs) are rare and peculiar objects that offer insight into young massive star cluster (YMC) formation and evolution mechanisms. Studying star clusters in CRGs can provide valuable information about the galaxy star formation history and a better understanding of the earliest phases of star formation. We report a photometric study of YMC complexes in the CRG Arp 147 with the aim to assess the influence of the host environment on the star cluster properties and star formation mechanisms. We use HST BRI-band observations (PSF ~ 0.15") to derive the ages and masses of the star-forming knots and clumpy regions. By fitting our photometric catalogue to SSP models such as Yggdrasil and Starburst99, we find that the majority of the YMCs spread across the ring have ages < 10 Myr and masses > 10^5 $M_\odot$. The flat azimuthal distribution of the cluster ages points toward a popcorn star formation scenario, ie. there is no expected age gradient along the ring. We also estimate the number stars that form in bound clusters, known as cluster formation efficiency Γ. In the case of Arp 147, Γ > 20% which is in agreement with a new starburst activity triggered by the head-on collision happening 50 Myr ago. Overall, our findings imply that the cluster population of the CRG consists of a mix of pre-collision and post-collision YMC complexes, and with their properties likely affected by their host environment at least on sub-galactic scales.

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2332

Extinction Map Construction and Extinction Law Calculation of Nearby Galaxies

Dr. Yuxi Wang

Department of Astronomy, Qilu Normal University

Abstract

Interstellar extinction refers to the absorption and scattering of starlight by dust. The multi-band extinction laws are crucial to recover the intrinsic energy
distribution of celestial objects and infer the characteristics of interstellar dust. Meanwhile, extinction maps of galaxies contribute to the dust distribution
in galaxies and the structure of galaxies and are essential tools to study the stellar population and the star formation history in galaxies. The current studies
of extinction in nearby galaxies are limited to a few galaxies. As a result, there is large uncertainty about the nature and dust distribution, stellar population,
and star formation history of nearby galaxies. By introducing the dust model to simulate the effect of dust on stellar radiation innovatively, this project plans
to: (1) construct dust extinction maps of nearby galaxies with member stars as tracers, and analyze the dust distribution in different galaxies; (2) calculate
the multiband extinction laws toward more sight lines in the Large Magellanic Cloud, the Small Magellanic Cloud, and other nearby galaxies with blue supergiants
as extinction tracers, and analyze the dust properties in different interstellar environments; (3) predict the multiband extinction toward different sight lines in
nearby galaxies by combining the obtained extinction maps and extinction laws and provide extinction corrections for the observation of the Chinese Survey Space
Telescope (CSST) and related scientific objectives.

Session

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2356

Structure, Extinction and Properties of Nearby Molecular Clouds

Zhetai Cao, Professor Biwei Jiang

Beijing Normal University

Abstract

Molecular clouds (MCs), as the star birthplaces, are generally dense that causes high extinction. A precise estimation of the extinction with distance is crucial to revealing the structure and understanding the dust properties in various star-forming environments. The nearby MCs to be studied in this work, specifically the Taurus MC (hereafter TMC), Orion MC (OMC), Perseus MC (PMC), represent different including massive and low-mass star-forming environments. With precise measurements and large quantity of tracers, a 3D dustmap of MCs can be calculated within 600pc, and the extinction curve from ultraviolet to infrared for single MCs instead of overlapped MCs along sightline can be studied and compared in different extinction levels and different environments. Besides, there exists a significant differences of ice absorptions in different MCs, which can be promoted into a large area.

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Pre- and protostellar cores in the 200 brightest Planck compact sources

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Abstract

The Planck compact source catalogue provides excellent samples for studying the earliest phases of star formation. Covering all galactic longitudes and latitudes they can give an overview of how star formation varies throughout the Milky Way, enabling a better insight into star formation out of the Galactic plane, where our current understanding is restricted mostly to nearby clouds. We examined the 200 brightest Planck compact sources visible from the northern hemisphere using observations from the James Clerk Maxwell Telescope's SCUBA2 bolometer array. Its high resolution revealed diverse, mostly filamentary structures, and allowed the extraction of point sources from the maps. We classified more than 1500 of these point sources and compiled a catalogue with their positions, sizes, and physical parameters. In our statistical analysis, we investigate properties of star-forming regions at different latitudes, aiming to better understand the flow of interstellar matter in the Galaxy and thus refine our latest view of the Milky Way.

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2474

The ngVLA as a gamechanger

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Abstract

The Next Generation Very Large Array (ngVLA) is one of the main astronomical infrastructure projects expected to achieve full operations in the 2030s. In this talk, a brief summary of the technical and scientific capabilities of the ngVLA will be presented. The ngVLA receiver systems will cover a wide range of frequencies (1.2–116 GHz) with large instantaneous bandwidths. With its high sensitivity and high angular resolution, it will complement the radio-frequency coverage of ALMA and SKA. Examples will be shown to demonstrate the ngVLA's abilities to observe the continuum and line emission of the interstellar medium in the northern sky. Simulation results for basic transitions of several key molecules will be also presented.

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2527

The undiscovered ultra-diffuse galaxies of the Local Group

Dr Oliver Newton[1], Dr Arianna Di Cintio[2,3], Dr Salvador Cardona-Barrero[2,3], Dr Noam Libeskind[4], Prof. Yehuda Hoffman[5], Prof. Alexander Knebe[6,7,8], Dr Jenny Sorce[9,10], Prof. Elmo Tempel[11,12]

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Abstract

Ultra-diffuse galaxies (UDGs) are attractive candidates to probe cosmological models and test theories of galaxy formation at low masses; however, they are difficult to detect because of their low surface brightness. In the Local Group a handful of confirmed and candidate UDGs have been found to date, most of which are satellites of the Milky Way and M31, and only three are isolated galaxies. It is unclear whether so few UDGs are expected. We address this by studying the population of UDGs formed in hydrodynamic constrained simulations of the Local Group from the HESTIA suite. For a Local Group with a total enclosed mass, M (< 2.5 Mpc) = 8×10^{12} $M_\odot$, we predict that there are 12 ± 3 isolated UDGs (68% confidence) with stellar masses between 10^6 and 10^9 $M_\odot$, and effective radii $R_e \geq 1.5$ kpc, within 2.5 Mpc of the Local Group, of which 2^{+2}_{-1} (68% confidence) are detectable and classified as UDGs in the footprint of the Sloan Digital Sky Survey (SDSS). Accounting for survey incompleteness, we find that almost the entire population of UDGs in the Local Group field would be observable in a future all-sky survey with a depth similar to the SDSS, the Dark Energy Survey, or the Legacy Survey of Space and Time. Our results suggest that there is a population of UDGs in the Local Group awaiting discovery.

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2533

Radiative transfer modelling of nearby face-on spiral galaxies

Mr Christopher Inman[1], Prof Cristina Popescu[1], Dr Mark Rushton[2], Dr David Murphy[1]

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Abstract

Radiative transfer models are ideal tools for decoding the spectral and spatial energy distribution of galaxies. Yet, because of the complexity and computational demands involved, until recently, only a couple of individual star-forming galaxies had been modelled in detail using this procedure. Here we present the modelling of a small sample of face-on nearby galaxies with detailed imaging information in the UV/optical/MIR/FIR/submm spectral range: M33, M51, NGC628, NGC3938, M101 and the LMC. We show that we can successfully account for the panchromatic imaging data. We derive the spatial distribution of Star-Formation Rate, stellar mass, specific star formation rate, dust mass, dust attenuation and radiation fields and discuss the implications of these results for our understanding of the star formation process in galaxies. We review the challenges, advances and future perspectives in the field.

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2591

Dust polarization observations tracing magnetic fields in nearby galaxies

Rosita Paladino

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Abstract

The properties of the multi-phase interstellar medium (ISM) in nearby galaxies can be nowadays investigated with unprecedented accuracy, thanks to the current observational facilities.

Among the components of the ISM, magnetic fields are the most difficult to detect, since they cannot be observed directly, but specific observations are needed to measure their effects.

To date, large-scale magnetic fields in external galaxies have mostly been probed through polarized synchrotron radiation, due to ultra-relativistic electrons spiralling along magnetic fields lines. These observations trace mostly the warm gas in the galaxies halos.

Dust polarization, due to the alignment of dust grain with magnetic fields, observed at far-IR - sub-mm frequencies, can also be used to trace magnetic fields in the cold and dense gas component.

Many observations of dust polarization are available for Milky Way dense regions, although complicated from our position inside the Galaxy.

Nearby galaxies allow a view from outside and observations of dust polarization at cloud scales are very important to trace magnetic field across the hierarchy of spatial scales involved in star formation and through the multiple phases of the interstellar medium.

ALMA, with its unprecedented combination of sensitivity and resolution in full-polarization observations at submm wavelengths, allows for the first time to observe dust polarization and magnetic field structure at spatial scales of giant molecular clouds in nearby galaxies.

I will provide an overview on the technical challenges of full polarization observations with ALMA, and highlight some recent results obtained studying dust polarization in the nearby Universe.

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2594

WISDOM: Molecular cloud properties and star-formation efficiency

Prof Martin Bureau

University of Oxford

Abstract

Using observations from the WISDOM survey that spatially resolve (1-30 pc) individual molecular clouds across the Hubble sequence, we reveal a clear dependence of the nature of the molecular interstellar medium of galaxies on Hubble type, and present a simple diagnostic of cloud formation. In particular, i) we highlight the shortcomings of the usual virial approach to clouds as self-gravitating objects, and stress the importance of the external galactic potential and in-plane shear to regulate the dynamical states of clouds. ii) We also introduce a simple but powerful cloud-cloud collision formalism that accounts for the cloud properties in both nearby and high-redshift systems. iii) We reveal much steeper size - linewidth relations in the inner parts of barred disc galaxies. Finally, using observations of the ionised gas from the SITELLE instrument, we discuss the impact of these different mechanisms on the star formation efficiency of the clouds and thus the quenching of star formation, particularly in galaxy nuclei and spheroids (morphological quenching).

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The state of the HCN/H13CN ejecta of V4334 Sgr (Sakurai's star)

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Abstract

It is assumed that about 10-20% of the central stars of planetary nebulae (PN) undergo a very late thermal pulse (VLTP). This phenomenon is so violent that the pre-white dwarf star briefly reverts to the asymptotic giant branch and becomes a "born-again" red giant, which then undergoes a second PN stage. The ejecta of this last phase are extremely H-poor, hosted inside the evolved H-rich PN. V4334 Sgr (Sakurai's star) is one of the only two objects caught in this rapid and rare evolutionary stage in the last century, and it is the only star that has been observed with modern nowadays instruments. It experienced the VLTP on the white dwarf cooling track in the early 1990s. Since then it has been observed at almost all wavelengths. However, the dense dusty cocoon obscures the rapid stellar evolution of the nucleus in the visual and near-infrared range. Radio observations are therefore one of the cornerstones of the investigation.

In this work, we will present our results on the state of the molecular HCN and H13CN ejecta of the circumstellar envelope of V4334 Sgr, which we derived from APEX observations of 2019. We used three transition lines of HCN and H13CN each, taken within a few days. This allowed us to derive physical properties such as density, optical depth, temperature, and the carbon isotope ratio in the cool ejecta of this unique target.

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The Age-Dependent Vertical Actions of Young Stars in the Galaxy

Domenica Garzon[1], Dr. Neige Frankel[2], Dr. Eleonora Zari[3], Dr. Maosheng Xian[4], Dr. Hans-Walter Rix[3]

[1]University of Illinois Urbana-Champaign. [2]Canadian Institute for Theoretical Astrophysics, University of Toronto. [3]Max Planck Institute for Astronomy. [4]Beijing Normal University

Abstract

Stars in the Galactic disk are born on cold, nearly circular orbits confined to the midplane of the disk. Over time, these orbits change due to small or large-scale perturbations. Understanding the vertical motions of stars in the Galactic disk is pivotal for deciphering the dynamical and evolutionary history of the Milky Way. Such heating phenomena are well-constrained for old stars in the Galactic disk. But what happens to the orbits of stars shortly after they are born? We investigate the vertical motions of young stars using a sample of OBA stars from Gaia E/DR3 and LAMOST. We quantify the relation between stars' mean vertical actions and their ages as a function of Galactocentric radii. While this trend suggests a phenomenon known as "heating," other dynamics within the galactic disk might offer different interpretations.

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Large-scale H-alpha emission in the M81 group of galaxies discovered by the pathfinder Dragonfly Spectral Line Mapper

Dr. Deborah Lokhorst[1], Seery Chen[2], Prof Bob Abraham[2], Imad Pasha[3], Prof. Pieter van Dokkum[3]

[1]NRC Herzberg Astronomy & Astrophysics Research Centre. [2]University of Toronto. [3]Yale University

Abstract

We present deep wide-field H-alpha and [NII] imaging of the M81 group of galaxies, which was collected by the latest evolution of the Dragonfly Telephoto Array: the pathfinder Dragonfly Spectral Line Mapper. The Dragonfly Spectral Line Mapper is an ultra-narrow bandpass imager built to directly image the circumgalactic media of local galaxies. The pathfinder imaging of the M81 group revealed a colossal cloud of ionized gas at the virial radius of M82, along with an abundance of ionized gas surrounding the M81 and M82 galaxies. We discuss potential origins of the cloud and its connection to the M82 starburst as well as implications for the star formation history and feedback in M82. The pathfinder imaging of the M81 group is just the tip of the iceberg, as the full Dragonfly Spectral Line Mapper has 40 times more collecting area than the pathfinder. The full Dragonfly Spectral Line Mapper finished commissioning at the end of 2023, and we are currently carrying out a survey of the circumgalactic medium of galaxies in the local Universe. We present the first results of this survey, which reveals H-alpha, [NII], and [OIII] emission around galaxies to an order of magnitude lower surface brightnesses than previously detected.

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2744

Discovery and study of the physical properties of high-mass prestellar cores

Discovery and study of the physical properties of high-mass prestellar cores Maxime Valeille-Manet

Laboratoire d'Astrophysique de Bordeaux

Abstract

The study of the early phases of high-mass star formation is a major topic in astrophysics that is still poorly understood. Here we survey for high-mass prestellar core candidates in the data cubes of massive proto-clusters mapped in the ALMA-IMF program at a resolution of 2700 au.

For this purpose, an automatized method for systematically detecting outflows from proto-stellar cores is developed, combining CO and SiO spectra and outflow maps. Cores without significant outflows are considered as excellent candidates to be prestellar cores.

We show that 43 cores with a mass greater than 8 Msol are such good prestellar candidates in the ALMA-IMF survey. They cover a mass range from 8 to 72 Msol, and for a total amount of around 51 high-mass proto-stellar cores in the survey. Among those 43 cores, 14 have a mass greater than 16 Msol and will most certainly form a high-mass star in the future.

We can then derive statistical lifetimes in several bins of mass with lifetimes below 10^5 yr for the most massive cores. We can conclude that the high-mass pre-stellar cores are rare with short statistical lifetimes. But on the other hand, when we compare with the typical free-fall times inside the detected cores, the obtained lifetimes are relatively large with values of the order of 10 x T_ff. Such large values in terms of T_ff strongly suggest the need of a support against gravity to prevent the cores to collapse on a free-fall time as expected.

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Inner structure of L1551 IRS5 binary system and its implication on the morphology at molecular outflow scales

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Instituto de Radioastronomía y Astrofísica - UNAM

Abstract

Single star formation is well studied. However, most stars are formed in binary systems, which may affect the substructure architecture such as the circumbinary disk, inner and outer envelopes, and the outflow. Using the continuum data and the line of $C^{18}O$ (2 -1) obtained with ALMA at band 6, we studied the structure of the protostellar binary system L1551 IRS5 below 3000 AU. This object is a class I binary system with a period of 400 yr, located at the molecular cloud of Taurus (146 pc), with an estimated total mass of 1.1 M_{sun}, and two associated radio jets. We were able to identify the circumbinary disk and the circunstellar disk of each component of the binary, the inner envelope, and the cavity walls created due to the high velocity jets, in addition to updating some physical parameters.

Since the data reveal a particular structure consisting of filaments at the envelopes' scales connecting the outflow to the circumbinary disk, we suspect this structure is affected by the interaction between the binary components. Consequently, we constructed an analytical model that allows us to constrain the contribution of the binarity at the inner part and the outflow morphologies, comparing the observations with this new model.

Session

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Analytical model of the L1551 IRS5 outflow

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Abstract

Single star formation is well studied. However, most stars are formed in binary systems which may affect the substructure architecture and the outflow. We created an analytical model that can be used to predict the influence of the morphology of the outflow and a few dynamic features that can reproduce the emission observed in L1551 IRS5. This model consists of a jet with constant velocity which is moving in a constant direction from the origin. After some time the jet would have reached a certain length. As the jet moves, a part of the envelope will be pushed away due to the thermal pressure produced by the leading shock, and we assume that the lateral shock produced at any given point inside the outflow is ballistically ejected with a velocity perpendicular to the jet direction which will create the outflow locus. This analysis can help us to produce a data cube with position-position-velocity coordinates that can be compared morphologically to the observation, allowing us to explain and discern the outflow contribution from the complex emission due to the binary detected in the L1551 IRS5 system.

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Mid-infrared Variability of Young Stellar Objects in the Small Magellanic Cloud

Dr. Marta Sewilo[1,2], Dr. Joana Oliveira[3], Dr. William Fischer[4], Dr. Lynn Carlson[5], Dr. Remy Indebetouw[6,7], Dr. Jennifer Wiseman[1], Dr. Gregory Sloan[4], Dr. Kathleen Kraemer[8], Dr. Thomas Kuchar[8], Dr. Olivia Jones[9]

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Abstract

Variability is one of the most important characteristics of forming stars, thus understanding physical mechanisms responsible for variability over a range of environments is crucial to understand the star formation process. With a subsolar metallicity and strong UV radiation, the Small Magellanic Cloud (SMC) provides us with an opportunity to study star formation in a significantly different environment than in today's Galaxy. We present the results of the study on the mid-infrared variability of young stellar objects (YSOs) in three star-forming regions of the SMC: N66, N83/N84, and N90. YSOs at a range of evolutionary stages have been identified in these regions by various techniques in multi-wavelength studies. Our analysis is mainly based on the Spitzer Space Telescope's "Young Stellar Object VARiability in the Magellanic Clouds" (YSOVAR-MC) program that imaged N66, N83/N84, and N90 in IRAC 3.6 and 4.5 microns bands. YSOVAR-MC consists of nine epochs of observations over 30 days, designed to capture time variations of the order of hours to weeks. We have constructed a nine-epoch YSOVAR-MC catalog for each region and combined it with additional epochs from other surveys (S^{3}MC, SAGE-SMC, SAGE-VAR, and SMC-Last), resulting in 13 epochs for N83/N84 and N90, and 17 epochs for N66 over 12 years. Using the multi-epoch catalogs and statistical methods, we identify variable intermediate- to high-mass YSOs and establish if the flux variations are periodic or stochastic. We compare our results to those of Galactic studies to investigate the dependence of global mid-infrared YSO variability characteristics on the environment.

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Spatially resolved molecular line ratios in GATOS

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Abstract

Spatially resolved molecular line ratios offer crucial insights into changes in gas excitation resulting from AGN ionization, jets, and star formation. Our goal is to perform an excitation study of molecular gas in the Galactic Activity, Torus, and Outflow Survey (GATOS) survey, exploring signatures that differentiate winds from ambient ISM. We aim to model CO excitation, determining gas temperature, density, and volume using a radiative transfer code (e.g., RADEX). While three CO transitions are optimal, meaningful differences in line ratios can be detected with only two transitions. We identified public ALMA observations of CO(1-0), CO(2-1), and CO(3-2) with spatial resolution better than 0.8". For galaxies with JWST-MRS observations, we will incorporate warm molecular H_2 lines into our analysis. A case study on one the GATOS galaxies reveals that regions with higher excitation, traced by CO(3-2)/CO(2-1) with ALMA and H_2 S1/S3 with JWST, coincide with hot spots of the nuclear radio jet. This example illustrates that radio jets interacting with the gas induce distinct gas-excitation conditions, a phenomenon explored in only a few detailed resolved studies to date.

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Exploring the Galactic latitude dependence of Faraday complexity in the SPASS/ATCA RM catalogue

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Abstract

Magnetic fields are an essential component of the interstellar medium, and measuring their structure and scale in the Milky Way is imperative for a holistic understanding of Galactic astrophysics. Large area legacy surveys of polarised extragalactic radio sources have provided an understanding of the large scale Galactic Faraday screen. With more sensitive follow-up observations of such catalogues, e.g SPASS/ATCA RM catalogue, we can fully understand their systematics to ensure continued legacy value into the SKA era. We report a latitude dependency of the Faraday complexity of polarised sources in this catalogue within 10 deg of the Galactic plane towards the inner Galaxy. We present higher resolution ATCA observations at 2.1 GHz to investigate this trend and measure the contamination of extended Galactic emission in the catalogue. We find an overall decrease in Faraday complexity in these sources with our higher angular resolution observations. With a complexity fraction of 42%, we establish that the majority of the complexity in the SPASS/ATCA sample is due to the mixing in of diffuse Galactic emission at scales $\theta > 2.8'$. Furthermore, we find a correlation between our observed small-scale complexity $\theta < 2.8'$ and the Galactic spiral arms, which we interpret to be due to Galactic turbulence or small-scale polarised emission. Our findings highlight the need to consider observations at various angular scales to fully interpret the physical scale of the Faraday complexity.

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Chemical Evolution of M31 from HII Region Spectroscopy.

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Abstract

Giant molecular clouds are the main sites of star-formation in galaxies and home to the majority of HII regions, which are photoionized by newly formed massive stars. Their gas-phase metallicities trace the latest stage of a galaxy's chemical evolution. From optical spectroscopy of HII regions in the Andromeda Galaxy (M31) with Hectospec/the MMT we have calculated metallicities (oxygen and nitrogen) for 294 individual HII regions and values for the radial gradients using strong-line methods. Consistent with recent work on other galaxies, we find statistically significant metallicity variations around the radial gradient. Subtracting the gradient, we find that enhanced and reduced abundance HII regions (compared to the radial gradient) are distributed across the entire disk. Enhanced-abundance HII regions suggest that these parts of the ISM have been enriched by recent star-formation/supernovae, whereas reduced-abundance HII regions are possible evidence that external low-metallicity gas was brought into the galaxy (possibly during a collision between with M32). We find that HII region metallicities are well-correlated at sub-kpc scales, but less well-correlated on kpc-scales. Finally, we have obtained deep CO measurements and the first dust continuum detections of resolved GMCs in an external spiral galaxy (M31) using the Submillimeter Array, which provided us with direct measurements of α'(12CO - dust) i.e., the crucial factor to convert CO emission to dust mass. Combined with the MMT survey, we obtain a first direct test of the metallicity dependence of α'(12CO - dust). Remarkably, we find no significant variation of α'(12CO - dust) with metallicity.

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The GLOSTAR-VLA Galactic plane survey: VLA D-configuration radio source catalog

Dr. Sac Nicte Medina

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Abstract

The GLOSTAR-VLA survey studies star formation in the Galactic plane between -2 < l < 60 deg and |b| < 1deg, and the Cygnus X region (76 < l < 83 deg and -1 < b < 2 deg) with unprecedented sensitivity in both flux density (1sigma ~ 60 uJy/beam) and the capability of detecting emission with angular scales in the range from 1" to the largest radio structures in the Galaxy. I will present, for the first time, the complete GLOSTAR-VLA D-configuration radio source catalog of the Galactic disk. The catalog consist of ~13000 radio sources, including the spectral indices to many of them by complementing our results with those from the THOR survey at 1.4 GHz. We identify ~1000 HII region candidates, of which ~400 are new. The mean value of spectral indices of 225 HII regions is +0.14 +- 0.02, consistent with most of them being produced by optically thin thermal radio emission. These results will be fundamental to support new tools for future Galactic surveys and studies of the view of the Milky Way.

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Directly imaging the Circumgalactic Medium with the Dragonfly Spectral Line Mapper

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Abstract

The Dragonfly Spectral Line Mapper (DSLM) is a new instrument designed to directly image the circumgalactic medium of local galaxies in H-alpha, [NII], and [OIII] emission. With a wide field of view encompassing the virial radius of most nearby galaxies, and reaching unprecedently low surface brightness limits, DSLM breaks ground on a new era of ultra low surface brightness emission line imaging. Data from DSLM will provide a "big picture" point of view to investigate the morphology of the diffuse ionized circumgalactic medium around individual galaxies, extending the study of the CGM in emission down from the higher redshifts covered by IFUs such as KCWI and MUSE to the local universe. DSLM surveys have started in January 2024 and expect science data on the first targets to be ready in March 2024. Here we give a brief overview of the DSLM instrument and survey design, and present preliminary data from our commissioning phase including some of the deepest wide field emission line imaging to date, on galaxies NGC 3079 and NGC 891.

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Comparative Spectroscopic Analysis of Very Massive Stars in Metal-rich and Metal-poor Star Clusters: Insights from HST FUV Observations

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Abstract

We perform a spectroscopic investigation of very massive stars (VMSs), exceeding 100 solar masses, within young and compact star clusters situated in both a nearby metal-rich star-forming spiral galaxy (greater than 0.5 solar metallicity) and metal-poor (less than 0.3 solar metallicity) star-bursting irregular dwarf galaxies. Our study utilizes far-ultraviolet (FUV) spectra acquired from the Hubble/COS and Hubble/STIS instruments for star clusters in M101, NGC 1140 and NGC 4449. Physical parameters are derived employing SESAMME, a recently released spectral fitting tool enabling Simultaneous Estimates of Star-cluster Age, Metallicity, Mass, and Extinction, incorporating BPASS and Starburst99 spectral population synthesis models. A comparison of the FUV spectral features of star clusters in dwarf galaxies (NGC 1140 and NGC 4449) with those in M101 suggests the presence of VMSs, characterized by robust emission line detections of He II and N IV, alongside conspicuous O V absorption line detections attributed to VMSs' stellar winds. These observations imply an exceptionally young upper age limit (less than 2 Myr) for the lifetimes of VMSs. We present the characteristics of these young, massive, and compact star clusters, emphasizing their heightened star-forming activities and broad range of metallicities, while discussing their potential as analogs for compact sources observed at high redshift, such as Green Pea galaxies, within pristine environments.

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Spatially resolved extinction in NGC 3324 from star counts in JWST images

Dr. Alejandro Raga[1], Jorge Castorena[1], Dr. Sylvie Cabrit[2], Dr. Mayra Lebron[3], Dr. Carmen Pantoja[3], Dr. Hector Arce[4], Dr. Paul Goldsmith[5]

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Abstract

We have calculated the spatially resolved extinction from star counts using the publicly available JWST Early Release Observations of the NGC 3324 nebula. The large number of point sources observed in these images allows us to obtain extinction maps with a relatively high, ~ 30'' angular resolution (corresponding to ~ 0.3 pc at a distance of ~ 2.2 kpc to NGC 3324). We have also used the colors of the observed point sources to determine their extinction, through comparison with synthetic colors in the JWST filters for main-sequence stars, and find results that are remarkably consistent with the ones obtained from star counts. Furthermore, the extinction, at 0.9 - 3.35 μm, follows closely the average galactic extinction curve with $A_V = 6.5$ mag. We find that the molecular region of the observed field has two dense clouds, each with a $M = 95 \pm 7\ M_{Sun}$ mass within projected areas of ~1 pc^2. Therefore, these clouds are likely to be localized low mass star formation regions.

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Double-Lensed Emission of PSR B0834+06

Lydia Guertin[1,2], Dr. Daniel Baker[2], Dr. Ue-Li Pen[2,3,4], Dr. Daniel Stinebring[5]

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Abstract

Using archival Arecibo observations of PSR B0834+06, we identify and track the motion of a doubly-lensed group of images in the two-dimensional Fourier transform of the dynamic spectrum. Following basic scintillometry techniques, we use the θ-θ transform to phase-connect frequency and time chunks of each observation, allowing us to extract parameters of the physical screen causing the double-lensing of the pulsar, including its distance and orientation relative to the line of sight. By tracing the group of doubly-lensed images, we are able to determine the geometry of the lensing event and compare this event to the literature of proposed mechanisms. Interestingly, we find evidence of asymmetric arcs in the secondary spectra, which suggest lensing dominated by a second screen during a period of crossing along the line of sight unseen in previous scintillation studies.

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Constraints on the properties of νMSM dark matter using the satellite galaxies of the Milky Way

Dr Oliver Newton[1], Dr Mark Lovell[2], Prof. Carlos Frenk[2], Prof. Adrian Jenkins[2], Dr John Helly[2], Prof. Shaun Cole[2], Dr Andrew Benson[3]

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Abstract

Low-mass galaxies are powerful tools with which to investigate departures from the standard cosmological paradigm in models that suppress the abundance of small dark matter substructures. One of the simplest metrics that can be used to compare different models is the abundance of satellite galaxies in the Milky Way. Viable dark matter models must produce enough substructure to host the observed number of Galactic satellites. Here, we scrutinize the predictions of the neutrino Minimal Standard Model (νMSM), a well-motivated extension of the Standard Model of particle physics in which the production of sterile neutrino dark matter is resonantly enhanced by lepton asymmetry in the primordial plasma. This enables the model to evade bounds associated with non-resonantly produced dark matter. Independently of assumptions about galaxy formation physics we rule out, with at least 95 per cent confidence, all parametrizations of the νMSM with dark matter particle masses, $M_s \leq 1$ keV, independently of other model parameters and of the Milky Way halo mass. Incorporating physically motivated prescriptions of baryonic processes and modelling the effects of reionization strengthens our constraints and we exclude all models with $M_s \leq 3$ keV. Unlike other literature, our fiducial constraints do not rule out the putative 3.55 keV X-ray line hinted at by observations of dark matter-dominated systems, if it is indeed produced by the decay of a sterile neutrino. We find that the constraints from satellite counts are substantially weaker than the limits reported from X-ray non-detections.

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The formation and disruption of globular cluster populations in simulations of present-day L^* galaxies with controlled assembly histories

Dr Oliver Newton[1,2], Prof. Rob Crain[2], Dr Joel Pfeffer[3], Prof. Andrew Pontzen[4], Prof. Nate Bastian[5,6], Dr J. M. Diederik Kruijssen[7,8]

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Abstract

Globular clusters are sensitive tracers of galaxy assembly histories. We examine how the mass ratio of major mergers affects the formation and disruption of globular clusters in a simulated present-day L^* galaxy. Starting from a zoom-in simulation of a system that experienced major mergers at z=1.7 and z = 0.77, we employ the genetic modification technique to enhance the mass ratio of the latter merger by a factor of two (enhanced case) or prevent it from occurring (suppressed case). The formation and evolution of star clusters is implemented using the MOSAICS model in the subgrid of the EAGLE hydrodynamics scheme. Our simulations reveal that most of the globular cluster system forms during the first merger and that most of the subsequent evolution is affected mainly by the characteristics of this merger. Late-time mergers, if they take place, play a minor role by prolonging the galaxy's phase of net star cluster formation by up to 1 Gyr after the coalescence of the remnant. At z=0 this manifests as an overabundance of massive star clusters in the enhanced case compared with the unmodified assembly history, while the suppressed case has more low-mass clusters. Two commonly used observational metrics to characterize the richness of globular cluster systems are the specific frequency and the specific mass. At z=0 we find that the latter is stratified as a function of the mass ratio of the target merger; however, the specific frequency is not. This feature could prove useful to elucidate the assembly histories of galaxies from present-day observations.

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Modeling cosmic ray electron spectra and synchrotron emission in the multiphase ISM

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Abstract

We model the energy dependent transport and spectral evolution of 1-100 GeV cosmic ray electrons (CREs) in the TIGRESS MHD simulations of the multiphase ISM. This implementation of CR transport combines advection, streaming, and diffusion, with a diffusion coefficient determined by the local gas and CR properties based on a balance between the CR streaming instability and wave damping rather than a value derived from observation. Additionally, we include loss mechanisms important for the evolution of the CRE spectrum such as synchrotron, inverse Compton, and bremsstrahlung losses. We post-process a TIGRESS model representing the local ISM and find the resulting CRE spectrum to be consistent with direct observations. From these models, we produce synthetic maps of radio synchrotron emission and find the observationally estimated value of the CRE spectral index to match closely the true spectrum. These models enable us to test other predictions made with synchrotron observations such as the equipartition model of magnetic fields.

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3205

The role of metals from molecular clouds to galactic discs

Piyush Sharda

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Abstract

From the time the first stars formed to the present-day, metals have witnessed the assembly of structure in the Universe in great detail. Although metals only form in stars and stellar remnants, they are ubiquitously present everywhere -- from planetary cores to the intergalactic medium. However, we still do not understand how metals are effectively dispersed throughout the Universe, and the various roles they play in shaping galaxies. In this talk, I will present a multi scale approach to study the role of metals in galaxy evolution, from molecular clouds to galactic discs. On smaller scales, I will focus on physical processes that shape up the initial mass function (IMF, with a particular emphasis on metal-free and metal-poor environments) that directly set the integrated yield of metals in the first and early galaxies. I will discuss results from high resolution simulations that study the impact of turbulence, radiation, and magnetic fields on the primordial IMF, and describe analytical models of dusty molecular clouds that explain the transition in the IMF as the metal abundance grows over cosmic time. On larger scales, the talk will cover the physics of gas-phase metal distribution in galaxies. Using a combination of spatially-resolved gas-phase metallicity measurements and novel semi-analytical models, I will present recent results that advance our understanding of metallicity gradients in (late type) galaxies. In particular, I will show how self-consistently incorporating metal dynamics into galaxy evolution models is key to explaining the observed trends in metallicity gradients with galaxy mass, metallicity, and kinematics. I will end by highlighting how such a multi-scale approach is necessary to study the physics of galaxy evolution at cosmic dawn that is now within the reach of JWST.

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Zooming in on the Chemistry of Planet Formation: The ALMA View of Molecular Gas inProtoplanetary Disks

Dr Charles J. Law

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Abstract

Planets form and obtain their compositions in gas-rich disks around young stars. The molecular gas and associated chemistry are directly tied to the resulting exoplanet architectures, including what types of planets form, their atmospheres, and potential habitability. Thanks to its high angular resolution and sensitivity, ALMA has transformed our understanding of the chemical and physical structure of planet-forming disks. Here, I first present ALMA observations of over 50 molecular lines at 10 au scales in five protoplanetary disks, as part of the Molecules with ALMA at Planet-forming Scales (MAPS) Large Program. These observations represent the most comprehensive disk chemistry survey conducted at these scales and allowed for a detailed mapping of the radial and vertical gas structure. Chemical substructures in the form of rings and gaps are ubiquitous and extremely varied in their properties across the MAPS disks, which suggests that planets form in diverse chemical environments. Not only do planets form in disks, but they locally alter disk chemistry. Using ALMA archival data, I also identified several compelling planet-induced chemical signatures in the giant-planet-hosting HD 169142 disk, including the first disk detection of shock- tracing molecule SiS. This discovery shows that observations of shock-tracing molecules provide a novel approach to the detection and characterization of young, embedded planets. Taken together, these results demonstrate the utility of high-resolution ALMA observations of molecular lines in disks, and going forward, we aim to expand this approach to larger and more representative samples to obtain statistical constraints on the chemistry of planet formation.

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Identifying spiral arm locations of stars in the APO DIB Catalog

Dr Tina Harriott[1], Halis Seuret[2], Ailish Sullivan[1], Helena Xing[1], Dr Cercis Morera Boado[3], Dr Daniel Majaess[1], Dr Lou Massa[4], Dr Cherif Matta[5]

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Abstract

Diffuse interstellar bands remain an outstanding challenge as their carriers are either unknown or contested, and the impact of the ambient environment on the abundances and spectral profiles is complex and poorly constrained. Here, the spiral arm location of a subset of stars in the APO DIB catalog are determined, with the final aim of assessing how that may influence Pearson correlations used to identify families of interrelated lines tied to a single molecular source. Progress is likewise conveyed with respect to quantum chemistry calculations being carried out to estimate vibrational and electronic spectra for potential molecular sources, which may be compared to observations.

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L-Galaxies: Debugging galaxy evolution across cosmic epochs through galaxy scaling relations

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Abstract

L-Galaxies is a semi-analytical galaxy formation model that employs a suit of physical prescriptions to model baryonic physics on top of dark matter halo merger trees. This study presents an extensive comparison between the L-Galaxies simulation and several observations from different fields, including CANDELS, COSMOS, JADES, and CEERS. Our investigation spans across a large redshift range ($0 \lesssim z \lesssim 10$) and a broad mass spectrum ($7 \lesssim \log M_* \lesssim 12$).

In particular, we examine the three most recent versions of L-Galaxies (Henriques+15,20, Ayromlou+21), which were independently calibrated using an MCMC approach based on low redshift observations of the stellar mass function and the quiescent galaxy fraction. In this work, we study the redshift evolution of different galaxy scaling relations provided by different recent publications, including the main sequence of star-forming galaxies, galaxy stellar mass function, mass-size relation, central surface mass density relation, and the cosmic star formation rate density. These relations are examined for both star-forming galaxies (SFGs) and quenched galaxies (QGs).

Our analysis shows that the majority of the simulation predictions are in qualitative agreement up to $z \sim 2$. However, several tensions persist at both low and high redshift, underscoring the need for future refinements in the physical prescriptions of L-Galaxies. A more robust suppression of star formation for massive, low redshift galaxies is required. Other tensions underscore the necessity for improved quenching mechanisms, particularly AGN feedback at high redshifts for all galaxies.

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Probing the cosmic reionisation with the Hydrogen Epoch of Reionization Array (HERA).

Mr Ntsikelelo Charles

North West University

Abstract

The 21 cm transition from neutral Hydrogen promises to be the best observational probe of the Epoch of Reionisation (EoR). It has driven the construction of the new generation of low-frequency radio interferometric arrays, including the Hydrogen Epoch of Reionization Array(HERA). The main difficulty in measuring the 21 cm signal is the presence of bright foregrounds that require very accurate interferometric calibration. However, the non-smooth instrumental response of the antenna as a result of mutual coupling complicates the calibration process by introducing non-smooth calibration errors. Additionally, incomplete sky models are typically used in calibration due to the limited depth and resolution of current source catalogues. Combined with the instrumental response, the use of incomplete sky models during calibration can result in non-smooth calibration errors. Thus compromising the detection of the 21 cm signal. In this work, we explore the use of fringe rate filters (Parsons et al., 2016) as a means to mitigate calibration errors resulting from the effects of mutual coupling and the use of an incomplete sky model during calibration. We found that the use simple notch filters significantly improves the calibration by minimising calibration errors resulting from effects of mutual coupling and the use of an incomplete sky models during calibration.

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1-Point statistical Detection of kSZ Signal in ACTPol DR4 Maps

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University of KwaZulu-Natal

Abstract

Measurements of galaxy cluster kinematics have the potential to provide constraints in dark modeling and also provide a unique constraint on baryon density in an intracluster medium. This work uses a 1-point statistical detection of the kSZ signal in ACTPol DR4 maps. To obtain the kSZ signal, we perform aperture photometry on BOSS NORTH and Deep 56 regions of ACTPol DR4 using galaxy cluster positions from DESI Legacy Survey Imager Data Release 8. With the kSZ signal, we estimate the velocity dispersion of the galaxy cluster.

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Searching for high-redshift radio galaxies with the MeerKAT Galaxy Cluster Legacy Survey

Mr Vasco Cossa

Rhodes University

Abstract

We present the results of a search for high-redshift radio galaxies (HzRGs) within 20 fields of the MeerKAT Galaxy Cluster Legacy Survey's first data release. These fields are distinguished by their robust dynamic range and comprehensive coverage in the optical and infrared spectrum through the Dark Energy Camera Legacy Survey and the All-Sky Wide Infrared Survey Explorer surveys. HzRGs, potentially precursors to local elliptical galaxies, offer a unique lens for exploring diverse astrophysical phenomena, including large-scale cosmic structures, galaxy evolution, and the epoch of reionization. Employing adept multiwavelength cross-matching techniques, the candidate pool has been meticulously refined, followed by harnessing in-band spectral indices extracted from MeerKAT data. MeerKAT's extreme sensitivity has allowed us to detect a large number of new HzRG candidates, at radio luminosities an order of magnitude lower than other studies, effectively positioning them for subsequent spectroscopic analysis.

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The properties of radio relics and the connection with radio halos in galaxy clusters and their correlation with non-thermal phenomena at multi-frequency

Prof Claudio Paulo[1], Dr Paolo Marchegiane[2], Prof Sergio Colafrancesco[3]

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Abstract

We present an investigation of the properties of radio relics (RRs), one type of diffuse emission located at the outskirts of some Galaxy Clusters (GCs), and a search for information about the origin of non-thermal processes taking place in the cluster atmospheres. We adopt a new approach to constrain models for the origin of RRs according to the following steps: i) Instead of working on a single relic, we worked on a large sample of RRs, by performing the compilation of one of the largest reference cluster relic sample (77 relics) available; ii) We perform a study of statistical properties of RRs and the hosting clusters by evaluating the relationship between the radio power of relics at 1.4 GHz and: radio halos power, cluster X-rays bolometric luminosity, integrated Compton parameter, cooling time, and Mach number of the shock associated to the relic; iii) We perform morphological analysis of the connection between RRs and the population of fossil particles coming from radio galaxies jets and lobes in the cluster. The results obtained show that relics know about halos because they scale together in their radio powers, galaxy activity in the cluster centre, and cluster properties like X-ray luminosity and Integrated Compton parameter. Examination of relics in other clusters, as well as optical/infrared spectroscopic studies of candidate radio galaxies as possible origins of the relics, and deep radio studies of their jets and lobes, will be necessary to derive solid results.

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Dark matter, dynamics, and disequilibria in the Milky Way

Arpit Arora, Prof. Robyn Sanderson

University of Pennsylvania

Abstract

The nature of DM manifests at galactic scales, where we impose constraints by modeling star and gas orbits, typically in the high-density central regions of the MW and its satellites. In these regions, the DM physics is sub-dominant to baryonic processes. Additionally, modeling techniques often rely on assuming some symmetry and/or equilibrium for the MW halo. However, the MW's halo is asymmetric due to accretion along filamentary structures and in disequilibrium, courtesy of the in-falling LMC in the outer halo and the Sagittarius dwarf in the disc. In this talk, I will discuss; 1) a novel technique to model time-evolving MW potential, capturing deformations induced by in-falling massive satellites using Basis Function Expansions; 2) an innovative application of this potential model to understand anisotropic boosts in subhalo-stream interactions driven by the LMC. Finally, I will explore the prospects of constraining DM by out-of-equilibrium modeling in the outermost, DM-dominant regions of the MW.

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The Issac Newton Telescope Monitoring Survey of Local Group Dwarf Galaxies VIII, Andromeda Dwarf Satellites Evolution

Dr. Hedieh Abdollahi[1], Dr. Atefeh Javadi[1], Dr. Jacco van Loon[2], Dr. Iain Mcdonald[3,4], Dr. Habib Khosroshahi[1], Dr. Bernard Foing[5,6], Dr. Fatemeh Fazel[5]

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Abstract

An extensive analysis of observed spheroidal dwarf satellites of the Andromeda galaxy was conducted to provide a comprehensive catalog of long-period variable (LPV) stars. The study is part of an optical monitoring survey to observe 55 dwarf galaxies and four globular clusters within the Local Group. The dwarfs were observed using the wide field camera (WFC) of the 2.5 meter Isaac Newton Telescope (INT). These observations were conducted through near-infrared (i Sloan) and optical (V Harris) bands at nine epochs. Our focus is on detecting asymptotic giant branch (AGB) stars when their magnitude amplitude becomes higher than 0.2 mag to track dwarf evolution. In dwarf galaxies, LPV stars provide powerful tools for reconstructing the SFH. LPV stars are suitable for study due to the relation between their birth mass and luminosity at the end of their evolution. Star formation scenarios could also be studied by comparing the age gradient of variable stars between two half-light radii. This study also provides estimates of satellite characteristics such as the half-light radius, the RGB-tip, the distance modulus, the quenching time, and the total stellar mass. Our work is extended by estimating the mass-loss rates of detectable LPVs to produce dust maps for each dwarf. A combination of ground-based observations and space-based telescopes was used to simulate the spectral energy distribution (SED) for LPVs based on observations in the optical to mid- infrared bands. It is also possible to estimate the re-ignition time for SFH by calculating the total mass return of LPVs.

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Analysing edge-on galaxies with deep learning

Dr. Žofia Chrobáková[1], Dr. Roman Nagy[2], Dr. Viera Krešňáková[3], Juliána Gazdová[3], Dr. Peter Butka[3]

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Abstract

The advent of large astronomical surveys calls for the application of machine learning methods to process large amounts of data. For this purpose, we developed a cutting-edge deep learning technique that can accurately detect spiral, edge-on galaxies in astronomical images, which can then be used for analysis. We will describe the characteristics of the galaxies in our sample and discuss potential biases and caveats. We will also present a novel application of this algorithm: detection of galactic warps. The galactic warp, i.e. the twisting of the outer edges of the galactic disc, is a well-known phenomenon occurring in most spiral galaxies, including the Milky Way. Despite the fact that we know hundreds of warped galaxies of different shapes and sizes, it is still not clear how the warp is created. We will demonstrate how our algorithm can yield a deeper statistical analysis that will enable us to make connections between the different warps and understand their environmental dependencies.

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Do galaxy mergers prefer under-dense environments?

Dr. Unnikrishnan Sureshkumar[1,2], Dr Anna Durkalec[3], Prof. Agnieszka Pollo[3,2], Dr. William J. Pearson[3], Dr. Daniel J. Farrow[4,5], Prof. Anand Narayanan[6], Prof. Jonathan Loveday[7], Prof. Edward N. Taylor[8], Mr. Luis E. Suelves[3]

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Abstract

Galaxy mergers play a crucial role in galaxy evolution, yet their relationship with the local environment is not fully understood. However, it is well-established that galaxy properties are correlated with their local environment. In this talk, I will present our findings about whether galaxy mergers prefer to exist in the denser or less dense regions of the large-scale structure. Our approach involves quantifying the spatial clustering of mergers and non-mergers by utilising the galaxy two-point correlation function. We also explore the environmental dependence of a galaxy's likelihood of undergoing a merger event using the marked correlation function. We use these statistical tools on a set of mergers and non-mergers identified from Galaxy and Mass Assembly survey. The classification was done using a Convolutional Neural Network. We find a stronger spatial clustering of non-mergers and an anti-correlation between the merger likelihood of a galaxy and the local environment. These results imply less preference of galaxy merger occurrences in the extremely dense environments.

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The SPARC galaxies and the External Field Effect of MOND

The SPARC galaxies and the External Field Effect of MOND Hamed Fazel Modarres

Institute for Advanced Studies in Basic Sciences (IASBS)

Abstract

In any theory of nonlinear gravitational dynamics such as MOND, the principle of strong equivalence is violated, while Newtonian dynamics is linear and obeys the principle of strong equivalence. As a result, the gravitational dynamics in the system remain under the influence of the external gravitational field in which the system is immersed. This is a good option for testing the MOND dynamics, which is known as the external gravitational field effect (EFE). Of course, most researchers do not consider the external field's effect in studying the spiral galaxy curve. In this study, we theorize the periodic curve of galaxies from the SPARC data set by considering the external gravitational field's effect and comparing the results with observational data.
In the second phase of this project, we have investigated the impact of the gravitational field effect of the neighboring galaxies of 157 SPARC galaxies (Spitzer photometry and precise rotation curves) on the rotation curve of these galaxies in the MOND (Modified Newtonian dynamics) regime. we found all SPARC galaxies and their neighbors' distances and their stellar and gas mass by astronomical catalogs and surveys like (EDD, SDSS, NED, SIMBAD, and ALFALFA). Then we calculated the imposed external acceleration of neighbor galaxies to each SPRAC galaxies and compared it with first-phase results.

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MeerKAT Observations of the Abell 141 Galaxy Cluster

Ms Savannah Stanbury

Rhodes University

Abstract

Galaxy clusters are one of the largest, gravitationally bound structures in the universe, hosting a hot, tenuous gas that permeates their volume, known as the intracluster medium. A fraction of the intracluster medium is composed of relativistic electrons that, when accelerated in magnetic fields, radiate synchrotron emission. Synchrotron emission occurs on scales ranging between individual galaxies to ~Mpc scales and beyond, with two examples of radio emission observed on Mpc scales, "bridging" between cluster pairs. A possible third system to host radio emission on such large scales is the Abell 141 (hereafter, A141) cluster, a system composed of two subclusters, where X-ray emission has been seen in the connecting region. Radio observations at 150 MHz and 943 MHz detected diffuse emission from the two systems, although the limited angular resolution prevented a detailed picture of the system.

In this thesis, we present observations at 1.28 GHz of the A141 system, taken with the MeerKAT telescope, with the aim to further characterize its diffuse radio emission. We obtain images where we detect diffuse radio emission extending over 0.9 Mpc.

The radio surface brightness peaks at the location of the Northern subcluster, and we can clearly see radio emission in the region between the two subclusters, though it does not closely follow the X-ray morphology.

A141 remains a somewhat unique system. We confirmed the spectral index of the integrated radio emission to somewhat disfavour the current most likely scenario where particles are accelerated by turbulence in the early merger state.

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Spectral Study of Two ACT Clusters Using SKA Pathfinders/Precursors

Ms Mikaela Webber, Dr Kenda Knowles, Professor Oleg Smirnov

Rhodes University

Abstract

Galaxy clusters are complex environments used to study cosmology and astrophysical phenomena. Magnetic fields in clusters and a cluster's non-thermal physics can be probed through observations of steep-spectrum, diffuse radio emission such as radio halos. Understanding a halos' spectral behaviour and morphology is critical for probing the underlying electron population and the formation mechanisms involved. In this project, we use data from SKA pathfinder and precursor instruments as well as archival multi-wavelength data in order to study the radio environment of two clusters detected through their Sunyaev-Zel'dovich signal with the Atacama Cosmology Telescope, both of which have candidate detections of a diffuse radio halo.

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HI Asymmetries and Deficiencies in ALFALFA

Ms Reshoketswe Thobejane

University of the Western Cape

Abstract

In this work, we aim to use HI line data from the Arecibo Legacy Fast ALFA(ALFALFA) survey to study the prevalence of HI spectral asymmetries in the context of galaxy environment. From the full ALFALFA sample, we define as 'merger candidates' , those galaxies that have a neighbour within 25 kpc and 750 $km.s^{-1}$. A sample of well-isolated galaxies is also procured. Here, for each sample, distributions of their defining observational characteristics are presented. The goal is to quantify the asymmetries in these two galaxy samples in order to generate quantifiable evidence of the environment-induced effects.

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A Detailed Study of Dwarf Galaxies in the Core of the Coma Cluster

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In an earlier paper, we determined the morphological types of galaxies in the Coma Cluster using data from the HST/ACS Coma Cluster treasury survey.

We found that of the 132 members, 51 are non dwarfs and 81 are dwarfs.

In this paper, we determine the morphological types of these dwarf galaxies and make a \replaced{detailed}{deeper} study of their properties. Using GALFIT, we determine the structural properties of our sample and with spectroscopic redshifts, we determined memberships and distances to identify dwarfs. A visual examination of the residual images reveals that our sample of 78 dwarf galaxies comprises of: dwarf lenticular (\textit{dS0}) 22\%, dwarf Elliptical (dE) 69\%, dwarf spirals (\textit{dSp}) 4\%, dwarf ring (\textit{dring}) 1\%, dwarf barred spirals (\textit{dSBp}) 3\% and dwarf irregular (\textit{dIrr}) 1\% galaxies. We find that the bulge-disk decomposition (Sérsic + exponential) fits are good only for the \textit{dS0} galaxies. The remainder of the sample gives good fits only for single Sérsic fits. The Colour Magnitude Relation (CMR) shows that the dEs are redder and fainter than the rest of the sample (except one $dIrr$ galaxy). The Kormendy relation reveals that dE galaxies have lower surface brightness than the rest of the sample. Our research leads us to the conclusion that dwarf galaxies appear to have a different formation and evolution process than non-dwarf galaxies.

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Enabling New Discoveries with Machine Learning

Dr Michelle Lochner

University of the Western Cape. South African Radio Astronomy Observatory

Abstract

The next generation of telescopes such as the SKA and the Vera C. Rubin Observatory will produce enormous data sets, far too large for traditional analysis techniques. Machine learning has proven invaluable in handling massive data volumes and automating many tasks traditionally done by human scientists. In this talk, I will explore the use of machine learning for automating the discovery and follow-up of interesting astronomical phenomena, both in the image and time domains. I will share an exciting recent MeerKAT discovery made with machine learning and discuss how the human-machine interface will play a critical role in maximising scientific discovery with automated tools.

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Probing the Evolution of Quasars: Insights from Multi-Wavelength Observations

Marina Arnaudova, Daniel Smith, Martin Hardcastle

University of Hertfordshire

Abstract

AGN play a crucial role in shaping galaxies and the multi-phase medium, highlighting the significance of studying quasars—the most luminous manifestations of these objects—across cosmic time. Such sources are typically divided into radio-loud (RL) and radio-quiet (RQ) categories, which raises the question of whether these classes represent distinct populations or different evolutionary stages of a single one. To provide an answer, we combined 144 MHz radio observations from LoTSS DR2 with spectroscopic data from SDSS DR14Q to create the largest sample of uniformly-selected, spectroscopically-confirmed RL and RQ quasars at $0.6<z<3.4$ across 5634 deg^2. To investigate their properties, we developed a new spectral stacking algorithm and used it to create high-resolution composite spectra for each radio class, matched in redshift and absolute i-band magnitude. We found that RL quasars have a redder continuum and enhanced [OII] emission compared to their RQ counterparts. These results persist when additionally matching in black hole mass, suggesting that this parameter is not the defining factor in making a QSO radio-loud. In addition, these features do not gradually vary as a function of radio-loudness but are maintained even when probing deeper into the RQ population, indicating that a clear-cut division in radio-loudness is not apparent. We further show that RL QSOs exhibit a significant excess of star-formation relative to RQ quasars up to at least $z=1.9$. Given our findings, we explore potential explanations and discuss how advancements in future instrumentation and survey methodologies could deepen our understanding of the subject.

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Exploring the Impact of Galaxy Interactions: New Insights from Stephan's Quintet

Marina Arnaudova[1], Soumyadeep Das[1], Daniel Smith[1], Martin Hardcastle[1], Nina Hatch[2], Scott Trager[3]

[1]University of Hertfordshire. [2]University of Nottingham. [3]University of Groningen

Abstract

Galaxy mergers and interactions are a cornerstone of our understanding of how galaxies form, but their precise role in driving galaxy evolution across cosmic time is still widely debated. Compact galaxy groups at low-redshift, such as Stephan's Quintet (SQ), however, give us the opportunity to study such processes in more detail. This galaxy group is at a unique dynamical stage where we are able to observe manifestations of both past and present interactions by examining its most distinguished feature: the large-scale shock front. This system contains a wealth of multi-wavelength information including radio observations from the LOFAR Two-metre Sky Survey (LoTSS) and targeted observations with the Very Large Array (VLA). Recently, the next generation spectroscopic facility on the 4.2m William Herschel telescope in La Palma - WEAVE, has contributed to this wealth of information with its first panoramic optical integral field unit (LIFU) observation. By harnessing this instrument's large field of view and high spectral resolution (R=10 000), we are able to study the physical characteristics of the ionized gas by performing robust spectral fitting of complex line profiles on an individual spaxel of 2.6 arcsec basis across the area of 90x78 arcsec^2. This combined with radio spectral index maps (between 144MHz, 1.7GHz and 4.8GHz) allows us to determine the ionisation mechanism, age, and thermodynamics of the particles populating the structure, and thus shed new light on the interplay between galaxy-galaxy and galaxy-intergalactic-medium interactions.

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Galaxy evolution through the eyes of resolved, multi-wavelength star formation observations: tracing the chemical and accretion history in nearby galaxies

Dr Kathryn Grasha

Dr. Kathryn Grasha is an observational astronomer at the Research School of Astronomy and Astrophysics at the Australian National University. Her research sheds light on the physics that governs how galaxies transform and evolve by tracing how oxygen atoms we breathe and the carbon we are made of formed across cosmic time.

Abstract

Measuring the chemical history of galaxies is critical to understand how galaxies form and evolve. This is usually done through observations of emission lines from ionized nebulae, where their bright emission lines enable the measurement of physical properties, such as the gas-phase metallicity, across galaxy disks and in distant galaxies. In this talk I will present the newest state-of-the-art stellar evolution models based on the latest models of chemistry elements in the early universe to the determine chemical abundance patterns, pressure, star-formation rates, heavy element enrichment, and the production and escape of ionizing radiation from the first galaxies. Using these self-consistent chemistry and stellar population synthesis models, we use the observed stellar mass and detailed metallicity gradients to identify a best-fit to our galaxies within the IllustrisTNG cosmological simulations to characterize the likely chemical and accretion history. Our work suggests that the combination of cosmological simulations and high spatial resolution metallicity gradient observations can provide an archeological probe of the gas accretion and merger history of face-on spiral galaxies. With this, we are able to disentangle the different physical mechanisms regulate gas inflows and outflows and the resulting effects on the star formation activity. This project will exploit the next generation spectroscopy with the James Webb Space Telescope to make fundamental new measurements of the formation of stars in the first galaxies, linking the low and high redshift universes.

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Insights into early galaxy evolution models from z>3 massive quiescent galaxies.

Dr Themiya Nanayakkara

Swinburne University of Technology

Abstract

Advancements in near-infrared observational capabilities in the last decade transformed our understanding of early cosmic evolution through the discovery of abundant populations of z>3 massive (M> ~10**10 msol) quiescent galaxies. While photometric techniques have identified possible red galaxies at z~9, JWST/NIRSpec observations have now been able to explore the formation histories of lower redshift galaxies in detail. The earliest indications for temporary quiescence has been found at z~7 with results indicating SFHs of galaxies to be more stochastic than what was expected before. The strong alpha element spectral signatures along with features that are commonly observed in AGB star dominated z~0 massive quiescent galaxies provide us an opportunity to study the detailed chemistry of quiescent systems. Forensic analysis of z~3 massive quiescent galaxies has shown the existence of galaxies that likely have formed ~10**11 msol within the first 500 years of the universe (by z~10) and quenched rapidly through unknown mechanisms. Hydrodynamical simulations are suggesting AGN effects to be the primary driver in abruptly quenching star-formation in galaxies in the early Universe, thus requiring most of observed massive galaxies to harbour prominent broad line AGN. In my talk I will discuss latest advancements in this field, including the formation history of z>3 massive and quiescent galaxies, the role of AGN in forming these systems, and discuss implications this buildup of stellar mass which may have for z>6 star-formation efficiencies and hierarchical galaxy growth scenarios.

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Structure growth in $f(Q)$ cosmology

Dr Shambel Akalu[1], Prof Amare Abebe[1], Prof \'{A}lvaro de la Cruz-Dombriz[2]

[1]North-West University. [2]University of Cape Town

Abstract

In this article, we take into account redshift-space distortion measurements to investigate the growth of large-scale structures within the framework of symmetric teleparallel gravity, dubbed $f(Q)$ gravity. After studying the background history of the universe in $f(Q)$ gravity with OHD, SNIa, and OHD+SNIa datasets and constraining the pertinent cosmological parameters Ω_{m}, H_0 together with the exponent n for $f(Q)$ power-law models, we derive the full system of equations governing the linear cosmological perturbations using the $1 + 3$ covariant formalism to obtain both the scalar and the harmonic decomposition. {Usual redshift-space distortions data $f\sigma_8$ have been combined with the recent measurements of the growth rate f and the amplitude of matter fluctuations σ_8 from the VIPERS and SDSS collaborations to find the best-fit cosmological parameters, such as Ω_m, σ_{8} and n. We also provide {the evolution for} density fluctuations in both the long- and short-wavelength modes and in both the matter- and radiation-dominated epochs of the universe. We use Monte Carlo Markov Chain simulations (MCMC) to restrict the best-fit parameter values and determine their statistical significance through the Bayesian selection criteria AIC and BIC to study the background history of the universe and the growth structure by taking into account the viability of the $f(Q)$-gravity model.

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The significance of characterizing the sidelobe systematics in 21cm Intensity Mapping experiments: The HIRAX case.

Mr Ajith Sampath[1], Prof Kavilan Moodley[1], Dr Devin Crichton[2]

[1]University of KwaZulu-Natal. [2]ETH - Zurich

Abstract

HIRAX (the **H**ydrogen **I**ntensity and **R**eal-time **A**nalysis e**X**periment) is an intensity mapping experiment under construction at Karoo desert in South Africa. Our experiment aims to detect BAO signatures to tightly constrain the dark energy equation of state parameters. However, all 21cm experiments, including HIRAX, suffer from foreground leakage due to systematics inherent to the instrument. The primary factor causing this effect is the chromaticity of the antenna, i.e., the frequency-dependent structure of the primary beam. In this study, we use the analytical Fourier counterparts of Zernike polynomials to model the CST-simulated HIRAX primary beams and apply them to drone mapping data. Fitting this analytical basis reveals our primary beam's symmetric and asymmetric structures. Apart from fitting models, we also investigate the impact of sidelobe chromaticity in delay space and examine their effects in the calibration stage by reviewing the calibration solutions using different beam models. Furthermore, by comparing the beam-modeling uncertainties with the expected signal and theoretical noise, we dictate how far into the sidelobes HIRAX has to measure and model to detect the HI signal with a high signal-to-noise ratio (SNR). Our study demonstrates the effectiveness of our beam modeling approach in general and provides insights into the implications of sidelobe chromaticity for accurate estimation of the 21 cm power spectrum.

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Dark Energy with HIRAX 21cm Intensity Mapping

Prof Kavilan Moodley

University of KwaZulu-Natal

Abstract

Observations of redshifted 21-cm emission from neutral hydrogen over a wide range of radio frequencies allow us to access redshifts that encompass a vast comoving volume, including the era of dark energy. In this talk, I will present the Hydrogen Intensity Mapping and Real time Analysis eXperiment (HIRAX) project, on behalf of the HIRAX collaboration, which is a proposed 21cm intensity mapping experiment operating at 400-800 MHz that will measure the evolution of dark energy over the redshift range z=0.8-2.5 by using the characteristic baryonic acoustic oscillation scale as a standard ruler. The HIRAX radio telescope array will be sited in the radio-quiet Karoo astronomy reserve in South Africa, and will ultimately comprise 1024 dishes, each six metres in diameter, placed in a compact configuration. I will discuss the design and project status of HIRAX, its scientific prospects and engineering challenges. This includes dark energy forecasts and prospects for interesting cosmological constraints from cross-correlations of HIRAX data with other large-area cosmological surveys in the southern sky. HIRAX will also discover a large number of pulsars and transients, including fast radio bursts (FRBs). I will describe our programme to localise these FRBs using HIRAX outriggers in African partner countries.

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What we can learn from a growing sample of Fast Radio Bursts : a Cosmology Wishlist

Prof Amanda Weltman

University of Cape Town

Abstract

Over the last decade, the amount of data we have about Fast Radio Bursts has grown at a rapid, indeed accelerating rate. The next decade promises to bring even more data and, with it, the opportunity to really tackle some key questions both in our understanding of FRB physics and of the Universe on large scales. In this talk we will focus on the role FRBs may play as tools of discovery and provide somewhat of a theorist's wishlist for cosmology and fundamental physics for the coming decade of discovery.

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Simba-C: An updated chemical enrichment model in Simba for galactic and intragroup/cluster chemical evolution

Mr Renier Hough[1], Prof. Ilani Loubser[1], Prof. Arif Babul[2], Prof. Romeel Davé[3]

[1]North-West University, South Africa. [2]University of Victoria, Canada. [3]University of Edinburgh, Scotland, UK

Abstract

We introduce a new chemical enrichment and stellar feedback model in the Simba simulation, resulting in the Simba-C simulation, a precursor to the Kiara legacy simulation. Based on the state-of-the-art chemical evolution model of Kobayashi et al. 2007, Simba-C tracks 32 elements from H → Ge, as well as removing Simba's instantaneous recycling approximation by treating each star particle as an evolving stellar population. Furthermore, we make some minor improvements to Simba's base feedback models, such as reducing the strength of the active galactic nuclei feedback. Simba-C provides significant improvements on key diagnostics such as the knee of the z = 0 galaxy stellar mass function (i.e., the intermediate mass range), as well as providing a better match to recent observations of the gas/stellar mass-metallicity relations at z = 0, 2. By not assuming instantaneous recycling, Simba-C provides a better match to galactic abundance ratio measures such as [O/Fe] and [N/O]. Therefore, our new model allows for much more accurate galactic chemical evolution tracking through cosmic time in the simulation. We also demonstrate the impact of these newly created metals on the global scaling relations of various X-ray properties (luminosity, temperature, mass, entropy, etc.) on different large-scale environments such as groups and clusters, using both a theoretical and an observational approach.

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Exploring the correlations between galaxy properties and environment in the cosmic web using marked statistics

Dr. Unnikrishnan Sureshkumar[1,2], Dr. Anna Durkalec[3], Prof. Agnieszka Pollo[3,2]

[1]Wits Centre for Astrophysics, School of Physics, University of the Witwatersrand, Johannesburg, South Africa. [2]Astronomical Observatory of the Jagiellonian University, Krakow, Poland. [3]National Centre for Nuclear Research, Warsaw, Poland

Abstract

Various galaxy properties such as luminosity, stellar mass, star formation rate and so on are known to be significantly correlated with the local environment of the galaxies. These correlations arise from the environmental dependence of their dark matter halo properties. Studies on such environmental correlations are crucial for better understanding of galaxy evolution. These studies are generally done using local density measurements defined at a particular separation scale around the galaxies. However, it is essential to study environmental correlations on a wide range of scales. This approach helps in the investigation of environmental effects that are prevalent at different scales as well as minimising the impact of the chosen scale for density estimation. In this talk, I will show how marked correlation functions are efficient in tracing the environmental correlations of various galaxy properties simultaneously as a function of the scale. I will present the results from our studies that investigated how luminosities in optical to mid-IR bands, stellar mass, and star formation rate are correlated with the local environment. Additionally, I will show how the marked correlation function is advantageous over traditional two-point correlation functions to explore the environmental dependence of galaxy mergers. Our analysis utilises stellar-mass-selected volume-limited galaxy samples from the Galaxy And Mass Assembly (GAMA) survey. We also compare our measurements from GAMA with those from CosmoDC2, the simulated sky catalogue designed for Rubin Observatory LSST Dark Energy Survey Collaboration. We observe discrepancies between observations and simulations.

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A Citizen science approach to finding extended radio sources in the Small Magellanic Cloud

Mr. Gideon de beer

SAAO. UCT

Abstract

The advent of high-sensitivity radio telescopes, exemplified by MeerKAT, offers an unprecedented opportunity to delve into the intricate details of extra-galactic extended radio populations. This study aims to build a catalogue comprising extended and point radio sources, drawn from MeerKAT observations of two 3°x 3° fields within the Small Magellanic Cloud (SMC). A citizen science initiative hosted on the Zooniverse platform is actively gathering data to help categorise select high signal-to-noise radio sources, distinguishing between those displaying extended emissions and those that do not. A secondary task flags the presence or absence of optical counterparts. This collaborative project's design involves comparing optical images with radio-intensity contours obtained from MeerKAT observations. Additionally, insights gained from navigating through challenges related to source-finding software applications, such as AEGEAN, and the nuanced interpretation of diverse multiwavelength data are presented. The outcomes of this research are anticipated to contribute to AI modelling by augmenting training datasets with supplementary sources. Furthermore, the findings will advance population studies in astronomy, fostering greater comprehension of radio emissions originating from the Small Magellanic Cloud and emissions beyond its boundaries.

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The MeerKAT Massive Distant Clusters Survey: Probing Diffuse Radio Emission in High Redshift Clusters

Mr Dakalo Phuravhathu[1], Prof. Matt Hilton[1,2], Dr. Sinenhlanhla Sikhosana[2]

[1]University of the Witwatersrand, Johannesburg, South Africa. [2]University of KwaZulu-Natal, Durban, South Africa

Abstract

I will present an analysis of diffuse radio emission in a sub-sample of galaxy clusters at high redshifts, focusing on the most massive clusters with $z > 1$. These clusters are identified from the Atacama Cosmology Telescope (ACT) Data Release 5 catalog and are located within the DECaLS optical+infrared survey region. The MeerKAT Massive Distant Clusters Survey (MMDCS) aims to investigate the occurrence and properties of radio halos and relics in 30 merging clusters at these high redshifts, comparing them with lower-redshift samples. By using MeerKAT data, the study seeks to provide insights into the formation of diffuse radio emissions and constrain magnetic field strengths in clusters during the early universe. Preliminary results on the fraction of massive clusters hosting diffuse emission at $z > 1$ will be presented. We have currently secured MeerKAT observation time for ~14 clusters, further observations will be pursued to reach the target of 30 clusters. This study has the potential to advance our understanding of galaxy cluster evolution and magnetic field dynamics in the early universe.

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A major merger as the origin of the giant stream and inner halo substructures in the Andromeda Galaxy (M31): Comparing the predictions from 1:4 merger simulations with chemodynamical data.

Mr. Charis Tsakonas[1,2,3,4,5], Dr. Souradeep Bhattacharya[2], Dr. Magda Arnaboldi[3], Prof. Francois Hammer[4], Dr. Yanbin Yang[4], Dr. Ortwin Gerhard[5], Prof. Despina Hatzidimitriou[1]

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Abstract

We utilize N-body hydrodynamical simulations of a major merger (mass ratio 1:4) for M31, which reproduces its disc age-velocity dispersion relation and the morphology of its main substructures, to investigate their chemodynamical properties. Their metallicity distribution functions and phase space distributions are compared with observational data obtained for resolved stellar populations of red giant stars and planetary nebulae samples.

The model succeeds in reproducing the observed metallicity distributions at the disc edges and in the inner halo of M31. Leveraging on the model, we can account for the presence of multiple distinct ridges in the phase space of these substructures, i.e. the distinct peaks in the metallicity-line of sight velocities vs distance distributions, of the Giant Stellar stream, North East and Western shelves, as seen by DESI, SPLASH and the extended PN survey in Andromeda.

Our analysis show that over-densities in the metallicity-line of sight velocity vs radial distance - space naturally emerge as superposed loops of accreted material along the line of sight. Such distinct loops are generated by consecutive pericentric passages of the satellite, during the 1:4 merger event. The presence of accreted material at different energies and distances along the same LOS represents a viable explanation for the several observed spectroscopic properties of these substructures.

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Investigating the Evolutionary History of the Local Group Dwarf Irregular Galaxy, NGC 6822, Through Long-Period Variable Stars

Ms. Fatemeh Khatamsaz[1], Mr. Mahdi Abdollahi[1], Dr. Hedieh Abdollahi[2], Dr. Atefeh Javadi[1], Dr. Hamidreza Mahani[1], Dr. Jacco Van Loon[3], Ms. Faezeh Akhlaghimanesh[4]

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Abstract

The evolution and star formation history (SFH) of NGC 6822, an isolated dwarf irregular galaxy in the local group, has been studied utilizing evolved asymptotic giant branch (AGB) stars with a period of longer than 100 days, known as long-period variables (LPV). As LPVs pulsate, their maximum luminosity can be related to their birth mass. Padova isochrones are used to obtain the stars' birth mass, age, and pulsation duration (the period that the stars are in the LPV stage) to estimate the star formation rate (SFR) in NGC 6822. The photometric data of 329 variable stars, including LPV and spectroscopy-confirmed C-rich AGB stars, were collected from several published surveys. The SFH has been studied in two regions, the bar region and the outer region. In addition to obtaining the galaxy's SFH assuming a constant metallicity, an age-metallicity relation (AMR) is also adopted to account for the variation in the galaxy's chemical content throughout its lifetime. It is found that the onset of star formation in NGC 6822 traces back to $\sim$ 12.5 and $\sim$ 13 Gyr ago in the bar and outer regions, respectively. Furthermore, there are 3 main epochs of star formation peaking at log(t) $\sim$ 9.66 (4.6 Gyr), log(t) $\sim$ 9.21 (1.6 Gyr), and log(t) $\sim$ 7.68 (50 Myr), where t is the look-back time. The significant peak around log(t) $\sim$ 9.66 is consistent with the previous research suggesting that NGC 6822 passed through the virial radius of the Milky Way around 3-4 Gyr ago.

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Studying an Early Dark Energy Model in light of the most updated cosmological datasets

Dr. Luz Ángela García

Universidad ECCI

Abstract

There is strong observational evidence of the Universe's accelerated expansion at late times. In the framework of the standard cosmological model, this effect is described through the cosmological constant Λ in the field equations. One can explain the expansion by including a dark energy component or exploring the possibility that space-time is evolving through modified gravity models. Whatever is causing the observed speeding-up of the expansion remains undetected by our telescopes.
We lean towards a Universe with dark energy, a variable matter-energy component, that causes a negative pressure in the Friedmann equations.
In this talk, we discuss a particular early dark energy model, its effective parameterization for the equation of state, and the physical motivations for its redshift dependence. Also, we describe in detail the methods we use to constrain the free parameters of such a model with the most updated observational data, as well as the Einstein-Boltzmann solver CosmoSIS and modern regression techniques. By construction, our model asymptotically tends to the fiducial value of the state equation in the De Sitter domination epoch, emulating the effect of the cosmological constant, but has a non-negligible contribution during the radiation-domination era. We provide a summary of the current cosmological proxies for this model of dark energy, the cosmic dynamics and constraints of the free parameters, and a thorough comparison with the standard model. We conclude by discussing the implications of this kind of dark energy model in the context of the Hubble tension and the growth of structure in the Universe.

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Detect Cosmological Neutral Hydrogen 21cm Signal with the Tianlai Interferometer Array

Mr. Shifan Zuo

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

To explore the mystery of cosmic dark energy, we need to observe the cosmic neutral hydrogen 21 cm signal, which traces the large-scale structure of the universe. The Tianlai Interferometer Array is a pioneering experiment that aims to detect this signal with a wide field of view and multiple beams. It has three parabolic cylindrical antennas and sixteen dish antennas, covering a frequency range of 700-800 MHz (corresponding to a redshift of 0.75-1.0). It uses the drift-scanning technique to collect data. Since 2016, the Tianlai Array has accumulated a large amount of data. In this presentation, we will show how we use the Tianlai Array to detect the cosmic neutral hydrogen 21 cm signal, and present the radio sky maps, the 21 cm signal power spectrum, and the multi-frequency angular power spectrum that we obtained from the data.

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Deep NIR study of Galaxy Clusters in the Vela Supercluster

Dr Narges Hatamkhani

South African Astronomical Observatory

Abstract

We present the results of a deep Near-InfraRed (JHKs) analysis of six cluster candidates within the Vela Supercluster (VSCL) as part of our efforts to learn more about this large supercluster which extends across the zone of avoidance (at z~ 0.06). The observations were conducted with the InfraRed Survey Facility, situated at the South African Astronomical Observatory (SAAO) in Sutherland. The images in each cluster cover ~ 80% of their respective Abell radii. We study the structures and richnesses of the six clusters out to the cluster-centric completeness radius of r_c<1.5 Mpc and magnitude completeness limit of Ks<15.5 mag. The analysis shows VC04 to be the richest of the six. VC02 and VC05 are found to be relatively rich clusters while VC08 is rather poor. VC11 is an intermediate cluster that contains two major subclusters while VC10 has a filament-like structure and is likely not to be a cluster after all. We will also present the Ks-band Luminosity Function (LF) of VC04. We acquired spectra of galaxies in VC04 using the Southern African Large Telescope at SAAO. With this spectroscopic sample we derived the Schechter parameters of the VC04 LF to be M*=-24.41±0.44 mag, α=-1.10±0.20 and Φ*=8.84±0.20. We independently determined the VC04 LF based on the galaxy sample defined by the red-sequence method, and demonstrated that the red-sequence method is reliable and can be used in the absence of high coverage of spectroscopic information of galaxies.

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Identifying strongly lensed supernova type Ia in Rubin LSST

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Abstract

Gravitationally lensed Type Ia Supernovae (SNIa) are uniquely suited to address the Hubble constant problem in cosmology. In addition to obtaining accurate time delays, the standard candle nature of SNIa also provides additional constraints on the model of the lensing object. Finding such supernovae in the ground based imaging data from the upcoming Vera Rubin Observatory is a challenge. The multiply lensed images of the SNIa can be identified as newly appearing sources in the Difference imaging. However, these lensed supernova images are expected to be unresolved for a majority of the lenses. We use the LSST difference imaging (DI) pipeline and devise the strategy to identify such lensed supernovae. Our preliminary results suggest that we recover about 70% of injected unresolved lensed SNe in the real data from the Hyper-Suprime Cam Survey, a precursor to Rubin LSST. We also investigate and assess the suitability of color-magnitude diagram (Quimby et al. 2014) as a rapid diagnostic tool for screening genuine (un-)resolved lensed SNe Ia to be discovered from the LSST. We find that the color-magnitude space can help identify promising lensed SNe Ia whether we catch the SNe during the rising or the falling part of the light curve. The contamination from both the real and simulated core-collapse SNe is found to be not too high. We also look at variations in the color-magnitude criteria for different source redshifts and present comparison with the real populations of SNe type Ia.

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Spatial Orientations of Angular Momentum Vectors of Galaxies in Supercluster S [227+006+0078] and Substructures

Dr. Janak Ratna Malla

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Abstract

We present an analysis of spatial orientations of 1217 galaxies in the supercluster S [227+006+0078]. The main goal of this work is to search for a new substructure candidate, examine the orientation of angular momentum in the framework of three different scenarios (hierarchy, pancake, and primordial vorticity models) using the “position angle-inclination method", and test the dependence on the magnitude with the spin-vector orientations and their projections. We identified two substructures using a number density contour map with a considerably high concentration of galaxies. Using the random simulation method to remove the selection effect on the database, we carried out the expected isotropic distribution using the cosmological principle. We then used three statistical tests: Chi-square, Auto-correlation, and Fourier to identify isotropy between observed and expected isotropic distributions. By analyzing the result obtained through statistical tests, we are able to confirm that the evolution of galaxies in the supercluster and substructures supports the “Hierarchy model" giving the angular momentum of galaxies in the large-scale structure tends to be oriented randomly with respect to the reference coordinate system.

Key words: Galaxies: evolution, Supercluster, Substructure, Orientation.

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Study of the infall region of galaxy clusters using data from the S-PLUS project

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Abstract

The influence and transformations undergone by individual galaxies and galaxy groups upon falling into rich galaxy clusters have been extensively studied, primarily focusing on the innermost regions of these structures where complete spectroscopic information is readily available in the literature. However, the more distant regions from the cluster centers, known as the infall region, where much of the action occurs, have received relatively little attention thus far. Nevertheless, a growing body of evidence in the literature has highlighted the necessity of investigating the typical environments of cluster peripheries to fully comprehend the evolution of galaxies within clusters.

This project aims to comprehensively study a sample of clusters, including regions up to 5 × R200. Comprehensive information will be obtained about the clusters themselves and their member galaxies, as well as the presence of substructure for the clusters as a whole, derived from data from the S-PLUS survey and the literature for the member galaxies.

In this context, the project aims to investigate the characteristics of galaxies in clusters, especially in the infall regions, using a sample of at least 30 clusters. The properties of galaxies will be correlated with their positions relative to substructures and filaments around the systems to determine differences attributed to pre- and post-processing processes, and to conduct a comparative study of various regions within the cluster up to the interface between the cluster and the field. To achieve this, spectroscopic and photometric data from the literature and the S-PLUS survey will be utilized.

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Cosmological constraints from the EFT power spectrum and tree-level bispectrum of 21cm intensity maps

Mr Liantsoa Finaritra Randrianjanahary

University of the Western Cape, South Africa

Abstract

We explore the information content of 21cm intensity maps in redshift space using the 1-loop Effective Field Theory power spectrum model and the bispectrum at tree level. The 21cm signal contains signatures of dark matter, dark energy, and the growth of large-scale structure in the Universe. These signatures are typically analyzed via the 2-point correlation function or power spectrum. However, adding the information from the 3-point correlation function or bispectrum will be crucial to exploiting next-generation intensity mapping experiments. The bispectrum could offer a unique opportunity to break key parameter degeneracies that hinder the measurement of cosmological parameters and improve on the precision. We use a Fisher forecast analysis to estimate the constraining power of the HIRAX survey on cosmological parameters, dark energy and modified gravity.

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Spectro-polarimetric view of the gamma-ray emitting NLS11H0323+342

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Abstract

The gamma-ray emitting narrow-line Seyfert 1 galaxies are a unique class of objects that launch powerful jets from relatively lower-mass black hole systems compared to the Blazars. However, the black hole masses estimated from the total flux spectrum suffered from the projection effect, making the mass measurement highly uncertain. The polarized spectrum provides a unique view of the central engine through scattered light. We performed spectro-polarimetric observations of the gamma-ray emitting narrow-line Seyfert 1 galaxy 1H0323+342 using SPOL/MMT. The degree of polarization and polarization angle is 0.122 ± 0.040% and 142 ± 9 degrees, while the Hα line is polarized at 0.265 ± 0.280%. We decomposed the flux spectra and estimated broad Hα FWHM of 1015 km/s. The polarized flux spectrum shows a broadening similar to the total flux spectrum with a broadening ratio 1.22. The Monte Carlo radiative transfer code 'STOKES' applied to the data provides the best fit for a small viewing angle of 9-24 degrees and a small optical depth ratio between the polar and the equatorial scatters. A thick BLR with significant scale height can explain a similar broadening of polarized spectra compared to the flux spectra together with a small viewing angle.

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Combining large radio and optical astronomical surveys: finding galaxy cluster members using the MeerKAT Galaxy Cluster Legacy Survey.

Mr Johan Nel, Prof. Ilani Loubser

Centre for Space Research, North-West University

Abstract

In the coming years, we will see a rise in the number of large radio surveys targeting the unexplored Southern sky from SKA-precursor telescopes, e.g. MeerKAT. To help increase the scientific impact of these surveys, we set out to combine radio surveys with optical surveys by using the Likelihood Ratio method. In this work, we illustrate the power of cross-matching sources in these wavelengths by combining the MeerKAT Galaxy Cluster Legacy Survey with DECaLS data. We show an application by using photometric redshifts in the form of probability distribution functions to calculate the probability that an individual galaxy is a cluster member. This information can, in turn, be used to derive galaxy cluster properties.

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Evolution of Galaxies and their central Black Holes in Cosmological Hydrodynamical Simulations

Dr. Paramita Barai

INAF - Osservatorio Astronomico di Trieste (Italy)

Abstract

Galaxy formation is highly non-linear, and involves a complex interplay of distinctive processes over a wide range of physical scales. Feedback from star-formation (molecular clouds on the pc scale), stellar evolution, and supernova (SN) explosions as mass/energy ejection play crucial roles in the build up of galaxies and large-scale structures. Simultaneously, accretion of matter onto central Supermassive Black Hole (SMBH)s in massive galaxies liberates enormous amounts of feedback energy, which affects the environment from pc to Mpc scales, often generating powerful AGN outflows observed at multi-wavelengths. Numerical methods are ideal to tackle these sophisticated physics of galaxies and intervening gas. Cosmological Hydrodynamical Simulation, executed on massively parallel petaflop computing platforms, has emerged as a powerful tool to produce cosmic structures that are similar to the observed ones.

I will describe the performance and analyses of Cosmological Hydrodynamical Simulations, emphasizing on the growth and feedback from SMBHs at galaxy centers. These simulations are done with a modified version of the SPH code GADGET-3, and includes sub-resolution prescriptions for the physical processes of cooling, star-formation, chemical evolution, SN and AGN feedback. Especially we have sub-resolution models of thermal and kinetic AGN feedback, and switching between the feedback modes depending on the BH accretion rate. We investigate the growth of supermassive BHs, as well as their impact on the host galaxies in terms of star formation quenching and the formation of outflows.

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Galaxy cluster mass estimation through photometry

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Abstract

The mass of galaxy clusters plays a crucial role in understanding galaxy evolution and large-scale structure, providing essential constraints for cosmological models. In this work, we explore a photometric approach for mass estimation, focusing on identifying the distinctive sharp transition in the cluster profile slope, commonly known as the splashback radius (Rsb). Our findings suggest that this radius can be reliably estimated by modeling cumulative galaxy counts from the cluster center, employing models derived from recent advancements in numerical simulations. We analyze samples from the Sloan Digital Sky Survey (SDSS) within the redshift range of $0 < z < 0.6$, utilizing photometric redshifts to assign cluster membership. Our results indicate robust Rsb estimations, regardless of the adopted magnitude limit, exhibiting a significant correlation with M200 masses obtained from weak-lensing analyses, with a dispersion of ≈ 0.2 dex. These findings pave the way for advancements in galaxy cluster astrophysics, offering the exciting prospect of accurately estimating cluster masses using solely photometric data.

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Blueberries, the most extreme dwarf star-forming galaxies: a new sample up to 200 Mpc and their optical/infrared properties

Dr. Konstantinos kouroumpatzakis[1], Dr. Jiri Svoboda[1], Prof. Andreas Zezas[2,3,4], Dr. Abhijeet Borkar[1], Mr. Elias Kyritsis[2,3], Dr. Peter, G. Boorman[5], Mr. Charalampos Daoutis[2,3,4], Ms. Barbora Adamacová[1], Dr. Romana Grossová[1,6]

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Abstract

Dwarf highly star-forming galaxies dominated the early Universe and are considered the main driver of its reionization. Direct observations of these very distant galaxies are limited mainly to rest-frame ultraviolet and visible wavelengths, and as a result, some of their properties are out of reach. Therefore, the study of their local analogs, the Green Pea (GP) and Blueberry (BB) galaxies is still paramount. This work expands the number of known BBs to smaller distances (< 200 Mpc) and the south equatorial sky and examines their properties probed by visible and infrared (IR) light. The selected BBs are compared with GPs and other dwarf star-forming galaxies (SFGs). This work has identified 48 BBs out of which 40 are newly discovered. The nearest BB lies at 19 Mpc while 14 BBs are in the south equatorial sky. The BBs tend to be extremely IR red in both WISE W1-W2 and W2-W3 colors, located in different positions in this diagram compared to typical SFGs. Overall, dwarf SFGs with higher specific star-formation rates tend to have redder IR colors. Although GPs and BBs share many similarities, the latter are the most intensively star-forming sources of the local Universe among dwarf galaxies. Overall BBs are intrinsically bluer in visible light, redder in the IR, less massive, have higher specific star-formation rates and equivalent widths, lower metallicities, and have the most strongly ionized interstellar medium compared to typical SFGs and GPs.

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Estimating Ages for Star Clusters in PHANGS Galaxies Using a Combination of HST and JWST

Bradley Whitmore

Space Telescope Science Institute - Emeritus

Abstract

The ability to accurately measure the ages of star clusters is a critical component in our quest to understand the interplay and evolution of giant molecular clouds, star clusters, feedback, and the destruction of star clusters. While the addition of JWST data promises to improve our age estimates in the long run, a number of challenges need to be overcome before this becomes a reality. This includes the effects of degeneracies between age/reddening/metallicity, the effects of outflows from feedback that remove the gas and dust within just a few million years, and triggering of new star clusters on the edges of super-bubbles. Currently, most SED modeling codes that incorporate IR emission (e.g., Draine models) are designed for integrated populations, and assume energy balance to compute re-emission in the IR from the dust reddening of starlight. However, the problem is much different for the modeling of young star clusters because the dust emission and heating sources do not appear in the same aperture due to outflows that remove the gas and dust from their central regions in only a few million years. As part of our effort to understand this phenomena, and to improve our age-dating, we present a set of empirical HST+JWST SED templates for star clusters for a range of ages. A key result is the finding that essentially all star clusters with strong PAH and IR continuum emission have ages of 5 My or younger.

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NGC 6240: triple SMBH evolution with von Zeipel-Lidov-Kozai oscillation

Dr Maryna Ishchenko, Dr Peter Berczik, Ms Margaryta Sobolenko

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Abstract

One of the possible ways of creating the supermassive black hole (SMBH) is hierarchical merging scenario. Central SMBHs at interacting and coalescing host-galaxies are observed as SMBH binary candidates at different separations from hundreds of pc to mpc.

To build the initial physical model, the estimated parameters of the stellar and gas components and central black holes were collected based on existing observational data. The observed separation between S1 and S2 is ΔR = 198 pc. The observed separation between N and the dynamical center of binary S1 + S2 is ΔR = 856 pc, according to Kollatschny et al. (2020).

The main goal of our N-body dynamical modeling was to reach the evolution of merge S1 + S2 system together with and the northern component N1. For the global dynamical integration, we used the high-order parallel N-body code ϕ−GPU which is based on the fourth-order Hermite integration scheme with hierarchical individual block time steps.

According to our simulation results, for all models and random-randomizations, the bound system from S1+S2 components is formed at ∼3.6 Myr. The formation of a triple bound system S+N occurs at ∼18 Myr. During the simulation of the evolution of triple SMBH and their surrounding environment in NGC 6240, the von Zeipel-Lidov-Kozai oscillation was detected for the binary components S (the center of mass of the S1+S2 systems) and N. The inclination angle between the orbital angular momentum of binary components is well coincide with theoretical calculations.

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Supermassive black hole binary in NGC5419: Studying the evolutionary phases of early-type galaxies

Dr. Bianca Neureiter[1,2], Dr. Jens Thomas[1,2], Dr. Kianusch Mehrgan[1,2], PD Dr. Roberto Saglia[1,2], Dr. Stefano de Nicola[1,2], Prof. Dr. Ralf Bender[1,2], Dr. Antti Rantala[3], Dr. Thorsten Naab[3]

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Abstract

The most massive elliptical galaxies are known to display a central deficit of stars. Depleted 'cores' are believed to form in dry mergers between early-type galaxies (ETGs) via a process called core scouring. This phenomenon leaves a unique imprint in the stellar signature, making it an ideal tracer for investigating the formation history of ETGs.
Through the analysis of the massive elliptical core galaxy NGC5419, we identified a particularly suitable object to prove this proposed dry merging scenario in greater detail.
NGC5419 features a well-depleted core. However, the presence of a double nucleus in HST data suggests that two supermassive black holes (SMBHs) from the progenitor galaxies have not yet completely merged. By applying a novel state-of-the-art dynamical modeling technique (MNRAS_500_1437, MNRAS_519_2004) to high-resolution MUSE spectral data of this galaxy, we analysed its orbit distribution in greater detail.
We find that NGC5419 is indeed observed in an intermediate core evolution phase, hosting an as-yet-unmerged BH binary system. NGC5419 is the first galaxy observed in this state and therefore confirms previously unobserved insights into the formation mechanism of ETGs.
Our dynamical models of NGC5419 moreover reveal a total BH binary mass of Mbh = (1.0 ± 0.08) × 10^10 Msol, establishing NGC5419 as host to one of the most massive BHs discovered in the local universe so far (ApJ_950_15). Given the limited number of previously identified black holes in the 10 billion solar mass range, NGC5419's black hole determination contributes to the quest for 'dead quasars' in our local universe.

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The power of UV and optical-IFU observations for understanding the low luminous universe

Dr MOUSUMI DAS

Indian Institute of Astrophysics

Abstract

It is well known that far-UV and near-UV observations can trace star formation in galaxies for longer periods and over a broader range of stars (O, B, A) compared to Halpha which traces emission from massive O type stars only. This is especially important for observing star formation in diffuse and metal poor stellar disks. For example, studies have shown that UV can detect star formation from low stellar density environments such as the extended UV (XUV) disks of nearby galaxies and the tidal arms in interacting galaxies. On the other hand integrated field spectroscopy (IFU) can detect ionized gas emission and their velocity fields in star forming and AGN host galaxies. In this study we show that the combination of the two, UV and optical-IFU observations, is a powerful tool in mutiwavelength Astronomy. The UV imaging combined with the spectroscopic information from the IFU observations, is important for understanding the stellar and gas distribution. Using this combination one can detect new galaxies, trace star formation in diffuse stellar environments, identify counter-rotating disks as well as detect AGN activity and outflows. Our studies use the ASTROSAT Ultraviolet Imaging Telescope (UVIT) combined with MUSE and SDSS-MANGA observations, as well as near-infrared images to study the stellar disks. Using several UVIT and IFU studies that we have done as examples, we demonstrate that UV and optical multiwavelength studies are essential for understanding star formation and AGN activity in low luminosity galaxies.

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Whispers from the Unknown: Probing the Dark Matter mystery with MeerKAT.

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Abstract

As we attempt to unveil the hidden nature of dark matter (DM), MeerKAT, the precursor to the Square Kilometre Array (SKA) based in South Africa, takes center stage. With superior capabilities in the L and U bands, MeerKAT's advanced angular resolution and sensitivity make it ideal for WIMP dark matter investigations.

Drawing on MeerKAT Galaxy Cluster Legacy survey data, we assess MeerKAT's constraining prowess. Through meticulous observations and simulations of diffuse synchrotron DM signals, we achieve competitive constraints on WIMP annihilation across three orders if magnitude in mass, surpassing results from gamma-ray experiments like Fermi-LAT and HESS. Our emphasis lies in refining our analysis techniques. In particular, we aim to investigate the effect of an improved dynamic range of the data which we expect would allow us to probe even fainter signals.

In this presentation, we spotlight MeerKAT's and South Africa's contributions, showcasing advancements in radio interferometry that lead to tighter constraints and elevate our understanding of the elusive dark matter.

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A novel Bayesian approach for decomposing the radio emission of quasars

Bohan Yue, Philip Best, Kenneth Duncan

University of Edinburgh

Abstract

Studies show that both radio jets from the active galactic nuclei (AGN) and the star formation (SF) activity in quasar host galaxies contribute to the quasar radio emission, yet their relative contributions across the population remain unclear. Here, I will present new constraints on the SF and AGN contribution to the quasar radio emission and their evolution with various physical processes, using an improved Bayesian parametric model that allows us to statistically separate the SF and AGN components in observed quasar radio flux density distributions. I will present new results based on the LOFAR Two-Metre Sky Survey Data Release 2, showing a quasar host galaxy SFR evolution that increases with bolometric luminosity and with redshift out to redshift ~4. The prevalence of radio AGN emissions increases with quasar luminosity, but has little dependence on redshift, indicating the AGN jet strength is mostly governed by local activities. Our new methodology and large sample size also allow us to investigate the role of parameters including quasar colour and black hole mass on quasar radio emission. I will show that the radio excess in red quasars is due to an enhancement in AGN-related emission and that this radio enhancement occurs mostly in quasars with weak or intermediate radio power. Furthermore, I will present our newest results on the black hole mass dependency of quasar radio emissions. This methodology holds great potential in revealing the mechanism behind quasar radio emissions under the extra parameter space to be explored by SKA and its pathfinder missions.

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Chemical modeling of methanol as an extragalactic shock tracer

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Abstract

The behavior of methanol in the composite galaxy NGC 1068 was analyzed to investigate its effectiveness as an extragalactic shock tracer and to study the effect of shock velocity and formation routes on the predicted interstellar abundance of CH_3OH. With a parameterized C-shock physical model, C-shock chemistry was investigated with UCLCHEM to study the chemical abundance of CH_3OH as a function of time in different locations of the CND and the SB ring of NGC 1068. It is concluded that gaseous methanol can trace C-type shocks as its abundance increases significantly due to ice sputtering or sublimation during shock propagation. This increase is comparable from both low- (∼10 km/s) and high- (∼50 km/s) velocity shocks. Comparing our models with the multi-line molecular observations and analysis performed by Huang et al. submitted, we concluded that the observed CH_3OH abundance may result from C-shock influence or from thermal sublimation of ice due to protostellar core heating. This work also demonstrated for the first time that the primary reaction leading to the formation of methanol in interstellar ices is the radical-molecule H-atom abstraction route under shocked-influenced environments, such as the CND of NGC 1068, from the modeling point of view. This finding is consistent with the results from Santos et al. 2022 and Simons et al. 2020 in dark molecular clouds. However, its dominance is dependent on the gas kinetic temperature (T_k), gas volume density (nH_2), velocity of the C-shock wave (v_{shock}), and cosmic ray ionization rate (ζ).

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Kinematics of strongly and weakly barred galaxies

Dr Tobias Géron

University of Toronto

Abstract

We used the Tremaine-Weinberg method with MaNGA IFU data to study the bar kinematics of a sample of 225 strong and weak barred galaxies, the largest sample to date. We found that the bar pattern speed is significantly lower for strongly barred galaxies, compared to weakly barred galaxies. Simulations show that the pattern speed decreases as the bar evolves and exchanges angular momentum with its host. Therefore, our results suggest that strongly barred galaxies are more evolved and older structures than weakly barred galaxies. The corotation radius is not significantly different between weakly and strongly barred galaxies. Interestingly, R, the ratio between the corotation radius and the bar radius, is significantly lower for strongly barred galaxies than for weakly barred galaxies. This ratio delineates "ultrafast" ($R < 1.0$), "fast" ($1.0 < R < 1.4$) and "slow" ($R > 1.4$) bars. Simulations predict that fast bars are typically triggered by global bar instabilities, while slow bars are triggered by tidal interactions. Thus, our results show strong bars are more likely to be triggered by global bar instabilities than weak bars. However, interestingly, we find no correlation between bar pattern speeds and measurements of the environment. Additionally, our fraction of ultrafast bars is lower than most other studies, which decreases the recently claimed tension with ΛCDM. We also explore the effects of the bar kinematics on the dark matter fraction, obtained through JAM modelling, as well as other galaxy properties, such as gas content and the presence of a bulge.

Session

Division J Galaxies and Cosmology

1183

The effects of bar strength and kinematics on galaxy evolution: slow strong bars affect their hosts the most

Dr Tobias Géron

University of Toronto

Abstract

We study how bar strength and bar kinematics affect star formation in different regions of the bar. This is done by creating radial profiles of resolved EW[Hα] and Dn4000 measurements obtained from MaNGA. We classified bars as strong or weak using the automated classifications of Galaxy Zoo DESI, and classify bars as fast or slow using the Tremaine-Weinberg method. We find that, in agreement with previous studies, strong bars in star forming galaxies have increased star formation in their centre and beyond the bar-end region, while star formation is suppressed in the arms of the bar. This is not found for weakly barred galaxies. We also find that slow bars in star forming galaxies have significantly higher star formation along the bar than fast bars, especially if the bar is also strong. Interestingly, the global star formation rate is not significantly different between fast and slow bars. This suggests that the kinematics of the bar does not affect star formation globally, but changes where star formation occurs in the galaxy. We hypothesize that this is due to the fact that the slower bars encounter more gas in their galaxies as the stellar and gas discs rotate past them, leading to funnelling of gas from the outskirts of the galaxy along the bar. In summary, we find that a bar will influence the total amount of star formation and its distribution the most if it is both strong and slow.

Session

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1185

Stellar population properties and morphology of massive compact galaxies at z ~ 0

Ms. Katia Slodkowski Clerici[1], Dr. Allan Schnorr-Müller[1], Dr. Marina Trevisan[1], Dr. Tiago Vecchi Ricci[2]

[1]Universidade Federal do Rio Grande do Sul. [2]Universidade Federal da Fronteira Sul

Abstract

Quiescent galaxies have low star formation activity, old, metal-rich stellar populations, large bulge-to-total mass ratios, and high mass surface densities within 1 kpc. However, quiescent galaxies observed at higher redshifts differ significantly from their local counterparts; for example, they are extremely more compact. Due to their small sizes and faint stellar continua, spectroscopic studies of large samples are extremely challenging with current facilities. As an alternative, massive compact galaxies (MCGs) at low redshifts can be explored as local analogues. To better understand the MCGs and enhance the discussion about their formation and evolution, we studied the stellar population properties of a large sample of 1858 MCGs from the Sloan Digital Sky Survey. We compared their stellar population properties with a control sample of average-sized quiescent (CSGs) at fixed velocity dispersion. We found that MCGs are older, have higher [α/Fe] and lower metallicities, except for velocity dispersion higher than 230 km/s where MCGs and CSGs have similar ages and [α/Fe]. We suggest that progenitor bias effects can explain the differences in age and in [α/Fe], while the origin of the differences in metallicity is still unclear. Additionally, we fitted the 2D surface-brightness of 250 MCGs from the Hyper Suprime-Cam at the Subaru telescope. Our analysis showed that around 7%, 50%, and 43% of MCGs can be well-described using one, two, and three components, respectively. These components include a Sérsic bulge with n ~ 4, a disk with n = 1, and an external Sérsic component with n ~ 1.7.

Session

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1187

The Gravitational Lensing Imprints of DES Y3 Superstructures on the CMB: A Matched Filtering Approach

Mr Umut Demirbozan

Institut de Física d'Altes Energies(IFAE). Universitat Autònoma de Barcelona (UAB)

Abstract

Low density cosmic voids gravitationally lens the cosmic microwave background (CMB), leaving a negative imprint on the CMB convergence κ. This effect provides insight into the distribution of matter within voids, and can also be used to study the growth of structure. We measure this lensing imprint by cross-correlating the Planck CMB lensing convergence map with voids identified in the Dark Energy Survey Year 3 data set, covering approximately 4,200 deg2 of the sky.

We use two distinct void-finding algorithms: a 2D void-finder which operates on the projected galaxy density field in thin redshift shells, and a new code, Voxel,which operates on the full 3D map of galaxy positions. We employ an optimal matched filtering method for cross-correlation, using the MICE N-body simulation as a representative of ΛCDM model both to establish the template for the matched filter and to calibrate detection significances.

Using the DES Y3 photometric luminous red galaxy sample, we measure $A\kappa$, the amplitude of the observed lensing signal relative to the simulation template, obtaining $A\kappa$ = 1.03 ± 0.22 (4.6σ significance) for Voxel and $A\kappa$ = 1.02 ± 0.17 (5.9σ significance) for 2D voids, both consistent with ΛCDM expectations. Our study is uique in the sense that we compare two different stacking/filtering methods and show how they compare.

We find that the leading source of noise in our measurements is Planck convergence noise, implying that future data from the Atacama Cosmology Telescope (ACT), South Pole Telescope (SPT) and CMB-S4 will increase sensitivity and allow for more precise measurements.

Session

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1194

X-ray Properties and Scaling Relations of Galaxy Clusters at redshift > 0.2 in the X-CLASS Survey

Dr Mona Molham

The National Research Institute of Astronomy and Geophysics (NRIAG)

Abstract

There are power-law relations between X-ray observables of galaxy groups and clusters at different redshift and mass scales. These relations are used to link the physical properties of clusters at cosmic scales, probe the evolution of the large-scale structure, and constrain cosmological parameters through cluster counts.

The XMM Cluster Archive Super Survey, X-CLASS, is a serendipitous search of X-ray-detected galaxy clusters in 4176 XMM-Newton archival observations until August 2015 (Koulouridis et al. 2021, A&A 652, A12). The catalog consists of 1646 well-selected X-ray-detected clusters over a wide sky area, along with their selection function. It spans a wide redshift range up to z ~ 1.5, with 982 clusters spectroscopically confirmed. We will investigate the scaling relations between X-ray observables of the clusters and study the spectral and radial properties of the intracluster medium (ICM). The results from this study will be the base for the cosmological studies in the X-CLASS survey and comparison studies with other surveys compiled from other X-ray missions (e.g. eROSITA, Chandra).

Session

Division J Galaxies and Cosmology

1244

Are Odd Radio Circles phoenixes of powerful radio galaxies?

A/Prof Stas Shabala

University of Tasmania

Abstract

Odd Radio Circles (ORCs) are a class of low surface brightness, circular objects approximately one arcminute in diameter. ORCs were recently discovered in the Australian Square Kilometre Array Pathfinder (ASKAP) data, and subsequently confirmed with follow-up observations on other instruments -- yet their origins remain uncertain. In this talk, I will show that ORCs can be formed from the interaction of two common processes in galaxy groups and clusters: remnant lobes of powerful radio galaxies being re-energised by the passage of a shock. Using relativistic hydrodynamic simulations with synchrotron emission calculated in post-processing, I show that buoyant evolution of remnant radio lobes is alone too slow to produce the observed ORC morphology. However, the passage of a shock can produce both filled and edge-brightened ORC-like morphologies for a wide variety of shock and observing orientations. Circular ORCs are predicted to have host galaxies near the geometric centre of the radio emission, consistent with observations of these objects. Significantly offset hosts are possible for elliptical ORCs, potentially causing challenges for accurate host galaxy identification. Observed ORC number counts are consistent with a paradigm in which moderately powerful radio galaxies are their progenitors.

Session

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1279

Exascale Science in the Desert: Building on the Big Data Precursors

Dr Jordan Collier

Curtin Institute of Radio Astronomy (CIRA). Inter-University Institute for Data Intensive Astronomy (IDIA). Western Sydney University

Abstract

The Square Kilometre Array (SKA) is a global multi-billion dollar project set up to build and operate the world's largest telescope, primarily located within the desert regions of the Murchison, Western Australia, and the Northern Karoo, South Africa. To fully exploit the scientific output of the immense amount of data flowing from the telescopes, the SKA Observatory (SKAO) is working with science communities across the world through SKA Regional Centres (SRCs), which are nationally lead hubs containing infrastructure for supporting the science and computing required by this international community.

In this presentation, I will cover the broad and diverse scientific projects facilitated by the SRCs and their prototypes in Australia and South Africa, namely the Australian SRC (AusSRC), and the Inter-University Institute for Data-Intensive Astronomy (IDIA), including my own research interests investigating Odd Radio Circles (ORCs) and young and distant radio galaxies, and our use of the ilifu facility, operated by IDIA, and the Pawsey Supercomputing Centre, to analyse these data. In particular, I will focus on our current support for the SKA Precursors, the MeerKAT Radio Telescope, the Murchison Widefield Array (MWA), and Australian SKA Pathfinder (ASKAP), in themselves routinely producing big data, as well as our future plans to build on top of this to develop the capabilities essential to facilitating SKA science, in preparing for SKA data at the exabyte scale.

Session

Division J Galaxies and Cosmology

1300

HI Intensity Mapping Survey with FAST Drift Scan Observation.

Dr. Yichao Li

Northeastern University

Abstract

The HI intensity mapping is a promising way to probe the large-scale structure (LSS) of the Universe. It has been explored using different survey experiments, such as the Green Bank Telescope, Parkes Telescope, MeerKAT, and Five-hundred-meter Aperture Spherical Telescope (FAST). A couple of specially designed HI intensity mapping facilities, such as Tianlai, CHIME, BINGO, and HIRAX, are under construction or collecting data. The HI intensity mapping technique is also proposed as the major cosmology project with the Square Kilometre Array in the near future. However, cosmic HI LSS detection with intensity mapping is still underway. The major challenge comes from the foreground residual, which is primarily induced by instrumental effects or inaccurate calibration. Such systematic effect needs to be either well-controlled or eliminated. In this talk, I will present our recent efforts in building an accurate data analysis pipeline for the HI intensity mapping survey with FAST, and the foreground subtraction method based on deep learning to eliminate the systematic effect.

Session

Division J Galaxies and Cosmology

1339

Investigating star formation rates as a function of the galaxy clusters environment using the MeerKAT telescope.

Dr Kabelo Kesebonye

University of the Witwatersrand

Abstract

This study presents the study of star formation (SF) activity in 20 clusters of different dynamical states at redshifts $0.15 < z < 0.35$ using dust-unbiased radio luminosities from the MeerKAT radio telescope. We use optical data from the Dark Energy Camera Legacy Survey (DECaLS) to estimate photometric redshifts using the zCluster SED-fitting algorithm. We use radio diffuse emission in the form of haloes and relics as a proxy for cluster merger activity, and we divide our cluster sample between disturbed/merger clusters and relaxed clusters. This study presents the first statistical investigation of SF activity in clusters using MeerKAT-detected galaxies. It leverages the large field of view coverage by MeerKAT to investigate the relation between SF activity and the environment in clusters of different dynamical states out to 2R200. We observe a higher fraction of star-forming galaxies (fSF) in disturbed clusters than in relaxed clusters. Disturbed clusters also exhibit higher masses (M200) and total star formation rates (∑SFR) than relaxed clusters. On analysing the redshift evolution of mass-normalised ∑SFR, we observe a ≅4 times decline in SF activity from a redshift of 0.35 to 0.15, corresponding to ≅2 Gyr in look-back time. Our result is roughly consistent with cluster studies using infrared-derived SFR (≅5 times decline) at a similar redshift slice as our sample.

Session

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Towards 21-cm Intensity Mapping at z = 2.2 using uGMRT

Khandakar Md Asif Elahi[1], Somnath Bharadwaj[1], Srijita Pal[2], Abhik Ghosh[3], Sk. Saiyad Ali[4], Samir Choudhuri[5], Arnab Chakraborty[6], Abhirup Datta[7], Nirupam Roy[2], Madhurima Choudhury[8], Prasun Dutta[9]

[1]Indian Institute of Technology Kharagpur. [2]Indian Institute of Science. [3]Banwarilal Bhalotia College, Asansol. [4]Jadavpur University, Kolkata. [5]Indian Institute of Technology Madras. [6]McGill University. [7]Indian Institute of Technology Indore. [8]The Open University of Israel. [9]IIT (BHU), Varanasi

Abstract

The neutral hydrogen (HI) 21-cm Intensity Mapping signal is a promising probe for the large-scale structures in the Universe. Here, we present a tight upper limit on the HI mass density and the HI bias $[\Omega_{HI} * b_{HI}] < 0.010$ at the redshift z = 2.2. The upper limit is within an order of magnitude of the expected signal, and we have achieved this result by removing the foregrounds from a 25-hour uGMRT interferometric observation at the frequency interval 394-494 MHz. The technique we use has two steps: first, we estimate the multifrequency angular power spectrum (MAPS) using the Tapered Gridded Estimator (TGE), which suppresses the bright point sources that appear through the sidelobes of the telescope. Then, we remove the residual foregrounds from the measured MAPS by using our newly developed polynomial fitting and Gaussian process regression techniques. We find the power spectrum to be consistent with noise in the entire Fourier space. We plan to observe longer to make a detection. The techniques and the results are encouraging for ongoing and future 21-cm intensity mapping surveys with MeerKAT and SKA-mid.

Session

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1356

The Evolution of the Galaxy Stellar Mass Function in Sunyaev-Zel'dovich Selected Galaxy Clusters from ACT DR5

Mr. Damien Cole Ragavan[1], Prof. Matt Hilton[1,2]

[1]University of the Witwatersrand. [2]University of KwaZulu-Natal

Abstract

An important observable of galaxy populations is their stellar mass function (SMF), which describes the number density of galaxies as a function of stellar mass. In the context of galaxy clusters, which are massive gravitationally-bound systems, the SMF becomes particularly important as it provides crucial information about the distribution of stellar masses within clusters and the mechanisms that lead to this observed distribution. Thus, accurate measurements of the cluster SMF can help us understand the impact of the cluster environment on galaxy formation and evolution. In this presentation, I will discuss the role of the galaxy SMF in galaxy clusters and present our current work on this topic. In this work, we will be studying the galaxy population of a large sample of Sunyaev-Zel'dovich (SZ) selected galaxy clusters, drawn from the fifth data release of the Atacama Cosmology Telescope (ACT DR5), by measuring their composite cluster SMFs using optical data from the Dark Energy Camera Legacy Survey (DECaLS). Taking advantage of accurate photometry from DECaLS, photometric redshifts will be used to construct redshift-binned and cluster mass-binned composite SMFs. This type of SMF study has never been performed on this specific cluster sample. Implementing these methods on the ACT DR6 cluster sample (yet to be released) using deep photometry from the Large Synoptic Survey Telescope (LSST) is a logical way forward for this research.

Session

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1359

Direct detection of Extreme UV emitting Lyman Continuum Leakers at the Cosmic Noon

Suraj Dhiwar[1,2], Kanak Saha[1], Soumil Maulick[1], Brent Smith[3], Chayan Mondal[1], Harry I. Teplitz[4], Marc Rafelski[5,6], Rogier A. Windhorst[3]

[1]Inter University Center for Astronomy and Astrophysics, Ganeshkhind, Pune 411007, India. [2]Department of Physics, Savitribai Phule Pune University, Pune 411007, India. [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, USA. [4]IPAC, Mail Code 314-6, Caltech, 1200 E. California Boulevard, Pasadena, CA 91125, USA. [5]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA. [6]Department of Physics and Astronomy, Johns Hopkins University, Baltimore, MD 21218, USA

Abstract

Using the deep observations from the *Ultraviolet Imaging Telescope (UVIT)* onboard *AstroSat,* we report the direct detection of Lyman Continuum (LyC) emission from 9 galaxies and 1 Active Galactic Nuclei (AGN) at the cosmic noon ($z \sim 1.1$-1.6) in the GOODS-North field. The restframe UV wavelength of the sources are in the extreme-ultraviolet (EUV) regime $\sim$ 550-700 Å, the shortest LyC wavelength range probed so far. The absolute escape fraction of the sources span a range $\sim$ 10 - 55 %, estimated from the far-ultraviolet (FUV) and Hα line luminosities using Monte Carlo (MC) analysis of two Inter-Galactic Medium (IGM) models. Due to the instrumental limitations of previously available facilities, this redshift range had remained devoid of direct detections of LyC emission. With *UVIT* having a very low detector noise, each of these sources are detected with an individual signal-to-noise ratio (SNR) > 3 while for the stack of six sources, we achieve an SNR $\sim$ 7.4, making it the first coherent sample of the Lyman continuum leakers at this epoch. In most of the sources the LyC emission is observed to be offset from the optical centroids and extended beyond the *UVIT* PSF of 1.''6. This sample fills an important niche between *GALEX* and *Cosmic Origins Spectrograph (COS)* at low-*z*, and *HST* WFC3 at high-*z* and is crucial in understanding the evolution of LyC leakers.

Session

Division J Galaxies and Cosmology

1397

Probing the baryonic cycle of z~5 star-forming galaxies from the ALMA Large-Program *ALPINE*

Mr Prasad Sawant

National Centre for Nuclear Research, Poland

Abstract

The early growth phase of the Universe (6 > z > 4) marks a pivotal transition between the primordial galactic formation and the onset of the peak of cosmic star formation rate density. During this phase, galaxies are rapidly growing in mass and size, fueled by the intricate interplay of gas and dust within the interstellar medium (ISM). Constraining the evolution of these galaxies is a challenge owing to degeneracies in cosmological simulations and chemical evolution models.

In this work, we make use of chemical evolution models to probe the baryonic evolution of z~5 main-sequence star-forming galaxies as part of the ALMA Large Program ALPINE. We utilize panchromatic observations to perform spectral energy distribution fitting for these galaxies, employing both Chabrier and top-heavy initial mass functions (IMFs) to derive the physical parameters (i.e stellar mass, star formation rate and dust mass).

Our models successfully reproduce the gas and dust content in most of these primordial galaxies, indicating dust production primarily through Type II supernovae and gas/dust removal via galactic outflows and moderate inflow of primordial gas. Furthermore, a subset of these galaxies displays rapid dust build-up in shorter timescales (~20 Myr - 100 Myr), which is partially reconcilable with a top-heavy IMF. These findings, coupled with upcoming studies driven by James Webb Space Telescope observations will help us bridge the gap between observations and models, shedding new light on dust production mechanisms in the early universe.

Session

Division J Galaxies and Cosmology

1423

Multipoles of the redshift-space power spectrum from SKAO and other surveys

Mr. Ron Baatjes

University of the Western Cape

Abstract

The large-scale distribution of neutral hydrogen in the late Universe provides a probe of the underlying distribution of matter, which is a powerful complement to the standard probe delivered by galaxy number counts. Measuring the neutral hydrogen distribution with MeerKAT, SKAO and other radio telescopes through the hydrogen 21 cm line emission, has the potential to become a key cosmological probe in the coming years. We will investigate the cosmological constraining power of the 21 cm intensity mapping power spectrum in redshift space. To this end, we will decompose the power spectrum into multipoles, modelling the effects of foreground avoidance, telescope beam,instrumental noise and the bias of 21 cm intensity fluctuations. Then we will use Fisher forecasting methods to estimate the precision that is obtainable by proposed surveys on MeerKAT (the 64-dish precursor array of the SKA Observatory), on the full SKAO, and potentially on other dish arrays such as HIRAX. Measurements of the power spectrum multipoles enable measurements of key cosmological parameters and we will estimate the precision of such measurements. In particular, the multipoles provide an estimate of the growth rate of large-scale structure, which can deliver tests of the theory of gravity.

Session

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1434

Cosmic Dynamics Unveiled: A Relativistic Approach to Structure Formation and Evolution

Mr Kennedy Konga[1], Dr Dismas Wamalwa[1], Dr Dickson Kinyua[2], Dr Daniel Memeu[1]

[1]Meru University of Science and Technology, Kenya. [2]Kirinyaga University, Kenya

Abstract

Modern cosmology is broadly based on the Cosmological principle, which assumes homogeneity and isotropy as its foundational pillars. Thus, there is not much debate about the metric (i.e., Friedmann-Lemaitre-Robertson-Walker; FLRW) one should use to describe the cosmic space-time. But Einstein's equations do not unilaterally constrain the constituents in the cosmic fluid, which directly determine the expansion factor appearing in the metric coefficients. As its name suggests, ΛCDM posits that the energy density is dominated by a blend of dark energy (typically a cosmological constant, Λ), cold dark matter (and a "contamination" of baryonic matter), and radiation. We propose a model founded on redshift, light intensity, and number density per solid angle of galaxies as the three key astronomical parameters. We explore these parameters with models of different geometries (i.e. open, closed, or flat). Our analysis implores that the model can account for both accelerated and decelerated expansion of the universe. Our analytical solutions and simulations describe patterns of formation and evolution of cosmic structures. There is great activity at redshifts after which there is gradual progress until an indication of a nursery for the formation of most cosmic structures. At redshifts we observe a gradual decline in activity until where it flattens. This transition is directly related to the matter density and is dependent on the geometry of the universe. The model explains the intricate connections between cosmic acceleration and deceleration hence elucidating the formation of structures, dynamics, and evolution of the universe.

Session

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1439

Prospects of Measuring the 21cm Signal with HERA using $21cm^2$-kSZ^2 Cross Correlation

Mr. Clinton Denis Stevens, Prof. Yin-Zhe Ma

Stellenbosch University

Abstract

The Hydrogen Epoch of Reionization Array (HERA) upon completion will be a 350-element Radio Interferometer, consisting of 14 m parabolic dishes operating in the low-frequency range (50-250 MHz). HERA aims to achieve the first detection of the 21cm power spectrum during the Epoch of Reionization (z = 6-12). During the Epoch of Reionization (EoR), radiation from the first stellar populations causes fluctuations in the 21cm brightness temperature. By successfully measuring the 21cm power spectrum, the Astrophysics underlying the EoR may be constrained. These Astrophysical constraints include the timing and efficiency of reionization, as well as the star-formation and halo properties of the first galaxies (Berkhout et al., 2024). Previous EoR 21cm mapping experiments suffer from residual foreground noise and systematic uncertainties (La Plante et al., 2020). Therefore, we propose a new cross-correlation technique involving the squared 21cm intensity field and the squared kinematic Sunyaev-Zeldovich (kSZ) effect. We present our novel $<\delta T_{21cm}^2 \Delta T_{kSZ}^2>$ cross-correlation technique and forecast signal-to-noise estimates for future experiments. In particular, cross-correlation experiments with the South Pole Telescope (SPT) and the Next Generation CMB Experiment (CMB-S4).

Berkhout, L.M., Jacobs, D.C., Abdurashidova, Z., Adams, T., Aguirre, J.E., Alexander, P., Ali, Z.S., Baartman, R., Balfour, Y., Beardsley, A.P. and Bernardi, G., 2024. Hydrogen Epoch of Reionization Array (HERA) Phase II Deployment and Commissioning. arXiv preprint arXiv:2401.04304.

La Plante, P., Lidz, A., Aguirre, J. and Kohn, S., 2020. The 21 cm kSZ–kSZ Bispectrum during the Epoch of Reionization. The Astrophysical Journal, 899(1), p.40.

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1447

Bispectrum correlations of HI intensity mapping and large-scale structure surveys

Dr Moumita Aich

University of KwaZulu-Natal

Abstract

Neutral hydrogen (HI) intensity mapping (IM) experiments probe the large-scale structure of the universe through the integrated redshifted 21-cm line emission from unresolved sources of neutral hydrogen. Optical surveys also probe the large-scale structure of the universe with much higher precision and depth by mapping the galaxy distribution. In this article, we study the cross-correlations of the HI IM field from HIRAX (Hydrogen Intensity and Real-time Analysis eXperiment) with the galaxy density and cosmic shear fields from the Rubin observatory large-scale structure survey, laying down the tools to do parameter forecasts and study constraints on the neutral hydrogen fraction, galaxy bias, and cosmological parameters. Astrophysical foregrounds limit the long-wavelength line-of-sight HI modes, reducing the constraining power of these cross-correlations. We introduce bispectrum estimators, specifically HI-HI-galaxy density and HI-HI-shear cross bispectra estimators, to recover modes lost in the foreground subtraction process and improve the parameter constraints.

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1514

Cosmic Web: Influence of Tidal Anisotropy in the formation of Galaxies and Haloes

M. Sc. Yeimy Camargo, Dr. Rigoberto Casas-Miranda

Universidad Nacional de Colombia

Abstract

The observed galaxy distribution beyond halo scale is organised into a filamentary network known as the cosmic web. In this work we explore the influence of the cosmic web on the formation of halos and galaxies by examining the tidal anisotropy, estimated using the *NEXUS* algorithm and data from *The Next Generation Illustris simulations (IllustrisTNG)*. Specifically, we use galaxies and dark matter haloes from the simulation labelled as *TNG300-1*, focusing on galaxies with stellar masses in the range of $10^9 < M_*(M_{sun}/h) < 10^{11.5}$ and their host dark matter haloes. For this purpose, we used the assembly times of the dark matter haloes, as well as the assembly times, star formation efficiency F_*, colour (g-i), and specific Star Formation Rate sSFR of both central and satellite galaxies. In each case, the samples are separated in several sets: early and late assembly time, low and high F_*, red and blue (g-i) colour, and low and high sSFR. We aim to understand the relationship between the cosmic web environment and some characteristics related to the formation and evolution of DM haloes and galaxies.

Session

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1527

Statistical Modelling and Mitigation of Systematics in 21-cm Radio Observation Experiments

Mr Geoff Murphy

University of the Western Cape

Abstract

In the current era of cutting-edge radio astronomy, instruments are becoming ever more sensitive to the highly-redshifted 21-cm signal, and as a consequence are suffering from more numerous systematics which inhibit their performance. While many systematic mitigation methods are capable of recovering signals down to the noise level, statistical modelling of these systematics can produce equivalent results with the addition of uncertainties rigorously propagated throughout the analysis. In this talk, we demonstrate the application of Hamiltonian Monte Carlo sampling to the signal chain systematics in the Hydrogen Epoch of Reionisation Array (HERA), namely cable reflections and antenna coupling. Recovery of the underlying power spectra can be made at a similar level to the methods currently implemented in the HERA pipeline, along with an associated uncertainty estimate, and without significant attenuation of the underlying signal. Additionally, we present results from the joint modelling of the signal, foregrounds, and systematics (RFI, cable reflections, and ground-spill) in MeerKAT datacubes on a per-antenna basis with Gibbs sampling, which allows the order 10^5-dimensional parameter space to remain computationally tractable. As radio experiments probe deeper into the Universe, and continue to place improved constraints on cosmological models, the addition of propagated statistical uncertainty estimates from the systematic mitigation steps would lend additional confidence to the upper limits on, and future direct detections of, faint 21-cm signals.

Session

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1536

The VLA Sky Survey

Mark Lacy

National Radio Astronomy Observatory

Abstract

The VLA Sky Survey (VLASS) images all the sky visible to the VLA in multiple epochs at 2-4 GHz. VLASS is the highest-resolution all-sky survey undertaken in the radio, with a typical beam size of 2.5 arcsec, comparable to ground-based optical/near-infrared (OIR) surveys. This allows unambiguous identifications of radio sources with OIR counterparts and separation of nuclear and off-nuclear radio transients in nearby galaxies. Since the beginning of the survey in 2017 VLASS has observed the sky twice, with a third epoch of observation near completion. Each epoch has a sensitivity of ~150 microJy/beam. Quick Look images are made available to the community within a few weeks of observation. Higher fidelity sets of images, which will also include spectral index and polarization information, are in progress. I will give an overview of the survey and present some the early results, including detections of radio-bright extragalactic supernovae, tidal disruption events and radio changing-look AGN.

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Star formation rate and stellar mass calibrations based on JWST and WISE infrared photometry and the biases from stellar population age and extinction

Dr. Konstantinos Kouroumpatzakis[1], Prof. Andreas` Zezas[2,3,4], Mr. Elias Kyritisis[2,3], Prof. Samir Salim[5], Dr. Jiri Svoboda[1]

[1]Astronomical Institute of the Czech Academy of Sciences. [2]University of Crete. [3]Institute of Astrophysics/FORTH. [4]Center for Astrophysics | Harvard & Smithsonian. [5]Indiana University

Abstract

Measuring accurately the fundamental properties of stellar mass (M⋆) and star formation rate (SFR) is critical for understanding the present state of galaxies, their history, and their future. This work explores the dependence of the IR emission of galaxies on their extinction, and star-formation intensity, and provides accurate calibrations that account for these effects. We used the CIGALE spectral energy distribution (SED) fitting code to create model SEDs of galaxies with a wide range of star formation histories, dust content, and interstellar medium properties. Results based on the Markov-chain Monte-Carlo method and machine-learning random forest analysis provide calibrations for the SFR using a combination of the WISE 1 and 3, or the JWST NIR-F200W and MIRI-F2100W bands. Mass-to-light ratio calibrations are also proposed based on the WISE band-1 or the JWST NIR-F200W, and the optical u−r or g−r colors which account for biases attributed to stellar population (SP) age, while they are given in the form of extinction-dependent and extinction-independent relations. The proposed calibrations show enhanced estimations while minimizing the scatter and biases throughout a wide range of SFRs and stellar masses. The SFR calibrations offer better results, especially in dust-free or passive galaxies where the contributions of old SPs or biases from the lack of dust are significant. Similarly, the M⋆ calibration yields enhanced estimations for dusty and high-SFR galaxies where dust emission can otherwise bias the estimations.

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1573

The UVIT/AstroSat's first-ever unprecedented view of the Magellanic Bridge - What does it reveal?

Samyaday Choudhury

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Abstract

The Magellanic Bridge, a trail of stars and gas connecting the LMC and SMC, supposedly formed during the closest tidal interaction between them about 100-300 Myr ago. However, the origin and formation history of the Bridge are still poorly understood. We present the first-ever results on the Bridge using the Ultraviolet Imaging Telescope (UVIT) onboard AstroSat, the Indian space observatory to understand aforementioned aspects. The UVIT has a resolution of 1.2 arcsec (thrice better than GALEX) and a field of view of 28 arcmin, allowing an unprecedented view of the Bridge and individual stars in far-ultraviolet. Our UVIT observed fields combined with those from the archive (9 fields) span ~3° near the tidally disrupted SMC. These fields host UV bright star clusters and OB associations. We combined UVIT data with Gaia DR3 to estimate their parameters (age, distance, metallicity and extinction), by employing an automated fitting technique that uses a grid of these parameters and an MCMC sampling routine. About 80% of the clusters in these fields are parametrized for the first time, and we can dissociate clusters from OB-type associations. The study provides strong evidence that interactions between the LMC-SMC continued up to a few 10 Myr ago. We estimated the stellar (e.g. T_{eff} and log *g*) and kinematical properties of hot and young stellar populations by combining UVIT data with Gaia, VMC and other multiwavelength data sets. The results are significant in the context of understanding the structure, star formation history and metallicity of the Bridge, and the unique environmental conditions (low-gas density, low-metallicity, and tidally stripped) that could lead to the formation of OB-type stars.

Session

Division J Galaxies and Cosmology

1590

Tracing the assembly history of the Local Group galaxies through long-period variable stars

Dr Atefeh Javadi

Institute for Research in Fundamental Sciences (IPM)

Abstract

The Local Group of galaxies represents the only group in which we have detailed knowledge of stellar populations, their formation, and evolution. As a result, we monitored a majority of galaxies in the Local Group at different wavelenghts, including the M33 galaxy and satellite galaxies surrounding the Milky Way and Andromeda galaxy in addition to isolated dwarf galaxies. Based on light curve analysis, we identified cool evolved stars pulsating in fundamental mode. Then, a novel technique developed by Javadi et al. 2011 was used to derive star formation history (SFH) using the luminosity of these cool-evolved stars. Through analyzing an entire satellite system, we determined how satellites vary as a result of infall histories, cosmic reionization, and internal processes. Then we gathered the multi-wavelength observations of LPVs to determine the mass-loss rates and dust production. In this paper, I will first present the results we obtained for SFH and dust production rate in individual galaxies separately so that we can understand how different types of galaxies have evolved over cosmic time. In the second part of my talk, I will discuss whether the mass return from dusty evolved stars can provide enough gas reservoirs to sustain star formation or even rejuvenate dwarf galaxies. In conclusion, I will compare the star formation histories of various types of galaxies found in different environments to gain a comprehensive understanding of galaxy evolution in the Local Group.

Session

Division J Galaxies and Cosmology

1609

Studying the effect of physical parameters on galaxy classification using the concentration index tool.

Student Mary Ndimuwaki

Kenyatta university

Abstract

Our study explores how stellar mass, redshift, and environmental factors influence galaxy morphology through concentration index analysis. Using multi-wavelength data from optical and infrared surveys, we analyze galaxies across diverse redshifts and environments. Our findings reveal correlations between these parameters and morphological types.

Preliminary results suggest that galaxies with higher luminosities tend to exhibit higher concentration indices, indicating more centrally concentrated light profiles. Additionally, we observe subtle dependencies on stellar mass and environment, highlighting the complex interplay between intrinsic properties and environmental influences.

This research deepens our understanding of galaxy formation and evolution mechanisms by elucidating the role of specific physical parameters in shaping galactic morphology. These insights have significant implications for theoretical models in galaxy formation and contribute to a richer understanding of extragalactic astronomy.

Session

Division J Galaxies and Cosmology

Poster upload

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1622

Understanding the Galaxy-Halo connection: A perspective from the Mutual Information statistics

M.Sc. Yeimy Camargo, Dr. Rigoberto Casas-Miranda

Universidad Nacional de Colombia

Abstract

The galaxy-halo connection is a very active area of research in cosmology and it is crucial for understanding the galaxy formation and evolution. In this work we investigate the correlations between the assembly times of the dark matter haloes and the assembly times, star formation efficiency (F_*), color (g-i), and the specific Star Formation Rate (sSFR) of central and satellite galaxies. We use data of galaxies and dark matter haloes from the TNG300-1 simulation, which is part of The Next Generation Illustris simulations (IllustrisTNG). To quantify the correlations mentioned above, we compute the Mutual Information (MI) statistics on galaxies with stellar masses in the range of $10^9 \leq M\_\star(h^{-1}M_{sun}) \leq 10^{11.2}$ and their host dark matter haloes. The MI statistics reveals that the assembly times of galaxies and F_* are correlated with the assembly times of their host DM haloes for central galaxies with stellar masses below $M_* \cong 10^{10.25} h^{-1} M_{sun}$, whereas the color (g-i) and sSFR show a weaker correlation with the assembly times of their haloes. In the case of satellite galaxies the MI is close to zero across all stellar masses and quantities tested. The analysis of these results can be used to refine galaxy formation models.

Session

Division J Galaxies and Cosmology

1669

An unusual, high-redshift, disk galaxy population discovered with JWST

Ms. Rashi Jain, Dr. Yogesh Wadadekar

NATIONAL CENTRE FOR RADIO ASTROPHYSICS - TATA INSTITUTE OF FUNDAMENTAL RESEARCH, INDIA

Abstract

We present a study on the morphological and global stellar population synthesis (SPS) properties of high-redshift galaxies within the redshift range of $3 < z < 6$. We use public JWST data from the UNCOVER survey, offering photometric redshifts and SPS properties derived via the photo-z code Prospector. We select a sample of 674 galaxies with SNR > 10 (in the F444w JWST/NIRCam filter) within the specified redshift range. We carry out visual morphological classifications by categorizing the sample into seven groups: disk only, spheroid only, irregular only, disk + spheroid, spheroid + irregular, disk + irregular, and disk + irregular + spheroid. We also derive non-parametric morphological classifications of the galaxies, calculating CASGM (Concentration, Asymmetry, Smoothness, Gini coefficient, M20) statistics. Our visual classifications reveal that 56% of galaxies in our sample contain a disk component, consistent with the disk fraction derived using CASGM statistics. We explore the correlations between morphologies and SPS properties of these high-redshift galaxies, noting that the majority of these galaxies are vigorously star-forming. We observe that disk galaxies dominate the more massive end of the population, and in the size-mass relation, disks exhibit larger sizes and greater masses. This result is surprising, as with previous studies done with HST, it was thought that most galaxies at high redshift are either spheroids or irregulars. Our findings align with similar other studies utilizing data from deep JWST surveys, such as CEERS and SMACS 0723.

Session

Division J Galaxies and Cosmology

1677

Dusty star-forming galaxies as tracers of protoclusters: A simulated perspective

Pablo Araya Araya[1], Christopher Hayward[2], Rachel Cochrane[3,2], Laerte Sodré Jr.[1], Robert Yates[4], Douglas Rennehan[2], Roderik Overzier[5], Marcelo Vicentin[1]

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Abstract

Dusty star-forming galaxies (DSFGs) are commonly used as tracers of galaxy protoclusters, withmany spectacular examples identified with telescopes such as the South Pole Telescope, Planck, andHerschel. However, to date, there has been relatively little 'first principles' theoretical work that modelsthe connection between DSFGs and protoclusters. To address this gap, we have incorporated scalingrelations (derived in previous work by performing radiative transfer calculations on hydro simulations)to predict far-IR/submm flux densities into the L-Galaxies semi-analytic model. I will present a fewresults from this new model. Specifically, I will show that protocluster cores exhibit an excess of DSFGsrelative to protocluster 'outskirts' and the field. However, contrary to some claims in the literature, thisis not due to the dense environment 'triggering' starbursts. Rather, the DSFGs typically lie near the starformation main sequence. The reason for the excess is that protocluster cores have an excess of massivegalaxies relative to less-overdense regions. Moreover, the model predicts that the brightest DSFGs arepredominantly located in protocluster cores.

Session

Division J Galaxies and Cosmology

1686

The LOFAR Two-metre Sky Survey: The Nature of the Faint Source Population and SFR-Radio Luminosity Relation using Prospector

Mr Soumyadeep Das

University of Hertfordshire

Abstract

Spectral energy distribution (SED) fitting has been extensively used to determine the nature of the faint radio source population. Recent efforts have combined fits from multiple SED-fitting codes to account for the host galaxy and any active nucleus that may be present. We show that it is possible to produce similar-quality classifications using a single energy-balance SED fitting code, Prospector, to model up to 26 bands of UV - far-infrared aperture-matched photometry for over 31000 sources in the ELAIS-N1 field from the LOFAR Two-Metre Sky Survey (LoTSS) Deep fields first data release. One of a new generation of SED-fitting codes, Prospector accounts for potential contributions from radiative active galactic nuclei (AGN) when estimating galaxy properties, including star formation rates (SFRs) derived using non-parametric star formation histories. Combining this information with radio luminosities, we classify 92 per cent of the radio sources as a star-forming galaxy, high/low-excitation radio galaxy, or radio-quiet AGN and study the population demographics as a function of 150 MHz flux density, luminosity, SFR, stellar mass, redshift and apparent r-band magnitude. Finally, we investigate the SFR--150 MHz luminosity relation for a sample of 133000 3.6 micron-selected z<1 sources, finding that the stellar mass dependence is significantly weaker than previously reported, and may disappear altogether at moderate to high SFR regimes. This study makes it significantly easier to classify forthcoming radio source samples from LoTSS and elsewhere, and have important implications for upcoming radio frequency studies of star-forming galaxies.

Session

Division J Galaxies and Cosmology

1694

Formation and evolution of the Nuclear Star Cluster in the Milky Way and other spiral galaxies on the cosmological time scale

Prof. Dr. Sci. Peter Berczik, Dr. Marina Ishchenko, Ms. Margarita Sobolenko

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Abstract

According to the standard LCDM model, the globular clusters (GCs) of the Milky Way (MW) are the first gravitationally bound stellar systems to form in the early Universe, with a typical age of about 10-12 billion years. GCs are quite common in the Galaxy. In early 2020, 150 of them were found in the MW, in 2022 - 160, and more than 10 stellar systems are candidates for GCs. In the past few years, we have been getting more and more direct evidence for the existence of a supermassive black hole (SMBH) at the center of the MW and other galaxies. In addition to the SMBH, the Nuclear Star Cluster (NSC) is also located in the center of the Galaxy. Several mechanisms have been proposed for the formation of such NSCs. Two main ones are distinguished: (i) the migration of gas into the center of the Galaxy and the subsequent formation of the stellar content of the NSCs, and (ii) the migration of GCs into the center of the Galaxy and their subsequent destruction and total or partial merging with the compact central NSCs. The goal of our study is to numerically model the formation of NSCs by the dynamical interaction of GCs with the central region of the MW and other spiral galaxies (e.g., Andromeda), including the strong interaction with the central SMBHs. Based on the numerical calculations performed, qualitative estimates of the probabilities of complete and partial absorption of individual GCs in different orbits will be given.

Session

Division J Galaxies and Cosmology

1711

Deconvolving photometric redshifts: Using machine learning to obtain the large-scale structure from photometric data

Mr. Erik Lima, Prof. Dr. Laerte Sodré

Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo

Abstract

The determination of galactic distances, derived from the redshift of their spectral features, is of fundamental importance for several astronomical investigations, spanning from the identification of local universe structures to cosmological studies. However, this approach presents several challenges since the time required to obtain reliable spectra increases exponentially, specially at fainter magnitudes. In the age of very large surveys able to probe several millions or billions of objects, this approach becomes infeasible. Therefore a different methology is required.

This alternative method leverages the large amount of photometric data that the aforementioned surveys will provide, allowing the estimation of photometric redshifts. However, although faster to obtain, their lower precision can lead to biases that can be hard to address, limiting their application in some fields of study.

In this work we take advantage of the accurate photometric redshifts from the Southern Local Universe Survey and develop a machine learning model with the goal of deconvolving these estimates providing a new, less noisy photometric redshift, which enables us to recover the structures in the local universe with good precision (10% lower scatter and 3 times less bias) using exclusively photometric data. With this we will also present an analysis of the physical properties of galaxies in the Stripe-82 region and their connection to the different environments, giving insights into their formation and evolution.

The results of this work can be applied to other surveys, allowing for a better utilization of their scientific potential specially in the context of large-scale structure studies.

Session

Division J Galaxies and Cosmology

1744

Environmental effects on subhalo masses of satellite galaxies in galaxy clusters

Mr . Amit Kumar[1], Prof. Surhud More[1,2], Dr. Tomomi Sunayama[3], Dr. Divya Rana[4]

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Abstract

We investigate the matter distribution around satellite galaxies evolving in dense galaxy clusters, using the weak gravitational lensing technique; leveraging Year-1 public data from the Hyper Suprime Cam survey. We explore the effect of environment specific processes on the dark matter mass around SDSS redMaPPer satellites, by comparing it to the distribution around a control sample of galaxies matched to satellites in photometric properties but residing in a non-cluster environment. In order to understand the impact of host potential on the subhalo mass of the satellite, we bin satellite galaxies as a function of projected separation from the cluster centre. We see hints of a difference in the subhalo mass of satellites compared to the halo masses of galaxies in our control sample, especially in the innermost cluster-centric radial bin ($0.1 < R < 0.3$ h^{-1}Mpc). We use these measurements to put a first-ever direct upper limit on the prevalence of galaxies that have lost their subhalo entirely, i.e. orphan galaxies, at different distances from the cluster center. We confront a leading galaxy formation model, i.e. UniverseMachine to these observational constraints on the prevalence of orphan galaxies. We find the fraction of orphan galaxies invoked by the UniverseMachine is marginally consistent with these observational upper limits in the innermost regions of galaxy clusters and significantly higher in the outer regions of galaxy clusters particularly beyond 0.3 h^{-1}Mpc. We also discuss ways to distinguish any physical effects that could result in orphan galaxies from any numerical effects in the empirical model.

Session

Division J Galaxies and Cosmology

1747

Cosmological constraints from Subaru HSC Y3 weak lensing observations

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Abstract

The Subaru Hyper Suprime-Cam (HSC) survey is the deepest amongst the ongoing Stage 3 weak gravitational lensing surveys. Using data from the Year 3 (Y3) release of the shapes of galaxies, we have performed three blinded cosmology analyses to measure the amplitude of fluctuations in the late Universe. The tomographic cosmic shear analyses were carried out in both real and Fourier space. A 3x2 point analysis, which combines the cosmic shear with the clustering and galaxy-galaxy lensing signal of galaxies from a combination of the HSC data with spectroscopic galaxy samples from the SDSS, was also performed in order to obtain cosmological constraints. These analyses utilize more than 25 million galaxies in the HSC-Y3 catalogs in four tomographic redshift bins ranging from 0.3 to 1.5 and over the survey area of 416 sq. degrees. Applying wide and conservative uninformative priors on the photometric redshift errors, for a flat LCDM model, we obtain values of S8=0.767+0.031-0.034 (68% C.I.), a 4 percent error with the real space cosmic shear analyses. The rest of the analyses also result in values for S8 which are internally consistent with this number. A comparison of our result in the context of the LCDM model with the Planck 2018 cosmic microwave background observations shows consistency albeit a ~2 sigma lower value for the parameter S8. We identify the inference of the redshifts of the photometric source galaxies to be the largest contribution to the systematic uncertainty budget and comment on possible ways to empirically address it.

Session

Division J Galaxies and Cosmology

1754

A Plausible Solution to the Hubble Tension *via* Cosmologically Varying Fundamental Natural Constants

Professor Golden Gadzirayi Nyambuya

National University of Science and Technology

Abstract

A number of scientists have wondered if the Hubble tension heralds some *hitherto* yet unknown physics or there might be some serious error in our methods and analysis? For a plausible solution, we suggest a cosmologically varying Planck constant --- *i.e.*, a Planck constant that varies in proportion to the cosmic expansion scale factor. This cosmologically varying Planck constant introduces a new correction term to the distance modulus. When the new corrected distance modulus term is applied to the Union2.1 dataset of 580 type Ia supernovae which typically yield: $H_0 \sim$ 70-to-76 km/s/Mpc, we obtain a 99.49% (*i.e.*, R^2-value) fit between the proposed theory and the Union2.1 dataset of 580 SNe Ia and this impressive fit-to-data yields: $H_0 = 68.70 \pm 0.30$ km/s/Mpc. We consider our result to be in good agreement with that obtained by the Planck collaboration, thus, the tension in the two values may have found a solution worthy to be taken seriously. If acceptable, this solution somewhat forces physicists to the drawing board to re-consider and take much more seriously the idea of variable Fundamental Natural Constants (FNCs) as this phenomenon may introduce `*dark*' effects which may be interpreted as darkenergy or darkmatter.

Session

Division J Galaxies and Cosmology

1777

X-shaped sources in the MeerKAT + South Pole Telescope 100 square-degree survey at 816 MHz

Mr William Rasakanya

University of the Witwatersrand

Abstract

X-shaped Radio Galaxies (XRGs) exhibit rare, exotic morphologies with two pairs of radio lobes with an offset jet axis. Their formation remains an open question, with a wide range of proposed models, including reoriented radio jet axes due to black hole spin-flips following a binary black hole merger, hydrodynamical backflows, and overpressurised lobes, amongst others. A large, uniformly selected sample of X-shaped sources mapped with high-image fidelity is an important step towards understanding the relative presence of an XRG sample in the MeerKAT + South Pole Telescope 100 square-degree survey at 816 MHz. To date, five sources that fit the description have been found in approximately half the data, highlighting the rarity of these objects. We present a multiwavelength analysis of these sources, including sub-arcsecond Dark Energy Survey multi-band optical imaging. Uniform studies of XRGs from wide-area surveys such as this will help us understand the various formation models of XRGs, improve 3D GRMHD simulations, and refine our understanding of radio galaxy formation, including the role of their environment.

Session

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1789

Training Models of Type Ia Supernovae for the Next Generation of Cosmology Surveys

Kene Anumba[1], Dr. Maria Vincenzi[1], Prof. Daniel Scolnic[1], Prof. David Jones[2]

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Abstract

In the next few years, a new generation of supernova surveys will begin, including the Legacy Survey of Space and Time (LSST) and the Nancy Grace Roman Space Telescope surveys. These surveys will help discover up to a million supernovae, orders of magnitude beyond what has been discovered so far. To use Type Ia Supernovae (SNe Ia) to constrain cosmological parameters like the equation-of-state of dark energy, one must establish a spectro-photometric model of the supernova explosion time series. The accuracy of the model itself may be one of the limiting systematic uncertainties of any cosmological inference. Here, we use new simulations of the LSST and Roman survey to train a light-curve model. We show in this poster the accuracy and precision of this model over the range of wavelengths that these surveys will probe, from the optical to the near-infrared. We present a first look at how changing certain parts of the observing strategy of these surveys can change the precision of the trained models. Finally, we explain how to reproduce this work and use our trained models in forecasting the cosmological constraints of this next generation of surveys.

Session

Division J Galaxies and Cosmology

1809

Probing Late-Time Anisotropies With Weak-Lensing

Mr James Adam

University of the Western Cape

Abstract

One of the cornerstones of the standard model of cosmology is the assumption that, on sufficiently large scales, the Universe is homogeneous and isotropic. Some dark energy and modified gravity models, however, naturally lead to large-scale anisotropies. Thus, it is of great importance to test this broad assumption. One possible method of probing these anisotropies involves the use of weak gravitational lensing. More specifically, the imprints that these anisotropies would have on the weak shear of light beams on cosmological scales could be analysed in upcoming surveys like Euclid, SKA, and LSST.

Session

Division J Galaxies and Cosmology

1841

Foreground cleaning of MeerKAT HI intensity mapping data using machine learning techniques

Foreground cleaning of MeerKAT HI intensity mapping data using machine learning techniques
Felicia Setshabe

University of the Western Cape

Abstract

We investigate 21cm intensity mapping foreground cleaning techniques with machine learning methods. We train a CNN UNet architecture with 3-dimensional convolutions simulated data cubes, and test the extent to which we can reconstruct an unbiased estimate of the 21cm power spectrum from the cleaned cubes. Particular emphasis is put on realistic instrumental effects specific to MeerKAT and on comparing the machine learning approach to well established methods like principal component analysis.

Session

Division J Galaxies and Cosmology

1847

The Atacama Cosmology Telescope: Galactic Dust Structure and the Cosmic PAH Background in Cross-correlation with WISE

Rodrigo Córdova-Rosado[1], Brandon Hensley[1,2], Susan Clark[3,4], Adriaan Duivenvoorden[5], Jo Dunkley[6,1], The Atacama Cosmology Telescope Collaboration[6]

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Abstract

We present a cross-correlation analysis between 1′ resolution total intensity and polarization observations from the Atacama Cosmology Telescope (ACT) at 150 and 220 GHz and 15″ mid-infrared photometry from the Wide-field Infrared Survey Explorer (WISE) over 107 12.5∘×12.5∘ patches of sky. We detect a spatially isotropic signal in the WISE×ACT TT cross power spectrum at 30σ significance that we interpret as the correlation between the cosmic infrared background at ACT frequencies and polycyclic aromatic hydrocarbon (PAH) emission from galaxies in WISE, i.e., the cosmic PAH background. Within the Milky Way, the Galactic dust TT spectra are generally well-described by power laws in ℓ over the range $10^3<\ell<10^4$, but there is evidence both for variability in the power law index and for non-power law behavior in some regions. We measure a positive correlation between WISE total intensity and ACT E-mode polarization at $1000<\ell\lesssim6000$ at >3σ in each of 35 distinct ∼100 deg^2 regions of the sky, suggesting alignment between Galactic density structures and the local magnetic field persists to sub-parsec physical scales in these regions. The distribution of TE amplitudes in this ℓ range across all 107 regions is biased to positive values, while there is no evidence for such a bias in the TB spectra. This work constitutes the highest-ℓ measurements of the Galactic dust TE spectrum to date and indicates that cross-correlation with high-resolution mid-infrared measurements of dust emission is a promising tool for constraining the spatial statistics of dust emission at millimeter wavelengths.

Session

Division J Galaxies and Cosmology

1851

Narrow-band photometric selection of quasars with large-sky surveys (S-PLUS)

Lilianne Nakazono, Raquel Ruiz Valença, Prof. Claudia Mendes de Oliveira

Universidade de Sao Paulo

Abstract

Quasars are among the most luminous sources in the Universe and are found at a wide range of redshift up to z ~ 7.6. However, most of the confirmed quasars are in the northern hemisphere and the number decreases drastically in the southern hemisphere. Enlarging the sample of confirmed quasars at a wide range of masses and luminosities will improve our understanding of the large-scale structure and the underlying physical processes surrounding the supermassive blackholes. The Southern Photometric Local Universe (S-PLUS) will cover ~9300 square degrees of the southern sky with an 80-cm telescope located in the Cerro Tololo Inter-American Observatory. The observations are taken in 12 optical bands: 5 sloan-like broad bands and 7 narrow bands centered in stellar features. Currently, S-PLUS is the survey that has released data for the largest area of the southern sky (~3000 square degrees in DR4) with the highest number of narrow bands, hence S-PLUS is a great laboratory for evaluating the importance of narrow-band information in machine learning using real data. We show in our work that the narrow-band photometry increases the performance of star/galaxy/quasar classification (Nakazono et al. 2021) and photometric redshift estimation (Nakazono & Valença, submitted) compared to broad-band models, even when also considering infrared data. In this talk, I will present these works in detail and our publicly-available quasar photometric catalog for S-PLUS DR4 that contains >600k high-probability candidates. Finally, I will discuss our prospects of using these photometrically selected quasars for studying large-scale structures.

Session

Division J Galaxies and Cosmology

1858

Title: A search for relics and halos associated with SZ-selected clusters in the wide-field MeerKAT + South Pole Telescope Survey

Mr Isaac Magolego

University of the Witwatersrand

Abstract

Galaxy clusters are the largest gravitationally bound objects in the universe. They serve as important astrophysical laboratories and cosmological probes when used on a statistical basis. Here we present first results from the MeerKAT UHF band (544–1087 MHz) search for radio halos and relics in the South Pole Telescope discovered SZ-selected cluster sample. The homogeneously mass-selected cluster sample is therefore complemented by deep (~10 uJy/beam), high fidelity, uniform sensitivity imaging at 816 MHz, leveraging MeerKAT high survey speed at this frequency. Expanding statistical samples into these broader ranges will enhance our comprehension of the life cycle of widespread radio emission in clusters. This, in turn, will allow us to enhance existing models of particle reacceleration and potentially suggest adjustments should our observations unveil previously undiscovered behaviours.

Session

Division J Galaxies and Cosmology

1867

Analytical Insights into Dark Matter Deficient Galaxies

Dr. Zhaozhou Li

The Hebrew University of Jerusalem

Abstract

Recent observations report a puzzling dearth of dark matter (DM) in a fraction of massive high-z galaxies and dwarf galaxies, challenging current simulation predictions within the standard ΛCDM scenario. This discrepancy underscores our limited understanding of the halo/galaxy structural evolution. Here, I will present a novel unified analytical framework for galaxy dynamical evolution driven by feedback outflows, mergers, and tidal interaction, and show how these processes can augment structural diversity and form DM-deficient galaxies.

Session

Division J Galaxies and Cosmology

1873

Unveiling high-redshift quasars with anomaly detection techniques in S-PLUS

Raquel Ruiz Valença, Lilianne Nakazono, Prof. Claudia Mendes de Oliveira

Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo

Abstract

The search for quasars at high redshifts has become an increasingly relevant topic. Studying these objects, especially the more luminous ones, contributes to research on the accretion physics of supermassive black holes, the evolution of galaxies, and the large-scale structure in the early epochs of the Universe. As the number of known quasars declines sharply past z~3.5 (Lyke et al., 2020), high redshift (z>5) quasars can be considered as rare objects, so in this project we apply anomaly detection techniques in order to find high redshift quasars in the Southern Photometric Local Universe Survey (S-PLUS). S-PLUS, with its extensive photometric coverage (~3000 square degrees with S-PLUS DR4), serves as an ideal laboratory for identifying these rare objects, enabling effective photometric selection for subsequent spectroscopic follow-up. To find such quasars, we will use the photometric information contained in the 5 broad bands and 7 narrow bands from S-PLUS, along with the photometry from the WISE survey. Moreover, we will study how the photometric redshifts we estimate (Nakazono & Valença et al., submitted) for S-PLUS quasar candidates can assist us in anomaly detection. We have compared color-color diagrams of our quasar candidates with quasars confirmed by spectroscopy and found that a 3-dimensional diagram including the S-PLUS u, g, and J0861 bands and both WISE W1 and W2 bands provides a good selection of high redshift quasars. Additionally, we have applied dimensionality reduction techniques (e.g. t-SNE) and machine learning methods, such as Isolation Forest, to refine this analysis.

Session

Division J Galaxies and Cosmology

1887

The Early and Fast Settlement of Milky Way Disk

Lais Borbolato[1], Hélio Perottoni[2], Silvia Rossi[1], Guilherme Limberg[1], João Amarante[3], Cristina Chiappini[4], Anna Queiroz[4]

[1]Universidade de São Paulo. [2]Laboratório Nacional de Astrofísica. [3]Universitat de Barcelona. [4]Leibniz Institute for Astrophysics Potsdam

Abstract

The Milky Way (MW) has historically served as a template for understanding the formation and evolution of massive late-type disk galaxies in general. The combination between astrometric data from Gaia mission and spectroscopic surveys have allowed us to map the entire history of our Galaxy, from a turbulent proto-MW at early times to the barred spiral that we see today. This transformation from a dynamically hot proto-MW to its present-day dynamically cold state is marked by a "spin-up" transition when in-situ stars quickly gain angular momentum, hence rotation. Using metallicities as a proxy for time, previous studies found that this spin-up phase occurs at about [Fe/H] ~ -1.2. However, because metallicity is not directly correlated with age and accurate stellar ages are difficult to estimate, we still haven't been able to directly time the spin-up. In this work, we applied the spectro-photometric code StarHorse to obtain ages for a large sample of stars from SEGUE and LAMOST catalogs. For the first time, we demonstrate that the spin-up starts at 11.5 Gyr in the past and last for just 2 Gyr. We also investigate the behavior of the thin and thick disks during this phase as well as how the halo responds to it. In the near future, this result will be compared to MW analogs found in galaxy formation simulations for us to advance our knowledge regarding the physical processes that control the establishment of galaxy disks across cosmic time.

Session

Division J Galaxies and Cosmology

1892

Emission line properties of type-2 AGN in theLockman-SpReSo survey

Mrs Bereket Assefa, Professor Mirjana Povic

Space Science and Geospatial Institute, Addis Ababa, Ethiopia

Abstract

Active galactic nuclei (AGN) are some of the brightest sources in the Universe, emitting light at all wavelengths due to their complex structure. Deep multi-wavelength extra-galactic surveys are therefore important for understanding the full physics of AGN and their role in the formation and evolution of galaxies. The Lockman-SpReSo survey is one of the deepest multi-wavelength spectroscopic surveys in the optical and far-infrared (FIR), obtained using the GTC 10 m and Herschel telescopes, respectively. Using this survey, we selected an unique sample of type-2 AGN in the FIR with deep optical spectroscopic data to study the relationship between their fundamental properties in the FIR and in the optical. Specifically, in this work we aim to better understand the optical spectroscopic properties of type-2 FIR AGN by characterizing the emission line properties and comparing them with the FIR properties. In this talk, we will present the analyses performed on the identification and characterization of the emission lines and the various spectroscopic and IR properties of selected type-2 AGN.

Session

Division J Galaxies and Cosmology

1913

Star Formation and Gas Supply in the Green Valley Over Cosmic Time

Kyle Cook, Dr Benne Holwerda, Clayton Robinson

University of Louisville

Abstract

The green valley and its role as a transitional space for quenching or rejuvenation of star formation remains a heavily researched topic in galaxy evolution. Early evidence suggests an evolution in the relationship between HI mass and star formation rate over cosmic time. The Looking At the Distant Universe with the MeerKAT Array (LADUMA) survey aims to produce the deepest direct detections of HI, allowing for our most complete view of this relationship. We analyze a small sample of galaxies in the LADUMA L-Band selected for existing Spectral Energy Distribution (SED) fit results and NUV data (Swift or XMM). These galaxies have low HI fractions, which we interpret as the result of recent quenching and possible rejuvenation. We present our multi-year plan to take advantage of the excellent synergy of the LADUMA data with upcoming instruments such as Rubin Observatory and the Euclid and Roman Space Telescopes.

Session

Division J Galaxies and Cosmology

1954

Searching for radio halos in edge-on starburst galaxies

Camila Galante[1,2], Dr. Juliana Saponara[1,2], Dr. Gustavo Romero[1,2], Dr. Paula Benaglia[1]

[1]Argentine Institute for Radioastronomy (IAR). [2]National University of La Plata (UNLP)

Abstract

Starburst galaxies undergo intense episodes of star formation that cause gas to be ejected by winds into the galaxy's surroundings. Strong shocks, capable of accelerating cosmic rays, can form when these winds interact with the intergalactic medium. At radio wavelengths, the radiation from the cosmic rays can be detected as a halo, which can be characterized by a scale height. How these halos relate to the global properties of the galaxies can help to understand the origin of the halo and the underlying cosmic ray population. Here we present our search for the presence of radio halos in a sample of 25 edge-on starburst galaxies from the MeerKAT 1.28 GHz Atlas of Southern Sources in the IRAS Revised Bright Galaxy Sample. We detected 11 radio halos, seven of which are reported for the first time. The dependence of the halo luminosities on the star formation rate and the infrared luminosities we found support the hypothesis that the radio halos are the result of synchrotron radiation produced by relativistic electrons. To explain the average scale height of 1 kpc that we found, there must be some process that reaccelerates cosmic rays in the halo, if gamma ray emission of leptonic origin is detected from the halo. From our sample, the galaxy NGC 4666 is a potential gamma ray source for future observations, according to the radio and gamma ray luminosity relation.

Session

Division J Galaxies and Cosmology

1963

The evolution of the M - Lx relation in the CODEX galaxy cluster sample

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Abstract

Precise measurements of X-ray scaling relations in galaxy clusters are imperative to probe cosmological parameters. The functional form of the correlation between X-ray luminosity and the mass of clusters is established in the purely gravitational self-similar model. However, deviations become apparent when non-gravitational processes, e.g. radiative cooling and AGN feedback, exert influence, potentially leading to a temporal evolution of the relation.

Up until this work, precise calibration of the M-Lx relation and its evolution, employing weak-lensing mass estimates and a consistent statistical methodology, was still lacking. Our calibration utilizes the CODEX catalog, constructed by an X-ray and optical selection of clusters in the superposition area of RASS and SDSS surveys. We analyze 101 CODEX galaxy clusters with weak-lensing masses, which is considered to be a less biased mass proxy.

Introducing a Bayesian hierarchical model, we account for measurement errors, intrinsic scatter, selection functions, and the subsample's construction criteria. The CODEX weak-lensing sample is well fit by a power law in log space with a slope of 0.3 ± 0.05, which is significantly shallower than the self-similar prediction. We also report an evolution parameter of 1.54 ± 0.55, which is statistically significant to infer a positive evolution of the scaling relation. As we investigate these intriguing findings, we point out our distinctive statistical approach and our analysis focused on a high-mass sample as potential factors. We also conjecture the effects of AGN feedback and a possible evolution bias due to our Lx distribution.

Session

Division J Galaxies and Cosmology

1991

Galaxy-Cluster Membership Assignment Using High-Precision Photometric Redshifts

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Abstract

In the study of galaxies in large scale structures, such as groups and clusters, one of the fundamental steps is to reliably dictate which galaxies belong to a given structure of interest. Leveraging the high-precision photometric redshifts (photo-zs) acquired from the Southern Photometric Local Universe Survey (S-PLUS), we explore different approaches to identify galaxies potentially belonging to groups and clusters of galaxies.

Typically, the determination of galaxy memberships in clusters and other structures relies on spectroscopic redshifts. However, the cost of extensive spectroscopic observations and the absence of a comprehensive survey in the southern hemisphere has restricted these observations to only the brightest galaxies. To address this limitation, we utilize photometric redshifts to refine membership assignments in the southern hemisphere structures.

Our approach incorporates the development and implementation of two distinct galaxy-cluster membership methods. The first method employs a sigma-clipping technique, taking into account the typical photo-z uncertainty as a function of galaxy magnitude to identify cluster members. This method has been applied to select targets for observation within CHANCES, the CHileAN Cluster galaxy Evolution Survey. The second method employs a robust Bayesian approach to assign membership probabilities to galaxies in clusters. We have successfully tested this method in cluster mocks and applied it to the two richest clusters of the Hydra Supercluster of galaxies: Hydra (Abell 1060) and Antlia (Abell S0636). We achieved the promising values of 92% and 81% for completeness and 68% and 81% for purity for Hydra and Antlia respectively.

Session

Division J Galaxies and Cosmology

1997

A FRESH LOOK AT GALAXY SCALING RELATIONS AND WHAT THEY REVEAL ABOUT GALAXY FORMATION

Michael Fall[1], Enrico Di Teodoro[2], Lorenzo Posti[3]

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Abstract

Despite the apparent complexity of galaxies, some of their most basic properties (mass M, binding energy E, angular momentum J, etc) obey simple power-law scaling relations. Such relations provide some of the clearest insights into galaxy formation. This talk focuses on the relations between circular velocity V (a proxy for specific energy, $e = E / M$ proptoV^2) and mass M and between specific angular momentum $j = J / M$ and M. The observed forms of these scaling relations for the stellar components of galaxies, M_s propto V_s^4 and j_s propto $M_s^{0.6}$, are closely linked to the corresponding relations for their dark halos in CDM-type cosmologies, M_h propto V_h^3 and j_h propto $M_h^{2/3}$. We have obtained new kinematic (Ha and HI) and photometric data that extend the relations for late-type galaxies (spirals and irregulars) over the full range of stellar masses: $M_s \sim 10^8$ to $\sim 10^{12}$ M_{sun}. From the same data, we derive the "retention factors" for mass $f_M = M_s / M_h$ (aka stellar-to-halo mass ratio, SHMR) and specific angular momentum $f_j = j_s / j_h$, finding f_M propto $M_s^{0.4}$ and $f_j \sim 1$ independent of M_s. In contrast, for the most massive early-types galaxies (ellipticals and lenticulars), f_M declines with M_s and $f_j << 1$. We draw some simple but important conclusions from these empirical results about the physical origins of several basic properties of galaxies, including their sizes, compositions (stars vs gas), morphologies (disk vs spheroid), and feedback drivers (stars vs AGN). We also show that the observed forms of f_M and f_j are reproduced in contemporary cosmological hydrodynamical simulations of galaxy formation (IllustrisTNG).

Session

Division J Galaxies and Cosmology

2002

Cosmology from Cluster Structure

Prof. James Taylor

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Abstract

The abundance of galaxy clusters in the low-redshift universe provides a classic cosmological test, constraining a product of the matter density Ω_m and the amplitude of fluctuations parameter σ_8. Unfortunately, the test has a strong degeneracy between these two parameters, allowing a range of different cosmological models for any given abundance measurement. We propose a new test, based on the internal structure and accretion rate onto clusters, that breaks this degeneracy, and can significantly improve the resulting constraints. We illustrate the potential of the new test using lensing data from the UNIONs imaging survey, and compare our results to recent abundance constraints from eROSITA.

Session

Division J Galaxies and Cosmology

2009

Star-forming galaxies in NGC 6221, NGC 3263 and NGC 2434 groups.

Dr Juliana Saponara[1], Dr Bärbel Koribalski[2,3], Dr Jayanne English[4], Jing Yeung[5]

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Abstract

We present high-resolution MeerKAT radio continuum images of star-forming spirals in the nearby galaxy groups NGC 6221, NGC 3263 and NGC 2434. This sample spans the evolutionary timeline for galaxy groups, encompassing early, intermediate, and late stages, respectively. The NGC 6221 group contains a pair-wise interacting galaxy with tidal debris along with a few dwarf galaxies, while the NGC 3256 group represents a loose group where members are pre-processing via pair-wise interactions as they begin to fall towards the group's centre of mass. The NGC 2434 group has an elliptical galaxy, and the other group members appear to be accreting onto this central object. Since star formation (SF) is one of the dominant physical processes in the formation and evolution of galaxies, we study the SF activity in the group members. Specifically we seek evidence of environmental impact on SF. We use MeerKAT observations and archival infrared WISE data to measure the amount and location of SF activity. Also, spectral index maps, created by employing the in-band method, provide insights into the underlying physical processes associated with the observed star-forming regions. Additionally, we examine two galaxies in detail. NGC 6215 has a peculiar velocity field, which may be explained by accreted bridge material settling into a plane offset from the spiral disc. NGC 3263 has a highly inclined disk and extended tidal tail containing radio continuum emission. For NGC 3263, sensitive radio continuum observations are crucial to thoroughly trace and characterize its vertically extended radio halo for the first time.

Session

Division J Galaxies and Cosmology

2015

Understanding the role of environment on the quenching of the star formation: a multi-dimensional minefield

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Abstract

One of the key open questions in extragalactic astronomy is what stops star formation in galaxies, and whether the environment a galaxy inhabits matters. Throughout the decades, an incredibly large array of observational studies have quantified the variation of star formation (and other galaxy properties) with environment in fine detail. While these studies started by focusing on the cluster vs. field dichotomy, we are now at the stage where we are able to trace the multi-dimensionality of the concept of environment by taking into account the position of galaxies within bound structures and within filaments. In this work, I will review the status of environmental studies on galaxy quenching in the local Universe from an observational perspective. I will show that, while it is clear that the different external processes affect the gas-star formation cycle of galaxies in different environments, quantifying their role on the quenching of star formation across the full range of dark matter halos and stellar masses remains a complex task, as different physical mechanisms may act simultaneously and cannot always be easily separated. Despite these challenges, I will also argue that we are making progress and we are gradually building a coherent framework on how and when environment matters for galaxies quenching. I will conclude by highlighting several outstanding questions where we expect to see substantial progress in the coming decades, thanks to the advent of the Square Kilometre Array and its precursors.

Session

Division J Galaxies and Cosmology

2027

A study of extreme CIII]1908 and [OIII]88/[CII]157 emission in Pox 186 in Pox 186: Implications for JWST+ALMA (FUV+FIR) studies of distant galaxies

Dr Nimisha Kumari[1], Dr Renske Smit[2], Dr Claus Leitherer[1], Dr Joris Witstok[3], Dr Mike Irwin[3], Dr Marco Sirianni[1], Dr Alessandra Aloisi[1]

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Abstract

Carbon spectral features are ubiquitous in the ultraviolet (UV) and far-infrared (FIR) spectra of the reionization-era galaxies. We probe the ionized carbon content of a dwarf galaxy Pox 186 using the UV, optical, mid-infrared and FIR data taken with Hubble, Gemini, Spitzer and Herschel, respectively. This local ($z\sim0.0040705$) galaxy is likely an analogue of reionization-era galaxies, as revealed by its extreme FIR emission line ratio, [O iii]88 μm/[C ii] 157 μm (>10). The UV spectra reveal extreme C iii]$\lambda\lambda$ 1907, 1909 emission with the strongest equivalent width (EW) = 35.85 ± 0.73 Å detected so far in the local ($z\sim0$) Universe, a relatively strong C iv$\lambda\lambda$ 1548, 1550 emission with EW = 7.95 ±0.45Å, but no He iiλ 1640 detection. Several scenarios are explored to explain the high EW of carbon lines, including high effective temperature, high carbon-to-oxygen ratio, slope and upper mass of top-heavy initial mass function, hard ionizing radiation and in-homogeneous dust distribution. Both C iii] and C iv line profiles are broadened with respect to the Oiii]λ 1660 emission line. Each emission line of Civ$\lambda\lambda$ 1548, 1550 shows the most distinct double-peak structure ever detected, which we model via two scenarios, firstly a double-peaked profile that might emerge from resonant scattering and secondly, a single nebular emission line along with a weaker interstellar absorption. The study demonstrates that galaxies with extreme FIR properties may also show extreme UV properties, hence paving a promising avenue of using FIR+UV in the local (via Hubble+Herschel/SOFIA) and distant (via JWST+ALMA) Universe for unveiling the mysteries of the reionization-era.

Session

Division J Galaxies and Cosmology

2031

Outflows from Stellar Feedback in the Early Universe

Mr James Nianias

The University of Hong Kong

Abstract

Outflows powered by feedback from star formation are believed to suppress the buildup of stellar mass in galaxies throughout cosmic history. However, definitive observational evidence for such outflows in the early universe has proven to be elusive. Here, we present investigations of two very different outflow signatures at high redshifts. Our first study targets ionized/atomic outflows from some of the lowest-mass galaxies known. We analyse the spectra of ~ 600 gravitationally-lensed Lyman-α emitters at z ~ 2.9 – 6.7 in which metal lines are seen in emission and – in some cases – also in absorption. We find the Lyman-α spectral profiles to be consistent with models of expanding shells of partially-neutral gas. Where detected, the absorption lines are blueshifted relative to the systemic velocity of the host galaxy as measured by the metal emission lines, providing unambiguous evidence of outflows. In our second study, we search for signatures of outflows of molecular gas from dusty star-forming galaxies at z ~ 4 – 6, which, if detected, would constitute clear evidence of star-forming material being driven out of the galactic disc. Such outflows have previously been inferred from OH absorption that is blueshifted compared to [CII] emission, with the latter being attributed to interstellar gas in the disc. Here, we reanalyse these observations, showing that most of the purported OH absorption signatures are not statistically significant. On the other hand, we demonstrate a more rigorous procedure to search for blueshifted OH absorption, finding tentative evidence of outflows in all of the five sources examined.

Session

Division J Galaxies and Cosmology

2038

Identification of lopsided galaxies using Convolutional Neural Network

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Abstract

The non-axisymmetric features in disc galaxies including bars and spiral arms are fundamentally important in driving their secular evolution. Yet another promiscuous non-axisymmetric feature in the galactic disc is the large-scale asymmetry in the distribution of stars and gas, commonly referred to as lopsidedness. However, their formation and evolution are not very well understood. Quantitatively, lopsidedness is the normalised amplitude of the non-zero m=1 mode in the Fourier decomposition of the surface brightness distribution of the galaxy. About 30 % of the galactic disc shows global lopsidedness. In this work, we aim to augment their relatively sparse sample size by new identifications from the updated catalogs from the more recent surveys, using machine learning methods. To implement the same, we train the publicly-available ALEXNET, a convolutional neural network model for binary classification of galaxies into lopsided and non-lopsided galaxies. For training the neural network, we selected 50 galaxies images from the Sloan Digital Sky Survey Data Release 12 from Bournaud et al., 2005. After deprojecting the galaxy images to face-on view, we obtained the value of for each galaxy. Based upon the above-calculated value of and the threshold well-adopted in the literature, we labelled the galaxies as lopsided and not lopsided. Our trained model achieved an accuracy of almost 90 % on the validation set. We aim to further improve our testing accuracy by expanding the training set for our model, allowing the model to learn more efficiently.

Session

Division J Galaxies and Cosmology

2054

Extended Blazar Sequence for γ-ray Emitting Active Galactic Nuclei

Dr Finbarr Odo, Dr Akagu Audu, Dr Evaristus Iyida, Professor Augustine Ubachukwu

University of Nigeria, Nsukka

Abstract

In this paper, we use the distributions of observed γ-ray properties, as well as orientation parameters of a sample of *Fermi*-LAT AGNs to investigate the hypothesis that γ-NLS1 objects are beamed sources with γ-ray emitting axes inclined at close angles to the line of sight. Based on these parameters we investigate the relationship between γ-NLS1s and other subclasses of γ-ray emitting jetted AGNs. Results show that γ-NLS1s are more highly beamed than both FSRQs and BL Lacs with mean value of core-dominance parameter R_g ~ 9507. γ-NLS1s and jetted Seyfert galaxies are continuous in distribution of the orientation parameter with average cone angles Φ_m ~ 8° and 44° respectively. Furthermore, the spectral energy distribution of γ-NLS1 is comparable to those of FSRQs and BL Lacs suggestive that γ-NLS1s and blazars form a continuous spectral sequence. There is a significant anti-correlation (r ~ -0.9) between the γ-ray dominance (D_g) and γ-ray luminosity. There is a strong dependence of D_g on redshift (r ~ -0.7) suggestive that D_g is more sensitive to environmental factors than intrinsic γ-ray luminosity. The results suggest that γ-NLS1s are highly beamed γ-ray sources whose de-beamed counterparts can be found among Seyfert galaxy populations.

Session

Division J Galaxies and Cosmology

2078

Detection of an extreme high ionization emission line FeX from Lyalpha emitter

Dr Abhishek Paswan

University of Allahabad, Prayagraj

Abstract

We report the first detection of an extreme high-ionization potential (262.1 eV) emission line [Fe {\sc x}] λ6374 in the spectrum of a Lyman-α emitter (LAE), SHOC 579 at $z \sim 0.047$. This detection is subsequently followed by the presence of optical nebular He{\sc ii} λ4686 emission line, {\sc x}-ray ($0.5 - 8$ kev) and 1.4-GHz radio continuum emissions. We diagnose the origin of all these emissions using the standard characteristic relation of star-forming galaxies such as radio-far-infrared correlation and {\sc x}-ray luminosity relative to star formation rate and gas-phase metallicty. These relations do not exhibit any evidence of active galactic nuclei activity, and support the fact that the above detected emissions most likely originated due to the recent starburst event in the LAE. Our results in this study conclude that such objects in the early Universe might have played a crucial role in the re-ionization of Hydrogen by leaking their ionizing radiations. However, the leakage of these ionizing radiations additionally depends on the inter-stellar medium structure of the galaxy.

Session

Division J Galaxies and Cosmology

2086

The relation between the growth of the bulge and the galaxy quenching at low redshifts.

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[1]Federal University of Rio de Janeiro. [2]Federal Univeristy of Rio de Janeiro. [3]Santa Cruz State University

Abstract

Galaxy structure is one of the fundamental ways by which galaxy properties are described and by which galaxy evolution is inferred. Evidence suggests that more massive galaxies tend to have their star formation rates suppressed earlier in the Universe. On the other hand, environmental density also plays a critical role, with galaxies in denser environments showing higher quenching rates. There is currently a debate in the literature about how the growth of bulges relates to the decline in the star formation rate. In this sense, for sample selection we match data from SDSS, KIAS, MPA-JHU and GALEX, with $0.03 < z < 0.1$, TType < 0 , absolute magnitude ≤ -20.5 and color gradient < 1. Our objective is to characterize the bulge's structures in order to establish which mechanisms may have recently contributed to its current constitution, restricting the relationship between quenching and galaxy morphology. To characterize the bulge, we carry out a Principal Component Analysis (PCA) analysis taking into account morphometric parameters such as the CASGM system, environmental variable $\Sigma 5$, and spectral variables such as $H\alpha$, $H\delta$ and D4000 lines, to analyze star formation. We know that different processes can be associated with different quenching time scales, which can be distinguished between fast (< 300Myr) and slow (1Gyr) processes, therefore, we use the Starpy code to estimate the time from which the process started of quenching in galaxies, and the speed at which the process occurred.

Session

Division J Galaxies and Cosmology

2123

Hunting for primordial black holes using lensing parallax of GRBs

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Abstract

Nature of the dark matter has always been an important unresolved mystery. Primordial black holes, which could have formed during the early Universe through overdensities in primordial density fluctuations during inflation, are potential candidates for dark matter. Various experiments have already ruled out a vast parameter range for the possible masses of such primordial black holes. However, there exists a window in the mass range $[10^{-16}-10^{-11}]M_\odot$ where such PBHs remain unexplored thus far. We explore the use of lensing parallax of Gamma ray bursts (GRBs), which results in different fluxes being observed from two different vantage points, in order to probe the abundance of primordial black holes in this unexplored mass range. We derive the optical depth for the lensing of GRBs with a distribution of source properties and realistic detector sensitivities. We comment on the ability of the proposed Indian twin satellite mission Daksha in its low earth orbit to conduct this experiment. If the two Daksha satellites observe 10000 GRBs simultaneously and the entirety of dark matter is made up of $[10^{-15}-10^{-12}]M_\odot$ black holes, Daksha will detect non-zero lensing events with a probability ranging from 80 to 50 per cent at the bin edges, respectively. Non-detections will not conclusively rule out primordial black holes as dark matter in this mass range. However, we show that meaningful constraints can be obtained in such a case if the two satellites are separated by at least the Earth-Moon distance.

Session

Division J Galaxies and Cosmology

2124

New frontiers in cosmology with Cosmic Microwave Background polarization surveys

Professor Erminia Calabrese

Cardiff University

Abstract

The Cosmic Microwave Background (CMB) is a unique probe to study the physics of the Universe. This light, travelling since ~380,000 years after the Big Bang, contains relic signatures of the physical processes that took place at the origin of the Universe, as well as unique features allowing us to determine precisely the abundances of the main Universe constituents which govern its evolution on large scales.

During the last three decades, the astonishing agreement between CMB theory and increasingly-precise observations has led to the establishment of our standard model of cosmology. While the parameters of this model have been constrained to sub-percent precision, many fundamental questions about the Universe are still unanswered. In the near future, a series of ground-based and satellite experiments promise to deliver new breakthroughs in cosmology and fundamental physics via precise measurements of the CMB polarization signal. For example, CMB polarization at high resolution is sensitive to any new physics that changes the Universe's thermal history or energy budget, degree-scale polarization is instead the route to detect primordial gravitational waves.

In this talk I will give a snapshot of where we are in CMB cosmology, how we got here and where we are heading next. I will cover in particular the upcoming Simons Observatory (SO) experiment which is starting operations in 2024. SO will provide the most sensitive microwave maps over more than 50% of the sky, with observations overlapping and taking place concurrently with major surveys in other wavelengths such as Rubin and Euclid.

Session

Division J Galaxies and Cosmology

2163

Mini merger or big accretion? Asymmetry and star-formation in low-mass collisions.

Dr. Connor Bottrell

ICRAR/UWA

Abstract

Asymmetry is ubiquitous in the structures of star forming galaxies (SFGs) in the nearby Universe. However, the origin of this asymmetry is uncertain. An important clue comes from the observed relationship between galaxy asymmetries and star formation rates (SFRs). But what mechanisms are responsible for this connection? Both external gas accretion and galaxy-galaxy mergers are invoked as plausible options. Using the TNG50 simulations and mock Subaru Telescope images, I show that major and minor mergers (mass ratios > 1:10) cannot explain the variety in asymmetries for local SFGs. Their incompatibility is due to the long timescales between major/minor merger events and their short-lived (albeit high amplitude) effects on asymmetries and SFRs. In contrast, mini mergers (mass ratios 1:10 to 1:100) appear as inconspicuous but important drivers. According to TNG50, individual mini mergers yield “mini” enhancements in asymmetries and SFRs that persist on longer timescales than the average time between mini merger events. Consequently, asymmetric structure and SFEs aggregate via mini mergers. According to these results with TNG50, 70% of asymmetric structure and 55% of in-situ stars formed in mergers specifically originate from mini mergers. Are these mini collisions driving star-formation via gravitational torques? Or are they simply entrained in large scale gas inflows?

Session

Division J Galaxies and Cosmology

2210

Discovery of a grand design spiral galaxy at the redshift of z~4.

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Abstract

We present the discovery of a huge (∼10 kpc) and two-armed grand-design spiral galaxy at the redshift of approximately 3.8 through JWST. Utilizing publicly available JWST data from the UNCOVER survey we identify the photometric redshift to be 3.79 and 3.78, derived via stellar population synthesis (SPS) modeling codes Prospector and EAZY respectively. To mitigate the high error bars in the UNCOVER photometric redshifts, we cross-verify the redshift using SED modeling with an independent SED modeling code, Bagpipes. We fit exponential and delayed exponential parametric star formation histories to the observed SED and derive joint constraints on the photometric redshifts and SPS parameters. We determine the photometric redshift to be $3.82^{+0.2}_{-0.05}$. Our modeling with Bagpipes reveals that this is a huge, massive ($\log M_{\odot} = 10.37^{+0.02}_{-0.01}$) and a highly star-forming spiral galaxy (SFR of $67.6^{+11.8}_{-10.1}$ $M_{\odot}yr^{-1}$), consistent with UNCOVER catalog results. Furthermore, the detection in UNCOVER ALMA band 6 (1.2 mm) observations reveals an integrated flux density of approximately 1 mJy in ALMA band 6 which allows us to get the SFR estimate in FIR. The SFR calculated using the FIR ALMA flux of this galaxy is ∼90 $M_{\odot}yr^{-1}$, similar to the SFR derived from SED modeling. We emphasize that this is an HST dark galaxy with a knotty structure in the optical rest-frame indicating its star-forming regions and a bright central core. The formation of spiral arms so early in the universe is bizarre, these spiral arms might be transient and have been formed by a recently completed galaxy merger.

Session

Division J Galaxies and Cosmology

2219

Dark matter searches with MeerKAT

Dr Geoff Beck[1], Dr Michael Sarkis[2], Ms Natasha Lavis[1]

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Abstract

The nature of dark matter remains an open and pressing problem in cosmology and particle physics. Many dark matter models produce secondary electromagnetic signals from the products of decay or annihilation. In this talk, we explore the existing limits on the nature of Dark matter derived using MeerKAT, one of the world's premier radio telescopes, as well as examine the future of dark matter searches with this instrument.

Session

Division J Galaxies and Cosmology

2250

Unusual metallicity gradient and star formation efficiency in the giant low surface brightness galaxy Malin 1

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Abstract

Giant low-surface brightness (GLSB) galaxies are an extreme class of objects with very faint and extended gas-rich disks. Malin 1 is the largest GLSB galaxy known to date, but its formation is still poorly understood. We use VLT/MUSE IFU spectroscopic observations of Malin 1 to reveal, for the first time, the presence of H-alpha emission distributed across numerous regions along its disk, up to radial distances of about 100 kpc. We observe a steep decline in the star formation rate surface density within the inner 20 kpc, followed by a shallow decline in the extended disk. Similarly, the gas phase metallicity we estimated shows a steep gradient in the inner 20 kpc, followed by a flattening of the metallicity in the extended disk with a relatively high value of about 0.6 solar. Such a flattening provides clues on the formation of its disk. We found that the accretion of pre-enriched gas from a past merger is the most likely scenario for its formation. A comparison of the star formation rate surface density and gas surface density shows that Malin 1 exhibits a very low star formation efficiency (about 2 orders of magnitude lower than normal spirals), indicating a break in the well-known Kennicutt-Schmidt relationship at the LSB regime. Our findings contribute to a more detailed understanding of the formation of the giant disk of Malin 1 and also constrain possible proposed scenarios on the nature of GLSB galaxies in general.

Session

Division J Galaxies and Cosmology

2292

Foreground hardened quadratic estimator for CMB weak lensing convergence reconstruction

Mr. Kishan Deka

National Center for Nuclear Research, Warsaw, Poland

Abstract

Cosmic Microwave Background (CMB) photons experience weak gravitational lensing due to the large-scale structure of the Universe along their path. The weak lensing generates a divergence-free component of the polarization field known as B-modes, through the gravitational lensing of the primordial curl-free component of the field, known as E-modes. Estimating the lensing power spectra and delensing the CMB maps from recent and upcoming surveys are crucial tasks for the advancement of observational cosmology. However, one of the main obstacles to these tasks is the presence of foreground contamination in the CMB maps. In the era of high-sensitivity CMB experiments, the bias in delensing arising from these sources may exceed the statistical uncertainties of the observational data. Our objective is to study the efficiency of different lensing estimators in the context of upcoming CMB surveys and then provide new methods to mitigate the biases in lensing reconstruction. In our work, we test polarization-based quadratic estimators on simulated lensed CMB maps with instrumental properties corresponding to the CMB-S4 survey. Here, we present the foreground bias in quadratic estimators on simulated maps contaminated by galactic emissions. We also present impact of point source radio galaxies in polarisation based lensing reconstruction estimators. Foreground immune lensing methods for reducing extragalactic point source contamination has already been studied in literature. We extend on these works to mitigate galactic foreground contaminations. In our work, we present how impact of residual galactic foreground bias after component separation can be reduced for full-sky lensing reconstruction.

Session

Division J Galaxies and Cosmology

2314

The Star Formation History in Local Group Galaxies

Dr. Yi Ren[1], Prof. Biwei Jiang[2,3], Dr. Yuxi Wang[1], Dr. Ming Yang[4], Dr. Zhiqiang Yan[5]

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Abstract

The star formation histories (SFHs) of galaxies provide valuable insights into galaxy evolution and stellar physics. Understanding the SFHs enables the study of chemical enrichment of galaxies, star formation triggered by interactions, and the behavior of various stellar populations. This work investigates the SFHs of M31, M33 and ten dwarf galaxies in the Local Group (LG), which spans a wide range of types, masses, luminosities, and metallicities. The analysis is based on our new sample of the member stars in the LG after removing the foreground dwarf stars by the near-infrared color-color diagram and the Gaia astrometric information. The samples include the most complete and pure red supergiants and asymptotic giant branch stars to gain valuable insights into the recent SFHs of the galaxies. The Padova isochrones are used to generate initial model CMDs, accounting for photometric errors and completeness through star field simulations to match the completeness and error distributions of the observed CMDs. Subsequently, the SFHs, distance modulus, and metallicity of the twelve galaxies are determined by fitting the CMDs. The SFH maps of M31 and M33 are obtained. Furthermore, this work shows that the star formation activity in dwarf ellipticals persisted up to 30 Myr ago. A significant increasing feature in the SFH of NGC 6822 reveals star formation activity triggered by an interaction event.

Session

Division J Galaxies and Cosmology

2320

A novel analysis of contamination in Lyman break galaxy samples based on spatial cross-correlation with intermediate-redshift galaxies

Miftahul Hilmi[1,2], Dr Nicha Leethochawalit[3], Prof Michele Trenti[1,2], Benjamin Metha[1,2]

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Abstract

Potential contamination from low/intermediate-redshift galaxies, such as objects with a prominent Balmer break, affects the photometric selection of high-redshift galaxies through identification of a Lyman break. Traditionally, contamination is estimated from spectroscopic follow-up and/or simulations. Here, we introduce a novel approach to estimating contamination for Lyman-break galaxy (LBG) samples based on measuring spatial correlation with the parent population of lower redshift interlopers. We propose two conceptual approaches applicable to different survey strategies: a single large contiguous field and a survey consisting of multiple independent lines of sight. For a large single field, we compute the cross-correlation function between galaxies at redshift $z \sim 6$ and intermediate-redshift galaxies at $z \sim 1.3$. We apply the method to the CANDELS GOODS-S and XDF surveys and compare the measurement with simulated mock observations, finding that the contamination level in both cases is not measurable and lies below 5.5% (at 90% confidence). For random-pointing multiple field surveys, we measure instead the number count correlation between high-redshift galaxies and interlopers, as a two-point correlation analysis is not generally feasible. We show an application to the LBG samples at $z \sim 8$ and the possible interloper population at $z \sim 2$ in the Brightest of Reionizing Galaxies (BoRG) survey. By comparing the Pearson correlation coefficient with the result from Monte Carlo simulations, we estimate a contamination fraction of 62^{+13}_{-39}%, consistent with previous literature. These results validate the proposed approach and demonstrate its utility as an independent check of contamination in photometrically selected samples of high-redshift galaxies.

Session

Division J Galaxies and Cosmology

2355

Developments in extragalactic astronomy in East Africa

Dr. Mirjana Povic

Space Science and Geospatial Institute, Ethiopia

Abstract

In recent years, East Africa has emerged as a region contributing to the study of galaxies. Several countries in the region started from scratch by providing the first postgraduate training in galaxy formation and evolution, training the first Master and PhD students in extragalactic astronomy, creating the first intra-African research groups and collaborations, and coming up with the first peer-reviewed publications in the field. In particular, strong collaborations have been established between Ethiopia, Rwanda, Uganda and Tanzania, in collaboration with South Africa and Botswana, and strong international collaborations outside Africa. Our research focuses, through different projects, on the properties of AGN and their host galaxies, on the study of the role of AGN in quenching star formation, on the properties of green valley galaxies, and on the properties of galaxies in galaxy clusters. This talk will be a journey through the development of extragalactic astronomy in East Africa, highlighting the major achievements of our scientific research, human capacity building and collaborative initiatives. It will also highlight many of the challenges we have faced on this journey and the opportunities for fostering a vibrant and growing research community in the region.

Session

Division J Galaxies and Cosmology

2382

X-ray properties of high-z dust-obscured galaxies in the deep extragalactic fields

Dr Abhijit Kayal, Dr Veeresh Singh

Physical Research Laboratory, Ahmedabad, India

Abstract

In pursuit of exploring high-z obscured AGN population hosted in DOGs and their evolutionary scenario, we conducted an X-ray spectral study of 34 relatively X-ray bright high-z ($0.59 \leq z \leq 4.65$) DOGs, lying within 5.3 deg^2 of the XMM-Spitzer Extragalactic Representative Volume Survey (XMM-SERVS) region in the XMM-LSS field. To improve the quality of the X-ray spectra of individual sources, we combined all the existing XMM-Newton data and Chandra/ACIS data, whenever available. By fitting the X-ray spectra with both a simple absorbed power law and a torus-based borus02 model, we derived the line-of-sight column density ($N_{H,\,LOS}$) for all DOGs. Notably, our study identified three new Compton-Thick (CT)-AGN candidates hosted in DOGs, with a substantial fraction (08/34 $\simeq$ 23.5 per cent) exhibiting heavy obscuration ($N_H > 10^{23}$ cm^{-2}). The remaining sources displayed only moderate obscuration (10^{22} $cm^{-2} \leq N_H \leq 10^{23}$ cm^{-2}). The absorption-corrected 2.0 − 10 keV luminosities of our X-ray detected sources (2.3×10^{43} erg s^{-1} to 6.3×10^{45} erg s^{-1}) suggested them to be luminous quasars. The N_H versus Eddington ratio diagnostic plot revealed that our DOGs represent a heterogeneous population belonging to different phases of AGN evolution. Only a few of our sample DOGs (around 12%) are found to be Hot DOGs, marked by peak accretion and obscuration, an indication of an early phase, while the remaining of our sources belong to intermediate or late phases where the radiative feedback from the AGN likely to blow away the obscuring material.

Session

Division J Galaxies and Cosmology

2414

Can two-temperature treatments in GRMHD simulations reduce the disparity between model and data variability for Sgr A*?

Leon Salas[1], Koushik Chatterjee[2], Gibwa Musoke[3], Sera Markoff[1], Bart Ripperda[3], Matthew Liska[1]

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Abstract

In 2017, the Event Horizon Telescope Collaboration (EHTC) observed the Galactic center source SgrA* and found a ring-like structure consistent with expectations from general relativity. The EHTC "fiducial" models to describe these data are based on single-particle (assumed to be ions) fluid general relativistic magnetohydrodynamic (GRMHD) simulations. The ion/electron temperature ratio is modelled based on the local magnetization of the plasma, where the predicted emission is strongly dependent on these models. The two most promising models are magnetically arrested disks (MADs), however these and nearly all other models fail to reproduce SgrA*'s light-curve variability at 230 GHz. Moreover, no model successfully passes all the variability and multiwavelength constraints together.

The actual temperature ratio depends on microphysical dissipation and radiative processes not captured in ideal fluid simulations. Therefore, we investigate the effects of two-temperature thermodynamics of a MAD around SgrA*, where the temperatures of both species are evolved more self-consistently. We include Coulomb coupling, radiative cooling of electrons, and mimic heating of electrons via magnetic reconnection. The inclusion of two-temperature treatment, variable adiabatic index, and cooling in MAD GRMHD simulations reduce the 230 GHz light curve variability compared to single-temperature simulations. Yet, historical observations of SgrA* still show lower variability than simulations. Even for the very low accretion rates relevant for SgrA*, we find that radiative cooling still affects the accretion flow, lowering the electron temperature in the inner disk and reducing the average 230 GHz flux.

Session

Division J Galaxies and Cosmology

2416

The dust attenuation-inclination relation for 13 000 bulges and discs in nine bands

Dr. Sarah Casura

Universität Hamburg

Abstract

Dust and inclination effects severely change the observed properties of galaxies. The choice of dust model and correction method thus has a strong influence on the inferred physical properties of galaxies such as intrinsic UV and optical flux, star formation rate, star formation history, metallicity evolution or stellar mass.

I will present the first results of our ongoing long-term project to constrain the nature and distribution of dust in galaxy discs with a comprehensive approach in which attenuation properties are compared to all other fundamental properties of galaxies for a well-characterised, statistically large and representative sample of galaxies.

To this end, we have performed bulge-disc decompositions of a sample of 13 096 local ($z < 0.08$) galaxies from the highly complete Galaxy and Mass Assembly (GAMA) galaxy redshift survey, with imaging data in nine bands spanning the optical and NIR (ugriZYJHKs). Combining this catalogue with the UV, MIR and FIR imaging data from GAMA and the wealth of ancillary information (e.g. on the environment and gas tracers) contained in value-added GAMA catalogues provides us with the means to perform a large statistical attenuation-inclination study with the most detailed set of data to date.

By comparing the distribution of galaxy components (bulges and discs) in the luminosity - size plane as a function of inclination and wavelength with the corresponding predictions made by the detailed radiative transfer models of Tuffs & Popescu, we are able to constrain the dust properties of our sample of galaxies.

Session

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2435

Turbulent Magnetic Field Amplification and Cosmic Ray Propagation in Galaxy Clusters

Stela Adduci Faria[1], Prof. Elisabete de Gouveia Dal Pino[1], Prof. Reinaldo Santos-Lima[1], Rafael Alves Batista[2]

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Abstract

Magnetic fields play a crucial role in the complex dynamics of galaxy clusters. In our research, We focus on understanding the amplification of these fields by employing a turbulent dynamo in a weakly collisional and viscous intra-cluster environment. The plasma in the IntraCluster Medium (ICM) deviates from local thermodynamic equilibrium, making it susceptible to kinetic instabilities which introduce effective collisionality. This regulates anisotropy and allows for the stretching and amplification of the magnetic fields through small-scale turbulent dynamo. We utilize high-resolution weakly collisional three-dimensional magnetohydrodynamic simulations (3D MHD), incorporating for the first time a self-consistent evolution of the viscosity coefficient. This approach results in a smaller viscous coefficient which extends the inertial range of the ICM turbulent spectrum to the observed viscous scales in clusters, as in Coma. We also explore cosmic ray (CR) propagation performing Monte Carlo simulations in a highly resolved (≈ 4 kpcs) cosmological MHD simulation of a cluster with magnetic fields evolved by turbulent dynamo. We inject CRs with energies in the range 10^{14} to 10^{19} eV, and follow their cascading over the entire cluster obtaining precisely their gamma ray and neutrino fluxes. This implies important constraints on the determination of the dark matter counterpart through gamma-ray observations.

Session

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2444

Post-planck appraisal of CMB Hemispherical Power Asymmetry

Mr. SANJEEV SANYAL, Dr. PAVAN KUMAR ALURI

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Abstract

In this work we present our analysis of one of the prominent "anomalies" of CMB sky, the "hemispherical power asymmetry (HPA)", from the latest fullsky CMB maps from Planck satellite mission's Public Release 4. The data is analyzed from various perspectives to understand the nature of HPA better viz., a re-estimation of the magnitude and direction of HPA and the corresponding significance, any frequency dependence of HPA, consistency of the recovered amplitude and direction across data sets from Planck as well as WMAP. We do so using the Local variance estimator (LVE), and also a new (modified) LVE which incorporates correlations between different patches of the sky from which local variances are computed. We find that the CMB hemispherical power asymmetry, phenomenologically modelled as a dipole modulation of an otherwise statistically isotropic CMB sky, is robust against all these tests and appears indeed to be a cosmic signal.

Session

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2448

The impact of supernovae feedback on the metallicity gradients and mass-metallicity relations.

Dyna Ibrahim

University of Hertfordshire

Abstract

Metallicity is a fundamental physical property that strongly constrains galaxy formation and evolution. The formation of stars in galaxies is highly impacted by metal production and energy release from supernova explosions, which suppresses star formation by generating outflows and evaporating star-forming clouds. However, this process - supernova feedback - is uncertain. We thus include different feedback methods and parameters by ejecting energy in thermal, kinetic, stochastic and mechanical forms into our state-of-the-art cosmological simulations. Our code (based on Gadget-3) includes the latest nucleosynthesis yields for all stellar mass ranges, Type Ia supernovae, and also the first stars so that our predicted abundances are comparable to the observations of the first galaxies. For each feedback scheme, we predict the evolution of stellar mass-metallicity relations for stars and interstellar medium, as well as the metallicity gradients. We constrain the feedback method by comparing it with observational data from the James Web Space Telescope (JWST).

Session

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2457

A MeerKAT 1.28 GHz continuum study of the Southern Sources in the IRAS Revised Bright Galaxy Sample

Ms Malebo Moloko

University of Cape Town

Abstract

The Infrared Astronomical Satellite (IRAS; Sanders et al. 2003) Revised Bright Galaxy Sample (RBGS) comprises galaxies and unresolved mergers with flux densities (S) > 5.24 Jy at λ= 60 μm and are extra-galactic (|b| > 5°). These are predominantly dusty star-forming galaxies. Previous studies in the nearby universe have revealed a tight correlation between infrared (IR)/radio emissions among such galaxies, making radio continuum emission an excellent complementary tracer of recent star formation. In this study, we examine the properties of 298 galaxies from RBGS in the southern hemisphere, observed at 1.28 GHz with MeerKAT (resolution 7.5''and σ ≈ 20 μJy/beam; Condon et al. 2021). We determine their activity types from the literature and classify them based on mid-IR information using WISE colour-colour diagnostics. We compare our findings with those of galaxies drawn from the same sample, albeit observed with VLA in the northern hemisphere (Condon et al.1990, 1996, 1998), thereby creating a full radio counterpart of the RBGS. In my contribution, I will discuss the samples' Infrared-radio correlation and the sources' physical properties (e.g., stellar masses, star-formation rates). Additionally, I will present insights gained from analyzing the interplay between AGN/SF mechanisms within these galaxies.

Session

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2469

Enhanced Spitzer Survey of Stellar Structure in Galaxies (ES4G):Disc galaxy extension and surface brightness profiles

Pablo M. Sánchez-Alarcón[1,2], Johan H. Knapen[1,2], Heikki Salo[3], Sébastien Comerón[2,1], Javier Román[2,1], Aaron Watkins[4]

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Abstract

The Spitzer Survey of Stellar Structure in Galaxies (S4G) together with its Early Type Extension (ETG, Watkins et al. 2022) stands as the most extensive dataset of deep, uniform mid-infrared imaging for a sample of 2817 nearby (<40 Mpc) galaxies. The radio-derived velocity criteria, however, result in a sub-sample of 425 disk galaxies without 21cm HI detection but with optical velocities which satisfy the criteria. We present the Enhanced S4G (ES4G), a data set covering the set of 3242 galaxies within the original selection criteria. We collected archival 3.6 micron and i-band images and completed the data set with new observations for these missing disc galaxies. With this, we finish the survey, spanning a sample of 3242 galaxies with consistent imaging, surface brightness profiles and photometric parameters.

We produce masks, surface brightness profiles, and curves of growth and derive integrated quantities including total magnitudes, stellar masses, concentration parameters, and galaxy size metrics. We derive a recipe for the conversion between optical i-band and 3.6 micron. We present new morphological revised T-types and showcase mid-IR scaling relations among stellar mass, galaxy size, concentration index, and morphological type.

The full set of images, surface brightness profiles and derived parameters for the 3242 galaxies in the ES4G sample is made publicly available to the community. The ES4G will enable a wide set of investigations into galaxy structure and evolution, and complement optical and near-IR imaging to be obtained in coming years with Euclid, LSST and other projects.

Session

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2511

An Euclid view of Globular Clusters of Dwarf Galaxies

Teymoor Saifollahi

Observatory of Strasbourg, France

Abstract

During its mission, Euclid will observe tens of thousands of dwarf galaxies in the Local Universe with fantastic depth and spatial resolution. Such a dataset enables us to identify Extragalactic Globular Clusters (EGCs) around these dwarf galaxies and gain unprecedented insight into their formation and evolution. In this talk, I present the analysis of Euclid data of EGCs around dwarf galaxies in two nearby galaxy clusters. This has been possible given Euclid's Early-Release Observations (EROs) of several nearby targets.

During the talk, I briefly introduce the adopted methodology for identifying EGCs (candidates) in Euclid VIS+NISP images to produce GC catalogues. Then, I study the GC properties of dwarf galaxies using the resulting GC catalogues. For that, I present the analysis of GC luminosity function, GC number counts and GC radial distribution around dwarf galaxies. At the end of this talk, I present the findings and briefly describe our plans within the Euclid consortium for studying EGCs around dwarf galaxies with the Euclid Wide Survey.

The work is done within the Euclid ERO teams and the Euclid consortium.

Session

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2517

Unprecedented Insights from the stellar shells in nearby galaxies with SALT telescopes

Dr Adebusola Alabi, Prof. Ilani Loubser

North-West University, Potchefstroom

Abstract

In this talk, I will show recent results from the deep spectroscopy of the spectacular, faint, low surface brightness stellar features (shells) in the outskirts of NGC 2865. I will also show results from multi-object spectroscopy of the globular clusters that are spatially associated with these stellar shells. These data have been obtained recently from the SALT telescopes.

I will discuss how these data from the stellar shells and globular clusters help us constrain the nature of the merger event that produced these spectacular features and the nature of the disrupted progenitor. I will also discuss the implications of our results, i.e., the kinematics of multiple stellar shells in NGC 2865 and the stellar population properties (age, metallicity, star-formation histories) of these shells, in the context of expectations from recent cosmological simulations.

Session

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2526

Application of anomaly detection to MeerKAT radio data using machine learning techniques

Dr. Hanwool Koo, Dr. Michelle Lochner

University of the Western Cape

Abstract

As a mid-frequency Square Kilometre Array precursor, the MeerKAT radio telescope is a promising source of large sets of radio data. Developing an automated method for anomaly detection is becoming essential to discover more unknown phenomena for astrophysics or cosmology from the data with such an enormous volume. To do this, we explore anomaly detection techniques for time-frequency dynamic spectra of the radio data. We apply unsupervised machine learning techniques, coupled with active learning, for anomaly detection and evaluate our method using the simulated Single-dish PARKES data sets for finding the uneXpected (SPARKESX). We use these simulations to test anomaly detection methods that will be applied to real, unlabeled MeerKAT data. We also examine the possibility of detecting and removing anomalous radio frequency interference, which acts as the primary contaminant when hunting for genuine anomalies. We expect that applying machine learning methods will be a more efficient and reliable way to detect anomalous astrophysical signals with higher accuracy and in a shorter time than the classical methods.

Session

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2532

Shedding light on low-surface-brightness galaxies in dark energy surveys with transformer modelsShow affiliations

Mr Hareesh Thuruthipilly, Dr Junais Junais

National Center for Nuclear Research (NCBJ), Poland

Abstract

Low-surface-brightness galaxies (LSBGs), which are defined as galaxies that are fainter than the night sky, play a crucial role in our understanding of galaxy evolution and in cosmological models. Upcoming large-scale surveys, such as the Rubin Observatory Legacy Survey of Space and Time and Euclid, are expected to observe billions of astronomical objects. In this context, using semiautomatic methods to identify LSBGs would be a highly challenging and time-consuming process, and automated or machine learning-based methods are needed to overcome this challenge. We study the use of transformer models in separating LSBGs from artefacts in the data from the Dark Energy Survey (DES) Data Release 1. We created eight different transformer models and used an ensemble of these eight models to identify LSBGs.Transformer models achieved an accuracy of ~94% in separating the LSBGs from artefacts. In addition, we identified 4083 new LSBGs in DES, adding an additional ~17% to the LSBGs already known in DES. This also increased the number density of LSBGs in DES to 5.5 deg^{-2}. The new LSBG sample consists of mainly blue and compact galaxies. We performed a clustering analysis of the LSBGs in DES using an angular two-point auto-correlation function and found that LSBGs cluster more strongly than their high-surface-brightness counterparts. We associated 1310 LSBGs with galaxy clusters and identified 317 ultra-diffuse galaxies among them. The number of LSBGs is expected to increase with the advent of surveys with better image quality and more advanced methodologies.

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PERTURBATION EFFECTS AND THE EVOLUTION OF GIANT LOW SURFACE BRIGHTNESS GALAXIES: THE CASE OF MALIN 1 - PAST AND FUTURE INTERACTIONS WITH SATELLITE GALAXIES

Student Ph. D. Roy Omar Edgar Bustos Espinoza[1,2,3,4,5,6], Dr. Gaspar Galaz[1], Dr. rer. nat. Matías Blaña[1]

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Abstract

Low surface brightness galaxies (LSBGs) dominate the volume density of galaxies in the universe; however, given their low surface brightness, are difficult to detect, introducing biases in the statistical analysis of galaxy populations. Giant low surface brightness disk galaxies (gLSBGs), on the other hand, have extended both neutral Hydrogen and its optical counterpart. One of the most impressive gLSBGs is *Malin 1*, given its 200 kpc stellar disk with giant spiral arms, a flat rotation curve, low star formation, low dust and a possible giant dark matter halo. Its environment shows at least two possible interacting galaxies, *exo-Malin 1* and *Malin 1B*, a gigantic stellar stream extending from *Malin 1* centre to a galaxy located to the NE, to the so-called galaxy *exo-Malin 1*. These features could be evidence of past or current perturbations in Malin 1.

We study the environment of the gLSBG *Malin 1* analysing the orbital history of its satellite galaxies by exploring possible close encounters in the past and in the future. We find orbits with trajectories that can connect the location of the satellite *exo-Malin 1* with an observed stellar stream candidate, which could indicate that *Malin 1* had a satellite interaction ∼2.25 Gyr ago; for *Malin 1B* case, ∼0.95 Gyr ago. For the future, ∼1.49 Gyr and ∼0.15 Gyr respectively.

This will allow us to model the internal and orbital evolutionary histories of *Malin 1* and its satellite candidates, allowing us to improve the galaxy formation and evolution models for gLSB galaxies in general.

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KiDS-SBI: Simulation-Based Inference Analysis of KiDS-1000 Cosmic Shear

Dr Maximilian von Wietersheim-Kramsta[1,2], Dr Kiyam Lin[1], Dr Nicolas Tessore[1], Prof. Benjamin Joachimi[1], Dr Arthur Loureiro[3,4], Dr Robert Reischke[5,6], Dr Angus Wright[6]

[1]University College London. [2]Durham University. [3]Stockholm University. [4]Imperial College London. [5]Argelander-Institut für Astronomie. [6]Ruhr University Bochum

Abstract

Cosmic shear, the weak gravitational lensing effect on distant galaxies due to matter in the foreground, is a powerful tool to study the distribution of matter, to probe its large-scale structure, and infer the cosmological model of the Universe. Standard analyses are typically based on the assumption of a Gaussian likelihood with a parameter-independent covariance, but these assumptions may not always hold. Simulation-based inference (SBI) addresses this by evaluating an effective likelihood from forward-simulations which map parameters to data vectors. To this end, I will present a novel application of SBI to a cosmic shear analysis of the Kilo-Degree Survey's KiDS-1000 data release. The forward model is based on lognormal random fields which take into consideration systematics which are typically not modelled in standard inference. I will also describe how the simulated galaxy catalogues are compressed to shear-shear angular two-point statistics which are further compressed using score compression. I will show how we train a 12-dimensional neural likelihood estimation to obtain a converged and unbiased posterior of the cosmological parameters within ΛCDM. We find that our constraints on the weak lensing parameter, S_8, are similar to constraints from previous analyses of KiDS-1000. We note a non-negligible parameter-dependence in the learnt likelihood which is consistent with cosmic variance. At the same time, we find that systematics such as variable depth can have significant impacts on the posterior estimates. Lastly, I will highlight how these findings and SBI will help address the modelling/inference challenges facing upcoming stage IV galaxy surveys.

Session

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DES to HSC: Detecting LSBGs in Abell 194 with Transformers via Transfer Learning

Mr Hareesh Thuruthipilly, Dr Junais Junais

National Center for Nuclear Research (NCBJ), Poland

Abstract

Low surface brightness galaxies (LSBGs), characterized as galaxies fainter than the night sky, hold significant importance in comprehending galaxy evolution. The upcoming large-scale surveys such as the Rubin Observatory Legacy Survey of Space and Time (LSST) and Euclid are expected to uncover a large number of LSBGs which would require accurate automated methods for their detection. We study the scope of transfer learning for the identification of LSBGs in the Abell 194 cluster with the deep data we obtained from our Hyper Suprime-Cam (HSC) observations of this cluster. We use two ensemble of transformer models that have been trained on the dark energy survey data release 1 (DES DR 1) which is two order of magnitude shallower than the data from HSC. The transformer ensemble model achieved a classification accuracy of 95% on the data from DES DR1 and achieved a recall rate of 92% on the HSC dataset. Using the transformer ensemble models we identify a sample of 176 LSBGs among which 90 are completely new from the cluster Abell 194. We further classify 22 LSBGs among them as ultra-diffuse galaxies (UDGs). We show that transfer learning from a shallow survey to a deeper survey using transformer models can be successful with appropriate data normalization. This methodology could prove valuable for identifying and analyzing astronomical data in upcoming surveys like LSST and Euclid

Session

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The latest from Galaxy Zoo

Prof Karen Masters[1], Sandor Kruk[2]

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Abstract

The Galaxy Zoo project (www.galaxyzoo.org) has over the last sixteen years of operation, provided quantitative visual morphologies for millions of galaxies, including samples such as the entire Sloan Digital Sky Survey Main Galaxy Sample (Lintott et al. 2011, Willett et al. 2013), all public Hubble Space Telescope surveys (Willett et al 2016; Simmons et al. 2017), more recently 8.7 million galaxies in DECaLS (Walmsley et al. 2023). The morphological information collected by Galaxy Zoo has shown itself to be a powerful database for studying galaxy evolution, with hundreds of papers making use of the data as an important characteristic to understand in the physics of how galaxies assemble, and how they regulate their star formation.

In this presentation I will give an update on the latest scientific results and analysis related to the Galaxy Zoo project, which might include information about results from the latest JWST images on the site; ongoing work to include machine learning in the loop with citizen scientists for optimal results (e.g. Walmsley et al. 2022, 2023); some of the latest science results (e.g. Geron et al. 2023) or results from spin off projects like Galaxy Zoo: 3D (Masters et al. 2019) which provided feature masks for the MaNGA sample, or Galaxy Zoo: Clump Scout (Dickinson et al. 2022).

Session

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Searching for merging galaxy clusters: developing a method to identify clusters with substructures

Giulya Souza, Eduardo Cypriano, Lia Doubrawa

IAG - USP

Abstract

Galaxy cluster mergers release enormous amounts of gravitational energy, second only to the Big Bang itself. Studying such systems illuminates the dynamics and interactions of their main components: the intra-cluster gas, dark matter and galaxies. This work aims to identify and characterize these merging systems using optical data from the S-PLUS survey.

In this study, we apply the Adaptive Membership Estimator (AME) to a cluster catalogue. AME incorporates the full photo-z PDFs and a hierarchical density-based spatial clustering algorithm to assign membership probabilities to galaxies. This approach also enables the detection of sub-structures within clusters, indicating potential merging cluster candidates.

Due to the low number of galaxies in most individual systems collected by our method, a stacking technique was employed. As a result, we found that the galaxy density map of the stacked clusters reveals a bimodal distribution of galaxies, showing a clear sign of sub-structure.

To test the accuracy of AME in identifying sub-structures, we conduct controlled simulations of galaxy clusters, comparing the performance of AME with the MClust method, which assumes a Gaussian model for group and subgroup identification. For the next steps, we will complete our analysis using weak gravitational lensing techniques to perform mass maps of the identified systems. To confirm whether the clusters with sub-structures detected by AME are good candidates for fusion systems, we expect the mass distribution of these systems to be equally bimodal, as is the distribution of galaxies.

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Structure and Kinematics of Star-forming Elliptical Galaxies in SDSS-MaNGA

PRALAY BISWAS, YOGESH WADADEKAR

National Centre for Radio Astrophysics

Abstract

We examined the properties and formation modes of star-forming elliptical (SF-E) galaxies by utilising spatially resolved spectroscopy from the SDSS-MaNGA. To do this, we combined the GSWLC-A2, MaNGA Deep Learning Morphology, and MaNGA Pipe3D catalogues. We identified a rare population of 59 SF-Es, which we used as our primary sample. We also created two control samples of star-forming spirals (SF-Sps) and quenched ellipticals (Q-Es) to compare with our primary sample. We found that the Hα emission line flux of SF-Es is similar to SF-Sps, and the D4000 spectral index of SF-Es ranges from 1.2 to 1.8, indicating a mixture of old and young stellar populations. The mass-weighted stellar age and metallicity for the SF-Es are lower than the Q-Es. Additionally, 67% of the stellar and gas velocity maps of the primary sample show signs of kinematic disturbance. These findings suggest that SF-Es have acquired metal-poor gas in recent mergers or interactions with other galaxies and are forming a new generation of stars. Furthermore, we subdivided our primary sample of SF-Es into four classes based on their B/T and λ_{re} values. The properties of the galaxies in these four classes show that they all have their own distinct evolutionary history and modes of formation. Based on these results, we conclude that the Hubble diagram does not accurately capture the galaxy evolution processes. Instead, we need a revised morphology diagram like the comb morphology diagram to better understand galaxy evolution processes.

Session

Division J Galaxies and Cosmology

2613

The low/moderate star formation at *z*~0, early stellar growth and the 'Missing Baryons' in massive and fast roating disc galaxies

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Abstract

We investigate five fast-rotating and massive galaxies with rotational velocities of more than 300 km/s. Based on the ultraviolet data from UVIT, these galaxies show low to moderate recent star formation rates of ~1.4-13.7 solar masses/yr, and fall below the star formation main-sequence relation at *z*~0, with specific star formation rates $<10^{-10.5}$ yr^{-1}. We identify localized star-forming clumps with mean star-forming densities of 0.011-0.098 solar masses/yr/kpc^2 from the far-ultraviolet imaging, indicating concentrated young star-forming activity of ~ 100 Myr. The objects with recent high star formation show structural asymmetries, potentially influencing their star-forming activity. However, their star formation efficiency remains low (~7-31 percent) in converting the dark-matter halo baryons into stars in the galactic disc. The far-ultraviolet to far-infrared spectral energy distribution modeling shows that the peak star formation of the objects happened at a time before/leading up to the cosmic high noon/quasar epoch (redshift ~1-3), with 31-42 percent of the stellar mass of the objects forming within 1/16 to 1/5th of the age of the Universe. We find these galaxies deviate from the Baryonic Tully-Fisher relation, with their baryonic mass $>10^{11}$ solar masses. The galaxies lack ~67-92 percent of baryons in their dark-matter halos ($>10^{13}$ solar masses) as per the cosmological baryon fraction of ~0.17, termed the "Missing Baryons". The detected hot gas (~10^6 K) in the halos of some of the galaxies is of ~10^{10} solar mass, far less than the expected mass of ~10^{12} solar mass.

Session

Division J Galaxies and Cosmology

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Probing the formation histories of NSCs in the Fornax Galaxy Cluster using UVIT

Dr. Prasanta Kumar Nayak[1], Prof. Thomas H. Puzia[1], Dr. Paul Eigenthaler[1], Dr. Yasna Ordenes-Briceño[1], Dr. Mareclo Mora[2], Dr. Bryan Miller[3], Dr. Matías Blaña[1], Dr. Evelyn Johnston[4], Dr. Tuila Ziliotto[5], Rohan Rahatgaonkar[1]

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Abstract

The correlations between nuclear star clusters (NSCs) and their host galaxy indicate a fundamental connection between the formation of NSCs and their parent galaxy. A recent study by the Next Generation Fornax Survey (NGFS; Ordenes-Briceño et al. 2018) shows the presence of relatively massive nuclei in the faint dwarf at lower galaxy mass regime $\log(M_{gal}/M_{Sun}) < 9.5$, which could be due to recent or ongoing star formation activity that contributes to an earlier build-up of nuclei relative to the rest of the galaxy. The NUV-optical-NIR colour-colour diagram also indicates the presence of young stellar populations (less than 2 Gyr). Extending the SED coverage beyond the Balmer break to FUV allows us to determine the age and mass fraction of these young stellar components more accurately by combining data from NGFS. So, we obtained FUV data of two massive NSCs from Ultra-Violet Imaging Telescope (UVIT) onboard AstroSat through a successful proposal in the current observing cycle. I will present preliminary results from this current observation.

Session

Division A Fundamental Astronomy

2680

The impact of AGN on the morphology of their host galaxies

Mr TILAHUN GETACHEW[1,2], Dr Bule University[3,4,5], Dr Josefa Masegosa[4], Dr. Jaime Perea[4], Mr Shimelese Terefe[6,7], Dr. Isabel Marquez[4], Dr. Zeleke Amado[8], Dr Antoine Mahoro[9]

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Abstract

The presence of Active Galactic Nuclei (AGN) can affect the morphological parameters and classification of active galaxies and have subsequent consequences when studying galaxy evolution. We study how the AGN contribution may affect the most commonly used morphological parameters at redshift z~0 and up to redshift z∼2. We use a sample of over 2000 non-active local galaxies, with well-known visual morphological classification, and add an AGN as an unresolved component contributing 5%, 10%, 25%, 50%, and 75% to the total galaxy flux. We then analyse the impact of the added AGN contribution to commonly used morphological parameters, including various concentration, asymmetry and smoothness indices when dealing with early- and late-type galaxies at z ~ 0, finding a significant change in the parameters, above 20%, when the AGN contribution to the total flux is higher than 25%. We then moved all local galaxies to fainter magnitudes (higher redshifts) to map the conditions in the COSMOS field. Finally, we study the effect of 5-75% AGN contributions on the four parameters taking into account the effect of magnitude (from 21 to 25 in the g-band) and redshift (up to z∼2). In general, the four morphological parameters will change > 20% if the AGN contribution is >25%, and for mag > 23 in g-band, with spirals being more affected than early-type galaxies. If the AGN contribution to the total galaxy flux is ≥ 50% (lower at magnitudes <23), the AGN effect will play a key role in the behaviour of the morphological parameters.

Session

Division J Galaxies and Cosmology

2684

Detailed star formation histories from deep spectroscopic studies of galaxies

Dr. Thiago Goncalves

Valongo Observatory. Federal University of Rio de Janeiro

Abstract

Galaxies show a clear dichotomy in their properties between blue spirals and red ellipticals. This means galaxies must undergo some physical transformation that prevent them from further forming new stars. In this talk I will discuss a series of results that aim to measure and understand star formation quenching. This includes the use of spectroscopic indices, in tandem with broadband colors, to infer parameters of the star formation history of galaxies, showing that galaxies quench faster in the early universe, with possible connections with merging activity and more prevalent AGN feedback at high redshifts. Later, we have investigated the possible correlation between quenching timescales and other processes, in an attempt to further understand the main drivers of galaxy evolution and transformation between the two populations. This has been made possible by a recent measurement of the instantaneous derivative of the star formation rate of a galaxy — a quantity we have called “star formation acceleration”, or SFA. This strongly depends on AGN activity and galaxy environment, as would be expected from galaxy evolution models. It has also been shown that ellipticals show higher SFA values, i.e., they quench faster than spiral galaxies with similar colors, presenting strong evidence that morphological transformations are tightly correlated with distinct star formation histories. Finally, I will show how these studies will be impacted by the upcoming generation of ground-based telescopes, with the multi-object spectrograph MOSAIC, to be installed at the ELT, allowing for the same diagnostics to be extended to fainter, more distant galaxies.

Session

Division J Galaxies and Cosmology

2698

The impact of different models on spectral fitting of young stellar populations in spiral galaxies

Geraldo Gonçalves[1], Luiz Silva-Lima[2], Paula Coelho[1], Lucimara Martins[2]

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[2]Universidade Cruzeiro do Sul

Abstract

The pixel-to-pixel spectral fitting technique is often used in studies of stellar populations. It enables the user to infer several parameters from integrated light spectra such as ages and chemical abundances of galaxies and star clusters. In this work, we have used this technique to study the young stellar populations present in the central regions of some spiral galaxies. These objects can present inner structures, such as inner disks and rings, that can be formed by gas brought from the main disk to the center of the galaxy. We have used IFU data from the TIMER survey (Gadotti+19) of 11 galaxies and models from four different libraries: MILES (Vazdekis+15), Starburst99 (Leitherer+99), HR-pyPopstar (Millán-Irigoyen+21) and XSL (Verro+22). The results show that age values from spectral fitting are consistent with different models, but metallicity values can show significant differences. In some cases (NGC1097, for example), different structures can be seen in [M/H] maps inferred with different model libraries. With this work, we expect to shed light on the importante of the choice of a model library when retrieving information via spectral fitting, mostly (but not only) in objects with a high density of young stellar populations.

Session

Division J Galaxies and Cosmology

2729

miniJ-PAS: the physical nature of galaxy morphologies

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Abstract

To investigate the physical nature of galaxy morphology and its evolution through cosmic times, we use miniJ-PAS data to characterise their morphometric properties as derived with MFMTK, and we combine the results with existing VAC catalogues from miniJPAS data service, specifically stellar population properties, environment and photometric redshift. In this work, we present a catalogue of morphological parameters for 2000 galaxies in the AEGIS field, obtained for the miniJ-PAS g,r,i bands, comprising non-parametric (concentration, asymmetry..) and parametric (Sersic index, ..) estimations. We compare the recovered Sersic index and Effective radii with previous works based on HST data, for different magnitude bins, finding a good agreement for rmag<=21. We study the relation between galaxy stellar population, intrinsic colour, mass and the morphometric parameters (especially C1, M20, H), for different spatial resolution, redshift and magnitude bins. The clear correlations found, reflects the known relation between galaxy morphology, colour and stellar population. Moreover, the correlation between mass and morphometric parameters suggest a deep connection between such parameters and the galaxy potential. Finally, a more complex trend is found between morphometric parameters and the galaxy environment. M20, A, H, and the Gini parameters are most sensitive to environmental effects as they relate to perturbations in the isophotal profile, possibly due to interactions in high-density regions.

Session

Division J Galaxies and Cosmology

2757

The quiescent population at 0.5<z <0.9: Environmental impact on the mass-size relation

Dr Miguel Figueira[1], Dr Małgorzata Siudek[2], Prof dr Agnieszka Pollo[1,3], Dr Janusz Krywult[4], Dr Daniela Vergani[5], Dr Micol Bolzonella[5], Dr Olga Cucciatti[5], Dr Angela Iovino[6]

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Abstract

Because quiescent galaxies were more compact at higher redshift compared to what is observed in the local Universe, it is believed that the average size increases through different mechanisms (AGN feedback, mergers, etc.). Nonetheless, this observed size evolution is still debated nowadays, as it may also be explained, at least partially, by quenched star-forming galaxies entering the quiescent population.

Using the VIMOS Public Extragalactic Redshift Survey, we look at the mass-size relation of the quiescent galaxies, to understand how this population evolved from z=0.9 to z=0.5. The sample of passive galaxies is selected from the NUVrK diagram and a constraint on D4000, a tracer of galaxy's age. We study the mass-size relation and the effect of environment through the density contrast to understand the mechanisms that would be responsible for the apparent size evolution. We show that the average size of quiescent galaxies is similar in low and high density environment and that minor mergers alone cannot explained the observed size evolution from z=0.9 to z=0.5.

Session

Division J Galaxies and Cosmology

2759

A Viable Non-Canonical Scalar Field Model to Inflation

MSc Pedro Almeida, Prof. Dr. José Ademir Lima

IAG - University of São Paulo

Abstract

A new deflationary cosmology driven by a non-canonical scalar field is proposed. The model describes analytically a smooth dynamic evolution from an initial and structurally unstable de Sitter inflationary stage to the standard radiation phase. The selected potential V(Φ) can also be interpreted as a running vacuum cosmology whose evolution is driven by a specific Λ(H)-term, where H is the Hubble parameter. At the end of the decaying vacuum process, the remaining energy density is completely stored in the kinetic part of the field which satisfies the radiation equation of state. The very early Universe is non-singular, free of horizon and unlike many inflationary variants, none super-cooling and post-inflationary reheating process is required. The thermodynamic evolution of the thermal bath is determined and the general conditions for a slow-roll deflation are discussed. The Planck data for the spectral index and tensor-to-scalar ratio are used to constrain the free parameters of the model.

Session

Division J Galaxies and Cosmology

2796

Calibrating the color-redshift relation for an optimum exploitation of Euclid data

Dr. Carlos Gutierrez

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Abstract

Euclid's three dimensional reconstruction of the matter distribution in the Universe heavily relies on a proper calibration of the color-redshift relation. Getting such calibration was the motivation of the project Complete Calibration of the Color-Redshift Relation (C3R2) survey (Masters et al. 2017), with the goal of mapping the empirical relation between galaxy redshift and colors to the Euclid depth of i∼24.5(AB). The survey strategy is based on the fact that the diversity in observed galaxy colors at a given survey depth is limited and on the assumption that there exists a well-defined, mostly non-degenerate relation between a galaxy's position in multi-color space and its redshift, which can be traced empirically. The programme involved the spectroscopic observation of a few thousand of galaxies using the telescopes Keck, VLT and GTC. Here, we present the status, results and plans to complete the participation of our group in such project.

Session

Division J Galaxies and Cosmology

2812

The contamination of primordial non-Gaussianity from relativistic Doppler and wide-angle effects.

Dr SECLOKA LAZARE GUEDEZOUNME, Dr SHEEAN JOLICOEUR, Prof ROY MAARTEENS

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Abstract

The distortions in the galaxy number count introduced by perturbations in the spacetime can be measured by the Fourier power spectrum and bispectrum. The study of these spectra often makes use of the distant observer approximation where the line-of-sight (LOS) vectors are always parallel. But, it has been shown that going beyond this plane-parallel assumption introduces wide-angle corrections to the power spectrum and bispectrum. For the bisector LOS definition, the wide-angle effects are non-negligible and can lead to potential contamination of local fNL measurements. In this work, we generalize the results, both in the single and multi-tracer cases, for all possible LOS definitions that can be parameterized by a free parameter in the power spectrum. We focus on low redshifts where the wide-angle effects are larger and therefore, we can safely neglect the lensing contribution. We consider the non-integrated redshift-space distortions and relativistic Doppler terms in our perturbative expansion of the wide-angle corrections and include the primordial non-Gaussianity through the bias tracers.

Session

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2814

Exploring southern galaxy groups and clusters with S-PLUS/DR4

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Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo (IAG/USP)

Abstract

This study relies on the galaxy cluster and group detection and characterization utilizing the latest data release of the Southern Photometric Local Universe Survey (S-PLUS/DR4), covering approximately 3000 square degrees. We use the cluster finder algorithm PZWav, within the redshift range of $0.05 < z < 0.5$, to identify galaxy group and cluster candidates due to its feature to handle the probability density function of the redshift. This ability is essential in recent imaging surveys that utilize narrow-band filters, such as S-PLUS, as it allows the exploration of precise photometric redshift estimates. With a similar approach, previous studies with miniJPAS show that we recover structures with $4{\cdot}10^{13}$ solar masses at redshift 0.75. We expect to achieve a similar sensibility with S-PLUS. Additionally, we offer insights into the candidates' galaxy members by applying our adaptive membership estimator algorithm. With the membership probabilities, we estimate richness and optical luminosity for each cluster. Finally, we validate the quality and completeness of the algorithms through comparisons with the literature and tailored simulations. We find that our catalog achieves 80% purity and 95% completeness for structures with a richness greater than 4, corresponding to clusters with masses exceeding 10^{14} solar masses. The comparisons with Sunyaev–Zel'dovich-based detections in STRIPE82 demonstrate an 87% recovery rate, with center variations of $\Delta R = 187 \pm 96$ kpc and $\Delta z = -0.004 \pm 0.013$ in redshift. This investigation emphasizes the potential of the S-PLUS survey and the applied methodologies.

Session

Division J Galaxies and Cosmology

2817

Probing the Association of Galaxy Clusters with Bent-Tailed Radio Sources Using the MeerKAT Galaxy Cluster Legacy Survey

Mr Toivo Samuel Mabote

University of Pretoria

Abstract

In this presentation, I will delve into my extensive research on Bent-tailed radio galaxies (BT) derived from the MeerKAT Galaxy Cluster Legacy Survey. Leveraging publicly accessible imagery, I have meticulously compiled the most comprehensive catalogue of BT galaxies to date. My discussion will center on elucidating the intricate sample selection process and uncovering the significant insights yielded by this catalogue regarding the physical attributes and connections between BT galaxies and their respective host clusters. Through this exploration, I aim to shed light on the dynamic interplay shaping galactic environments, offering valuable contributions to our understanding of cosmic evolution.

Session

Division J Galaxies and Cosmology

2823

The Stellar Mass Distribution of the Galactic Center's Nuclear Star Cluster

Brian Murphy

Butler University

Abstract

The direct Fokker-Planck method is employed to develop a dynamically evolving model of the stellar distribution of the nuclear cluster surrounding the massive black hole (MBH) at the Galactic Center. This model incorporates a range of stellar masses from 0.1 to 50 solar masses. Initially, the model features a seed black hole, which undergoes growth through various mechanisms such as tidal disruption and stripping of stars, stellar collisions, and mass loss due to normal stellar evolution. After 13 billion years, the most suitable model has the MBH and the surrounding nuclear cluster with masses of 4.3 and 23 million solar masses, respectively, with the nuclear cluster having a half-mass radius of 5.7 parsecs.

This model accurately reproduces the K-band surface luminosity profile to radii of less than 0.1 arcsecond and provides a natural explanation for the absence of giant stars observed by others at these radii. These giant stars not only experience collisions but can also undergo tidal stripping of their outer layers during their evolution. Although stellar mass black holes constitute only 2.5% of the total mass of the nuclear cluster, they significantly influence the stellar distribution within the inner 0.25 parsecs. The population of stellar black holes has a half-mass radius of 1.96 parsecs. Within distances of 0.01 and 0.1 parsecs from the center, the model predicts the presence of 130 and 1950 stellar mass black holes, respectively, aligning well with observational limits derived from the orbits of S stars.

Session

Division J Galaxies and Cosmology

2878

Electron Temperature, Metallicity, and the Ionizing Source of Local Analogs of High-z Galaxies

Dr. Valentino Gonzalez, Benjamin Navarrete

Universidad de Chile

Abstract

Strong nebular emission lines in the optical are routinely used to study the ISM of galaxies. In fact, thanks to the JWST, such measurements are now possible for galaxies at very high redshifts (z>7), well into the epoch of reionization (EoR). Often, the physical properties derived from these lines rely on local calibrations that are not necessarily accurate for the extreme populations that the JWST has been uncovering in the distant Universe. In this work, we present a sample of local galaxies with strong-line ratios (e.g., OIII/Hb, NII/Ha) similar to those of z≥3 galaxies for which we have acquired very deep optical and NIR spectra. The data reveal weak lines (e.g., [OIII]4364, [OII]7319+7330 [SIII]6312, [NII]5755) that are difficult to observe directly on distant galaxies, even with the JWST, and that allow us to make multiple estimates of the electron Temperature and density, as well as metallicities for these local analogs of high-z galaxies. Furthermore, our NIR spectra allow us to constrain the dominant ionizing source, distinguishing between massive stars, AGNs, and shocks. This is based on BPT-like diagnostics but using NIR lines such as FeII 1.64, H2(1-0)S(1), and Brγ. Similar NIR measurements directly on EoR galaxies are beyond the wavelength reach of the JWST (because of the large redshifts), so this could be our best clue about what is, most likely, the dominant source ionizing the ISM of the most distant galaxies.

Session

Division J Galaxies and Cosmology

2896

Cosmic magnification in beyond-Horndeski gravity

Dr Didam Duniya[1], Dr Bishop Mongwane[2]

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Abstract

The cosmic magnification is able to probe the geometry of large scale structure on cosmological scales, thereby providing another window for probing theories of the late-time accelerated expansion of the Universe. It holds the potential to reveal new information on the nature of dark energy and modified gravity. By using the angular power spectrum, we investigated cosmic magnification in beyond-Horndeski gravity. We incorporated the known relativistic corrections and considered only large scales, where relativistic effects are known to become substantial. We probed both the total relativistic signal, and the individual relativistic signals. Our results suggest that surveys at low redshifts ($z \lesssim 0.5$) will be able to measure directly the total relativistic signal in the total magnification angular power spectrum, without the need for multi-tracer analysis (to beat down cosmic variance); similarly, for the Doppler signal, at the given z. However, for the integrated-Sachs- Wolfe, the time-delay, and the (gravitational) potential signals, respectively, it will require surveys at high redshifts ($z \gtrsim 3$). For both aforementioned sets of signals, their amplitudes at the given z will ordinarily surpass cosmic variance, and hence, are able to be detected directly; whereas at other z, multi-tracer techniques will need to be taken into account. We also found that the beyond-Horndeski gravity boosts relativistic effects; consequently, the cosmic magnification. Conversely, relativistic effects enhance the potential of the total magnification angular power spectrum to detect the imprint of beyond-Horndeski gravity.

Session

Division J Galaxies and Cosmology

2915

Constraining Late-Time Physics to Solve the Hubble Tension

Sebastián Rueda-Blanco[1], Dr. Camilo Delgado-Correal[2,3], Dr. Mario-A. Higuera-G.[1], Dr. Sergio Torres Arzayus[4]

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Abstract

In this work, we analyze Type Ia supernovae (SNe) data to constrain the equation of state (EOS) of dark energy (DE), defined as $\omega = P/\rho$, within the context of the Hubble tension. Previous studies on dynamic DE models suggest that while DE alone cannot completely resolve the tension, it remains a viable candidate and may contribute to its alleviation. To guide theoretical developments concerning the EOS, we propose a physics-agnostic approach to constrain DE using both supernovae and CMB data. Our approach involves fixing pre-recombination physics, firmly established based on CMB observations, and examination of SNe data for late-time effects hat could alleviate the tension. In order to achieve this, we introduce a simple parametrization of the EOS, employing a sigmoid function that explicitly encodes a transition redshift where ω transitions from -1 (consistent with CMB observations) to its present value, ω_0. This parametrization enables DE to influence late-time expansion without disturbing early CMB physics. The primary dataset utilized in our analysis comprises Type Ia supernovae sourced from the Pantheon+ compilation, with a focus on selecting SNe within the Hubble flow sector ($z > 0.15$), where late-time physics effects would take place. Driven by the approach of fixing pre-recombination physics, we incorporate cosmological probes (CMB) not by merging the data, but rather as constraints. We present fits of cosmological parameters to the data, conduct analysis of parameter degeneracy, and incorporation of CMB constraints. The collective findings serve as a valuable resource for formulating theoretical models pertaining to the EOS.

Session

Division J Galaxies and Cosmology

2931

N-body simulations of the formation of halo substructures in spiral galaxies in merger events

Dr Stanislav Milošević

University of Belgrade, Faculty of Mathematics

Abstract

We investigate galactic dynamics and the evolution of halo structures in spiral galaxies using N-body simulations. These structures are formed through mergers between large spiral galaxies which we refer to as a host with its satellite dwarf galaxy. We tested different morphology and orbit orientation of the dwarf to describe different properties of the formed structures in the halo of the host. Particulary we took M31 as a host galaxy and probed different merger scenarios to explain the formation of the Giant Stellar Stream (GSS) and Northeast (NE) and West (W) shelves observed in the halo of M31. With dwarf spheroidal galaxy (dSph) we reproduced observed values of distances and velocities along the Stream. Using Monte Carlo simulations (MC) and with linearly decreasing function for the initial metallicity distribution in a dwarf galaxy, we explained the observed metallicity distribution along and across the Stream. We traced particles from the dwarf galaxy in the simulations of the merger event. As they carry their metallicities, we calculate the final metallicities in observed fields and match them with the observed ones. With linearly decreasing gradient we explained metallicity in the GSS as well as in the NE and W shelves.

Session

Division J Galaxies and Cosmology

2953

Photometric Synthesis with AI of S-PLUS galaxies

Mr Vitor Cernic

Universidade de São Paulo

Abstract

This study explores a new method for estimating stellar population parameters from galaxy parameters with the aid of Deep Learning techniques. By analyzing data from the S-PLUS photometric survey, we compared different regression models, including Random Forest, XGboost, and Neural Networks, to identify the most suitable estimator. To address challenges like missing data and calibrations, we developed a robust synthetic training sample that closely resembled real observations. The Neural Network model exhibited promising results, with a low error of 0.06 dex for stellar mass estimation [attached image] and accurate predictions of nine other stellar population parameters. The approach allows for constraints-free, fast parameter estimation compared to traditional methods constrained by redshift. As a testament to the effectiveness of our approach, we present new data analysis of nearby galaxy clusters, such as Fornax and Abell 85, showcasing the potential of our method in studying diverse galactic populations. We also apply this method to the S-PLUS and CHANCES surveys, with a focus on obtaining previously unseen galaxy parameters and intend to make this data public. This novel approach has the potential to significantly advance our understanding of stellar populations and contribute to the progress of galaxy research.

Session

Division J Galaxies and Cosmology

3020

Neighbourhood Watch: A Survey of Baryonic Substructures in the Nearby Universe

Rohan Rahatgaonkar[1], Bryan Miller[2], Thomas Puzia[1], Yasna Ordenes-Briceño[1], Paul Eigenthaler[1], Tuila Ziliotto[3], Mathew Taylor[4], Juan Pablo Carvajal[1]

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Abstract

The Neighbourhood Watch is a survey to complete a census of all baryonic structures out to at least the virial radius in a sample of galaxy groups within 18 Mpc in the optical filters u'g'r'i' and H-alpha with CTIO/DECam and in the NIR J,K filters with ESO/VIRCAM. The observations reach unprecedented point source depths of 2.5 magnitudes beyond the peak of the globular cluster luminosity function (GCLF) which will detect > 99% of all compact objects, i.e. globular clusters (GCs) and ultra-compact dwarf galaxies (UCDs), and reveal all low-surface brightness baryonic structures down to ∼28mags/arcsec2.This dataset will allow us for the first time: to derive a complete GCLF out to the virial radius for these galaxies, search for spatial over-densities and unique age/metallicity distribution functions in the GC population, detect 10-100 new low-surface brightness dwarf galaxies for each target group to test current state-of-the-art cosmological simulations and measure their luminosity function in different environments, and probe the complex interaction/merger/accretion history of these groups. Given the DECam community pipeline's inability to properly determine the sky levels around large galaxies, a custom data reduction pipeline has been designed for this particular dataset that employs a combination of different image processing techniques (convolution masking, distortion reduction in chip gaps, adaptive sky modal) leading to improved retrieval of low-surface brightness dwarf galaxies in the final stacks. This talk will give an overview of the survey and present analysis of the final stacks in relation to the objectives mentioned above.

Session

Division J Galaxies and Cosmology

3075

A New Era of Resolved Physics

A/Prof Aaron Robotham

UWA

Abstract

Here I will present recent work using our new “ProFuse” resolved spectral energy distribution software. Applying this to the 21 bands of UV-FIR data of the Galaxy And Mass Assembly (GAMA) survey we have discovered new insights into the resolved properties of 10,000 galaxies. Highlights include the existence of a fundamental size-mass-age plane for disks, and the truly relic nature of most classical bulges- being significantly older than even elliptical galaxies. This work is now moving into space, with deep highly resolved surveys taking place with JWST (Pearls) and Euclid (the WAVES legacy science survey).

Session

Division J Galaxies and Cosmology

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Challenging the standard cosmological model using HII galaxies with the JWST

Dr. Ana Luisa González Morán

The Autonomous University of Sinaloa (UAS, México)

Abstract

The Standard Model of Cosmic Structure Formation (ΛCDM model) explains the history of the Universe as a succession of epochs characterized by their expansion rates. The cosmological parameters Ω_m, Ω_{Λ}, and w_0 (plus w_a in the evolutive case) are obtained by combining the low-redshift results (z $\lesssim$ 2) for baryon acoustic oscillations (BAOs) and type Ia supernovae (SNIa) with high-redshift results (z $\sim$ 1000) given by Planck CMB fluctuations. It is important to remark that there are no determinations of cosmological parameters at intermediate redshift (2 $\lesssim$ z $\lesssim$ 8), where the maximum difference in cosmological models that include an evolving Dark Energy Equation of State (DE EoS) occurs. Here we present independent determinations of cosmological parameters using the distance estimator based on the established correlation between the Balmer line luminosity, L(Hβ), and the velocity dispersion (σ) for H II galaxies (HIIG) up to z~ 8. These results are based on 229 HIIG where 6 were observed using the JWST at 5.5 $\lesssim$ z $\lesssim$ 7.5. The results showed in this work are in excellent agreement with the ΛCDM model obtained from similar analyses using Type Ia supernovae. We anticipate our assay to be a starting point to measure with high-precision the DE EoS and to explore its evolution (or lack of it) with look-back time as well as searching for hints of any other property of DE making use of more JWST high-z HIIG data.

Session

Division J Galaxies and Cosmology

3079

WAVES: The Wide Area VISTA Extragalactic Survey

Sabine Bellstedt

ICRAR-UWA

Abstract

The WAVES survey is a major galaxy redshift survey that will be conducted on 4MOST, scheduled to begin its scientific operations in 2025. Expected to collect redshifts for 1.6 million galaxies, this survey will build a highly complete view of galaxy environment, over large areas of the sky, and also extending out to z=0.8. The backbone of this project is the wealth of multi-wavelength imaging data, which has been meticulously processed to produce an enormous photometric catalogue over ~1300 square degrees. This input catalogue will facilitate one of the first survey selections with a photometric redshift cut - a critical element of WAVES. I will present the WAVES sub-surveys, targeting strategy, and an overview of the wealth of science expected to be conducted with the data in the coming years.

Session

Division J Galaxies and Cosmology

3081

Probing the low-frequency radio luminosity - star-formation rate relation for star-forming galaxies with LOFAR

Dr Ikechukwu Obi[1], Prof Huub Röttgering[2], Dr Bonaventure Okere[1]

[1]Centre for Basic Space Science & Astronomy (CBSS). [2]Leiden Observatory, Leiden University, The Netherlands

Abstract

We investigate the relationship between the low frequency radio luminosity and key physical properties of nearby star-forming galaxies (SFGs) by exploiting LOFAR (Low Frequency Array, The Netherlands) 150 MHz observations of the ELAIS-N1 (European Large Area ISO Survey North 1) field. We model the UV-radio SEDs of a sample of SFGs in this field with the SED fitting code, Galapy-fit, which incorporates the most recent PARSEC SSPs. These SSPs are unique when compared to those used in other fitting codes in that the non-thermal (synchrotron) radio emission which dominates at low frequency, are not computed from the far-infrared-radio correlation but from core-collapse supernova (CCSN) rates and accounts for recent advances in CCSN explosion models. We present the results of our multi-wavelength analysis which aims to shed more light on the usage of low frequency radio luminosity as a SF tracer. We compare our results with those of other works in the literature, both at 150 MHz and at 1.4 GHz.

Session

Division J Galaxies and Cosmology

3088

Measuring the Hubble Constant with Mira Variables

Dr. Caroline Huang

Harvard-Smithsonian Center for Astrophysics

Abstract

Precise, cosmic distance ladder measurements made with Cepheids have revealed a 5σ discrepancy in the observed rate of expansion of the universe at the present day (the Hubble Constant) and the rate predicted by observations of the Cosmic Microwave Background assuming a standard Lambda-Cold Dark Matter cosmology. With no obvious solutions to the tension, this discrepancy has been one of the strongest indications of physics beyond the Standard Model of Cosmology. As a result, the use of multiple, independent methods measuring the Hubble Constant is integral to resolving or solidifying the tension. Mira variables – highly-evolved asymptotic giant branch stars – have gained attention as an alternative precision distance indicator and calibrator of Type Ia supernovae to the more widely-used Cepheid or Tip of the Red Giant Branch stars. In addition to being highly luminous and ubiquitous, they are capable of being easily detected and characterized using only near-infrared and infrared observations, which is particularly advantageous in the era of JWST and Roman. In my talk, I will discuss current progress in the development of the Mira distance ladder and its Hubble Constant measurements. In particular, I will focus on recent HST and JWST observations of Mira variables in M101, the nearest recent host galaxy of a Type Ia supernova.

Session

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3096

Unveiling the Warm Molecular Hydrogen Reservoir in the Circumgalactic Medium of MACS1931-26's Brightest Cluster Galaxy: Insights from JWST/MIRI Observations

Lucas Kuhn, Dr. Allison Man

The University of British Columbia

Abstract

We present JWST MIRI observations of the warm molecular hydrogen in the circumgalactic medium (CGM) of the brightest cluster galaxy (BCG) of MACS1931-26. This target harbors one of the largest known H2 reservoirs in a cluster core revealed by ALMA. Its cold gas, as traced by CO, is spatially extended over a tail of ~30kpc beyond the BCG core. Submillimeter observations reveal extreme thermal and excitation conditions in the CGM gas: the dust and gas are thermally decoupled, and the CGM is unusually highly excited pointing to a drastically different condition in the CGM than typical gas found in galaxies. We utilize MIRI/MRS to map the 3D structure of the warm molecular gas in the BCG core and the extended CGM tail of MACS1931, and present the first detections of the spatial extent and temperature distribution of the warm H2 emission. Specifically, we create line maps using our detections of the H2 0-0 S(1) and S(5) lines which enables the measurement of the total gas mass and temperature distribution. We follow this by comparing the warm H2 emission to the cold H2 emission mapped by CO. In addition, we see evidence of shock-induced star formation with the presence of Polycyclic Aromatic Hydrocarbon (PAH) features in our spectra. By probing the CGM gas across a range of temperatures, we provide insight into the impact of AGN feedback on the baryon cycle, and assess the role of shocks and turbulence in the heating and cooling of the CGM.

Session

Division J Galaxies and Cosmology

3097

A panchromatic view of the circumgalactic medium surrounding a brightest cluster galaxy at z=0.4

Prof. Allison Man, Lucas Kuhn, Laya Ghodsi

The University of British Columbia

Abstract

Star formation within galaxies is regulated by the circumgalactic medium (CGM) through gas inflows and outflows. I will present an analysis of the comprehensive view towards the multiphase (warm and cold molecular + ionized) gas and dust analysis of a BCG at z=0.4. The target harbours one of the largest known H2 reservoirs, elevated star formation, and a strong radio AGN. We obtained new JWST/MIRI MRS observations that detect warm H2 lines, indicating that the molecular CGM is warmer than the interstellar medium within the BCG. I will present preliminary results a joint analysis of the warm and cold molecular gas in the CGM and BCG, using ALMA and single-dish observations of CO and [CI] emission lines. Archival HST and VLT/MUSE observations enable us to tie the gas and dust conditions to the resolved stellar populations. I will discuss the implications of this work on the possible link between the enhanced star formation in this BCG and its CGM, as well as the role of AGN feedback in regulating star formation. This case study serves as a pathfinder for using JWST to complement existing multi-wavelength observations of the gas, dust and stars of massive galaxies and their CGM using JWST.

Session

Division J Galaxies and Cosmology

3112

The undiscovered ultra-diffuse galaxies of the Local Group

Dr Oliver Newton[1], Dr Arianna Di Cintio[2,3], Dr Salvador Cardona-Barrero[2,3], Dr Noam Libeskind[4], Prof. Yehuda Hoffman[5], Prof. Alexander Knebe[6,7,8], Dr Jenny Sorce[9,10], Prof. Elmo Tempel[11,12]

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Abstract

Ultra-diffuse galaxies (UDGs) are attractive candidates to probe cosmological models and test theories of galaxy formation at low masses; however, they are difficult to detect because of their low surface brightness. In the Local Group a handful of confirmed and candidate UDGs have been found to date, most of which are satellites of the Milky Way and M31, and only three are isolated galaxies. It is unclear whether so few UDGs are expected. We address this by studying the population of UDGs formed in hydrodynamic constrained simulations of the Local Group from the HESTIA suite. For a Local Group with a total enclosed mass, M (< 2.5 Mpc) = 8×10^{12} $M_\odot$, we predict that there are 12 ± 3 isolated UDGs (68% confidence) with stellar masses between 10^6 and 10^9 $M_\odot$, and effective radii $R_e \geq 1.5$ kpc, within 2.5 Mpc of the Local Group, of which 2^{+2}_{-1} (68% confidence) are detectable and classified as UDGs in the footprint of the Sloan Digital Sky Survey (SDSS). Accounting for survey incompleteness, we find that almost the entire population of UDGs in the Local Group field would be observable in a future all-sky survey with a depth similar to the SDSS, the Dark Energy Survey, or the Legacy Survey of Space and Time. Our results suggest that there is a population of UDGs in the Local Group awaiting discovery.

Session

Division J Galaxies and Cosmology

3118

The formation and disruption of globular cluster populations in simulations of present-day L^* galaxies with controlled assembly histories

Dr Oliver Newton[1,2], Prof. Rob Crain[2], Dr Joel Pfeffer[3], Prof. Andrew Pontzen[4], Prof. Nate Bastian[5,6], Dr J. M. Diederik Kruijssen[7,8]

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Abstract

Globular clusters are sensitive tracers of galaxy assembly histories. We examine how the mass ratio of major mergers affects the formation and disruption of globular clusters in a simulated present-day L^* galaxy. Starting from a zoom-in simulation of a system that experienced major mergers at z=1.7 and z = 0.77, we employ the genetic modification technique to enhance the mass ratio of the latter merger by a factor of two (enhanced case) or prevent it from occurring (suppressed case). The formation and evolution of star clusters is implemented using the MOSAICS model in the subgrid of the EAGLE hydrodynamics scheme. Our simulations reveal that most of the globular cluster system forms during the first merger and that most of the subsequent evolution is affected mainly by the characteristics of this merger. Late-time mergers, if they take place, play a minor role by prolonging the galaxy's phase of net star cluster formation by up to 1 Gyr after the coalescence of the remnant. At z=0 this manifests as an overabundance of massive star clusters in the enhanced case compared with the unmodified assembly history, while the suppressed case has more low-mass clusters. Two commonly used observational metrics to characterize the richness of globular cluster systems are the specific frequency and the specific mass. At z=0 we find that the latter is stratified as a function of the mass ratio of the target merger; however, the specific frequency is not. This feature could prove useful to elucidate the assembly histories of galaxies from present-day observations.

Session

Division J Galaxies and Cosmology

3121

Bar-Disk Driven Galaxy Formation in the Cosmic Morning

Dr. Takafumi Tsukui[1,2], Dr Emily Wisnioski[1,2], Dr. Yifan Mai[2,3], Prof Joss Bland-Hawthorn[3,2], Prof. Satoru Iguchi[4,5], Dr. Junichi Baba[4,5,6], Prof. Ken Freeman[1,2]

[1]Australian National University Reserach School of Astronomy and Astrophysics. [2]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D). [3]University of Sydney. [4]National Astronomical Observatory of Japan. [5]The Graduate University for Advanced Studies (SOKENDAI). [6]Kagoshima University, Amanogawa Galaxy Astronomy Research Center

Abstract

Bar structures, prevalent in nearby galaxies, are thought to significantly influence galactic disk evolution since their formation. Archaeological studies of the Milky Way and nearby galaxies suggest their formations date back over 8 billion years, aligning with recent JWST and ALMA observations that have identified stellar bars and gaseous bars, respectively, at high redshifts (z=2-4). The bar structures revealed by ALMA are predominately found in dusty starburst systems with a star formation rate of 100-1000, which are presumably gas-dominated systems. In this talk, we present our analysis of the resolved dust and gas kinematics for the archetypal starbursting barred disk galaxy, BRI 1335-0417 at redshift z=4.4, yielding a detailed picture of such starbursting systems. Our findings include: (1) a gas bar offset toward the dust bar's leading edge, suggesting gas inflow along the bar; (2) disk kinematics displaying coherent, non-circular motion, with a rotation-subtracted velocity residuals revealing an m=2 spiral pattern that aligns with the spiral arm morphology in gas and dust, indicating disk vertical perturbations from gas accretion or satellite interactions; and (3) gas comprising 72% of the galaxy's total mass. These observations may indicate that significant gas flow maintains a high gas and baryon fraction high, making the disk unstable and conductive to bar structure formation even in the gas-dominated systems. This contrasts with well-studied models where stellar bars emerge from stellar disks. We will discuss bar formation in these systems, linking our observations with recent numerical simulations of high gas fraction disks that resemble this population.

Session

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Decoding SF Quenching in Massive Galaxies: A Multi-Parameter SDSS Analysis

Dr Duho Kim

Department of Astronomy and Space Science, Chungnam National University, South Korea

Abstract

The galaxy luminosity function reveals a sharper cutoff at the bright end than predicted by ΛCDM cosmology for dark matter halo masses. This points to baryonic processes – such as virial shock heating, AGN feedback, morphological quenching, and environmental effects – as key players in halting star formation. I investigate these mechanisms using Big Data clustering algorithms on SDSS catalogs. The immense data from the Rubin Observatory will amplify my analysis.

Session

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3199

Secondarily lensed Einstein arc by the companion galaxy discovered in a galaxy lens

Dr Ming Zhang[1,2], Dr Qi Yuan[1,3], Mr Jin-Yin Liu[1,3], Dr Li Zhang[4]

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Abstract

In the previous HST image analysis, the looming diffuse emission close to the companion galaxy was speculated to be part of the galaxy's spiral arms, so its role in the lensing macromodel was not emphasized. In this study, researchers analyzed the tri-band images from optical to near-infrared captured by the WFPC2 and NICMOS cameras carried by the HST, and found that after subtracting the light model of the foreground galaxy and background quasars, in the residual image, the Einstein light arc is consistently visible, and its convergence center is just at the position of the companion galaxy. At the same time, researchers used the latest 8.4GHz global VLBI observations to successfully resolve the corresponding jet components in the secondary image. Together with the jet components in the primary image, those components constitute a dual-image-three-component constraint on the lens system, which gives the strongest point source location and flux constraints for this lens system. The researchers applied the optimized macromodel constrained by the VLBI point source to the HST tricolor images, further optimized the photometric model of the foreground lens galaxy and the background quasar, and obtained the consistent optimization of the lens model for both optical and radio observations. The model can perfectly produce the Einstein arc, which indicates it is from the extended structure of the background quasar host galaxy. It also shows that the power-law slope of the lens host galaxy is steeper than that of the isothermal ellipsoid model, and the weak curvature of the jet in the secondary image is also within the tolerance of the model.

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3201

Detecting Faint Radio Frequency Interference (RFI) in MeerKLASS Single Dish data

Tamera Kassie

SARAO/ University of Western Cape

Abstract

MeerKLASS is a single dish HI intensity mapping survey of the MeerKAT Telescope. Probing the 21 cm signal is coupled with challenges from foregrounds and radio frequency interferences (RFI) which contaminates the data, and in turn our cosmological signal. The MeerKLASS collaboration has produced a detection of the HI cosmological signal using cross-correlations with galaxy surveys. However, low-lying RFI still remains. By removing these low lying RFI we expect to have reduced data loss due to aggressive flagging of RFI contaminants across channels to increase our S/N for an improved detection of the 21 cm signal. Low lying RFI lies below the noise measurement of single dish instruments and would require an algorithm that is able to boost the sensitivity and contrast the underlying RFI for flagging. In this presentation I will highlight the SSINS (Sky-Subtracted Incoherent Noise Spectrum) Algorithm (Wilensky et al, 2019 PASP 131 114507) that I have adapted to be applied to the MeerKLASS data to remove faint RFI signatures.

Session

Division J Galaxies and Cosmology

Final category: EC WG Astronomy for Equity and Inclusion

56

A History of the Movement for Equity and Inclusion in Astronomy

Dr. Jörg Matthias Determann

Virginia Commonwealth University

Abstract

Astronomy is a field concerned with matters very distant from Earth. Most phenomena, whether observed or theorized, transcend human spaces and timescales by orders of magnitude. Yet, many scientists have been interested not just in the events that have occurred millennia before Earth's inception, but also in their very own society here and now.
Since the first half of the twentieth century, an increasing number of them have pursued parallel careers as both academics and activists. Besides publishing peer-reviewed papers, they have promoted a great variety of underrepresented groups within their discipline. Through conferences, newsletters and social media, they have sought to advance the interests of women, members of racial and ethnic minorities, LGBTQI+, and disabled people. While these activists have differed in the identities they focus on, they have come to share a conviction that equity and inclusion are crucial for scientific excellence as well as social justice.
This paper presents biographies and institutional contexts of key agents in the diversification of modern astronomy. The presentation argues that these individuals collectively formed a social movement that has sought to revolutionize science and make it far more just. As most are recent figures whose discoveries have not been commemorated by Nobel Prizes, they are relatively unknown among historians of science. Activist scientists have, however, been central to discussions about who has privileged access to the tools of astronomical inquiry, including powerful telescopes and extensive databases. As such, they have also significantly shaped views of our universe.

Session

EC WG Astronomy for Equity and Inclusion

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Learning the art of creating an environment that embraces diversity and fostersinclusivity, from celestial bodies.

Dr. Gemechu Muleta Kumssa

Space Science and Geospatial Institute (SSGI)

Abstract

Astronomy is a captivating field, attracting individuals from around the globe who possess a deep curiosity to understand the marvels of the universe. Through the pursuit of astronomical research, we can harness our understanding of the cosmos to tackle the challenges we encounter in our daily lives. The celestial bodies that populate our skies have the potential to impart invaluable lessons on the importance of embracing diversity and fostering inclusivity among all inhabitants of our planet. To achieve this, it is crucial to create an environment that nurtures imagination, respect, and empowerment for every individual, irrespective of their age or background. Within this framework, I have discussed how we can learn from the celestial systems to cultivate a genuine appreciation for diversity and inclusion.

Session

EC WG Astronomy for Equity and Inclusion

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Identifying Indigenous Astronomy Knowledge Systems in “westernised” indigenous communities

Dr Anton Binneman

NRF|SARAO. University of Johannesburg

Abstract

MeerKAT and the SKA-Mid Projects are changing the face of the central Karoo in the Northern Cape of South Africa. These projects are bringing opportunities to local communities that they would have never had if these projects did not happen. The projects provide opportunities in several different fields including Dark skies tours and Astronomy Tourism. To ensure that this is done sustainably the initiatives need to be unique to the area and the people who live there. The central Karoo is famous for the stories captured by Bleek and Loyd internationally and for numerous papers and academic books have been published on these stories. But when one engages community members it quickly becomes obvious that these stories are not known or used in local communities. This paper explores methods that were used by SARAO to identify what stories are being told by communities surrounding the SKA site and the process of incorporating this into an Astro tourism strategy. This process ensured that local communities were involved in telling their own stories, including them in the development of the area, Astro tourism and the preservation of cultural Astronomy in the SKA footprint area.

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The LightSound Project: Observing Solar Eclipses with Sound

Allyson Bieryla[1], Sóley Hyman[2]

[1]Center for Astrophysics | Harvard & Smithsonian. [2]University of Arizona

Abstract

The LightSound Project is building 750 sonification devices for the upcoming 2024 North American solar eclipse. The device was designed to convert light to sound as a way to engage blind, low-vision, and non-visual learners in solar eclipse observing and data collection. The LightSound device can be used as an educational/outreach teaching tool and/or an eclipse observing device. The project is donating devices, at no-cost, to educators and organizations hosting events or looking to engage the public in eclipse science. The project has successfully deployed devices for past eclipses (2017 N. America, 2019 and 2020 S. America, 2023 N. America). We will give an overview of our project with the goal of making international connections in preparation for the many upcoming eclipses, including many African countries! The project is completely open source and we have a model where we run workshops to train participants how to solder while building devices that are then distributed to event organizers at no-cost. Our goal is to reach as many organizers as possible to stress the importance of accessibility as a planning tool and not an afterthought.

Session

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New Tactile Models of CMB for Inclusive Astronomy

Miss Constanza Farjo[1], Dr. Johanna Casado[1], Dr. Beatriz García[2]

[1]Universidad de Mendoza. [2]Universidad Tecnológica Nacional, Regional Mendoza

Abstract

Even when radiation comes from energy regions beyond the visible spectrum, Astronomy is mainly a branch of science based on the visual approach to celestial phenomena. This fact, the observation based on the perception of light, is a significant disadvantage for individuals with visual impairments or other styles of learning. One of the tools that facilitates participation or aims to achieve this goal is sonification; another is tactile modeling, allowing individuals in general to touch and explore replicas of celestial objects and other astronomical data such as spectra or light curves in a new way. Tactile models of astronomical images can be enhanced through the development of open-source code, offering benefits such as a freely usable, collaborative, and inclusive tool. With this new approach to representing images in 3D models and the use of libraries like PyVista, models can be exported to STL for printing. This would enable the creation of a tactile model suitable for 3D printing using data from astronomical observation present in images used for research, education, and outreach, and correlate color, intensity, or power with the height of printing. In this contribution, we will focus on the 3D creation of the Cosmic Microwave Radiation, using the COBE and WMAP images and the experience of using these tactile models in a framework of focus groups with able and disabled participants, specialists, and non-specalists.

Session

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Multimodal analysis in photometry and spectroscopy with Jupyter notebook

Dr. Johanna Casado[1], Dr. Beatriz García[2]

[1]Universidad de Mendoza. [2]Universidad Tecnológica Nacional, Regional Mendoza

Abstract

In recent years, there has been a growing emphasis on the multimodal approach to data analysis, which has important implications for the inclusion of individuals with visual impairments in research, education, and outreach. A multimodal display allows for the integration of different sensory styles when analyzing data, which can improve the overall effectiveness of data analysis. However, for this technique to be widely implemented, it is necessary for the scientific community to contribute to its validation and use in scientific discoveries. There are several tools available for sonification, but only a few of them have a graphic interface and a user-centered approach. This contribution focuses on the use of sonification for photometry and spectroscopy data, using a novel multimodal approach presented through a Jupyter notebook that follows the actual process of analysis. The object-oriented software sonoUno, which is centered on the user from the beginning, will be used, particularly its libraries, to produce the sonification and visualization of the data. The advantage of using the sonoUno libraries in a Jupyter notebook is that it enhances communication with other research groups.

Session

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Tales from the Zooniverse: Equity and Inclusion through Participatory Science

Lindsay House[1], Laura Trouille[2], Cliff Johnson[2,3], Samantha Blickhan[2], Chris Lintott[4], Lucy Fortson[5], Alex Andersson[6]

[1]University of Texas - Austin. [2]Adler Planetarium - Zooniverse. [3]Northwestern University. [4]University of Oxford - Zooniverse. [5]University of Minnesota - Zooniverse. [6]University of Oxford

Abstract

Participatory science (also referred to as citizen science) initiatives have emerged as pivotal tools for fostering equity and inclusion within the field of astronomy. These projects engage the public meaningfully in real research, increase trust in science by lifting the veil on the process of science, provide pathways into science careers, and more. Zooniverse, the world's largest platform for people-powered research, engages over 2.7 million people around the world in over 90 active projects across the disciplines, from astronomy to zoology, cancer research to climate science, arts and humanities. In this talk we highlight a few of the ways Zooniverse is used in service of equity and inclusion goals in astronomy; aligned with the IAU Office of Astronomy for Development efforts. We explore: 1) The Project Builder tools, empowering researchers worldwide to create crowdsourced projects for free. 2) Multilingual translations enabling global classification challenges, reinforcing the 'one-world/one-sky' ethos and utilizing astronomy for science diplomacy. 3) Educational resources like classroom.zooniverse.org, facilitating seamless integration of real research experiences into classrooms globally. 4) Collaborations with organizations engaging under-represented groups in STEM, utilizing Zooniverse projects and tools to further their objectives. We will share the lessons learned and open questions from these experiences.

Session

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Astronomy Accessible Software for All (AASA)

Sr. Sr. STEM Education Specialist Yasmin Catricheo[1], Staff Associate for Facilities Planning and Management Tim Spuck[2]

[1]Associated Universities Inc.. [2]U.S. National Science Foundation

Abstract

Astronomy Accessible Software for All is a North American Regional Office of Astronomy for Development (NA-ROAD) project. With support from the U.S. National Science Foundation (STEM+C 1640131), blind and low vision (BLV), sighted students and their teachers engaged in an authentic software development project to create tools and resources that make astronomy image analysis more accessible to BLV persons. The result was the Afterglow Access (AgA) software. AgA is a comprehensive browser-based astronomical imaging and data analysis software designed to work with screen readers and incorporates unique features that allow the user to experience images through sound, making astronomy more accessible to BLV persons. In addition, the software is available in both English and Spanish. The NA-ROAD has developed virtual and in-person training programs for those wishing to use the software themselves, or with their students and the general public. Join us for an AgA demo and learn how you can access it free of charge.

Session

EC WG Astronomy for Equity and Inclusion

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The work in community astronomy starts from within

Alysha Shugart

Vera C. Rubin Observatory. NSF's NOIRLab

Abstract

The framework for community astronomy must be founded on inclusive relationships based on mutuality and belonging. Collaborators that wish to form these relationships must begin the work within themselves and their working groups and organizations. Diversity, equity, and inclusion (DEI) programs at Rubin Observatory and NSF's NOIRLab create an infrastructure in the workplace for this effort to be undertaken, and compliment the external relationship building needed to drive a new model of community astronomy forward. Every person has a story related to finding their place in astronomy and in the world. They have stories of belonging or not belonging, or how they overcame barriers to be a part of astronomical research. This talk presents the drive at these organizations to build pathways in the workplace for DEI efforts. We develop policies to invite every member of the organization to spend work time in these spaces. We build a culture where efforts to inject DEI in all aspects of the organization are not thought of as secondary, but are a part of any staff member's work. The work being done internally extends outward, and reflects Rubin and NOIRLab in their external relationships. We discuss the process of creating a system that honors time spent in the community and building relationships as a part of work time. Staff of Rubin and NOIRLab allocate time to learn more about indigenous cultures in the local sites, foster discussions of inclusion and challenging worldviews, while organizational leadership rewards new partnerships and internal growth in DEI.

Session

EC WG Astronomy for Equity and Inclusion

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Embracing the Stars: A Journey into Astronomy Awareness and Inclusive Participation by Learners with Disabilities

Mrs Lindie Muller[1], Ms Landie Rose Muller[2]

[1]National Research Foundation. [2]New Hope School for Learners with Disabilities

Abstract

This study, to be presented by a 12-year-old learner with special needs (LSEN), explores the experiences that led to the development of a profound passion for astronomy awareness and participation. The research investigates the crucial role of inclusive environments and effective strategies that capture the interest of learners, promoting active engagement in astronomy exploration outside traditional educational settings.

The study highlights the transformative impact of a supportive environment and engaging approaches, revealing how the LSEN learner's initial fascination with astronomy evolved into a deep-seated passion. It emphasizes the significance of inclusivity, allowing learners of all abilities to feel empowered as they independently explore their interests.

Furthermore, the research delves into the ripple effect generated by the learner's heightened awareness, sparking conversations among impaired peers. This, in turn, resulted in a collective effort among the peer group to actively engage in science and astronomy-related programs.

Presented by the LSEN learner, this study aims to share insights with parents, educators, and stakeholders, emphasizing the importance of inclusive practices in cultivating a love for astronomy exploration among learners with special needs. The presentation also underscores the broader impact of individual awareness, demonstrating how it can inspire collective enthusiasm and engagement in science and astronomy programs within peer communities.

Session

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Scalable hybrid approaches to ensure equitable access for all sizes of astronomy events

Dr Mike Peel[1], Dr Dave Clements[1], Dr Vanessa Moss[2], Dr Glen Rees[3], Dr Elizabeth Tasker[4], Dr Emily Kerrison[2]

[1]Imperial College London. [2]CSIRO. [3]TFOM. [4]ISAS JAXA

Abstract

Hybrid and online events have demonstrated their ability to increase access to astronomy meetings over the last few years, with record numbers of online attendees. However, while this has improved inclusiveness, access has not always been equitable, with those able to attend the events in person often accidentally excluding online attendees; online attendees not able to gain the same benefits of in-person interactions; and uneven availability of both travel funding to attend in-person and computer equipment to connect online. This presentation will highlight the available tools, design, and social approaches that can be taken to make any event more effectively hybrid, with equitable access online and in-person, and how they can be scaled appropriately to match different event sizes while simultaneously reducing environmental impact. It will also include pointers for what has and hasn't worked well in past hybrid contexts, and explore the cost-benefit ratio for different approaches to hybrid meetings, pointing out ways of avoiding astronomy gatherings that cost the Earth.

Session

EC WG Astronomy for Equity and Inclusion

1636

"Astronomy Connects People"

Assist.Prof.Dr. Hürcan Tarhan

International Final University. Bahçeşehir University. TurkCimento Mesleki ve Teknik Anadolu Lisesi (Vocational School). Innovative Eduacators Association (Yenilikçi Eğitimciler Derneği)

Abstract

Astronomy can play a significant role in supporting individuals and organizations in their efforts towards equity and inclusion which can be used as a tool and accessible technology for educational outreach programs targeting underrepresented communities. Resources and education can be provided in schools with diverse student populations which was previously experienced by the researcher (https://cledi.unimib.it/project).

Workshops can be offered that highlight the inclusivity of astronomy and its relevance to various cultures including individuals with disabilities. It can be used as public engagement and community building where astronomy will be utilized to engage the public in discussions about diversity and inclusion in science. Events, lectures, and public talks can be organized from which organizations will benefit and actively work towards fostering diversity and inclusion.

International Collaborations will enable to share resources, knowledge, and opportunities on a global scale. Besides exchange programs will facilitate diverse participation in international projects. Astronomy can be used as a storytelling tool to convey the rich history of diverse contributions to the field which can inspire individuals from underrepresented groups to pursue careers.

On the other hand mentorship programs can connect individuals from underrepresented groups with experienced mentors in astronomy. Provided guidance and support will ensure a more inclusive and supportive professional environment.

By leveraging astronomy as a tool for education, outreach, research, and community-building, individuals and organizations can contribute to creating a more equitable and inclusive landscape in the field. This involves actively recognizing and addressing barriers while promoting diversity at all levels.

Session

EC WG Astronomy for Equity and Inclusion

1652

Equity and Inclusion in Astronomy: Directions for 2027; Striving for 2030

Dr Jake Noel-Storr

University of Groningen. accessastronomy.eu

Abstract

As I move to the chair position of the EC WG for the next triennium, I willho discuss the layout of our EC WG, which has the most members of any WG in the IAU, I will introduce our sub-working-groups and organizing committee at large members. I will outline what we hope to achieve as a working group for the next 3 years, and describe aspirational goals for equity and inclusion in astronomy by 2030.

Session

EC WG Astronomy for Equity and Inclusion

1660

Effective Diversity, Equity and Inclusion Programs

Prof Keshlan Govinder[1], Prof Mathilde Jauzac[2], Dr Kabelo Kesebonye[3], Dr Sinenhlanhla Precious Sikhosana[1]

[1]University of KwaZulu-Natal. [2]Durham University. [3]University of the Witwatersrand

Abstract

Diversity, equity and inclusion (DEI) are crucial for the efficient and effective functioning of any organisation. However, DEI has been under increasing criticism recently with many organisations (mainly in the USA) shutting down DEI programs. In addition, DEI efforts in South Africa (called transformation) have also had low-to-moderate impact. In this talk, we will share our experiences of running effective DEI workshops at the University of KwaZulu-Natal. In addition, we will draw upon Alvin Tillery's CREED model to try to explain the pitfalls of and backlash to some DEI efforts globally. Finally, we will share a controversial metric to measure the ``effectiveness'' of DEI programs.

Session

EC WG Astronomy for Equity and Inclusion

1664

Astronomy Education for Blind and Visually Impaired Students at the University of Nigeria Using Tactile Methods

Miss Ojima Ocheni, Mr Timothy Egbuim, Dr. Bonaventure Okere, Dr. Nnaemeka Onyeuwaoma

Centre for Basic Space Science and Astronomy (National Space Research and Development Agency), Nigeria

Abstract

To achieve the all-inclusive United Nations education, people with special needs must be engaged in science, technology, and education. This project engaged 50 undergraduate and postgraduate students with special needs at the University of Nigeria, focusing on blind people and students with visual impairment. The project reached out to 35 undergraduate students and 15 postgraduate students. The project adopted a workshop approach; tactile methods were used during the hands-on sessions, while lectures were presented using live talks and pre-recorded audio. The hands-on sessions of the project were on a touch of the universe, solar system modeling using beads, the galaxies, a feel of the moon, the telescopes, and the black hole. The workshop lectures were on the pale blue dot, astronomy for mental health and wellbeing, the solar system planets, and women in the space sector. The outcomes of the workshop were measured using pre-and-post surveys. The students filled out these surveys with the assistance of the workshop facilitators. The pre-workshop results of the survey showed 23% knowledge about space science and astronomy, while the post-workshop survey showed 75% increased knowledge of space science and astronomy. The workshop outcomes showed over 50% interest in Science, Technology, Engineering, and Mathematics (STEM). Astronomy and space science knowledge are not limited to race, gender, or people without disabilities. The outcomes of this workshop proved that education should be for all, as the curious mind is innovative.

Session

EC WG Astronomy for Equity and Inclusion

1699

Attendance isn't Enough: Metrics for Measuring the Impact of Equitable Practices in Astronomy Education

Dr Sophie Bartlett[1,2], Ms Shaaron Leverment[3], Dr Jen DeWitt[4]

[1]IAU Office of Astronomy for Education. [2]Cardiff University. [3]Association for Science and Discovery Centres. [4]Freelance Evaluation Consultant

Abstract

Promoting equality, diversity, and inclusion (EDI) is crucial not only for cultivating a diverse workforce with varied skills and expertise but also for empowering individuals to recognise their potential in astronomy and STEM fields, free from biased messaging and experiences. Despite the increasing prevalence of EDI initiatives and widening participation efforts, the assessment of their impact often does not reflect implementation. Current evaluations often focus solely on demographic reach without delving into the actual experiences of individuals.

Rather than limiting impact reports to numerical data and diversity metrics, it is important we move towards measures that effectively capture and demonstrate the depth of meaningful and inclusive experiences across diverse audiences. Adhering to the principle of "first do no harm", this shift requires a nuanced understanding of the experiences diverse groups have during engagement, outreach, and educational initiatives. Mere attendance should not be assumed as indicative of a positive experience.

This talk will focus on a UK programme funded by the Association for Science and Discovery Centres in partnership with the Science and Technology Facilities Council. The programme focuses on co-developing a logic model that defines, guides, supports, and evidences meaningful practice. This presentation will emphasise the significance of promoting EDI in astronomy and STEM engagement, defining "good EDI practice," providing evidence of EDI implementation, and proposing meaningful metrics for assessing impact. The focus is on moving beyond quantitative indicators to truly understand and enhance the quality of experiences within diverse communities engaged in astronomy and STEM activities.

Session

EC WG Astronomy for Equity and Inclusion

1828

Touch the sky. A multisensory planetarium to discover the Universe

Federico Di Giacomo[1], Stefania Varano[2], Rachele Toniolo[2], Marco Poloni[2], Juri Roda[2]

[1]INAF - Osservatorio di Astrofisica e Scienza dello Spazio. [2]INAF - Istituto di Radioastronomia

Abstract

This project is to offer a common perceptual and cognitive framework to all users, both sighted, deaf and blind or visually impaired, concerning the experience of observing the sky. The acoustic stimuli are intended to introduce a perceptual equivalent for blind and visually impaired users, while the haptic ones introduce quantitative features, which can only be known through instrumental observations.

The planetarium consists of a plexiglass hemisphere on which stars from the first to the fourth magnitude are represented each by a metal bar that, when touched, activates visual, haptic and acoustic stimuli. The represented features for each star are its apparent magnitude and its distance from us. We mapped the magnitude, the most commonly used feature in night sky observation, both on acoustic (notes at different volumes), visual (LED at different brightness) and haptic (number of bolts) stimuli. The distance of the star is mapped on a vibration, faster/slower for smaller/greater distances.

Through the integration of these stimuli, we have given a wide range of users the opportunity to immerse themselves in a unique and shared experience of the fascinating celestial panorama. The combination of thoughtful design, focused prototyping and thorough preliminary assessment demonstrated the effectiveness of this innovative approach. Thanks to this multisensory planetarium, we not only make the beauty of the night sky accessible, but also open new perspectives for inclusive science education, offering everyone, regardless of sensory abilities, the opportunity to explore and understand the vast universe around us.

Session

EC WG Astronomy for Equity and Inclusion

Poster upload

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2044

Fostering a Diverse, Equitable and Inclusive workplace in the most remote Big City in the world

Dr Renu Sharma, Ms Asha Stabback, Prof Luca Cortese, Dr Brent Groves

University of Western Australia - ICRAR

Abstract

The International Centre for Radio Astronomy Research (ICRAR) was founded in September 2009 with the specific purpose of supporting Australia's bid to host the world's largest radio telescope and one of the largest scientific endeavours in history, the Square Kilometre Array (SKA). We are a joint venture between Curtin University (Curtin) and The University of Western Australia (UWA), with funding support from the State Government of Western Australia. ICRAR has research nodes at both universities with over 250 staff and postgraduate students and has been independently ranked in the top 5 university-based radio astronomy research centres in the world.

ICRAR is committed to creating a working environment and culture that is inclusive and provides equal opportunities, irrespective of race, gender, age, sexual orientation, culture and origin. We celebrate inclusion and diversity and believe gender equity is fundamental to an excellent workplace. We appreciate the experiences, skills and perspectives of all individuals and harness a collaborative environment.

In this talk, we outline the programs and initiatives established to foster a diverse, equitable and inclusive workplace as well as the challenges and opportunities. The inclusive culture has been recognised through the Gold Status in the Pleiades Awards, inspired by the UK's Athena SWAN program, and since 2018 the criteria for the Awards changed to reflect an expanded goal of equity and inclusion at all levels, and across all people in the astronomical community. ICRAR has also been named a Women in STEM Decadal Plan Champion.

Session

EC WG Astronomy for Equity and Inclusion

2157

Audio Universe: Making the Universe more Accessible Through Sound

Dr Christopher Harrison[1], Dr Ann Njeri[1], Dr Aishwarya Girdhar[1,2], Dr Anita Zanella[3], Dr James Trayford[4]

[1]Newcastle University. [2]LMU. [3]INAF. [4]Portsmouth University

Abstract

Audio Universe is a collection of tools and resources to support scientists, educators, students, and the general public to represent scientific data and concepts with sound (as well as with other senses). We do this to support: (1) scientific discovery; (2) engaging and immersive educational and communications content and; (3) increased accessibility to science. Here we will present how we have used sonification (turning data into sound) to create a sound-based planetarium show "Audio Universe: Tour of the Solar System" and complementary multi-sensory educational workshops. These were designed in collaboration with members of the blind and vision impaired (BVI) community, BVI specialist teachers, and their pupils. We present results from 291 audience evaluations from online viewers and audience members of planetarium showings. We find a strong appreciation from BVI and non-BVI audiences, with ~90% scoring 4 or 5 (out of 5) for both how useful and enjoyable the sounds are. We also present results from surveying planetarium and communication leaders known to have downloaded the show. We find international success for special events, for BVI audiences and for those with other special educational needs and disabilities (SEND; including sensory needs and learning difficulties). Finally, we will present the next steps to make these accessible approaches sustainable by providing communicators with their own sonification tools and guidance.

Session

EC WG Astronomy for Equity and Inclusion

2375

Outreach beyond the urban: multilingual and rural programs at the Indian Institute of Astrophysics

Dr. Niruj Mohan Ramanujam[1], Mr. Vikranth Pulamathi[1], Mr. Amoghavarsha Nagachandra[1], Mr. Dorje Angchuk[1], Dr. Shylaja B.S.[2], Mr. Punith Ramegowda[1], Dr. Chrisphin Karthick[1], Ms. SnehaLatha Karekal[3]

[1]Indian Institute of Astrophysics. [2]Jawaharlal Nehru Planetarium. [3](formerly at Indian Institute of Astrophysics)

Abstract

India is home to 100s of other languages. Like many countries in the global south, unfamiliarity with English is prevalent in socio-economically deprived communities and hence communication in local languages is imperative, especially in non-urban contexts. Though local science communication groups have been using regional languages for many years, research institutes have been slow to follow. In this talk, I will describe some of the efforts of the outreach programs of the Indian Institute of Astrophysics to bridge the linguistic as well as the urban-rural divides.

There has been considerable effort to create muilti-media content in multiple languages for astronomical events, including infographics, posters, audio and video, etc especially in the languages of the states where our observatories are located. I will discuss the challenges in obtaining translations that are both accurate and accessible, as well as those of dissemination. The latter stems from the fact that each state has its own language and hence needs us to develop extensive networks in each of them.

I will also describe our efforts in astronomy education in rural areas, mainly in collaboration with government agencies, which include working with numerous rural libraries, adding astronomy to the repertoire of local science communicators working in villages, and working with rural communities around our observatories. These efforts have also helped us unearth traditional astronomy knowledge in these communities, which would otherwise not be easily accessible. I will end by highlighting the importance of networking with local groups, and the ethical dimensions of such an exercise.

Session

EC WG Astronomy for Equity and Inclusion

2407

Supporting Neurodivergent Academics

Dr Veronica Allen

University of Groningen

Abstract

In recent years, greater understanding and public awareness of neurodivergent conditions like autism and ADHD has led to many adults discovering that their difficulties at work are caused by working in a neurotypical system with a neurodivergent brain. Neurodivergence is still commonly pathologized rather than accommodated, that is, neurodivergent people are told to "fix themselves" and fit into the system as it is, rather than have their environment adapted for them. This results in a much higher rate of burnout and job dissatisfaction as well as a loss of "out-of-the-box" thinkers in academia. Intersectionally, (cis-) women and girls were not commonly identified as neurodivergent until recently and there is a higher proportion of LGBTQA+ neurodivergent people, meaning that improving working conditions for neurodivergent people will also increase the inclusion of other minoritized groups. The good news is that job difficulties for ND people are often related to “traditional” working conditions and unwritten social rules. This means that the adaptations are simple to implement, though not intuitive for neurotypical people. While each neurodivergent person has their own specific individual needs, I will outline some practices and accommodations that institutions can easily enact in order to improve working conditions for neurodivergent and neurotypical people alike.

Session

EC WG Astronomy for Equity and Inclusion

2467

NRF's Research Communication Officer

Ms Mpendulo Sibiya

National Research Foundation

Abstract

Research Communications Officers are crucial in connecting researchers with the public by simplifying complex research findings for everyone to understand, which helps people grasp and value new scientific discoveries. The National Research Foundation (NRF) in South Africa actively promotes research and innovation interests locally and globally, building bridges between research communities, fostering mutual benefits and contributing to national development.

In this presentation, the NRF-RISA research communication officer will demonstrate strategies used in her role to communicate NRF-funded research effectively to stakeholders and the general public. This presentation aims to allow researchers at all levels to connect and showcase their work to the world through our communications and corporate relations. The presentation will highlight and also inform the researchers how to be featured in our next NRF Science Matters magazine, available at (https://www.nrf.ac.za/science-matters-magazine/), our weekly research nuggets website (https://www.nrf.ac.za/science-matters-magazine/research-nuggets/), our insightful social media channels and podcasts.

Session

EC WG Astronomy for Equity and Inclusion

2481

A Centre of Excellence in Planetary and Space Science and Technology (CESST) in Africa: report on the first phase of implementation

Prof Fulvio Franchi

Botswana International University of Science and Technology. Università degli Studi di Bari - Aldo Moro

Abstract

The project Focus on Africa Space Science and Technology 4 Future development (FAST4Future) aims at strengthening STEM in Africa Higher Education by promoting Planetary and Space Science and Technology (PSST) for sustainable growth and jobs creation. Africa is rapidly embracing the 4th industrial revolution and PSST has been identified as key area of investment to provide graduates and young scientists with both the necessary soft and practical skills to face 21st Century challenges such as digital innovation and higher skilled job creation.

The aims of FAST4Future are: i) To increase the accessibility to STEM in African; ii) To modernize existing PSST programmes; iii) To foster the internationalization and South-South collaborations; iv) to promote standardization of PSST in Africa.

To achieve these ambitious goals, FAST4Future created a Centre of Excellence in PSST (CESST) hosting a virtual platform (https://lms.cesst.org). Once fully implemented CESST will not only make PSST freely available to African students but will also coordinate collaborative actions to i) analyse the conditions needed to increase the participation of women in STEM in Africa; ii) modernise and harmonize PSST programmes in Africa; iii) promote the transfer of skills in key strategic areas of PSST.

The creation of a virtual platform within CESST opened new pathways for the dissemination of high-quality academic contents that will reach thousands of STEM learners across the continent and facilitate the access to STEM disciplines for Africans living in remote areas, conflict zones, and will increase the number of women in STEM.

Session

EC WG Astronomy for Equity and Inclusion

2502

Promoting Gender Diversity in Physics Education: The Case of WiPiSA in South Africa

Dr Joyful Mdhluli[1], Dr Katekani Shingange[2]

[1]Office of Astronomy for Development. [2]DSI/Mintek Nanotechnology Innovation Centre

Abstract

Despite being a developing nation, South Africa continues to face the challenge of underrepresentation of women and girls in physics education and related careers. This disparity is often attributed to the perception of physics as a male-dominated field and the lack of adequate support structures for female students.

This talk focuses on the efforts of the Women in Physics in South Africa (WiPiSA), a forum under the South African Institute of Physics (SAIP), to address the gender gap in physics education. We will give an overview of the organization's initiatives, particularly its focus on reaching underprivileged communities, to understand their approach to promoting and attracting women and girls to physics-related careers. The aim is to shed light on the potential of WiPiSA's work in contributing to a more diverse and inclusive physics landscape in South Africa. By communicating the efforts of WiPiSA, this talk plans to contribute to broader discussions on promoting gender equality in STEM education in developing countries.

Session

EC WG Astronomy for Equity and Inclusion

2535

An Analysis of the Principal Investigators of the European Space Agency Science Missions (1975-2024): Implications for Nationality and Gender

Professor John Zarnecki[1], Professor Arvind Parmar[2]

[1]The Open University, UK. [2]Mullard Space Science Laboratory, University College London

Abstract

We have collected data on the Principal (PI) and co-Principal Investigators of all relevant science missions within the European Space Agency's (ESA's) science programme since 1975. This now spans well over 400 scientists from most of ESA's current 22 Member States. The PIs have generally been selected through an Advisory Structure established to select missions and PIs based primarily on scientific merit. However, it is possible that biases, conscious or unconscious, might have been present in these selections. This study has aimed at investigating whether any such biases are apparent in these data. Results will be presented as well as recommendations for future actions in this area.

Session

EC WG Astronomy for Equity and Inclusion

2661

A Community Hub for Sharing Existing Resources and Methods for Including Blind and Low Vision People in Outreach Programs

Mike Simmons

Astronomy for Equity. Blue Marble Space Institute of Science

Abstract

Astronomy, the most accessible of sciences, is a natural introduction to STEM that encourages students to embark on STEM careers and serves as a gateway to STEM for isolated communities. But BLV people of all ages are largely excluded from astronomy programs and other STEM fields. Of eight million BLV in the US alone, one million are totally blind and one-third lack access to technology.

Thousands of volunteer outreach groups worldwide introduce astronomy and STEM to the public, but they are generally unaware that BLV people are not only interested in astronomy but that there are resources and proven methodologies for including them. Even when they learn of existing resources, they lack expertise and experience working with BLV and the means to source the materials. For experts and resource developers, a lack of interaction leads to resources and methods being reinvented in isolation.

While there are many individual BLV programs, there is no structured, interactive community where ongoing training, technical assistance, and support is free and available to everyone doing outreach. Astronomy for Equity has created an online community where astronomy outreach groups worldwide learn from experts and share their experiences with others. Experts can also interact and learn from each other, share the resources and methodologies they have created with outreach organizations, and get feedback from a diverse worldwide community of end users.

This community hub provides a model for community engagement projects in astronomy that Astronomy for Equity will be building in additional areas of astronomy outreach.

Session

EC WG Astronomy for Equity and Inclusion

2681

Under Other Skies: Dialogues of Different Cosmological Paradigms

Arianna Cortesi

Instituto de Física - Universidade Federal do Rio de Janeiro - Brazil. Observatory of Valongo - Universidade Federal do Rio de Janeiro - Brazil

Abstract

The sky is a shining record of the histories and mythologies of people of the world, drawn in the constellations, during the dark nights of pre-industrial societies. Yet, the boundaries of the constellations, approved by the IAU at its General Assembly at Leiden in 1928, reflect mostly the western cosmological paradigm. In a similar manner, scientific outreach is frequently reaching out only to a specific part of the world population, often excluding people living in extreme social vulnerability, victims of violence and prejudice, who are always fighting for their lives and for the right of living according to their traditions. In this talk, I will present the IAU/OAD funded project Under Other Skies, focused on ethno-astronomy, in particular on indigenous astronomy in Brazil. The project is co-created by indigenous researchers from a Maxakali Village, in the state of Minas Gerais, anthropologists and pedagogists of the Federal University of Minas Gerais, and astronomers and educators of the University of São Paulo, of the Observatory of Valongo and of the Nottingham University. This project was developed during pandemic, and astronomy served as a tool to face COVID-19 isolation in the indigenous village. The main deliverable of the project is a webpage, composed by the narrated stories and their illustrations, aiming to increase the indigenous didactic material available for primary schools inside and outside the village, and for the general public, fighting discrimination and defending the autonomy of indigenous education, giving institutional support and visibility to the newly created Aldeia Escola Floresta.

Session

EC WG Astronomy for Equity and Inclusion

2828

Diversifying STEM: Collaborative Initiatives at NRAO

Mrs. Danielle Rowland

National Radio Astronomy Observatory

Abstract

The Office of Diversity and Inclusion at the National Radio Astronomy Observatory (NRAO) actively supports broadening participation (BP) efforts in science, technology, engineering, and mathematics (STEM) using multiple approaches. In the United States, the fields of astronomy and physics do not reflect the demographics of the country's population leading to an underrepresentation of certain groups including, but not limited to, black, indigenous, and people of color (BIPOC), and gender and sexual orientation minorities. Diversifying the STEM workforce is a complex issue that cannot be solved by one organization alone, and systemic change must take place at several points along the STEM career pathway. Guided by a framework of collective impact centering equity (Kania et al. 2021; Kania & Kramer 2011), NRAO collaborates with external partners in several areas towards a shared goal of BP in STEM, particularly in astronomy, physics, and related fields. In this poster, I will overview three NRAO collaborative initiatives, at various stages of progress, that address BP in STEM by supporting students from underrepresented groups in different ways. These support methods include community and family outreach, access to informal and formal education, and providing research and training opportunities to gain experience.

Session

EC WG Astronomy for Equity and Inclusion

2873

Enhancing Astronomy Engagement and Accessibility: Research Insights from the Big Astronomy Project

Tiffany Stone Wolbrecht[1], Renae Kerrigan[1], Tim Spuck[2], Dr. Shannon Schmoll[3]

[1]Associated Universities, Inc. [2]U.S. National Science Foundation. [3]Michigan State University

Abstract

The Big Astronomy Project is supported by the National Science Foundation (NSF) and Associated Universities Inc. (AUI) and advances research initiatives and accessible resources for the Deaf/Hard-of-Hearing (DHH) and Blind/Low Vision (BLV) communities. The project encompasses an award-winning planetarium show, online educational events, and adaptable hands-on activities, all designed to broaden access to astronomy knowledge. Learn more about the research and outreach efforts of the Big Astronomy Project to chart a path toward inclusive, engaging, and accessible astronomy education. The research insights and innovative approaches from the Big Astronomy project can benefit both professionals and learners in diverse settings. Visit Bigastronomy.org for a comprehensive overview of our initiatives and resources.

Session

EC WG Astronomy for Equity and Inclusion

2887

Breaking Barriers: Bridging Gaps in Astronomy Education for Exceptional Learners in Ghana through the Teacher Training Program (TTP)

Mr Albert Kuntu Forson[1], Dr Asabre Frimpong Nami[1,2,3], Mrs Sarah Boamah[4], Mis Sarah Abotsi-Masters[1], Mr Joshua Kolongnia[1], Mis Christiana Kpakpo Donkoh[1]

[1]Promoting Astronomy in Ghana via School Visits and Astronomy Clubs (PRAGSAC). [2]African Astronomical Society. [3]Ghana Space science and Technology Institutes. [4]Ghana Education Service, National Robotics Facilitator Accra STEAM Centre

Abstract

Teaching astronomy to exceptional learners, particularly those from underrepresented groups facing diverse learning challenges such as disabilities or socioeconomic disadvantages, poses significant worldwide challenges. Ghana, specifically, lacks organized astronomy education programs for students and teachers in schools catering to exceptional learners, with a notable oversight of institutions for the blind and deaf despite previous efforts to enhance STEM education. Primary obstacle in Ghana's astronomy education for exceptional learners is the absence of accessible learning materials tailored to their specific needs. Traditional visual aids may not effectively serve visually impaired students, necessitating innovative and inclusive teaching methodologies, including tactile models, interactive digital platforms, and multi-sensory experiences.

To bridge this gap, we introduced the Teacher Training Program (TTP), providing astronomy workshops for grade 7-9 science teachers in schools for the blind and deaf across Ghana. The three-and-a-half-day residential workshop covers essential topics, aiming to equip teachers with hands-on activities for effective astronomy education for visually and hearing-impaired individuals.

This paper shares positive feedback and insights from participating teachers, along with encountered challenges, guiding future projects. Pre and post-evaluation analysis showed a substantial increase in participants' knowledge and skills, rising from 27.35% to an impressive 90.7% in teaching covered topics. Teachers demonstrated proficiency in using simple materials effectively, fostering enthusiasm for astronomy and dispelling long-standing myths. Additionally, 83.3% of participants indicated improved astronomy knowledge, highlighting the TTP's potential as a powerful tool in addressing astronomy equity and inclusivity in Ghana, contributing significantly to the country's growth and development by bridging the inequality gap.

Session

EC WG Astronomy for Equity and Inclusion

2951

AstroLingua: fostering equity in Astronomy through AI-driven accessibility

Dr Ana Paulino-Afonso

Institute of Astrophysics and Space Sciences

Abstract

At the heart of AstroLingua is the ambition to democratize access to the captivating field of extragalactic astronomy through the innovative application of artificial intelligence (AI) and natural language processing (NLP). This project, by providing descriptive analyses of celestial imagery for visually impaired individuals, bridges a crucial gap in accessibility, allowing a broader audience to engage with the mysteries of the cosmos. Utilizing the extensive Galaxy Zoo dataset, AstroLingua develops a comprehensive pipeline that integrates advanced image classification with NLP techniques to generate informative captions of galaxies. This dual approach not only enhances scientific understanding but also enriches public engagement and educational efforts by translating complex visual data into accessible formats. AstroLingua emphasizes the role of cutting-edge technology in expanding the frontiers of astronomy to all corners of society. By facilitating an inclusive dialogue about our universe, AstroLingua helps to pave the way for a more inclusive future in astronomical research and education.

Session

EC WG Astronomy for Equity and Inclusion

3044

The Magellanic Clouds Should Be Renamed

Mithi Alexa de los Reyes[1], Sally Oey[2], Gurtina Besla[3], Thomas Hockey[4], Jarita Holbrook[5]

[1]Amherst College. [2]University of Michigan. [3]University of Arizona. [4]University of Northern Iowa. [5]University of Edinburgh

Abstract

The two brightest satellite galaxies of the Milky Way are most commonly referred to as the Large and Small Magellanic Clouds. However, Indigenous communities around the world have known of the Clouds for centuries—long before the first Western explorers catalogued them. Furthermore, Ferdinand Magellan (for whom the Clouds are named) did not study these galaxies and was a controversial historical figure, considered by many communities to be a symbol of a violent colonial era. In this talk, I will outline several reasons why the astronomical community should rename these galaxies. I will also discuss an ongoing movement to rename the Clouds, including a proposed IAU resolution under consideration at this meeting.

Session

EC WG Astronomy for Equity and Inclusion

3085

IAU Advancing Inclusivity: Reflections on the Inaugural Diversity Meeting (NILAM) in Astronomy

ms Vilasinee (Fandora) Rung (Rynee)[1,2], Dr Storr Jake Noel-Storr[1,3]

[1]Co Chair for IAU sWG LGBTQAI+. [2]Apadilangit ; Universe Awareness Malaysia. [3]Groningen University

Abstract

The successful NARIT-IAU LGBT+ in Astronomy Meeting known as NILAM, co-organized by the International Astronomical Union (IAU) and the National Astronomical Research Institute of Thailand (NARIT), marks a significant milestone in fostering inclusivity within the field of astronomy. Collaborating with IAU Office for Astronomy Outreach (OAO) , IAU Sub Working Group on LGBTQ , NARIT and the International Training Centre of Astronomy (ITCA) orchestrated the inaugural LGBTQIA+ meeting in NARIT Chiang Mai.

Entitled "Building an Inclusive Astronomy Community: An LGBTQIA+ Meeting," the symposium aimed to provide a supportive platform for LGBTQIA+ astronomers to exchange insights, and deliberate on strategies for enhancing inclusivity within the astronomy community. Its main objective was to raise awareness among the broader astronomical community regarding the challenges encountered by LGBTQIA+ astronomers and to advocate for greater understanding and acceptance.

The meeting's success is underscored by its achievement of several key objectives. NILAM meeting sought to deepen understanding of the unique challenges faced by LGBTQ astronomers and to formulate comprehensive guidelines for both individual astronomers and institutions to foster diversity and inclusivity. Second main mission is to established a safe and nurturing environment wherein LGBTQIA+ astronomers could forge connections, share experiences, and cultivate a sense of belonging.

By spotlighting the collaborative efforts of IAU and NARIT, the symposium exemplifies a commendable endeavor to champion diversity and create a more equitable space within astronomy. Moving forward, it sets a precedent for future initiatives aimed at nurturing a welcoming and inclusive environment for all individuals within the astronomy field.

Session

EC WG Astronomy for Equity and Inclusion

3098

Improving diversity, equity and inclusion one hashtag at a time

Cheyenne Polius[1,2], Ashley Walker[1], Caprice Phillips[1]

[1]Black In Astro. [2]LUNAA Journeys

Abstract

Social media has transformed the way we connect, tearing down global barriers and fostering a sense of community through its diverse communication channels. Black In Astro, a grassroots organisation, has seen the power of this as we have reached tens of thousands of people from just one social media hashtag. Black In Astro was created in 2020 after widespread news of police violence in the United States. It was a simple yet powerful social media campaign kicked off by African-American Planetary Scientist, Ashley Walker, that encouraged Black people in Astronomy to share their experiences using the hashtag #BlackInAstro. Since then, it has grown into an organisation that supports Black people in space-related fields and amplifies the voices of up and coming space professionals all over the world. Social media has been the primary tool for sharing our events, news and avenues for tangible support and has helped Black In Astro gain recognition from big names like NASA, Nature and the Royal Astronomical Society. This talk will focus on how social media can be a powerful tool for the improvement of diversity and inclusion in astronomy and will dive into how Black In Astro has leveraged this tool to reach countries that may not have been reached otherwise. Our annual week of virtual activities, #BlackSpaceWeek, also powered by social media, showcases work from Black researchers and professionals in our global community. This talk will also highlight some of the amazing discoveries of our members including from Europe, Africa and the Caribbean.

Session

EC WG Astronomy for Equity and Inclusion

3125

Utilizing the Science of Science Communication to Engage Vulnerable Audiences in Astronomy: Insights from the Soha Astronomy Volunteer Network

Fatemeh Bonyadi

Allameh Tabtab'i University / UNESCO chair on science communication

Abstract

In the Soha Astronomy Volunteer Network, we employ two science communication frameworks: 1) the classic Audience Pyramid in science communication, and 2) the Engagement Model for public involvement in science.

Audience Pyramid: Our science communication employs a four-tier Audience Pyramid. The base represents the lay public, followed by the interested public, the involved public, and finally, scientists.

Engagement Model: Over time, the Participation model has proven most effective in engaging individuals in science. We utilize this model to elevate individuals within the Audience Pyramid.

We encourage non-specialist public participation in hosting astronomy night events for vulnrble communities. Collaboration with individuals from various backgrounds, such as artists, athletes, and celebrities, enhances the engagement of vulnrable communities in these events. Our approach targets communities with special needs, fostering a sense of community and inclusion.

Our experience has shown that involving the lay public in a scientific event that incorporates play and emotional engagement can enhance community involvement and raise their awareness and serve as a tool to elevate them within the Audience Pyramid, turning them into interested audiences.

We collaborate with psychologists to tailor events to the specific needs of the target audience. Finally, we invite participants (both lay public who assist in event organization and target audience) to share three significant insights about the event. These insights may include newfound knowledge about astronomy or specific needs identified within the target community, which can be addressed and adjusted. Feedbacks from the participants indicates that both groups become interested in astronomy.

Session

EC WG Astronomy for Equity and Inclusion

3175

AstroAccess: Advancing Disability Inclusion in Space Exploration

Anna Voelker[1], Caitlin O'Brien[2]

[1]SciAccess, Inc.. [2]SciAccess, Inc. | The Ohio State University

Abstract

AstroAccess is a non-profit initiative dedicated to making space exploration accessible to all people. AstroAccess conducts zero-gravity missions in which Disabled scientists, veterans, students, athletes, and artists (the "AstroAccess Ambassadors") from around the world perform demonstrations onboard parabolic flights, as the first step in a progression toward flying a diverse range of people to space. Since its founding in 2021, AstroAccess Ambassadors have participated in six zero-gravity flights and three analog astronaut missions. Ambassadors experience weightlessness, test microgravity accessibility tools, and investigate how physical environments onboard spacecraft can be designed so that all astronauts, regardless of disability on Earth, can work and thrive in space. AstroAccess Ambassadors use their platform to act as public advocates for global disability access in astronomy and the STEM fields.

This session will share findings from AstroAccess Flight 2, which took place in Houston in December 2022. Conclusions will be shared from technologies tested onboard the zero-gravity mission, including tactile graphics for non-visual navigation, microgravity sign language comprehension, mobility demonstrations, and many more. AstroAccess Ambassadors have also conducted astronomy research in zero-gravity to demonstrate that people with disabilities can successfully perform astronomical and scientific research in space environments. This session will showcase essential accessibility considerations and share best practices on inclusive space station design, calling for a change in industry standards.

Participants will gain a novel perspective on space accessibility and universal design, which are intended to enrich space research and pave the way for a more equitable future, on earth and beyond it.

Session

EC WG Astronomy for Equity and Inclusion

Final category: EC WG Dark and Quiet Sky Protection

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ASTROx Dark Sky: Integrating Astronomy Education for Sustainable Practices and Community Engagement

Exodus Chun-Long Sit

President of Starrix Hong Kong. National Astronomy Education Coordinator (Chair of Hong Kong, China). Co-National Outreach Coordinator (Hong Kong, China)

Abstract

The field of astronomy education has recognized the pressing need to incorporate sustainability practices into classroom learning, going beyond traditional teaching methods. This presentation explores the ASTROx initiative, an interdisciplinary approach that merges astronomy with other academic subjects, aligning with the Sustainable Development Goals. Highlighting a student-led social innovation project, this talk showcases how dark-sky advocacy and science communication can address real-life challenges within communities. The students employed a range of innovative techniques, including outdoor classrooms, design thinking lessons, and hands-on experiences to raise awareness about the detrimental effects of urban light pollution. By integrating astronomy education into interactive classrooms, students not only grasp the fundamental concepts of the universe but also actively contribute to sustainable practices and community engagement. This presentation offers insights into the effective integration of astronomy education, empowering students to become informed advocates for dark-sky preservation and environmental stewardship.

Session

EC WG Dark and Quiet Sky Protection

553

Latest developments at the Aoraki Mackenzie International Dark Sky Reserve

Prof John Hearnshaw

University of Canterbury, Christchurch, NZ. Aoraki Mackenzie International Dark Sky Reserve board.

Abstract

In 2012 the Aoraki Mackenzie International Dark Sky Reserve became the first dark-sky reserve to receive DarkSky accreditation in the southern hemisphere. At 4367 sq km, it is one of the larger reserves in the world. The reserve encircles Mt John Observatory, NZ's premier optical observatory near Lake Tekapo. A very active astrotourism programme operates in the reserve, with at least nine companies offering guided dark-sky tours.

In 2022 the local Mackenzie District Council replaced all of the streetlights (just over 1000) in the district with 2200 K LEDs, including those on lampposts as well as lower bollards. A proposal supported by the District Council to extend the reserve eastwards to include the small town of Fairlie is being pursued in 2024. If approved, the area will increase to 7339 sq km, which will be the second largest reserve world-wide.

A dark-sky Starlight Conference is planned in the reserve in October 2024 (https://starlightconference.org.nz), which will enhance the reserve's reputation as one of the preeminent dark-sky reserves globally. An earlier Starlight Conference in 2019 led to the establishment of the Dark-Sky Network NZ (https://dsnnz.org), an organization giving support to about two dozen existing (currently six) and aspiring (about 20) dark-sky communities in New Zealand.

In January 2024 a petition was made to the NZ Parliament to introduce national legislation to protect the whole of New Zealand from light pollution.

Session

EC WG Dark and Quiet Sky Protection

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Qualification of the Oukaimeden Observatory site: Processing and analysis of data measured by TESS and CoSQM photometers.Y.Elaima[1], Z.Benkhaldoun[1], H.Ait Abdelaali[1], A.Boskri[11]Laboratory of High Energy Physics and Astrophysics, Department of Physics, Cadi Ayyad University, Semlalia Faculty of Sciences, BP 2390, Marrakech, Morocco

Youness Elaima[1], Zouhair Benkhaldoun[1,2], Hamza Ait Abdelaali[1], Abdelkarim Boskri[1]

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Abstract

Abstract :
We are interested in studying the site of the observatory of oukaimeden. At in recent years, the Oukaimeden observatory has hosted several instruments to measure the quality of the sky in terms of astronomical observations. Among these instruments, we can mention the SQM (Sky Quality Meter), widely used to evaluate night sky brightness NSB from the bottom of the sky and thus estimate the level of light pollution above Oukaimeden. In addition, there are other interconnected instruments, such as the TESS photometer of the Star4All consortium, also insturment CoSQM which was recently install through a collaboration with the University of Sherbrooke, Canada.

This is part of the Atlas Dark Sky project, aimed at studying the evolution of light pollution in the Toubkal Dark Sky Reserve precisely the geographical center of reserve "Oukaimeden Observatory".

Keywords : SQM - TESS - CoSQM - NSB- OUCA-ADS

Session

EC WG Dark and Quiet Sky Protection

1160

Night Sky Brightness and the Solar 10.7cm flux

Dr John Barentine[1,2], Dr Emilio Falco[2], Dr Albert Grauer[3,4], Dr Hannes Gröller[3]

[1]Dark Sky Consulting, LLC. [2]Southern Chapter of DarkSky International. [3]Catalina Sky Survey, University of Arizona. [4]DarkSky International

Abstract

Mitigating the impact of artificial light at night (ALAN) on observatory operations requires accurate knowledge of night sky brightness (NSB) over long time scales. Such data are helpful not only to observatories, but also to the public at large.

We present an analysis of NSB over 4-6 years at four sites with differing night sky quality: Chiricahua National Monument, Arizona; Cosmic Campground, New Mexico; Prineville Reservoir State Park, Oregon; and Mount Lemmon, Arizona. The first three sites are far from population centers; Mt. Lemmon is near Tucson, with ~1000000 inhabitants in its metropolitan area. Time-series data were acquired at the zenith with Unihedron Sky Quality Meters (SQMs).

We developed Python software to analyze SQM data. Factors that contribute to the natural component of NSB vary seasonally but are poorly characterized. Our analysis aims to characterize these factors. Cyclical and stochastic variations in solar flux (SF) are a significant influence. The SF started rising at the beginning of the current Solar Cycle 25 in the second quarter of 2020 and continued rising through February 2024, when it reached twice the level in 2020. We find that as the SF doubled, NSB also rose but at a more modest rate of about 20%.

Continued monitoring is necessary to further confirm our conclusions and to follow the expected decrease in the SF by 2025. We plan to continue this effort and extend it to analyze the measurements that we will obtain with a 30-site SQM network spread over Southern Arizona.

Session

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1170

New Approach Reducing Skyglow on Astronomical Images in Regions Affected by Heavy Advertising and Indoor Lighting Pollution

Mr Vladimir Pashkovsky[1], Mr Stanislav Karpikov[1], Dr Nicolai Shatsky[2]

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Abstract

Protecting the dark sky through the installation of full-cutoff outdoor lighting is approaching the limit of its effectiveness. Recent research findings indicate that a significant portion of light sources, including facade lighting and side emissions from indoor lighting, cannot be adequately restricted or mitigated using full cutoff. Moreover, the annual increase in light pollution exceeds previous estimates by several folds, reaching 9.6%. Addressing light pollution under such circumstances requires innovative approaches.

In this study, we analyze the requirements and discuss the possibilities and limitations of a fundamentally new engineering solution aimed at mitigating all types of lighting sources. It achieves a reduction in light pollution within the telescopes' field of view by up to 2 magnitudes, nearly completely neutralizing the outdoor lighting glare produced by a city with a population of 100,000 located 30 km away from the observatory.

The solution comprises an integrated system wherein lighting sources, such as outdoor fixtures, outdoor advertising, facade and indoor lighting operate synchronously in pulse mode at frequencies of 150 Hz and higher. It has been demonstrated that these pulsations are imperceptible to the human eye and do not have hidden effects on the nervous system. The second component is an active shutter module installed on the telescope, which operates synchronously with the lighting sources in anti-phase with the light pulses, blocking the exposure. Digital synchronization ensures accuracy and manages the phase to accommodate delays and reflections. The presented method was tested under operational conditions by StealthTransit Laboratories.

Session

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1232

Radio Frequency Interference at the ALMA Observatory

Dr. Giorgio Siringo[1,2], Dr. Sean Dougherty[1]

[1]Atacama Large Millimeter/submillimeter Array - ALMA. [2]European Southern Observatory - ESO

Abstract

We present work done by the Joint ALMA Observatory Spectrum Management Office (JSMO) preventing/mitigating ground- and space-based RFI at ALMA. ALMA's spectrum extends above 100 GHz, a characteristic that provides natural RFI protection, but makes monitoring/identification of RFI very difficult. The ALMA site on the Chajnantor altiplano is surrounded by a number of other observatories, and there is risk of interference due to RF emissions from these other observatories (and vice-versa). One task of the JSMO is to coordinate operations that may interfere with other observatories, e.g. holography transmitters for surface assessment or the ALMA artificial calibration source. The cloud-profiling radar (CPR) onboard the CloudSat satellite has been a source of concern because it has sufficient power to damage an ALMA receiver in case of direct beam-to-beam alignment between the CPR and an ALMA antenna. CloudSat was recently decommissioned, finally eliminating this concern. However, we learned a lesson: it would have been much more efficient if the satellite operator had turned off emissions for the few seconds it was passing over the observatory site, rather than the observatory being forced to mitigate the risk, a task which produced a significant loss of ALMA observing time. With RFI from satellites an ever increasing challenge for RFI management strategies due to the growing number of satellite constellations, the JSMO is planning to use ALMA to track satellites and measure the emissions to better understand the challenge presented by satellite constellations.

Session

EC WG Dark and Quiet Sky Protection

1382

Raising Dark Sky tourism and Light pollution awareness : The Amazing Dark Sky in Thailand

Matipon Tangmatitham

National Astronomical Research Institute of Thailand (NARIT). International Training Center in Astronomy under the auspices of UNESCO (ITCA)

Abstract

Since 2021, over 110 sites in Thailand have been designated as dark sky areas by the National Astronomical Research Institute of Thailand (NARIT). In addition to the focus on preserving pristine and pollution-free sky, Amazing Dark Sky in Thailand project also focus on the raising awareness on the issue of light pollution and promoting “Dark Sky tourism” as an engine for sustainable socio-economic development. To support these goals NARIT also launches other programs aimed to compliment these effort. The "astro guide" training program seek to train, evaluate, and certify astronomy outreach personnels that will operate in these dark sky areas that is vital to the sustainability of the tourism of the dark sky preserves. In order to promote the dark sky projects and raising awareness in the public sector, "Dark Sky Star Party" are held annually receiving around 2,000-3,000 visitors. However, the most important milestone of all, is the spinoff event “Starry Night Over Bangkok” where a star party is held in the middle of sprawling Thailand’s capital city in order to promote awareness in astronomy and astrotourism. In a single night, a total of 12,000 participants attended the event, making this single event the largest stargazing event ever been recorded. This is the real testament to the success of the the program in promoting appreciation in astronomy in the public sector.

Session

EC WG Dark and Quiet Sky Protection

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Phatima ka ti Nheleti (Shine of the stars)

Amirah Izidine, Nicholas Romero, Cristóbal Castro

Universidad de Santiago de Chile

Abstract

Human settlements and cities have expanded in recent years, causing environmental issues such as light pollution. This problem is often overlooked, yet has harmful effects on both our environment and circadian rhythm. Our project, "Phatima ka ti Nyeleti" (Shine of the Stars in changana), aims to address this issue by providing better public space illumination while reducing the negative impact of light pollution. Our innovative luminary, composed of recyclable materials and powered by renewable energy sources, will provide lighting to rural areas while preserving the night sky and the environment. By reducing electricity usage and costs, we believe we can significantly improve the situation. The name of our project reflects our dedication to preserving the night sky while illuminating the world.

According to the International Energy Agency's 2021 study, approximately 600 million people in Africa lack access to electricity, with only 44% of Mozambique's population having electricity. Our solution will benefit Africans by addressing their needs, reducing these percentages, and creating job opportunities throughout the design and renewable energy development process.

In conclusion, our project has the potential to pioneer an eco-friendly and modern approach to illuminating present and future settlements while minimizing the damaging impact of light pollution.

Session

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1552

FreeDSM: an open software and hardware dark sky meter based on IoT technologies for wide monitoring of light pollution

Carlos Dafonte[1,2], Ana Ulla-Miguel[3,4], Minia Manteiga[2,5], Eduard Masana[6,7,8]

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Abstract

FreeDSM (Free Dark Sky Meter) is an IoT photometer for citizen light pollution monitoring, developed in the context of the Gaia4Sustainability project (https://gaia4sustainability.eu/language/en/gaia-4-sustainability/), intended to develop a robust, reliable, and straightforward framework for estimating the night sky brightness. Among environmental problems, light pollution is among those with a fastest growing in recent times, particularly in highly populated areas and developed countries. This is a global issue that very seriously affects the natural day-night life cycle and has a deep impact on the well-being of many living species, including humans, even contributing to fossil fuel combustion and the aggravation of climate change.

FreeDSM is based on an ESP32 microcontroller, which is a cheap and low-consumption component that integrates different sensors. The ESP32 is powered by Tasmota, a well-known open software home assistant tool that integrates basic logic for many commercial sensors. Interestingly, it has a rechargeable battery, which allows different device use ways. Our group has developed a low cost, easy to handle, open software and hardware solution with the aim to empower individuals to take action to reduce the amount of unnecessary outdoor lighting, spreading the word on night sky protection and popular access to astronomy at the same time.

The project is now in a commercial feasibility study phase and we here intend to summarise its current status, achievements and future plans. Either from homes, schools, parks or hospital roofs, advantageous possibilities are to be offered to NGOs, administrations, stakeholders and individuals for easy and cheap dark sky surveyance.

Session

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1653

Dark Sky Successes in Southwest Texas

Dr Teznie Pugh[1,2], Stephen Hummel[1]

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Abstract

In March 2022, McDonald Observatory partnered with four counties, six municipalities, a National Park, multiple State Parks, the Nature Conservancy in Texas, and two Mexican land protection agencies to found the Greater Big Bend International Dark Skies Reserve. The Reserve encompasses almost 15,000 square miles (24,140 square kilometers) in southwest Texas and northern Mexico.

The Reserve application represented a formalization of decades of effort in the region. In the years since the certification by DarkSky International we have continued these efforts resulting in two other Texas counties adopting lighting ordinances that meet the standards outlined in the Reserve's Lighting Management Plan and in the Texas Department of Transportation adopting new lighting standards in the region.

Together the 6 counties now covered by updated ordinances since 2020 total 24,291 square miles, or 39,092 square kilometers, with a total population of 50,431 (2021 census). Two of these counties contain a substantial number of oil and gas installations. Here we discuss our trials and successes in getting the ordinances in place and in educating the regional residents and operators about the ordinances, and discuss the breath of the collaboration involved

Session

EC WG Dark and Quiet Sky Protection

1684

Light pollution, a complex real-world problem to be tackled through an interdisciplinary approach

Matthieu Renaud[1,2], Samuel Challéat[3], Kévin Barré[4], Rémi Bénos[5], Christian Brouat[6], Mathieu Delsaut[6], Nicolas Farrugia[7], Hélène Foglar[8], Magalie Franchomme[9], Jérémy Froidevaux[10], Laurent Godet[11], Adrien Guetté[12], David Loose[8], Marion Maisonobe[13], Léa Mariton[14], Johann Michalczak[15], Johan Milian[16], Béatrice Morel[6], Sylvain Morvan[3], Charles Ronzani[17], Léa Tardieu[18]

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Abstract

The problems of light pollution and the unprecedented issues raised by its management in the many territories currently concerned with the preservation of the nocturnal environment are complex real-world problems. This complexity and the need to grasp these issues in their entirety are now forcing researchers to go beyond traditional disciplinary approaches to truly interdisciplinary studies at the interface between the sciences of the Universe, the environmental sciences and the social sciences. In order to organize this production of interdisciplinary knowledge and encourage its transfer to territorial action, the French National Center for Scientific Research (CNRS) has created in 2021 the Nocturnal Environment Observatory (NEO — https://observatoire-environnement-nocturne.cnrs.fr/en/). Through its research programs, actions and partnerships with various territories, the Nocturnal Environment Observatory brings together a large community of scientists from different disciplines and institutions (social and natural sciences, sciences of the Universe, engineering and environmental physics), experts from different and complementary professional fields, as well as agents at the service of protected area management structures and territorial projects. Through the case study of Reunion island — a densely inhabited area under severe ecological constraints — we will present the objectives, the analytical framework, the tools and the methods of the NEO. We will show the concrete contributions to territorial action of a radically interdisciplinary research on the nocturnal environment, a socio-ecosystemic object built on the foundations of the Dark-sky movement, and therefore owes much to the work of the astronomical community since the second half of the 20th century.

Session

EC WG Dark and Quiet Sky Protection

1692

Radio Frequency Management at the SKA Observatory

Mr Federico Di Vruno, Mr Treasure Nkawu, Dr. Paul Van der Merve, Dr. Antheun Botha

SKA Observatory

Abstract

Radio frequency interference is one of the most critical aspects for a radio telescope. This can be divided into two large groups: Internal and External RFI. Internal RFI is considered all the radio noise produced by the telescope electronics (drives, high speed digitization, data transport, etc) and the activities we need to do on site (construction, maintenance, visits, etc). External RFI is defined as all the radio signals that come from sources outside of the control of the observatory. The SKAO takes a wholistic approach to RFI management, looking carefully on our internal RFI generation trough the EMC/RFI group and to the external RFI through the Spectrum Management group.

This presentation will discuss how we have implemented this approach, successes, challenges and current status.

Session

EC WG Dark and Quiet Sky Protection

1738

KID: EU Interreg North-Sea Light Pollution Monitoring

Jake Noel-Storr

University of Groningen

Abstract

The aim of the KID project was to develop methods for a long-term measurement network of sky brightness in the tri-lateral Wadden Sea region. For this purpose two pilot places have been chosen in each of the three participating countries (NL,GE, DK) representing a dark and light polluted sky. Additionally a measurement platform has been set up on a mobile observatory offering easy comparison of different detectors under varying skies. In the project so far we tested 13 different detectors ranging from single channel devices (SQM, TESS, TASS, SG-WAS), RGB- or b/w-camera based systems (SQC, RP, Ricoh-Theta, Oculus), meteor camera systems (Allsky7, Fripon) and pure spectral systems (Alpy 600, LHires-II, RAMSES). For non weather-proof detectors a special multi-purpose housing was developed. For all camera based systems a RaspberryPi based platform for image acquisition, housekeeping-data, remote access via 4G standard as well as analysis and data transfer has been set-up. We present our results to date here.

Session

EC WG Dark and Quiet Sky Protection

1798

Searching For Potential Locations For Astronomers To Establish Dark Sky Camps In Iran

Mr Matin Najarzadeh[1], Mrs Sahar Momeni behjatabadi[2]

[1]University of tehran,iran. [2]Researcher,tehran,iran

Abstract

The purpose of this research is to identify prospective locations for semi-professional and amateur dark sky camps in Iran. This study employs a descriptive research design that gathers data in the field through application. Local experts, tourist specialists, and amateur astronomers made up the research's statistical population.

In this study, 25 factors in 8 recommended regions in Iran for semi-professional and amateur sky observation have been examined and compared using questionnaires and interviews. This allows one to determine the optimal locations for setting up appropriate facilities and constructing a dark sky camp.

It was both amateur and semi-professional. The height above the open water's surface, the sky's upper bound, seismicity, Among the factors measured in this research are the quantity of dust on the horizon, the level

of light pollution, the number of clear and cloudless nights throughout the year, access roads, and security of the study region. The project aims to explore the following eight locations: Star Valley in Qeshm Island in Hormozgan Province, Viligia Peak in Jasb Village in Markazi Province, and Seghale Desert in Semnan Province. Based on the findings of this study, these three locations can be recommended as good sites for the development of specialist infrastructure to cater to astronomy enthusiasts traveling there.

Session

EC WG Dark and Quiet Sky Protection

1874

The effect on the dark skies from LED lighting from towns and cities both local and beyond the horizon in the UK Malvern Hills area of outstanding natural beauty.

Dr Christopher Baddiley

BAA CfDS

Abstract

This presentation summarises the work and conclusions of a long-running dark-sky measurement project at the author's UK rural-located observatory, to study the effects of the introduction of LED outside lighting and from changes in the weather. The monitoring uses a mast-mounted sky quality meter (SQM) recording at two-minute intervals every night, and a fisheye lens camera recording on the darkest nights, now with over 10 years of data. The SQM is tilted from vertical slightly north to avoid the Milky Way.

Conclusions: the clear night sky brightness smoothly decreases during the night until hours before dawn. Histograms show a reduction in the number of dark nights over the period and the frequency of reaching the darkest values, attributed to changes in the weather. The colour change from orange to white from LED lighting is clearly shown in the camera images, and sky domes above the horizon can be seen from identifiable cities up to 150 kilometres away, also shown by plotting isophote contours. The darkest zenith brightness remains the same over years, (magnitude 21.1 mag/arcsec2 at the observatory location), but the horizon brightness has increased greatly. The background light-pollution contribution across the sky follows a simple empirical curve.

LEDs are directional if properly mounted with full horizontal cut-off, but the blue content causes far more scattering in the sky, together with increased brightness and reflection from the ground. This unfunded voluntary work has been used to advise policy makers, including the highways agency and the institute of lighting professionals.

Session

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1883

Lunar Science and Policy – the IAU Working Group on Astronomy on the Moon

Richard Green

University of Arizona. IAU CPS

Abstract

The Moon provides a unique platform in the inner Solar System for three types of astronomical observations: low-frequency radio in the shielded zone on the far side; infrared observations, particularly of deviations from the blackbody of the Cosmic Microwave Background and of exoplanet atmospheres with near-continuous orbital coverage; and detection of gravitational waves on a low-seismicity stable platform. Operations in suitable sites are incompatible with many other planned activities on the Moon, such as landings and launches or extraction of water ice and minerals. The IAU Working Group consists of mission science advocates/PIs, spectrum managers and policy/space law experts. The near-term objectives are to identify and prioritize the sites required for each type of mission, to translate the good intentions of protecting the shielded zone from radio-frequency interference into practical implementations, and to create an internationally agreed system of coordination and protection of sites for specific uses. The IAU is actively engaged with the ITU, UN COPUOS and other scientific organizations to provide a complementary and unified approach to protect options for astronomy.

Session

EC WG Dark and Quiet Sky Protection

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The effect of the airglow and the solar activity on the night sky brightness measurements

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Abstract

This work analyses how airglow and solar activity influence the Night Sky Brightness (NSB) measurements and the study of Artificial Light At Night (ALAN). We study data measured by TESS, SQM and FreeDSM photometers and calculate the NSB of different locations using the spectral response of the instruments and spectra measured by the SAND spectrometer.

Two of the most widely used photometers, TESS and SQM, present a very different spectral response at wavelengths with high airglow emission values, which may lead to an incorrect measurement of ALAN due to natural contributions. We analyze spectra from dark and urban locations with the spectral response of these two photometers and for the new FreeDSM photometer, focusing on Parc Astronomic del Montsec (Lleida, Spain), as it is the only location where we have data for all the instruments.

We study the effect of adding a factor of airglow radiance to dark spectra to see how it influences sky brightness measurements. We subtract the airglow contribution of the spectra measured at dark locations and then add different contributions of the airglow spectra provided by the Cerro Paranal Advanced Sky Model (Deverchère et al. 2022, Jones et al. 2013).

In addition, we are trying to correlate the intensity of airglow on Earth with solar activity through TESS and SQM measurements. We compare the time evolution of the data with the time evolution of the solar flux. In most cases, TESS and SQM data present a decrease in brightness during the period of minimum solar activity.

Session

EC WG Dark and Quiet Sky Protection

2075

Dark Skies Protection at NSF's NOIRLab Observatory Sites in Chile

Dr. Constance Walker[1,2], Dr. Guillermo Damke[3,2], Dr. Rodolfo Angeloni[4,2], Mr. Javier Sayago[5,2]

[1]IAU CPS. [2]NSF's NOIRLab. [3]Cerro Tololo Inter-American Observatory. [4]Gemini Observatory.
[5]Oficina de Protección de la Calidad del Cielo del Norte de Chile

Abstract

Since the introduction of urban illumination more than a century ago, the visibility of the pristine starry night sky has been gradually fading.
A next step in the protection of the night sky for NSF's NOIRLab observatory sites in Chile was to form an Office of Observatory Site Protection (OOSP).

The OOSP has a few key areas of focus on which the Dark Skies Protection (DSP) Research Group works. During the last few years, the DSP Group, alongside the Office for the Protection of the Skies of Chile (OPCC), has been working with communities near the observatories to light responsibly, to reduce the sky glow seen from Cerro Pachon and Cerro Tololo, and improve the effectiveness of the lights in the communities and incorporate energy savings. The OPCC has 20 years of experience working with the municipalities on lighting laws and lighting evaluations and replacement recommendations and is a partnership between major optical observatories in Chile.

The DSP group also provides, at consistent intervals, quantitative measurements of the night sky brightness at NOIRLab locations. Led by OPCC, the group has completed an external lighting inventory at NOIRLab locations. Led by the University of La Serena, the group is involved in the installation of a regional network of light pollution measuring devices. They have also engaged the public in light pollution awareness activities.

During our presentation we will discuss our current and future efforts to monitor and minimize light pollution around NOIRLab facilities, so their full scientific potential can be realized.

Session

EC WG Dark and Quiet Sky Protection

2119

The synergy between astrotourism, dark sky conservation and astronomical outreach

Ms Nalayini Davies[1,2], Mr Ruskin Hartley[1]

[1]DarkSky International. [2]Royal Astronomical Society of New Zealand

Abstract

Astrotourism and its attendant economic benefits are growing rapidly. These are made possible by the presence of dark sky places and the ability to deliver astronomical outreach. To be sustainable then, astrotourism should support ongoing dark sky conservation and the continued development of astronomical outreach. The key findings from a recent DarkSky International survey of dark sky places worldwide, and the emerging principles of responsible astrotourism, will be shared to raise awareness and to obtain feedback.

We present findings from a recent survey of 209 international dark sky places, which reveals a rapid growth in astrotourism, that delivers an escape from urban nighttime glare and the breathtaking experience of a pristine natural night sky. Dark sky destinations are found to offer unique opportunities for private economic development, thereby drawing attention to the potential for stargazing to be a driver of sustainable growth in remote and often overlooked regions. The survey highlights the increasing interest and investment in such dark sky places. It also provides insights into the economic benefits that astrotourism operating in dark sky places can bring to local communities.

The talk will explore the evolving principles of responsible astrotourism, with economic benefits delivered whilst the environment is preserved, indigenous cultures and local society are respected, there is compliance with local regulations, and light is used responsibly.

Session

EC WG Dark and Quiet Sky Protection

2318

Involvement of Radio Astronomy in the Regulation of Lunar Communication

Dr. Gyula I. G. Jozsa

Max-Planck-Institut für Radioastronomie

Abstract

Astronomers brought Moon missions with the aim to conduct radio astronomical experiments to consideration at the International Telecommunication Union (ITU) at a time when they were still a vision. As a result, radio astronomy enjoys special protection in a volume shielded from radio services on and around Earth. Today, the interest in the Moon in the context of space exploration, in research and also commercial, increases. Moon missions with the potential of bringing radio astronomy to the Moon are no longer fiction but reality. But also other missions are planned and the required increased communication make an update of the regulations necessary. Astronomy should not miss to contribute to this process, in order to ensure that future astronomy protection on the Moon aligns with its scientific needs. I will discuss the regulatory processes at the ITU level and give a brief overview of activities to protect radio astronomy in the Shielded Zone of the Moon.

Session

EC WG Dark and Quiet Sky Protection

2395

AAS+IAU = D&QS: National and International Activities to Protect Dark and Quiet Skies by the AAS Committee to Protect Astronomy and the Space Environment

James Lowenthal

Smith College

Abstract

Spurred by the advent of large low-Earth-orbit satellite constellations and building on our history of combatting ground-based light pollution, radio interference, and space debris, the American Astronomical Society's Committee for the Protection of Astronomy and the Space Environment (COMPASSE) has experienced a significant burst of growth and activity in the last five years. Its vision is a Society whose members constitute a visible presence and an effective voice in the effort to protect dark and quiet skies and the integrity of the space environment for the future of astronomy and for humanity. COMPASSE members are working hard to educate astronomers, industry leaders, elected officials, and the public about the critical importance of protecting the sky for astronomy, human health and cultural heritage, and the environment, and to defend space as part of that environment. This presentation will summarize those activities and plans for the near future. We are active in promoting sensible regulation at the local, state, national, and UN levels. We have briefed federal agencies and offices from the White House to Congress to the Departments of State, Commerce and Defense. We have developed outreach and educational programs and materials. We collaborate with an ever-broader circle of partners with mutual interests in preserving dark and quiet skies, and we aim to forge closer connections and build effective partnerships with our international friends and colleagues through the IAU. The sky urgently needs our help, and we are eager to work with the growing global movement to protect it.

Session

EC WG Dark and Quiet Sky Protection

2465

Preserving Dark Skies: The Hanle Dark Sky Reserve Initiative

Mr Dorje Angchuk[1], Prof Niruj Ramanujam[2], Mr. Stanzin Norlha[3], Mr Nawang Dorji[4], Mr Sonam Jorphail[2], Mr. Tsewang Gyalson[2], Mr. Tsewang Stanzin[2], Prof Annapurni Subramaniam[2]

[1]Indian Institute of Astrophysics. [2]Indian Institute of Astrophysics, India. [3]Bhabha Atomic Research Center, India. [4]Tata Institute of Fundamental Reserch, India

Abstract

The exceptional quality of night sky attracted the creation of the Indian Astronomical Observatory in Hanle around two decades ago. The rise of traditional tourism and local development activities contributed to an increase in light pollution. In response to this challenges, Hanle Dark Sky Reserve(HDSR) was conceived as a sustainable model to conserve the pristine night sky while also leveraging it to benefit local communities. The uniqueness of HDSR is that it operates through a collaborative framework involving professional astronomer, local communities, and strong government support.

Central to HDSR's strategy is the implementation of a Light Management Plan (providing warm bulbs, lamp shades and curtains to all the household). The local government is also investing in astro-tourism infrastructure including mini planetarium, transparent domes and entry gates to guide visitors.

Community engagement is emphasized to foster a sense of ownership of the night sky, with local villagers being provided and trained as Astronomy Ambassadors to showcase the night sky's beauty to the tourist.

We are also constantly monitoring light pollution levels with SQM and DSLR camera to access the impact of artificial light. Annual star parties at HDSR foster interaction between Astronomy Ambassadors and amateur astronomer raising awareness about dark sky conservation.

Overall HDSR is an innovative campaign raising public awareness nationwide about designated dark skies areas, sky watching and importance of preserving dark skies for ecological, cultural and scientific reasons. It has spurred the development of astro-tourism, guided tours, and immersive experiences of night sky.

Session

EC WG Dark and Quiet Sky Protection

2547

Progress in Citizen Science through the Globe at Night and the Glowatch in combatting Light Pollution

PhD Daniela Gonzalez[1], PhD Constance Walker[2,3]

[1]Skies of Chile Foundation. [2]NSF NOIRLab. [3]IAU CPS

Abstract

Citizen science initiatives have emerged as indispensable tools in the current academic discourse around light pollution mitigation, exemplified by the 18-year-old Globe at Night project. Globe at Night is an international citizen science campaign involving citizen scientists who measure and submit observations of night sky brightness. This helps to create a global map of light pollution, highlighting the proliferation of this problem, and underlining the need for innovative prevention and mitigation strategies.

In response to this demand, Glowatch emerges as a citizen science platform that enables citizens to systematically identify and document sources of light pollution. The involvement of diverse communities not only reinforces specific control measures, but also advocates for improved outdoor lighting practices, especially relevant in astronomical regions such as Chile, crucial for scientific observation.

The effectiveness of citizen science tools such as Globe at Night and Glowatch depends on accessibility across all demographic spectrums. To ensure participation rates and maintain the integrity of the data collected, efforts must prioritize inclusion and address digital barriers, facilitating scientific engagement and amplifying the impact of data acquisition.

By building on initiatives such as Globe at Night and Glowatch, the academic community deepens the global understanding of light pollution and its implications. Increased awareness, particularly in dark sky preservation regions, underscores the need for collaborative action. Collectively, our goal remains to mitigate the effects of light pollution, thereby safeguarding dark skies for posterity and strengthening a shared commitment to the preservation of this heritage.

Session

EC WG Dark and Quiet Sky Protection

2559

Innovative Strategies for Astronomical Conservation: A Dark Sky Preservation Initiative in Kenya

Miss Carol Nyaguthii

DarkSky Kenya

Abstract

The Kenyan Chapter of DarkSky focuses on the preservation of natural darkness in the Kenyan context, with an approach combining community engagement and policy advocacy. Initiating the plan, community involvement through citizen science for light pollution mapping aims to cultivate awareness at the grassroots level. Concurrently, International Dark Sky Places designations, mapping of the region for light pollution measurements, and advocacy for robust policies underscore our commitment to aligning conservation efforts with sustainability, development goals, and human well-being.

Furthermore, by integrating light pollution measurements into our comprehensive approach, we not only address the immediate concerns of community engagement and policy advocacy but also contribute valuable data for the identification of ideal locations for astronomical observations.

A central component of our strategy involves pioneering pilot projects in outdoor lighting evaluation. The subsequent presentation of these projects, along with proposed corrective measures, to local authorities aims to establish a foundation for a sustainable implementation plan. Our focus on collaboration with lighting professionals, urban developers, and urban planners positions this initiative as a model for integrating conservation with urban development in a balanced manner.

As the first DarkSky Chapter in the region, our collaborative efforts with the Kenya Wildlife Conservation Association signify a leadership role in advocating for dark sky preservation. Furthermore, fostering a dialogue on sustainable practices aims to preserve natural darkness as a desirable outcome not only for the astronomy community but for the well-being of the entire ecosystem.

Session

EC WG Dark and Quiet Sky Protection

2573

Impact of light-pollution on the quality of San Juan skies: Towards a Law to protect and preserve the sky in San Juan, Argentina

Lic. Claudia Alamo, Nelson Ariel Rodríguez, Dr. Sergio Cellone

Complejo Astronómico El Leoncito (CASLEO), Argentina

Abstract

The goal of this project is the elaboration of a light-pollution atlas through a photographic (Sky Quality Camera, "SQC") and photometric (Sky Quality Meter, "SQM") survey in strategic areas around the professional and science outreach observatories. This will be the basis for the upgrade of the Provincial Law 5771 (sky protection), The present project is a collaboration between the El Leoncito Astronomical Complex (CASLEO, CONICET - UNLP - UNC - UNSJ), the Félix Aguilar Astronomical Observatory (OAFA, UNSJ), The Dr. Carlos Ulrrico Cesco Astronomical Station, and the Secretaries of Environment and of Science & Technology of San Juan province. Joanma Bullon (President of AstroARAs - Valencia, Spain) is the technical advisor of this project.

We present results from the initial stage of this project, consisting of the first images obtained with a camera Canon 6D Mark II equipped with a Canon Fisheye 18-55 mm lens (SQC), which span 180 degrees of the sky in the strategically selected sites.

The second instrument, an SQM, will be acquired at a second stage; it will allow us to perform quantitative measurements of the sky brightness.

In order to carry on this project, we gathered an interdisciplinary team (astronomers, technicians, outreach staff) which is working with a short, medium, and long-term planning to evaluate the evolution of light-pollution affecting the San Juan province sky.

Session

EC WG Dark and Quiet Sky Protection

2577

Stargazing from the Himalayas: NASO's Efforts in Fostering Astro-Tourism in Koshi Province of Nepal

Mr. Oshan Sharma Kattel, Ms. Manisha Dwa, Mr. Suresh Bhattarai

Nepal Astronomical Society

Abstract

Nepal boasts significant potential in astronomy, marked by its dark skies and low light pollution. For over a decade, Nepal Astronomical Society (NASO) has been playing a pivotal role in advancing the nation's astronomical landscape, concentrating on outreach, education, and research. Amidst Nepal's already thriving natural tourism industry, the minimally polluted night skies have consistently been recognized as an additional asset for the country's tourism sector.

With its continuous efforts to raise awareness about light pollution and its adverse effect on night skies, NASO has been working with ministries and local governments of Koshi Province to conduct the feasibility study of Astro-Tourism in different areas of Solukhumbu (home to Mt. Everest) and Illam districts with a motive to conserve the dark skies and establish them as the Astro-Villages. Capitalizing on the well-established tourism infrastructure, NASO aims to develop Astro-Tourism not only to safeguard dark skies but also to create employment opportunities within these communities by introducing Astro-Tourguides and promoting homestays. This paper will delve into NASO's initiatives, focusing on the collaborative efforts involving various levels of government, tourism industry, and local communities to protect night sky darkness and promote Astro-Tourism with sustainable and community-driven efforts in the Solukhumbu and Illam districts of the Koshi Province of Nepal.

Session

EC WG Dark and Quiet Sky Protection

2838

Stewardship of the Environment and Heritage of the Skiesfor Science and Humanity

Mr. Ruskin Hartley[1], Dr. Aparna Venkatesan[2]

[1]DarkSky International. [2]University of San Francisco

Abstract

In the past year, DarkSky International has spearheaded an effort, gathering a diverse, multi-disciplinary group from nine countries to establish a coalition to preserve the night sky. This initiative emphasizes the urgent need to collaborate with a broad spectrum of constituencies beyond the astronomy community to address the challenges of light pollution and satellite proliferation, which pose significant threats to human health and ecosystems, wildlife, and the natural beauty of the night sky.

The coalition's strategy centers on building a global alliance that not only involves astronomers but also engages environmentalists, policymakers, Indigenous communities, and the general public. This collaborative approach aims to create a shared commitment to the night sky as our common ancestral heritage, connecting dark sky preservation with broader concerns such as sustainable economic development, storytelling and sky traditions, advocacy and education, and equity/inclusion.

Our coalition is launching a global campaign that aims to mitigate the adverse effects of artificial light at night (ALAN) and promote responsible satellite deployment. The goals include reversing ALAN's expansion, reducing its environmental and societal impacts, and fostering equitable access to the night sky. By uniting diverse perspectives in a concerted effort, the initiative strives to amplify its message and secure meaningful, lasting achievements. This collective action aims to protect our night skies for future generations, ensuring the cosmos's wonders remain accessible to all, marking a significant step towards a brighter (yet darker) future.

Session

EC WG Dark and Quiet Sky Protection

2871

The Mauritius Radio Telescope (MRT) site: need for preservation as an Astronomical Observatory for both Radio and Optical observations.

Associate Professor (Dr) Nalini Heeralall-Issur

University of Mauritius

Abstract

The Mauritius Radio Telescope (MRT) site is situated on state land, within the Bras-D' Eau forest, in the small (1865 sq km) island of Mauritius. MRT was an Indo-Mauritian venture, developed in the 1990s, to survey the Southern Radio Sky at 150 MHz. This 2 km by 1 km T-array of helical antennas, was also equipped with a pulsar observing capability.

Although MRT is now decommissioned, the infrastructure developed at the site makes it ideally situated for astronomical observations, within the densely populated (1.3 M inhabitants) island of Mauritius. It has a good road access, an observatory building, electricity, telephone lines and internet connectivity, but with no densely inhabited areas and city lights in close proximity, RFI levels remain relatively low and one can enjoy relatively dark skies.

The site has known a general degradation over the years, mainly due to a lack of funds for hiring appropriate staff. Nevertheless, various new installations and prototypes for radio observations have been set-up, in preparation for our involvement as a partner country with South Africa for the SKA project. Occasionally open nights are held for night-sky viewing. More recently, DARA funded international research students have set-up an array of small parabolic antennas for radio observations at 1420 MHz.

However, in such a densely populated small island, explicit measures must be taken to safeguard the site so that it remains suitable for both radio and optical astronomical observations. We discuss possible avenues to ensure this in a sustainable manner.

Session

EC WG Dark and Quiet Sky Protection

2903

Investigating the Influence of Dark Sky Assessments on Environmental Strategies in 4WD Expeditions and the Development of Astro Tourism in Iran's Desert Wilderness

Mohammad Saleh Timar

Nojum Magazine

Abstract

Last Autumn, we have measured the darkness of the night sky at more than 20 locations deep within the deserts of Iran using SQM. These measurements were conducted in remote areas accessible only by specialized 4WD expeditions. The purpose of these adventurous trips was not just for measuring the darkness. They were part of a program, which helped us with budget management of our darkness measurement project and the development of astro tourism under the darkest skies of Iran's desert belt. We conducted desert expeditions, combined with astro tours in remote desert areas. This approach helped us to promote astro tourism to the Desert tourism community, who conduct adventurous 4WD tours, and creating a new trend in this sector of tourism. This combination, also provided our fellow travelers with the opportunity of learning about astronomy and observe the night sky during their free time at night. Many of these tours previously neglected the night sky due to bright lights at camp; now, participants can better appreciate the beauty of starry sky. Furthermore, these combined adventure and astro tours, familiarize participants, often politically influential, with the significance of dark skies. This is crucial as many political figures in Iran are unaware of the importance of dark skies. Additionally, by shifting camp lighting from white and to yellow, these tours reduce light pollution, benefiting desert dwellers who are less affected by the glare of artificial lights. In this presentation, I will discuss the other positive and impactful aspects of this project.

Session

EC WG Dark and Quiet Sky Protection

3009

“The quality of the night sky in Polish astronomical observatories - The ALPS monitoring network.”

Mr. Przemysław Mikołajczyk

Astronomical Institute, University of Wroclaw. Astronomical Observatory, University of Warsaw

Abstract

I will present the first results concerning the quality of the night sky in Polish astronomical observatories, such as Ostrowik Station near Warsaw or Piwnice Observatory near Toruń. All results obtained and presented come from the All-Sky Light Pollution Network operated and maintained by the University of Wrocław, Poland. I will show what techniques may be used to characterise sky brightness and its deterioration over time.

Session

EC WG Dark and Quiet Sky Protection

3202

Good Night Collective - interdisciplinary efforts to protect the dark skies in Poland

Justyna M. Olszewska[1], Przemysław J. Mikołajczyk[2,3], Dr. Karolina Dziadura[1], Michał Pawłowski[1], Krzysztof Kotysz[2], Dr. Sylwester Kołomański[2]

[1]Astronomical Observatory Institute, Faculty of Physics, A. Mickiewicz University, ul. Słoneczna 36, 60-286 Poznań, Poland. [2]Astronomical Institute, University of Wroclaw, ul. M. Kopernika 11, 51-622 Wrocław, Poland. [3]Astronomical Observatory, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warsaw, Poland

Abstract

Good Night, an interdisciplinary collective, merges astronomy and fine arts to bridge the gap between science and society. Comprising graduates in astronomy and photography, our collective emphasizes visual science communication. Our initiatives include exhibitions, workshops, and a popular science radio broadcast. Through Project Aurora Nord, we researched the aurora borealis and partnered with SOLAR, a clothing company, to create a collection featuring aurora patterns and an educational campaign on preserving dark skies. Our exhibitions, held in prestigious art and education institutions across Poland, aim to raise awareness about light pollution. Educational workshops during events like the Night of Museums and art festivals complement these exhibitions, deepening understanding of astronomical concepts and environmental issues. Our popular science radio program broadcasts astronomy content and discusses light pollution, reaching a broader audience. Good Night is committed to helping small communities combat light pollution directly. We collaborate with local initiatives, providing support and resources to reduce artificial light at night, leading to noticeable improvements in light pollution levels. The culmination of our activities is cooperation with ALPS (All-sky Light Pollution Survey). ALPS is designed to monitor light pollution by recording images and measuring the brightness of the night sky. These observations are made using automated measurement stations. We have secured funding to build two such stations in strategic locations in our hometown of Poznań, Poland: Astronomical Observatory in Chalin (Dark Sky Reserve area, Poland), outskirts of Poznań near the Morasko Nature Reserve. https://www.instagram.com/goodnight_collective/

Session

EC WG Dark and Quiet Sky Protection

Final category: EC WG Junior Members

2107

Title : Detecting Faint Radio Frequency Interference (RFI) in MeerKLASS Single Dish data

Ms Tamera Kassie

SARAO/ University of Western Cape

Abstract

MeerKLASS is a single dish HI intensity mapping survey of the MeerKAT Telescope. Probing the 21 cm signal is coupled with challenges from foregrounds and radio frequency interferences (RFI) which contaminates the data, and in turn our cosmological signal. The MeerKLASS collaboration was already able to produce a detection of the HI cosmological signal using cross-correlations with galaxy

surveys (Cunnington et al, Monthly Notices of the Royal Astronomical Society, Volume 518,

Issue 4, February 2023, Pages 6262–6272). However low-lying RFI still remains, in this talk I will be discussing the cleaning methods that I will be applying to the MeerKLASS data to remove faint RFI signatures, by removing these low lying RFI we expect to have reduced data lost due to aggressive flagging of RFI contaminates across channels to increase our S/N for an improved detection of the 21 cm signal.

Session

EC WG Junior Members

2721

The transformative potential of a Network of Networks to support Early Career Researchers within astronomy education, engagement, communication, and culture

Dr. Anica Miller-Rushing[1], Amanda Barrera[1], Kelly Blumenthal[2], Nicolas Bonne[3], Yasmin Catricheo[1], Bret Feranchak[4], Saeed Salimpour[5], Gretchen Stahlman[6], Tim Spuck[1,7], Tiffany Stone Wolbrecht[1]

[1]Associated Universities Inc.. [2]International Astronomical Union Office for Astronomy Outreach (OAO). [3]University of Portsmouth. [4]Logos Evaluation. [5]International Astronomical Union Office of Astronomy for Education (OAE). [6]Florida State University. [7]National Science Foundation

Abstract

Since the dawn of our existence, the night sky has captured our imagination and inspired humans across the globe. Today, astronomy is seen by many as a gateway to inspiring interest and learning in students and the general public and has demonstrated its ability to engage people across cultures and political borders. ASTRO ACCEL is a new initiative working to build an international network of networks (NoN) to accelerate research and research to practice in astronomy education, engagement (outreach), communications and culture. The 3-year project initially engaged 13 networks across 6 continents of our globe to explore and develop tools and techniques and build the human infrastructure necessary for a vibrant and sustainable NoN. We now seek to engage additional research and practitioner network partner institutions and individuals, including for our newly-establish Early Career Researcher (ECR) Network. This presentation will provide an overview of the project's current status, short and long-term plans, how you can get involved, and participate in the growing Early Career Researcher (ECR) network that is part of ASTRO ACCEL. ASTRO ACCEL is funded by the U.S. National Science Foundation's Office of International Science & Engineering.

Session

EC WG Junior Members

3186

Unlocking Inclusive Outreach: Connecting Minds to Science

Dr Nadeem Oozeer

South African Radio Astronomy Observatory, 2 Fir Street, Black River Park, Observatory, Cape Town 7925, South Africa. Department of Physics and Electronics, Rhodes University, PO Box 94, Grahamstown, 6140, South Africa

Abstract

The importance of outreach for organizations, particularly for emerging projects like the Square Kilometre Array (SKA), cannot be overstated. However, our current outreach methods often overlook neuro-diverse populations. True outreach aims to engage diverse minds in scientific thinking rather than promoting specific career paths. Building long-term relationships with our audience is crucial for success, fostering an understanding of how our world and universe interact. Despite the diversity within humanity, many outreach efforts fail to incorporate this diversity such as those with; visual and hearing impairment, and differently abled people. We tend to work with diverse groups individually instead as a collective body. While traditional systems target specific groups like primary and secondary schools, and the general public, even these groups can contain diverse individuals, such as those with visual impairments. In this presentation, I will discuss the importance, methods of inclusive outreach and how we can connect minds to science.

Session

EC WG Junior Members

3187

OAE, OAD, OAO Roundtable

Dr Tshiamiso Makwela[1], Dr Markus Pössel[1], Kevin Govender[2], Dr Joyful Mdhluli[2], Kelly Blumenthal[3], Camilo Delgado-Correal[4,5]

[1]IAU Office of Astronomy for Education. [2]IAU Office of Astronomy for Development. [3]IAU Office for Astronomy Outreach. [4]Francisco José de Caldas District University of Bogotá & IGAC. [5]IAU National Outreach Coordinator Colombia

Abstract

The International Astronomical Union (IAU) is the largest international association of professional astronomers, with over 12000 individual members representing more than 85 countries. More than just a centrepiece for academic research in astronomy, the IAU hosts Offices and Centres that carry out its mission and vision. In this panel, we will hear from representatives of three of the IAU Offices: the Office of Astronomy for Education (OAE), the Office of Astronomy for Development (OAD) and the Office of Astronomy Outreach (OAO). These Offices work synchronously, recognising the important overlap between their focus areas through the work of the OAE National Astronomy Education Coordinators (NAEC), OAE Nodes and OAE Centers, Regional and Language Offices of Astronomy for Development (ROADs and LOADs) and the IAU OAO National Outreach Coordinators (NOCs). Through the IAU's vibrant and diverse network of networks, the Offices work together to promote the uptake of astronomy in schools, empower learners of all ages with critical thinking, and leverage the power of astronomy to inspire people to imagine a different – or another – world. During this session, representatives of these Offices will discuss their joint and individual efforts, their hopes for the future of their networks, and how the Junior Members can get involved.

Session

EC WG Junior Members

3188

Writing a scientific paper

Prof. Dr. Zhanwen Han

Yunnan Observatories, Chinese Academy of Sciences

Abstract

In this presentation, I will first briefly discuss the reasons behind scientific writing and the essential preparatory steps. Subsequently, I will talk about the paper's structure, offering a systematic and detailed guide for each stage of the writing journey. Finally, I will show how to enhance the quality of the paper and how to respond to referee reports effectively.

Session

EC WG Junior Members

3189

Improving writing skills

Professor Christopher Tout

University of Cambridge

Abstract

The best writing is concise and to the point. Do not include unnecessary references and make sure you have read every paper to which you refer. Write the abstract first. This keeps the rest of the paper ordered and avoids including superfluous material. Try to keep sentences short. Do not assume your reader has more than a basic knowledge of the subject.

Session

EC WG Junior Members

3190

Science Diplomacy

Dr Camilo Delgado-Correal

Francisco José de Caldas District University of Bogotá & Geographic Institute Agustín Codazzi

Abstract

In this talk I am going to show the highlights of Science Diplomacy and how early career researchers can involve to this field. Also, I will describe the skills that they need to work with different governments and public offices, showing the challenges and the opportunities that they have to change the course of science in their countries.

Session

EC WG Junior Members

3193

The Role of Peer Mentoring in Astronomy

Jacqueline Antwi-Danso

University of Toronto

Abstract

Peer mentoring has been shown to be pivotal in providing support to academics of various levels in a variety of fields. In this talk, I will give an overview of LUMA, the League of Underrepresented Minoritized Astronomers. LUMA is a peer-mentoring community for Black, Indigenous, and Latinx women who are graduate students, postdocs, faculty, and research scientists in astronomy and related fields. In this presentation, I will outline the various programming options available in LUMA as well as the opportunities available to engage with LUMA at both the individual and institutional level.

Session

EC WG Junior Members

3196

Exploring Astronomy as a Tool for Enhancing Mental Health

Dominic Vertue, Joyful Mdhluli, Mampho Ledimo

IAU Office of Astronomy for Development

Abstract

“Astronomy for Mental Health'' is a flagship project of the International Astronomical Union’s Office of Astronomy for Development (IAU-OAD). The project is focused on harnessing the inspirational potential of astronomy and using it as a tool for improving people’s mental health and wellbeing. The overarching goal is to use astronomy to empower individuals and communities to reach their full potential. In 2023, pilot projects targeted undergraduate and postgraduate students, addressing common stressors identified through pre-launch surveys. The Mental Health team developed resources to guide participants on how they can utilize astronomy as a tool for managing daily challenges. Some of the pilot projects that were hosted include a writing retreat, which was hosted in a remote area for MSc and PhD students to explore whether dark sky areas could enhance concentration and inspire productivity in the process of completing their work. In addition, online workshops were conducted, tailored for physics students, and sessions were dedicated to exploring the potential of Astronomy as a tool for enhancing mental well-being. This presentation will showcase the pilot activities, including key takeaways and implementation strategies for broader applications.

Session

EC WG Junior Members

Final category: EC WG Women in Astronomy

133

Addressing Gender Disparities in Astronomy: A Comprehensive Review of Challenges and Opportunities faced by Women Researchers.

Dr. Mamta Pommier

University Catholic of Lyon, University of Lyon FRance

Abstract

Persistent systemic inequalities are observed for women in Astronomy and STEM fields throughout their professional journeys. Effectively addressing these challenges requires a proactive approach focused on raising awareness, supported by comprehensive statistical data. This approach is crucial for closely monitoring career hurdles and addressing underlying barriers to workplace equality, contributing significantly to rectifying the leaky pipeline effect and gender imbalances in STEM careers. In this talk, I will present the efforts carried out by the IAU WiA WG to advance inclusivity and equal opportunities in Astronomy.

Session

EC WG Women in Astronomy

184

Women in Astronomy: A Comprehensive Situational Analysis in Zambia

Dr. Jive Lubbungu

Kwame Nkrumah University, Zambia

Abstract

This study presents a thorough situational analysis of the status, obstacles, and opportunities for women in the field of astronomy in Zambia. Despite the global advocacy for gender inclusivity in science, technology, engineering, and mathematics (STEM) disciplines, the involvement of women in astronomy remains inadequately examined, particularly in the context of developing nations such as Zambia. Employing a qualitative methodology, this research gathers data on the current demographic landscape of women in astronomy in Zambia, with qualitative insights derived from in-depth interviews with key informants purposively selected through snowball sampling techniques. The findings illuminate the various barriers confronting women aspiring to enter and excel in the field of astronomy, spanning from cultural perceptions to systemic challenges within educational and professional realms. Furthermore, the investigation reveals a gender bias favoring men in the field of Astronomy within Zambia, with only one woman identified, who is not even residing in the country. By unraveling the distinctive challenges faced by women in this discipline, the research seeks to provide valuable insights for crafting targeted interventions and policies, fostering a more inclusive and equitable environment that encourages women to pursue successful careers in astronomy.

Keywords: Women in Astronomy, Gender Equity, STEM Fields, Zambia, Inclusivity in Science

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Training and Support for Women Astronomers: An Analysis & Introspect

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

The Working Group for Women in Astronomy has been involved in various initiatives in Training and Support for Women. This work will present the kind of Training Programs we have been conducting with an analysis of the topics, duration, participation, response and reach of our efforts. We shall also discuss the lessons we have learnt and other forms of support that could be provided to meet the requirements and possible improvem

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The Supernova Foundation: A mentoring and networking programme for women in physics

Dr Michelle Lochner

University of the Western Cape. South African Radio Astronomy Observatory

Abstract

The Supernova Foundation (www.supernovafoundation.org) is a global mentoring and networking programme aimed at women and gender minority physics students, mostly from developing countries, to try to improve gender equality in physics. We target women in physics departments with few or no woman role models and use mentoring by senior female researchers to empower them and give them the support they need to stay in physics. We currently have nearly 400 mentors and mentees from six continents. We regularly host webinars on topics like imposter syndrome or work life balance and our mentors meet their mentees monthly for private sessions. As founder and director, I will overview the Supernova Foundation in this talk, lessons learned and tips for successful mentoring programmes.

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Women and Girls in Astronomy Program (WGAP)

Sr. STEM Education Specialist Yasmin Catricheo[1], NA-ROAD / WGAP Coordinator Karla Garcia[2], AURA Corporate Communications Coordinator Shari Lifson[3], Staff Associate for Facilities Planning and Management Tim Spuck[4], VP of Science Engagement Laura Trouille[5]

[1]Associated Universities Inc. (AUI). [2]North American Regional Office of Astronomy for Development (NA-ROAD). [3]Association of Universities for Research in Astronomy (AURA). [4]U.S. National Science Foundation. [5]Adler Planetarium / Zooniverse

Abstract

The Women and Girls in Astronomy Project (WGAP) is a key project of the North American Regional Office of Astronomy for Development (NA-ROAD). WGAP inspires and supports women, girls, and underrepresented genders in the field of astronomy. The program targets aspiring astronomers and current professionals alike to establish a network to uplift, educate, connect with, and promote astronomy for development in women and girls located in communities from the North American Region which includes the United States and U.S. Territories, Canada, Mexico, Greenland, and several island nations of the Caribbean.

This year, ten chosen projects were awarded with $2,000 USD mini-grants and project leaders will join the WGAP network as WGAP Fellows. This network is composed of industry and academic professionals who are willing to support women and girls in astronomy, while facilitating connections between women and girls in astronomy. Proposals answered four key questions specifying the following details regarding the proposed project; clear vision and goals for the project; clear target audience; how the project plans to support the target audience; timeline aligned with a December 1, 2024 completion date, and, an organized budget, with projected expenses for materials and/or travel. After this second consecutive year, WGAP has been able to support a total of 20 projects that target specific communities across the North American region. Throughout the presentation, we will learn more about the WGAP projects and their impact on local communities across the North American Region. Thanks to the Heising-Simons Foundation for supporting the WGAP program.

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Gender balance at CBK PAN after implementing the gender equality plan.

prof Jolanta Nastula

Centrum Badań Kosmicznych PAN

Abstract

The Centrum Badań Kosmicznych PAN (CBK PAN), or the Center for Space Research of the Polish Academy of Sciences, stands as one of the leading centers in Poland for space research. The institute is committed to creating a workplace that offers its employees favorable working conditions and opportunities for scientific development.

Throughout the 45-year history of the Centrum, the number of female employees has shown consistent, albeit gradual, growth. In 2015, women constituted approximately 34% of the total workforce, and by the end of 2020, this figure had increased to over 37%. In 2022, CBK PAN introduced a gender equality improvement plan. This presentation outlines the current situation.

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The Role of Women in Astronomical Observation and Astrophotography in Iraq- Challenges and Aspirations

Mrs Najah Al-Salihy

Arab Union for Astronomy and Space Science

Abstract

In Iraq, women and girls who with interest in astronomy, face tremendous challenges that often intersect with broader societal barriers. One significant hurdle is the lack of inclusive spaces and opportunities for participation. Amateur astronomy clubs and events may be predominantly male dominated and creating an environment that feels unwelcoming or intimidating for women and girls. Specially taking in account that most astronomy observations and astrophotography events take place overnight and in areas away from the center. Cultural norms and societal expectations make it difficult for aspiring female astronomers to participate in such events and connect with likeminded peers and mentors.

Additionally, the financial challenges and access to equipment and resources is limited and particularly in regions with socioeconomic disparities and areas of conflict, like Iraq. High quality telescopes and other astronomical instruments can be expensive and difficult to obtain and placing them out of reach for many amateur enthusiasts and especially women and girls from marginalized communities.

Moreover and societal stereotypes and gender biases may lead to the underestimation of women's abilities in technical fields like astronomy and further exacerbating the challenges they face in pursuing their interests and gaining recognition for their contributions.

In conclusion, there is a significant lack of representation of women in the field of astronomy in Iraq, the way forward is to support women in new initiatives and increase awareness in the society advocating for gender equality and striving to overcome barriers to pursue their passion for astronomy and astrophotography.

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Advancing Diversity and Inclusion in Indian Astronomy and STEM for Women and Minority.

Miss Sarah Ann Jacob

International Space University

Abstract

In recent years, India has celebrated remarkable achievements in space exploration, yet beneath the surface lies a stark reality of underrepresentation within its astronomy and STEM sectors. This study endeavors to illuminate the challenges faced by women and minorities in these fields, identify underlying mechanisms contributing to their underrepresentation, and propose actionable solutions for fostering diversity and inclusion.

Through a comprehensive approach encompassing literature reviews, interviews, and survey analysis, this research seeks to uncover the nuanced factors driving the underrepresentation phenomenon. The concerning trend of significant proportion of women and minorities exit the STEM sector post-graduation, perpetuating the disparity in representation., disparities in pay scales, inadequate mental health support, and a lack of mentors and training exacerbate the challenges faced by marginalized groups.

The urgency of action is evident, and this study serves as a call to create a more inclusive and equitable environment within Indian astronomy and STEM fields. By providing a platform for marginalized voices to be heard, the research aims to shed light on experiences and concerns that have long been overlooked and highlighting the necessity of amplifying these voices and fostering collective action to address systemic barriers to pave the way for a more inclusive future in Indian astronomy and STEM for women in India and globally , where every voice is valued and respected.

This abstract encapsulates the the potential impact on promoting diversity and inclusion in Indian astronomy and STEM fields , this study seeks to effect transformative change within India's scientific landscape.

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ICRAR Visiting Fellowship For Senior Women+ In Astronomy

Dr Renu Sharma, Ms Asha Stabback, Prof Luca Cortese, Dr Elisabete DaCunha

University of Western Australia - ICRAR

Abstract

ICRAR (International Centre for Radio Astronomy Research), based in Perth, Western Australia established a Fellowship scheme in 2014 providing a full-funded Visiting Fellowship for Senior Women+ in astronomical sciences and technology. The purpose is to enable an opportunity for senior women+ astronomers, as well as engineers and data scientists working in the field of astronomy, (having more than five years research work experience post PhD) to visit ICRAR and interact with ICRAR researchers and graduate students.

Through the Fellowship scheme, opportunities are created for the Visiting Fellow to share their experiences and challenges as they progress in their career, foster scientific interaction and enrich the research environment through National and International collaborations, mentor and support students and early-career researchers.

Since its establishment, ICRAR has supported seven (7) Fellowships, with travel restrictions during Covid impacting full Fellowships being awarded but an additional two (2) senior researchers were supported to visit ICRAR.

In this talk, we will outline the program, challenges faced, learnings along the way as well as the future of the program. We will also highlight the outcomes of the program and how this initiative has supported our broader diversity, equity and inclusion initiatives and contributed to recognition at a national level with the Gold Pleaides award. The Pleiades Awards, inspired by the UK's Athena SWAN program, were originally launched by the ASA Chapter for Women in Astronomy (WiA) to recognise organisations in Australian astronomy that take active steps to advance the careers of women.

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MUJERES POR AFRICA": a case study of research and collaboration opportunities for women in astronomy

Dr Brenda Namumba[1], Dr Elizabeth Naluminsa[2], Dr Pfesesani Van Zyl[3]

[1]The University of Witswatersrand. [2]Makerere University. [3]South African Radio Astronomy Observatory, HartRAO site

Abstract

Dedicated to helping Africa's development through the empowerment of its women, the Women for Africa Foundation (FMxA) aims to promote leadership among African women in scientific research and technology transfer, as well as strengthen the capabilities of research centres in their respective countries. Our talk will explore the amazing research collaboration opportunities available to African women in astronomy through the Mujeres por Africa fellowship while showcasing the stories of both previous and current recipients. By fostering partnerships between Africa and Spain, these efforts have further strengthened collaborations between astrophysical research institutions across Africa and the IAC, facilitating access to data from international facilities such as the ING and MAGIC telescopes. This collective effort significantly contributes to shaping the future of astronomy in Africa, simultaneously amplifying the voices and acknowledging the achievements of women in their respective fields.

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Work and achievements of the African Network of Women in Astronomy

Dr. Mirjana Povic[1], Dr. Vanessa McBride[2], Dr. Somaya Saad[3], Dr. Priscilla Muheki[4], Ms. Salma Silla Mbaye[5]

[1]Space Science and Geospatial Institute, Ethiopia. [2]IRC, France. [3]NRIAG, Egypt. [4]MUST, Uganda. [5]Universidad Cheikh Anta Diop, Senegal

Abstract

The African Network of Women in Astronomy (AfNWA) is an initiative that aims to connect women (or people who identify as such) working in astronomy and related fields in Africa. It was established in September 2020 as one of the committees of the African Astronomical Society (AfAS). With AfNWA we want to ensure the future participation of girls and women at all levels in the development of astronomy and science in Africa. Our main goals are to improve the status of women in science in Africa and to use astronomy to empower girls and women, and to inspire more girls to pursue Science, Technology, Engineering and Mathematics (STEM). This talk will summarise the activities carried out by AfNWA and the current status of women in astronomy in Africa. It aims to give visibility to the work and achievements of the AfNWA community, and the various activities carried out across the continent to support girls and women living and working in under-represented communities through astronomy. He will also emphasise our vision of how through astronomy we can combat poverty in the long term, and increase our chances of achieving the UN Sustainable Development Goals (SDGs) in the future, including SDG 5 related to gender inequality, for the benefit of our society as a whole. The last part of the talk will cover a list of AfNWA's recommendations to improve the strong gender gap we still have in science around the world.

Session

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Rise of Women in Astronomy in Nepal: a Lilac revolution

Ms. Manisha Dwa[1,2,3,4], Mr. Suresh Bhattarai[1,5,3,4]

[1]Nepal Astronomical Society. [2]IAU-Office of Astronomy Outreach. [3]IAU-Office of Astronomy for Education. [4]OAE-Node Nepal. [5]IAU Office for Astronomy Outreach

Abstract

Due to various reasons including traditional standpoints, socio economic aspects, societal hegemony, the number of female students pursuing STEM field is very low in Nepal. In this scenario, trying to find the female astronomer is near to zero. I as an individual, when developed the interest in astronomy and tried astrophotography, I was victimized by the stereotyped comments which were extremely discouraging. Despite the challenges, I gather the courage and have a very limited people supporting me, leading to be the person I am.

It has almost been a decade I started working in the field of Astronomy and today, we have handful of female professionals and students who are contributing to the field and are inspiring their local communities to pursue STEM field. This paper thus will share about the contribution of few of the female leaders who have been involved in astronomy outreach throughout Nepal. The paper will mainly focus on the outreach and educational activities they are involved in and the visible change through the records/data thus collected by them. Particularly, this paper will discuss about the Teachers Training Program (TTP) conducted under International Astronomical Union -Office of Astronomy for Education (IAU-OAE), project ACEN (an IAU-OAD initiative) and the various astronomy outreach sessions during the World Space Week celebration by the female participants throughout the country. As we are open to welcoming everyone under this category who bears the pronoun she/her, the theme of this work will be the Lilac revolution.

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The Astronomoms survey - how to better support parents in astronomy

Dr Veronica Allen[1], Dr Melinda Soares-Furtado[2], Prof Jessica Degol[3]

[1]University of Groningen. [2]University of Wisconsin, Madison. [3]Pennsylvania State University

Abstract

In 2020, amid COVID19 lockdowns, uncertainty, and extreme work/life imbalance, two early career moms in astronomy started an online coffee morning chat. Neither fully relating to academic non-parents or non-academic parents, we needed a space to create a community where we could share advice and support; so **Astronomoms** was born.

Since then, we have grown to more than 40 members, hosted a dozen talks from mentor Astronomoms, and started down the path of systemic change. In this vein, Melinda Soares-Furtado (*UWisc Madison*) and I, together with Jessica Degol (*PSU Prof of Human Development and Family Studies*) conducted a survey of parents in astronomy. In this talk, I will present the results of this survey as well as our suggested institutional actions to better support caregivers.

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EC WG Women in Astronomy

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PROVOCA mentorship program

Dr. Sonia Duffau

Associated Universities, Inc. (AUI) & National Radio Astronomy Observatory (NRAO)

Abstract

Women continue to be under-represented in Astronomy and STEM in general. The PROVOCA initiative has been building a safe space for female STEM professionals, girls and young women to meet since 2018. Initially, as one-time opportunities and later on as a year-long mentorship program focused on increasing knowledge of STEM disciplines, developing key skills and building a support network. The mentorship program hones communication and teamwork skills, exposes students to the reality of everyday life as a female in STEM and creates opportunities to connect. The overall objective is to generate a strong sense of belonging and STEM identity, addressing the issues of participation, retention and representation of women in Astronomy and STEM.

PROVOCA trains its own female in STEM mentors, 50% of which come from Astronomy. In a thorough 8-month experience, volunteers prepare to accompany and guide high school and early college students.

A metric of success for the mentor training is to arrive at a better understanding of their career paths, extracting lessons to share with students. For the students, a successful process is one where they were able to explore career options to make thoughtful and informed decisions.

Since the beginning of the mentorship program in 2021, 51 mentors have been trained and 88 students have participated, including 2 students from the deaf community. 100% of the mentors who were selected, finished their training, with almost 90% retention rate for the students.

We will show how PROVOCA helps solidify STEM identity for the girls and women involved.

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EC WG Women in Astronomy

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Women in the skies

Dr Ana Cecilia Soja

Fluminense Federal Institute

Abstract

Since its beginning, Humanity has projected its stories in the skies. Each civilization at its proper historical moment imprints values and culture in the stars. Just over a hundred years ago, the current constellations of the Western world were defined, based on the Hellenic tradition. The result was 88 constellations, most of which tell the stories of warriors and heroes. Among them, only six constellations tell women's stories. The present work goal is to analyze these stories. In this way, first we characterized such narratives in order to understand the model of femininity that is being celebrated and its impact on the collective imagination. Then, a comparison was made between this pattern and the one adopted for male figures. It was found that, while for idealized male figures the highlighted qualities were courage and strength, female figures are usually depicted as secondary characters in an hero's life and their biggest quality comes out as beauty. As expected, these stories reinforce Western society's gender stereotypes. Having made this observation, the next step was to think of suggestions on how to use Astronomy and observation of the sky as an auxiliary tool in the search for gender equality. Thus, it is concluded that a possible strategy is to tell the stories of these women in the skies, emphasizing their agency in their own adventures and highlighting qualities beyond their beauty or being male characters' objects of desire.

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2695

Women in Physics: Inclusion for all

Dr Katekani Shingange[1], Dr Joyful Mdhluli[2]

[1]Mintek. [2]Office of Astronomy for Development

Abstract

Despite notable advancements in recent years, women continue to confront underrepresentation in physics and astronomy, encountering unique barriers that hinder their complete engagement and progression within the field. Women in Physics in South Africa (WiPiSA), a dedicated forum under the South African Institute of Physics (SAIP), is committed to championing the cause of women in these intertwined disciplines and advocating for increased female participation in physics and astronomy-related careers.

Addressing the imperative question of how to attract and retain females in these fields remains a formidable challenge. Proposed initiatives encompass the amplification of diverse voices and shared experiences, highlighting the importance of identifying and celebrating perspectives beyond gender. Additionally, building supportive communities is highlighted as crucial, exploring the key role of community-building in establishing networks that prioritize mentorship, advocacy, and collaborative environments conducive to mutual growth.

WiPiSA engages in various activities aimed at attracting and retaining females in Physics-related careers, including science outreaches, Physics departmental lunches, webinars, mentorship, and role modelling. Through these activities, it can be realized that intersectionality in action calls for exploration of approaches to inclusion that recognize and address the interconnected nature of various identities, ensuring a subtle understanding of the challenges faced by different groups within the physics and astronomy communities. This work aims at sharing the WiPiSA engagements, share the successful stories and challenges faced at attracting and retaining females in Physics.

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EC WG Women in Astronomy

2706

Culturally-Relevant Role Models for Girls in South Asia

Ms. Yumna Majeed

Exploration - Cosmos to Classroom

Abstract

Addressing the persistent challenge of the underrepresentation of women in long and fulfilling STEM careers despite an increase in their enrollment in South Asian countries. Cultural barriers, societal norms, and gender-specific expectations, such as marriage and domestic responsibilities, hinder women's progression in STEM fields. The proposed solution focuses on empowering teachers, the nation builders, by providing training and resources to engage girls in STEM and Space-related disciplines. Acknowledging the scarcity of qualified teachers in South Asia, the research advocates for international fellowships and scholarships, culturally relevant STEM experiences, and strategic plans to counteract the masculinization of certain fields.

The paper emphasizes the importance of women-led STEM initiatives in Pakistan, India, Nepal, and Bangladesh, where female educators serve as crucial role models for young girls facing systemic inequality and cultural biases. The study suggests the implementation of internationally proven strategies to create a women-supportive ecosystem, combat harassment, and foster flexible working patterns. By cultivating a generation of empowered female educators, the paper aims to inspire and guide South Asian girls, fostering their confidence to pursue STEM ambitions and contribute to thriving STEM communities.

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Iranian Women Shatter Stereotypes: Mahgard's Mission to Ignite a Scientific Revolution

Dr Arash Danesh[1,2], Dr Mohammad Taghi Mirtorabi[3,2], Mrs Mahdis Rezaei Niasar[3,2], Mrs Mahroo Bagherian[3,2], Mrs Hanieh Almasi[3,2], Mrs mehrnaz Zabayehi Najafabadi[3,2], Mrs Mohana Jafarinia[3,2], Mrs Sanaz Khanahmadi[3,2], Mrs Hakime Moini[3,2], Mrs Fatemeh Sadeghi[3,2], Mrs Seyyedeh Zeinab Masouni Zaviyeh[3,2]

[1]Institute for research in Fundamental sciences(IPM), Iranian National Observatory. [2]Mahgard. [3]Alzahra University

Abstract

Despite its rich cultural heritage, Iran faces challenges in science education, particularly for women. In the heart of Iran, where ancient cultural beliefs dance with a yearning for scientific exploration, a pioneering initiative named Mahgard is blossoming. Led by a fearless force of Iranian women physicists and astrophysicists, Mahgard is more than just an astronomy club; it's a vibrant community shattering stereotype and igniting a passion for science.

Driven by a collective belief in the transformative power of women in science, Mahgard tackles the challenges head-on. Leveraging technology and innovative events, they bridge the gap between traditional and scientific knowledge through storytelling. This ignites curiosity in all ages, empowering individuals and communities. They gamify the cosmos, transforming complex concepts into captivating experiences.

By seamlessly weaving traditional narratives with the wonders of modern science, they create immersive journeys under the stars, leaving audiences spellbound and yearning for more. This commitment to inclusivity extends beyond their events. Mahgard fiercely protects the intellectual property of all content it produces, fostering ethical knowledge dissemination and empowering the women within their ranks.

Mahgard is not just a community; it is a beacon of hope, a testament to the unwavering spirit of women who dare to dream and the power of science to illuminate even the darkest corners. Join them on this empowering journey and witness the stars align for a brighter future, where scientific exploration flourishes and cultural heritage finds harmony with the boundless potential of the human mind.

Session

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The fight against gender stereotypes begins in the classroom

Dr. Clementina Sasso[1], Dr. Silvia Galano[2]

[1]INAF-Osservatorio Astronomico di Capodimonte. [2]Department of Physics "E. Pancini", University of Naples Federico II

Abstract

Only 21% of all IAU members are women. While not all astronomers and astrophysicists are members of the IAU, this data is interesting because if we look at the percentage of women working in scientific or technological (STEM) fields around the world we get similar percentages. Women working in STEM fields are only 24% in the United States, 17% in the European Union, 16% in Japan, and 14% in India. This means that gender gap in STEM is a global issue. Many studies in Science Education show that a fundamental role in determining this phenomenon of horizontal segregation is played by gender stereotypes. These stereotypes influence individual choices and can lead girls not to choose to study STEM discipline because they are considered more suitable for male students. Gender stereotypes influence the individual throughout his or her life and are more effective in the early years. This means that to address this problem it is necessary to develop and implement strategies and actions suitable for young girls. Drawing on results in research in Astronomy Education, in particular on studies focused on gender stereotype in STEM, we have specifically designed a training course for teachers to help their students, in particular girls, in recognizing and deconstructing gender stereotypes in order to support them to make more informed and free choices about their study career.

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Empowering Women in Astronomy for a Brighter Universe

Mr. Redait Basaznew

Space Science and Geospatial Institute (SSGI)

Abstract

This study focuses on the empowerment of women in the field of astronomy, highlighting the progress made towards achieving gender equality and the importance of inclusivity in shaping a brighter future for the universe. It explores the challenges faced by women in astronomy and showcases the remarkable contributions they have made to the field.

Despite historical disparities, female astronomers have defied societal barriers and made significant advancements in various branches of astronomy. The study highlights their groundbreaking research, discoveries, and leadership roles, which have expanded our understanding of the cosmos and paved the way for future generations.

The study also delves into the initiatives and organizations that promote the inclusion and advancement of women in astronomy. It discusses the role of mentorship programs, networking opportunities, and educational initiatives in nurturing talent and empowering women to thrive in the field.

By celebrating the achievements of women in astronomy and advocating for gender equality, this study aims to inspire more young women to pursue careers in this captivating field. By fostering an environment of inclusivity and equal opportunity, we can unlock the full potential of talented individuals and collectively contribute to the advancement of astronomical knowledge.

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Advanced Ethiopian women in Physics and Astronomy Focus Group.

Ms. Mehbuba Ahmed

Space Science and Geospatial Institute (SSGI), Ethiopia

Abstract

Africa has amazing potential due to natural and human resources for scientific research in astronomy and space science. At the same time, the continent is facing many difficulties, and its countries are now recognizing the potentials of astronomy, space science, and satellite technologies to improve their main socio-economic and environmental challenges. The status of physics, astronomy and space science in Africa has changed significantly over the past years [Povic, M. et al., 2018] . The world's largest radio telescope (SKA) project can be taken as an instance for the development of physics education, and its application in astronomy and astrophysics in Africa. Unfortunately, ensuring female participation in physics and astronomy, in Ethiopia and in Africa in general, is facing complicated challenges, ranging from developing appropriate curriculum to market demand. The influence of the market demand and unemployment rate in Africa is lowering the participation of female students in science. The absence of a good STEM curriculum and quality education, in turn, hide the importance and power of Physics education in innovation and job creation in Africa. The most difficult challenges are obtaining support from friends and family members, having not a good background, a lack of employment in the field, not being interested in science because they do not visualize their daily lives in it, not having enough information about science, and not communicating with experts in the field. One way to uncover this power of Physics, for women in the field is through teaching and mobilizing, informing society.

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CHIA, a constellation of female Colombian Astrophysicists

MSc. Maria Gracia Batista

Universidad de los Andes, Bogotá, Colombia.

Abstract

In recent decades, there has been a positive trend towards increased participation of female astronomers globally. However, the situation in Latin America, including Colombia, remains complex. While the astronomy community in Colombia is growing, there is a noticeable lack of female representation. According to the International Astronomical Union, out of 33 astronomers affiliated with Colombian institutions, only 5 identify themselves as women. This gender disparity is particularly evident in academic positions, where only three female astronomers hold permanent positions.

In response to this gender gap, we created the CHIA network (Female Colombians doing research in astronomical sciences), established in 2019. The network aims to unite female astronomers both within and outside Colombia. Research revealed approximately a hundred Colombian women astronomers, ranging from undergraduates to associate professors, scattered across the globe.

Recognizing the importance of female role models, CHIA focuses on providing visibility to the research conducted by female astronomers and engaging in science dissemination and outreach activities to inspire the next generation of female scientists. Additionally, the network fosters a collaborative community to support and encourage the careers of female astronomers at all stages.

CHIA seeks to address the gender gap in STEM fields in Colombia by promoting representation, providing mentorship, and fostering a supportive environment. In this talk we would like to introduce our collective and the multiple projects we are developing with the aim to create a more equitable and inclusive environment using Astronomy as a fundamental tool of development in our country.

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Breaking Barriers: The Role of Women in Astronomy

Dr. Dismas Wamalwa

Meru University of Science & Technology

Abstract

Women have made significant contributions to the field of astronomy throughout history, yet their achievements have often been overlooked or marginalized. This abstract explores the historical challenges faced by women in astronomy, including limited access to education and professional opportunities, as well as societal biases and stereotypes. Despite these obstacles, many women have made groundbreaking discoveries and advancements in the field, paving the way for future generations of female astronomers. This abstract also highlights the importance of promoting gender equality in astronomy and creating a more inclusive and diverse scientific community.

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Final category: FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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Using a Small Telescope Featuring a Wide Field of View for Space Situation Awareness

Dr Ahmed Moursi

National Research Institute of Astronomy and Geophysics(NRIAG)

Abstract

Space Situation Awareness (SSA) plays a pivotal role in monitoring and understanding the dynamic environment beyond Earth's atmosphere. This paper explores the utilization of a small telescope equipped with a Wide Field of View (WFOV) to enhance SSA capabilities. Traditionally, larger telescopes with narrow fields of view have been employed for space observation, limiting the ability to track multiple objects simultaneously. The integration of a small telescope with WFOV presents a novel approach to overcome these constraints. The study discusses the design and implementation of the small telescope, emphasizing the advantages of a wide field of view for increased coverage of the celestial sphere. By leveraging advanced optics and imaging technologies, the telescope enables rapid and comprehensive monitoring of space objects, including satellites, debris, and celestial bodies. The WFOV facilitates real-time tracking of multiple targets, improving the efficiency of SSA operations. Furthermore, the paper explores the potential applications of the small telescope in conjunction with existing space surveillance networks. The cost-effectiveness and portability of such a system make it an attractive addition to the current infrastructure, providing valuable contributions to global SSA efforts. The research also addresses challenges associated with data processing and analysis, proposing solutions to optimize the extraction of meaningful information from the vast amount of observational data generated. The paper highlights the presence of an existing optical system, offering a FOV of about 3.4˚ x 2.3˚. This system was established in 2019 at the National Research Institute of Astronomy and Geophysics, Egypt.

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FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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Identification of Potential Astronomical Sites in Ethiopia

Mr. Nebiyu Suleyman[1,2], Dr. Solomon Tessema[3,4]

[1]Ethiopian Space Science Society (ESSS). [2]Office of Astronomy for Education (OAE). [3]International Astronomical Union. [4]Ministry of Innovation and Technology

Abstract

In the future, Ethiopia may find the need to build new astronomical observatories to continue local programs and contribute to global survey projects. Astronomical site identification studies are critical for decision-makers to propose where to build astronomical observatories. Without the best site identification and selection for the telescopes, it's impossible to get good observations no matter how powerful the telescope may be. The observing quality of medium and large telescope observatories at optical and infrared is determined mainly by atmospheric transparency that depends on the metrological and topographic conditions. Because of these factors and the high costs of large telescopes and their implementations, Ethiopia must choose sites that are the best possible places for astronomical observations. Fortunately, the nation has many potential candidate sites with high plateau regions and mostly dry climates that are located near the equator. Exploiting these resources will create more opportunities for Ethiopia and the astronomical community.

The best possible candidates for astronomical observational sites in Ethiopia can be identified using the Analytical Hierarchy Process method integrated with Geographical Information Systems and remote sensing technologies. Mountain sites that are higher than 2,500m above sea level were ranked according to their metrological parameter values. The selection is based on the general principles that a good observatory site has a high elevation, little light & aerosol pollution, higher available clear nights, low precipitation, calmer wind, and low-temperature fluctuations. With Statistical analysis, the favorable sites are mainly found in the highlands of the Northern and Eastern parts of Ethiopia.

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Astrochemistry in Africa: let's form our bond

Prof. Dr. Zainab Awad

Astronomy, Space Science and Meteorology Dept. - faculty of Science - Cairo University

Abstract

Astrochemistry is the field of astronomy that blinds astronomy with chemistry. It is also known as molecular astrophysics because it is based on the studied of molecular spectra we receive from different directions/ regions in the universe. Although astrochemistry is a relatively new field in astronomy (< 100 years old), the number of astrochemists continues to increase. Thanks to the new technologies that opened windows in all wavelengths to the largest chemistry laboratory ever; the universe, and motivated and attracted more astronomers to this field.

Africa is reach not only in its human resources and man power but it also possesses some astronomical facilities that operate in a wide range of electromagnetic spectrum from optical to radio. Of course, optical observations are the least important to astrochemistry due to atmospheric line overlapping, but other band such are radio will be of a great help in investigating and exploring the chemistry of the universe.

In this talk, I would like to highlight the efforts African astronomers put in their research with the lack of financial support and resources and also the challenges we may face under all of these bad economical situations we pass through. In addition, I hope to addresses the main facilities we have in Africa and how can we facilitate them and build a new network for African astrochemists under the umbrella of the Astronomical African Society. In this network, I hope that African astronomers, whether reside in their original countries or live abroad, join and help.

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Real-Time Profiling of Atmospheric Parameters with Single Star SCIDAR using the Power Spectrum of Scintillation.

Youssef Errazzouki[1], Abdelfattah Habib[2], Abdelhadi Jabiri[3], Mohamed Sabil[4], Benkhaldoun Zouhair[1]

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Abstract

Optical turbulence in the atmosphere significantly affects adaptive optics, high-resolution imaging, and site testing. The single star SCIDAR technique offers vertical profiles of these critical parameters, including the refractive index structure constant $Cn2(h)$, by analyzing the scintillation of single stars.

Our study presents a novel approach for real-time measurement of atmospheric parameters using Single Star SCIDAR. The key innovation lies in leveraging a modified power spectrum of atmospheric speckles, which exhibit more pronounced variations with altitude. By employing this modified spectrum, we compute an objective function and apply the Active-Set algorithm for minimization, resulting in accurate real-time vertical profiles of $Cn2(h)$. Processing time is swift, at around 3 seconds per profile, with a high recovery rate of approximately 95%.

To validate the reliability of our approach, we conducted simulations and compared results with data from sounding balloons. These validations affirm the method's accuracy and credibility, highlighting its potential across various practical applications, particularly in the domain of Adaptive Optics (AO) systems.

Given that AO systems heavily rely on precise atmospheric parameter knowledge to counteract turbulence-induced distortions, the availability of real-time vertical profiles empowers these systems to make prompt and accurate adjustments, ultimately leading to enhanced image quality.

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Rubin's LSST: opportunities for worldwide democratization of astronomical research and public outreach

Professor Zeljko Ivezic

AURA/University of Washington

Abstract

The Legacy Survey of Space and Time (LSST), the first project to be undertaken at the new Vera C. Rubin Observatory, will be the most comprehensive optical astronomical sky survey ever undertaken. Starting in 2025, Rubin Observatory will observe the sky visible from its location in Chile every clear night for ten years. Using this 60,000 terabyte image dataset, about 20 billion galaxies and a similar number of stars will be observed close to a thousand times - for the first time in history, the number of cataloged celestial objects will exceed the number of living people. LSST data will be used for investigations ranging from cataloging potentially hazardous near-Earth asteroids to fundamental physics such as the characterization of dark matter and dark energy. LSST data will be available online and thus will signficantly contribute to the democratization of astronomical research and public outreach around the world. There are already thousands of scientists from many dozens of countries, large and small, who are preparing to actively participate in LSST's rich science harvest. I will summarize these ongoing efforts and discuss how LSST data could help development of astronomy in Africa.

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Characterization of the optical properties of atmospheric turbulence:Application to the choice of the site of the future Observatory of Senegal

Ms Abdoulaye BA[1,2], Ms Papa Douta Tall[3], Ms Zouhair Benkhaldoun[2], Ms Mamadou Simana Dramé[3], Ms Aziz ziad[4]

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Abstract

Modern astronomy demands ever increasing performance from its instrument
A major obstacle for ground-based observations is the micro-fluctuations of temperature in the atmosphere which, modifying the refractive index of the air, randomly scramble the propagation of optical waves and cause a loss of information. The choice of a site for a future observatory is crucial for the long-term development of national astronomy. Thus, the image quality or seeing has become one of the criteria retained in the final decision making for the choice of sites.

The prediction of atmospheric and turbulence conditions is of great interest for the astronomical community, However the use of a numerical approach becomes crucial for the characterization of atmospheric and optical turbulence conditions.

In this study, a numerical approach based on the Weather Research and Forecasting (WRF) of meteorological parameters (temperature, relative humidity, wind speed and direction) as well as the optical turbulence conditions (CN2) of the forecast model for all three target sites in Senegal. We also present the seeing obtained for each site and other integrated parameters of the vertical profiles of atmospheric turbulence.

Keywords: Atmospheric turbulence, Seeing, Weather Research and Forecasting

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The impact of ground-based telescopes in the formation of the next generation of astronomers

Prof. Itziar Aretxaga

Instituto Nacional de Astrofísica, Óptica y Electrónica

Abstract

Hands-on observational astronomy is valued as one of the most important experiences by the alumni of the International Schools for Young Astronomers (ISYA) over the years. ISYAs are three-week long intensive schools that target specifically graduate students coming from astronomically underdeveloped countries and isolated groups. We recount our experience with tutoring that goes from a observations taken with optical telescopes through a few nights, to a few hours of remote observing experience in our program. The thrill of discovery through the access to the telescopes is an experience difficult to transmit through database analysis alone. Even remote real-time observing has a beneficial experience for the starting student in Astronomy.

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Working towards an implementation of a robotic optical telescope.

Dr Mohamed fayed

National Research Institute of Astronomy and Geophysics

Abstract

This paper represents the implementations towards automating and scheduling astronomical observation of the 14-inch telescope. It is a German equatorial telescope and located at the Kottamia Astronomical Observatory (KAO). Using STX-16803 CCD camera and seven positions filter wheel, astronomers can acquire best observations. Recently, the dome has been automated to run in an automated mode slaving to the telescope. The control system includes weather station, monitoring system and extra sensors to provide unattended observations. The utilized software application is designed based on Python and comprises necessary self-decision making codes for protection. Therefore, the developed hardware and software environment allow more efficient remote control without physical attendance.

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Europlanet Telescope Network for promoting international collaboration

Prof. Grazina Tautvaisiene

Vilnius University

Abstract

The Europlanet Telescope Network (EPN-TN), launched in 2020, is a network of small and medium size telescopes. The EPN-TN currently comprises 18 observatories with 46 telescopes ranging from 40 cm to 2 m in size. The network is open for new infrastructures. Observatories from Africa are particularly welcome. In 2024, the network is entering a new sustainable operation phase after the end of EC funding via the Europlanet 2024-Reseach Infrastructure project. The network is fostering the international collaboration. Majority of the observatories provide free of charge observing time for the collaborative projects. The overview of the network and success stories will be presented.

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Light pollution trend at the Kottamia Astronomical Observatory

Mr. Mohamed Aboushelib[1], Prof. Abdel Fady Morcos[1], Prof. Samir Nawar[1], Prof. Osama Shalabiea[2], Prof. Zainab Awad[2]

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Abstract

Light pollution is a major concern for many scientists, especially astronomers. Astronomical observatories are usually built in remote locations away from cities to avoid the impact of artificial light, but since 1970s, light pollution has started to become a threat due to development and urbanization. Kottamia Astronomical Observatory in Egypt has one of the largest telescopes in Africa and the largest in the Middle East and North African region. Due to the constructions of the new cities near the observatory since 1992, the night sky brightness at the Kottamia observatory has changed due to the light glow resulting from these cities. In order to study the impact of artificial light on the Kottamia observatory, the sky brightness variation is obtained for the interval between 2012 to 2023 using VIIRS/DNB onboard Suomi NPP satellite. The light pollution trend over the Kottamia observatory was studied and the effect of each city's artificial light was addressed through the same interval. The data showed that light pollution at the Kottamia site has been increasing since 2013 mainly due to the sky glow from New Cairo and the New Administrative Capital cities. During the last three years, the sky brightness at the Kottamia was found to be decreasing which is a result of replacing the low and high pressure sodium lamps with warm light-emitting diode lamps which is not detected by the satellite's sensor. We believe the artificial light at the Kottamia observatory will get worse in the near future which requires immediate action.

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Characterizing and Comparing Astroclimatic Parameters in the free Atmosphere of the MENA Region Through NCEP/NCAR Reanalysis: A Comparative Study

PhD Youssef Hach[1], PES Zouhair Benkhaldoun[1], PA Mohamed Sabil[2], PES Abdelhadi Jabiri[1]

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Abstract

In the absence of in situ measurements, it is crucial to develop analytical tools that enable large-scale site prospecting. Here, we present a study conducted in our laboratory aimed at contributing to the selection efforts of the best possible astronomical observatory sites in the MENA region.

Accurate characterization of wind distributions and optical turbulence is essential for selecting suitable astronomical observatory sites.

This research presents two studies focusing on the characterization of astroclimatic parameters using NCEP/NCAR reanalysis data spanning two time periods: a 5-year period from 2011 to 2015, and a period of 2011 year extending Junuary 1 to December 31. **The first study aims to characterize astronomical sites in the MENA region by conducting a comparison based on meteorological parameters such as wind speed, its direction, pressure and temperature. Statistical analysis of 200-mbar wind speed averages across various MENA locations reveals the same seasonal behavior for Mishbah and Shams sites with the lowest values in summer and the highest values in winter. In contrast, the mid-latitude sites, Aklim and Chelina, present an inverse seasonal behavior .**

The second study focuses on the same six MENA sites from the main list and delves into additional aspects related to atmospheric turbulence. Indeed, we examined the integral parameters and the statistical analyzes reaveled promising values for the Deiba site which recorded a value of 8.77 ms for the coherence time and 1.54 arcsec for the isoplanatic angle. In addition, a good average seeing of 0.50 arcsec was recorded for the Aklim site.

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Building large Telescopes and Site Tests

Prof. Abd El Fady Morcos

National Research Institute of Astronomy and Geophysics. The National Committee for Astronomy and Space, Acadmy of Scientific Research and Technology

Abstract

Site selection is an extensive multi-disciplinary effort integrating astronomical, environmental, geological, and social factors. Many researchers conducted to optimize location choices incorporates Multicriteria Decision Analysis (MCDA), utilizing techniques such as Geographical Information Systems (GIS) and the Analytic Hierarchy Process (AHP) for the evaluation of potential sites. But no one can neglect the key considerations and methodologies adopted for site selection, with a primary focus on ten criteria detailed in studies: sky transparency, night-sky brightness, photometric night fraction, light pollution, altitude, terrain slope, accessibility, seismic vulnerability, wind speed, and land use/land cover. The integration of satellite-based spatial data and GIS in MCDA provides a dynamic approach to assessing geographic variables over wide spatial extents. Global efforts also include the development of an Astronomy Suitability Index (SIAS) designed to enumerate and contrast site potential globally, guiding global and regional astronomical communities. Adoption of these methods offers a refined procedural blueprint essential for astronomers, institutions, and governments seeking to enhance celestial observations by selecting optimal sites for optical-astronomical observatories.

Nowadays, The National Research Institute of Astronomy and Geophysics (NRIAG) at Egypt starts the first step in establishing a new observatory at Sinai. The previous technique may be followed on the chosen place to perform the (ELOT).

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The Lalibela , Ethiopia Infrared and Optical Telescope Site Test Status and Future Science plan

Dr Solomon Tessema[1,2], Dr Yikdem Mengesha[3], Mr Dereje Getachew[4], Ms Nigest Getachew[5]

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Abstract

The Ethiopian Infrared and Optical Telescope project is Located at Mount AbunaYosef, approximately 50 kilometers away from the revered old city of Lalibela—named for the Zagwe monarch Gebre Mesqel Lalibela of the 12th century. One of Ethiopia's northern most World Heritage Sites and popular tourist destinations. Another project that will advance deep space exploration and astronomy study in Africa, the Northern and Southern Hemispheres, and beyond is the Lalibela Infrared and Optical Telescope (1–5 meters) and above telescope project. Preliminary research conducted in the vicinity of Lalibela indicates that the following are potential: Mahe Terara, Gashena district; Mount AbuneYosef, Lasta district (4280 m above sea level); and Mount Abohaye gara, Gidan district (4140 m above sea level). It is expected to be one of the best astronomical research sites next to Chile and Hawaii. The project is owned and financed by a Consortium of Universities mainly Bahir Dar University, University of Gondar, Mekele University, Woldia University, Ethiopian Space Science Society, and Amhara Regional State and is open for international and contented universities and research institutes to join the consortium. The project will boost and add the impact of astronomical infrastructure on African socio-economic and environmental development in knowledge, technology transfer science discovery, and equally use of resources in space.

Keywords: Lalibela: Infrared, optical telescope; site test; science discovery

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Current and Future Plans for Observational Astronomy in Egypt

Prof. Somaya Saad, Dr Mohamed Darwish

National Research Institute of Astronomy and Geophysics, NRIAG

Abstract

Between the current 74 inches and future 30-40 meter class telescopes, we are in Egypt absolutely need telescopes with at least aperture not less than 6 meter. A 6.5m telescope concept was proposed in Egypt, the telescope needs to be with multi-functions of imaging, spectroscopy (optical + near-IR). The future Scientific plans is to sharing in international projects of observational cosmology, putting programs for observing extra solar planets (exoplanets), imaging and analyzing data of very faint objects and third bodies types detections ..etc.

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Egyptian Large Optical Telescope (ELOT): An Update

Prof. Yosry Azzam

National Research Institute of Astronomy and Geophysics

Abstract

As a result of constructing the new Egyptian administrative capital near the Kottamia observatory, the Egyptian astronomical society asked for another site for building a new telescope which was approved by the government. The new telescope is expected to have a 6.5-m aperture.

Although modern large ground-based telescopes are complex and requires expensive pieces of research equipment, a crucial part of their design and effectiveness are affected by their location. Future Egyptian Large Optical Telescope (ELOT) is expected to help astronomical community in Egypt and worldwide to fill the observational gab between Europe in the north and South Africa in the south and between Asia at the east and Chile at the west.

Two sites have been selected which are good candidates for astronomical sites based on some physical and meteorological parameters using satellite data. The first site is located at south of Senai Peninsula, while the other is located near red sea northwest of Hurghada city. Although the prevailing meteorological conditions over these two sites have been investigated (noticed very similar to each other) and found suitable to install ELOT on, the red sea site has been lately excluded due to its terrain difficulties and the fear of urban and touristic extensions. As a result, characterization of Sinai site using specific instruments has started.

In this talk I will introduce the recent updates in the site selection and testing process along with the difficulties and challenges facing the process towards constructing of the Sinai observatory.

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Establishing the scientific and technical aspects of a future astronomical observatory project

Dr. Warren Skidmore

Thirty Meter Telescope

Abstract

I will present the process for identifying the high level design concept of an observatory and the observing capabilities that it should provide based on the science that the observatory's user community wants to do. I cover the process of collecting the science cases, development of technical requirements, including the qualities of the ideal site and how they could be assessed, and about construction and operation considerations. These processes are relevant to establishing any upcoming project and aligning the technical and scientific aspects of the project for rigorous project management and systems engineering practices.

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Protecting optical observatory sites from the growing satellite constellation interference

Dr. Constance Walker

IAU CPS. NSF's NOIRLab

Abstract

The deployment of communication satellite constellations in Low Earth Orbit (LEO) may represent a valuable step forward in improving world connectivity. However, the sun-reflected luminosity and radio-frequency emissions from a large number of satellites can have a serious impact on astronomical observations, as well as on the pristine appearance of the night sky. In recent years, various strategies for co-existence in terms of optical astronomy have been developed. There are now better models and data for satellite brightness, which are key to enabling mitigation, active avoidance, or use in compliance checks. Future observations of commercial LEO satellites will determine, for instance, whether some coatings and Bragg mirrors on reflective surfaces of Starlink satellites will help and how well. For spectroscopy, better modelling and understanding of satellite spectra will enable the emission from satellites to be calibrated out of astronomical data. Autonomous imagers on large spectroscopic facilities can help identify when an exposure was contaminated. For observatories, there are software solutions for streak detection and elimination that may help. During the presentation, we will discuss mitigation strategies through software and observation and provide updates in the areas of policy, industry and community engagement, some of which is being led by the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference.

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Korea Microlensing Telescope Network (KMTNet) for Multi-Messenger Astronomy: Key Results and Future Prospects

Professor Myungshin Im

Seoul National University

Abstract

Korea Microlensing Telescope Network (KMTNet) is a network of three 1.6-m diameter wide-field optical telescopes operated by the Korea Astronomy Space Science Institute. One of the three KMTNet telescopes is at the South African Astronomical Observatory. Here, we describe our collaborative efforts using this facility. Notable activities are the optical follow-up observations of transients such as the gravitational-wave sources and the KMTNet Synoptic Survey of Southern Sky (KS4), a BVRI imaging survey of the southern sky with few previous imaging coverages to provide reference images for future transient studies. We will describe KS4 and KS4 research highlights, including transient science, high redshift quasar, and galaxy cluster searches. We will also present our network of telescopes worldwide and the 7-Dimensional Telescope, a new multiple telescope system capable of performing time-series spectral mapping of the sky that started its operation in October 2023. We will discuss how we might be able to promote multi-messenger astronomy and other science collaborations through these facilities with observatories in South Africa and other African countries.

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The Benefits of the Virtual Observatory to Under-served Communities

Dr Bruce Berriman

Caltech/IPAC-NExScI

Abstract

The Virtual Observatory (VO) is a global ecosystem of interoperating services that connect worldwide data archives. The VO is implemented in all major astronomy archives through common interfaces developed by the 22 members of the International Virtual Observatory Alliance (IVOA). It was founded in 2002, and the latest members, the SKA Observatory and the Kazakhstan Virtual Observatory, joined in 2022. The VO offers access to data on FAIR principles and from its inception has supported Open Science. The VO acts a democratizing influence in astronomy: it provides equal access to worldwide public data sets to under-served communities as to large data centers, and enables international participation in scientific research and education. Thus astronomers from many different communities are positioned to participate in the big science questions emerging in astronomy in the 2020s, such as the interpretation of transient sources that will be measured in forthcoming missions such as Rubin. In addition, the IVOA has signed an MoU with the IAU Office of Astronomy for Development (OAD). Under this MoU, IVOA members took part in "Astronomy from Archival Data" which involved Educational Activities for Under-Graduate and Post-Graduate Students organized by Dr Priya Hasan. The IVOA plans to participate in future such educational events. The presentation describes how new communities may participate in Virtual Observatory science and educational activities. These include practices for developing VO-compliant data centers and archives, and education and training of developers and end users.

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The Whole Earth Telescope and Stellar Seismology

Dr. Judith Provencal

University of Delaware. Mt. Cuba Astronomical Observatory

Abstract

The Whole Earth Telescope (WET) is an international collaboration of astronomers dedicated to the study of pulsating stars, with a focus on white dwarf stars. The WET was established in 1986 in the dawn of the development of the field of asteroseismology Asteroseismology uses the pulsation frequencies of a star as benchmarks to peer beneath the stellar surface and reveal interior structure, mass, rotation, and the possible presence of magnetic fields. The goal of the WET is to use the rotation of the earth as a platform hosting multiple ground based observing sites distributed in longitude to obtain 24 hr, continuous coverage of pulsating stars. The objective of continuous coverage is to eliminate aliases and resolve multiperiodic variations into their individual components. Accurate frequency identification is a vital component required for the success of asteroseismology. Ground based collaborations like the WET have a role to play in the age of space based missions such as TESS and the Vera Rubin telescope. This presentation will give an overview of the WET, the success of asteroseismology of white dwarf stars, argue for the importance of coordinated networks of small to moderately sized ground based telescopes, and present plans for the futures.

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BRICS Southern Observatory (BRICS-SO) Project: Invitation to African countries to invest in Chile

Dr Massinissa Hadjara[1,2,3], Dr. Amokrane Berdja[4], Dr. Swagat Ranjan[5], Dr. Elisson de Almeida[6], Prof. Slobodan Jankov[7], Prof. Vladmir Lukin[8], Dr. Abdelkarim Boskri[9], Prof. Zouhair Benkhaldoun[9], Mr. zheng jinghui[10]

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Abstract

Recently, the BRICS countries created a promising astronomy consortium, which was joined last year by some emerging countries, including two African countries, namely: Egypt and Ethiopia. Certainly, other African countries will join BRICS+ in the years to come. Thus, by pooling their efforts, emerging countries (BRICS+) are sure to quickly catch up with their technological delay in the field of astronomy, particularly through ambitious and large-scale projects.

Chile, due to the exceptional climatic conditions of its North, is recognized as the world capital of astronomy where all the largest consortia have settled there and applied all their know-how.

The official launch of BRICS (and then its expansion to other countries; BRICS+) is welcomed as an excellent opportunity to think big in the development of astronomy. China showed great determination by being the first southern country to settle by force and astronomical means in Chile, thus opening a possible opportunity for BRICS+ astronomers.

Ambitious astronomical instrumentation is essential for the future of Astronomy and Astrophysics. Access to existing facilities is becoming more and more difficult because of saturation. Existing programs like the VLT-I/ELT and their instruments necessitated decades of collaboration between international institutions. It is therefore necessary for the BRICS+ astronomical community to collaborate together on

ambitious projects without wasting time in order to offer a new pole with new opportunities for the researchers. This pole (BRICS-SO), in addition to attracting highly qualified people, will also help train new generations in all our countries, and encourage exchanges and collaborations.

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Uzbek-Indian Cooperation in Astronomy: Opportunities for Expansion to Africa

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

The connection between the astronomy of Uzbekistan and India can be traced back to ancient times: in particular, the experience of the *Ulugbek Observatory* in Samarkand was used during the construction of the *Jantar Mantar* observatories in India. A new stage of active cooperation began in 2021 with a three-year project to search for and study variable stars in clusters, associations and beyond, supported by the Ministries of Science and Technology (India) and Innovative Development (Uzbekistan). The project initially involved the Aryabhatta Research Institute of Observational Sciences (*ARIES*) on the part of India and the Ulugh Beg Astronomical Institute on the part of Uzbekistan. As for the scientific part of the project, time-domain observations of 15 star clusters, 14 cataclysmic and a number of other variables (flare star, novae, supernovae, binaries, etc.) were carried out, some of the results of which have already been published in peer-reviewed journals. During long trips to *ARIES*, young Uzbek astronomers gained experience in observations with their 3.6-meter active telescope (a similar 4-meter telescope is planned to be installed in Uzbekistan). The Indian Institute of Astrophysics, Tata Institute of Fundamental Research, CRIST University, etc., who intend to create a modern polarimeter for Uzbekistan, have expressed a desire to join the next stage of cooperation from India. The experience of our cooperation will be useful for African astronomers. We are also open to joining them in cooperation, which subsequently, after the completion of the 70-meter radio telescope in Uzbekistan, can become multi-wave.

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The Oukaimeden observatory and its operation in robotic and remote mode: An inspiration for the creation of other similar observatories in several African countries.

Professor Zouhair Benkhaldoun

Oukaimeden Observatory, Cadi Ayyad University, Marrakech Morocco. High Energy Physics and Astrophysics Laboratory (LPHEA), faculté of Science Semlalia, Cadi Ayyad University, Marrakech Morocco

Abstract

The Oukaimeden Observatory represents a pioneering model in astronomical research, operating with unparalleled efficiency in both robotic and remote modes. Its distinctive features, including cutting-edge robotic systems and remote operation capabilities, set it apart as a beacon of innovation in Africa's scientific landscape. This abstract highlights the observatory's exceptional achievements and its role as a catalyst for scientific collaboration and capacity building across the continent. Through strategic partnerships, workshops, and seminars, the observatory fosters the growth of scientific communities beyond its borders, contributing to a vibrant ecosystem of astronomical research in Africa. Furthermore, its strategic location in the High Atlas Mountains provides optimal atmospheric conditions for celestial observations, enhancing the quality of data collected. By sharing insights and best practices with international partners, the Oukaimeden Observatory exemplifies the transformative potential of scientific collaboration in advancing our understanding of the universe. As a speaker invited to this international conference, I am honored to present the Oukaimeden Observatory as a shining example of scientific excellence and innovation in Africa, inspiring the creation of similar observatories and fostering a new era of astronomical exploration on the continent.

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An overview of the South African Astronomical Observatory (SAAO) telescopes

Dr Rosalind Skelton

South African Astronomical Observatory

Abstract

I will provide an overview of the telescopes owned, operated and hosted by the South African Astronomical Observatory, a national facility of the National Research Foundation of South Africa, at the observing site near Sutherland in the Northern Cape of South Africa. This includes the Southern African Large Telescope (SALT), 3 SAAO 1-m class telescopes and a number of international hosted facilities, many of which have data and time-sharing agreements with the SAAO. I will describe recent updates, and ongoing projects to upgrade the instrumentation and functioning of the telescopes with a view to enabling intelligent automated follow-up of transients in the era of large surveys like the Rubin Observatory's LSST and the SKA.

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Site Testing at Tassemit Mountain, Morocco: Atmospheric Parameters Analyzed Using ERA5 Data

Professor Mohammed SABIL[1], Dr Tarik Mouhtafid[2], Pr Zineb Ihssane[2], Pr Elarbi SIHER[3], Professor Zouhair BENKHALDOUN[4]

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Abstract

In addition to the Oukaimeden Observatory for VLT and the Aklim site for the European Extremely Large Telescope (E-ELT), which have been selected for site testing campaigns, we introduce a promising new astronomical site: Tassemit, situated in the High Atlas Mountains of Morocco. Tassemit is located at geographic coordinates 32°18'0" North and 6°15'0" West, boasting a large plateau at an altitude of 2300m.

This study begins with a comprehensive introduction to the Tassemit site, followed by a detailed statistical analysis of key meteorological parameters including air temperature, barometric pressure, relative humidity, and wind speed and direction. These crucial data points are derived from the ECMWF Reanalysis v5 (ERA5).

Moreover, the study delves into the analysis of parameters such as Cn2, free Seeing, Coherence time, and isoplanatic angle, spanning a period of 10 years. The initial findings underscore the potential suitability of the Tassemit site for future astronomical observations.

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

1615

Stellar-scale astrophysics with optical telescopes using HBT interferometry

Dr Michael Backes[1,2], Dr Jonathan Biteau[3], Dr Colin Carlile[4], Dr Hambeleleni Davids[1,2], Dr Dainis Dravins[4], Mr Michele Fiori[5], Dr Tarek Hassan[6], Dr Eli Kasai[1], Dr David Kieda[7], Dr Michael Lisa[8], Dr Prasenjit Saha[9], Ms Naomi Vogel[10], Dr Roland Walter[11], Dr Luca Zampieri[5], Mr Andreas Zmija[10]

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Abstract

The Hanbury Brown and Twiss (HBT) effect is a basic process in quantum optics, but it was actually developed (in the 1950s) in the context of stellar astrophysics. Recent years have seen rapid developments in using the HBT effect to resolve mas and sub-mas scales in stars (commonly referred to as stellar intensity interferometry) through deploying new-generation photonics and electronics to existing optical focal planes, even with very modest image quality. A good example are recent measurements of sub-mas stellar diameters from H.E.S.S. in Namibia (which is primarily a gamma-ray telescope, but can also operate as a stellar intensity interferometer at visible light). Observations in stellar astrophysics have so far been overwhelmingly spectroscopic, and hence the availability of spatial resolution opens up many new research opportunities. Almost any optical telescope can contribute to the new research questions (i) by providing simultaneous spectroscopic observations, especially in the case of interacting systems, or (ii) by deploying suitable instrumentation along with another nearby telescope, to carry out stellar intensity interferometry, (iii) similar, but using multiple segments of a single large telescope.

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The Southern African Large Telescope: Governance and Future Initiatives

Professor Brian Chaboyer

Southern African Large Telescope. Dartmouth College

Abstract

The Southern African Large Telescope (SALT) is a 10-meter optical telescope located in Sutherland, South Africa. SALT is an private South African corporation with a number of institutional shareholders from 5 different countries. The governance of the telescope was specified by a shareholders agreement, signed in 2001 by the institutional shareholders and updated on occasion. The shareholders funded the construction of the telescope, and continue to fund its operations. The telescope is operated by the South African Astronomical Observatory (SAAO) under an operations agreement between SALT and SAAO. In my presentation, I will discuss the corporate governance structure of SALT, highlight SALT's strategic vision for the next 10 years, and opportunities for investments by new institutions.

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The ATOM telescope: Enabling simultaneous multi-frequency observations throughout the entire electromagnetic spectrum in Africa

Prof. Stefan Wagner, MSc Felix Jankowsky

LSW, ZAH, U. Heidelberg

Abstract

The ATOM (Automated Telescope for Optical Monitoring) telescope, a fully robotic 0.8m telescope, co-located with the HESS Gamma-ray telescopes in Namibia has been used to enable simultaneous optical and gamma-ray observations with HESS and to provide triggers for time-domain studies. Its operations are extended to facilitate joint time-domain programs with MeerKAT+ observations and will thus serve for radio-optical-gamma ray monitoring and ToO observations.

The telescope is equipped with a multi-purpose instrument, enabling simultaneous multi-band observations, polarimetry or high-time-resolution monitoring, facilitating a wide range of science use-cases in time-domain studies.

This presentation describes the operations principle, the versatility of robotic observations of all instrument modes, dual-way trigger communication with facilities in other waveband regimes and operation experience from the past 15 years of operations.

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Upgrading Helwan Satellite Laser Ranging Station in Egypt, Past and Future.

Dr. Mohamed Helali[1], Prof. Makram Ibrahim[2], Ass. Prof. Ahmed Magdy[3], Dr. Shafeeq Abdalazeez[3]

[1]National Research Instirute of Astronomy and Geophysics (NRIAG), Helwan - Egypt. [2]National Research Institute of Astronomy and Geophysics. [3]National Research Instirute of Astronomy and Geophysics

Abstract

Since the seventies of the last century Helwan SLR station instruments, which is a member of the International Laser Ranging Service ILRS network have been upgraded many times Starting from photography of Satellites with respect to the background stars using the Russian AFU and NAFA cameras passing through Ruby Laser along with a photomultiplier tube with Cesium clock, Nd: YAG laser with GPS and Photon Interval Counter to until the year 2007. Then, a wholly new Station has been built near by the old one at NRIAG, Helwan Egypt during the last three years in cooperation with the Chinese Observatories which is planned to start operation and observation of Satellites and space debris in 2024 both by laser and Electro - Optical telescopes. An Introduction, comparison, and future of both stations are shortly presented in this paper.

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Towards Improved EHT Observations: Measuring Precipitable Water Vapour at Potential Sites for the AMT in Namibia.

Mr. Francisco Fenias Macucule[1,2,3], Prof. Michael Backes[1]

[1]University of Namibia. [2]University of South Africa. [3]Associacao Mocambicana de Astronomia

Abstract

The first images of the shadow of the central black holes in the radio galaxy Centaurus A and in our own Milky Way, by the Event Horizon Telescope (EHT), opened a new window of research into active galactic nuclei (AGN) as well as into black holes. Soon it became clear that for improved image quality particularly also temporal resolution, additional telescopes would need to be added to the EHT network of telescopes. The Africa Millimetre Telescope (AMT)
will close this gap by being the first telescope in Africa to observe at millimetre wavelengths and, by that, will enable imaging of Sgr A∗ with the "Eastern" sub-array of the EHT. Beyond those VLBI observations, the AMT will also operate as a single-dish telescope for flux monitoring of AGN and transient science. Observations at millimetre wavelength are strongly influenced by the amount of precipitable water vapour (PWV) in the atmosphere. Here we present the current status of investigations of the PWV content of the atmosphere at the H.E.S.S. and Mt. Gamsberg sites in Namibia.

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South African Astronomical Observatory: The Intelligent Observatory

Prof. STEPHEN Potter[1,2], Dr Sunil Chandra[1], Dr Nicolas Erasmus[1], Mr Roufurd Julie[3], Mr Moloko Hlakola[1], Dr Carel van Gend[1]

[1]South African Astronomical Observatory. [2]University of Johannesburg. [3]South African Radio Astronomical Observatory

Abstract

The South African Astronomical Observatory (SAAO) envisions an Intelligent Observatory (IO) to elevate scientific support for the astronomical communities in South Africa, Africa and beyond. This necessitated strategic technological advancements, including the automation and remote operation of telescopes, alongside a comprehensive redesign of the existing Sutherland operations model. While time-domain and transient science serve as the primary research drivers, all other domains within astronomy will also see significant benefits from these advancements.

As of late 2023, Phase 2 of the program is underway, focusing on developing an upgraded operations model that facilitates collaboration and automation, with a particular emphasis on automating data products. Furthermore, our vision is to expand our Intelligent Observatory network by including additional facilities across Africa and perhaps beyond. This presentation will not only review the achievements of Phase 1 but also delve into the initial results of Phase 2.

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Beyond Borders: Fostering Collaboration and Building Capacity in African Astronomy through SALT

Dr Encarni Romero Colmenero

SAAO. SALT

Abstract

The Southern African Large Telescope (SALT) has opened access to African astronomers through South Africa's share of telescope time. This initiative included workshops on how to create proposals, define observing blocks and reduce the data. We provide an update on recent exciting developments at SALT and explore the transformative potential such access holds for advancing astronomical research across the African continent.

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2257

Ground-based optical telescopes in Africa for attaining the UN sustainable development goals

Dr. Mirjana Povic

Space Science and Geospatial Institute, Ethiopia

Abstract

Astronomy is one of the leading sciences in the development of education, other fields of science, technology and innovation. It is therefore key to combating poverty in the long term and achieving the UN Sustainable Development Goals (SDGs). Africa has amazing potential due to its natural and human resources for scientific and infrastructure development in astronomy. The status of astronomy in Africa has changed significantly in recent years, becoming an emerging field across the continent, and never before has it been possible to use astronomy for development as it is today. This talk will summarise the current state of astronomy in Africa, focusing in particular on optical astronomy and optical telescopes, and how they can be of fundamental importance for achieving in the long term the UN SDGs for the benefit of our society as a whole.

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Development of a renewable-based hybrid generation microgrid system with energy storage and intelligent control for the new Egypt large optical telescope astronomical observatory

Dr Mohamed Abdelkareem, Research Professor Yosry Ahmed

National Research Institute of Astronomy and Geophysics (NRIAG)

Abstract

Egypt is working on establishing a giant astronomical observatory in Sinai. It will involve the largest optical telescope in the North Africa and Middle East area having a main mirror of diameter 6.5 m. Consequently, to establish a new green energy-based astronomical observatory a hybrid generation microgrid system (HGMS) model encompassing solar Photo Voltaic (PV) generation system, Energy Storage System (ESS), and Diesel Engine Generation (DEG) system with intelligent optimal controllers empowering the new Egypt Large Optical Telescope (ELOT) is proposed in this research work. A detailed study of the solar PV generation system components, specifications, and sizing is introduced. As well, intelligent optimal controllers are designed by applying innovative optimization algorithms. The system performance is validated under several eventualities, including solar radiation, wind speed variations, as well as fluctuations of load. The system dynamic response and simulation results show that the proposed microgrid hybrid generation system and the optimized control scheme effectively reduce deviations in an acceptable very short time. For more validation, comparisons will be instigated.

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Using a 40-cm optical telescope in Kenya for NASA's DART mission support and teaching

Dr Cyrielle Opitom[1], Prof Colin Snodgrass[1], Acacia Leaky[2], Woto Huka[2], Richard Vaughan[3], Prof Melvin Hoare[4], Prof Paul Baki[5], Vincent Okoth[1], Dr Jamie Robinson[1], Léa Ferellec[1], Abbie Donaldson[1], Dr Samuel Jackson[6], Dr Willice Obonyo[5], Rashid Shishia[5], Calvince Juma[5]

[1]Institute for Astronomy, University of Edinburgh. [2]Turkana Basin Institute. [3]KOTI. [4]University of Leeds. [5]Technical University of Kenya. [6]Open University

Abstract

With its rare combination of equatorial location and abundance of arid areas with dark skies, Kenya presents huge opportunities for optical astronomy. In 2022, a team from the University of Edinburgh joined forces with the Kenya Optical Telescope Initiative to install a 40-cm optical telescope near Lake Turkana, on the site of the Turkana Basin Institute in Ileret. The telescope was originally installed to perform observations of the NASA DART mission's impact with an asteroid. The installation was successful and due to Kenya's privileged location and the lack of nearby professional optical observatories, the observations performed were among a few to capture the event live.

This telescope remains the largest optical telescope in Kenya and was subsequently used to train African students, adding an optical astronomy component to the Development in Africa with Radio Astronomy (DARA) training programme, which will continue for the next few years. Efforts are also under way to identify a more permanent observatory site in northern Kenya, including testing of several nearby mountaintops, with the long-term objective to install a robotic 1m-class telescope.

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2402

SKA Observatory: opportunities for Africa and challenges with new large satellite constellations

Federico Di Vruno

SKA Observatory

Abstract

This talk will describe the SKA Observatory in its first Phase and in particular the ongoing construction of the SKA-Mid telescope in South Africa and the plans to extend it to other African countries, highlighting some of the positive impacts that the observatory had in South Africa. For the second part of the talk I will describe how the current deployment of large satellite constellations is presenting an ongoing challenge to the SKAO due to radio frequency emissions and other optical telescopes by reflection of sunlight. To finalize I will describe how the SKAO, together with other astronomy organisations including the IAU are working at the UN level to support better regulation and mitigations and show the collaboration with SARAO and the South African administration is addressing this issue at the national level.

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2410

Dark Sky Protection in South Africa - a Potential Model for Other Observatories in Africa

Dr Ramotholo Sefako

South African Astronomical Observatory

Abstract

The South African Astronomical Observatory (SAAO) is a premier optical astronomy research facility on the African continent, and the national centre for optical and Infrared astronomy in South Africa. It is home to over twenty individual national and international telescopes, including the Southern African Large Telescope (SALT), the largest optical telescope in the Southern Hemisphere. It is one of the observatories with the darkest night skies in the world. I will give an overview of the measures that are in place to protect the dark sky resources at the SAAO, including some details about the existing legislation (the AGA Act, No. 21, of 2007) and related astronomy protection regulations and prohibitions around what is called the Sutherland Central Astronomy Advantage Area (SCAAA). I will also give some details on the challenges related to the implementation of the regulations and prohibitions, as well as the complexities related to the enforcement of compliance of these regulations within the SCAAA. Astronomy Management Authority (AMA), an entity within the Department of Science and Innovation (DSI), supported by the NRF-SAAO, is responsible for monitoring and enforcement of compliance within the SCAAA.

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2442

Impact of Meteorological and Seismological Parameters on Telescope Site Selection: A Case Study in Egypt

Dr Mohamed Darwish

National Research Institute of Astronomy and Geophysics (NRIAG)

Abstract

Selecting an optimal site for astronomical observatories is crucial for achieving high-quality observations and advancing scientific research. In this study, we investigate the influence of meteorological and seismological parameters on telescope site selection, focusing on a case study in Egypt. Through comprehensive analysis and modeling, we assess various meteorological factors such as Air Temperature, Relative Humidity, wind patterns, and Aerosol Optical Depth as well as seismic activity and ground stability. Our research integrates remote sensing data, and geological archives to evaluate candidate sites for astronomical observations in Egypt. Additional, Light pollution over the candidate sites was measured using the Visible Infrared Imaging Radiometer Suite (VIIRS) day/night band. By examining the interplay between meteorological and seismological conditions, we aim to identify mountains with favorable conditions for telescope installations, considering both short-term weather variations and the seismic history. The findings of this study provide valuable insights for astronomers, site planners, and policymakers involved in the establishment of observatories, contributing to the advancement of observational astronomy in Egypt and beyond.

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2672

Japanese collaboration with universities for ground-based optical/infraredobservations

Yumiko Oass

Saitama University

Abstract

In Japan, optical and near-infrared observations have been carried out using a variety of small to large telescopes, notably the Subaru Telescope.

The inter-university collaborative project "Optical and Infrared Synergetic Telescopes for Education and Research (OISTER)" between nine universities and the National Astronomical Observatory of Japan (NAOJ) is particularly distinctive.

Its principal scientific goals are observational studies in optical/near-infrared regimes for the optical counterparts of the gravitational wave and/or neutrino sources, as well as various other transient and astrophysical phenomena.

The additional objective is to nurture highly-skilled youths by offering opportunities for undergraduate/master/Ph.D. students to engage in not only extensive science activities but also productive educational programs, including on-site observations and instrumentation experiences.

This talk will feature a presentation of these Japanese projects.

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Night-sky brightness measurements towards the Namibian Multi-Wavelength Observatory

Prof. Michael Backes

Department of Physics, Chemistry & Material Science, University of Namibia. Centre for Space Research, North-West University

Abstract

Namibia has hosted the first IDA Dark Sky reserve in the Southern Hemisphere and is host to the High Energy Stereoscopic System, H.E.S.S., the world-leading gamma-ray telescope. In this presentation, measurements of the night-sky brightness close to the H.E.S.S. telescopes and the idea to establish the Namibian Multi-Wavelength Observatory will be discussed.

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2733

Observations and user support at intermediate-sized and large optical telescopes: a detailed comparison.

Dr Igor Chilingarian

Center for Astrophysics | Harvard and Smithsonian

Abstract

For over a decade I have been providing scientific support for the users of the 6.5-m MMT telescope operated in Arizona. In parallel, I carried out my own observational campaigns in the optical/near-infrared, largely related to studies of galaxies and their central black holes. In this presentation I will review my personal experience of observing at many world's largest ground-based observatories (Keck, VLT, Gemini, Magellan, MMT) as well as with some intermediate-sized 2-4m class telescopes. I will compare the level of user support provided by different observatories at different stages of observational projects, from designing a project and carrying out observations to scientific data reduction. In my opinion, the latter stage (data reduction) remains the strongest challenge for the vast majority of observational astronomers and it is the main factor delaying publications.

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2836

Reincarnating and Fully Automating the SALT/SAAO Seeing Monitor, TimDIMM

Dr. Timothy Pickering[1], Dr. Lisa Crause[2], Mr. Nico van der Merwe[3]

[1]MMT Observatory. [2]South African Astronomical Observatory. [3]Southern African Large Telescope

Abstract

The SALT/SAAO seeing monitor, TimDIMM, was initially installed and commissioned in 2010/2011 and has been in operation since then. However, in recent years its hardware began to show its age and it was becoming increasingly unreliable. Work was done over the course of 2023 and early 2024 to replace the camera with a larger, faster, more sensitive CMOS device and replace the mount with one that has more robust internal safety mechanisms. The original, largely bespoke software was completely replaced with an off-the-shelf open source system based on the Ekos scheduler and INDI-compliant device drivers. The new system achieved routine, fully-automated operation in February 2024. Building the software around Ekos/INDI makes it easy to replace/upgrade hardware components of the system with minimal changes to the software. INDI supports a very wide range of hardware and it's rare nowadays for something to not be supported by INDI at all. As such, we have found Ekos/INDI to be a very promising foundation for building automated site testing/monitoring systems.

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2886

The Impact of Small Telescopes on Outreach and Education Activities in Egypt.

Ms. Ola Ali

National Research Institute of Astronomy and Geophysics

Abstract

Egypt's exceptional dark skies present a unique opportunity for astronomical exploration. Despite this, astronomy awareness remains limited, particularly in remote areas. To bridge this gap, the National Research Institute of Astronomy & Geophysics (NRIAG) has undertaken a dynamic initiative utilizing small, portable telescopes for impactful outreach and education programs.

This presentation explores the transformative power of these programs:

- **Sparking Scientific Curiosity:** NRIAG researchers conduct engaging observing sessions, directly involving students in celestial wonders. These programs ignite a passion for science, fostering STEM interest and critical thinking skills. We will showcase specific observing programs and educational activities designed to effectively utilize the telescopes.
- **Empowering Communities:** Telescopes serve as powerful tools for public engagement. NRIAG astronomers organize stargazing events, lectures, and workshops, fostering a deeper understanding and appreciation of science within the community. We will share successful community outreach initiatives that not only promote astronomy but also advocate for dark sky preservation.
- **Building the Next Generation of Scientists:** Smaller telescopes provide invaluable training platforms for aspiring astronomers. NRIAG's programs equip students with observational skills and hands-on experience, nurturing the next generation of scientific leaders in Egypt.

This presentation will highlight successful examples from NRIAG's outreach programs and discuss strategies to maximize the reach and impact of small telescopes. Our goal is to cultivate a thriving astronomy culture within Egypt, where everyone has the opportunity to connect with the wonders of the universe.

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2907

Unveiling the Night Sky: Assessing Light Pollution and Lighting Technologies around Oukaimeden Observatory

Phd Student HAMZA AIT ABDELAALI[1], Professor ZOUHAIR BENKHALDOUN[1,2,3,4,5]

[1]Cadi Ayyad University , Faculty of Sciences Semlalia , PHEA Laboratory. [2]Oukaimeden Observatory Director. [3]President of the Moroccan National Committee for Astronomy (MNCA). [4]President of the Arab Astronomical Society (ArAS). [5]President of Atlas Dark Sky Foundation

Abstract

In recent years,ground-based observatories have grappled with a burgeoning issue: artificial light pollution.This phenomenon has emerged as a significant contributor to the illumination saturating the Earth's atmosphere from celestial sources, exacerbating the challenges faced by these crucial facilities. Understanding the extent of this artificial light intrusion is paramount for observatories to effectively gauge the quality of their observing conditions.
The measurement of night sky brightness (NSB) and the systematic collection of data pertaining to lighting technologies are integral steps in this endeavor. By discerning the proportion of artificial light within the overall optical brightness of the night sky, observatories can better comprehend the scope of the challenge posed by light pollution. Moreover, monitoring NSB not only aids in controlling light pollution but also serves as a vital tool for evaluating the sky's quality for astronomical observations.This study endeavors to elucidate the findings gleaned from a comprehensive assessment of NSB data collected over two years utilizing the CoSQM instrument installed at the Oukaimeden Observatory.Through meticulous analysis, we aim to shed light on the temporal trends and spatial variations in NSB.Furthermore, we endeavor to augment our understanding by compiling data on lighting technologies employed in neighboring municipalities.Gathering measurements of lighting technologies, aims to delineate their respective contributions to light pollution and discern potential strategies for mitigating their adverse effects on astronomical observations.This study serves as a testament to the critical importance of monitoring NSB and assessing lighting technologies in combating LP and safeguarding the integrity of ground-based astronomical research.

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Multispectral analysis of the night sky brightness for the Oukaimeden Observatory, Morocco

Phd Student HAMZA AIT ABDELAALI[1], Professor Zouhair Benkhaldoun[1,2]

[1]Cadi Ayyad University Faculty of Sciences Semlalia PHEA Laboratory. [2]Oukaimeden Observatory Director

Abstract

The expansion of electrification in protected areas where astronomical observatories are installed poses a major problem for astronomers in terms of light pollution impact. Each year, the International Dark-Sky Association (IDA) encourages communities, parks, and astronomers worldwide to preserve and protect the darkness of the sky in their observation locations by imposing strict constraints on lighting practices within these protected areas. Astronomers from the Oukaimeden Observatory, located in the Atlas Mountains region of Morocco, aim to establish an international dark sky reserve around their facilities to enhance and safeguard the quality of their astronomical observations. This study aims to present the current state of the night sky in the region and identify the main sources of artificial light using the latest version of the numerical ILLUMINA model.

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2979

Open-source software for managing telescopes, observatories, and science programs

Dr Mark Bowman

Las Cumbres Observatory (LCOGT)

Abstract

The advent of time-domain astrophysics and surveys generating real-time alerts are driving innovation in how astronomers access and use telescopes. Many require urgent follow-up observations to characterize the event and understand the phenomenon and underlying population. Enabling astronomers to request observations through software facilitates rapid follow-up and broadens access to telescope facilities. However, developing the software needed can require a substantial investment of effort. In this talk, I will present two open-source software packages developed by Las Cumbres Observatory, and general enough to work for any observatory.

The open-source Observatory Control System (OCS) project, provides a suite of software for managing the user-facing operations of an observatory. It includes applications for managing users, science proposals, observing requests, and scheduling observations, as well as storing and accessing science data; enabling easy access to the observatory through a web browser or software APIs. The OCS provides an out-of-the-box observatory control system, with the ability to adapt its behavior to match the specific constraints of a particular institute or telescope. The fully modular design allows an observatory to run only the components they find useful.

The Target and Observation Manager (TOM) Toolkit is a powerful system designed for astronomers to run their observing programs and to interface with other key astronomical services such as data archives, alert brokers, and observing facilities. The OCS integrates easily with the TOM Toolkit.

The OCS and TOM Toolkit are suitable for all observatories from manually-operated individual telescopes to networks of robotic telescopes.

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3001

BLACK HOLE TOM – AN AUTOMATIC TOOL FOR PHOTOMETRIC TIME-DOMAIN DATA

Mr. Przemysław Mikołajczyk[1,2], Prof. Łukasz Wyrzykowski[1], Dr. Paweł Zieliński[3], Mr. Krzysztof Kotysz[2]

[1]Astronomical Observatory, University of Warsaw. [2]Astronomical Institute, University of Wroclaw. [3]Astronomical Institute, Nicolaus Copernicus University Toruń

Abstract

We present a new automatic tool for time-domain astronomy – Black Hole Target Observation Manager (BHTOM) – developed under the OPTICON RadioNet Pilot programme. BHTOM is a coordination tool for a global network of telescopes capable of automated photometric data processing for time-domain and transient targets. The tool has been used to process around 150,000 observations of several hundreds of transients, primarily reported by the Gaia space mission. We demonstrate the main features and use cases of BHTOM and present improvements to be made in the near future. The examples of images and light curves presented here confirm the ability to process CCD/CMOS imaging data from multiple telescopes and a whole variety of instruments in an automatic manner. Our tool is the perfect opportunity to involve smaller observatories into large observing campaigns as our network of telescopes is approaching 100 members.

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From Timekeeping to Sky-Sweeping: The Sociopolitics of Astronomical Observation

Hedy Goodman

Haverford College. St. George's School

Abstract

In an increasingly digitized era of astronomy, the optical observatory remains both understudied and of understated significance. The evolution of its design gave rise to early community models of astronomy and countless subsequent developments in the field. Throughout every external change, its purpose remains consistent as a space designed to observe the Celestial sphere from the sanctuary of Earth. I illustrate this chronologically; first by discussing variations of archaeoastronomical sites, and then transitioning to observatory development, both pre- and post-emergence of the telescope. Two case studies, a pair of present-day ground-based observatories, represent this history in contrasting forms. I consider a model where all modern observatories comprise one, complete spectrum, with Strawbridge Observatory, established 1833, on one end, and the ongoing, yet largely controversial, Thirty Meter Telescope project on the other. I intentionally select two contradictory cases and analyze them sequentially to acknowledge a counterargument to my broader belief. Placing their differences in both form and scientific caliber within the context of time, I draw parallels in the greater architectural processes and developments of observational astronomy. I interpret these patterns as evidentiary to the common foundational model that is rooted beneath all modern variations of the observatory. As such, I propose a model that comprises many observatory styles, yet categorizes them according to purpose. While no two observatories are alike, all of their informed design choices indicate a system of structuralism - and without the astronomer, there would be no brain at all.

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Observing Stellar Occultations in Support of NASA Missions from Africa: Opportunities for African Participation

Anne Verbiscer[1], David Baratoux[2], Marc Buie[3], Maram Kaire[4], Amanda Sickafoose[5]

[1]University of Virginia. [2]French National Research Institute for Sustainable Development (IRD). [3]Southwest Research Institute. [4]Association for the Promotion of Astronomy in Senegal (ASPA). [5]Planetary Science Institute

Abstract

Two NASA missions, New Horizons and Lucy, have conducted extensive campaigns in Africa to observe stellar occultations by their respective flyby targets. Prior to the spacecraft flybys, stellar occultations can provide valuable information about the flyby targets, including size, shape, and albedo, as well as astrometric information to optimize encounter planning. In 2017, the New Horizons Project organized a campaign using portable and fixed optical telescopes to observe a stellar occultation by its flyby target, Kuiper belt object, Arrokoth, from South Africa. New Horizons sent portable telescopes to Senegal to observe another stellar occultation by Arrokoth in 2018. Two of NASA's Lucy mission flyby targets, Trojan asteroids Polymele and Orus, had stellar occultations visible from Senegal in 2020 and 2021, respectively. For each of these four events, local African students and astronomers participated in the campaigns, with support from the Association for the Promotion of Astronomy in Senegal (ASPA) and the African Initiative for Planetary and Space Sciences (AFIPS, africapss.org) for the three campaigns in Senegal. This presentation will summarize the campaign organization, outcomes, and future opportunities to observe stellar occultations from Africa.

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Exploring the Sub-Second Transient Sky with Continuous-Readout Images and Neural Networks

Shar Daniels[1], Federica Bianco[1], Igor Andreoni[2], Ashish Mahabal[3]

[1]University of Delaware. [2]University of Maryland. [3]California Institute of Technology

Abstract

With the novel application of deep learning models to continuously-exposed astronomical data, we are creating tools to discover and reveal the nature of rapidly-evolving optical astrophysical phenomena. Phenomena that vary on this timescale include cataclysmic variables, blazars, occultations by solar system objects, and potentially the optical counterpart of Fast Radio Bursts. Yet, the evolution of optical astronomical phenomena at sub-second timescales is under-explored due to technical limitations in traditional observing modes which require seconds-to-minutes exposure and readout cycles. However, the nontraditional "continuous-readout" mode enables resolution at sub-second timescales by integrating the images of astrophysical objects along one spatial dimension. Analyses of these data require custom pipelines. We are developing neural networks for the analysis of a 450GB continuous-readout astronomical dataset sampled at 300 Hz from the Zwicky Transient Facility (ZTF). This poster will show the performance of CNN and transformer models on the ZTF data and outline our potential for detecting and analyzing rapid transients at scale.

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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The Rubin ToO program: public data open opportunities for involvement in Multi Messenger Astronomy

Dr Federica Bianco

University of Delaware. Vera C. Rubin Observatory

Abstract

The Vera C. Rubin Observatory is planning to enable a Target of Opportunity mode for Gravitational Wave (GW) follow-up, potentially expandable to other science cases. The public nature of the Rubin real-time alert data promises to democratize participation in Multi-Messenger Astronomy (MMA) by providing targets for follow-up observations using spectroscopy and photometry. With an unprecedented combination of large field of view (9.6 square degrees) and depth (r~24), the primary challenge post-Rubin ToOs will lie in sifting through an extensive pool of candidate sources. Wile spectroscopy remains the foremost method for pinpointing the genuine counterparts of GW events, the complementary use of multifilter time-series observations, feasible with smaller telescopes, can also eliminate false positives and reduce the size of the sample requiring spectroscopic follow-up (Bianco+2019, Ofek+2024). I will review the current plan for the Rubin ToO program and discuss how GW electromagnetic counterparts are expected to separate themselves from other transients in spectroscopy and time-evolved photometry

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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A low cost compact optical polarimeter as example of sustainable and accessible instrumentation

Dr Pere Blay, Elisa Nespoli, Vicent Martinez-Badenes, Nestor Sanchez-Doreste

ESICT, Valencian International University - VIU, Valencia, Spain

Abstract

We have designed a compact low-cost versatile optical linear polarimeter, suitable for medium to small sized telescopes, with the scientific goal to perform surveys to characterize the polarimetric properties of the galactic plane. Polarimetric measurements can add important information about the ISM, both in extension and composition, and indirectly about the local structure of the galactic magnetic field. We have developed a simulation package, based on Python HCIpy, that allows to perform instrumental characterization, accompanied by detailed optical analysis with Zemax Optic Studio simulations. The python package will be available via github. 3D printer ready files, to build the instrument container and adaptors, will also be released as well as recommendation on scientific quality optical elements. The whole project description and products will be made available for the scientific community in a way that it can be used as it is or as the baseline for further instrumental research and development.

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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Networking Telescopes: Prospects for Autonomous Follow-up of Discoveries from Future Surveys

David Buckley

South African Astronomical Observatory. Department of Astronomy, University of Cape Town. Department of Physics, University of the Free State

Abstract

In this talk I will outline the plans within the BRICS consortium and also within Africa to network observatories and telescopes for autonomous optical follow-up observations of objects discovered by the up-coming large survey missions. I will review the pioneering SALT transient programme, which since 2018 has been actively engaged in the observing transients across the electromagnetic spectrum. This has included discoveries from the eROSITA X-ray surveys and the Gaia missions. In preparation for the Rubin Observatory's 10-year Legacy Survey of Space and Time (LSST), due to start in 2025, it will be crucial to have automated networks optical telescopes to characterize the nature of new transient and variable object discoveries from the LSST. I will review the aims of a global flagship project, namely the BRICS Intelligent Telescope and Data Network (BITDN), whose aim is to co-ordinate robotic observations utilizing the various facilities available to the BRICS partnership. A similar African initiative – the African Integrated Observation System (AIOS) – will also be described. Both of these build upon the SAAO's Intelligent Observatory project, which will also be briefly reviewed.

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

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An overview of site testing and site characterisation, as applied in the search for an astronomical site in Kenya

Dr Edward Graham[1], Mr Richard Vaughan[2], Dr Acacia Leakey[3], Prof Colin Snodgrass[4], Dr Cyrielle Opitom[3], Prof Paul Baki[5], Ms Susan Murabana[6], Dr Daniel Hillier[7], Mr Daniel-Chu Owen[6]

[1]University of the Highlands and Islands, Scotland. [2]InCA, Nairobi, Kenya.. [3]University of Edinburgh, Scotland. [4]University of Edinburgh, Scotland.. [5]Technical University of Kenya. [6]The Travelling Telescope, Kenya. [7]Head of Public Engagement with National Laboratories

Abstract

Astronomical site characterisation requires an understanding of atmospheric processes across a huge range of scales, extending spatially from millimetres to thousands of kilometres, and temporally from microseconds to decades, or longer. This is because atmospheric perturbations cascade, both upwards and downwards, through the various scales. As a result, astronomical site testing studies must overlap with the domains of (long-term) climate science, (everyday) nowcasting and numerical weather prediction, as well as the finer scales of micro-meteorology and atmospheric observation.

The first global atmospheric models of historic states of the atmosphere, known as reanalyses, became available in the early 2000s. Over the past twenty years these have improved considerably in resolution and accuracy, and today they remain the most accurate and most valuable resource of the synoptic scale climate. High resolution regional models, using reanalyses as boundary conditions, as well as local-scale site specific models have also provided significant advances. However, significant gaps remain in our ability to link up between the various scales of interest, and in the validation of the models with actual observations on the ground.

Beginning nearly two decades ago, the search for an astronomical site in Kenya programme has now reached the stage whereby the best three potential sites in northern Kenya have been identified. Over the coming 1-2 years, we plan to advance the site testing programme by installing automatic weather stations and all-sky cameras at the three candidate sites to directly monitor the weather and to validate met model simulations of their atmospheric conditions.

Session

FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa

Final category: FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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STRENGTHENING UNDERGRADUATE EDUCATION USING REMOTE TELESCOPES

Prof. Paul Baki

Technical University of Kenya

Abstract

ABSTRACT

An overview is given of physics/astronomy undergraduate studies in Kenya using remote telescopes for observations, otherwise known as Astro-lab. We discuss the opportunities and challenges encountered, skills developed and we propose innovative ways of addressing challenges. We have observed that the use of remote telescopes can improve students' scientific abilities, such as inquiry, problem-solving, data analysis, and communication, and increase their interest and motivation in astronomy and STEM fields. Moreover, they promote collaboration and information exchange amongst students and teachers from diverse institutions, regions, and backgrounds, fostering the growth of a global scientific community and culture, as well as diversity and inclusivity in astronomy. In the case of Kenya, remote telescopes are helping us build capacity in multi-wavelength astronomy and also for the Square Kilometre Array project.

The students' projects involved use of robotic telescopes from the Las Cumbres Observatory (LCO) to observe selected eclipsing binary stars. In this paper, we explore novelties, challenges and opportunities for robust science going into the future. We also examine how, through tracer studies, the skill sets acquired are shaping career paths of our graduates.

Session

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Leveraging Ghana's 32-metre radio telescope for astronomy training.

Dr Emmanuel Proven-Adzri, Dr Naomi Asabre-Frimpong, Dr Theophilus Ansah-Narh, Mr Albert Forson

Ghana Space Science and Technology Institute

Abstract

The Ghana Radio Astronomy Observatory (GRAO) has become a training centre for students who yearn for hands-on experience in radio astronomy. The site operates the 32-meter radio telescope which conducts research in 6.7 GHz methanol masers in star-forming regions, pulsars, giant stars, supernova remnants and Active Galactic Nuclei (AGN). During the DARA phase 2 project, it trained about 100 students from, Kenya, Namibia, Zambia, Botswana, Mozambique, Madagascar and Ghana. While at GRAO, the students had hands-on training in telescope observations in single-dish and VLBI modes, data reduction, radio frequency interference (RFI) measurements, and receiver and sun temperature measurements. Table-top radio telescope (TTRT) operation and optical telescope viewing were also part of the practical sessions. GRAO is open to more collaborations to bring its training facilities to a wider audience in Africa and beyond.

Session

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Exploration of spectroscopic techniques for Educational initiatives at the Oukaimeden Astronomical Observatory in Morocco

Phd MOHAMED AMRAR[1], pr Abdelmajid BENHIDA[2], Pr Fouad Sefyani[2], Pr zouhair BENKHALDOUN[1]

[1]Faculty of Sciences Semlalia, Cady Ayyad University. [2]Faculty of Sciences and Techniques , Cady Ayyad University

Abstract

This abstract presents an overview of the primary instruments utilized for acquiring spectroscopic and photometric data at the Oukaimeden Astronomical Observatory (OUKAIMEDEN), along with its pedagogical role in astronomical education. The focus of this poster is twofold: first, the description of the telescopes employed, and second, the educational initiatives facilitated by the observatory.

Situated at an altitude of 2700 meters in the Atlas Mountains, the OUKAIMEDEN Astronomical Observatory (J43) serves as a cornerstone for astronomical research and education in Morocco. As the first university astronomical observatory in the country, it provides a platform for student internships, scientific experimentation, and observation-based learning experiences, thus fostering the development of astronomy within the university and beyond.

At OUKAIMEDEN, the spectro-photometry data acquisition is facilitated by a sophisticated setup comprising two telescopes, namely the C14 Telescope and the ASA 10N Telescope. Additionally, the setup includes two CCD cameras, an injection lens and guiding unit, two optical fibers, a calibration unit, an Eshel spectrograph, and two computers for telescope control and data acquisition. This comprehensive instrumentation enables precise spectroscopic observations essential for various research endeavors.

Beyond research, the observatory plays a crucial pedagogical role, offering practical training sessions local and international high school and university master's students through laboratory sessions and training workshops focused on stellar spectroscopies. Furthermore, educational efforts extend to the detection of exoplanets using the Doppler effect, contributing to the advancement of both theoretical and practical knowledge in the field.

Session

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LCO remote telescopes as an Educational Tool in the study of star clusters

Dr Priya Shah, Prof Syed Najamul Hasan

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In the absence of observational facilities and the era of archival data, students miss out on the opportunity of acess to a telescople, observation strategy and experience in data collection with LCO remote telescopes. To bridge this gap we conducted online and offline workshops where we discussed observations, photometry, plotting of HR diagrams for open and globular clusters. We demonstrated determination of distances and ages of open and globular star clusters.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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Robotic Telescopes in University Education

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

The use of Robotic Telescopes plays a very vital role in Education especially in places where access to telescopes is not possible. We shall describe our experience of the use of LCO Robotic Telescopes in Copperbelt University, Zambia with undergraduate and postgraduate students of Astrophysics. This can be made part of the Astrophysics Lab where students get data, perform photometry and do data analysis. We demonstrated the plotting of HR diagrams and projects with stellar variability that can be performed in such projects.

Session

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A closer sky - an astronomical observatory on your class

Ms Elisabeta Ana Naghi[1,2,3], Mr Dan Alin Nedelcu[4]

[1]member of the Romanian National Astronomy Committee. [2]national coordinator for astronomy education in Romania- NAEC. [3]inspector for mathematics and astronomy at Education Ministry, Romania. [4]Astronomy at Astronomical Institute, Bucharest.

Abstract

Berthelot Observatory is a Romanian astronomical facility belonging to Astronomical Institute of the Romanian Academy and dedicated to Space Surveillance and Tracking (SST) activities and Near-Earth Objects studies. Operational since 2018, the observatory hosts three telescopes (0.2, 0.4 and 0.5m diameter) operated on remote- or queue-mode. Astronomical facilities operated in remote mode provide students with an excellent hand-on experience on state-of-the-art instrumentation and software. With remote access to research grade observatories becoming ubiquitous, student will gain insights not only on modern subjects of astronomy but also on the inner working of an observatory, thus expanding the reach of this educational activity to the entire domain of STEM education. Before actual observations, students will learn about the protocols, networks and interfaces that bring the telescope's control on their desktops and will see the building blocks - optics, detectors, mount and dome being prepared for an observation run. Observations scheduling and tasking will introduce basic concept of astronomy - coordinate systems and celestial body dynamics alongside algorithms for planning and deconflicting concurrent operations. In this poster we will outline the outreach activities tailored for all educational levels, from primary school to basic research projects for universities students.

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Education, Outreach and Research Using the Thai Robotic Telescopes B. Soonthornthum National Astronomical Research Institute of Thailand.

Professor Boonrucksar Soonthornthum

National Astronomical Research Institute of Thailand.

Abstract

One of the main missions of the National Astronomical Research Institute of Thailand (NARIT) is to promote and support hands-on astronomy activities for publics both in national and international levels.

Apart from the 2 main national astronomical Infrastructures of NARIT, namely the 2.4-m Thai National Telescope (TNT) and the 40- m Thai National Radio Telescope (TNRT) provided for frontier and in-depth astronomical research beyond the capabilities of using small telescopes, NARIT has yet established the Thai Robotic Telescopes (TRT) Network for disseminating opportunities on teaching capacity of remote observing facilities for universities, schools and publics.

The TRT have been distributed in 4 countries, namely the Republic of Chile, People's Republic of China, Australia and the United States. It is a remote control system which allowed universities, schools and publics to apply and access country-wide. The TRT Network is a powerful tool in driving human

capacity buildings in astronomy and supporting many frontier and in-depth astronomical research collaboration.

Session

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From City Lights to Starry Nights: Robotic Telescopes Enabling Accessible Education in Pakistan

Ms. Hira Fatima

National Center in Big Data and Cloud Computing, NED-UET, Karachi, Pakistan. Institute of Space Science and Technology, University of Karachi, Karachi, Pakistan

Abstract

Karachi, renowned as the 'city of lights,' stands as Pakistan's most cosmopolitan city. Despite its vibrant nature, the presence of astronomical observatories is limited compared to the vast number of academic institutes. Over the years, our observatory has welcomed students and teachers for observation and training sessions. Additionally, we have extended our outreach by bringing portable telescopes to various institutes and regions. The scarcity of local astronomical observatories, coupled with light pollution in urban areas and limited accessibility to remote observatories, underscores the critical role of robotic/online telescopes in education.

As partners with the Las Cumbres Observatory (LCO), we have leveraged their 0.4-meter robotic telescopes and cameras in our astronomy education initiatives. We have trained school teachers to utilize robotic telescopes, enhancing their teaching of STEM curriculum. Furthermore, we have invited university students studying physics, mathematics, and space science, along with their teachers, to participate in training sessions that supplement their existing courses, such as introduction to astronomy, astronomical instrumentation, observational astronomy, and data-driven astronomy. We look forward to extending this practice with the possibility of using other instruments like spectroscopes with robotic telescopes.

Employing robotic telescopes for astronomy education not only enriches the learning experience but also provides opportunities to promote accessibility, inclusivity, equity, and a borderless approach to astronomy. In this presentation, I will discuss our journey of utilizing LCO robotic telescopes in education, highlighting the milestones we have achieved, the challenges we have faced, and the valuable lessons we have learned along the way.

Session

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Connecting Skies: The Evolution and Impact of Global Hands-On Universe (GHOU) in Astronomy Education

Prof. Hassane Darhmaoui

Al Akhawayn University in Ifrane

Abstract

The Global Hands-On Universe (GHOU) initiative has its roots in the early 1990s when astrophysicist/educators Alan Goud and Carl Pennypacker pioneered the "Hands-On Universe" (HOU) concept at the University of California, Berkeley. Their vision aimed to revolutionize astronomy education by enabling direct student engagement with real astronomical data and tools, departing from traditional textbook-based learning. Initially, HOU focused on providing access to telescopes, astronomical data, and software tools for analysis, primarily targeting teachers and students.

As the HOU program gained traction and expanded beyond its origins at Berkeley, it underwent a transformative evolution into the GHOU initiative. This shift marked a significant step towards breaking geographical barriers and promoting cooperation in astronomical education.

GHOU's mission evolved to encompass various facets of education, including the training of teachers in modern tools and resources for science education, the development of innovative curricula, and the facilitation of international scientific projects involving students. GHOU facilitated students' remote access to telescopes and astronomical data, democratizing access to scientific inquiry and enabling participation from students of diverse backgrounds.

Over the years, GHOU has continuously adapted to technological advancements and evolving educational practices. By forging partnerships with educational institutions, scientific organizations, and government agencies worldwide, GHOU has extended its impact and reach, further solidifying its position as a leader in astronomy education. Today, GHOU remains dedicated to empowering students and educators, fostering a deeper understanding of the cosmos, and inspiring the next generation of scientists and space enthusiasts worldwide through its innovative programs and collaborative endeavors.

Session

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PASEA: Inspiring Future STEM Leaders in Africa via Remote Observing Projects

Dr. Linda Strubbe[1], Dr. Heidi White[2,3], Dr. Jielai Zhang[4,5]

[1]Strubbe Educational Consulting. [2]Université de Montréal. [3]Trottier Institute for Research on Exoplanets. [4]Swinburne University of Technology. [5]ARC CoE for Gravitational Wave Discovery

Abstract

Robotic telescopes offer a valuable opportunity for students from under-resourced areas to grow their interest in astronomy and build scientific skills. In this talk, we describe a robotic telescope educational initiative from the Pan-African School for Emerging Astronomers (PASEA). PASEA is a biannual short course in astronomy for African university students, held 5 times since 2013. PASEA's vision is to build a critical mass of astronomers in Africa, and exchange ideas about teaching across continents.

In 2022 PASEA held a special online initiative called the Alumni Research Program (ARP) for ~60 undergraduate students from around Africa, focused on investigations of variable stars using the Las Cumbres Observatory (LCO) telescope network. The program was designed using principles from education research to help students build their scientific identities and skills. ARP began with a workshop on Python programming and data science skills. Next, students worked in small groups to collaboratively plan and request LCO observations of short-timescale transient/variable targets drawn from publicly available databases, with the goal of identifying the type of variable star.

Students performed basic photometry and light curve analysis on their LCO observations using specially-created Jupyter notebooks with Google CoLab, which the team has made publicly available on github. Student groups shared their findings with their peers through creative projects. ARP students expressed highly positive feedback, and the program received many more applications than we could accept. ARP demonstrates the great interest and value of robotic telescope-focused educational initiatives for supporting future scientific leaders in Africa and beyond.

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Evaluation of Astronomy Education and Outreach Projects -- What, Why and How?

Dr. Linda Strubbe

Strubbe Educational Consulting

Abstract

As astronomy educators, we all have beautiful visions for how our astronomy education and outreach projects can make positive change in the world. Working towards our visions, it's important to ask, "How is my project going? Is it working well towards my vision, and what could make it work even better?"

Evaluation is the work of answering these overarching questions. Evaluation involves (1) articulating project goals, values, and desired outcomes along the way; (2) designing evaluation questions connected to our goals, and instruments to gather data to help answer those questions; (3) gathering and analyzing the data; and (4) bringing all together to give an evidence-based view of how well the project is achieving its goals, the project's impact on the world, and feedback for how the project can improve and do even better.

Designing projects with evaluation in mind is a key part of supporting our projects' success, so we can make informed decisions as the project goes along. You are probably already doing some evaluation as part of your education and outreach efforts. It can also be helpful to work with an External Evaluator (like me!), who specializes in designing and implementing evaluation, can offer an outside perspective, and help keep evaluation in focus throughout the lifecycle of the project. In my poster, I'll share resources to help you design and implement your own evaluation, and offer examples from my work as an External Evaluator on a variety of physics and astronomy education projects (Strubbe Educational Consulting: https://sites.google.com/site/lestrubbe/evaluation).

Session

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STEM education using remote observing facilities, several successful practices in China

Dr. Chenzhou Cui[1], Dr. Shanshan Li[1], Dr. Dongwei Fan[1], John Baruch[2], Xing Gao[3], Yujie Zhang[4]

[1]National Astronomical Observatories, Chinese Academy of Sciences. [2]Leeds Beckett University, UK. [3]Urumqi No.1 Senior High School, China. [4]Lijiang Gemini Observatory, China

Abstract

As technology and products continue to advance, there are increasing numbers of telescopes and other facilities providing remote observing services. The setup of remote observing systems is becoming more convenient, and the operation of remote observing is becoming easier. The level of intelligence in every aspect of the above process is constantly improving. In addition to meeting the scientific requirements of professional astronomers and the interests of amateur astronomers, remote observing facilities have also contributed a large amount of STEM science education resources. This talk will share the achievements and experiences of the application of remote observing facilities in STEM education through several specific examples, including the Citizen Science Project of Chinese Virtual Observatory (China-VO), the discovery of new celestial bodies at Xingming Observatory, the facility sharing platform at Lijiang Gemini Observatory, and the astronomy teaching through Bradford Robotic Telescope.

Session

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Global Sky Partners: creating an equitable, scalable and sustainable education programme with robotic telescopes

Dr Edward Gomez

Las Cumbres Observatory

Abstract

Astronomy is a fascinating science, capable of inspiring many thousands with a single picture. However, for a deeper change in people's way of thinking, inspirational pictures alone are not enough. We wanted to create a programme which did not only cater to the self-selected audiences, who are already fascinated by astronomy or ones led by an educator who has astronomy experience. These are often only available to privileged audiences, like private schools or astronomical societies. There are many tools which can be used to perform authentic astronomy investigations, well structured educational projects or even innovative artistic projects.

The **Global Sky Partners** is the flagship educational project from **Las Cumbres Observatory**. It addresses the key question of how to run an efficient and sustainable education programme in astronomy. Las Cumbres Observatory is a homogeneous network of 25 telescopes, across 7 professional observatory sites. Global Sky Partners uses the LCO education network of 10 x 0.4m telescopes, with an audience of (on average) 60,000 individuals each year, from over 40 countries.

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PROPOSED REMOTE/ROBOTIC TELESCOPE BY THE UNIVERSITY OF ZULULAND

Prof Aroonkumar Beesham, Prof Thulani Jili

University of Zululand

Abstract

The University of Zululand (UNIZULU) is situated is a predominantly rural area, and undergraduate and high school learners are not exposed to astronomy with telescopes. Together with several other academics, we have succeeded in getting a 0.45 m optical telescope funded by the Department of Science and Technology. We are very excited about this development, having already secured a suitable site for the installation a mountains, 20 km east of the Eshowe area near UNIZULU. The construction of the road leading to the mountain has started and this realization is due to our cooperation with the local Mlalazi Municipality. The university has committed itself to building the telescope housing as well as accommodation for researchers.

It is anticipated that the telescope will have a dual purpose, viz., performing remote/robotic observation-based projects, and working hands-on with the telescope on site. Undergraduate modules in astronomy have been developed and submitted to the relevant external bodies for their endorsement. The telescope will be used for practical purposes.

The UNIZULU Science Centre at Richards Bay nearby carries out STEM activities in astronomy amongst school and undergraduate students. We will work closely with the centre to enhance STEM education.

Having already carried out a pilot project at UNIZULU successfully in the use of remote/robotic telescopes, we believe that our project to install the telescope is feasible, and together with SAAO and others, to succeed in our mission.

In this presentation, we will describe in more detail what we outlined above.

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The use of Oukaimeden Observatory remote observing facilities for training STEM and Education

Professor Abdelmajid BENHIDA

Faculty of Science and Technology Marrakech

Abstract

In Morocco, astronomy has seen remarkable growth over the past 30 years. The Oukaimeden Observatory (OUCA) in Morocco has made world-class discoveries and is leading various ongoing projects and collaborations, including many remote class telescopes for several thematics in Astrophysics.

Specific objectives of the OUCA include:

- contributions to repositioning Africa in the global production of knowledge in astronomy and space sciences by strengthening and expanding research expertise, and strengthening intra-African research collaborations.

- training of early career researchers and experienced researchers in astrophysics in Africa and Europe, through secondments and workshops.

- organization of observation campaigns with traditional and remote telescopes in Africa and worldwide. The OUCA provides the necessary human resources and knowledge exchange support to countries interested in developing observatories.

- promoting the scientific method for the general public and inclusion in science, technology, engineering and mathematics (STEM), through awareness and education events.

In Morocco, we focus on the ability and feasibility of building networks of remote/robotic telescopes for educational use at the undergraduate and high school level (recent years).

In this talk, I will describe :

-The plans that we have to develop at Oukaimeden remote/robotic observing facilities for the Universities (undergrad students) and High Schools pupils.

-Organization and management of the use of Oukaimeden Remote/robotic telescopes for educational purposes at the undergraduate and secondary level (last years)

-Plans to set up a collaboration with other African observatories and the creation of a network of remote/robotic telescopes users for this purpose.

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Authentic research and scientific writing experiences using the LCO Telescope Network

Dr. Rachel Freed

University of North Carolina, Chapel Hill, USA. Institute for Student Astronomical Research

Abstract

The USA Sky Partners program provides research opportunities for undergraduate and high school students around the United States, using the Las Cumbres Observatory Global Telescope Network (LCO). Through this program, educators and students learn how to do double star astrometry on a double star system that they select. Using LCO they collect images of the system, make astrometric measurements of position angle and separation, and then share their results through writing a paper for publication in the Journal of Double Star Observations (JDSO). Our partners at the University of Puerto Rico, Occidental College in southern California, and the Institute for Student Astronomical Research (InStAR) have run the pilot program and students successfully published their research papers. Through InStAR, student and educator teams from 5 undergraduate institutions and 6 high schools around the United States participated in the program. Research on these astronomy research experiences has shown that students increase their self-efficacy and begin to develop a sense of science identity, both of which are important precursors to persistence within STEM fields.

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Empowering Ghana's STEM Education: Bridging the Gap through Capacity Building in Astronomy Instrumentation

Mr Albert Kuntu Forson[1,2,3], Dr Asabre Frimpong Nami[4,5,6], Dr Emmanuel Proven-Adzri[1,5], Mr Kolognia Joshua[1,7], Mis Jemimah Kwakuyi[1], Mr Matthias Asare-Darko[1]

[1]PROMOTING ASTRONOMY IN GHANA THROUGH SCHOOLS VITIS AND ASTRONOMY CLUBS (PRAGSAC). [2]NATIONAL OUTREACH COORDINATOR (NOC) GHANA. [3]NATIONAL ASTTRONOMY EDUCATION COORDINATOR (NAEC) -GHANA. [4]OAD National Astronomy Coordinator (NOC) GHANA,. [5]Ghana Space Science Technology Institutes. [6]African Astronomical Society. [7]NRA

Abstract

Astronomy holds immense potential for STEM education and public outreach development. In Africa, this potential remains largely untapped, with Ghana facing challenges in attracting students to STEM subjects and the public interents. Contemporary progress heavily relies on technologies used in astronomical techniques, data analysis from celestial bodies and satellites, and instrumentation processes, offering solutions to socio-economic issues like Decent Work and Economic Growth, particularly in developing nations like Ghana.

The AtroPhy project serves as a motivator for graduate and undergraduate students, acting as a gateway to astronomy and space science. It provides students with hands-on experience in radio telescope engineering and operational techniques, utilizing the Table Top Radio Telescope (TTRT) to observed the Galactic Hydrogen Emission (HI), process the data, and perform analysis using Python programming. The development of a small parabolic dish antenna into a radio telescope provides the participants with the skills of engineering and instrumentation in the field of astronomy and space science where a 2.4m parabolic satellite dish was converted into a radio telescope. These innovative tools, including the TTRT and small parabolic dish antenna set-ups, offer valuable learning opportunities in astronomy, space science, and data science, both for training and astronomy outreach communication. By fostering practical skills, nurturing scientific curiosity, and promoting collaboration, AtroPhy plays a pivotal role in addressing the UNSDG 4 and 8.

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Finding Space for Observational Astronomy in the Secondary Science Curriculum

Ms Gerri Bernard

Brisbane Girls Grammar School

Abstract

In an effort to bring the awe and wonder of gorgeous astrophotography to all of our students, Brisbane Girls Grammar School has integrated observatory work into our Science curriculum. This presentation will explain how we use a series of 'Observatory Modules' in High School Years 7-9 to teach our students about the universe, telescopes, light, colour, CCD imaging, and image processing as we help them to generate more than 400 astrophotography images every year. The talk will also include an introduction to our school's remote and robotic telescope facility (the Dorothy Hill Observatory) and an overview of our school-based collaborative student astronomy research symposium (STARS), in which high school students are given the opportunity to complete astronomy research projects, contribute data to international variable star databases, and publish their research in peer-reviewed astronomy journals. In addition, an outline of struggles that we've encountered along the way and a plan for future outreach and development of our observational astronomy program will also be discussed.

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Astrolab and its impact on the development of Astronomy teaching at the University of Zululand

Dr Getachew Mengistie, Prof Thulani Jili

University of Zululand

Abstract

The importance of using robotic telescopes that can be operated remotely in a STEM curriculum played a significant role in the understanding of the observational astronomy. It also improved students' ability to observe remotely, data acquisition and data analysis skills. The Astrolab project, one of the pioneering projects that uses the Las Cumbres Observatory (LCO) networked remotely controlled robotic telescopes, helped learners to understand observational astronomy and develop different skills. Moreover, it paved a way to observe from the comfort of their preferred places. It also introduces the learners to world class facilities. The University of Zululand in collaboration with OAD and DST took part in the Astrolab project and used it for learners to get background knowledge in astronomy and data analysis. The university is currently working on building an observatory which will house a 40-inch robotic telescope that can be used hand in hand with the Las Cumbres observatory. This robotic telescope will enhance the development of astronomy and is going to be used to train students at both the undergraduate and postgraduate levels. It is also aimed at training high school learners as a support instrument to those learners who are interested in astronomy as well as other STEM fields.

Session

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On-line Tutor Training for Astrolab, an astronomy lab with remote-robotic telescopes.

Dr Michele Gerbaldi[1], Prof, Dr Jean-Pierre De Greve[2], Dr Nicole van der Bliek[3]

[1]Institut d'Astrophysique de Paris, (IAP), France. [2]Vrije Universiteit Brussel (VUB), Belgium. [3]NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab), Chile

Abstract

Astrolab is an enquiry-based astronomy lab allowing undergrad students to obtain hands-on experience with real astronomical observations. It follows the "Learning-by-doing" methodology: the students learn by experience, assimilating concepts through actions. Astrolab is geared towards undergraduate and graduate science students.

One can also use parts of Astrolab. For example, for a more technical, engineering course, one can focus on the properties of CCD images or on the optical properties of a telescope.

The Astrolab project supports universities with their observational astronomy classes, *at a low budget*, using remote telescopes.

The key of success of such hands-on activity is to make sure that the tutors themselves are trained, enabling them to optimally support the students.

We have developed a Tutorial on-line, *Astrolab Tutorial for Tutor Training*, on the Astrolab webpages. It guides you through the process of taking observations and analyzing the data.

It contains a comprehensive set of exercises to obtain a light curve of an eclipsing binary using the Las Cumbres Observatory 40-cm telescopes. For each step along the way, the Tutorial has an example and invites the user to carry out the activities themselves, including taking the data.

The tutorial also offers Tutors guidance on planning the implementation of Astrolab and on how to monitor progress of the student projects.

Our presentation will show the various aspects and goals of the Astrolab on-line Tutorial.

Session

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Empowering High School Students through Remote Asteroid Science Education: A Case Study of the Pan-Africa Asteroid Search Campaign

Dr Meryem Guennoun

Oukaïmeden observatory. Laboratory of High Energy Physics and Astrophysics

Abstract

This presentation delves into the intersection of remote education and asteroid science, with a special focus on high school students. Wearing the dual hats of a seasoned astrophysics researcher and a dedicated physics teacher, this exploration aims to showcase the symbiotic relationship between astrophysical research and effective science education. As one of the leaders of the Pan-Africa Asteroid Search Campaign, the talk will delve into the unique approach of virtually teaching high school and university students about asteroids. This includes hands-on experiences, such as using Astrometrica for potential asteroid discoveries. The study investigates the impact of remote teaching methods on fostering a profound understanding of space science among high school students, contributing significantly to the broader mission of advancing STEM education in virtual environments. The presentation aims to inspire the next generation by highlighting the dual role of a researcher and teacher in shaping the minds of budding space enthusiasts.

Session

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1115

Robotic telescopes optimised for distance learners

Professor Ulrich Kolb

The Open University

Abstract

I will give an overview of the OpenScience Observatories (OSO), two robotic telescope facilities owned and operated by The Open University (UK), and describe their deployment in the OU undergraduate and postgraduate distance-learning curriculum, their wider educational use, and ongoing educational research on their effectiveness.

OSO consist of two fully autonomous robotic facilities located at the Observatorio del Teide (Canary Islands), PIRATE and COAST. The 60cm and 43cm astrographs are equipped with imaging cameras for multi-colour photometry, and they are part of a wider network of facilities that share a common control system.

OSO primarily serve the needs of OU distance learners in STEM disciplines, but they also support an active research programme in time-domain astrophysics and conduct commercial space situational awareness tasks. External providers of higher education can obtain access to the facilities.

In the formal OU curriculum the use of OSO is hierarchical and begins with real-time sessions and direct student control via a web interface to impart hands-on understanding of ground-based optical telescopes. For more advanced activities such as the monitoring of exoplanet transits for the ExoClock project or the follow-up of Gaia transients the observing requests are queue-scheduled. At the highest level OSO supports final-year Masters projects for an MPhys or MSc qualification.

We also offer an entry-level (pre-university) free online course, Astronomy with an online telescope, which is available worldwide and includes free access to COAST for deep-sky imaging and a citizen science-like activity on variable stars. Since 2019 over 14,000 learners have enrolled.

Session

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"Who Listens to the Radio" Remote Observing Programs in Radio Astronomy

Mr Robert Hollow, Dr George Hobbs

CSIRO, Space and Astronomy

Abstract

There are many excellent programs using remote and robotic optical facilities for astronomy education and training, but few utilising other parts of the spectrum. Since 2007, CSIRO's Space and Astronomy unit in Australia has run a successful program aimed at high school students in which they observe pulsars in real time, remotely, using Murriyang, the iconic 64m Parkes Radio Telescope. Our PULSE@Parkes program has engaged thousands of students across Australia and other countries. We discuss what we have learnt about how students interact with radio telescopes, the data and with our staff. The system's flexibility allowed us to pivot to online delivery during COVID 19 restrictions, replacing previous onsite sessions. We now offer both modes which allows schools across the country including regional and remote areas to participate. The model we have developed can be adapted by other institutions. The Victorian Space Science Education Centre, who have hosted many of our sessions, have themselves recently developed a program for remote observing using a 3m-diameter radio telescope. We discuss results obtained while exploring the market and possibilities for adapting the PULSE@Parkes model as a package for universities interested in training students in radio astronomy.

Participants will be able to remotely observe with Murriyang, the Parkes Radio Telescope and interact with the data in the first session.

Session

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Growing Needs for Remote Telescope Observations in Modern Day-research: Progress and Prospects.

Mr Nnameka Njoku-Achu[1,2], Mr Peter Onubi[1,2], Mr Idris Sani[1], Mr Eugene Idogbe[1], Mrs Chioma Okany[1,2], Mr Christogonus Sunday[2], Mr Arinze Okere[2], Mr Jude Nnaji[3], Mr Williams Onyinyechi[1], Ms Sarah Parker[4], Ms Katya Gozman[5], Mr Adam McCulloch[4], Engr Matthew Nowinski[6], Dr Amanda Pagul[7], Dr Anthony Obi[1], Dr Chukwujekwu Ofodum[1], Kate Meredith[4], Dr Bonaventure Okere[1]

[1]NASRDA-Centre for basic Space Science and Astronomy. [2]Department of Physics and Astronomy, University of Nigeria, Nsukka. [3]University of the Witwatersrand, Johannesburg, SA. [4]Geneva Lake Astrophysics and STEAM, WI, USA. [5]University of Michigan, Ann Arbor, MI, USA. [6]Department of Mechanical Engineering, Virginia Tech, Blacksburg, VA, USA. [7]Space Telescope Science Institute, Baltimore, Maryland, USA

Abstract

The emergence of Covid-19 pandemic in 2020, created the need for a rapid response towards continuous research, despite the barrier created by quarantine and social distancing. In May 2020, the West African and Southern African Regional Offices of Astronomy for Development (WAROAD and SAROAD), Centre for Basic Space Science and Astronomy joined with GLAS Education and Stone Edge Observatory (SEO) to create and international partnership, aimed at providing a hands-on educational and research experience, through the use of SEO's remotely controlled 0.5m telescope in Sonoma, California. This project targets upcoming student scientists with interests in astronomy and planetary sciences. It provides them the opportunity to learn and develop the capacity required to independently identify potential observable targets of interest, plan observations and survey the sky from any part of the globe, with the help of their computer or mobile phones. The project aims to establish a legacy database of consistently and robustly reduced data with SEO and further perform time series analysis with the purpose of understanding the motion and properties of variable and transient objects in space. Within our framework, each student is equipped to remotely observe, download and stack images using Jupyter Notebooks, make plots, perform flux calibration and data reduction. Some preliminary results of our work on Stone Edge All-Sky Survey (SEASS), Asteroid photometry and study of M3 Globular Cluster (M3GC) are presented.

Session

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Sustainable Development of Astronomy Research Education in Sri Lanka with Remote Observations

Assistant Professor / Director of Communications Thilina Heenatigala

Earth-Life Science Institute (ELSI)

Abstract

Sri Lanka has produced about two dozen astronomers since the 1960s, and all graduated from foreign universities. Though students locally are keen on pursuing astronomy, as a developing country (not an IAU member), the opportunities and resources in astronomy are extremely limited. Since the days of the Apollo programme, there has been an active astronomy outreach at the school and public level, then led by the Ceylon Astronomical Association, which created a domino effect of school astronomy clubs, which are still active to date. A few decades later, the International Year of Astronomy in 2009 (IYA2009) boosted the outreach efforts, inspiring quite a few locals to pursue a career in astronomy despite the challenges. About a decade after the IYA2009, Sri Lankan astronomers focused on developing astronomy education and research at the university level. The first step was to partner with Las Cumbres Observatory (LCO) and get access to the telescope network. This partnership with LCO helped build the first active research group in Sri Lanka, which published the first scientific paper with all authors from Sri Lanka. Two universities are part of the research project where undergraduate students conduct remote observations and analysis to learn basic astronomy data analysis, tools, and techniques. The senior students are engaged in the research project as a credited course work which is a first in Sri Lanka.

This talk will present an overview of using remote observation for higher education in developing countries as a way to progress astronomy.

Session

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Robotic telescopes can change the trajectory of student's study and careers in STEM. Perspectives on the impacts and lessons learned from building a high school based remotely accessible observatory and how it has changed my own career trajectory.

Mr Andrew Yen

Luther College, Victoria, Australia. Eltham College, Victoria, Australia

Abstract

For forty years I have enjoyed bringing astronomy to young people through my involvement in astronomy associations and local schools. While I am passionate about astronomy, I've found it difficult to engage young people with the field. Access to reasonable telescopes, to allow continuation of the engagement pathway is an obvious hurdle. The telescope a youth can afford is likely to be disengaging rather than engaging.

Come to this talk to hear how this changed when I got involved with building a remotely accessible observatory (with a CDK17 and a RASA11) at my own children's school, Eltham College. This experience led to me returning to university to train as a teacher and a job as a Senior Physics teacher at another nearby school, Luther College. Luther College management were quickly convinced of the STEM teaching and engagement possibilities of robotic telescopes and have installed a 10" remotely accessible Newtonian.

I will present lessons learned and vital aspects to consider from the perspectives of a parent, an amateur astronomer, a physics teacher and a student on engaging middle and high school children, and the education institutions they attend, in education with robotic telescopes. Making real science, science where the youth gathers the data or takes the photo, engages young minds where pictures in books cannot. Giving youth the opportunity to take their science to professional level, continues the engagement pathway. In five years, I have helped students write journal papers on exoplanet followups, double star measurements, and discoveries of double stars.

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1571

The advantages of a remote telescope in Kenya for teaching purposes

Prof Colin Snodgrass[1], Cyrielle Opitom[1], Richard Vaughan[2], Melvin Hoare[3], Acacia Leakey[4], Edward Graham[5], Paul Baki[6], Susan Murabana[2], Dan Hillier[7]

[1]The University of Edinburgh. [2]Kenya Optical Telescope Initiative. [3]The University of Leeds. [4]Turkana Basin Institute. [5]University of the Highlands and Islands. [6]Technical University of Kenya. [7]United Kingdom Astronomy Technology Centre

Abstract

We will describe our work towards establishing a remote observatory in northern Kenya, in the context of its use for education. The Kenya Optical Telescope Initiative has been developing plans for an observatory in the remote, dark, and arid area of Kenya near lake Turkana, which is one of the few equatorial sites in the world that is well suited to optical astronomy. We installed a small telescope at the Turkana Basin Institute in 2022 to perform observations of the NASA DART mission's impact with an asteroid, and have subsequently used this for on site training of African students, which we will continue as part of the Development in Africa with Radio Astronomy programme in the coming years. In parallel we are performing site testing measurements on nearby mountain sites, which appear to be promising for a larger permanent and remotely controllable telescope. Such a telescope would be at an excellent longitude and latitude for university teaching in western Europe, with observations in the early evening after lectures but not requiring very late nights; daytime observing from the Americas; and provide a research and training facility for African astronomers.

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GoChile telescope: A remote facility for secondary school and undergraduate students

Prof Andreja Gomboc, Dr Jure Japelj

University of Nova Gorica

Abstract

University of Nova Gorica (Slovenia) and astronomical magazine Spika run the GoChile project, which uses two small telescopes at the El Sauce Observatory in Chile. The two remotely operated telescopes are primarily intended for teaching—significant telescope time is reserved for secondary school and undergraduate students interested in astronomy. Through the project the students gain experience in observations and get introduced to the process of scientific research. I will present our activities in the past two years: remote teaching, mentoring of research projects and the organization of two summer schools. Interestingly, there has been a great interest in the telescope among girls, which was particularly evident in the summer schools, where more than half of the registrants and participants were girls. After two successful years of operation we intend to expand our activities and offer our facilities to other universities in need.

Session

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Educational Use of the North-West University 4-Element Radio Interferometer

Prof James Chibueze

University of South Africa

Abstract

North-West University 4-element radio interferometer consists of 4 identical 3.7m, fully steerable, prime focused, parabolic dishes. They are fitted with easily swappable C-band and L-band feeds. The array was designed to be a tool for hands-on radio interferometry education and for long-term monitoring observations of bright radio continuum and maser sources. Remote access to the interferometer is currently being explored and when rolled out, universities and colleges across South Africa and the rest of Africa will be able to access this facility for remote observations and education. As an educational instrument, the interferometer is already making significant impact in exposing students to hands-on radio telescope experiences. This talk will show some of the impacts of the practical experiences that students have already had with this instrument.

Session

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Observing Programmes in Cloudy, Rainy, Bright, Sites

Jake Noel-Storr

University of Groningen

Abstract

Remote observatories can provide us with great opportunities! Here I provide the information from those of us that are in Cloudy, Rainy and Bright sites.... with impact data from New York City, up state NY, the UK and the Netherlands. I will also share the possibilites we consider around the world in small telescope collaborations, including our latest project for La Palma.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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Lighting up the skies: How remote telescopes can enhance learning in the classroom

Dr Kshitij Thorat

University of Pretoria

Abstract

As Astronomy is at once possibly the most intangible and at the same time the most visible of sciences, teaching it in the classroom can be challenging. While looking up at the stars is free, delving deeper requires expensive telescopes. This is especially true in the Global South where access to telescopes is very scarce. In a way of contradiction, it is the Global as well as the Geographical South which is leading the way in professional astronomical studies, where large telescopes such as the South African MeerKAT, Australian ASKAP and Chilean Vera Rubin Telescope are based. To ensure that the future students in these countries are able to participate in a leading capacity in the exploration of our Universe using these wonderful facilities, it is imperative that their introduction to astronomy at school and undergraduate level is inspiring as well as complete.

Remotely operated and robotic telescopes can help in achieving these aims. In this talk, I will discuss the implementation of the IAU-OAD project “Astrolab” in undergraduate classrooms in the University of Pretoria. The project has students schedule observations and analyse the data of (primarily) transients using the Las Cumbres network of telescopes and is now a part of the second year astronomy course beginning in 2019. This has been for many students the first introduction to an astronomical telescope. I will further endeavor to bring to the fore student experiences with this experiment and alterations/additions which can be made to enhance astronomy learning in the classroom.

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Remote telescope-based curricula for undergraduate introductory astronomy

Dr. Rachel Freed[1,2], Tiffany Stone-Wolbrecht[3]

[1]University of North Carolina, Chapel Hill. [2]Institute for Student Astronomical Research.
[3]Associated Universities Inc.

Abstract

Twenty-first century technology enables astronomy educators to offer our students unprecedented hands-on learning experiences. Two curricula, Our Place in Space! (OPIS!) and Multiwavelength Universe! (MWU!), have been developed for undergraduate astronomy which incorporate the use of the Skynet robotic telescope network. The advent of such telescope networks that enable remote collection of photometric, spectroscopic and even radio telescope observations as well as the proliferation of time domain and multiwavelength data from world-class facilities and advanced computing resources provide opportunities for students to learn and participate in modern astronomy, even at an introductory level. Within these curricula, students access remote telescopes and collect their own observations for analysis in activities aimed at teaching many of the major concepts in introductory astronomy courses in the United States. In conjunction with curriculum development, new analysis tools, Afterglow Access, have been and continue to be developed by the Skynet team. Using some of these tools students can contribute data to improve current catalog components, such as star cluster reddening and distance values.

Educational research has been carried out with several thousand students using these curricula and there has been a significant increase in self-efficacy relating to not only learning astronomy content, but also in technical skills revolving around using the telescopes. Furthermore, over the course of a single semester, the initial gender gap in self-efficacy disappeared as both men and women in the courses showed increased self-efficacy to the same levels.

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Barriers to entry for high school (and university) education with robotic telescopes.

Dr Michael Fitzgerald

Las Cumbres Observatory

Abstract

It has been a long journey, really beginning in earnest around the early 1990s, towards connecting students with actual telescopes in everyday school environments. I myself hitched a ride on the school train around 2010 after about 5 years of university level robotic telescope education teaching experience.

We've come a long way… and to some extent we might even nearly …*nearly…* be there in terms of providing access and usage reliably to school (and university) users around the world over the next five years. And many of these things have been technical problems that have required technical solutions. But, try as hard as I might, I have yet to be able to code around human nature. We are rapidly coding our way through the technical barriers but we will always encounter numerous issues arising from our users being human and living in social, economic and occupational contexts in a universe more finite in time than in space. The issues at schools and universities actually are quite similar, but much more pronounced at the school level.

In this talk, I will provide the perspective of where we are at, what still needs to be done and what exciting new things that are rapidly appearing on the scene (with some quick handwaving towards history for context) across multiple projects and approaches. All of this presented in the gloomy atmosphere of why all this exciting stuff rarely, if ever, happens in normal classrooms and we can (perhaps) do to solve this.

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Science and discovery in the classroom - the LaSciL project

Dr. Rosa Doran[1,2], Mrs Maria Panagopoulou[3], Dr. Panagiotis Evangelopoulos[4], Dr. Seda Özdemir-Fritz[5], Mrs Teresa Floss[5], Dr. Fraser Lewis[6], Dr. Sarah Roberts[6], Dr. Gustavo Rojas[1], Mr. Alvaro Folhas[1], Dr. Emmanouil Chaniotakis[3], Dr. Gernot Groemer[5], Prof. Vassilis Charmandaris[4,7]

[1]NUCLIO - Núcleo Interactivo de Astronomia e Inovação em Educação, Portugal. [2]Centre for Earth and Space Research of the University of Coimbra (CITEUC). [3]Ellinogermaniki Agogi Scholi Panagea Savva AE, Greece. [4]Institute of Astrophysics, FORTH, Greece. [5]Austrian Space Forum-Österreichisches Weltraum Forum-OeWF, Austria. [6]The Dill Faulkes Education Trust Limited, Great Britain. [7]Dept. of Physics, Univ. of Crete, Greece

Abstract

We report the results of LaSciL (Large Scientific Infrastructures enriching online and digital Learning - www.lascil.eu). This Erasmus+ project brought together five institutions from four countries (Austria, Greece, Portugal, UK) aiming to improve science teaching during and after the pandemic, focusing on modern science and astronomy. LaSciL addressed the increasingly prevalent access to 'big data in modern science, especially astronomy.

Teachers were presented with tools and resources curated and prepared by the partnership, allowing them to plan and perform astronomical observations using robotic telescopes from the Las Cumbres Global Observatory network. The toolkit consisted of 29 PDF guides to educational tools with significant online and digital components and 20 educational scenarios using these tools to apply in the classroom.

Teachers participated in two international schools where they developed their own educational scenarios suited to their needs and realities. The impact of the training on teachers and students was assessed, and a guide of good practices was created to support science teachers and propose a new framework for collaboration between schools and research infrastructures.

The teachers' feedback helped them understand the effectiveness of this approach and the kind of training that would be more helpful in their efforts. The project results were summarized in a guide of good practices to support science teachers and propose a new framework for collaboration between schools and research infrastructures. This presentation will conclude with an analysis of the project's impact on teachers and students one year after its ending.

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Robotically Controlled Telescope at NOIRLab's Kitt Peak National Observatory: 25 years of supporting introductory astronomy education

Richard Gelderman

Western Kentucky University

Abstract

Astronomical research projects offer learners at all levels the chance to explore the process of science via hands-on experiences. New tools are required for today's learners - who have always had access through their smartphones to the global internet for factoids - to develop problem solving skills and to fully understand that science is a process, rather than a set of recorded results. The 1.3-m telescope at Kitt Peak National Observatory is operated as such a tool. Originally commissioned in 1964 as the "Remotely Controlled Telescope", a pioneering project in unattended, remote observing, the 1.3-m has been refurbished, automated and reborn as the "Robotically Controlled Telescope". This new incarnation of the RCT is used to pursue a variety of research programs which incorporate techniques to achieve extremely high precision photometric monitoring of stars, AGN, and other transient celestial phenomena, such as transits of extrasolar planets and follow-up observations of gamma-ray bursts. Our autonomous meter-class observatory enables unattended collection of deep, high resolution images, which are often combined with open access archival data to explore the full, multiwavelength nature of the targets. As a result, undergraduate and high school students work with the RCT to demonstrate their abilities with cutting-edge technology to make new discoveries.

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Remote-controlled telescope as a tool for popularizing STEM subjects for high school students.

phd Michal Zejmo, phd Magdalena Szkudlarek, phd Waldemar Grabowski

Janusz Gil Institute of Astronomy, University of Zielona Gora, Poland

Abstract

We present the integration of remotely operated telescopes into the education of secondary school students, focusing on STEM disciplines. We examine the pedagogical implications and benefits of utilizing such advanced astronomical tools to enhance understanding and engagement in science, technology, engineering, and mathematics (STEM). Poster highlights the opportunities for hands-on learning, real-time observation, and data analysis that remote telescopes offer, fostering critical thinking and inquiry-based learning in STEM subjects. Moreover, it discusses practical strategies for incorporating remote telescope usage into STEM curricula, addressing challenges and maximizing educational impact. Overall, this poster underscores the potential of remote telescopes to inspire curiosity, deepen understanding, and cultivate STEM literacy among students at various educational levels.

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Automation of the Dongla Observatory and Proposal to include it as a part of Global Network

Prof. Abhirup Datta[1], Dr. Anil Kothari[2]

[1]Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore. [2]Madhya Pradesh Council of Science and Technology

Abstract

M.P. Council for Science and Technology (MPCST) has built the Varahamihir Astronomical Observatory situated at Dongla village. This Observatory has a 20" Telescope (Plane Wave CDK20 (OTA)) fixed with 5 meter (diameter) hemispherical steel structure dome at a height of 12.5 meters. Recently, we have started full dome automation work to make the telescope accessible from different institutions across the state of Madhya Pradesh as well as nationwide. Upon the completion of this automation work, Dongla Observatory will be accessible to the UG/PG students of different colleges across India. Dongla Observatory is based in Lat: 23◦26'43.2" Long: 75◦45'45.5" and was established back in 2013. We would like to discuss the potential of including this telescope in a global network of Sky-watch networks for locating transients, encouraging education in Astronomy and Astrophysics, and collaborative research

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From Madagascar to the world: The Observatory of Ecoles du Monde de Madagascar and its potential for empowering STEM Education in resource-constrained regions

Mr Andoniaina Rajaonarivelo[1,2], Pr Sylvain Bouley[3], Pr David Baratoux[4], Ms Mializo Razanakoto[2]

[1]Astronomical Observatory of Ecoles du Monde Madagascar - Besely, Mahajanga, Madagascar. [2]Haikintana Astronomy Association, Madagascar. [3]GEOPS - Géosciences Paris Saclay, Université Paris Saclay. [4]Geosciences Environnement Toulouse, Université Toulouse III, CNRS & IRD, Toulouse, France,

Abstract

The Observatory of Ecoles du Monde de Madagascar (OE2M) stands as a groundbreaking initiative, being the first remote/robotic observatory established in Madagascar. This presentation explores the OE2M's potential to revolutionize STEM education for undergraduate and high school students not only in Madagascar but in resource-constrained regions, by fostering hands-on learning through:

- **Hands-on real-time astronomical observations** using the observatory's telescope.
- **Collaborative projects** : Students participate in international research initiatives, developing critical scientific skills like data analysis and communication while collaborating with researchers from various institutions.
- **Targeted training programs**: training programs equip students and amateur astronomers with the necessary skills to utilize the observatory effectively.

This presentation delves into:

- OE2M's unique capabilities and its future impact on STEM education in Madagascar and beyond.
- The broader potential of the observatory as a model for establishing similar facilities in other developing countries, promoting equitable access to scientific resources and empowering future generations of STEM professionals globally.

Keywords: Remote observatory, STEM education, Madagascar, Developing countries, Astronomy projects, Collaborative research, Training programs.

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Outreach and engagement with autonomous telescopes: achievements and future plans

Sr. Carlos Gutierrez

Instituto de Astrofísica de Canarias. University of La Laguna

Abstract

This contribution highlights the successes of the Liverpool Telescope (LT) outreach programs and present the future of our engagement plans with the LT's partner, the New Robotic Telescope (NRT).

Since 2004, the LT has dedicated a considerable amount of observing time to educational and astronomy outreach programs aimed at students, teachers and amateur astronomers in the UK, Spain and other countries through The Schools' Observatory (TSO) and PETeR (The Educational Project with Robotic Telescopes). These programs allow that 1,200 teachers and their students each year develop an inquiry project by taking and analyzing their own astronomical images through an online platform designed to be accessible and easy to use.

The NRT, the 4m sibling of the LT, will provide autonomous, rapid optical observations of transient phenomena in the northern hemisphere sky. Set to come online in the late 2020s, the NRT is an innovative and challenging project that brings together astronomy and engineering to build a unique and flexible system of many complex parts. The NRT project is focusing its outreach efforts on showcasing the variety of skills of the team members, along with the adaptability and scope of people with science and engineering degrees. Through collaborations with TSO and PETeR, the NRT will host a range of STEM-focused careers activities on their website, designed to highlight exciting prospects and educate school-age children about the range of roles available within science and engineering; particularly within a project environment.

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Observing Experiences for Undergraduate Students with the Skynet Robotic Telescope Network

Megan Dubay, Dr. Daniel Reichart, Joshua Haislip, Vladimir Koupiranov, Reed Fu

University of North Carolina at Chapel Hill

Abstract

The Skynet Robotic Telescope Network ("Skynet") consists of 20+ fully automated, professional-grade optical and radio telescopes at various sites around the world. Skynet is a global network of robotic telescopes and sophisticated web-based software that can control most commercially available hardware and provide users with straightforward observation scheduling. The Skynet mission includes both research and education initiatives. Research interests vary from near-Earth objects to supernovae and gamma-ray bursts. On average, Skynet data appears in peer-reviewed publications every 24 days.

We developed introductory astronomy undergraduate curricula over the past 16 years that leverage Skynet to allow for hands-on learning using professional instrumentation. Afterglow Access and Astromancer graphing, analysis, and modeling tools are in development to further advance opportunities for students to do the same science that required advanced knowledge just a few years ago. These curricula, *Our Place in Space! ("OPIS!")* and *Astrophotography of the Multi-Wavelength Universe! ("MWU!")* focus on teaching students how to do the science they learn about in their classes for themselves, and see how the practice of astronomy works. Multi-million dollar grants from NSF and DoD STEM are being used for development, expansion, and education research of these curricula. OPIS! focuses on a cosmic distance ladder approach, and has been expanded to serve ~1.5% of all introductory astronomy students in the US. MWU! uses astrophotography as a hook for the color-based exploration of stellar and galactic formation and evolution.

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STEM education with robotic telescopes: lessons from the PETeR project

Nayra Rodríguez-Eugenio, Alejandra Goded Merino

Instituto de Astrofísica de Canarias (IAC)

Abstract

The *Instituto de Astrofísica de Canarias* (IAC) is a Spanish astrophysics R&D centre that operates the Canary Islands Observatories, which house the telescopes of some 60 institutions from more than 20 countries. The IAC and the owner institutions sign cooperation agreements whereby Spain receives a percentage of the observing time on each telescope. In 2004, the IAC decided to allocate part of its guaranteed time on some robotic telescopes to education and created the Educational Project with Robotic Telescopes (PETeR), an online inquiry-based laboratory that allows schools to carry out their own observations and research projects in astronomy. Access to several telescopes, which also offer different types of observations through user-friendly portals, has allowed us to open the project to the entire Spanish educational community, from primary to secondary schools. Currently, some 450 schools are PETeR users.

All our users have access to the variety of resources and educational approaches we offer: predefined observations of selected objects, activities and research projects with previously observed data, guided research projects and open astronomical investigations, using both automatic and remote-controlled observations. This makes PETeR a unique laboratory to assess the suitability of each of these models to the type of user, as well as their strengths and weaknesses.

In this talk we will review the advantages and disadvantages that we have identified of each approach, the type of user that prefers each of them, as well as the resources, training and support that users require to be able to develop them effectively.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

2900

Skynet Astromancer and Astronomicon: designing a suite of tools to facilitate course-based research with robotic telescopes at the introductory level

Daryl Janzen[1], Ruide Fu[2], Mandela Fraser[1], Daniel Reichart[2], Joshua Haislip[2], Vladimir Kouprianov[2], Megan Dubay[2], Kalee Tock[3]

[1]University of Saskatchewan. [2]University of North Carolina at Chapel Hill. [3]Stanford Online High School

Abstract

Technological advances over the past two decades have enabled us to develop global networks of research-grade robotic telescopes with image reduction pipelines that give introductory astronomy students access to photometric data collection across the entire night sky. For the educator, this opportunity comes with a challenge, to design projects with data reduction and analysis procedures, and avenues to publish the results of these research projects, that are similarly accessible to our students. To this end, we will provide an overview of the tools available through Skynet's web-based data processing, analysis and catalogue suites. In particular, this talk will focus on the tools we've created to enable large introductory classes to study star clusters—from observation to colour image processing, automated source extraction and photometry, to field star removal and isochrone modelling, to results publication in an updatable catalogue. Challenges and open issues associated with building and maintaining this suite of tools will be discussed along with plans for next steps.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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Training of astronomy club leaders in Senegal : ORION Astro Lab project

PhD Salma Sylla

Université Cheikh Anta Diop

Abstract

Here we present our experience in training astronomy club leaders in Senegal. Over the past six years, Senegal has been the scene of major astronomy activities such as NASA's three occultation space missions in 2018, 2020 and 2022, online and/or face-to-face training workshops thanks to various facilities such as Office of Astronomy for Development and Office of Astronomy for Outreach funding, and collaborations between various local and international structures. ORION Astro Lab program is one of these initiatives. This program was developed in collaboration with Madagascar. With the support of the Office of Astronomy for outreach, this project has trained twenty (20) astronomy club leaders in Senegal.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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Teaching astronomy with ASTROLAB, a Peruvian experience

Dr Myriam Pajuelo[1], Aldo Panfichi Sanborn[1], Dr Nicole van der Bliek[2]

[1]Pontificia Universidad Catolica del Peru. [2]NSF's NOIRLab

Abstract

We present our experience teaching an introductory astronomy course at the Pontifical Catholic University of Peru (PUCP). Students both attend theoretical sessions and participate in practical experiences. The course uses the ASTROLAB (Starlight in the university laboratory) tutorial, developed by Michele Gerbaldi and Jean-Pierre De Greve. Astrolab is a project of the Office of Astronomy for Development (OAD) of the IAU. There is a need to have access to telescopes and instruments to perform practical work - in this sense, remote/robotic telescopes are a very good option given the few opportunities that Peruvian undergraduate students have to do observational astronomy, and also due to the fact that the few astronomical facilities that exist in the country are far from the university.

The students are introduced to scientific research methods as they go through the same steps astronomers take when preparing and carrying out an observing program. Alongside these sessions, students enthusiastically learn how to plan observations, submit proposals, process their data, and analyze their results; having access to professional software and query of database (Gaia, CDS, etc) and Virtual Observatory (VO) tools on images obtained from remote telescopes in professional observatories from Las Cumbres Observatory 40 cm telescopes. This teaches students to develop teamwork abilities, understand the complexity and ambiguity of empirical work, develop practical skills, error analysis, defend their results both in written and oral form, and most importantly: develop critical thinking.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

3015

The use of robotic telescopes in astronomy and physical sciences classes at university level in Puerto Rico

Dr. Mayra Lebron[1], Dr. Carmen Pantoja[1], Dr. Lisa Storrie-Lombardi[2], Dr. Edward Gomez[2], Dr. Rachel Freed[3], Dr. Sabrina Stierwalt[4]

[1]University of Puerto Rico - Río Piedras Campus. [2]Las Cumbres Observatory. [3]InStAR. [4]Occidental College

Abstract

The USA Sky Partner is a pilot program, adapted from the Astronomy Research Seminar of INStar, funded by the National Science Foundation Partnerships in Astronomy & Astrophysics Research and Education (PAARE) program. USA Sky Partners allows undergraduate students to learn about science through an astronomy research project of double stars. The participating students work on most parts of a research process including the use of the 0.4m robotic telescopes of Las Cumbres Observatory for the observations, data analysis, result dissemination and peer review paper publication. The Río Piedras Campus of the University of Puerto Rico (UPR-RP) is part of this pilot program. At UPR-RP we have implemented the experience as part of a general astronomy course (ASTR3005) and a general studies science course (CIFI4005), with the participation of 47 undergraduate students. This research experience resulted in 4 articles submitted to the Journal of Double Star Observations (two have been accepted and two are under revision) and four student presentations at local undergraduate research conferences and one presentation at the American Astronomical Society meeting. In this work we present the experience, benefits and challenges during the implementation of the USA Sky Partner project in the courses ASTR3005 and CIFI4005 at UPR-Río Piedras.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

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FUT – a telescope in Australia being remote-controlled by high-school students in Denmark

Karsten Brogaard[1,2], Jørgen Christensen-Dalsgaard[1]

[1]Department of Physics & Astronomy, Aarhus University, Denmark. [2]Department of Physics & Astronomy, University of Bologna, Italy

Abstract

We present our observing facility, which is a telescope in Australia that can be remote-controlled by Danish high-school students via a web-based control-panel. Pipeline reduced data and project descriptions are freely available to everyone at fut.phys.au.dk.

Session

FM 10 Teaching capacity of remote observing facilities for the Universities and High Schools

Final category: FM 11 Multi-wavelength Astrometry

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Correlating IceCube-170922A Neutrino Event with γ-Ray Spectrum from TXS 0506+056 using *Fermi*/LAT Data

Mr. Rajendra Neupane[1,2], Dr. Niraj Dhital[1]

[1]Central Department of Physics, Kirtipur, Kathmandu, Nepal. [2]Birendra Multiple Campus, Bharatpur, Chitwan, Nepal

Abstract

We conducted an analysis of γ-ray data of TXS 0506+056 detected by *Fermi* LAT spanning from August 13, 2010, to August 12, 2023. We generated a comprehensive light curve covering the entire thirteen-years period. Through this analysis, we identified potential flaring events within the data and the correlation of the IceCube-170922A neutrino event with the flaring. In 30-day time intervals, we determined energy flux, photon flux, and spectral index. The spectral index was at its lowest value of 2.003 ± 0.057, and the energy flux was at (1.945 ± 0.211) × 10^{-4} MeV cm−2 s^{-1} during the time frame when the IceCube-170922A neutrino event was detected. This indicates a significant flattening/hardening of the spectrum during the detection of the IceCube-170922A neutrino event. There is no correlation between the highest flux state and the high energy IceCube-170922A neutrino event detected on September 22, 2017 because the highest energy flux of (3.329 ± 0.452) × 10^{-4} MeV cm−2 s^{-1} was obtained during the period between June 28, 2017, and July 27, 2017.

Session

FM 11 Multi-wavelength Astrometry

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JASMINE: near-infrared space astrometry mission

Professor Naoteru Gouda[1], JASMINE team[2]

[1]National Astronomical Observatory of Japan. [2]ISAS/JAXA, NAOJ and other institutes

Abstract

JASMINE is a satellite mission to perform infrared astrometric observations in the direction of the Galactic nuclear region. JASMINE was selected by ISAS/JAXA (Institute of Space and Astronautical Science/the Japan Aerospace Exploration Agency) for the JAXA Competitive Middle-Class Science Missions No.3. This mission is unique in that the same astronomical object can be observed frequently, and observations will be performed in the near-infrared band, in which the effect of absorption by dust is weak. JASMINE uses an infrared camera under development in Japan to observe in the Hw band of wavelengths from 1.0 microns to 1.6 microns. JASMINE will determine parallaxes (proper motions) accurate to between 25 μas （25μas/y) and 125 μas (125μas/y), depending mainly on the star magnitude. This mission will help to achieve revolutionary breakthroughs in astronomy and astrophysics, including the formation history of the Galactic nuclear structures (Galactic Center Archeology) and the supermassive black hole at the Galactic Center etc. In terms of understanding our Galaxy's structure, and its formation and evolution, the Galactic nuclear region is particularly important region because stars of various ages have different spatial distributions and motions according to their ages in this region although this region covers only a small part of the sky. It's like having different strata in geology. JASMINE will also be useful for exploring dark matter, black holes, X-ray binary star systems, and stellar clusters, in the inner region along the Galactic plane. The brief overview and recent progress of the JASMINE mission will be explained.

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STEP II: Precision Narrow-Angle Space Astrometry in Orbit

PhD Ding Chen[1], Fei Huang[2], Heqing Wang[2], Zhuoer Shao[3]

[1]Shanghai Aerospace and Space Technology. [2]Shanghai Aerospace Control Technology Institute. [3]Cornell University

Abstract

Search for Terrestrial Exo-Planets (STEP) mission aims at the Micro-arcsecond Narrow Angle Space Astrometry, which offers a unique astronomical instrument for the astronomers and the planet scientists to start a new view on the research. After the success of the Pathfinder mission (STEP I) in orbit in the past two years, we started a medium science mission STEP II, going to be launched soon this year, which will provide a special Narrow-Angle Space Astrometry tool for the Astronomers worldwide to use and will be a good complementation to the wide-angle global survey astrometry mission such as the noted Gaia mission. The primary scientific purposes of this mission will be the precision astrometry on the nearby Stellars and the Exo-planets detection. The overall design and the detail info. of the mission will be introduced in this talk. The additional suggested targets, interesting scientific goals, observation proposal, collaborations or special Astronomical scientific purposes are welcome!

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NEW ASTROMETRIC SOLUTION AUS2024A BY GEOSCIENCE AUSTRALIA

Dr Oleg Titov[1], Dr Simon Willcocks[1], Dr Yulia Lopez[2], Ms Angelina Osetrova[3]

[1]Geoscience Australia. [2]University of Tasmania. [3]Saint-Petesburg State University

Abstract

Herewith we present a new Celestial Reference Frame (CRF) solution produced by Geoscience Australia (aus2024a.crf). A 30-year set of geodetic VLBI observations was processed with self-calibration of the wet troposphere delay and gradients along with reference clock offset variations. The formal accuracy of all astrometric parameters is improved by a factor of three with respect to the standard solution. We analyzed more than 15 million group delays and provided high precision coordinates of 5428 radio sources with the best formal positional error of about 2 μas. Additionally, the negative parallax effect with an amplitude of -15.8 +/- 0.5 μas was detected. Independent estimate of this effect by the Gaia optical mission (EDR3 release) is -17 μas, i.e. the estimates from the two independent techniques are consistent. We tend to think that the negative parallax effect could be caused by a real physical reason rather than instrumental problems. More investigation is required to develop a plausible explanation of the detected effect.

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Progress Towards ICRF4 at X/S and K Bands

Dr. David Gordon[1], Dr. Aletha de Witt[2], Christopher Jacobs[3], Dr. Hana Krásná[4]

[1]U.S. Naval Observatory. [2]South African Radio Astronomy Observatory. [3]Jet Propulsion Laboratory, California Institute of Technology. [4]Technische Universität Wien

Abstract

ICRF4 is scheduled to be submitted to the IAU for approval at the 2027 IAU General Assembly in Rome. This report will summarize the progress made towards expanding and improving the ICRF at X/S and K bands during the 5 years since ICRF3 was generated. The current X/S band CRF now consists of over 5700 sources constructed from more than 18 million VLBI observations using over 7100 VLBI sessions taken over a 43 year period. The distribution of sources north of -45° declination is fairly uniform, with some over-density near the ecliptic plane to provide more sources for spacecraft navigation. The X/S sources in this part of the sky are dominated by VLBA observations. South of -45° declination, the density of sources is much lower due to fewer observations from fewer and less sensitive antennas in the southern hemisphere. The K band CRF now has over 1300 sources from 161 K band sessions with over 2.5 million observations from 2002-2024. K band sessions have been made with the VLBA, the HARTRAO-HOBART26 network, the HARTRAO-YEBES40m network, and the Korean VLBI network (KVN) with HARTRAO, YEBES40M, SEJONG and MOPRA. The distribution of K band sources is fairly uniform between both hemispheres, however position uncertainties increase rapidly in right ascension south of -40° and in declination south of -10°. Efforts are underway to improve the southern precision by getting more observations to HARTRAO, HOBART26 and MOPRA.

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X/S versus K Band Source Stabilities from Time Series Analysis

Dr. David Gordon, Dr. Phil Cigan, Dr. Christopher Dieck

U.S. Naval Observatory

Abstract

It has commonly been assumed that quasar positions should be more stable at higher radio frequencies. But is this correct? We investigate this question by comparing VLBI time series source positions at X/S and K bands for several hundred sources. At X/S band, we use time series solutions from VLBA, RDV, R1 and R4 sessions from 2016-2024. At K band we use VLBA astrometry sessions, also from 2016-2024. Comparisons of the data show slightly less scatter for K band in right ascension, but greater scatter in declination, presumably due to the smaller north-south extent of the VLBA and accompanying larger declination uncertainties.

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The statistics of Gamma-Ray Burst redshifts

Istvan I. Racz[1], Istvan Horvath[1], Zsolt Bagoly[1,2]

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Abstract

An extensive analysis using almost 600 precise distance measurements of gamma-ray bursts (GRBs) was conducted. Unfortunately, an observed trend indicates a decline in the number of redshift measurements associated with GRB sightings. While previous studies have revealed significant cosmic structures leveraging GRB data, a more comprehensive understanding necessitates an increased spatial distribution of GRB observations to investigate their relationship with conventional cosmological structures. To address this gap, we examined the distribution of known GRB distances with the aim of estimating distances for GRBs lacking redshift measurements. We propose a potential methodology for calculating distances to Swift GRBs based on observed parameter values.

Session

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Optical/IR interferometric astrometry: the key diagnostic when understanding complex massive binary systems

Dr Abigail Frost

European Southern Observatory (ESO)

Abstract

Massive stars (those greater than 8 solar masses) are hugely important objects in our Universe. They synthesise heavy elements through and produce huge amounts of ionising radiation and distribute this into the interstellar medium. Their winds shape their local star forming regions and also affect the morphology of galactic superwinds (Leitherer 1994). Additionally, gravitational waves are the end product of massive stellar mergers, with black holes and neutron stars colliding to create ripples that are felt across the galaxy (Abbot et al 2016). The effects of a massive star can be irrevocably changed by their multiplicity. At least 90% of massive stars are expected to be in at least a binary system (e.g. Moe & di Stefano 2017) and 70% of these stars are expected to interact with eachother (e.g. Sana+ 2012). In this talk I will discuss how astrometry, particularly from spectrointerferometry with the VLTI, is now proving invaluable in the study of complicated massive binary systems. Through the presentation of two case studies, I will describe how the precise data of VLTI/GRAVITY is allowing us to break degeneracies when characterising orbits, attribute spectral features to specific stars and in doing so allow us to definitively identify massive stellar systems that have gone through interactions (e.g. Frost 2022) and even main sequence merger events (Frost 2024, in press).

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Towards ephemerides of ICRF quasars

Dr. Valeri Makarov

U.S. Naval Observatory

Abstract

ICRF quasars are not stationary radio sources on the sky. Their positions change in time along complex jittery trajectories, that are quite obvious in precision geodetic VLBI measurements separated by day of observation. The contribution of this intrinsic instability is best seen for the radio-bright sources, which tend to be defining and most frequently observed, where it becomes up to a factor of 3 greater than the formal error of astrometric measurement. These epoch-dependent variations, which we call "cosmic error" in analogy with astrometric binaries, have adverse effect on the main applications of ICRF, such as UT1-UTC monitoring and Earth orientation parameters determination. We investigate the properties of this effect in the statistical sense and quantify the impact on the Maximum Likelihood mean positions and proper motions for the general ICRF3 sample.

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TOWARDS CORRECTING SOURCE STRUCTURE FOR AN IMPROVED K-BAND (24 GHz) CELESTIAL REFERENCE FRAME.

Namakau Shirac Mwiya[1], Aletha de Witt[2], Christopher Jacobs[3], Hana Krásná[4], Michael Bietenholz[2], Marisa Nickola[2], Megan Johnson[5]

[1]University of Pretoria. [2]SARAO. [3]Jet Propulsion Laboratory, California Institute of Technology. [4]TUWien. [5]USNO

Abstract

The AGN that define the radio Celestial Reference Frame (CRF) are not perfect stable point sources and are known to vary in both flux density and structure on timescales of months to years. The variations in structure can lead to significant errors in astrometric Very Long Baseline Interferometry (VLBI) measurements. Ideally, the effects of source structure should be accounted for in the VLBI analysis, but such modelling requires an ongoing imaging effort for all CRF sources. Observing at 24 GHz, higher than the traditional-used frequencies below 10 GHz, allows for better resolution and astrometric accuracy.

Using a systematic compilation of 24 GHz VLBI images, we extracted image properties and studied the source compactness in order to comprehensively characterize the structural attributes of targeted sources. Fourier transform, variance analysis, and correlation studies were employed to assess the sources' temporal stability and specifically investigate the correlation between VLBI astrometric position offsets and source structure. Through this analysis, we sought to precisely quantify the impact of source structure on observations at 24 GHz. This quantitative analysis will inform the development of a corrective model tailored for addressing source structural effects. Subsequently, this model will be integrated into existing VLBI analysis software, enhancing its capability to account for and mitigate the influence of source structure on observations.

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FM 11 Multi-wavelength Astrometry

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VGOS CRF 2024a: using radio multiband data to create a CRF for geodesy

Hana Krasna[1], Christopher Jacobs[2]

[1]Technische Universität Wien (TU Wien), Austria. [2]Jet Propulsion Laboratory, California Institute of Technology, USA

Abstract

The next generation Very Long Baseline Interferometry (VLBI) Global Observing System (VGOS) for geodesy and astrometry simultaneously observes the active galactic nuclei in four radio bands, ranging from 3 to 11 GHz. The goal of VGOS is to improve the accuracy of geodetic and astrometric data products, such as the Earth orientation parameters or the terrestrial and celestial reference frames. We present the celestial reference frame (CRF) estimated from group delays coming from VGOS Operational (VGOS-OPS) and Research and Development (VGOS-RD) 24-hour sessions. The first five test sessions were conducted in December 2017, followed by regular VGOS-OPS sessions starting in January 2019 with a two-weekly cadence.

The VGOS CRF 2024a comprises over 400 radio sources, with the majority located at declinations higher than -45 degrees. This is due to the CRF being computed using observations from 13 antennas, of which only two (Hobart12 and Kath12m) are located in the southern hemisphere. We show the comparison to ICRF3-SX and to Gaia optical celestial frame. Solving for just 3-D rotations, the arc-differences vs. arc-length show agreement with ICRF3-SX to 10 microas, if in addition to the usual no-net-rotation constraint also the delta declination vs. declination slope is constrained. The further improvement of the VGOS CRF depends mainly on building more VGOS telescopes in the southern hemisphere. This will further lower the formal precision in declination of the southern radio sources and it will improve the global distribution of the sources included in the VGOS frame.

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Status of the Q-band CRF in 2024 and roadmap forward: extending the CRF to higher radio frequencies

Hana Krasna[1], Christopher Jacobs[2], Aletha de Witt[3], Frederic Jaron[1], David Gordon[4], Taehyun Jung[5]

[1]Technische Universität Wien (TU Wien), Austria. [2]Jet Propulsion Laboratory, California Institute of Technology, USA. [3]South African Radio Astronomy Observatory (SARAO), South Africa. [4]U.S. Naval Observatory (USNO), USA. [5]Korea Astronomy and Space Science Institute (KASI), Korea

Abstract

We present a preliminary Q-band (43 GHz) CRF catalog, built from three 24-h Very Long Baseline Array (VLBA) sessions observed as part of an imaging comparison campaign. Nearly simultaneous VLBA sessions in S, X, K and Q-band were organized monthly from April to June 2021, observing radio sources from the same list. This Q-band CRF consists of more than 400 radio sources and their 67 thousand group delay observations. The median formal precisions are about 200 microas in right ascension and about 350 microas in declination. The global agreement with the ICRF3-SX and the Gaia optical celestial frame is at the level of 1.5 parts per billion. The motivation to explore the ability of radio observations of extragalactic sources at 43 GHz to build the CRF, is mainly the reduction of plasma distortion of the signal and the more compact morphology of most of the sources compared to lower frequencies. The prospects for future improvements are bright, covering the potential to add Q-band VLBI observations using the Korean tri-band (K, Q, W-band) system; exploring the southern baseline observations between Mopra, Australia and CART 40m, Argentina; and proposing more Q-band time on the VLBA with the planned upgrade from 4 to 8 Gbps data rates. We acknowledge that the VLBA time is being sponsored under the USNO time allocation.

Session

FM 11 Multi-wavelength Astrometry

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The infrared reference frame in Gaia era based on AllWISE and CatWISE catalogs

Dr. Jia-Cheng Liu

Nanjing University

Abstract

The launch of Gaia in December 2013 ushered in a new era of space astrometry, allowing for fundamental reference research at an unprecedented level of precision. The international celestial reference frames (ICRF) in radio band and the Gaia celestial reference frame (Gaia-CRF) in optical band have been established and are consistent within several micro-arcseconds for axes orientation. To bridge the gap between the visual and radio bands, an infrared reference frame should be investigated. We present a study aimed at constructing an infrared reference frame using the observations from the AllWISE and more recent CatWISE catalog. After cross matching with Gaia DR3, systematic differences in positions and proper motions, such as magnitude or color equations and vector spherical harmonics are derived. These systematic differences are comparable to the random errors in the infrared astrometry and can be used to improve the source positions and proper motions, making the AllWISE or CatWISE catalog a valuable extension of the all-sky reference frame in the infrared band. Our investigation reveals that extragalactic sources and stars in the infrared catalogs exhibit different astrometric properties. The global difference between the extragalactic source reference frame and the stellar reference frames is found to be about several mas for global rotation and glide amplitudes, respectively. Such internal inconsistency should be mentioned when exending the Gaia stellar reference frame to longer wavelength.

Session

FM 11 Multi-wavelength Astrometry

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Extragalactic radio and optic fundamental astrometry

Leonid Petrov

NASA Goddard Space Flight Center

Abstract

A lot of efforts were put into running dedicated absolute astrometry VLBI campaigns during last three decades. Analysis of data collected in these campaigns allowed us to produce a catalogue of radio source positions of over twenty thousands of active galactic nuclei (AGN) with nanoradian accuracies. Analysis of the ongoing space astrometry Gaia mission resulted in a catalogue of over one million AGNs with comparable accuracies. Radio and optic astrometry has a lot of common features, but also has certain distinctions. Analysis of these commonalities and differences will be presented. When commonalities in two astrometric catalogues can be used for strengthening positional astrometry and what are limits in combining two catalogues will be discussed.

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FM 11 Multi-wavelength Astrometry

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The masses of Milky Way globular clusters using GAIA data.

Jane Letsoalo[1], Dr Bruno Letarte[1], Dr Zolile Mguda[2]

[1]North-West University. [2]UNISA

Abstract

Globular clusters, dense groups of stars formed from a common molecular cloud, offer valuable insights into star formation as they exhibit similar chemical composition, age, and kinematics. Serving as natural laboratories, they enable the study of fundamental parameters such as distances, ages, metallicities, sizes, and masses.

This study employs the Leonard-Merritt method to measure the masses of the ten nearest globular clusters. The mass distribution is modelled by fitting the photometric characteristics of each globular cluster to the King model. The gravitational potential is determined using proper motion data from the Gaia space telescope, leveraging precise astrometric measurements for accurate proper motion throughout the galaxy. The Gaia mission's high-precision astrometry facilitates mass measurements for numerous globular clusters using a unified dataset and a single measurement technique. This study establishes a robust reference point for the Leonard-Merritt technique by comparing its results against the literature masses of the selected globular clusters. The comprehensive approach ensures accurate and reliable mass determinations, contributing to our understanding of globular cluster dynamics and their role as crucial astronomical laboratories.

Session

Division A Fundamental Astronomy

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Accurate VLBI astrometry and strong lensing as a direct test to the LambdaCDM model

Dr. Cristiana Spingola

INAF Institute for Radioastronomy

Abstract

Accurate astrometry of strong lensing systems can address fundamental open questions in cosmology. In particular, the micro-arsec astrometric accuracy achievable with Very Long Baseline Interferometry (VLBI) can infer the nature of dark matter, as it allows to directly detect at high significance the milliarcsec-level gravitational effect of the (expected) sub-halos on the lensed images. Our results on the astrometry of VLBI-observed gravitational arcs can constrain the dark matter particle mass at the same level of the number statistics of the satellites of our Galaxy and demonstrate the power of the method, anticipating what SKA-VLBI will be able to reveal.
Strong lensing also provides a magnified view of distant background sources, which cannot be detected and spatially resolved with current instruments. With a multi-band dataset that includes VLBI, HST and Chandra observations, we started a systematic astrometric analysis to search for offset and dual AGN at high-z. Our results reveal multi-band offsets on hundreds of parsecs in sources at $z > 1$ and we found a dual AGN candidate that, if confirmed, implies an order of magnitude mismatch between the observed and predicted dual AGN systems.
Accurate astrometry is also important for finding strong lenses. I will discuss our effort in developing efficient methods to find lenses using wide-field radio surveys, in preparation for the SKA1-MID surveys that will reveal 10^5 strong lenses.

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ngVLA for VLBI in the 2030's and beyond

Dr Megan Johnson[1], Dr David Gordon[1], Dr Phil Cigan[1], Dr Lucas Hunt[2]

[1]US Naval Observatory. [2]National Radio Astronomy Observatory

Abstract

The next generation Very Large Array (ngVLA) is proposed for the 2030's timeframe and if approved, will include long baselines to replace the current Very Long Baseline Array (VLBA). We present an overview of the goals for the ngVLA long baselines for supporting scientific topics including, compact object research, stellar imaging, extrasolar planetary systems, fast radio bursts, pulsars, and fundamental astrometry including the International Celestial Reference Frame (ICRF) in the 2030's and beyond. The breadth of science that the ngVLA long baselines will provide will inevitably change our views of the Universe. One of the areas we plan to contribute most is in the maintenance and improvements of the ICRF. Integrating and sustaining a multi-wavelength ICRF will be challenging in the coming decades. We explore some of these challenges related to very long baseline interferometry (VLBI) and discuss how ngVLA might be realized to support these ambitions. We will also present some recent results towards this effort from data collected on the VLBA and showcase the USNO Fundamental Reference Image Data Archive (FRIDA), a repository of ICRF multi-frequency radio images.

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FM 11 Multi-wavelength Astrometry

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Ultra-Precise relative Astrometry with next-generation VLBI: Methods, Opportunities and Requirements

Dr Maria J. Rioja[1,2], Dr Richard Dodson[1]

[1]ICRAR-UWA. [2]OAN-IGN

Abstract

We are at the cusp of a generational shift in the power of radio interferometers, with exciting next-generation instruments, such as SKA, ngVLA and upgraded EHT, that are coming online. Next-generation VLBI observations bring a potential order-of-magnitude improvements in sensitivity and in astrometric performance, provided that the requirements for optimum calibration methods and usability are not designed out. We have been exploring the implications for astrometry of these new instruments, as sensitivity alone will not improve over the current astrometric limits - being systematic and not driven by thermal noise. Thus using traditional phase-referencing techniques will not be able to significantly overcome the current astrometric accuracy nor extend the moderate range of operational frequencies.

The developments that drive forward the field of ultra-precise astrometry constitute a very active field of research. Next-generation methods such as *Source-Frequency-Phase-Referencing* and/or *MultiView*, combined with next-generation technology, offer an order-of-magnitude increase both in accuracy and in the range of operating frequencies across the radio spectrum, for both ground and space-VLBI domains. In this talk I will report on the fundamentals, potential and recent on-going steps to confirm that these new methods will deliver on their promise and to ensure that any technological requirements are not designed out from the next-generation instruments. We foresee that the combination of the next-generation developments (on instruments, methods and technology) will have the greatest impact in the compilation of large and unbiased ultra-precise astrometric surveys, compared to current instruments, expanding the role of VLBI into new areas of research.

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Prospects for sub-mm astrometry with the ngEHT

Dr Richard Dodson[1], Dr Maria J. Rioja[1,2]

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Abstract

Astrometry at the very highest of frequencies is an unexplored frontier for VLBI observations. Astrometry is vital to connect observations at different times and different frequencies. The former is used for measuring proper motions and parallaxes to derive distances to the targets - and thus their physical characteristics. The latter is to reference two images at different frequencies together, which is equally important. No spectral index or rotation measure is valid if the observations are not registered.

One of the exciting new facilities that will be available in the near term is the next generation Event Horizon Telescope. This has recently been extended so that multiple frequencies will be observed simultaneously; 86-, 230- and 340-GHz. Multi-frequency observations result in a transformational boost in the capabilities of the ngEHT, providing the vital phase referenced registration between frequencies.

We will describe how this new capability will allow ultra-precise bona-fide astrometric studies, based on simulations. We will report on our first attempts to apply frequency phase transfer at mm-wavelengths. In addition we will discuss MultiView astrometry, which was designed for `lower' frequencies, but we are also pushing it towards mm-wavelengths, with observations at 43GHz and proposals for 86GHz. The combination of these techniques would offer all varities of astrometric measurements at these extreme frequencies, and thus investigations of the most extreme of physical conditions.

Session

FM 11 Multi-wavelength Astrometry

1267

Astrometry of Variable Stars in Clusters

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

The search and study of variable stars in star clusters and associations is of interest not only for studying the nature of their variability, but also for understanding the physics, kinematics and evolutionary characteristics of these groups of stars themselves. We present current results of long-term photometric monitoring campaign of the 15 galactic open clusters of different ages carried out under the international Uzbek-Indian research project. We obtained the extensive photometric time series database of these clusters during 3 years in 2021-2023. In addition to new data set, the time series were also obtained for 7 clusters earlier in 2003, i.e. with the twenty-year break. The aggregate analysis, together with the available data obtained by *TESS* and *Gaia* missions, made it possible to discover a significant number of new variable stars in different clusters, check the few known variables in these clusters and determine their belonging to the cluster (membership), their kinematics, distance, age and other parameters of the native cluster. The resulting observational database and the current results of its analysis in combination with *TESS* and other data is discussed. Processing and in-depth analysis of this data using original pipelines and existed *BigData* analysis software for *Gaia* and *TESS* is currently ongoing together with our Indian partners.

Session

FM 11 Multi-wavelength Astrometry

1329

Astrometry in Africa

Dr Aletha de Witt

South African Radio Astronomy Observatory (SARAO)/ Department of Science and Innovation (DSI)

Abstract

Africa has a rich history of astrometry dating back to ancient times when celestial observations were crucial for navigation and timekeeping. Modern astronomy in South Africa originates from the maritime challenges faced by European explorers along the coastline during the 17th/18th centuries. The need for precise stellar positions for navigation led to the establishment of the Royal Observatory at the Cape of Good Hope in 1820, now the South African Astronomical Observatory (SAAO). Established in 1974, the Hartebeesthoek Radio Astronomy Observatory (HartRAO) remains a vital contributor to the Celestial Reference Frame (CRF) through Very Long Baseline Interferometry (VLBI), housing Africa's only VLBI-capable radio telescope for astrometry. Looking forward, the addition of a new geodetic telescope at HartRAO and potentially others to the VLBI Global Observing System (VGOS) will significantly contribute to the VGOS CRF. The Africa Millimetre Telescope (AMT) project plans a millimetre radio telescope in Namibia, linking to the Event Horizon Telescope (EHT) Network as Africa's first. Additional millimetre telescopes, including on Mount Kilimanjaro, are considered, augmenting astrometric capabilities for CRF work. The African VLBI Network (AVN) project aims to establish VLBI-capable radio telescopes in the African SKA partner countries. Initiatives like Ghana's conversion of a telecommunications antenna into a radio telescope and plans for a new telescope in Botswana exemplify this progress. The SKA itself in VLBI mode will play a crucial role in detecting new, weaker radio sources and measuring their astrometric positions with sub-milliarcsecond precision. All these efforts promise a vibrant future for African astrometry.

Session

FM 11 Multi-wavelength Astrometry

1345

Modern astrometry: Gaia, VLBI, and beyond

Prof Dr Sergei Klioner

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Abstract

The present state-of-the-art in astrometry will be reviewed. After a very brief historical overview, the status of the optical astrometry with Gaia will be discussed. Advantages and disadvantages of a Gaia-type astrometry and the radio astrometry with VLBI will be summarized. The problems related to the use of different wave-bands for astrometry will be discussed as well.

Session

FM 11 Multi-wavelength Astrometry

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Characterising Gaia's Compact Object-Luminous Companion Binaries using Multi-wavelength Followup

Dr. Sourav Chatterjee, Mr. Anindya Ganguly

Tata Institute of Fundamental Research

Abstract

Gaia's astrometry has revealed over one hundred candidate compact objects (COs) by resolving the orbital motions of the luminous companions (LCs) in wide orbits around them. While astrometric solutions provide constraints on the mass function of these binaries, it is crucial to estimate the stellar properties of the LCs and COs for categorisation. Such characterisation would also help us constrain progenitor properties such as metallicity and age for the COs, a crucial ingredient to improve detailed models of supernova and CO formation. We use multi-wavelength followup studies spanning infrared (IR) to ultraviolet (UV) for the CO-LC binary candidates identified from Gaia's third data release to construct their spectral energy distributions (SEDs). Using SED modelling we constrain the stellar properties for the LCs including age, metallicity, mass, radius, bolometric luminosity, and effective temperature. In several cases, we can clearly identify the CO as white dwarf (WD) from significant excess UV flux relative to the expected SED from the LC. For these, we constrain WD properties including age, effective temperature, mass, and radius. Deep radio followup is underway for several of these candidate CO-LC binaries. To improve the existing census of WD-MS binaries, we have developed a novel method to identify them even when they are hidden within the main-sequence of an optical CMD by their relative locations on multiwavelength CMDs followed by confirmation through SED modeling. I will talk about our latest key results.

Session

FM 11 Multi-wavelength Astrometry

1511

Astrometry of Exoplanets Using Optical Interferometry: Insights from the GRAVITY Instrument

Dr. Sylvestre Lacour[1], ExoGRAVITY Collaboration[2]

[1]Observatoire de Paris. [2]..

Abstract

In March 2019, the GRAVITY collaboration unveiled the first spectrum and astrometry of an exoplanet achieved through optical interferometry. Four years on, we reflect on how this technique has changed our view of imaged exoplanets, offering enhanced astrometry (typically by several tens of milliarcseconds) and superior spectra compared to those obtained with single telescopes. But to what extent has this transformation occurred? What levels of precision can we now achieve, and what are the implications? In this talk, I will detail the method that facilitated these high-contrast observations and weigh its pros and cons. Furthermore, I will highlight some of the key results to date and explore the future prospects of this technique.

Session

FM 11 Multi-wavelength Astrometry

1594

Astrometric bias caused by inhomogeneous background

Dr. Anatoliy Ivantsov

Royal Observatory of Belgium

Abstract

All kinds of measurements are taken against some background. The greater the signal-to-noise ratio is, the smaller error is expected in both position and magnitude of an object. If we take measurements of the objects that are slightly less than the magnitude of the background, their positions will be affected by background inhomogeneity. In the case of point sources with the Gaussian-like distribution of intensity, the symmetry is broken, and the source's position is biased. We provide an analytic solution for the bias of the Gaussian image if the neighbourhood background gradient is known or measured. The solution explains the exponential-looking degradation of the astrometric errors with respect to the magnitude and gives a way to balance the reduction by the proper weights introduced. The abstraction allows correcting the bias in the astrometry of Gaussian-like sources whatever wavelengths or instruments are used.

Session

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A Multioctave 8 GHz–40 GHz Receiving System for Astrometry and Navigation

Joseph Lazio[1], Jacob Kooi[1], Melissa Soriano[1], Jay Blanchard[2], James Bowen[1], Zubair Abdulla[1], Lorene Samoska[1], Andy Fung[1], Raju Manthena[1], Daniel Hope[1], Hamid Javadi[1], Timothy Crawford[1], Darren Hayton[3], Inmaculada Malo-Gomez[4], Juan Daniel Gallego-Puyol[4], Ahmed Akgiray[5], Bekari Gabritchidze[1], Kieran Cleary[6], Jim Brown[2], Ray McFarlin[2], Christopher Jacobs[1]

[1]Jet Propulsion Laboratory, California Institute of Technology. [2]National Radio Astronomy Observatory. [3]Oxford Quantum Circuits. [4]Yebes Observatory. [5]Ozyegin University. [6]California Institute of Technology

Abstract

NASA's deep space spacecraft are navigated via astrometric measurements relative to the Celestial Reference Frame. There is an increased emphasis on the use of K band (25.5 GHz–27 GHz) and Ka band (31.8 GHz–32.3 GHz) communications, both to increase the downlink data rates and because of spectral congestion and interference at lower frequencies. The same equipment used for communications is used also for generating signals for navigation, with an aspect of deep space navigation involving relative astrometry between the spacecraft and International Celestial Reference Frame (ICRF) sources. The IAU recently adopted the third ICRF, which now includes observations at K- and Ka bands as well as the legacy S-X–reference frame. We describe a prototype wide-band receiver system for the Very Long Baseline Array (VLBA) that covers from 8 GHz to 40 GHz simultaneously. The system consists of a quadridge feed horn, a cryogenic package containing wide-band low-noise amplifiers (LNAs), and a downconverter to transform the received signals to the VLBA's signal transport system. The receiving system was tested at the Jet Propulsion Laboratory, California Institute of Technology, then deployed to the VLBA's Owens Valley antenna. We describe its performance, which includes detection of fringes in observations with other VLBA antennas.

Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

Session

FM 11 Multi-wavelength Astrometry

1708

Study of the hadronic synchrotron mirror model for orphan flares in blazars - Application to3C279

Mrs Laenita De Jonge, Professor Markus Böttcher

North West University (NWU)

Abstract

Blazars are a class of Active Galactic Nuclei (AGN), found in the centres of elliptical galaxies, that are radio loud and have a small angle between the jet and the observer's line of sight. In some cases, flaring events in one frequency band are not accompanied by flaring in other bands. Such events are called orphan flares. The causes of this variability and conditions in and location of the high energy emission region are not completely understood. As a possible explanation for rapid orphan gamma-ray variability, the hadronic synchrotron mirror model has been suggested in previous work. A TeV orphan flare was observed on the 28th of January 2018 by the H.E.S.S. observatory from 3C 279. A primary flare was observed 11 days earlier by Fermi-LAT. The hadronic synchrotron mirror model is applied to this flare. A study uses the SED and multi-wavelength light curve results to determine which parameters provide the best fit and to draw conclusions about the radiation mechanism that caused this orphan flare. A search for neutrino emission is also conducted to establish if orphan flares are a possible source.

Session

FM 11 Multi-wavelength Astrometry

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The VLBA New Digital Architecture: A New Digital Backend for the VLBA

Lucas Hunt[1], Walter Brisken[1], Steven Tremblay[1], Adriana Escobar[1], Bruce Rowen[1], David Schafer[1], Hichem Ben Frej[1], James Allison[1], Jay Blanchard[1], Jon Cooper[1], Justin Linford[1], Mark Wainright[1], Paul Demorest[1], Steve Wimbrow[1], Barry Clark[1], Andrew Jameson[2], Adam Deller[3], Jonathon Kocz[4], Mitch Burnett[4]

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Abstract

The Very Long Baseline Array (VLBA) is the premier astrometric instrument, used for both defining the International Celestial Reference Frame and for determining positions and motion of sources throughout the Milky Way and the Universe. Part of this success comes from the capabilities provided by the current backend for the VLBA, the Roach Digital Backend (RDBE). The RDBE has been in operation since 2011, and ushered in a new era of higher sensitivity observations, but it has recently become difficult to maintain. The National Radio Astronomy Observatory (NRAO) has been working through more frequent failures and fewer available spare parts. We have undertaken the VLBA New Digital Architecture (VNDA) project to modernize the digital backend system on the VLBA.

VNDA will allow for a larger number of configuration combinations of bandwidth, bits per sample, and number of channels. VNDA will also remove restrictions on tuning within the band, useful for working around parts of the band with strong RFI. Finally, VNDA has the capacity to accommodate future VLBA upgrades, for example new receivers or updates to the IF system. The expanded capabilities VNDA provides will allow the VLBA to continue performing as a premier astrometric instrument as we anticipate the capabilities of the ngVLA.

Session

FM 11 Multi-wavelength Astrometry

1817

A Telescope on Mount Kilimanjaro, Tanzania

Dr Noorali Jiwaji, Dr Gordon MacLeod, DR Said Ally

Open University of Tanzania

Abstract

The genesis of a telescope on Mount Kilimanjaro was born in 2010 during a visit to South Africa by a scientific delegation from Tanzania. It was proposed to explore the possibility of astronomy on Mount Kilimanjaro. Desktop studies suggest sites on the Saddle, an area of about 20 square kilometers above 4,500-m, may be suitable for millimeter and submillimeter wavelength astronomy. However, appropriate site testing is required to verify. We have navigated a lengthy process to receive permission to carry out preliminary atmospheric transmission studies on Kilimanjaro, and we anticipate starting this activity at a 4,720m elevation site in the near future.

Following these studies, installation of a 10-m class radio telescope (actual size not yet determined) with high efficiency (~70% at up to 230 GHz) will be explored. Our goals are to operate as a stand-alone observatory for a range of radio science topics, and to participate in high frequency Very Long Baseline Interferometry experiments that resolve the event horizons of nearby supermassive black holes. Other serious issues must still be overcome, in particular environmental and aesthetic impact during the construction phase, in addition to addressing cultural, economic and educational issues and opportunities. These issues will be discussed here.

Session

FM 11 Multi-wavelength Astrometry

1837

Update of the CNS5 catalogue: a multi-wavelength census of the solarneighbourhood

Alex Golovin, Dr. Sabine Reffert

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Abstract

Catalogues of nearby stars represent the best-characterised stellar and substellar populations and, as such, are fundamental tools for studying the solar neighbourhood and the composition of the Galactic disk, for selecting targets for exoplanet surveys, and for testing stellar evolution models.
By combining astrometry across different wavelengths, the Fifth Catalogue of Nearby Stars (CNS5) provides the most volume-complete sample of all known stars and brown dwarfs which are possibly located within 25 pc of the Sun.
The CNS5 is compiled based on trigonometric parallaxes from Gaia DR3 and Hipparcos, and supplemented with astrometric data from Spitzer and ground-based surveys carried out in the infrared, as well as radio astrometry from ALMA, VLA, and VLBA.
After its initial release, the CNS5 has been continuously updated with observational data for nearby stars from various sources.
In this talk, we review this census, including new additions to the 25 pc sample, and present an update of the CNS5.
We also discuss how our methods for constructing an astrometrically clean catalogue of nearby stars have enabled us to discover and characterise new nearby white dwarfs.

Session

FM 11 Multi-wavelength Astrometry

1880

KOSMIC: K-band VLBI Observations with Improved Scheduling and Ionospheric Corrections

Benedikt Soja[1], Aletha de Witt[2], Marcel Iten[1], Arno Rüegg[1], Matthias Schartner[1], Hana Krásná[3], Marisa Nickola[2]

[1]ETH Zurich. [2]South African Radio Astronomy Observatory. [3]Technische Universität Wien

Abstract

Very Long Baseline Interferometry (VLBI) has revolutionized astrometry by accurately measuring the angular directions of compact extra-galactic radio sources, forming the celestial reference frame (CRF). The K-band (24 GHz) CRF, introduced in the multi-wavelength ICRF3, promises enhanced precision over lower frequencies but faces challenges like ionospheric effects and network geometry issues. The project KOSMIC, a consortium between ETH Zurich, HartRAO, and TU Wien, aims to address these challenges to enhance the precision and stability of the K-band CRF, impacting astronomy, geodesy, and space exploration. These efforts align with the IAU's ICRF maintenance call and support multi-wavelength CRF development.

In the first part of the project, we will develop a machine learning-based ionospheric model to optimally correct K-band VLBI observation for ionospheric effects. The model will rely on Global Navigation Satellite System (GNSS) data and be specifically tuned to perform well at the sites of the VLBI stations participating in K-band efforts. In the second part of the project, advanced scheduling techniques based on the VieSched++ software will be implemented in K-band observation plans to partially compensate for the limitations of the network geometry.

This contribution provides an overview of the project, outlining our strategies to address the objectives and highlighting the initial results achieved. Our new approaches regarding ionospheric corrections and scheduling will be operationally implemented to enhance future K-band observations and the corresponding CRF.

Session

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2063

Comprehensive Compilation of Stellar Data in M33's Central Region: Unveiling the Final-Stage Evolution Through Near-Infrared Survey

Ms Mina Alizadeh[1,2], Dr. Atefeh Javadi[2], Prof. Jacco Van Loon[3], Dr. Yousef Ali Abedini[1], Dr. Hedieh Abdollahi[2]

[1]Zanjan University. [2]IPM (Institute for theoretical Physics and Mathematics). [3]Keele University

Abstract

We obtained data using three cameras at the UK InfraRed Telescope (UKIRT) between 2003 and 2007. The observations in the K-band were conducted by the UKIRT Fast-Track Imager (UFTI) over three consecutive nights in August 2005. The Wide Field Camera (WFCAM) data in the J and H bands were collected between 2005 and 2007. Additionally, UIST data in the K-band for the central region of M33 were gathered from 2003 to 2007.

Our focus was on stars in the final stage of their evolution, where luminosity is more directly related to birth mass. By combining data from multiple instruments and projects, we aim to identify long-period variables in the galaxy's central region, as this area provides the deepest and most comprehensive investigation of the galactic center due to the nature of the data. The identification of variables will involve photometry on the WFCAM data with PSF calibration followed by a re-examination of the data.

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2079

ICRS realizations and their inherent inconsistencies: a geodesist view

Dr. Maria Karbon[1], Santiago Belda[1], Esther Azcue[2], Jose Manuel Ferrandiz[1], Alberto Escapa[3]

[1]Universidad de Alicante. [2]Instituto Geografico Nacional. [3]Universidad de Leon

Abstract

One of the primary goals of Very Long Baseline Interferometry (VLBI) is the determination of the International Celestial Reference Frame (ICRF). The third realization of the CRF, the ICRF3, was adopted by the IAU in August 2018, which replaced the ICRF2 from 2009. The novelty was the supplement of the catalog at standard geodetic and astrometric radio frequencies (8.4 and 2.3 GHz) with data collected at higher radio frequencies (24 GHz and dual-frequency 32 and 8.4 GHz). However, in contrast to the standard procedure in geodesy, e.g. in the determination of the International Terrestial Reference Frame (ITRF) or the Earth rotation parameters (EOP), where intra- and inter-technique combinations are performed operationally, the three individual catalogs forming the ICRF3 stand independently from each another. The CRF realized by Gaia stands alone as well.

Within this work we investigate known inconsistencies and systematics inherent to the ICRF3 (and in relation to Gaia-CRF) and quantify their impact, point out unsolved issues in the determination and realization of these frames and suggest methods to address them. We illustrate the methods and works pursued in geodesy to reach the highest possible precision.

Session

FM 11 Multi-wavelength Astrometry

2090

Photometry of a Select Sample of Large Magellanic Cloud Cepheids: Light Curves, Color Curves, Amplitudes, Mean magnitudes and Multi-Wavelength Covariance across the Optical (BVI), Near-Infrared (JHK) and Mid-Infrared (3.5 and 4.5 micron) Bands.

Mr Mahdi Abdollahi[1], Prof. Barry F. Madore[2,3], Dr. Atefeh Javadi[1]

[1]School of Astronomy, Institute for Research in Fundamental Sciences (IPM). [2]The Observatories, Carnegie Institution for Science. [3]Department of Astronomy & Astrophysics, University of Chicago

Abstract

Thanks to the multiwavelength data collected in several surveys conducted by TMMT and Spitzer, we can consider the Period-Luminosity (PL) relation from optical to mid-IR. It is evident that as we move to longer wavelengths, the dispersion of PL data decreases, indicating a reduction in statistical errors due to the diminishing effect of temperature. Working in redder wavelengths (near- and mid-IR) provides us with more reliable results, leading to more accurate determinations of H0.

Observations in this range of wavelengths are challenging and often impossible with ground-based telescopes, necessitating space-based telescopes such as JWST. However, these observations are constrained by time limitations due to the many observations they must conduct. This poses a challenge in requiring time-averaged data in subjects like PL relation. This idea emerged from the question: is it possible to derive time-averaged magnitudes from single-epoch observations?

In this project, we aim to discover a relationship to correct random-phase data, resulting in narrower PL data. This method tackles errors originating from the single-epoch observations by utilizing information from observations in another filter, leading to time-averaged data. The technique relies on correlations between residuals from Period-Luminosity (PL) relations and magnitude-magnitude diagrams across various bandpasses, primarily spanning different ranges of wavelengths.

Finally, we selected the J and B bandpasses to calibrate and test our method, with the J bandpass representing the random-phase data component. The findings illustrate that this correction reduces the scatter around the PL fitted line by approximately √2 in the J bandpass, From 0.24 to 0.17 magnitude.

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A digital-spectroscopy-type water vapor radiometer for high accuracy radio astrometry

Prof. Hiroshi Imai[1], Prof. Noriyuki Kawaguchi[2]

[1]Kagoshima University. [2]National Astronomical Observatory of Japan

Abstract

We have tested a digital-spectroscopy-type water vapor radiometer (WVR) installed at the Stewart platform focus in one of the VERA (VLBI Exploration of Radio Astrometry) 20-m dish radio telescopes for directly measuring the excess path delay length (EPL) due to Earth's precipitable water vapor toward astrometry targets (i.e. background reference and astrometrically targeted radio sources). Such measurement is crucial to high accuracy astrometry for sources at low telescope elevations (e.g. sources in the Galactic Center observed from VERA in Japan) because the difference in the EPLs towards the targets at slightly different elevations (by degrees) may innegligibly affect the astrometry at a micro-arc seconds level. Although new calibration techniques for VLBI astrometry have been developed, such as the multi-view technique, the WVR technique should be explored for millimeter VLBI astrometry in which a coherent time for fringe visibility integration is too short for applying such new techniques. The WVR based on a compact analogue-digital high-speed sampler enables us to install it on the upper cabin of the telescope. We will present the present status of the development of the WVR technique, in which the measured EPLs shall be applied to more precise calculation of phase-tracking models used for visibility calibration. The feasibility of the WVR technique will be evaluated by comparison between the EPLs derived from the WVR and GNSS station data and improvement of the astrometric accuracy with applying the technique.

Session

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The scientific goals of the Lunar-based UV-Optical-IR Telescope/Array for ILRS

Huijuan Wang[1,2], Mikhail Sachkov[3], Subo Dong[4], Xianyong Bai[1,2], Andrey Shugarov[3], Xiaojun Jiang[1,2], Hui Tian[5], Ning Jiang[6], Yuanyong Deng[1,2], Gongbo Zhao[1,2], Taoran Li[1], Vladimir Shmagin[3], Yongliao Zou[7], Lin Xu[7], Xiaoming Zhang[1,2], Jiaqi Wang[1], Jianfeng Wang[1,2]

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Abstract

By tapping into the unique lunar-based and lunar orbital environment, we have the opportunity to conduct multi-wavelength observations across an extensive range of wavelengths, from EUV to IR. In 2021, our collaborative research teams from Russia and China proposed the construction of a Lunar-based UV-Optical-IR telescope/array for the International Lunar Research Station (ILRS). Since then, we have been continuously refining our scientific objectives. This presentation will explore the scientific goals, simulations of the capabilities, and considerations for payload requirements. The optimized scientific goals of the lunar-based telescope/array are focused on:

1. To conduct a UV sky survey and detailed observations from the lunar surface, create a dynamically updated and comprehensive UV catalog, investigate galaxy formation and evolution, and develop a timeline of galaxy evolution covering 80% of the universe's history.
2. To capture dynamic cosmic "movies" in the near UV band, investigate high-energy transients in the local universe, and comprehensively study the ultraviolet features of variable sources within the Milky Way.
3. To explore the habitability of exoplanets from a fresh and distinctive viewpoint, we will take into account space weather phenomena and the impact of small bodies within planetary systems; Furthermore, to uncover new terrestrial exoplanets within habitable zones, analyze their characteristics, and envision potential future habitable environments for humanity.
4. To investigate the interaction between Earth's magnetosphere and exosphere with the solar wind from an external perspective using a UV telescope on the Moon's orbiter, and to survey the heliosphere in Lyα.

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FM 11 Multi-wavelength Astrometry

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The X/Ka (8.32 GHz) 2024b Celestial Reference Frame: Systematic Errors

Mr. Christopher Jacobs

Jet Propulsion Laboratory, California Institute of Technology

Abstract

The X/Ka-band (8.4/32 GHz) Celestial Reference Frame became one component of the ICRF-3 in 2018. In the six years since, the X/Ka data set has increased by a factor of two as well as adding the much needed north-south geometry from Japan to Australia. Median formal precision is now better than 100 micro-arseconds. The accuracy of the frame is limited by systematic errors larger than the formal precision. The limited network geometry allows for geometric distortions—most notably quadrupole 2,0 distortions. This paper will compare the use of three data weighting methods to account for the dominant noise from wet tropospheric fluctuations and the resulting impact on systematic frame distortions:
1) white noise weighting,
2) elevation dependent white noise,
3) correlated observation noise based on Kolmogorov spectrum troposphere refractivity fluctuations.

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FM 11 Multi-wavelength Astrometry

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Insights into the Synchrotron Polarization Emission from the Bright Gamma Ray Blazars

Dr. Krishna Kumar Singh[1,2], Prof. Peiter J Meintjes[3], Dr. Kuldeep K Yadav[1,2]

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Abstract

Blazars are an extreme class of astrophysical gamma-ray sources powered by accreting super-massive black holes at the center of an active galaxy. They possess oppositely directed relativistic plasma jets emanating from the central engine and oriented towards the Earth. Measurements of strongly polarized radiation from the blazar-jets provide key evidence for the synchrotron emission at low energies ranging from radio to soft X-rays. The highly variable synchrotron radiation with often quite peculiar polarization behavior in the optical waveband is connected to the high energy gamma-ray emission process, which is an open question in the area of blazar research. In this contribution, we investigate the physical properties of the optical polarization from a sample of bright gamma ray blazars. We use the informations obtained from the phenomenology of the optical polarization to study the processes of relativistic particle distribution in the blazar jets.

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Quasiperiodic Oscillation in the Gamma-Ray Light Curves of selected Blazar Sources

Ms. Manisha Dwa[1,2], Dr. Niraj Dhital[1]

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Abstract

Blazars are one of the brightest and the most energetic objects in the sky whose powerful emission spans the entire electromagnetic spectrum. Detection of quasiperiodic oscillations in the light curves of blazar sources can have important implications including among others the structure and the nature of various regions of the active galactic nuclei.

In this contribution, results from the quasiperiodic oscillation search in the gamma-ray light curves obtained from the Fermi/LAT of the selected blazar sources will be presented. The methodologies used in the work and the plausible scenarios which can explain the observed quasiperiodic oscillations will be presented as well.

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FM 11 Multi-wavelength Astrometry

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PASIPHAE survey : PSF photometry methods for the WALOP instrument

Mr. Kishan Deka

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Abstract

Polarization studies of cosmic microwave background radiation (CMBR) are useful in order to probe the large scale structures and fluctuations in the early universe. But, contamination from various sources in the CMB maps poses a great problem to observational cosmologists. One of the main sources of contamination is the polarized emission from prolate dust particles aligned with the galactic magnetic field. Understanding the magnetic field structure of our galaxy is important to subtract these foreground contaminations. Linear polarisation data of stars provides a unique way to study the intervening galactic field tomography of the Milkyway galaxy. This the main purpose of the PASIPHAE survey which aims at creating a dataset of polarization of numerous stars in the galactic polar regions with the help of upcoming state-of-the-art polarimeter named WALOP. In this presentaion, I will discuss how we use polarization data of stars to create a tomographic map of the galactic magnetic field in the context of the PASIPHAE survey. High-sensitivity polarimetric experiments with such scientific goals demand high accuracy in photometric measurements. The WALOP instruments are designed to have a large field of view (about 30 × 30 arcminutes) that can measure the stokes parameters (I, Q, U) of multiple stars in one shot with 0.1% accuracy. I will present the photometry and polarimetry methods we used in developing the pipeline for carrying out high accuracy polarimetry with the WALOP instrument. In this work, we present a method known as PSF photometry for the WALOP instrument.

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Towards the next multi-waveband realization of the International Celestial Reference Frame

Dr. Patrick Charlot

Laboratoire d'Astrophysique de Bordeaux, Université de Bordeaux, CNRS, France

Abstract

This presentation will review the current status of the VLBI frames at 8 GHz (X band), 24 GHz (K band) and 32 GHz (Ka band) in terms of sky coverage, precision and systematic errors, in view of preparing for the next realization of the International Celestial Reference Frame (ICRF) which will be multi-waveband. As such, the next ICRF will incorporate the Gaia optical frame in addition to the three above radio bands. Potential frames that may emerge at other radio frequencies in the coming years, namely at 43 GHz (Q band) or with the VLBI Global Observing System of the International VLBI Service for geodesy and astrometry, will also be covered. Finally, questions relating specifically to the construction of the multi-waveband frame like treatment of Galactocentric acceleration, alignment of the individual frames in the different bands, dealing with non-uniform sky distributions, along with considerations regarding wavelength and time-dependent source positions will be addressed. The targeted date for completion of the next ICRF, as proposed by the IAU Multi-waveband ICRF Working Group, is 2027, meaning a possible adoption by the IAU General Assembly that will take place the same year.

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VLBI monitoring of the structure of the ICRF sources - The Bordeaux VLBI Image Database

Arnaud Collioud, Patrick Charlot

Laboratoire d'Astrophysique de Bordeaux, Université de Bordeaux, CNRS, Pessac, France

Abstract

The extragalactic radio sources that make up the International Celestial Reference Frame (ICRF) can exhibit extended and time-variable brightness distributions (or structures) on VLBI scales, setting limits on the accuracy of the astrometric source positions determined from VLBI. For this reason, regular VLBI observations are organized to image and monitor these structures. The primary observations used for this purpose are the so-called ``Research \& Development with the VLBA'' (RDV) sessions, initiated almost three decades ago. Systematic imaging of the sources observed in these sessions is carried out by the Bordeaux group with the goal of tracking the structural evolution of the ICRF sources on the long-term. The VLBI images produced along with metrics that characterize the source structure are made available to the scientific community via the Bordeaux VLBI Image Database (BVID). Occasionally, other sessions, either at higher radio frequencies, i.e. K band (24 GHz) and Q band (43 GHz), or from other observing programs, are also used for imaging, At present, the database includes more than 8000 VLBI images for more than 1500 sources, with up to 50+ epochs per source. The available data may be used for astrometric and astrophysical research, like selecting the defining sources for the ICRF, modeling source structure in astrometric and geodetic VLBI, and studying the nature and evolution of the sources. The BVID is accessible at the following url: https://bvid.astrophy.u-bordeaux.fr

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Dynamical Masses of Young Stellar Multiple Systems with the VLBA (DYNAMO-VLBA)

Dr. Sergio Dzib Quijano

Max-Planck-Institut fuer Radioastronomy

Abstract

Very Long Baseline Interferometry (VLBI) provides ultra high angular resolution images and has been used for stellar astrometry for decades. As part of our previous Very Long Baseline Array (VLBA) observations, we unveiled a significant number of tight binary and multiple pre-main-sequence stars, whose components have detectable radio emission and typical separations of the order of milli-arcseconds; thus Gaia will not provide information on their orbital parameters and VLBA observations are an excellent tool to keep studying them. Dynamical mass estimations are free of assumptions on the physical parameters of the stars and, thus, DYNAMO-VLBA results could be used to test evolutionary models of pre-main-sequence stars. I will present the first Dynamical mass determinations of young binary systems with DYNAMO-VLBA. Our first findings show that the dynamical masses of these systems do not correspond with those expected from evolutionary models.

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The Magellanic Clouds with high resolution glasses

Óscar Jiménez-Arranz

Institut de Ciències del Cosmos (ICCUB)

Abstract

The exquisite astrometric dataset that Gaia DR3 offers to the scientific community makes the Magellanic Clouds (XMC) a unique test laboratory to investigate and refine methodologies and models. Classification strategies based on Neural Networks allow to select LMC and SMC samples with less than 10% contamination from the MW (Jiménez-Arranz+23a,b). Also, the LMC is the first galaxy for which we can map a 3D velocity field of the complete galaxy (Jiménez-Arranz+23a) and endeavour dynamical studies in detail, such as the determination of the LMC bar pattern speed using different methods (Jiménez-Arranz+23c). For the first time, we can analyse the internal kinematics of an external galaxy and compare them with what theoretical models predict. The results highlight the evidence of the need of high resolution simulations to provide a dynamical interpretation of the information shown by the data. In this talk, we introduce KRATOS (Jimenez-Arranz+24, submitted), a suite of 28 pure N-body simulations of isolated and interacting LMC-like galaxies, to study the formation of substructures in their disc after the interaction with an SMC-mass galaxy, and a review of the planned scientific exploitation of these data. We also discuss the potential impact of the upcoming astrometric mission GaiaNIR on our understanding of these galaxies.

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Use of GPS satellites for time calibration

Dr. David Tholen

University of Hawaii

Abstract

The accurate determination of orbits for solar system objects depends not only on having accurate positional information for the target, but also accurate temporal information. The Gaia reference catalogs have enabled a significant improvement in the accuracy of positional information, but they have done nothing for the improvement of temporal information. Even if computer clocks are synchronized using NTP software or other similar technology, the latencies in mechanical shutters can introduce small delays in the occurrence of an observation relative to the timestamp provided. We have been observing GPS satellites during evening and morning twilight to confirm the accuracy of the temporal information. By comparing the measured position of the satellite with the well-known ephemeris position, it is possible to measure shutter delays down to the few millisecond level. The details of our procedures will be presented during the meeting.

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VLBI detections of nearby (<100 pc) young stars

Dr. Sergio Dzib

Max-Planck-Institut fuer Radioastronomy

Abstract

I will present a new project aiming to increase the number of sources with Very Long Baseline Interferometry (VLBI) astrometry available for comparison with the Gaia results. Using the Very Long Baseline Array, we have observed 31 stars with recently reported radio emission, located <100 pc from the Sun, and all are in the Gaia DR3 catalog. Our first observations yielded 10 detections (a 30% detection rate). Using the astrometric Gaia results, we have extrapolated the target positions to the epochs of our radio observations and compared them with the position of the radio sources. I will discuss the results of this analysis and the importance for further Gaia - VLBI stellar astrometry comparisons.

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Unveiling the Multi-wavelength connection from Correlations of astronomical and astrometric/geodetic data of AGN sources in the K-band Celestial Reference Frame (CRF) Catalogue.

Dr. Pfesesani van Zyl[1], Dr. Aletha de Witt,[2], Dr. Janeth Valverde,[3], Dr. Jeffrey Hodgson,[4], Dr. Hana Krasna,[5]

[1]South African Radio Astronomy Observatory, South Africa. [2]South African Radio Astronomy Observatory (SARAO), South Africa. [3]NASA-GSFC/UMBC, United States. [4]Sejong University (SU), South Korea. [5]Technische Universit ät Wien (TU Wien), Austria

Abstract

Active galactic nuclei (AGN) constitute the largest population in the gamma-ray sky, and host the most extreme environments capable of accelerating particles that radiate in the entire electromagnetic spectrum, while also launching stable mega-parsec (Mpc) scale jets. However, understanding the nature and location of their fast variability emission zone remains a challenge, necessitating population studies to better grasp the characteristics of these intricate objects.

The K-band Celestial Reference Frame (CRF) catalogue project recently published 5078 high-resolution Very Long Baseline Interferometry (VLBI) images, capturing 731 AGNs across 27 epochs. Leveraging this unique and incredibly extensive dataset, our study integrated VLBI flux-density time-series and images, complemented by gamma-ray data from the space-based Fermi Large Area Telescope (Fermi-LAT, 0.1->300 GeV).

We focused on investigating the multi-wavelength connections within 43 AGNs carefully selected from the K-band CRF catalogue. Our analysis delved into the intricate relationships among radio and gamma-ray, and positional time-series data from astronomical and astrometric/geodetic observations. Preliminary results suggest the existence of correlations between the positional offsets and gamma-ray data, as well as between radio and gamma-ray data in select AGNs. Additionally, intriguing patterns of long-term variability among the chosen AGNs were also uncovered, shedding light on the dynamic interplay between radio and gamma-ray emissions.

These findings offer crucial insights into the underlying physical processes, contributing to a deeper understanding of the astrophysical mechanisms governing AGN behavior. Our work represents an important step forward in our ongoing pursuit to comprehend the complex nature of AGN.

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The GaiaNIR mission: Future Space Astrometry in the Near Infrared

David Hobbs

Lund University

Abstract

Our Galaxy contains many different types of stars and planets, interstellar gas and dust, and dark matter. These components are widely distributed in age, reflecting their formation history, and in space, reflecting their birth place and subsequent motion. Objects in the Galaxy move in a variety of orbits that are determined by the gravitational force, and have complex distributions of different stellar types, reflecting star formation and gas-accretion history. Understanding all these aspects in one coherent picture is being partially achieved by Gaia, which surveys around 1% of the Galaxy and is still ongoing today. However much more could be done by using Near InfraRed (NIR) light to peer through the dust and gas to reveal the hidden regions of the Galaxy.

A new all-sky NIR astrometric mission will expand and improve on the science of Gaia using basic astrometry. NIR astrometry is crucial for penetrating obscured regions and for observing intrinsically red objects. The new mission is aimed at surveying around 12 billion stars in the Galaxy, revealing important new regions obscured by interstellar gas and dust while also improving on the accuracy of the previous results from Gaia. The mission will explore the Galaxy, particularly the very important hidden regions, to reveal nature's true complexity and beauty in action.

In 2019 ESA announced the next planning cycle for their long term Science Programme, called Voyage 2050. The program called for White Papers outlining new ideas for future space mission themes. In June 2021 Voyage 2050 finally set sail, with ESA having chosen its future science mission themes. Our proposal on All-Sky Visible and Near Infrared Space Astrometry has been selected as one of two possible themes for a future Large category mission for ESA or as a Medium class mission with international partners. This talk will give an update on the science goals, the mission design and its current status.

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Astrometry with the Africa Millimetre Telescope

Michael Janssen

Department of Astrophysics, Institute for Mathematics, Astrophysics and Particle Physics (IMAPP), Radboud University, P.O. Box 9010, 6500 GL Nijmegen, The Netherlands. Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

Abstract

I will describe the Africa Millimetre Telescope (AMT), which is planned to be built on top of the Gamsberg in Namibia and be operational in 2028. As the first millimetre telescope in Africa, the primary focus is to enhance observations of the Event Horizon Telescope. The AMT will facilitate dynamic image reconstructions of Sgr A* and improve our current GR, plasma, accretion, and jet physics tests. Centimetre wavelength receivers for the AMT are planned to be added in the future. This will enable participation in VLBI astrometric observations with the EVN and AVN. I will also describe more exploratory astrometric applications at the shorter millimetre wavelengths. Here, black hole shadows can serve as reliable reference points, unaffected by core-shift effects that have to be taken into account for astrometry with active galactic nuclei at lower observing frequencies. Finally, mm VLBI in-beam phase referencing will be able to improve the astrometry of our galactic centre, particularly the alignment of galactic radio and infrared reference frames. Here, the advantage is that the short wavelength observations are less affected by the interstellar scattering screen towards Sgr A*.

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Advancements and Innovations in the Korean VLBI Network (KVN) for mm-VLBI Astrometry and Geodesy

Taehyun Jung

Korea Astronomy and Space Science Institute (KASI)

Abstract

The Korean VLBI Network (KVN) is distinguished by its unique multi-frequency receiving system, allowing simultaneous observations across four bands (18-26, 35-50, 85-116, 124-142 GHz). This capability greatly enhances our broadband observational capabilities in radio astronomy and geodesy. Overcoming atmospheric phase fluctuations, a major challenge in millimeter VLBI (mm-VLBI), is made possible through KVN's innovative calibration technique known as Frequency Phase Transfer (FPT). Consequently, multi-frequency astrometry at mm-VLBI, extending up to 130 GHz, has become feasible, together with the detection of the largest number of sources at this frequency by KVN. These broadband multi-frequency radio observations open up new avenues for VLBI astrometric and geodetic studies.

In this presentation, I will introduce our recent advancements and innovations, including: (1) the first geodetic observation results at 22/43/86/129GHz, (2) the development of a photonic instrumental phase calibration system, and (3) the establishment of common time/frequency standards across the KVN through a fiber network. I will also discuss the synergies and future prospects from these developments for astrometry and geodesy.

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Mapping the Distribution of Gamma-Ray Bursts using Open Data GIS

Mr Mercy Akintola

AfAS

Abstract

1. Gamma-ray bursts (GRBs) are fascinating astronomical phenomena thought to be caused by the collapse of massive stars or the merger of binary neutron stars. To gain insights into the distribution and properties of GRBs, we used open data GIS to map the distribution of GRBs in the sky. We collected data on GRBs from publicly available databases such as the Gamma-ray Burst Coordinate Network (GCN), the Gamma-Ray Burst Monitor (GBM), and the Swift Burst Alert Telescope (BAT), and conducted spatial analysis to identify regions of the universe with high and low densities of GRBs. Our analysis revealed that GRBs are distributed non-uniformly in the sky, with a higher density of GRBs observed in certain regions of the universe. I identified several clusters of GRBs that were located near each other in space, suggesting that they may have a common origin. Our density maps showed that GRBs are most common in the outskirts of galaxies, where star formation is also high. These results suggest that the formation of GRBs is closely linked to the formation and evolution of stars in galaxies. My findings demonstrate the power of open data GIS in providing new insights into the distribution and properties of astronomical phenomena, and highlight the importance of open data sharing in advancing scientific research.

Keywords: open data GIS, gamma-ray bursts, spatial analysis, clustering analysis, kernel density analysis.

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Wide-field gamma-ray observatories as probes of fundamental physics

Professor Vitor de Souza

University of São Paulo

Abstract

Wide-field of view gamma-ray observatories detect the photons with highest energy known in the Universe and therefore their data offers an unprecedented test for fundamental physics and beyond the standard model proposals. Interactions of the very energetic photons with the intergalactic media or the presence of anomalous effects allows the test for Lorentz Invariance Violation, axion-like particles and dark matter candidates. The removal of systematic effects and false-positive signals requests the detection of a large population of sources from a variety of types at a wide range of distances and directions highlighting the potential of wide-field of view gamma-ray observatories in relation to other techniques. In this talk, we will review the current limits on Lorentz Invariance Violation, axion-like particles and dark matter calculated with the use of high-energy gamma-rays. We will also discuss the possible enhancements in detection and data analysis achievable with the next generation of observatories.

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Probing Gamma-Ray Bursts as Cosmological Standard Candles using Spectral information in Machine Learning models

Ms Tamador Aldowma[1,2], Prof Soebur Razzaque[1]

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Abstract

Gamma-ray bursts (GRBs) represent the most powerful explosions detected across electromagnetic wavebands, originating from the deaths of massive stars (Long-duration) or the merger of two neutron stars (Short-duration). GRBs have been observed from redshift up to z = 9.2, underlining their significance as cosmic probes similar to supernovae type Ia. Extensive efforts have been devoted to using GRBs as cosmological standard candles, leading to the discovery of several empirical relations. In this study, we leverage GRB data from the Fermi-GBM and Kouns-Wind catalogs to estimate pseudo-redshifts for a number of GRBs. This estimation is accomplished by applying Machine Learning techniques, specifically deep neural networks in stacking with the Random Forest algorithm, forming an ensemble model. Subsequently, we conduct a joint spectral analysis using data from Fermi (GBM-LAT) and Swift (BAT-XRT) to attain the most optimal fit, using the ThreeML software. Using the best-fit spectral parameters alongside the pseudo-redshift data, we investigate the Amati relation, a correlation between the intrinsic peak energy ($E_{i,peak}$) of the spectrum, and isotropic energy (E_{iso}) over the burst duration (T_{90}). Furthermore, we also explore the Yonetuko relation, which correlates between Ei, peak, and the peak isotropic luminosity (L_{iso}). These analyses aim to deepen our understanding of GRB characteristics and their potential as cosmological standard candles.

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The multi-wavelength view of gamma-ray-detected radio-loud active galactic nuclei

Prof. Markus Boettcher

North-West University, Potchefstroom, South Africa

Abstract

This talk will review the current status of multi-wavelength observations of radio-loud active galactic nuclei detected in very-high-energy gamma-rays (blazars and gamma-ray loud radio galaxies), as well as recent advances in the theoretical understanding of their multi-wavelength and possibly multi-messenger emission. Special emphasis will be placed on the question what progress can be made by an improved census of gamma-ray-loud AGN, expected from the next-generation ground-based wide-field gamma-ray observatories.

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Investigate the impact of magnetar on the kilonova afterglow emission in short GRBs through late-time radio observations.

Dr. Ankur Ghosh[1], Professor Soebur Razzaque[1], Dr. Kuntal Misra[2], Dr. Resmi Lekshmi[3], Mr. C.S Vaishnava[4], Professor K.G. Arun[5], Dr. Amitesh Omar[6]

[1]CAPP, University of Johannesburg, South Africa. [2]Aryabhatta Research Institute of observational sciencES (ARIES), India. [3]Indian Institute of Space Science and Technology (IIST), India. [4]Physical Research Laboratory (PRL), India. [5]Chennai Mathematical Institute (CMI), India. [6]Indian Institute of Technology (IIT) Kanpur, India

Abstract

The coincident detection of gravitational waves (GW 170817) and short gamma-ray bursts (GRB 170817A) confirmed their common origin from the coalescence of binary neutron stars (BNS). Depending on the BNS masses and equation of states, the outcome could be a black hole or a millisecond magnetar. In the presence of a magnetar, a significant portion of its rotational energy is transferred to the emerging ejecta, leading to late-time radio brightening known as "kilonova afterglow" emission upon interaction with the ambient medium. Detection of this late-time radio brightening in short GRBs has profound implications for understanding the progenitor physics. This study presents the deepest and most extensive search for late-time radio emission from short GRBs until 2016, incorporating proper frequency regime, wider observation span and relativistic correction. Utilizing the Giant Metrewave Radio Telescope (GMRT) at 1250, 610, and 325 MHz bands, observations were conducted between 2 and 11 years post-burst for five short GRBs. The estimated upper limits are used to constrain the parameters of the burst and its surrounding environment. With appropriate modifications, the magnetar model constrains the number density of the ambient medium for these bursts to be between 10^{-4} and 10^{-2} cm^{-3}. Our analysis rules out a stable magnetar with an energy of 10^{53} erg for four out of the five GRBs in our sample. The upcoming radio telescope like the Square Kilometer Array (SKA) (in MHz frequencies) with increased sensitivity of μJy level will push the detection limits of kilonova afterglow emission at late times.

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Multi-messenger synergies with wide-field ground-based gamma-ray observatories

Prof Soebur Razzaque

University of Johannesburg

Abstract

Gamma-ray astronomy is a thriving field with exciting results in the Very-High Energy (VHE, > 100 GeV) range from the Imaging Air-Cherenkov Telescopes (IACTs) and from the wide-field particle detector arrays. The latter have extended the observational range of gamma-ray astronomy beyond 100 TeV. VHE emission from astrophysical sources requires extreme environments where particles accelerate and interact to produce gamma rays, and in case of hadronic interactions, neutrinos. In this talk I will review multi-messenger aspects of astrophysical sources and synergies with ground-based gamma-ray observatories.

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Exploring the Influence of Cosmic Voids on the propagation of TeV Gamma Rays and the Puzzle of GRB 221009A

Hassan Abdalla

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Abstract

The recent detection of a gamma-ray burst GRB 221009A has drawn attention due to its record brightness and the first-ever detection of very-high energy (VHE, > 10 TeV) gamma rays from a GRB at such redshift z=0.151. This distance is significant enough for severe attenuation of the gamma-ray flux at these energies due to gamma-gamma pair production with the extragalactic background light (EBL). In this talk, I will discuss whether the presence of cosmic voids along our line-of-sight to the source can significantly impact the detectability of such VHE gamma-ray photons andthe prospects for future detection of TeV photons from extragalactic sources, such as GRBs or blazars, could be enhanced if such detections occur in directions where cosmic voids are present.

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The Spatial Distribution of GRBs and the Cosmological Principle

Zsolt Bagoly[1,2], Istvan Horvath[1]

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Abstract

We made a survey of the spatial distribution of 542 Gamma-Ray Bursts with precisely determined positions. In the northern galactic hemisphere, we observed a notable cluster of four GRBs within a narrow redshift range ($0.59 < z < 0.62$), coinciding with the previously recognized Hercules–Corona Borealis Great Wall (in a redshift range of $0.9 < z < 2.1$). Conversely, in the southern galactic hemisphere, we observed the previously identified Giant GRB Ring within the redshift range of $0.55 < z < 1.35$. Both the Hercules–Corona Borealis Great Wall and the Giant GRB Ring have become more prominent with the expansion of the GRB sample size.

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Do optically bright and dark GRBs differ physically?

Lajos G. Balazs[1,2], Zsolt Bagoly[3,4], Istvan I. Racz[3], Istvan Horvath[3]

[1]Dept. of Astronomy, Eötvös University. [2]HUN-REN CSFK Konkoly Observatory. [3]University of Public Services. [4]Dept. of Physics of Complex Systems, Eötvös University

Abstract

Using the discriminant analysis of the multivariate statistical analysis we compared the distribution of the physical quantities of the optically dark and bright GRBs, detected by the BAT and XRT on board of the Swift Satellite. We found that the GRBs having detected optical transients (OT) have systematically higher peak fluxes and lower HI column densities than those without OT.

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A decade surveying the extreme cosmos with the HAWC gamma-ray observatory

Dr Alberto Carramiñana

Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE). The HAWC Collaboration

Abstract

HAWC, the High Altitude Water Cherenkov gamma-ray observatory, is an extended air shower array optimized to survey and monitor celestial sources of TeV gamma rays over two thirds of the sky. Located at 4100m of altitude in the Northern slope of Volcán Sierra Negra, Central México, HAWC has been in full-operations for over nine years. Taking over MILAGRO, its direct predecessor, HAWC has detected over seventy sources of very high-energy gamma rays, the majority of them related to pulsars, the engines behind the previously unknown TeV halos, together with energetic supernova remnants, star forming regions and microquasars, some of these sources emitting well above 100 TeV. Beyond the Milky Way, HAWC has found evidence of TeV emission from about half a dozen of relatively nearby powerful active galactic nuclei. Operated by a multi-national collaboration, HAWC is one of the most relevant scientific projects undertaken by Mexico.

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SABHASAT : A GAMMA-RAY BURST DETECTION CUBESAT

Mr Snehadeep Kumar

Kalinga Institute of Industrial Technology

Abstract

SABHASAT, developed by The Nebula Space Organisation, is a pioneering 3U CubeSat engineered for gamma-ray burst observations in Low Earth Orbit (LEO) at 650 km altitude. As the potential first Cubesat gamma-ray observatory in Asia and the world's second, it integrates cutting-edge detector technologies, encompassing an Active Attitude Control System, Distributed Command and Data Handling, Communication systems, Electronic Power System, and Peak Power Tracker.

The mission of SABHASAT centers on realizing innovative, distributed, and modular instruments, emphasizing cost-effectiveness and swift development. Leveraging off-the-shelf technologies in nanosatellites, like CubeSats, showcases their efficient utilization in the space economy, offering solid performance at a constrained cost. Despite a single sensor's compromised effective area compared to conventional gamma-ray detectors, the distributed design allows for an innovative instrument with unexplored perceptivity.

In a proposed cargo configuration within a 1U CubeSat, a scintillator-grounded sensor utilizing Silicon Drift Detectors detects low-energy X-rays and low-energy gamma rays. With a total power consumption of 4W and a weight under 1.5 kg, the cargo unit must meticulously consider resource limitations on a CubeSat. The gamma-ray detection process involves the scintillating target, flash of light collection by the photosensor, and subsequent signal processing via front-end electronics, ADC, and On-Board Computer before transmission to the ground. The gamma-ray detector's core comprises four optically independent scintillating crystals housed in an aluminum casing.

In conclusion, SABHASAT's advanced design and technology contribute significantly to the exploration of space radiation phenomena within the confined parameters of CubeSats, promising valuable insights into solar and gamma-ray bursts.

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Gamma-ray Bursts at VHEs

Dmitry Khangulyan

The University of Tokyo. IHEP

Abstract

Recently, the observational study of gamma-ray bursts (GRBs) in the very-high-energy (VHE) regime has advanced with several long-awaited detection with MAGIC, H.E.S.S., and LHAASO telescope systems. Currently, the list of GRBs with VHE emission measured with very high significance, $\sigma \gg 5$, contains GRB 190114C, GRB 190829A, and GRB 221009A. Several more bursts were detected with lower significance or reported as source candidates. Detection of GRB afterglows in the VHE regime allows obtaining essential information on particle acceleration by relativistic shock waves. This makes GRB afterglows to be important sources for high-energy astrophysics and their studies have an exceptionally broad scope. Two detected GRBs provided us with exceptionally viable data because of the proximity (GRB 190829A) and record-breaking luminosity (GRB 221009A). In this case, Cherenkov detectors provide us with detailed spectral information and well-measured light curves. In the former case, one H.E.S.S. revealed an unexpectedly long signal duration, up to 56 hours after the trigger, and accurately measured the spectrum in a relatively broad energy interval, spanning between 0.18 and 3.3TeV. From the latter GRB, LHAASO detected more than 60,000 photons during the onset of the afterglow, which resulted in unprecedentedly accurate measurement of the light curve and VHE spectrum, which extends beyond 10TeV. The obtained temporal and spectral properties of the VHE emission challenged the earlier prediction and promoted further development of existing models and formulation of new approaches. In this talk and will review the key observational findings and developments in the modeling.

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Modelling multiwavelength afterglows of the VHE-GRB population

Dr Monica Barnard[1], Dr Ankur Ghosh[1], Dr Jagdish C. Joshi[2], Prof Soebur Razzaque[1]

[1]University of Johannesburg. [2]Aryabhatta research institute of observational sciencES (ARIES), India

Abstract

The recent detections of very-high energy (VHE, ≥ 100 GeV) afterglow emission from several gamma-ray bursts (GRBs) have opened a new window into the GRB science. Until now synchrotron-self-Compton (SSC), assuming both the stellar wind and constant density circumburst scenarios, has been primarily used to model VHE emission from GRBs. Hadronic emission mechanisms such as photo-pion and photo-pair processes, and proton synchrotron have also been considered. We interpret the VHE emission as a combination of external Compton radiation and SSC, in both the stellar wind and constant density environments. We use publicly available NAIMA radiation modelling code to do a population study of VHE afterglow emission from several GRBs via multi-wavelength light curves and energy spectra. NAIMA already includes optimisation tools to fit radiative models to multiwavelength data. Finding a more robust fit of the model to the latest multiwavelength observations implies better constraints on the GRB environment and the particle energy requirements for the emission observed at late times. These findings have implications on future VHE observations of GRBs.

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MHD numerical simulations of CWBs in Star forming regions: high energy particles and TeV gamma-rays emission

Prof Diego Falceta-Goncalves

University of Sao Paulo

Abstract

The collision of the stellar winds in massive WR/O binaries produces strong shock fronts, where particles are accelerated to very high energies. Magnetic field is also amplified in the shocked region on which the acceleration of particles greatly depends. In this work, we show high resolution three-dimensional magnetohydrodynamic simulations of colliding winds coupled to the kinematics of passive charged test particles. We show that colliding-wind binaries are indeed able to produce a significant population of high-energy particles beyond TeV energies, in relatively short timescales, compared to the dynamical and diffusion timescales. We provide estimates of detection from ground based telescopes, such as the CTA array.

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Unveiling the Enigmatic Nature of Peculiar Long GRBs in Swift's Third Catalog

Mr Esteban Cárdenas[1], Mr Nicolas Noriega[1], Ms Jennifer Chacon-Chavez[2], Dr Nicolás Vásquez[1], Dr Jonathan Quirola-Vásquez[3]

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Abstract

Traditionally, long gamma-ray bursts (LGRBs) have been associated with the collapse of massive stars. However, our systematic search using a recalibrated Epeak-Eiso plane has revealed five LGRBs that defy conventional categorization.Recently, there have been reports of apparent LGRBS, but upon analysis, it has been revealed that they are associated with mergers and exhibit extended emission, leading to confusion during their classification. Through meticulous temporal and spectral analysis, we have delved deeper into the characteristics of these events, providing insights into their elusive progenitors. Our investigation includes a thorough examination of temporal estimators, including emission time, spectral delay, and isotropic energy, derived from Swift GRB observations. Subsequent phases of our research will explore the properties of the host galaxies and the surrounding media to provide a complete understanding of these puzzling phenomena. By challenging established paradigms, our study contributes significantly to the ongoing evolution of GRB classification and improves our understanding of the most powerful explosions in the Universe.

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SST-1M mini-array progress at the Ondřejov observatory

Dr Marek Nikolajuk[1], SST-1M Consortium[2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]

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Abstract

Single-Mirror Small-Sized Telescope (SST-1M) was originally developed as a prototype of a Cherenkov telescope by a consortium of institutes from Poland, Switzerland, and the Czech Republic. In 2021 and 2022, two of our SST-1M telescopes were relocated from Poland and re-installed in the Czech Republic.

The prototypes are undergoing commissioning at the Ondřejov observatory, and they have already accumulated dozens of hours of observations. They have successfully observed Cherenkov events in both stereo and mono modes of celestial gamma-ray sources (e.g., Crab Nebula, Mrk 421), demonstrating the suitability of the telescopes for carrying out observations in better astronomical conditions until their final location is decided.

SST-1M, with a 9.42 m^2 multi-segment mirror and a 5.6 m focal length, is optimized to detect high-energy gamma rays, ranging from about 1 TeV up to 300 TeV. The telescopes are equipped with digital DigiCam cameras based on 1296 hexagonal silicon photomultiplier (SiPM) sensors, covering a field of view of 9.1 degrees. The camera has a fully digital trigger system and readout, which can digitize waveforms in individual pixels with 4 ns sampling.

In this contribution, I will provide an overview of the telescope and camera design. Preliminary results obtained from the commissioning data and daily analyses collected at the observatory will be presented.

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Latest results from the searches for ultra-high-energy photons

PhD Indira Dajhana Vergara Quispe[1,2], Pierre Auger Collaboration[3]

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Abstract

The Pierre Auger Observatory is the largest and most accurate air-shower experiment for cosmic rays at ultra-high energy (UHE). An essential characteristic of the Pierre Auger Observatory is the hybrid concept, combining a Surface Detector array (SD) with a Fluorescence Detector (FD), offering a large exposure and unique discrimination capabilities to photons with energy above 10^{17} eV. Currently, the Pierre Auger Observatory, upgraded with multi-hybrid detectors, extends its measurement capabilities to energies as low as approximately 6×10^{16} eV. The results, presented here, are the product of the analysis of signals obtained from both the long-standing and the newly integrated detector components, such as the Underground Muon Detector (UMD) for the AMIGA project. Thus, the analysis of data taken over 20 years, in hybrid mode as well as with the SD alone, allows various searches for UHE photons including the search for a diffuse UHE photon flux, a flux from point sources of UHE photons, and UHE photons from sources of Gravitational Wave events, obtaining the most stringent upper limits on the photon flux in the UHE regime.

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Search for GeV Gamma-Ray Emission from SPT-SZ selected Galaxy Clusterswith 15 years of Fermi-LAT data

Mr. Siddhant Manna, Professor Shantanu Desai

Indian Institute of Technology Hyderabad

Abstract

Galaxy clusters could produce gamma-rays from inverse Compton scattering of cosmic ray electrons or hadronic interactions of cosmic ray protons with the intracluster medium. It is still an open question on whether gamma-ray emission (> GeV energies) has been detected from galaxy clusters. We carry out a systematic search for gamma-ray emission based on 300 galaxy clusters selected from the 2500 deg^2 SPT-SZ survey after sorting them in descending order of M_{500}/z^2, using about 15 years of Fermi-LAT data in the energy range between 1-300 GeV. We were able to detect gamma-ray emission with a significance of about 6.1σ from one cluster, viz SPT-CL J2012-5649. The estimated photon energy flux from this cluster is approximately equal to 1.3×10^{-6} MeV cm^{-2} s^{-1}. The gamma-ray signal is observed between 1 − 10 GeV with the best-fit spectral index equal to −3.61 ± 0.33. However, since there are six radio galaxies spatially coincident with SPT-CL J2012-5649 within the Fermi-LAT PSF, we cannot rule out the possibility this signal could be caused by some of these radio galaxies. Six other SPT-SZ clusters show evidence for gamma-ray emission with
significance between 3 − 5σ. None of the remaining clusters show statistically significant evidence for gamma-ray emission.

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A RPC-based GRB Hunter

Dr. Piccolo Davide[1], Dr. Barbara Liberti[2], Dr. Giuseppe Di Sciascio[2], Dr Fabio Muleri[3], Dr. Giovanni Piano[3]

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Abstract

The observation of transient emission of high energy photons (>GeV) starting from the prompt phase is crucial in a multi-messenger study of the Universe.

The Resistive Plate Chambers (RPCs) can be extensively used in Cosmic Ray Physics and Gamma-Ray Astronomy. Indeed, the ARGO-YBJ detector, a 7000 m2 full coverage RPC carpet, was operated at YangBaJing (Tibet, 4300 m asl) with very low maintenance and excellent performance for more than a decade. It provided: high efficiency detection of low energy showers, down to the GeV range, by means of the high granularity of the read-out sampling; wide energy range investigated, up to 10 PeV, by means of the combined digital/charge read-outs; good energy and angular resolutions with unprecedented details in the shower core region.

Therefore, RPCs provide the ideal detector to observe flaring emissions of photons starting from the GeV range from astrophysical objects such as Gamma-Ray Bursts (GRBs) or Active Galactic Nuclei (AGN).

In this contribution a proposal for a RPC-based GRB hunter made by a wide field of view shower array instrumented with a full coverage core made by RPCs is introduced. The activities to build a small size RPC carpet demonstrator to be installed in the framework of a SWGO R&D project and to study the performance of a hybrid system done of WCD tanks and RPC detectors, will also be reported.

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Particle Acceleration to Very High Energies in Pulsar Wind Nebulae

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Abstract

Pulsar wind nebulae (PWNe) accelerate electrons to very high energies (VHE), but the acceleration mechanism(s) and site(s) remain uncertain. We review and discuss here several possible mechanisms. In particular, we discuss particle acceleration at the pulsar wind termination shock (TS). We find that drift motion along the shock surface keeps either electrons or positrons in a ring-shaped region of the TS, close to the equatorial plane of the pulsar, where they are accelerated to VHE by the first-order Fermi mechanism. Applying our findings to the Crab Nebula, we find that both its high-energy synchrotron emission and gamma-ray emission can be reproduced by this model. We show that the recent observations by LHAASO of the Crab Nebula up to PeV energies allow for putting new constraints on parameters of the Crab pulsar wind that are still poorly known. Finally, we present results from Particle-In-Cell simulations of pulsar wind TS. They confirm the above results, and also suggest that a second electron acceleration mechanism (namely, reconnection) operates downstream of the TS, in the equatorial current sheet. We show that the latter provides a natural explanation for the inner-ring knots in the Crab Nebula, whose origin has remained elusive so far. We will also discuss possible origins for the Crab flares detected by Fermi.

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Imprint of intrinsic broad-line region absorption in the gamma-ray spectrum of blazar jet

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Abstract

When relativistic jets in blazars are directed toward observers, they intensify emitted radiation, condensing the entire output into a focused, point-like object. Blazars typically exhibit emissions spanning the electromagnetic spectrum, spanning from radio frequencies to very high energies. The GeV spectrum within these relativistic jets of blazars is primarily shaped by the non thermal emission processes internal to the jet. However, the external thermal environment surrounding the high-energy emission site is expected to leave an imprint of pair production absorption at high energies, particularly if the emission region resides within the influence of the nearby external jet environment. This could help further constrain the debatable gamma ray dissipation site in blazars.

Our study reveals for the first time, GeV breaks in the range of 40 - 85 GeV, well described by γ-ray absorption through photon-photon pair production on H-alpha or H-beta lines photons , specifically during the high state of the source. Remarkably, this absorption feature is absent during the low flux state, suggesting an additional absorption effect imprinted specifically during the high activity period of the source beyond the expected extragalactic background light (EBL) absorption. **The observed GeV break in the high state, as opposed to its absence in the low state, supports the notion that gamma-ray emission sites within or at the edge of the Broad Line Region (BLR) transition into fainter gamma-ray emission zones beyond the BLR.** Additionally, the coexistence of fast variability further supports that the high-energy emission region is mostly confined towards the edge of BLR.

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Ultra-High-Energy Gamma-Ray Observation with the Tibet ASγ Experiment

Dr. Kazumasa Kawata

ICRR, University of Tokyo

Abstract

Cosmic rays are thought to be accelerated up to a few PeV by the most powerful sources, the so-called "PeVatron" in the Galaxy. On the other hand, gamma rays beyond 100 TeV are expected by the neutral pion decays caused by the interaction of these cosmic rays with the interstellar medium. Therefore, the gamma-ray observation is key to unveiling a long-standing mystery, the origin and the propagation of very-high-energy cosmic rays in the Galaxy, because gamma rays go straight unaffected by the magnetic field, pointing back to the sources.

The Tibet air shower (AS) array and the underground water-Cherenkov-type muon detector (MD) array have been successfully operating, at an altitude of 4,300 m in Tibet, China since 2014. The gamma-ray energy and arrival direction are determined by the surface AS array, while the underground MD array enables us to drastically suppress the background cosmic rays above 100 TeV, by means of counting the number of muons in an air shower. Using these Tibet AS+MD arrays, we have succeeded for the first time in observing gamma rays above 100 TeV from the Crab Nebula [Amenomori et al. PRL, 123, 051101 (2019)] and the Galactic plane [Amenomori et al. PRL, 126, 141101 (2021)]. In this presentation, we will review recent observations with the Tibet ASgamma experiment and discuss the most powerful cosmic-ray source "PeVatron" in our Galaxy.

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The TAIGA-1 - a hybrid complex for gamma-ray astronomy, cosmic ray physics and astroparticle physics: first physical results and future plans

Professor Nikolay Budnev

Irkutsk State University

Abstract

The physical motivations and performance of the TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) project are presented. The TAIGA astrophysical complex addresses ground-based gamma-ray astronomy at energies from a few TeV to several PeV and cosmic ray physics from 100 TeV to several EeV and astroparticle physics. The TAIGA approach is the cost effective way to construct a Cherenkov array with tens square kilometers area for gamma astronomy of super high energy. The pilot TAIGA-1 complex is located in the Tunka valley, ~50 km west of the southern tip of lake Baikal. At present time it includes a timing Cherenkov TAIGA-HiSCORE array with 120 wide-angle optical stations distributed over an area of about 1 square kilometer and four 4-m class Imaging Atmospheric Cherenkov Telescopes of the TAIGA-IACT array. The effective aria of the TAIGA-1 is about 0,9 km^2 for detection of gamma quanta with energy more than 100 TeV. There are three approaches to selecting gamma quanta from the hadron background in the TAIGA experiment: (1) IACT operation in standalone mode; (2) Stereo mode operation of two or more IACTs; (3) Hybrid mode operation -joint operation of TAIGA-HiSCORE and IACTs.. Present status of the project, the first experimental results including Crab nebula gamma emission energy spectrum in energy range 4 – 300 TeV reconstructed using TAIGA data in framework stereo and hybrid ways and plans for the constructing of the future 20 km^2 TAIGA array are presented.

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New insight into the gamma-ray binary system HESS J0632+057

Miss Natalie Matchett, Prof. Brian van Soelen

University of the Free State

Abstract

Gamma-ray binaries, a small sub-class (only 9 known) of high mass X-ray binaries (HMXBs), consist of an O/Be type star and a compact object in the mass range of a black hole or neutron star. These systems continuously produce the majority of their non-thermal, multi-wavelength emission at energies greater than 100 MeV. The gamma-ray binary HESS J0632+057, consists of an undetected compact object in a ~317.3 day orbit around a B0 Vpe star. The X-ray and TeV lightcurves from this source display a double peak, which is believed to coincide with the compact object passing through the circumstellar disc of the Be star. However, this system lacks a clear orbital solution, as two incompatible solutions were obtained by Casares et al. (2012) and Moritani et al. (2018), which has made it difficult to interpret the observed emission. Long-term optical spectroscopic monitoring of HESS J0632+057 was undertaken with the High Resolution Spectrograph on the Southern African Large Telescope in order to trace the radial velocity of the system and the behaviour of the circumstellar disc of the Be star. During the last observing semester, for the first time, a third component was observed in the Balmer emission lines, giving an indication of structure in the disc and orbitally modulated disc behaviour. We present the latest results, covering ~70% of the orbit.

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Non-thermal emission from local young massive stellar clusters and detection prospects

Dr Silvia Celli[1,2], Dr Alison Mitchell[3], Dr Giovanni Morlino[4], Dr Stefano Menchiari[4], Dr Andreas Specovius[3]

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Abstract

Cosmic ray acceleration up to PeV energies has been suggested to take place in massive and young stellar clusters. The formation of a strong termination shock driven by the collective action of stellar winds in a compact cluster offers a promising location where efficient particle acceleration might take place. The subsequent hadronic collisions of these particles result into gamma-ray and neutrino production. Within a scenario of particle acceleration at the cluster wind termination shock, we compute the emerging gamma-ray and neutrino signals expected from the local young stellar clusters within the Milky Way, recently detected by GAIA. We further evaluate detection prospects of the emerging gamma-ray flux with the Cherenkov Telescope Array (CTA) and the Large High Altitude Air Shower Observatory (LHAASO).

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The multiwavelength view of the gamma-ray binary PSR B1259-63/LS 2883

Prof Brian van Soelen[1], Prof Maria Chernyakova[2], Dr Denys Malyshev[3]

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Abstract

The gamma-ray binary PSR B1259-63/LS 2883 was the first radio pulsar discovered to be in a binary system with an early main sequence star. This source has subsequently been found to persistently produce unpulsed, non-thermal emission from radio up to very high energy gamma-rays every 3.4 years around the time of the periastron passage. Increases in the non-thermal radio, X-ray and likely TeV gamma-ray emission are found to coincide with the time of the pulsar crossing through the plane of the circumstellar disc surrounding the Be-type companion. However, at GeV energies, the source shows highly luminous, short time scale flares, between 40 to 80 days after periastron. During the last periastron passage we undertook a detailed radio, optical and X-ray campaign and, for the first time, detected a third peak in the X-ray emission as well as a break in the correlation between the radio and X-ray light curves. We present an overview of our multi-wavelength coverage of the 2021 periastrion passage, a proposed model for the third X-ray peak, as well as propsect for future observations.

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LHAASO Observations on Pulsar Wind Nebula and TeV Halo

Dr. Ziwei Ou, Prof. Hao Zhou

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Abstract

Extended TeV sources associated with pulsars can be divide into two categories: pulsar wind nebula with TeV emission originating in the zone dominated by the pulsar; TeV halo with escaped particle diffusing into the ISM. The First LHAASO Catalog of Gamma-ray Sources found 35 sources with pulsar association. Based on it, we unveil the correlation between LHAASO sources and associated pulsars by spectral and morphological analysis. The observed properties of a PWN/TeV halo can be used to constrain the physical characteristics of the pulsar and surrounding environment. The spectral evolution of PWN/TeV halo shows that peak energy increase with pulsar age. Nebula and halo are explained in a unified scheme.

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Orbitally-modulated TeV photons expected from spider binaries

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Abstract

Multi-wavelength observations have now led to the detection of about 50 'spider' binary systems - black widow and redback compact binaries differentiated by their companion's mass. In these systems, a millisecond pulsar heats and ablates its low-mass companion via the intense pulsar wind. The rich empirical phenomenology includes radio eclipses, optical light curves from the heated companion, as well as non-thermal X-ray and GeV light curves and spectra that point to the presence of relativistic leptons that have been accelerated at the intrabinary shock, as well as a hot companion. This represents an ideal environment for the creation of orbitally-modulated inverse Compton fluxes in the TeV band that should be within reach of current and future Cherenkov Telescopes. We have now included an updated synchrotron kernel, broken power-law injection spectrum, and a more realistic intrabinary shock geometry in our emission code to improve our predictions of the TeV flux. Our updated spectral and energy-dependent light curve outputs may aid in constraining particle energetics, wind properties, shock geometry, and system inclination of several spider binaries.

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LHAASO observations on young massive clusters

prof ruizhi yang

University of science and technology of China

Abstract

Young massive cluster are regarded as gamma-ray emitters and cosmic ray accelerators. In this regard, LHAASO has discovered a giant gamma-ray bubble up to PeV energy range. In this talk I will introduce the LHAASO observations towards Cygnus region as well as other young massive cluster system. I will discuss the implications of these results and possible prospects.

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Surveying the gamma-ray sky with H.E.S.S.

Prof. Stefan Wagner

LSW, ZAH, U Heidelbr

Abstract

The H.E.S.S. telescope array in Namibia is an array of Imaging Atmospheric Cherenkov Telescopes (IACTs) with excellent sensitivity and angular resolution. Its large field of view facilitates sky surveys of the Southern gamma-ray sky. A wide range of surveys have been (and are being) performed with the H.E.S.S. telescopes, including, in particular, several surveys of the Galactic plane, the inner regions of the Milky Way, the Magellanic Clouds, pioneering surveys of the extragalactic sky, and time-domain surveys. The depths of these surveys varies from shallow, wide-field surveys to deep fields that mark the sensitivity limit of current generation gamma-ray instruments.

The surveys continue to provide the most successful search for new types of gamma-ray sources. They are pathfinders pinpointing interesting targets and permit statistical studies on source class properties, flux distributions and luminosity functions. The surveys led to the discovery of sources without counterparts in other waveband regimes (dark accelerators). Advanced analysis also permits studies of diffuse emission extending over areas that are considerably more extended than the 20 square degree field-of-view.

The talk will provide an overview of the survey projects carried out by the H.E.S.S. collaboration and present highlights of the different surveys. Case studies of the different use-cases will be illustrate the state of the art and future goals.

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Global and local particle feedback on 3D PIC-RMHD simulations of astrophysical jets

Augusto Carvalho[1], Elisabete Maria de Gouveia Dal Pino[1], Tania Medina-Torrejón[2,1], Grzegorz Kowal[3]

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Abstract

In magnetically dominated regions of Astrophysical systems like the inner regions of relativistic jets, magnetic reconnection driven by turbulence has been lately invoked as a dominant particle acceleration mechanism. Previous works by our group analyzed this in 3D relativistic numerical simulations of blazars using the PLUTO and RAISHIN codes. It was found that particles can be accelerated up to ~ 10^18 eV when turbulent magnetic reconnection is present. However, in such cases the feedback of the particles into the background plasma was not accounted for. We compute such interaction by considering the work performed by the particles (component 1) and comparing it with that performed by the jet (component 2). This work is accounted for in terms of the Lorentz force of each component, and then a particle-to-jet work ratio is obtained. We consider a global ratio, meaning that the whole simulation domain with ~ 1.67 x 10^7 cells is taken into account, and a local one, where only the cells containing particles are accounted for, i.e. 4.7 x 10^4 cells. We consider jets with sigma ~ 1 and sigma ~ 10 to find that, in all cases, the average ratio is below zero in the regions where the energetic particles are localized, being more accentuated for the sigma ~10 case. Our results indicate that particle feedback is negligible. This result has strong implications on the derivation of the emission at very high energies in blazars and relativistic jets in general.

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Misidentification of Short GRBs as Magnetars in Nearby Galaxies

Elisa Schösser

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Abstract

Time-domain astronomy is a rapidly growing field with ever more instruments dedicated to measuring transient events on the sky. As the number of observations grows, the likelihood of chance coincidences between these events or with temporally static astrophysical objects grows. In this young field, the proper statistical techniques to compute these chance coincident detection probabilities do not yet fully exist.

We examined one such association to derive its misidentification probability: Recent observations of GRB 200415A and 231115A, short and very bright pulses of gamma-rays, have been claimed to be extragalactic magnetar giant flares (MGF) as their origins were associated with the nearby galaxies NGC 253 and M82. However, as the redshifts of the transient objects were not measured, it is possible that the measured locations of the transients on the celestial sphere and the location of the local galaxy merely coincided. Thus, their real progenitors could have been arbitrarily far away, leaving the standard model of short gamma-ray bursts (SGRBs), the merger of two compact objects, as an explanation for the observations. We estimate the false-alarm rate of SGRBs being incorrectly identified as MGFs using population synthesis.

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Physically motivated emission model for high-state blazar emissions powered by magnetic reconnection

Juan Carlos Rodríguez-Ramírez[1], Elisabete de Gouveia Dal Pino[2], Ulisses Barres de Almeida[1]

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Abstract

Blazars are widely acknowledged as extragalactic particle accelerators and promising candidates for producing ultra-high-energy cosmic rays (UHCRs). However, the mechanism(s) responsible for blazar high-energy (HE) emission, as well as the region(s) within the blazar jet where particle acceleration occurs, remain open questions. In this context, peculiar features exhibited by blazars during high states could provide key constraints on their nature as particle accelerators. Here we present a physically motivated model for blazar emission powered by magnetic reconnection along the transition from magnetic to kinetic-dominated flow in the blazar jet. With this model we reproduce the multi-messenger spectrum of the blazar TXS0506+056, as well as TeV spectral spikes like the one observed in the historical X-ray high state of Mkr 501. Based on our data fitting, we constrain the location of the particle acceleration regions in the jet and show that very and ultra high energy cosmic-rays can be produced under such a scenario.

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Search for dark matter subhalo candidates in the fourth Fermi-LAT catalog with kernel Mahalanobis distance methods

Dr. Kenji Yoshida

Shibaura Institute of Technology

Abstract

The fourth Fermi-LAT catalog (4FGL) lists 7195 gamma-ray sources. Among these sources, 4767 gamma-ray sources have been identified/associated with blazars, pulsars, and other source types, while there are still 2428 gamma-ray sources yet to be identified, constituting approximately 34% of the aggregate. Various machine learning and deep learning methods have been reported to classify these unidentified gamma-ray sources in the Fermi-LAT catalog. The present study involves the application of kernel Mahalanobis distance methods to spatial, spectral, and temporal features of gamma-ray sources listed in 4FGL. The evaluation encompasses the classification performance concerning blazars, pulsars, and other source types, alongside outcomes pertinent to classifying unidentified gamma-ray sources. Leveraging the robust discriminatory capabilities of the kernel Mahalanobis distance methodology in isolating anomalies, we explore potential gamma-ray sources as candidates for dark matter subhalos, whose annihilating or decaying gamma-ray signals could appear as gamma-ray sources without detectable counterparts at other wavelengths. The results of our study might be of interest for follow-up searches with IACTs and the CTA.

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Effects of Cosmic Ray Bounce Diffusion in Highly Turbulent and Magnetized Environments

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Abstract

Cosmic rays interacting with the turbulent interstellar medium (ISM) produce non-thermal emissions and secondary particles, observable from Earth. However, understanding their diffusion and acceleration within the ISM remains a complex scientific challenge. This work investigates the effects of bounce diffusion and scattering using new theoretical and observational insights.

We combine three-dimensional magnetohydrodynamic (MHD) simulations of star-forming regions with test particle simulations to study particle diffusion. Our findings reveal that while MHD turbulence alters overall particle diffusion, particles are not simply trapped in magnetic mirrors. Instead, their parallel diffusion is affected, while perpendicular diffusion continues due to the super-diffusion of the magnetic field.

In general, we find that bounce diffusion (Lazarian & Xu 2021) plays a significant role in the parallel diffusion of particles. Notably, diffusion can be affected by the initial particle pitch angle, especially if resonant scattering is somehow suppressed. Particles with larger initial pitch angles take longer to diffuse parallel to the magnetic field, highlighting the need to revise conventional diffusion coefficients used in the ISM and around sources.

Our calculations suggest a diffusion coefficient of ~10^{27}cm^2/s for particles with energies of the order of 100 TeV, aligning with HAWC gamma-ray observations around pulsars like Geminga. These results will be incorporated in forthcoming studies of diffuse gamma-ray emission in molecular clouds and massive star formation regions.

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Development of a Lake Array Proposal for SWGO

Dr. Ziwei Ou, Mr. Tianyang Li, Prof. Hao Zhou

Tsung-Dao Lee Institute, Shanghai Jiao Tong University

Abstract

The Southern Wide-field Gamma-ray Observatory (SWGO) is a proposed next-generation gamma-ray survey experiment with high sensitivity and a wide field of view. Covering the southern sky, it will be built in South America to complement HAWC and LHAASO in the Northern Hemisphere. We designed a lake array proposal for SWGO to record particles from extensive air showers initiated by high energy gamma-rays. It would consist of two types of detectors: surface detectors and muon detectors. Surface detectors will be placed on the lake for the detection of electromagnetic particles. They are small tanks filled with water and equipped with a photomultiplier tube (PMT) at the bottom. Muon detectors will be deployed underwater, where lake water will be a natural filter to absorb electromagnetic components while allowing the measurement of muon particles. A lake array is being proposed for SWGO motivated by advantages over ground-based arrays, such as lower cost, fewer constraints on the detector shape, and electromagnetic component rejection for muon detectors, which create more possibilities to optimize detectors and the array. A number of technological solutions are being proposed for the implementation of SWGO, including both lake- and ground-based arrays, and a final decision on the adopted technology is expected soon, with the conclusion of the project's R&D phase.

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TAIGA - detection of the Crab Nebula using a random forest analysis of TAIGA IACT data

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Abstract

TAIGA (Tunka Advanced Instrument for cosmic ray and Gamma-ray Astronomy) has implemented a new, hybrid observation technique, based on a combination of the imaging air Cherenkov telescope (IACT) technique, and the HiSCORE timing array concept. Our aim is to explore gamma-ray sources at energies of a few 10s of TeV to several 100 TeV, an energy range particularly important to spectrally resolve the cutoff regime of the galactic Pevatrons. TAIGA currently consists of an array of 121 wide angle (0.6 sr) air Cherenkov timing stations distributed over an area of the order of 1 square-km and three IACTs with a diameter of 4.75 m and a field of view of 9.7∘.

Two independent reconstruction and analysis chains were implemented within the TAIGA collaboration. In this contribution, the current status of one of these analysis chains is discussed and the detection of the Crab Nebula, with the first IACT in operation, are presented.

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A new air shower array experiment ALPACA in Bolivia to explore sub-PeV gamma-ray astronomy in the southern sky

Dr. Sei Kato for the ALPACA Collaboration

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Abstract

ALPACA (Andes Large-area PArticle detector for Cosmic-ray physics and Astronomy) is a new air shower array observatory to be constructed in Mt. Chacaltaya, Bolivia in 2025. It mainly focuses on the discovery of astrophysical accelerators of Galactic PeV (= 10^{15} eV) cosmic rays called PeVatrons through the observation of sub-PeV (> 10^{14} eV) gamma rays from celestial sources in the yet-unexplored southern sky. The observatory has two components: a surface air shower array (AS array, 83,000 m^2) composed of 401 plastic scintillation detectors and an underground muon detector array (MD array, 3,600 m^2) containing water. The AS array captures air shower particles produced by primary cosmic rays and gamma rays in the atmosphere and reconstructs their energies and arrival directions. On the other hand, the MD array records the Cherenkov light signals given by air shower muons produced as a consequence of the hadronic interaction, leading to great improvement in the sensitivity of the observatory to primary gamma rays. The prototype array called ALPAQUITA has already been constructed and started data taking in September 2022 and its performance is studied from the observation of the cosmic-ray Moon's shadow. ALPAQUITA is also to be equipped with an MD in 2024 to improve its sensitivity to gamma-ray sources, and the work for the construction is now ongoing. This presentation gives an overview of the gamma-ray astronomy promoted by ALPACA and the current results of the ALPAQUITA data analysis.

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Variability Analysis of Fermi-LAT data to improve prospects with the Cherenkov Telescope Array and the ASTRI Mini-Array

Luana Passos Reis[1], Dr. Elisabete M. de Gouveia Dal Pino[2], Dr. Tarek Hassan[3], Dr. Jonathan Biteau[4], Dr. Santiago Pita[5], Dr. Jean-Philippe Lenain[6], Dr. Atreya Acharyya[7]

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Abstract

Investigating variability of Active Galactic Nuclei (AGN) sources is crucial for understanding particle acceleration processes and the magnetic-field behavior in those compact objects. AGNs are highly variable, with non-thermal emission in all wavelengths, which is generally attributed to relativistic particles accelerated in shocks or magnetic reconnection regions along the jet. In this study, we conduct statistical analyses, focusing on variability, utilizing the latest release of the Fermi-LAT catalog (4LAC). We correlate this variability with the detected AGN population to enhance measurement prospects for the Cherenkov Telescope Array (CTA), in order to extrapolate them to the VHE gamma-ray band and to produce synthetic SEDs and light-curves of selected AGNs to make predictions for the forthcoming CTA and ASTRI Mini-Array facilities.

Our analysis encompasses 3814 AGN sources selected from the catalog, examining parameters such as Fractional Variability and Excess Variance across three typical SED classes observed in blazars. Supplementing the annual and 2-month data provided in the 4LAC catalog, we have extended this variability study using the complementary public Fermi-LAT light curve repository, providing information for 3-day, weekly, and monthly intervals.

Moreover, we curate a subset of the catalog targeting AGN sources for detecting flares within CTA's gamma-ray spectral range. Our collaboration with the WG Redshift determination, AGN Population and AGN Variability Task Forces within the CTA aims to define a comprehensive target population of very high-energy objects. By bridging Fermi-LAT observations with CTA's capabilities, we strive to advance our understanding of AGN variability and its implications for the CTA extragalactic survey.

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Search of dark matter annihilation in stellar streams with the Fermi LAT

Cristina Fernández-Suárez, Dr. Miguel Ángel Sánchez-Conde

IFT (UAM-CSIC)

Abstract

In this talk, I will present our current research on stellar streams as a new and complementary target for dark matter (DM) indirect searches with gamma rays. The aim of this project is to unveil the unknown properties of the DM using stellar streams, which are astrophysical objects never used before in this context. Stellar streams form when a satellite, such as a dwarf galaxy (dG) or a globular cluster (GC), is tidally disrupted by the gravitational potential of its host galaxy. In particular, those streams whose progenitor is a dG are particularly intriguing targets for indirect DM searches, since dGs are thought to be highly DM-dominated systems. We expect them to have lost most of their DM content during the stretching process, but still contain a non-negligible amount of DM within their core. If the DM particles are Weakly Interacting Massive Particles (WIMPs), they could annihilate in the streams' core, producing a detectable gamma-ray signal. We analyze data from the Fermi LAT looking for a potential annihilation signal of WIMPs from the direction of some selected stellar streams, and use the results to place constraints on the DM parameter space.

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Gamma-ray bursts at Very High Energy: Clues from their host environments

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Abstract

Gamma-ray bursts (GRBs) begin to be regularly detected by Cherenkov telescopes at the TeV range. It has been discussed if the local environment in which the explosion is produced may play a role in the production of these VHE photons.

Here I will present a systematic study of the host environment of GRBs detected at VHE with Cherenkov telescopes. We observed the host galaxies in optical and IR and derived the host galaxy properties from spectral energy distribution fits. These results are complemented with broad-band and spectroscopic observations of the afterglows. Comparing with the general sample of GRB host galaxy environments, we search for peculiarities, such as large circumburst densities or local dust content. With the conclusions of this study we will verify emission mechanisms and discuss future expectations for VHE GRB observations.

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Perspectives on the Future Developments of Ground-Based Gamma-ray Astronomy

Dr Ulisses Barres de Almeida

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Abstract

Ground-based gamma-ray astronomy is a powerful tool to study cosmic-ray physics, providing a diagnostic of the high-energy processes at work in the most extreme astrophysical accelerators of the universe. Ground-based gamma-ray detectors apply a number of experimental techniques to measure the products of air showers induced by the primary gamma-rays over a wide energy range, from about 30 GeV to few PeV. These are based either on the measurement of the atmospheric Cherenkov light induced by the air showers, or the direct detection of the shower's secondary particles at ground level. After decades of continuous developments and breakthroughs, and thanks to the recent achievements of new and highly sensitive ground-based gamma-ray detectors, important scientific results are emerging which motivate new experimental proposals, at various stages of implementation. In this talk I will present the current expectations for future experiments in the field and discuss its synergies and impact to other areas of modern astronomy.

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Status of the ASTRI mini-array gamma-ray experiment: technology and science using wide-field aplanatic IACT telescopes

Dr Giovanni Pareschi

INAF - Osservatorio Astronomico di Brera

Abstract

The ASTRI program was launched 10 years ago to develop small-sized dual-mirror aplanatic wide-field IACT telescopes as a precursor to the array of small-sized telescopes (SSTs) for the Cherenkov Telescope Array (CTA) observatory's southern site. The program initially received INAF and MUR (the Italian Ministry for Universities and Research) support. Still, it gained support from other international partners such as the University of Sao Paulo/FAPESP, Nort-West University/South Africa, IAC, FGG, and Université de Geneve at different project stages. The program's first significant achievement was the development of the end-to-end ASTRI-Horn prototype and its installation at the INAF site of Serra La Nave. The prototype featured an innovative compact camera based on SiPM sensors. It proved the dual-mirror Schwarzschild-Couder optical configuration as an aplanatic system while detecting the Crab Nebula in gamma rays. The telescope underwent significant refurbishment and is now used to observe the volcano's bright gamma-ray sources, cosmic rays, and muon radiography studies. Meanwhile, the ASTRI mini-array is being implemented in Tenerife to study the gamma-ray sky in the 1-100 TeV energy band with unprecedented angular resolution (3 arcmin), which complements astroparticle arrays like LHAAZO perfectly. This talk discusses the project's status, scientific goals, and expectations.

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Cosmic Ray Propagation and Multi-Messenger Emission by Galaxy Clusters

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Abstract

Non-thermal processes taking place in the intracluster medium (ICM) can provide important insights into the properties and dynamics of galaxy clusters. Particles accelerated either by shocks in the ICM or by sources in the clusters can interact with the surrounding medium, resulting in the production of high-energy particles such as gamma rays and neutrinos. Detection of gamma-rays and neutrinos from galaxies within clusters would represent a crucial advancement in our understanding of the processes involved in particle acceleration within the intra-cluster medium (ICM) and the confinement of cosmic rays. Previous studies have identified these large structures as potential sources for confining and accelerating particles to high energies. We present results of a detailed Monte Carlo simulation of cosmic-ray propagation using cosmological MHD simulations of a Coma-like cluster, which we use to predict fluxes of gamma rays and neutrinos. We inject CRs with energies in the range 10^{14} to 10^{19} eV, and follow their cascading over the entire cluster obtaining precisely their gamma-ray and neutrino fluxes associated with high-resolution individual clusters. This work will be able to reproduce more realistic observed gamma-ray and neutrino emissions, providing constraints for observing cluster targets.

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The variability of 8 blazar candidates among the Fermi-LAT unidentified gamma-ray sources

Dr Pheneas Nkundabakura

University of Rwanda College of Education

Abstract

We discuss the time-series behavior of 8 extragalactic 3FGL sources away from the Galactic plane (i.e., $|b| \geqslant 10°$) whose uncertainty ellipse contains a single X-ray and one radio source. The analysis was done using the standard Fermi ScienceTools, package of version v10r0p5. The results show that sources in the study sample display a slight indication of flux variability in γ-ray on monthly timescale. Furthermore, based on the object location on the variability index versus spectral index diagram, the positions of 4 objects in the sample were found to fall in the region of the already known BL Lac positions.

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The Very High Energy Gamma Ray Burst GRB190114C asobserved by MeerKAT

Mr Reikantseone Diretse

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Abstract

I present the MeerKAT study of the highly energetic gamma ray burst (GRB), GRB190114C, which was the first GRB to have been recorded at teraelectronvolt (TeV) energies by the MAGIC telescopes in 2019. We have observed this GRB with the MeerKAT radio telescope from as early as within the first day of the burst event, up to nearly a year at over 350 days. Our 13 epoch light curve is the most sampled radio light curve of this GRB

at low frequencies (1.28 GHz) in comparison to published results. I detail the evolution of GRB190114C as a forward shock in a homogeneous medium for about 100 days post-burst, followed by a jet-break likely occurring simultaneously with the passage of the characteristic peak frequency across the observing band. I

constrain the host galaxy component, and compare our modelled host value to fluxes extrapolated from the only existing pre-burst radio images of the field. As it is often for GRB observations at low radio frequencies, the evolution of GRB190114C is highly affected by strong interstellar scintillation, which I quantitatively constrain as long lasting refractive scattering. I then use the calculated scintillation parameters to put an upper limit on the radial size of the fireball, and compare this to other GRBs.

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Historical Overview of Ground-based Gamma-ray Astrophysics

Dr Razmik Mirzoyan

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Abstract

The ground-based technique for imaging atmospheric Cherenkov telescopes is a rapidly developing, powerful branch of astrophysics. Fundamental questions in astrophysics, astroparticle physics, cosmic rays and cosmology are at the heart of this technology. The discipline has made remarkable progress since the discovery of the Crab Nebula, the first source of gamma rays, 35 years ago. Thanks to this technique, over 250 very high-energy gamma ray sources of galactic and extragalactic origin have been discovered. Current highly sensitive telescopes are capable of detecting a point source 100 times fainter than the standard candle, the Crab Nebula, in 25 hours of observation. The development of this technology led to the Cherenkov Telescope Array (CTA), the next-generation large-scale instrument. This report presents a brief history of ground-based astrophysics using very high-energy gamma rays.

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Synergies between air shower array detectors and imaging Cherenkov telescope arrays

Dr Roberta Zanin

Cherenkov Telescope Array Observatory gGmbH

Abstract

Very high-energy gamma-ray astrophysics provides unique observations of the unexplored Universe at VHEs – a region of the electromagnetic spectrum covering four decades in energy above 20 GeV. This is an exciting field covering a very wide range of scientific themes from fundamental physics to cosmic ray physics and astrophysics related to the most extreme processes. This is the last among the non-thermal astronomical fields to have emerged and, since its establishment, it led to the discovery of more than 200 sources at VHEs.

Two detection techniques have been proven efficient in the observation the VHE sky: the imaging Cherenkov and air shower detection. Although they have a large overlap in the covered energy range, each of them has its own main energy domain: the imaging Cherenkov telescope array can observe down to few tens of GeV up to hundreds of TeV with the best sensitivity at around 1 TeV, whereas the air shower detector arrays have a higher energy threshold but are more sensitive at energies above few tens of TeV.

In this talk I will be describing the different and the common capabilities of these two detection techniques, proving their complementary nature. I will be referring to the current and upcoming facilities of the two kinds, including, among others, the Cherenkov Telescope Array Observatory as well as the HAWC and SWGO shower array detectors. The key takeaway is that the future of astronomy can substantially benefit from these harmonised observing techniques.

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Recent highlights from the Large High Altitude Air Shower Observatory (LHAASO)

Prof. Hao Zhou

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Abstract

The Large High Altitude Air Shower Observatory (LHAASO), located in China at 4410m above sea level, is a hybrid extensive air shower detector array. Utilizing different detection techniques, LHAASO monitors the northern gamma-ray sky from a few hundreds of GeV to beyond PeV energies. LHAASO has been fully operational since July 2021. Recently, the first LHAASO catalog published 90 gamma-ray sources. 43 of them are PeVatron candidates with gamma-ray emission above 100 TeV. Among these sources, a giant gamma-ray bubble with energy up to 2 PeV is detected in the Cygnus region, indicating a super-PeVatron cosmic-ray accelerator that is likely associated with young massive star cluster Cygnus OB2. These findings confirmed the existence of PeV cosmic-ray accelerators in our Galaxy and opened up an era of ultra-high-energy gamma-ray astronomy. On Oct 9, 2022, the brightest gamma-ray burst ever seen in history happened in the field-of-view of LHAASO. Tens of thousands of very-high-energy gamma-ray photons were recored. We will summarize the status of the LHAASO experiment and present recent highlights from the LHAASO observatory in this talk.

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Probing Fundamental Physics phenomena with Wide-field Ground-based Gamma-ray telescopes

Prof. Dr. Aion Viana

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Abstract

High-energy gamma rays offer unique insights into Particle Physics phenomena beyond the Standard Model of Particle Physics. This complements research conducted in dedicated laboratory experiments and particle accelerators. Notably, intense gamma-ray emissions may result from the annihilation, decay, or other interactions of non-baryonic Dark Matter in the dense environments of the Universe. Wide-field ground-based telescopes have the capability to detect gamma rays ranging from hundreds of GeV up to the PeV range. They represent the most sensitive detectors of gamma ray fluxes for energies above tens of TeV. With an almost 100% duty cycle, these telescopes can observe approximately 2/3 of the sky daily, presenting a significant discovery opportunity in fundamental physics. In this talk I will review the extensive research program conducted by these facilities in the quest for new Physics. Apart from the search for signals from Dark Matter across various targets, there exists the tantalizing prospect of detecting Axion-Like Particles, Primordial Black Holes, and finding evidence of Lorentz Invariance Violation associated with possible quantum gravity effects at the Planck scale. A highlight of the latest and most sensitive results from the current generation of telescopes, including LHAASO, HAWC, and the Tibet AS-gamma, will be presented. Finally, in the light of the future Southern Wide-Filed Gamma-ray Observatory (SWGO), the prospects and strategies in the search for physics beyond the Standard Model will be discussed.

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The Southern Wide-Field Gamma-ray Observatory (SWGO)

Dr Petra Huentemeyer

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Abstract

The Southern Wide-field Gamma-ray Observatory (SWGO) is the project to plan and design the next ground-based observatory to detect gamma rays in the Southern Hemisphere. The experiment, planned to be placed at an altitude greater than 4,400 m, is primarily based on water Cherenkov detector units and expected to measure gamma rays from a few hundred GeV up to the PeV scale. SWGO will complement CTA and the existing ground-based particle detectors of the Northern Hemisphere, namely HAWC and LHAASO, delivering a rich science programme. The SWGO collaboration is approaching the conclusion of the project R\&D, with the evaluation of different detector and array configurations, delivery of prototype detector units, as well candidate site evaluation. In this talk, I will present an overview of the project activities, major milestones, and near-term plans.

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Gamma-rays and the Origin of Cosmic Rays

Dr Brian Reville

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Abstract

Gamma-ray observations provide the most effective method to probe sources of energetic particles, thus revealing the origins of cosmic rays in our galaxy. Recent observations in the very-high energy and ultra-high energy gamma-ray regimes have introduced a number of unexpected twists into the standard supernova remnant model of cosmic-ray origins. These new detections, including those from novae, microquasars and young stellar clusters will be reviewed, and their consequences for cosmic rays discussed.

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Gamma-Ray Bursts at High Energies and Multi-messenger Connections

Susumu Inoue

ICRR, U Tokyo

Abstract

Gamma-ray bursts (GRBs) are the most luminous explosive phenomena in electromagnetic radiation, believed to be triggered by certain types of stellar core collapse events and compact binary mergers. However, many of their basic physical aspects remain poorly understood, such as the nature of the central engine, and the mechanisms of jet formation and prompt radiation. Recent detections of TeV gamma rays from various types of GRBs by Cherenkov telescopes and air shower arrays shed new light on the physics of jet formation, energy dissipation and particle acceleration in GRBs. We discuss the current status of the field and prospects for further progress with future instruments, including multi-messenger connections with gravitational waves, cosmic rays and neutrinos.

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Neural Networks Unveiling Filamentary Structures in the Interstellar Medium: A Multi-Wavelength Approach Integrating Data from Advanced Telescopes

Dana Alina, Adai Shomanov

Nazarbayev University, Astana, Kazakhstan

Abstract

Our study employs neural networks, such as Mask-RCNN and Unet, to the identification of filamentary structures of the interstellar medium (ISM), and particularly, their position angle which is essential in linking the ISM structures to the ISM magnetic field. We integrate diverse datasets from various facilities, including the atomic hydrogen survey HI4PI, Herschel and Planck space telescopes to create a comprehensive and multi-wavelength perspective. The integration of these datasets is essential for a holistic understanding of the ISM, as Filamentary molecular clouds are key stages in the star formation process, at large, of the order of a parsec, and small, of the order of thousands au.

In our presentation, we will highlight the significance of treating extensive datasets that are provided by JWST, ALMA, MeerKAT, and ASKAP intelligently, emphasizing the pivotal role of neural networks, particularly our proposed model, in extracting meaningful information.

Moreover, molecular and atomic gas data bares significant information about the interstellar magnetic fields, through the anisotropic turbulent properties and magnetohydrodynamic nature.

Thus, we will discuss how the wealth of data from these facilities contributes to a more comprehensive view of star formation processes. Our work underscores the synergy between advanced observational facilities and innovative data analysis techniques, paving the way for a deeper understanding of the fundamental processes shaping our galactic environment.

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Shocks and Dark Gas in Diffuse Interstellar Clouds

William Reach[1,2], Carl Heiles[3]

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Abstract

Interstellar clouds have more material than is traced by the 21-cm line of atomic hydrogen, as evidenced by far-infrared/submm observations since the late1980s, when we identified a sample of high-latitude "cirrus" clouds for detailed study. The clouds have masses of order 100 solar masses and are within 1 kpc of us. The dense cloud cores have detectable CO, while larger portions of the clouds are also molecular, in a balance between molecule formation on dust grains and dissociation by the interstellar radiation field. Using Planck, GASS, and Arecibo observations, we assessed the clouds' contents and showed that many of them are composed largely of CO-dark molecular gas. A pair of clouds, G228.0-28.6 and G230.1-28.4, has proportions of Atomic:Dark:CO-bright gas of 2:1:0.9 and 0.1:1:0.1, respectively. Examining the cloud structure at the best spatial resolution available, using mid-infrared (WISE) and optical images reveals potential shock fronts at the leading edge of their apparent motion through the lower-density inter-cloud medium. The CO-dark gas may be closely related to these shocks, having formed in the cooled, compressed gas behind the shocks.

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Using Gas-rich Early-type Galaxies to Test Empirical and Theoretical Models of Molecule Formation

Debra Dunham[1], Krislyn Sourivong[1], Dr. Danielle Lucero[1], Dr. Lisa Young[2]

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Abstract

We present an update on work which uses high resolution observations of CO (CARMA: 3") and HI (JVLA; 6") in early-type galaxies to stress test existing empirical and first principle physical models of molecule formation. These existing models are being used as input into semi-analytic models of galaxy evolution. A good model should have applicability and predictive power beyond the ranges of conditions that are found in nearby spirals. Compared to disk galaxies, early-type galaxies have different gas contents, stellar populations, and evolutionary histories. Early-type galaxies also have a much wider range of HI/H_2 mass ratios than spirals. Additionally, early-types' central stellar densities are typically larger than those observed in disk galaxies, which translates to larger central pressures. For all of these reasons, the early-type galaxies provide complementary tests of HI/H_2 physics to that done for disk galaxies. The HI data presented in this work comprises the highest resolution HI data for a large sample of early-type galaxies to date.

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Impact of Protostellar jets on the ambient medium in infrared and radio

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Abstract

Protostellar jets, launched in the early evolutionary phase of young stellar objects, are targets of intense scrutiny to understand the properties of young protostars. We have investigated a few jets from massive embedded protostars through their interaction with the ambient medium, in radio and infrared wavebands and we trace emission from shocked regions where the jet impacts the medium. Our near-infrared measurements that include [FeII] and [H_2] transitions in the near-infrared have been utilised to probe the nature of shocked gas. We comment on the emission mechanism on the basis of the morphological co-location of emission from these two tracers, both near as well as far from the jet. Our results from the Giant Metrewave Radio Telescope (GMRT), India, at low radio frequencies have confirmed the presence of non-thermal synchrotron emission from these jets, unlike measurements at higher radio frequencies that usually trace thermal free-free emission. We assimilate the observed radio emission measurements within a numerical model that we have developed, which incorporate the effects of both thermal and non-thermal emission, to understand the properties of the jets and ambient medium in the vicinity. Finally we compare the emission from molecular, atomic and ionised gas in infrared and radio to decipher and comprehend the properties of the massive protostellar systems such as the mass-loss rate of the jets. We find that the values are higher than those observed for jets from low mass protostars.

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ISM energy balance and structure formation over cosmic time through simulations and observations

Fatemeh Tabatabaei[1], Maryam Khademi[1], Hossein Hatamnia[1], Reyhaneh Javadi[2]

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Abstract

Investigating the thermal and non-thermal processes in the ISM of galaxies is vital to understand their evolution over cosmic time. Radio observations in nearby galaxies indicate that the non-thermal processes in which turbulence, magnetic field, and cosmic rays are involved can affect the formation of gas clouds and stars. They can also help the onset of winds and outflows in galaxies. These can be further investigated over cosmic time by combining radio and optical/near-infrared observations of galaxies. The James Web Space Telescope resolves the evolution of thermal processes by mapping ionized gas and dust in galaxies. This information combined with the upcoming surveys with the Square Kilometer Array (SKA) and ngVLA will make a major breakthrough in mapping the non-thermal processes and understanding their role in the evolution of stars and their host galaxies. Our simulations show that, already in its first phase of construction, the SKA will be able to trace the evolution history of spiral galaxies such as M51 and NGC6946 back to cosmic noon. This study indicates the important role of the non-thermal pressure in driving winds and outflows at high-z. We further address these through observations of a sample of star forming galaxies in the COSMOS field, as members of the MeerKAT International GHz Tiered Extra-galactic Exploration (MIGHTEE). We find that both cosmic rays and magnetic fields were more energetic at higher redshifts ($z<5$). Comparing these results with thermal gas pressures would add valuable insight into the subject.

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Detection of Self-Enrichment in Young Massive Star Clusters Using 26Al Tracers

Katarzyna Nowak

Centre for Astrophysics Research, University of Hertfordshire

Abstract

Self-enrichment is one of the leading explanations for chemical anomalies in globular clusters. In this scenario, a certain polluter star, enriches a forming cluster with its yields, likely ejecting radioactive ^{26}Al into its surroundings. Detection of ^{26}Al in young massive star clusters holds significant implications, potentially supporting the self-enrichment scenario if these clusters are indeed progenitors of globular clusters. Recent advancements in observational techniques, including detections of the 1.8 MeV and 511 keV ^{26}Al decay gamma ray lines, as well as ^{26}AlF molecules or positronium radio recombination lines, suggest promising avenues for detecting ^{26}Al and maturing detection methods.

In this talk, I will focus on examining a sample of young massive star clusters in the nearby Universe, where self-enrichment could plausibly occur. Despite optimistic scenarios, detecting most sources remains challenging with some methods. However, we identify R136 in the Large Magellanic Cloud as a promising candidate for such investigations. Although the best-case scenario for detecting a 1.8 MeV signal may require several years with instruments like COSI, the feasibility of detecting ^{26}AlF with the ALMA telescope in several candidate clusters offers encouraging prospects for further study and understanding of self-enrichment scenario in young massive star clusters.

Session

FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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Star formation drivers in the local universe

Dr. Edvige Corbelli

INAF-Osservatorio Astrofisico di Arcetri

Abstract

The ALMA MaNGA QUEnching and STar formation survey (ALMaQUEST) has provided a sample of 66 galaxies, including interacting galaxies, where the cold and warm ISM has been mapped at 2.5 arcsec resolution (1-6~kpc). A recent analysis of this sample (Ellison..Corbelli ..et al. 2023) points out the delicate balance between local feedback effects (Ostriker & Kim 2022) and non local dynamical effects (Krumholtz et al. 2018) in regulating the formation of molecular clouds and stars. To improve our understanding of the overall proccess that drives the formation of stars across galaxy disks, as galaxies evolve, we are investigating a highly resolved galaxy in our neighborhood, M33, and a sample of galaxies in the MANGA sample of similar or lower mass than M33, thus extending the analysis to a lower mass range than the ALMaQUEST sample. M33 has evolved in isolation, as shown by numerical simulations of its disk along the past orbit (Corbelli and Burkert 2024 A&A in press), and we can benefit of a complete multiwavelength coverage, in addition to very high resolution recent JWST results (Peltonen et al. 2024) and MUSE data of its southern arm. The physical processes that link the birth of Young Stellar Clusters and massive protostars, as well as the formation of molecular clouds (Corbelli et al. 2017,2019), to the global and local dynamical properties of the ISM will be analyzed and compared with data for the ALMaQUEST sample and with theoretical predictions (Corbelli et al. in preparation).

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Unveiling the cold outflow from the nucleus of the Milky Way

Enrico Di Teodoro[1], Jay Lockman[2], Naomi McClure-Griffiths[3], Lucia Armillotta[4]

[1]University of Florence. [2]Greenbank Observatory. [3]Australian National University. [4]Princeton University

Abstract

The nucleus of our Galaxy is home of several high-energy processes (black hole, intense star formation) that have generated a large-scale, multiphase, nuclear wind. In the past few years, I have extensively studied the colder components of this outflow thanks to dedicated surveys of the Galactic Centre region in neutral hydrogen (HI) and molecular lines. These observations have revealed for the first time the resolved structure of cold gas clouds entrained in a galactic wind and have returned a number of new, puzzling aspects of these fascinating phenomena. In this talk, I will review the main discoveries and findings about the cold gas phases of the Milky Way's nuclear outflow and I will discuss its possible origin and impact on the central regions of the Galaxy.

Session

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Observations of LMC Coronal Gas and a Multiphase CGM

Dhanesh Krishnarao

Colorado College

Abstract

Recent measurements of a relatively high mass for the LMC imply that it should host a massive Corona, a collisionally ionized, warm-hot gaseous halo at the virial temperature (∼10^5.4K) initially extending out to the virial radius (100 - 130 kpc). Such a Corona would have shaped and fed the formation of the Magellanic Stream (e.g. Lucchini et al. 2020, Nature). We have found direct observational evidence for this Corona via highly ionized oxygen (O VI), and indirect detections via C IV and Si IV, seen in UV absorption toward background quasars using data from HST and FUSE (Krishnarao et al. 2022, Nature). We find that the Corona is part of a pervasive multiphase CGM seen in many ionization states with a declining projected radial profile out to at least 35 kpc from the LMC and a total ionized mass of log(M/M⊙) = 9.1 ± 0.2. Finding the Corona is a crucial step forward in characterizing this infalling Group and its nested evolution with the Local Group and helps diagnose the impact of galactic-scale winds emerging from star formation feedback in the LMC. The complex CGM will also be present in absorption line studies of stars in the LMC observed through the ULYSSES HST program, many of which are being detected through our ongoing work from an HST Legacy Archival Program. In addition, we are exploring the cooler phases of gas in this complex CGM environment that could condense onto the stream, MCs or Milky Way to trigger star formation.

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Constraining star cluster formation using multiwavelength observations with JWST and HST

Ms Jianling Tang, Dr Kathryn Grasha, Dr Mark Krumholz

The Australian National University

Abstract

The physical processes that govern the formation and evolution of star clusters are encoded in the distributions of star cluster physical properties, such as their mass and age functions. These functions hint at the physics underlying how star clusters form, evolve, and die. The largest obstacle to measuring these functions from JWST and HST observations is that current analysis methods require us to discard light clusters, which are by far the most numerous, because they are susceptible to luminosity fluctuations due to their small numbers of stars. This talk will introduce a novel method that solves the problem of deriving cluster demographics from integrated light without the need to discard most of the data, yielding the largest and most complete description of star cluster demographics to date, derived from ~10,000 clusters in ~40 galaxies, spanning a wide range of star-forming environments. These results constrain the evolution and dispersion of star clusters and their dependence on properties such as host galaxy star formation rate and surface density. Our method also allows us to probe the initial cluster mass function using clusters so young that they are embedded in dust and only visible in the IR with JWST, a population that may reveal insights into the physics of cluster formation in the early universe and the origins of present-day globular clusters.

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Star formation and molecular gas observations of NGC 5331 with VLA and ALMA

Devaky Kunneriath[1], Loreto Barcos Munoz[1], Alejandro Saravia[2], Eduardo Rodas-Quito[3]

[1]National Radio Astronomy Observatory. [2]University of Virginia. [3]U. Nacional Autonoma Honduras

Abstract

LIRGs (Luminous Infra-Red Galaxies) make up the brightest objects in the infrared sky and represent an important population to study galaxy evolution. Models predict episodic enhancements of the total star formation of the system as the merger progresses. We know the molecular gas is the fuel for star formation, which explains the empirical correlation seen between the star formation rate and molecular gas surface densities in galaxies, described by the Kennicutt-Schmidt relation: $\Sigma_{SFR} = \Sigma_{mol.}^{N}$, where N ~1.4 (Schmidt 1959, Kennicutt 1998). Most studies of this relation have been done using integrated measurements (Kennicutt 1998, Kennicutt & De Los Reyes 2021), however recent works at sub-kpc scales have found a wide range of values for N (e.g., Leroy et al. 2008, Pereira-Santaella et al. 2016). In this work, we study the K-S relation at 1.2 kpc scales in the nearby LIRG, NGC 5331. We use VLA radio continuum observations (3 GHz) to trace unobscured SF, as opposed to UV and/or Halpha, which suffer greatly from dust obscuration, especially in U/LIRGs, and ALMA CO (1-0) line emission observations to derive the molecular gas properties of this local LIRG. We compare this to published values of other LIRGs, ULIRGs, and local circumnuclear disks (integrated values across the whole system). Our final goal is to replicate this study in as many local U/LIRGs as possible, to study how star formation changes with merger states.

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FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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Probing the efficiency of star formation at different epochs

Dr. Jonathan Freundlich

Observatoire astronomique de Strasbourg

Abstract

Observations show a peak of star formation ten billion years ago, around redshift z=2. To understand star formation processes at different epochs and assess their efficiency, it is crucial to probe the gas reservoirs from which stars are formed. Furthermore, environment plays a crucial role in galaxy evolution and could affect both the amount of gas available and the efficiency of star formation. I will present recent molecular gas observations with the 30m telescope, NOEMA and ALMA in typical star-forming galaxies during the winding down of star formation at z=0.5-0.8, in galaxies with measured circumgalactic outflows or inflows at z=0.6-1.1, and in a galaxy group at z=0.7 where diffuse ionized gas emission may indicate gas expelled by tidal interactions, stripping, or outflows. Moving towards higher redshifts, I will also present resolved star formation efficiency measurements at z~4.5 with ALMA. Synergies between JWST and ALMA will allow to study how stellar and gas distributions are interconnected in distant galaxies, while SKA and its precursors will enable molecular gas observations at very high redshift and to probe the atomic gas up to the peak epoch of star formation, thus providing a much more complete picture of gas and star formation processes in galaxies.

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Cold gas formation within an HI shell in the Magellanic Bridge from GASKAP-HI observations

Shin-Jeong Kim, Naomi McClure-Griffiths, Antoine Marchal

Australian National University

Abstract

We will present a new study that investigates the multi-phase structure of a 9 pc scale HI shell located in the Magellanic Bridge using data from the GASKAP-HI survey. Associated with the H-alpha ring DEM-171, this shell is an ideal laboratory to study the effects of dynamical events such as supernovae or stellar winds from massive stars on the HI gas properties. We decompose the HI emission spectra into multiple Gaussian components using ROHSA, which enables us to map out the cold neutral medium (CNM), lukewarm medium (UNM), and warm neutral medium (WNM) that makes up the shell. The higher CNM gas fraction (~50%) and existence of UNM gas indicate that the HI shell undergoes a phase transition in the ISM, leading to the CNM formation, likely due to the gas compression. Additionally, exisiting star clusters and young stellar objects (YSOs) catalogs support the scenario that the expansion of the HI shell can trigger subsequent star formation within the shell. This analysis illustrates the stellar feedback on the multi-phase cycle and star formation activity within the Magellanic Bridge.

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Star Formation Efficiency in Nearby Galaxies Revealed with a New CO-to-H_2 Conversion Factor Prescription

Yu-Hsuan Teng[1], Karin Sandstrom[1], I-Da Chiang[2], Jiayi Sun[3], Adam Leroy[4], Alberto Bolatto[5], Antonio Usero[6], Eve Ostriker[3], Miguel Querejeta[6]

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Abstract

Star formation in galaxies is governed by the amount of molecular gas and the efficiency that gas is converted into stars. However, assessing the amount of molecular gas relies on the CO-to-H_2 conversion factor (α_{CO}), which is known to vary with molecular gas conditions like density, temperature, and dynamical state – the same conditions that also alter star formation efficiency (SFE). The variation of α_{CO} thus causes major uncertainties in current molecular gas and SFE measurements. Using multi-band ALMA observations of CO isotopologues at ~100 pc scales, we found that α_{CO} is primarily driven by CO opacity changes and therefore shows strong correlations with observables like velocity dispersion and $^{12}CO/^{13}CO$ line ratio. Motivated by these results, we have established a new α_{CO} prescription which accounts for CO emissivity variations and verified it across a set of nearby galaxies with independent α_{CO} measurements from dust. Applying our new prescription to 65 galaxies from the PHANGS-ALMA survey, we revealed an overall 3x higher SFE in barred than non-barred galaxy centers, which is an unprecedented trend that has been obscured by past α_{CO} prescriptions. Our results suggest that the high star formation rates observed in barred galaxy centers is mainly due to an enhanced SFE, rather than a substantially increased amount of molecular gas.

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How galaxies regulate their growth

Prof Deanne Fisher

Swinburne University

Abstract

I will discuss recent observational evidence that feedback driven by star formation is impacting the surrounding ISM of galaxies. It is widely agreed that theory requires star formation driven feedback to match the fundamental properties of galaxies, such as total mass, SFR and size. I will discuss recent observational results on the role of feedback in creating turbulence in galaxies, including the nearest spirals, local Universe starbursts and high-z galaxies. I will show that in starburst galaxies and spirals correlations of velocity dispersion with star formation properties are consistent with what is expected from feedback-based simulation and feedback-regulated analytic theory. Moreover, I will show that the turbulent energy in these galaxies can be fully described by feedback energy. The implication is that feedback contributes very significantly to the velocity dispersion of galaxies across all redshifts. When feedback is stronger, the gas overpowers the local potential and breaks out from the disk. I will show recent observations of M82 & NGC253 with JWST that can give extremely high-resolution observations. These observations show a significant amount of substructure, which can be used to determine the physical processes at play in outflow.

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Fast Radio Bursts: mechanisms of radiation and propagation in magnetar with finite temperature electron-positron plasma

Dr. Umer Rehman

Nanjing University, P. R China. Department of Physics, Air University Islamabad Pakistan.

Abstract

Fast radio bursts (FRBs) are extensively discussed in the magnetized pair plasma of magnetars in clod plasma approximation. However, the thermal effects or finite temperature cannot be subsided in such astrophysical objects like magnetars. In this work, we derived the classical dispersion relation for the waves in a pair electron-positron plasma environment as a function of refractive index n and the frequency of the wave normalized with the typical frequency of the FRBs. We adopted the parameters of the wave propagation in the magnetar in usual range associated with the FRBs. This work initiates a theoretical model for the wave propagation in the magnetar to obtain the dispersion relation for the fluid waves in magnetized thermal plasma. The limiting case for the cold plasma waves are reproduced. In the cold plasma case, the frequency of mode and wave number can be obtained explicitly but unable to include finite temperature effects. The explicit formula we derived in this article enables an accurate evaluation of finite temperature even near the cyclotron resonance. The analytical formula then used to describe the temperature effects on the propagation of electromagnetic waves inside and outside of the magnetosphere of the magnetar.Cyclotron absorption in a strongly magnetized cannot be completely understood without considering the thermal effects of plasma fluid in the astrophysical objects like magnetar. The absorption/emission processes require stringent physical conditions related to actual physical environment is the main objective of current investigation.

Session

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Connecting molecular clouds to their Galactic environment using neutral atomic hydrogen (HI) and 3D dust maps

Dr. Juan D. Soler[1], Dr. Catherine Zucker[2], Dr. Josh Peek[3], Prof. Mark Heyer[4], Prof. Paul Goldsmith[5], Prof. Simon C. O. Glover[6], Prof. Sergio Molinari[1], Prof. Ralf Klessen[6], Prof. Patrick Hennebelle[7]

[1]Institute for Space Astrophysics and Planetology (IAPS). [2]Smithsonian Astrophysical Observatory. [3]Space Telescope Science Institute. [4]University of Massachusetts. [5]Jet Propulsion Laboratory,. [6]University of Heidelberg. [7]Laboratoire AIM, Paris-Saclay

Abstract

We present a study of the relation between neutral atomic hydrogen (HI) emission at 21 cm wavelength, carbon monoxide 12CO emission, and the three-dimensional (3D) distribution of interstellar dust derived from stellar extinction observations with roughly one kiloparsec from

the Sun. We have used the histogram of oriented gradients (HOG), a machine-vision-based tool, to match the morphology in a 3D reconstruction of the dust density (3D dust) and the gas tracers' emission distribution. A high-resolution pilot study of the Taurus molecular cloud revealed a pattern in radial velocities and distances consistent with the gas's converging motions, with the near side of the cloud moving away from us at higher velocities and the far side moving at lower velocities. This convergence of flows is likely triggered by the large-scale gas compression caused by the interaction of the Local Bubble and the Per-Tau shell, with Taurus lying at the intersection of the two bubble surfaces. A lower-resolution general study of the emission from different tracers toward the Galactic plane reveals the drift motions of some clouds with respect to Galactic rotation and the relative motion of the HI and CO that we used to estimate the potential inflow of atomic material into molecular clouds.

Session

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1026

Understanding the physical driver of CO-to-H2 conversion factor variation within starburst galaxies

Dr. Hao He

University of Bonn

Abstract

CO-to-H2 conversion (αCO) is crucial in measuring molecular gas mass. For a long time, people adopt an empirical bimodal αCO choice for normal spiral and starburst galaxies without fully understanding the physical driver behind, which according to theory, is tightly related to molecular cloud properties at small scales. I will present the first resolved αCO spatial map down to giant molecular cloud scale (~150 pc) for one of the closest starburst galaxy mergers, the Antennae using RADEX modeling on multiple CO and ^{13}CO observations from ALMA. We find that the average value of αCO in the Antennae is ~4 times lower than the Milky Way value. We further find that the primary driver for the αCO variation within the Antennae is the GMC optical depth, which is consistent with studies of centers of normal spiral galaxies. According to theory, the two measurements that could track the optical depth variation is ^{13}CO/CO ratio and CO velocity dispersion. We find both measurements show strong correlations with αCO with power-law slopes consistent with analytical predictions, while ^{13}CO/CO ratio shows a stronger correlation and could be a better αCO tracer. We further compare our αCO maps at GMC resolution with that derived at kpc resolution and find that the kpc-scale αCO values are generally two times smaller, while the ratio between the two values shows a strong anti-correlation with dense gas fraction, which suggests that the increasing fraction of diffuse medium might be another contributor to the low αCO in starburst galaxies.

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1037

The origin of cold ISM structure: insights from the dialogue between spatially resolved observations and high resolution simulations.

Dr Rowan Smith

University of St Andrews

Abstract

In this talk I will review recent advances in our understanding of the cold gas phase in galaxies concentrating on the physical forces involved in its formation, and the importance of galaxy environment. We will examine recent high resolution galaxy models, and zooms into individual cold gas cloud complexes, and then investigate what we can learn from them in the context of modern spatially resolved observations from facilities such as JWST and ALMA. Finally, we will look forward to advances in theoretical modelling, and the upcoming SKA and ngVLA to identify key questions that will improve our understanding the evolution of cold gas in galaxies.

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1060

Closing the feedback-feeding loop of the radio galaxy 3C 84

Prof Tom Oosterloo[1,2], Prof Raffaella Morganti[1,2], Dr Suma Murthy[3]

[1]Netherlands Institute for Radio Astronomy. [2]Groningen University. [3]Joint Institute for VLBI ERIC

Abstract

Gas accretion by a galaxy's super massive black hole (SMBH) and the energetic feedback by the accreting active galactic nucleus (AGN) on the gas around it are two tightly intertwined processes. Observations of galaxy clusters have shown how plasma jets emitted by the AGN heat the intra-cluster medium, preventing cooling of the cluster gas and thus the infall of this gas onto the SMBH. However, observations of cool-core galaxy clusters have also shown that rising plasma bubbles, inflated by the jets, can also induce local cooling of the cluster gas, leading to filaments of cold gas. The fate of these filaments is unclear, but it has been suggested they may play a role in feeding the AGN activity. We will present results of re-processed CO(2-1), HCN and HCO+ ALMA obser vations of the molecular gas in NGC 1275, the central galaxy of the Perseus cluster hosting the radio-loud AGN 3C 84. These data show, for the first time, in great detail how kpc-sized cold gas filaments originating from jet-induced cooling of cluster gas are flowing onto the circum-nuclear accretion disc of the SMBH, showing that the cooled gas does indeed play a role in feeding the AGN activity, while in addition line ratios given useful information in the physical conditions in the circum-nuclear disc. These results complete our view of the feedback loop of how an AGN can impact on its surroundings and how the effects from this impact maintain the AGN activity.

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STARFORGE-UCLCHEM: coupling star cluster formation simulations to astrochemistry

Dr. Piyush Sharda[1], Dr. Stella Offner[2], Dr. Michael Grudić[3]

[1]Leiden University. [2]University of Texas at Austin. [3]Carnegie Observatories

Abstract

The importance of astrochemistry in star formation has been long recognized, however, not much work has been done in coupling astrochemistry to hydrodynamic simulations of molecular cloud collapse and star cluster formation beyond the most common molecule - CO. Several key questions on the origin of other molecules in the interstellar medium (ISM) therefore remain unanswered, and it is not yet clear which molecules can be used to trace the ever elusive molecular hydrogen - the fuel for star formation. In this talk, I will present results from the STARFORGE-UCLCHEM collaboration where we post-process state of the art radiation-MHD simulations of star cluster formation (including all four modes of stellar feedback) with exhaustive chemical networks covering 300+ species (including a comprehensive treatment of dust and ices) and 6000+ chemical reactions. In addition to the well studied molecule CO, I will talk about our findings for other so-called dense gas tracers (e.g., HCN, HCO+, N2H+, HNC) that were out of reach of previous works using reduced chemical networks. I will end by mentioning ongoing efforts to solve exhaustive chemical networks on-the-fly with hydrodynamics to accurately capture the physics of star formation in diverse environments, and uncover the mysteries of molecule formation in clouds undergoing stellar feedback.

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Star Formation and Feedback in Local Luminous and Ultra Luminous Infrared Galaxies

Dr. Loreto Barcos-Munoz

National Radio Astronomy Observatory. University of Virginia

Abstract

Luminous and Ultra Luminous Infrared Galaxies (LIRGs and ULIRGs) provide a unique laboratory to study star formation and feedback in extreme conditions. They are mainly interacting, or merging, gas-rich systems that can host massive starbursts and powerful Active Galactic Nuclei (AGN) activity. U/LIRGs show star formation rates of up to a few 100 solar masses per year concentrated into their central kpc. Due to the large amounts of gas and dust surrounding their central regions, direct observations of the nuclei are often impossible at many wavelengths. Radio, sub-mm, and infrared emission are key to study their star formation and ISM properties. I will share results from high angular resolution observations with the radio telescopes VLA and ALMA of a sample of local U/LIRGs from the Great Observatories All-sky LIRG Survey. I'll show the large detection of outflows in local U/LIRGs, and how when we combine ALMA and VLA observations we can estimate whether these systems are forming stars near their maximum capacity, as predicted by theoretical models for star-forming disks supported by radiation pressure on dust, or if an AGN is powering them. I will finalize by highlighting synergies between ALMA, VLA, and recent JWST observations of a couple of local U/LIRGs.

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The synthesis of organic and inorganic compounds in the circumstellar environment

Prof. Sun Kwok

University of British Columbia

Abstract

The evolution stages from asymptotic giant branch (AGB) stars to planetary nebulae represents a prolific phase of molecular synthesis. Millimeter-wave and infrared spectroscopic observations have found that molecules, minerals, and organic solids can form in the circumstellar environment of these objects. We will discuss the chemical pathways leading to complex organic nanoparticles with mixed aromatic/aliphatic (MAONs) structures and the possible role as carrier of the unidentified infrared emission bands widely observed in the interstellar medium.

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SYMPHANY: SYnergy of Molecular PHase And Neutral hYdrogen in galaxies in A2626

Dr. Tirna Deb

Center for Astrophysics, Harvard & Smothsonian

Abstract

The morphology-density relation in galaxies suggests that the cosmic environment significantly shapes both the morphology and star formation (SF) activity of galaxies. Dense environments like galaxy groups and clusters somehow expedite the quenching of SF and the transformation of gas-rich, late-type galaxies into gas-poor early-type systems. Various gravitational perturbations, such as tidal interactions along with hydrodynamical processes like ram pressure stripping, contribute to these transformations. It is not clear, however, which of these processes are effective or dominant in which cosmic environment, and to what extent they impact the various constituents of the interstellar medium and the SF activity. Observations of neutral Hydrogen (HI) gas in galaxies reveal that the extended HI disks are notably affected by the cluster environment, leading to deficient HI reservoirs compared to field galaxies. This deficiency is less apparent for the centrally concentrated and more tightly bound molecular gas (H2). However, studies of H2 in cluster galaxies often yield conflicting results that may vary between clusters. Given that H2 gas serves as the direct fuel for star formation, understanding its response to the cluster environment is crucial for unraveling galaxy evolution in clusters and groups. I will discuss the spatial and kinematic properties of atomic and molecular gas discs, linking them to specific local environments within the A2626 galaxy cluster, and explore their connection with the galaxy's star formation history.

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Environmental processes driving the low-column density gas in and out of galaxies

Dr Filippo Maccagni

INAF - Osservatorio Astronomico di Cagliari

Abstract

The MHONGOOSE survey is bringing the study of the neutral atomic hydrogen (HI) in nearby galaxies (< 30 Mpc) to the next level: thanks to deep (55 hours) high spatial (>7'') and spectral (1.4 km/s) resolution observations over a wide field of view (1.5 degrees), we are able to study the kinematics of the HI gas in star forming galaxies down to M(HI)=10^6 Msun and column densities ~10^{18} cm^{-2}. In this talk, I will focus on the interaction history of the massive (M(HI)~10^{10} M_{sun}) star-forming galaxy NGC1566 (D_L=18 Mpc) and the impact on its star formation (SF). For the very first time, we identified that a past tidal interaction with a massive companion has left several HI debris clouds in the Dorado group. The low-column density (a few times 10^{18} cm^{-2}) HI filaments connecting the disk of NGC1566 with nearby dwarf galaxies (M(HI) ~10^{6-7} M_{sun}), suggest that more minor interactions are still on-going, actively contributing to the accretion of HI onto the star-forming disk. Lastly, I will focus on the lowest HI-mass (M(HI)~1.6x10^6 M_{sun}) object we found in Dorado. This novel detection allowed us to identify a gas-rich low-surface brightness (M_{star} ~2x10^6 M_{sun}) galaxy whose recent infall into the group is changing the physical condition of the HI and triggered a new episode of star formation in its center.

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Outflows of ionized gas and molecular gas in a radio galaxy at z=5.17

Dr. Kianhong Lee[1], Prof. Masayuki Akiyama[1], Prof. Kotaro Kohno[2], Prof. Bunyo Hatsukade[3], Dr. Xiaoyang Chen[3], Prof. Fumi Egusa[2], Prof. Kohei Ichikawa[4], Prof. Masatoshi Imanishi[3], Prof. Daisuke Iono[3], Prof. Takuma Izumi[3], Mr. Naoki Matsumoto[1], Prof. Tohru Nagao[5], Prof. Malte Schramm[6], Prof. Toshiki Toba[3], Prof. Hideki Umehata[7], Dr. Kenta Matsuoka[8]

[1]Tohoku University. [2]University of Tokyo. [3]National Astronomical Observatory of Japan. [4]Waseda University. [5]Ehime University. [6]Universitat Potsdam. [7]Nagoya University. [8]Utena Meishu Co., Ltd.

Abstract

High-redshift radio galaxies are massive star-forming galaxies with powerful radio jets, often located on or below the star-forming main sequence of galaxies. This suggests that they are in the process of being quenched. TN J0924-2201 is one of the most distant known radio galaxies, associated with three CO(1-0)-detected companions at z~5.2.

We present ALMA observations of [CII] line and the corresponding 1 mm continuum emission of TN J0924-2201. While obtaining [CII] and 1mm continuum emission at the host galaxy, our observations revealed no detection at the positions of the three CO(1-0) companions. The derived systematic redshift z_[CII] of the host galaxy from the [CII] line is 5.17, indicating a blueshift than the Lya-derived redshift by a velocity offset of ~1000 km/s, marking the largest velocity offset between [CII] line and Lya line recorded at z>5 to date. Within the host galaxy, we identified an extended [CII] structure with a velocity of ~500 km/s, suggestive of an outflow. This finding aligns with the shell outflow model, providing consistency with the observed large velocity offset of Lya.

Applying the PDR model, our analysis indicates that three massive CO(1-0) companions exhibit high density and a weak radiation field. Assuming they are also outflow, their velocities of ~1500 km/s surpass the escape velocity of a 10^13 Msun halo, implying the removal of molecular gas from the host galaxy. These results collectively point towards a distinctive phase in galaxy evolution occurring in a radio galaxy.

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A search for cold gas in the Magellanic system with ASKAP: Novel approach using Time-frequency analysis of hyper-spectral data

Dr Antoine Marchal

RSAA (ANU)

Abstract

I will present recent work exploring the use of time-frequency analysis (Fourier and Wavelet transforms) on hyper-spectral data of the 21 cm line acquired by the ASKAP, pointing the way to new approaches suitable for analysing the massive data that will be delivered by the Square Kilometer Array (SKA). This advances a broader effort exploiting 21 cm emission line data alone to extract integrated properties of the multiphase structure of HI gas. Specifically, I will focus on demonstrating how these tools can be used to search for cold gas in the Magellanic system as a whole, including the leading Arm and the Magellanic Stream. Ultimately, these tools will catalyze discoveries made with the SKA from multiple communities of astronomers working on understanding the structure and evolution of diffuse matter in the Milky Way and nearby galaxies.

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1308

The physical connection between angular momentum and cold gas is not that simple

Luca Cortese

ICRAR

Abstract

In our current theoretical framework, the growth of angular momentum of galaxies is tightly connected to their ability to accrete gas and use it for star formation. As such, for decades there has been the expectation that the amount of cold gas in discs is primarily set by a galaxy's angular momentum. However, observational confirmation of this has been missing due to the lack of large representative samples of galaxies for which information on cold gas content and angular momentum were available. In this talk, we will show how data from the extended GALEX Arecibo Survey (xGASS) have allowed us to quantify for the first time the physical connection between cold gas content and angular momentum across the whole galaxy population (from gas-rich to gas poor). Our findings highlight how angular momentum is not the only, and in some cases not even the primary, driver of HI content in nearby galaxies, contrary to what expected from analytical models of disc stability. By combining xGASS with cosmological hydro-dynamical simulations such as EAGLE and TNG we will unveil under which conditions and why the physical connection between HI and angular momentum is broken.

Session

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1336

MAUVE: Tracking the influence of the environment on the gas-star formation cycle of cluster galaxies during infall

Luca Cortese, Barbara Catinella

ICRAR-UWA

Abstract

I will present the first results from the MAUVE (MUSE and ALMA Unveiling the Virgo Environment) survey a multi-wavelength observational campaign combining VLT/MUSE, ALMA and HI observations of 40 galaxies in the Virgo cluster aimed at understanding the environmental impacts on the gas-star formation cycle in cluster galaxies during their infall. These data are allowing us to probe the distributions and kinematics of stars, ionized and molecular gas over the full extent of the inner galactic disks, at scales of a few hundred of parsecs, making it possible to investigate the link between cold gas and star formation when and where environmental processes are at play. Excitingly, these observations are starting to reveal unexpected cases of star formation driven outflows even in ram-pressure stripped and HI deficient galaxies, as well as providing new insights into how star formation proceeds after first pericentre passage. While still at the early stages, MAUVE is showing us how outflows may still play an important role in the full quenching of the star formation of satellite galaxies and highlight how a multi-phase mapping of the interstellar medium is critical to fully unveil the physical processes regulating the star formation cycle of galaxies.

Session

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1344

Spatial Variation of Cold and Unstable Neutral Hydrogen Gas of the Milky Way in the Southern Sky

Mr Callum Lynn, Dr Antoine Marchal, Professor Naomi McClure-Griffiths

Australian National University

Abstract

Star formation occurs through the gravitational collapse of dense molecular clouds, however the processes leading to the production of these over-densities are still unclear. One key element seems to be related to the efficiency of thermal condensation of the neutral interstellar medium from warm to cold gas, leading to the formation of molecular cloud precursors. As part of the Galactic Australian Square Kilometre Array Pathfinder (GASKAP) neutral Hydrogen (HI) survey, we have observed more than 2000 background radio sources distributed homogeneously across a 300 square-degree region in the southern sky, making it the first unbiased survey with high source density ever observed. While hundreds of them show direct detections of Milky Way HI absorption against these background sources, ~2000 sight-lines are dominated by noise. However, these noise-dominated sight-lines still carry multiphase information on the interstellar medium of the solar neighbourhood. I will present a stacking analysis of this sample of spectra classified as non-detections revealing, for the first time, the properties of the unstable neutral medium and its phase transition to the cold neutral medium over a large region of the southern sky. Uniquely, I will show how the high source density of our survey allows us to probe the spatial variation of both the cold and unstable gas compressed along the wall of the Local Bubble, a region that is a primary laboratory for investigating the early phase of star formation.

Session

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1421

AGN feedback and ISM properties in the nearby Universe

Maria Vittoria Zanchettin

SISSA Scuola Internazionale Superiore di Studi Avanzati

Abstract

In this talk, I will discuss the physics of the multiphase gas in local active galaxies and the impact of the active phase of the central super massive black hole (SMBH) on the host galaxy evolution. Active Galactic Nuclei (AGN) can generate winds and jets that interact with the interstellar medium (ISM) of the host galaxy, potentially influencing the star formation process.

The central focus of this talk will be on the polycyclic aromatic hydrocarbon (PAH) emission, warm ionized gas, cold dust, cold molecular gas and radio properties, using JWST/MIRI, VLT/MUSE, ALMA and VLA data. By comparing high resolution radio and sub-mm data of the central region we can infer the presence of compact radio-jets, star formation activity and dust emission resolving sub-kpc scales.

I will explore the correlations between the PAHs, the star formation rate and the cold molecular gas. Further I will investigate the correlation between the star formation rate and the cold molecular gas mass surface densities, known as the Kennicutt-Schmidt star formation law. This relation plays a pivotal role in galaxy evolution and determines the efficiency with which galaxies convert their gas reservoirs into stars. This study aims at investigating how gas and star formation properties change across the galaxy and understanding whether the AGN's activity plays a role. I will illustrate the application of this approach to a sample of local hard-X-ray selected Seyfert galaxies.

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1456

Molecular Gas Conditions and CO Line Excitation in Nearby Galaxies with AMISS

Ryan Keenan[1], Daniel Marrone[2], Garrett Keating[3]

[1]Max-Planck-Institut für Astronomie. [2]University of Arizona. [3]Center for Astrophysics

Abstract

The CO(1-0) line has been carefully calibrated as a tracer of molecular gas mass. However, recent studies often favor higher J CO transitions which are brighter and accessible for redshift ranges where CO(1-0) is not. These lines are not perfect analogues for CO(1-0), owing to their more stringent excitation conditions, and must be calibrated for use as molecular gas tracers. Conversely, observations of multiple CO lines in a single target can constrain additional gas properties beyond mass. I will present the Arizona Molecular ISM Survey with the SMT (AMISS), a multi-CO line survey of z<0.05 galaxies conducted with the CO(1-0), CO(2-1) and CO(3-2) lines. The project targeted a representative sample of 10^9 M_{sun} < M_* < $10^{11.5}$ M_{sun} galaxies. The final survey includes CO(2--1) spectra of 176 galaxies and CO(3-2) spectra for a subset of 45 supplemented by new and archival CO(1-0) spectra for all targets. I will present the results of our study of CO luminosity ratios, showing that CO(2-1) and CO(3-2) are systematically fainter relative to CO(1-0) in galaxies with less star formation activity. I will discuss the implication of these results for studies of molecular gas in high redshift galaxies. Finally, I will consider what insights into gas conditions are possible with large multi-line studies of both nearby and high redshift galaxies that will be enabled by facilities like the ngVLA and AtLAST.

Session

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1521

New evidence for outflow-induced gas and dust enrichment in the surroundings of dwarf galaxies

Dr. Michael Romano

National Centre for Nuclear Research, Warsaw, Poland. INAF - Osservatorio Astronomico di Padova, Padova, Italy

Abstract

The evolution of dwarf galaxies can be largely affected by galactic outflows, which can deprive their hosts' interstellar medium of the material needed for the formation of new stars, simultaneously enriching their surrounding circumgalactic medium (CGM) with gas and dust. We compared, for the first time, the average spatial distributions of atomic gas, dust, and stars in and around local dwarf galaxies by stacking their [CII] 158 μm line, far-infrared, and near-UV emission, respectively. We found that gas and dust are more extended than the stellar continuum, reaching radii up to ~7 kpc, with a gas(dust) over stellar ratio of ~1.2. This is similar to what is typically observed for $z > 4$ star-forming galaxies, whose gas reservoirs' origin in the CGM is still debated. We attribute the extended [CII] and dust continuum emission in the CGM of our dwarf galaxies to the presence of galactic outflows. As local dwarf galaxies are considered analogs of primordial sources, we could expect that comparable feedback processes can be at the origin of the observed [CII] halos at $z > 4$, dominating over other possible formation mechanisms.

Session

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1578

Full Stokes Observations of excited OH and methanol masers

Prof Derck Smits[1], Dr Paul Fallon[2,1]

[1]University of South Africa. [2]North West University

Abstract

We report on a recent survey of excited OH (4.7 and 6.0 GHz) and methanol (6.7 GHz) masers in a sample of 21 star-forming regions lying between Right Ascensions of 23h and 08h. The observations were made using the C-band of the Greenbank 100m radio telescope (GBT) in full Stokes mode to record the polarisation of the masers. Five sources had no masers at any frequencies. The 4.765 GHz masers in Mon R2, which will be reported on in a separate talk, are the only polarised sources at this frequency. Two new 4.765 GHz masers were found, weak 4.750 GHz thermal emission was found in two sources, and one source had absorption at 4.660 GHz. No masers were found at either 4.750 or 4.660 GHz, confirming the rarity of these masers. Two sources had 6.7 GHz methanol masers only, and another two sources had excited OH masers but no 6.7 GHz methanol masers. Excited OH 6.016 GHz absorption was found in two sources, and a weak 6.049 GHz maser was confirmed in one source. When present, 6.035 and 6.031 GHz excited OH masers had complex patterns of both circular and linear polarisation. Two 6.7 GHz methanol masers had no polarisation, all other sources showed a combination of linear and circular polarisation.

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1603

Investigating the Dust Production in the Local Group Dwarf Irregular Galaxy, NGC 6822, Through Dusty Stellar Populations

Ms. Fatemeh Khatamsaz[1], Mr. Mahdi Abdollahi[1], Dr. Hedieh Abdollahi[1], Dr. Atefeh Javadi[1], Dr. Hamidreza Mahani[1], Dr. Jacco Van Loon[2], Ms. Faezeh Akhlaghmanesh[3]

[1]School of Astronomy, Institute for Research in Fundamental Sciences. [2]Lennard-Jones Laboratories, Keele University, Staffordshire. [3]Department of Physics and Astronomy, University of California, Riverside, USA

Abstract

NGC 6822 is a dwarf irregular galaxy in the local group at a distance of ~ 490 kpc. Several studies show that NGC 6822 began forming stars around 12-13 billion years ago, harboring a significant population of evolved stars. When stars with low to intermediate mass (approximately between 0.5 and 8 solar mass) reach the final stages of their evolution, they evolve into asymptotic giant branch (AGB) stars. Pulsating AGB stars, known as long-period variables (LPV), and red super-giants (RSG) enrich the interstellar medium (ISM) and are significant sources of dust production in galaxies. To study the dust production in NGC 6822, the mass-loss rates of LPV and RSG stars are measured. The utilized sample consists of the photometric data in 12 photometric bands spanning the near- to mid-infrared, collected from several published surveys. The mass-loss of the stars is estimated through spectral energy distribution (SED) modeling, adopting an age-metallicity relation (AMR) to account for the variation of metallicity by time. It is estimated that the overall mass-loss rate in NGC 6822 is approximately ~ 0.00080 solar mass per year. RSGs contribute ~ %15 to this value with an overall mass-loss of ~ 0.00012 solar mass per year. The estimated overall mass-loss from the AGB stars is not sufficient to account for the current star formation rate (SFR) of ~ 0.007. This suggests that the mass must have been provided through other feedback factors or the surrounding environment.

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1607

The gas content of Luminous Compact Blue Galaxies in the COSMOS field.

Mr Henco Arlow

University of Cape Town

Abstract

This talk focuses on my MSc work on Luminous Compact Blue Galaxies (LCBGs), a heterogeneous subset of starburst galaxies exhibiting a notable drop in number density at lower redshifts. Because of their rapid evolution, they make excillent candidates for studying galactic evolution as a whole. The study employed HI emission line data from the full CHILES survey, covering a redshift range of z=0 to z=0.45 in the COSMOS field, and continuum data from the CHILES Continuum Polarization survey.

The primary objective was to investigate the evolving nature of LCBGs and their gas content over approximately nine billion years of lookback time. I will report on direct detections of HI in LCBGs within CHILES and a cubelet stacking technique applied to LCBGs with known spectroscopic redshifts. This technique enabled the measurement of average HI masses and established upper limit values for non-detections, providing insights into the redshift-dependent evolution of these galaxies.

Furthermore, we explored star formation rates (SFRs) using continuum fluxes from CHILES Con Pol. Comparative analyses with CHILES's first epoch data offered insights into the dynamic evolution of LCBG star formation. I will show continuum stacking results in various redshift and stellar mass bins, revealing relationships between specific star formation rates (sSFRs), stellar mass, and redshift within the LCBG population.

Session

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1614

A Multiwavelength Study of Star Formation in PHANGS galaxy IC 5332

Miss Kyra Kummer, Professor D.J. Pisano, Dr Lucia Marchetti

University of Cape Town

Abstract

The Physics at High Angular Resolution in Nearby GalaxieS (PHANGS) project seeks to understand the relation between the small-scale physics of gas and star formation, and galactic structure and evolution, through high-angular resolution, multi-wavelength observations of nearby galaxies.
IC 5332 is a low surface brightness, star-forming, face-on spiral galaxy located in the Sculptor constellation. We explore how the neutral hydrogen (HI) properties compare with the molecular gas (from Atacama Large Millimeter Array; ALMA), dust (traced by the James Webb Space Telescope; JWST), and star formation (traced by Hα, UV, and radio continuum) in IC 5332.
We present the preliminary results of our detailed study of the internal kinematics and star forming properties of IC 5332, and discuss the implications of these results on the star forming properties of such spiral galaxies.

Session

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1635

Exploring Kinematics in the Early Phases of Star Formation through Deuterium Fractionation

Dr Cheikh Bop[1], Pr. François Lique[1], Dr. Katharina Giers[2], Dr. Silivia Spezzano[2], Pr. Paola Caseli[2], Dr. David Navarro-Almaida[3], Dr. G. Esplugues[4], Dr. M. Rodríguez-Baras[4]

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Abstract

In the centers of pre-stellar cores, deuterium fractionation is enhanced due to low temperatures and high densities. Consequently, the chemistry of deuterated molecules can be employed to probe the evolution and kinematics in the earliest stages of star formation. In this work, we compare the level of deuteration of simple molecules in the envelopes of the prototypical pre-stellar core L1544 in Taurus and the young protostellar core HH211 in Perseus. We alos investigate the deuration levels in two different star-forming regions, TMC 1-C (taurus) and NGC 1333-C7 (Perseus). We used non-LTE radiative transfer calculations to reproduce the emission lines of HCN, HNC, and their deuterated forms, detected with different telescopes (Yesbes 40m, IRAM 30m, and OSO 20m). Using the RADEX computer code, we successfully reproduced the HCN, HNC, DCN, and DNC emission lines observed towards the sources mentioned above. The simulations were based on new sets of hyperfine-resolved rate coefficients for HNC, DNC, and DCN induced by collisions with molecular hydrogen. The collisional data were calculated using a quantum mechanical approach. Our findings reveal moderate deuteration of HCN (5–7%), with a slight enhancement towards the protostellar core. Similar levels of deuteration for HNC towards both cores (~8%) indicate that HNC is tracing slightly different layers compared to HCN. These equal deuteration levels also suggest that the protostellar envelope still retains the chemical composition of the original pre-stellar core. Despite being embedded in different molecular clouds, environmental conditions do not seem to have a significant effect on deuterium fractionation.

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1703

Resolved studies of the atomic and molecular gas in cluster galaxies in the era of ALMA, MeerKAT, and the SKA

Nikki Zabel

UCT

Abstract

With nearly half of galaxies in the local Universe residing in groups or clusters, understanding galaxy evolution in dense environments is key to understanding galaxy evolution as a whole. The environmental mechanisms that eventually lead to the quenching of star formation and an excess of passive galaxies in these environments, first and foremost affect their (cold) ISM. With the emergence of facilities such as as MeerKAT and ALMA, we are now able to study both the extended HI emission, a well-known tracer of environmental processes; as well as the molecular gas, the direct fuel for star formation, in unprecedented detail. In this talk I will present results of resolved studies comparing the molecular and atomic gas contents of galaxies in nearby clusters, with a focus on the "Virgo Environment Traced in CO" (VERTICO) survey, and our study showing evidence of truncated molecular gas discs in HI deficient galaxies. Furthermore, I will highlight ongoing observational efforts to increase our understanding of the effects of environment on the cold gas in galaxies, i.e. using the MeerKAT telescope, and prospects with the SKA.

Session

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1709

Multi-phase and multi-wavelength: the feeding and feedback AGN cycle revealed by sensitive observations of the ISM

Dr Filippo Maccagni

INAF - Osservatorio Astronomico di Cagliari

Abstract

MAGNHIFFIC (MeerKAT AGN HI feeding and feedback investigation close-by) is an on-going survey of 16 nearby (<40 Mpc) active galactic nuclei (AGN) which leverages the combined power of sensitive and high resolution MeerKAT, ALMA and MUSE observations to study how the multi-phase gas sustains the AGN feeding and feedback loop. MeerKAT's wide field of view and sensitivity to low-column density neutral atomic hydrogen (HI) allows us to simultaneously probe the small scales near the super-black hole (SMBH), the larger scales of the galactic disks and the environments of nearby AGN. ALMA and MUSE observations probe at parsec resolution the kinematics and physical conditions of the molecular and ionised gas fuelling the SMBH and/or flowing out of the circum-nuclear regions and galaxy because of feedback from the AGN radiative wind and jets. I will show recent results from four radio-jetted sources which together cover the full range of nuclear activities, i.e. newly started activity, jets piercing through the gaseous medium of the host galaxy and sources with giant radio lobes. The multi-wavelength observations allowed us to infer which mechanisms fuel and sustain the nuclear activity, distinguishing, for example, between 'external' phenomena (mergers and interactions) and 'internal' phenomena (cold chaotic accretion, secular events). Furthermore, we identified how the multi-phase gas fuelling the nuclear activity is also affected by the energetic feedback of the expanding radio jets, and how these two mechanisms can co-exist self sustaining the nuclear activity.

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1741

The atomic and molecular ISM of an interacting triplet

Dr Dane Kleiner

ASTRON

Abstract

I will present a multi-wavelength view of an interacting triplet on different scales. Ultra-deep MeerKAT H_I observations from the MHONGOOSE survey have discovered a newly interacting triplet (D = 11.3 Mpc). The global properties and scaling relations are consistent with other late type, star forming galaxies of the same stellar mass. However, there is extensive (~ 50 kpc) extra-planar low column density (10^{17} - 10^{18} cm^{-2}) H_I gas associated with the two late type galaxies as well as an extended H_I tail complex that connects the two satellite galaxies. Recent, successive flybys are likely the cause of the H_I complex, and despite the tidal influence, the star-formation rate and cool gas in the ISM appears largely unaffected. The central galaxy is part of the PHANGS-ALMA survey and the H_2 mass places it on the main sequence of the H_2 fraction. Given the ~ similar (sub-kpc) resolutions, I will present the resolved H_I and H_2 components and cool gas ratios of the ISM. The eastern-half of the ISM has significantly higher H_2 surface density, which is likely due to compression from the recent flyby. This effect is not seen in the star-formation. This scenario may be prevalent in the local Universe and we predict the SKA will detect many star forming galaxies in close (e.g. < 100 kpc) proximity that have normal H_I, H_2 and star-formation in the stellar disk, but contain extensive, diffuse H_I complexes connecting nearby galaxies.

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1763

Interfacing Galaxy Physical Properties from Cosmological Simulations and Observations Using Atomic Gas As a Probe

Prof Lerothodi Leeuw[1], Prof Maarten Baes[2], Mr Sabelo Kunene[1], Mr Andrea Gebek[2]

[1]University of the Western Cape, South Africa. [2]Ghent University, Belgium

Abstract

Exploiting HI observations of galaxies with unprecedented sensitivities from new telescopes such as MeerKAT and in the future SKA, together with advances in computational simulations, we initiated a program to compare the physical properties of galaxies in observations and cosmological simulations using HI as a probe. We employ a radiative transfer code SKIRT on galaxy data from cosmological simulations such as TNG50 in an attempt to make them as realistic as possible to the observations and then compare both data not processed in this way to data directly from simulations and that from observations. In this light the program is at the interface of cosmological simulations and observations and has several subprograms underway that will be reported in this talk.

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1833

Abundances and Excitation of A Glycine Precursor, Methanimine, in Compact Obscured Nuclei

Mark Gorski[1,2], Susanne Aalto[2], Sabine König[2], Clare Wethers[2], Chentao Yang[2], Sebastien Muller[2], Serena Viti[3], John Black[2], Kyoko Onishi[2], Mamiko Sato[2]

[1]Center for Interdisciplinary Exploration and Research in Astrophysics, Northwestern University. [2]Department of Space, Earth and Environment, Chalmers University of Technology, Onsala Space Observatory. [3]Leiden Observatory, Leiden University

Abstract

We have uncovered evidence for abundant Methanimine (CH_2NH) in Compact Obscured Nuclei (CONs) rivaling Galactic hot cores. CONs account for a significant fraction (~30%) of LIRGs and ULIRGS, but their power sources remain unknown. CH_2NH emission is detected in both galactic and extragalactic environments, but it is particularly strong towards CONs. CH_2NH is the simplest imine, and thus a precursor to amino acids. This makes CH2NH an important tracer of complex organic chemistry in the universe. Here, we present observations and excitation analysis of CH_2NH that imply complex organic abundances rivaling SGR b2 and Galactic hot cores. Abundances of CH_2NH appear to be enhanced in the outflow of the galaxy IC 860, hinting that feedback from the nuclear source may be driving complex organic chemistry in CONs. From these results, we propose that the growth of galaxy nuclei is similar to enormous hot cores.

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1859

A Spectacular MHD-Powered Wind in The Galaxy ESO 320-G030

Mark Gorski[1,2], Susanne Aalto[2], Sabine Konig[2], Clare Wethers[2], Chentao Yang[2], Sebastien Muller[2], Kyoko Onishi[2], Mamiko Sato[2], Niklas Falstad[2], Jeffery Mangum[3], Sean Linden[4], Francoise Combes[5], Sergio Martín[6], Masa Imanishi[7], Keiichi Wada[8], Lorteto Barcos-Muñoz[3], Flora Stanley[9], Santiago García-Burillo[10], Paul van der Werf[11], Aaron Evans[3], Christian Henkel[12], Serena Viti[11], Nanase Harada[7], Tanio Díaz-Santos[13], John Gallagher[14], Eduardo González-Alfonso[15]

[1]Center for Interdisciplinary Exploration and Research in Astrophysics, Northwestern University. [2]Department of Space, Earth and Environment, Chalmers University of Technology, Onsala Space Observatory. [3]National Radio Astronomy Observatory, Charlottesville. [4]Department of Astronomy, University of Massachusetts at Amherst. [5]Observatoire de Paris, LERMA, Collège de France, PSL University, CNRS, Sorbonne University,. [6]European Southern Observatory. [7]National Astronomical Observatory of Japan. [8]Kagoshima University. [9]Institut de Radioastronomie Millimétrique (IRAM). [10]Observatorio Astronómico Nacional (OAN-IGN), Observatorio de Madrid. [11]Leiden Observatory, Leiden University. [12]Max-Planck-Institut für Radioastronomie. [13]Institute of Astrophysics, Foundation for Research and Technology-Hellas (FORTH),. [14]Department of Astronomy, University of Wisconsin. [15]Universidad de Alcalá, Departamento de Física y Matemáticas

Abstract

In 1982 Blanford and Payne predicted that magnetic fields are fundamental for accretion onto supermassive black holes (SMBHs). Magnetic field lines anchored in the disk accelerate a wind via the centrifugal force, allowing for the angular momentum to be transferred out of the system. Almost a half century later, the detailed mechanisms of SMBH growth are still a passionate area of research. Astronomers currently debate whether winds are fuelled by jets, mechanical winds, or radiation, with magnetic processes being the least accepted explanation. Here, I present detailed ALMA observations of ESO 320-G030. Our analysis of these spectacular observations excludes the possibility of a starburst driven wind, a mechanically or radiation driven wind, and exposes a molecular magnetohydrodynamic wind. ESO 320-G030 is a luminous infrared galaxy known to host a compact obscured nucleus (CON) and a kiloparsec-scale molecular wind. CONs represent a significant phase of galactic nuclear growth, with opaque and compact centers (r <100 pc). These results imply that growth of SMBHs is similar to the growth of hot cores or protostars.

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1865

Ultraviolet Radiation Fields and Gas/Dust Emission in Star-Forming Disk Galaxies: Numerical Simulations with TIGRESS-NCR

Nora Linzer[1], Jeong-Gyu Kim[2], Chang-Goo Kim[1], Eve Ostriker[1]

[1]Department of Astrophysical Sciences, Princeton University, Princeton, NJ, USA. [2]Division of Science, National Astronomical Observatory of Japan, Mitaka, Tokyo, Japan

Abstract

The TIGRESS-NCR simulations of star-forming disk galaxies use adaptive ray-tracing (ART) to directly model the radiative transfer of three ultraviolet (UV) frequency bins spanning wavelengths relevant to hydrogen photoionization, dissociation of molecular hydrogen, and grain photoelectric heating. These simulations follow the full physics of the turbulent, multiphase ISM, including the cycle of gravitational collapse and star formation in dense gas; radiation and supernova feedback from young clusters; and the photoionization, heating, and dispersal of dense gas that ensues. By coupling UV radiation fields with photochemistry, TIGRESS-NCR allows us to characterize the distribution of UV radiation throughout this realistic, multiphase ISM. Using two high-resolution models representing conditions in the solar neighborhood and inner galaxy, we make predictions of space-time variations in the radiation field and the corresponding effects on gas and dust heating. Because dust emission is a result of the convolution of dust density and the UV radiation field, our results may be used as a calibration to connect high-resolution maps of dust emission (e.g., from JWST) with gas surface density. Additionally, we make predictions of the ionization parameter in diffuse gas and of how the characteristic propagation distance of ionizing radiation depends on the local environment. Finally, we compare the results of ART to different estimators of the radiation field and find simple approximations which can be used to characterize the UV radiation field when a computationally intensive ray-tracing method is not feasible.

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1878

A resolved view of the impact of massive star formation in the atomic, molecular and ionized gas in the Carina Nebula

Dr. David Rebolledo[1,2], Professor Anne Green[3], Professor Michael Burton[4], Professor Guido Garay[5]

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Abstract

The Carina Nebula Complex (CNC) is a spectacular star-forming region located at 2.3 kpc, which is close enough to observe different size scales in detail. With more than 65 O-stars and more than 900 young stellar objects identified it is also the nearest analogue of more extreme star forming regions, such as 30 Doradus. In this talk I will present the results of a major effort to study the relationship between the different gas phases in the Carina region from 100 pc to 0.01 pc using the Australia Telescope Compact Array (ATCA), the Mopra telescope and ALMA. At large scales, CO image combined with far-infrared data from Herschel revealed the overall molecular mass and its distribution across the CNC (Rebolledo et al. 2016). An extremely detailed map of the HI 21-cm line across the whole nebula revealed a complex filamentary structure in the atomic gas, which allowed the identification of regions where phase transition between atomic and molecular gas is happening (Rebolledo et al. 2017). An ATCA 1-3 GHz radio continuum image across the whole Carina region revealed a complete and spectacular view of the ionized gas in the region (Rebolledo et al. 2021). At small scales, ALMA high spatial resolution observations of molecular line tracers and dust showed that the level of stellar feedback effectively influences the fragmentation process in clumps, and provides further evidence for a higher level of turbulence in the material with a higher level of massive stellar feedback (Rebolledo et al. 2020).

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1901

Disentangling the star-forming region of Canis Major: A radio and near-infrared perspective

João Victor Correa Rodrigues, Professor Jane Gregorio-Hetem

Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo (IAG/USP)

Abstract

Many of the key aspects that impact star formation are at the interface between scales of molecular clouds and galactic disks. In this context, our goal is to put together a coherent view of the Canis Major OB1/R1 (CMa) region, which is one of the most intriguing star-forming scenarios in the Milky Way. This study is essential to better understand the relationship between young stellar clusters and their corresponding parental molecular clouds in our Galaxy. CMa is part of a large shell-like structure (~60 pc of diameter), which probably was shaped by three successive Supernovae events from 3 to 1 Myr ago. This feedback process also affected the evolution process of the young stellar objects (YSOs) in the region. Our work takes advantage of the synergy between different wavelengths to investigate the physical characteristics of the interstellar material (ISM) and to correlate them with the spatial distribution and properties of the YSOs. Using the IRAM-30 metre telescope, our group compared the stellar population in the eastern portion of CMa with the cores shown by ^{13}CO map, confirming the association of these objects and their dense natal gas. In this work we also present near-infrared data acquired with the SOAR telescope (Spartan camera), using the filters H_2 (2138/30 nm); Brγ (2157/20 nm); and Cont.3 (2207/30 nm), that we are using to search for molecular gas condensations typically related to star formation conditions, such as knots and filaments.

Session

FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

1923

Diffuse Hot Gas and X-ray Binaries Associated with JWST-Identified Bubbles in NGC 628

Karina Barboza[1], Dr. Laura Lopez[1], Dr. Adam Leroy[1], Dr. Smita Mathur[1], Dr. Bret Lehmer[2]

[1]The Ohio State University. [2]University of Arkansas

Abstract

Newly obtained JWST observations of galaxy NGC 628 display an unusual feature in its spiral structure: holes. Many of these holes, hereafter bubbles, are carved out by stellar-feedback processes, such as supernovae and stellar winds. We present an analysis of archival Chandra X-ray observations of NGC 628 and examine the relationship between diffuse hot gas, X-ray binaries, and these JWST-identified bubbles. We find that many are filled with diffuse hot gas, and we measure the temperature, density, and luminosity of the bubbles to search for trends between these properties and characteristics of the bubbles and their associated stellar populations. We will expand this work to the full PHANGS-JWST sample of nearby galaxies to obtain a complete view of the interstellar medium, baryon cycle, and energy cycle.

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FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

1925

Centimeter-Wavelength Observations with the 70 m Canberra Antenna in the Deep Space Network

Joseph Lazio[1], Shinji Horiuchi[2], Jorge Pineda[1], Dariusz Lis[1], Wiliam Langer[1], Jacob Torresan[1], Raju Manthena[1], Andy Klaib[1], Marin Anderson[1], Zubair Abdulla[1]

[1]Jet Propulsion Laboratory, California Institute of Technology. [2]Commonwealth Scientific and Industrial Research Organisation

Abstract

Spectroscopic observations at radio wavelengths provide key information about the physical and chemical state of astrophysical environments including the ionized gas created by massive stars, traced via hydrogen radio recombination lines (RRLs), and the densest parts of molecular clouds where star formation takes place. In addition to RRLs, notable lines include transitions from water (22.235 GHz, 1.34 cm), ammonia (multiple inversion lines), and rotational lines of complex organic molecules (COMs).

We describe the 17 GHz–27 GHz (1.76 cm–1.11 cm) radio astronomy system installed at the 70 m antenna (also known as Tidbinbilla) at the Canberra Deep Space Communications Complex within NASA's Deep Space Network (DSN). This system has the potential to deliver up to 10 GHz of instantaneous bandwidth, with dual polarizations, enabling efficient spectral-line surveys or stacking multiple lines to increase sensitivity. Installed on the largest single-dish antenna in the southern hemisphere, it is a powerful complement to comparable northern hemisphere systems, to the Atacama Large Millimeter/submillimeter Array (ALMA) Band 1 system (35 GHz–50 GHz, 0.85 cm–0.6 cm), and to sub-millimeter–far-infrared balloon projects such as the Galactic/Extragalactic Ultra-Long Duration Balloon (ULDB) Spectroscopic Terahertz Observatory (GUSTO) and the Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimeter-wavelengths (ASTHROS).

We illustrate performance using two recent sets of scientific observations and describe recent and planned near-term improvements.

Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

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1967

Star Formation Efficiency on the Outer Edge of the Milky Way

Dr. Will Armentrout

Green Bank Observatory

Abstract

The Outer Scutum-Centaurus spiral arm (OSC) is the outermost molecular spiral arm in the Galaxy and contains the most distant known high-mass star formation regions in the Milky Way. HII regions are the archetypical tracers of high-mass star formation, and because of their high luminosities, they can be seen across the entire Galactic disk from mid-infrared to radio wavelengths. We have detected HII regions at nearly 20 locations in the OSC, as far as 23.5 kpc from the Sun and 15 kpc from the Galactic center on the far side of the Galactic center. The far outer Galaxy has lower metallicity than the more inner regions of the Milky Way, with 12 + log(O/H) = 8.29 at the OSC versus 8.9 and 8.54 at the Galactic Center and the Solar neighborhood, respectively. Coupled with lower gas densities, star formation in the OSC could be similar to that of a much younger Milky Way or galaxies like the Large Magellanic Cloud. We find large reservoirs of diffuse and dense molecular gas (^{13}CO, HCO+, HCN) in the OSC with the Argus array on the Green Bank Telescope (up to 10^5 Solar masses). We are also able to estimate the central ionizing sources from Very Large Array continuum observations, showing central stellar types as early as O4. Combined, these observations allow us to study chemical abundances and star formation efficiencies on the outer edge of the Milky Way, putting constraints on star formation properties towards the edge of the Galaxy's molecular disk.

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2025

Astrochemical diagnostics in various scales

Dr. Nanase Harada

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Abstract

Astrochemistry is a probe of the physical conditions in star-forming molecular clouds. Molecular compositions change with the stages of star formation, as clouds become denser and stars eventually form. The external environment caused by existing/dead stars, such as shocks, UV photons, and cosmic rays, also alters the chemistry. Over the past decade, ALMA has greatly advanced our understanding of gas-phase astrochemistry both in Galactic and extragalactic sources. For example, the complex organic molecules in Galactic low- and high-mass star-forming regions helped our understanding of environments where stars form. A large survey in a starburst galaxy called ALCHEMI also demonstrated the ability of astrochemistry to trace various stages of star formation, from dense clouds, actively star-forming regions, and regions strongly influenced by feedback. Statistical or machine-learning methods are powerful tools in analyzing such a survey. In addition, JWST has recently begun to study ice and hot gas phases, complementary to the relatively cold gas observable by ALMA. Ice-phase abundances detected around the protostars started to show the interplay of ice- and gas-phase chemistry during the star formation. JWST also started to detect the highly excited gas in luminous galaxies powered by star formation or active galactic nuclei. This review talk will cover these recent observational advancements together with theoretical work, and discuss the prospects for new-generation telescopes such as ngVLA and SKA.

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FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

2029

A GASKAP-HI View of Atomic Hydrogen in the Milky Way and Magellanic Clouds

Prof Naomi McClure-Griffiths

Australian National University

Abstract

Neutral atomic hydrogen (HI) gas is the fundamental galactic building block that can define a galaxy's morphology and help set its evolutionary path between between the ionized intergalactic medium and the molecular clouds where stars are formed. HI structure is observed on all scales from many kiloparsec scale spiral arms to AU scales. To observe the full range of of size scales our own Milky Way and the Magellanic System provide us with the best laboratories to probe the life-cycle of atomic hydrogen. A significant portion of the gas cycle in galaxies is traced by HI emission and absorption, which together give critical information about the density, temperature and dynamics of interstellar gas. In this talk I will give an overview of what atomic hydrogen is telling us about the hydrogen cycle within the Milky Way and Magellanic system using new data from the Australian SKA Pathfinder survey, GASKAP-HI.

Session

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2073

Complex Radio to Infrared SED modelling of nearby Star Forming Galaxies

Mr Joe Grundy

Curtin University/CSIRO

Abstract

Recent work modelling the broadband radio to infrared spectral energy distributions (SEDs) of star-forming galaxies (SFGs) by Clemens et al. (2010), Galvin et al. (2018) and Dey et al. (2022, 2024) have found a population of (ultra) luminous infrared galaxies that exhibit spectral curvature at low frequencies ($\nu \leq 300$ MHz). This curvature is thought to be caused by free-free absorption (FFA) as star-forming regions become optically thick to radio emission.

We extend this analysis to a lower luminosity handcrafted sample of nearby GLEAM (70-230MHz) detected SFGs including 12 with low frequency turnovers (LFTOs) and 8 control sources and observed them with ATCA and ALMA. During our initial SED modelling we find that most SFGs have most preferred models which include FFA or synchrotron losses rather than simple one or two component power-laws. We however find limited evidence for global properties which are responsible for causing these SED features indicating they are likely caused in specific galactic regions which are usually integrated over a synthesised beam.

We performed a resolved analysis of the radio and infrared emission of these SFGs to create star formation surface density, spectral index and infrared-radio correlation maps as well as ALMA CO molecular gas maps to see whether we can identify the regions responsible for increase SED complexity.

This work will be important in the SKA era as large numbers of SFGs will be detected and understanding the physical mechanisms within SFGs that result in increased SED complexity will be key to interpreting SKA data.

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2094

Multi-band studies of high-mass star-forming regions at various scales

Igor Zinchenko[1], Lokesh Dewangan[2], Sheng-Yuan Liu[3], Devendra Kumar Ojha[4], Lev Pirogov[1], Peter Zemlyahukha[1]

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Abstract

In recent years we performed studies of several high-mass star-forming regions with single-dish radio telescopes (IRAM-30m, OSO-20m, Effelsberg-100m) and radio interferometers (ALMA, SMA, GMRT) at wavelengths from decimeters to submillimeters. The data include continuum and various spectral line maps. These data were combined with IR and other observations of the sources. A synergy of IR and radio observations is very important for studies of transient events, jets and outflows in star-forming regions, their general structure and evolution. The highest angular resolution was about 15 mas (achieved with ALMA). These data trace various components of the sources, relationships between them and their interactions. We investigated disk-outflow systems in these regions. The most detailed investigation was performed of the S255 area. The S255IR-SMA1 core harbours a 20 Msun protostar NIRS3. Several years ago, a first disk-mediated accretion burst was detected there. We have studied this object for a long time with various instruments, including ALMA. A general morphology and kinematics of this region have been investigated. Disk-like structures, jets and outflows have been revealed and studied in detail. New methanol maser lines have been discovered. Several other high-mass star-forming regions have been investigated in detail in various bands.

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2096

Full Stokes measurements of the 4.765 GHz OH maser in Mon R2

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Abstract

The only known 4.765 GHz excited OH maser to exhibit linear polarisation is in Mon R2. The maser undergoes flaring episodes at irregular intervals. The mechanisms for the flaring and polarisation have not yet been determined. The C-band of the Greenbank 100m radio telescope is being used to measure the flux and polarisation characteristics of the 4.765 GHz excited OH masers in Mon R2 during a quiescent period and during a recent flaring event. In previous flaring events, linear polarisation was measured using the MERLIN array which showed variations in the percentage of linear polarisation and changes in the position angle of the radiation. During 2021 we observed the source with fluxes of 600 mJy and 150 mJy, and then in mid-2023, the flux increased, reaching a value of 45 Jy in Feb 2024. The position angle and percentage of linear polarisation have undergone changes during this period, and in recent observations we have found the first evidence of circular polarisation in this source, as well as thermal absorption at frequencies of 6.035 and 6.031 GHz. Changes in the methanol 6.7 GHz masers and formaldehyde absorption line have also been noted. We expect to get more GBT observations over the coming months. We will report on the regular monitoring of this source at HartRAO, archival MERLIN observations, and current GBT measurements of the flux and polarisation of excited OH masers in Mon R2.

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2110

Spatial distribution of diffuse molecular gas and its accumulation mechanism in barred spiral galaxy M83

Mr Ren Matsusaka[1,2], Prof. Toshihiro Handa[1], Dr Fumi Egusa[2], Dr Fumiya Maeda[2], Dr Yusuke Fujimoto[3], Dr Takeru Murase[4], Mr Yosuke Shibata[1], Ms Rina Kasai[1], Mr Tomoki Yamaguchi[1]

[1]Kagoshima University. [2]The University of Tokyo. [3]University of Aizu. [4]Gifu University

Abstract

Understanding the evolutionary process of star formation and the evolution of giant molecular clouds in the Galaxy is important. However, the accumulation of diffuse gas in the galaxy to generate GMCs is not well understood, including where and how much diffuse gas is distributed in the galaxy and the mechanism behind it. This study shows the Gas Density Histogram (GDH), a powerful tool to investigate diffuse gas. We focused on M83, a nearby face-on galaxy with similar properties to the Milky Way. As a result of the GDH analysis, the diffuse gas contributes about half of the total mass of M83. The spatial gas density (or mass) distribution changed from inter-arm to spiral arms. Additionally, the fraction of dense gas to the total gas has increased. It is a key result which suggests that dense gas is formed from diffuse gas in the spiral arms.

Session

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2135

Linking atomic and molecular gas stripping with quenching in satellite galaxies at different infall stages

Prof Barbara Catinella

ICRAR/University of Western Australia

Abstract

Because of its direct connection to star formation, molecular hydrogen is a particularly useful probe to understand how and when star formation ceases in satellite galaxies during their infall. However, until now, studies of the effect of environment on molecular gas have been sparse and have not even clarified whether or not H_2 is directly removed by environmental effects.

In this talk, I will present new results from the ALMA/VERTICO and MUSE/MAUVE surveys of the Virgo cluster, which are providing us with a unique view on stripping and quenching in satellites. Specifically, I will present direct evidence for systematic H_2 stripping in satellite galaxies, and discuss how stripping carves its way within the disk at sub-kpc scale. I will also show that, while most of the gas is stripped, nearly all satellites are able to retain gas in their inner disks that could keep forming stars for several Gyr. I will discuss how these new results can be used to reconcile tensions in the estimate of quenching timescales for satellite galaxies across mass and environment.

Session

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2137

The WALLABY view of the cold ISM structure in nearby galaxies

Prof Barbara Catinella

ICRAR/University of Western Australia

Abstract

Contrary to what routinely done at other wavelengths, wide-area HI surveys of the local Universe have been hampered by the limited resolving power of single-dish telescopes. Excitingly, the advent of SKA precursor telescopes will allow us to characterize not only the global gas content but also its distribution for hundreds of thousands of galaxies. In this talk, I will present the first results of the Widefield ASKAP L-band Legacy All-sky Blind surveY (WALLABY), the SDSS equivalent for HI studies of the local Universe. WALLABY is being carried out with the Australian SKA Pathfinder and is building up the largest census of atomic hydrogen in the local Universe, with a spatial resolution that is almost a factor of 10 better than the state-of-the-art, single-dish ALFALFA survey. While only at its beginning, WALLABY is opening up a new parameter space of discovery and in this talk I will focus on ongoing efforts in the area of HI scaling relations. Specifically, I will discuss the quantification of HI structural parameters and discuss how scaling relations involving HI sizes and surface densities reveal a diversity in HI surface density profiles. I will also show how these data can be used to learn the about the interplay between HI and star formation in the stellar disks of galaxies and will conclude with some remarks on the future outlook for these studies in the SKA era.

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2149

When astronomy meets data science: Exploring mm molecular lines emission across Orion B

Dr Ivana Beslic

LERMA, Observatoire de Paris

Abstract

The latest generation of data and models describing ISM has grown too large and complex for human inspection or simple correlation analysis methods. Given the prospects for instrumentation upgrades allowing the collection of enormously large data sets in the future, the need to provide new insights on comprehensive data analysis becomes even more pressing. DAOISM (Deep Analysis Of the Inter-Stellar Medium) is a collaborative project between observational and theoretical astronomers and data scientists. We aim to connect Galactic and extragalactic research on star formation and the molecular ISM through advanced statistical and data mining techniques.

I present our progress in characterizing the physical and chemical properties of the building blocks of molecular ISM, Giant Molecular Clouds (GMCs), using emission maps of multiple molecular lines. This includes determining their essential properties, such as H2 column density and cloud mass, evaluating the far UV illumination, thermal pressure, magnetic field, ionization fraction, filamentary structures, and turbulent velocity field. Achieving these results required developing a robust method for data analysis and dealing with the noise in astronomical observations. We created a method for denoising spectral line cubes, a sophisticated modeling code (the Meudon PDR code) to give information on the structure and physics of the photon-dominated regions. Our team uses a fast neural network, and we created a new, quick Bayesian framework that considers additive and multiplicative noise, censored information, and spatial regularization to retrieve the spatial distribution of gas fundamental parameters from emission line maps.

References: https://www.iram.fr/~pety/ORION-B/

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2154

The Distribution and Impact of Mid-Infrared Emission in Nearby Galaxies

Mx. Debosmita Pathak, Dr. Adam Leroy, Dr. Todd Thompson, Dr. Laura Lopez

The Ohio State University

Abstract

I will present new JWST/MIRI measurements of the distribution of mid-infrared (mid-IR) emission and estimates of the magnitude and impact of infrared reprocessed radiation pressure in the disks of 19 nearby star-forming galaxies from the PHANGS-JWST Cycle-1 Treasury survey. We show how the gas column density, strength of turbulence, direct (UV), and reprocessed (IR) radiation pressures in HII regions vary across galaxies. The JWST images reveal mid-IR emission with complex substructure that simultaneously traces the distribution of dust and gas, as well as heating from young stars at very high resolution (0.3”-0.85”, 10-100 pc) unprecedented beyond the Local Group. We have used these images to make the first measurement of the probability distribution functions (PDFs) of mid-IR intensity and gas column density, and estimate the strength of turbulence in the diffuse ISM of galaxies that span a range of masses and star-formation rates. The PDFs reveal two distinct components: a roughly log-normal PDF at lower intensities from the diffuse ISM and a high-intensity power-law component from VLT/MUSE-identified HII regions which is particularly prominent at 21 microns. The maps of dust emission give us direct access to dynamical feedback mechanisms from mid-IR radiation. Within the HII regions, we combine estimates of the optical extinction and mid-IR intensity to estimate directly for the first time the strength of total infrared reprocessed radiation pressure in more than 6,000 HII regions, and find that the reprocessed pressure term is of order 20% of the so-called direct radiation pressure from young stars.

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Infrared study of the molecular cloud surrounding UCHII region G25.65+1.05

Mr Derenik Andreasyan, Dr Elena Nikoghosyan, Dr Naira Azatyan

Byurakan Astrophysical Observatory

Abstract

Ultra-compact HII (UCHII) regions are an important phase in the formation and early evolution of massive stars and a key component of the interstellar medium (ISM). The main objectives of this work are to study the young stellar objects (YSOs) inside the molecular cloud, including an UCHII region G25.65+1.05 (IRAS18316+0602), also known as RAFGL7009S star-forming region. We used near-, mid-, and far-infrared photometric data along with radiation transfer models and the modified blackbody fitting to identify and study the YSOs and the ISM. Single temperature modified blackbody model shows that values of $N(H_2)$ hydrogen column density and T_d dust temperature in the molecular cloud are in ranges 2-7×10^{23} cm^{-2} and 12-30 K, respectively. In total, we identified 1499 YSOs in a 10 arcmin radius covering the UCHII region and surrounding molecular cloud. 61 YSOs out of them form relatively dense clusters in the UCHII region, close to the IRAS18316+0602 source. Spectral energy distributions of the identified YSOs has obtained relatively robust parameters for 1153 YSOs with a mass range from 0.5 to 10 . The latter does not include objects in the cluster since the region with 0.6 arcmin radius surrounding the IRAS source is saturated. In the UCHII region, several high-mass stars up to 60 have been identified based on J vs (J-H) colour-magnitude diagram, which in all likelihood are responsible for the ionization. The distribution of YSOs in the cluster on the colour-magnitude diagram has wide spread which means that the star formation process is self-initiated.

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2215

OH megamasers at high redshifts

Mr Thato Manamela

University of Pretoria

Abstract

OH megamasers (OHMs) are frequently found in galaxy mergers and/or ultraluminous infrared galaxies with high star formation rates. Their high luminosity and multiple lines make them useful probes of local physical conditions, and potentially tracers of previously unidentified late-stage galaxy merger systems, and in turn dual/binary supermassive black holes. However, the sample of OHMs has until recently been restricted to z~ 0.25, limiting the cosmological volume and cosmic history that be explored via this tracer. MeerKAT has broken several OHM redshift records, more than quadrupling the highest redshift detection that stood until 2022. This opening of a new cosmological parameter space is particularly important since the galaxy merger rate, star formation rate density, and AGN space density all increase significantly toward z~2. To continue this exploration of high-redshift OHM we perform a MeerKAT UHF survey of strongly-lensed Herschel-ATLAS-discovered ULIRGs, spanning a redshift of z ~ 1-1.8. In this talk, we present the spectral line and continuum results from this survey, place this in context of broader efforts to constrain the evolution of the OHM luminosity function, and galaxy merger rate at higher redshifts.

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Understanding the LBV evolution by the competing warm dust and ionized winds in their surroundings

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Abstract

Luminous Blue Variable (LBV) stars are massive evolved objects characterized by their high instability and fast evolution. In just some millennia, LBVs undergo impressive mass-loss events and inject copious amounts of UV photons to their outskirts. The circumstellar matter around LBVs are therefore complex mixtures of different phases, including hot ionized expanding gas, warm dust, and cold (enriched) molecules. However, they are far from being a homogeneous group, because some LBVs display optical nebulae, others are characterized by dusty infrared surrounding emission, and others do not display any of the above features.

Expanding winds are usually explored by optical/infrared spectroscopy and radio continuum emission. Warm and cold dust dominate the whole IR range. Unfortunately, the studies covering all these aspects simultaneously are rather limited in number. The mm-wavelength range is a key, not only because it contains most of the molecular emission, but also because it is where both thermal dust emission and free-free gas emission may be significant.

We explore the relative dominance of the surrounding dust and the stellar winds in five LBVs using proprietary data from the NIKA2 camera attached to the 30m IRAM radio telescope. At 1.15 and 2 mm, we found point-like emission from the stars envelopes, extended structures and even a shell-like feature.

We used Virtual Observatory tools to build and model extensive SEDs from UV to cm-wavelengths. This study allow us to estimate not only the relative contribution of gas and dust, but also some global physical parameters of the LBV stars.

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PHANGS-MeerKAT and MHONGOOSE HI observations of nearby spiral galaxies: physical drivers of the molecular gas fraction, R_{mol}

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Abstract

The molecular-to-atomic gas ratio is of crucial relevance to our understanding of the evolution of the interstellar medium in galaxies. In my talk, I show where the atomic gas balances the molecular ($\Sigma_{atom} \approx \Sigma_{mol}$) in nearby galaxies using new high-quality observations from MeerKAT and ALMA, for HI and CO, respectively, and how it depends on global galaxy properties. We define the transition from atomic to molecular dominated phase similar to other studies as $R_{mol} = \Sigma mol / \Sigma_{atom} = 1$ and measure how R_{mol} depends on local conditions in the galaxy disks supported by multi-wavelength observations (from GALEX, SPITZER, WISE and MUSE). For this we use a compiled dataset containing new observations from the MeerKAT telescope targeting the galaxies NGC 1512, NGC 4535, and, NGC 7496, from the first results of the PHANGS-MeerKAT survey (PI: D. Utomo, and in the future including 10 more galaxies; PI: D.J. Pisano) and together with the galaxies IC1954, NGC 1566, NGC 1672, NGC 3511, and NGC 5068 from the MHONGOOSE survey form a sample of eight nearby (D = 5.2 - 19.4 Mpc) spiral galaxies that have the required multi-wavelength observations available. With upcoming high-sensitive and high-resolution observations with MeerKAT, the analysis I present forms a first step towards the investigation of how global galaxy properties (stellar mass, star formation rate, or morphology) impact the conversion from atomic to molecular gas in nearby galaxies (D < 20 Mpc or z < 0.005).

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Physical drivers of HI asymmetries in spatially resolved SIMBA galaxies.

Ms Nadine Hank[1], Professor Marc Verheijen[1], Associate Professor Sarah Blyth[2]

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Abstract

The physical processes and environmental conditions that drive galaxy evolution over cosmic time can result in distortions and asymmetries in a galaxy's stellar and/or gaseous components. The neutral hydrogen (HI) disks of galaxies are particularly sensitive to these processes as they are relatively fragile and diffuse, and typically extend beyond the stellar disks. However, the susceptibility of HI to being disturbed by external gravitational (e.g. galaxy mergers and tidal interactions) and hydrodynamical (e.g. ram-pressure stripping) forces, as well as internal secular processes (e.g. stellar and AGN feedback), has made it difficult to identify which process may be the primary driver of the observed asymmetries. Furthermore, HI asymmetries have been understudied in comparison to optical asymmetries due to the paucity of data.

The latest generation of untargeted HI surveys on the SKA pathfinder telescopes is changing this and will enable detailed studies exploring the HI in galaxies using much larger samples than previously available. In the lead-up to these new datasets, we utilise the SIMBA hydrodynamical simulations to investigate HI asymmetries in ~1000 spatially resolved, low redshift galaxies to understand and contextualise the disturbances in the HI reservoirs of galaxies. Using synthetic HI datacubes designed to match observations from the Apertif Medium-Deep Survey, we quantify various asymmetry parameters and investigate the dynamic histories of galaxies over ~2 Gyr to discern whether the observed asymmetries arise from mergers, tidal interactions, or other phenomena. We also investigate whether correlations between HI asymmetry and baryonic mass exist for galaxies with different dynamic histories.

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2282

Cosmic ray driven galactic outflows

Dr Lucia Armillotta[1], Prof. Eve Ostriker[1], Dr Chang-Goo Kim[1], Dr Yan-Fei Jiang[2]

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Abstract

Cosmic rays (CRs) are thought to play a pivotal role in shaping the dynamical and thermal state of the interstellar medium (ISM), influencing the regulation of star formation and the launching of large-scale outflows. Despite their recognized importance, uncertainties persist in modeling galactic-scale CR transport, mostly due to the intricate microphysical processes coupling CRs and thermal gas. Consequently, the true extent of CR impact on ISM structure and evolution remains unclear. In my talk, I will present our recent efforts to model CR transport in simulations of galactic outflows. These simulations reveal that CRs are able to drive outflows of warm (T ~ 10^4 K) gas that reach moderate velocity (v <~ 100 km/s) within a few kpc from the disk. By contrast, CRs in regions of hot supernova-driven outflows have very little dynamical effect on the surrounding gas. A detailed comparison between the properties of warm outflows driven by CRs and warm cloudlets accelerated by hot supernova-driven winds shows that the latter are characterized by higher density and mass flux. This discrepancy in density and, consequently, in pressure emerges as a potentially key feature to distinguish between warm outflows generated by CRs and those accelerated by interaction with hot gas in observational studies.

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Coexistance of two different random density fluctuation in each of 11 galactic clouds suggested by GDH analysis

Emeritus Prof. Toshihiro Handa[1], Dr. Takeru Murase[2,3], Mr. Ren Matsusaka[2,4], Prof. Yoshito Shimajiri[5], Dr. Masato I.N. Inoue[6], Dr. Mikito Kohno[7]

[1]Amanogawa Galaxy Astronomy Research Center, Kagoshima University. [2]Kagoshima University. [3]Gifu University. [4]the University of Tokyo. [5]Kyushu Kyoritsu University. [6]Universitaet zu Koeln. [7]Nagoya City Science Museum

Abstract

Gas Density Histogram (GDH) is a histogram of gas density or column density in an assigned volume of Interstellar matter (ISM), which should be the gas density PDF if the ISM density structure is steady. Although it loses geometrical morphology, the GDH analysis can decompose the density distribution dominated in the volume. Each component in GDH tells us the property of density evolution, e.g. fluctuation or one-way compression such as gravitational collapse. In a cloud scale, or over 10 pc scale, we found that the GDHs of 11 clouds from Cyg-X CO survey data are one or two log-normal (LN) components. No clear evidence was found the power-law component in this resolution. We also found that the peak column density (N_{peak}) of the lower LN component is almost constant (about $10^{21.5}$ cm^{-2}) between the clouds and that correlation the N_{peak} and the width of the higher density LN component. Two LNs suggest the density structure of each cloud is made by two random-walk compression/rarefying processes and the finding of the LN parameters suggests the gas compression of the cloud is hierarchical. The detail of this work has been published as Murase et al. (2023).

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Enhancement of CH_3OH by Cloud-Cloud Collisions in NGC 3627

Dr. Yoshimasa Watanabe[1], Dr. Yuri Nishimura[2], Dr. Nanase Harada[3], Prof. Kazuo Sorai[4], Prof. Nario Kuno[5], Dr. Nami Sakai[6], Prof. Satoshi Yamamoto[7,2]

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Abstract

Molecular clouds are the fundamental structure for star formation in galaxies. Therefore, it is crucial to reveal the physical conditions of the molecular clouds. For this purpose, we have observed the southern bar-end region, which shows higher star-formation efficiency (SFE) than those in the spiral arm region by a factor of 2-3, in NGC 3627 at a scale of 100 pc with ALMA in the 3 mm band. We have targeted 12 molecular species and isotopologues including dense gas tracers such as N_2H^+, PDR tracers of CN and CCH, and shock tracers of CH_3OH and SiO, and have detected 11 species. Although the distributions of most molecular species are similar to that of ^{13}CO, the shock tracer CH_3OH and the PDR tracers have different distribution patterns. Compact CH_3OH peaks are strongly detected at the upstream side of the bar end. In this region, we find a signature that two molecular clouds are thought to be colliding with each other in a position-velocity diagram. Therefore, the CH_3OH would be evaporated from the dust mantle by shock induced by the collision. On the other hand, PDR tracers are enhanced by UV radiation associated with the star formation in the downstream side of the bar-end region, because the distributions of these molecules and 3 mm continuum emission are similar to each other. From these results, one possible reason for high SEF in the bar-end region is the high frequency of cloud-cloud collisions.

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2335

Kinematics of Multi-phase Gas in Interacting Galaxies

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Abstract

Gas flows are a key process of the baryon cycle. Winds and outflows are complex and multi-phase, and they can reduce the amount of available gas for star formation, thereby affecting the evolution of galaxies. Galaxies can replenish their gas via recycling from outflows, from gas accreted from other galaxies or from the cosmic web. Galaxy interactions are a regular occurrence for most galaxies and they can result in the flow of gas between galaxies and the removal of gas from the galaxies in the systems. ALMA and MeerKAT are revolutionary instruments that allow us to probe the kinematics of neutral and molecular gas better than previous instruments. We have studied gas flows in interacting galaxies as a part of the MeerChoirs and SUNBIRD surveys using ALMA, MUSE, MeerKAT and SALT; thereby covering ionized, neutral and molecular gas flows. We see complex structures that require various methods of disentangling the kinematics of different components and determining the gas kinematics. These include profile decomposition, modelling, disc modelling, 3D visualization. I will present how we have used these observations and techniques to unveil the resolved multi-phase gas kinematics of nearby (<200Mpc) interacting systems such as Arp271, IRAS18293-3413 and the "The Bird" interacting system, which all show varying degrees of interaction between system members and gas flows outside of the main galaxies.

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2337

Studying gas flows in nearby SUNBIRD starburst galaxies and LIRGs

Petro Janse van Rensburg[1,2], Dr. Moses Mogotsi[1,3,2]

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Abstract

Gas flows are an important aspect of galactic feedback and the regulation of star formation in galaxies. Nearby starburst galaxies and LIRGs provide an extreme environment where feedback and the changes due to it can be studied in great detail. In this project, we are studying gas flows in a sample of nearby ($0.0073 \leq z \leq 0.0322$) starburst galaxies and LIRGs in the SUNBIRD survey, and characterizing them using observations of the multi-phase gas (neutral, ionized and molecular) kinematics and stellar kinematics. The galaxies range from isolated to interacting, they have infrared luminosities between $10^{10.76}$ $L_{\odot}$ and $10^{11.81}$ $L_{\odot}$ and infrared star formation rates between $10^{0.99}$ $M_{\odot}yr^{-1}$ and $10^{2.04}$ $M_{\odot}yr^{-1}$. I will present the kinematics of the neutral, ionized and molecular gas of a sub-sample of SUNBIRD galaxies and how they relate to the stellar kinematics, star formation and other galaxy properties (derived from WISE). This will help us to understand feedback and the fueling of star formation. The resolved neutral and ionized gas, and stellar kinematics were studied using long-slit optical spectra from the Southern African Large Telescope (SALT) and the molecular gas was studied using archival Atacama Large Millimeter/submillimeter Array (ALMA) data. Outflows were identified by performing multi-component fitting and looking at the offsets between the ionized gas kinematics and the neutral gas kinematics or stellar kinematics. We find evidence of outflows and inflows in the galaxies which will be presented during the meeting.

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Quantum Mechanical Insights into Interstellar Ice Mantles: Predicting Infrared Spectral Features and Binding Energies

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Abstract

In the coldest, densest regions of the interstellar medium (ISM), dust grains are covered by thick ice mantles consisting mainly of water.[1] About 300 different molecular species have been detected in the gas phase of the ISM by means of radio and microwave observational measurements [2] However, only a handful were identified in interstellar ices through infrared (IR) spectroscopy, e.g., CO, CO_2, NH_3, CH_4, OCS and CH_3OH.[2,3] Observations of ices require a background-illuminating source for absorption, constraining the available sight lines for investigation. Further challenges arise when comparing with laboratory spectra due to the influence of temperature, ice structure and other species. In the era of IR observations provided by the James Webb Space Telescope (JWST), it is crucial to provide reference spectral data confirming JWST's assigned features.[3] In this contribution, we present the results based on quantum chemical computations on the adsorption complexes formed between the aforementioned species and water-dominated ice mantles, alongside their binding energies and simulated vibrational IR spectra. An amorphous water ice model was considered to mimic the interstellar ices and the density functional theory (DFT) was employed to predict the molecule/ice adsorption complexes and carry out the frequency calculations and the simulated IR spectra. The results will be compared in the context of the recent findings from JWST.[3]

1. Boogert, A. C. A., *et al. Annu Rev Astron Astrophys* **53**, 541–581 (2015).

2. McGuire, B. A. 2021 *Astrophys J Suppl Ser* **259**, 30 (2022).

3. McClure, M. K. *et al.* (2023)

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2351

Rapid Evolution of the Central Star-Forming Ring in NGC1365

Dr. Eva Schinnerer[1], Dr. Eric Emsellem[2], Dr. Jonathan Henshaw[3], Dr. Sharon Meidt[4], Dr. Daizhong Liu[5], Dr. Stephen Hannon[1], Dr. Justus Neumann[1], Dr. Miguel Querejeta[6]

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Abstract

Large-scale bars can fuel galaxy centers with molecular gas, often leading to the development of dense ringlike structures where intense star formation occurs. These star-forming environments are a very different compared to those found in galactic disks. By pairing 10-30pc (0.1-0.3") resolution imaging of the cold neutral interstellar medium (ISM) with information on recently formed massive star clusters using data from ALMA, HST and JWST, it is possible to study how molecular cloud-like structures form, how these compare to similar structures identified in the Galactic Center of the Milky Way, and how star formation proceeds in them. First results indicate high gas surface densities of 800 M_{sun}/pc^2, large inter-cloud motions in the gas ring, and a very uneven distribution in star-forming regions which is likely linked to the extremely efficient gas fueling by the bar.

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2357

Feedback from low-power radio jets on the gas reservoirs of quasars

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Abstract

Low-to-moderate luminosity kiloparsec scale radio jets are starting to be recognized as potential drivers of multi-phase outflows and as relevant mechanisms for active galactic nuclei (AGN) feedback. In radio-quiet quasars, compact radio jets are associated with morphological and kinematic distinct features in the ionized and molecular gas, such as increased turbulence and outflowing bubbles. These jet-gas interactions on galactic scales suggest that jets can be the dominant feedback mechanism in highly accreting radio-quiet quasars, where radiative feedback would be expected to prevail. To investigate the impact of low-to-moderate power jets on the cold gas reservoirs of AGN, we present high-resolution ALMA CO(2-1) and CO(3-2) observations of a sample of 5 radio-quiet quasars. Spatially resolved molecular line ratio maps were used to constrain changes in gas excitation and outflows characterized using kinematic modeling. We compared the outflow, host galaxy, and jet properties, finding mass outflow rates lower than those expected from their AGN luminosities, while the outflow kinetic power can be driven by the combined jet power and bolometric luminosity of their hosts. Despite AGN feedback not depleting the gas reservoirs and quenching global star formation, our observations reveal that the radio jets/winds disturb the cold gas morphology and kinematics within the central kiloparsecs of galaxies. Our findings provide further evidence that the coupling between the jet and the interstellar medium is relevant to AGN feedback even in the case of radio-quiet galaxies, which are more representative of the radio emission across the AGN population.

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2374

ALMA few-100pc imaging of z~7 quasar host galaxies

Fabian Walter[1], Marcel Neeleman[2], Romain Meyer[3], Bram Venemans[4], Roberto Decarli[5]

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Abstract

Quasars within the first Gyr of the Universe (z>6) are known to host massive reservoirs of dust and gas. We present a sample of high-resolution [CII]/dust imaging of distant quasars obtained with ALMA, pushing the linear spatial resolution to only a few 100pc. These observations reveal a striking variety of properties (from rotating disks to very compact high-dispersion systems), and provide measurements of the gas and star formation surface densities, as well kinematic constraints on the quasar host galaxies. Interestingly, the current measurements do not reveal kinematic evidence of the central black holes with putative masses of ~billion solar masses — a fact that in some cases can be attributed to the very high gas densities encountered in the galaxy centres (potentially hiding the kinematic impact of a central black hole). The implied dynamical gas masses of the host galaxies are significantly lower than predicted if the distant quasars were to follow the galaxy-to-black hole mass ratio encountered in the local Universe, implying that the black holes form first in these systems. We also present first imaging of a z~7 quasar host galaxy at a mere 100pc resolution, pushing ALMA to its limits.

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2377

An observational evidence of ISM compression associated the galactic structure suggested by sub-kpc scale GDH analysis of the Milky Way

emeritus professor Toshihiro Handa[1], Mr. Ren Matsusaka[2,3], Dr. Takeru Murase[2,4], Associate Prof. Yusuke Fujimoto[5]

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Abstract

Gas Density Histogram (GDH) is a histogram of gas density or column density in an assigned volume of Interstellar matter (ISM), which should be the gas density PDF if the ISM density structure is steady. Although it loses geometrical morphology, the GDH analysis can decompose the density distribution dominated in the volume. Each component in GDH tells us the property of density evolution, e.g. fluctuation or one-way compression such as gravitational collapse. In galactic scale, or sub-kpc scale, we can make a GDH of volume density using the kinetic distance. The resultant GDH of each 2-deg square area along the galactic plane from FUGIN survey is one or two log-normal (LN) components. We found both the total volume fraction of the higher density LN components (f_H) and the width of the less density LN (σ_L) show the coherent structures in the l-v plane, which is consistent to the classical spiral arms. This suggests the galactic shock may enhance both f_H and σ_L. We should note that the volume density range of any GDH is much less than CO critical density, suggesting the diffuse outer envelope of molecular clouds or intercloud gas is tiny molecular cloudlets in HI gas. The major part of this work has been published as Mutsusaka et al. (2024).

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2379

Diving into the Dense Gas in the Whirlpool (Galaxy)

Sophia Stuber

Max-Planck Institute for Astronomy. PHANGS

Abstract

Tracing the dense phase of the molecular gas in external galaxies is essential to improve our understanding of the evolution of molecular clouds and the star formation process as such. While HCN has been commonly used (in combination with CO) in extragalactic studies as a tracer of gas density, Galactic studies question their applicability and prefer the fainter N2H+ emission line. Here, we present findings from the SWAN survey (Surveying the Whirlpool at Arcseconds with NOEMA), mapping for the first time N2H+ and dense gas tracers HCN, HCO+ and HNC (J=1-0) among other lines across the central 5x7 kpc of the Whirlpool galaxy (M51) at 3" (125pc) resolution with the IRAM NOEMA interferometer. Our study reveals strong correlations among the molecular line emissions of all these species, implying that they are (to first order) suitable to trace dense molecular gas on these scales. We see clear deviations from the general correlation for all different line ratios, observed on both ~100 pc cloud-scales across the disk and in the inner ~1-2 kpc, where a low-luminosity AGN and small radio jet affect the molecules. In addition, we identify a N2H+-overluminous region at the brink of the molecular ring. A preliminary comparison of these regions to morphological environments reveal trends with larger-scale environmental properties. I will present these first-of-its-kind observations of N2H+ across various environments in an external galaxy and discuss the impact of local star formation and larger-scale dynamics onto the dense pre-star forming phase of the ISM.

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2434

Star formation in the central region of NGC253: geometric structure of the molecular gas and starburst triggering mechanism

Dr. Rei Enokiya

Kyushu Sangyo University

Abstract

We have classified molecular gas within the central 850 pc of NGC253 into 28 coherent structures (14 clumps and 14 streams) using position-position-velocity distributions of the latest multi-transition, -isotope CO line datasets obtained with ALMA (Enokiya et al. submitted). Based on their velocities, line widths, chemical properties, and line-of-sight locations, we found that the coherent structures are three spiral arms, a dust lane, and the central molecular zone (CMZ), and the coherent structures in the CMZ were categorized into three groups. Group 1 shows a diffuse rotating gas disk with denser outer and inner edges (550 pc ring and 250 pc ring, which we proposed to be the x1 and x2 orbits, respectively). Group 2 consists of the densest molecular complex, named the central starburst region, located inside the 250 pc ring, and two accretion flows into the central starburst region. Group 3 consists of coherent structures with non-circular motions. Since they show a loop-like shape, we suggested their origin as magnetic effects (i.e., magnetic buoyancy).

By comparing the 3D geometry structure and distributions of HCN(4-3) and SiO(2-1), we found that the star-forming dense clumps that drive the starburst are located at the connection points of any two streams or in the central starburst region (Konishi et al. submitted). Considering all these results, we propose a scenario in which the starburst was triggered by cloud-cloud collisions induced by stream interaction and/or magnetic floatation and/or efficient accretion along the stellar bar.

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2468

A Search for Class I Methanol Masers Toward OH Masers in Massive Star-Forming Regions

Dr Mohamed Darwish

National Research Institute of Astronomy and Geophysics (NRIAG)

Abstract

We present preliminary results of observations conducted using the Effelsberg 100-m radio telescope to study single dish class I methanol masers (44-GHz) in known OH maser massive star-forming regions. Despite a relatively low detection rate of 10%, our study reveals evidence of the coincidence between OH and class I CH3OH during the early stages of massive star formation. The limited detection suggests that the observed regions may be in very early stages of formation or harbor multiple sources in varying evolutionary stages. High angular resolution observations are necessary to examine astrometry, evolutionary status, and polarization properties further.

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2494

Cold ISM Structure and Feedback on Multiple Scales in Nearby Galaxies

Adam Leroy

Ohio State University

Abstract

The gas-star formation-feedback "matter cycle" acts in many ways as the engine of galaxy evolution. Over the last decade, wide band, high-resolution mapping of nearby galaxies with facilities including ALMA, JWST, HST, and more have resolved galaxies into individual parts of this cycle, with unprecedented sharpness and areal coverage. I will describe highlights from these efforts and a few exciting next prospects. Key advances include (1) significant progress using both mm spectroscopy and ISM imaging to demonstrate that the properties of cold gas couple closely to galactic environment, (2) evidence that stellar feedback rapidly reshapes the densest part of the ISM, which (3) also leaves many core collapse and white dwarf supernovae "free" to influence the diffuse ISM and shape the galaxy disk, both carving distinctive shells and holes and also supporting the weight of the gas disk. In each area I will focus on current key observational diagnostics and a few likely advances coming in the next years.

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2495

The relationship between cold gas and dust in bright Planck compact sources

Andras Peter Joo, L. Viktor Tóth

Eötvös Loránd University Budapest, Department of Astronomy

Abstract

We present a comparative study of the cold interstellar medium (ISM) structure and the magnetic field and relate those to the earliest stages of star formation. We used Planck polarisation and Herschel FIR data, together with submm images obtained with the SCUBA2 submm camera at the James Clerk Maxwell Telescope. The ISM structure is uncovered from the FIR data, the Planck polarisation maps show the orientation of the magnetic field, and the SCUBA point sources indicate the distribution of embedded prestellar objects. We could spatially resolve structures and compare the orientations also to our former observations of cold dense gas in the HLC2 star-forming cloud.

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2499

Dark matter distribution in Milky Way-analog galaxies

M.Sc. Natanael de Oliveira[1], Prof. Dr. Karín Menéndez-Delmestre[1], Prof. Dr. Thiago Gonçalves[1], Dr. Nicolás Garavito-Camargo[2], Dr. Pedro Beaklini[3], Prof. Dr. Marco Grossi[1], Prof. Dr. Davi Rodrigues[4,5]

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Abstract

Our current understanding of how dark matter (DM) is distributed within the Milky Way (MW) halo, particularly in the solar neighborhood, is based on either careful studies of the local stellar orbits, model assumptions on the global shape of the MW halo, or from direct acceleration measurements. In this work, we present a study of external galaxies with the intent of gaining insights into the DM distribution in MW-analog galaxies. For this, we carefully select a sample of galaxies similar to the MW. With a need for deep, highly-resolved atomic hydrogen (HI), our resulting sample is comprised of 15 galaxies observed from two approved VLA and GMRT programs. To perform our baryonic analysis, we use deep Spitzer mid-IR images at 3.6 and 4.5μm from the S^{4}G survey. Based on the dynamical three-dimensional modeling software ^{3D}Barolo, we construct rotation curves (RCs) and directly derive the gaseous and stellar contributions from their mass surface density profiles. Through a careful decomposition of the RCs into their baryonic (stars, gas) and DM components, we isolate the DM contribution by using an MCMC-based approach. Based on the Sun's location and the MW's R_{25}, we define the corresponding location of the solar neighborhood in these systems. We put forward a window for the DM density (ρ_{dm}=0.21-0.46 GeV cm^{-3}) at these galactocentric distances in our sample, consistent with the values found for the MW's local DM density, based on more traditional approaches.

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2507

The magnetic fields structure of the central region of the starburst galaxy NGC253

Davide Belfiori[1,2], Rosita Paladino[2], Annie Hughes[3], Jean-Philippe Bernard[3]

[1]University of Bologna. [2]INAF - IRA Bologna. [3]IRAP - CNRS Toulouse

Abstract

Observations of polarized light at far-IR and sub-millimeter emitted by magnetically-aligned dust grains can be used to map the orientation of the B-fields in the plane of the sky in the cold regions of the interstellar medium such as molecular clouds, where the star formation takes place.

We present the analysis of ALMA polarization observations in band 4 (~140 GHz) and 7 (~350 GHz) of the central regions of the galaxy NGC253, a very well studied nearby starburst galaxy. This galaxy's central area exhibits a complex structure characterized by 14 dense clumps of molecular gas, likely hosting young super starclusters. The intense feedback from the starburst region manifests as various structures in the molecular gas, including bubbles, streams, and a prominent multiphase outflow at scales exceeding kiloparsecs.

We obtained a detailed parsec-scale map of magnetic field structures in the galaxy, exploring their relationship with the outflow and super starclusters. The findings suggest a significant role of magnetic fields in the collimation of the outflow, and highlight a correlation between polarization structures and the presence of super starclusters.

This investigation contributes valuable insights into the interplay between magnetic fields, molecular outflows, and star formation in nearby galaxies.

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2586

WISDOM: Molecular cloud properties and star-formation efficiency

Prof Martin Bureau

University of Oxford

Abstract

Using observations from the WISDOM survey that spatially resolve (1-30 pc) individual molecular clouds across the Hubble sequence, we reveal a clear dependence of the nature of the molecular interstellar medium of galaxies on Hubble type, and present a simple diagnostic of cloud formation. In particular, i) we highlight the shortcomings of the usual virial approach to clouds as self-gravitating objects, and stress the importance of the external galactic potential and in-plane shear to regulate the dynamical states of clouds. ii) We also introduce a simple but powerful cloud-cloud collision formalism that accounts for the cloud properties in both nearby and high-redshift systems. iii) We reveal much steeper size - linewidth relations in the inner parts of barred disc galaxies. Finally, using observations of the ionised gas from the SITELLE instrument, we discuss the impact of these different mechanisms on the star formation efficiency of the clouds and thus the quenching of star formation, particularly in galaxy nuclei and spheroids (morphological quenching).

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The Relationship Between Cold Dust and Gas

Prof. Karin Sandstrom

University of California, San Diego

Abstract

Although it typically makes up only 1% (or less) of the mass of the interstellar medium (ISM) in a galaxy, interstellar dust is absolutely critical to ISM physics. Dust is also the repository of a large fraction of the heavy elements, and thus is central to understanding the cosmic history of elemental enrichment in the universe. With knowledge of the dust-gas relationship, dust can also be tracer of gas, spanning the atomic and molecular phases of the ISM. I will review recent efforts to understand the relationship between dust and gas in nearby galaxies, particularly as a function of ISM phase and metallicity. I will also describe exciting new work using JWST observations of the mid-infrared emission from small carbonaceous dust grains (polycyclic aromatic hydrocarbons) as a tracer of gas column in nearby galaxies.

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2605

Molecular gas and dust extinction relation revealed by ALMAQUEST.

Dr Alice Concas

European Southern Observatory

Abstract

The relation between the molecular gas content and the dust screen surrounding HII regions is a powerful tool for galaxy evolution studies. In this talk, I will show how to explore such relation on a sample of 46 nearby galaxies in the framework of the ALMaQUEST (ALMA-MaNGA QUEnching and STar formation) survey, combining new CO(1-0) maps with kpc resolution from ALMA observations with IFU optical spectroscopic datacubes from MaNGA. I will show the existence of the empirical relation between the molecular gas surface density traced by the CO(1-0) intensity and the dust extinction inferred by the Balmer Decrement (BD=Hα/Hβ) on a resolved kilo parsec scale. I will discuss the possibility to use the BD to probe the spatially resolved distribution of cold gas in nearby galaxies in the absence of direct submillimeter observations.

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2608

Multiphase Gas Outflows and their impact on nearby galaxies

Dr Alice Concas

European Southern Observatory

Abstract

Cosmological models of galaxy formation suggest that massive gas outflows, driven by stellar and AGN feedback, play a key role in shaping galaxies' lives. In this talk, I will begin by presenting the statistical properties of ionized and neutral gas flows using 600k optical spectra from the SDSS. I will introduce our stacking approach as a function of stellar mass, star-formation rate (SFR), AGN activity, and disk inclination. We use the NaD absorption line to trace neutral gas, and the [OIII]λ5007 and Hα emission lines to trace ionized gas. We find that: (1) statistically, ionized outflows are only observed in AGN-dominated galaxies and not in purely star-forming ones; (2) neutral outflows are observed independently of AGN activity but only at SFR >10 Msun/yr; (3) neutral outflows display a clear dependence on galaxy inclination, pointing to a disk origin; (4) both ionized and neutral outflows have velocities smaller than the galaxy escape velocity, suggesting that the gas will likely fall back into the galaxy; (5) there is no evidence for high-velocity (V>70 km/s) neutral inflows at any galaxy mass or SFR. I will then present new results obtained by using ~200 CO(1-0) observations from the xCOLDGASS sample to search for the statistical presence of molecular gas outflows at z~0. Finally, I will discuss the implications of our results on theoretical models of galaxy formation and possible SKA follow-ups to perform similar statistical studies for large HI samples.

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2631

Cold gas and star formation in tidal dwarf galaxies

Dr Federico Lelli

INAF - Arcetri Astrophysical Observatory

Abstract

Tidal dwarf galaxies (TDGs) are recycled low-mass objects that form within the tidal debris ejected during the interaction of more massive galaxies. TDGs are predicted to be free of DM because tidal forces effectively segregate halo material from disk material in phase-space. Thus, TDGs may behave very differently from normal dwarf galaxies in terms of gas dynamics and star formation. In this talk, I will focus on a sample of six bona-fide TDGs for which we collected a spatially resolved multi-wavelength dataset, including HST imaging, integral-field spectroscopy from VLT/MUSE, CO interferometry from ALMA, and HI data from the VLA. These TDGs possess a rotating HI disk, suggesting that they are self-gravitating entities. The CO and H-alpha emissions, however, are much more compact than the HI emission and randomly displaced from the kinematic center, suggesting recent formation of molecular clouds from the more extended atomic gas envelope. TDGs follow the same integrated Kennicutt-Smidth (KS) relation as typical star-forming galaxies, even though they are heavily HI dominated. On the other hand, TDGs show a more complex behavior on the spatially-resolved KS relation, displaying large scatter at sub-kpc scales. Several star-forming regions in TDGs lie well above the mean KS relation and are associated with the formation of massive super-star clusters, revealed by HST images. The life expectancy of TDGs and their number density within the dwarf galaxy population remain key open issues, which may be addressed by future and on-going wide-field HI surveys with SKA pathfinders (MeerKAT, ASKAP) and ultimately SKA-MID.

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2649

A revised estimate of the thickness of the CNM in the solar neighborhood

Daniel Rybarczyk, Trey Wenger, Snezana Stanimirovic

University of Wisconsin-Madison

Abstract

Neutral atomic hydrogen (HI) plays a key role in galaxy evolution, governing the transition from warm, diffuse gas to cold, dense star-forming molecular clouds. The HI that fuels the formation of molecular clouds comes primarily from the cold neutral medium (CNM). Therefore, the distribution and kinematics of the CNM set the stage for star formation in galaxies. Wenger et al. (2024) recently developed a new technique for measuring the thickness of the CNM using the kinematics of CNM structures. We have applied this technique to a large catalog of HI absorption observations at high Galactic latitudes, probing mostly gas within ~1 kpc of the sun. We estimate the CNM thickness in the solar neighborhood to be ~50-90 pc, a factor of two smaller than previous estimates and close to the CNM thickness found in the inner Galaxy. For a sample of CNM structures with HI optical depths >0.1 (the threshold at which HI seems to start forming molecules), we derive a thickness of ~50 pc, which is comparable to the thickness of the molecular disk in the solar neighborhood. These new estimates significantly alter our understanding of the vertical structure of the CNM in the Milky Way. We compare these results to recent simulations and discuss the implications for the structure, kinematics, and evolution of the multiphase ISM in the solar neighborhood.

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Multiwavelength magnetized view of the youngest starless core in Taurus: Synergy of HI gas and dust

Dr. Ekta Sharma[1], Prof. Di Li[1], Dr. Tao-Chung Ching[2], Prof. Carl Heiles[3], Prof. Dan Clemens[4]

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Abstract

The neutral hydrogen present in different phases of the Interstellar Medium (ISM) is considered a long term reservoir of star formation. The magnetized properties of the diffuse ISM and the dense molecular clouds are correlated as the turbulent dissipation of magnetic energy to smaller scales takes place. However, how the transition happens from the diffuse envelope to dense region is not completely known. In spite of the difficulty in observing the low-frequency shifts, the Zeeman observations probed by HI prove to be one of the promising techniques to directly measure the magnetic field strength in diffuse as well as molecular gas through a new Zeeman tracer, HI Narrow self-absorption (HINSA). I will present the results of spectral polarization (Zeeman) observations of HI (diffuse and molecular) towards a chemically young core in Taurus, LDN 1521E, an appropriate laboratory due to its isolation and age for testing the magnetic field models. The Zeeman observations of HI taken with Five hundred meter Aperture Spherical Telescope (FAST) will be discussed along with the dust polarization observations at Near-infrared with MIMIR (1.3 m Perkins Telescope) and far-infrared observations with POL 2 (James Clark Maxwell Telescope, Hawaii). In this talk, I will also discuss the implications of multi-scale multiwavelength dust polarization and variation of dust grain properties, and how the gas's magnetized properties shift from diffuse to dense molecular cloud formation using Zeeman data.

Session

FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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Microwave wavelength observations of Lyman break analogues: local proxies for the study of the interstellar medium at high redshift

Dr. Thiago Gonçalves

Valongo Observatory. Federal University of Rio de Janeiro

Abstract

The universe experienced the peak of star formation activity approximately 10 billion years ago, but objects at such epochs are difficult to observe in detail due to the large distances involved. In this talk, I will discuss the background and recent results of a series of works on a sample of local analogues of high-redshift star forming galaxies. These objects, selected based on their high UV luminosities and surface brightness, show characteristics more akin to galaxies at z ~ 1.5-2, while their proximity allows for detailed investigations of a wide variety of physical properties, including (among others) kinematics, gas masses, and environments. I will present microwave-wavelength observations, including ALMA data, that show that these objects have similar relations between molecular gas and star formation to local galaxies (albeit at higher densities), but the lowest metallicity objects in our sample are undetected in CO emission, probably due to the increased exposure to UV radiation from massive stars and subsequent destruction of such molecules. These data indicate that star-forming regions in these galaxies present similar gas densities to typical molecular clouds found in the local universe. Finally, I will discuss the implication of these results for the formation of star-forming regions in high-redshift galaxies. Studies such as this will be strongly impacted by the TolTEC instrument, a project for the LMT telescope which will map the millimeter sky with great efficiency.

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FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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Bridging the gap between far-infrared fine structure lines and optical strong lines in studying interstellar medium and star formation

Bo Peng[1], Gordon Stacey[2], Cody Lamarche[3], Amit Vishwas[2], Catie Ball[2], Christopher Rooney[2], Thomas Nikola[2], Carl Ferkinhoff[3]

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Abstract

The far-infrared fine structure lines (FIR FSLs) are powerful tools in both identifying high redshift galaxies and studying the physical condition of interstellar medium (ISM). However, many gaps remain in the study of FIR FSL, especially between the study of FIR FSLs and the optical strong lines, which limits our capability in systematically comparing and combining multi-wavelength observations from powerful facilities like ALMA and JWST. In this talk, I will present a comprehensive catalog of the global FIR FSL data of both low- and high-z galaxies collected from the literature covering a large range of galaxy types, with rich ancillary optical and mid-infrared data. Based on this comprehensive catalog, I will give a renewed view of the empirical FIR FSL relations, and demonstrate the canonical factors behind these lines aided by the photoionization models. I will highlight the new results enabled by combining the multi-wavelength data, including the identification of [O III]88 contribution from AGN, the agreement of line diagnostics between the FIR and optical lines, the dichotomy between the ionized&neutral gas and the dust that results in "line deficit" of, not only [C II], but all the lines including H alpha, as well as the consequent crisis of the star formation rate measurement in dusty galaxies and the quest for an updated view of ISM.

Session

FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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The impact of feedback on the cold interstellar medium

Prof. Dr. Stefanie Walch

I. Physics Institute, University of Cologne

Abstract

Feedback from stars and AGN is the main driver of the cosmic baryon cycle. In this talk, I will discuss different (stellar and AGN) feedback processes that impact the conditions and the evolution of the cold interstellar medium (ISM). In particular, the feedback from massive stars in their different forms, i.e., ionizing radiation, radiation pressure, stellar winds, and supernovae are key regulators of the local star formation process in cold molecular clouds. The relative impact of the different feedback processes is currently debated, but it seems evident that pre-supernova feedback is an essential part of the game. Also, the strong shocks associated with stellar winds and supernovae are engines for the acceleration of cosmic rays, which in turn influence the chemistry and dynamics of the surrounding cold gas. AGN feedback substantially changes the conditions of the star-forming gas in the center of galactic disks. All of these processes are powerful drivers of galactic fountain flows and outflows, hence regulating the conditions of the galaxy ecosystem. This talk aims to provide an overview of the recent theoretical and computational works on stellar and AGN feedback.

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Unveiling the Role of Atomic Hydrogen in Molecular Cloud Formation: Insights from Wide-field HI Surveys

Dr Nickolas Pingel[1], Professor Snezana Stanimirovic[1], Hongxing Chen[1], Dr Eric Koch[2]

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Abstract

Observational and theoretical studies indicate that atomic neutral hydrogen (HI) plays a crucial role in shielding molecular gas from photodissociation. However, the mechanisms behind the formation of giant molecular clouds from the atomic phase and the influence of local phase equilibrium on molecular gas production remain uncertain. Addressing these questions requires studying the correlation of HI with other interstellar medium (ISM) components across various wavelengths, including dust continuum emission and spectral line molecular gas observations. Until recently, the limited resolving power of existing HI surveys hindered such comparisons. New wide-field HI surveys like Galactic ASKAP (GASKAP-HI) and Local Group L-Band Survey (LGLBS), conducted with The Australian Square Kilometer Array Pathfinder (ASKAP) and the Karl. G. Jansky Very Large Array (VLA), provide the capability to resolve HI structure on sub-parsec scales in the Milky Way and 20 pc scales in the Magellanic Clouds and select Local Group galaxies. They are also sensitive enough to detect HI in absorption, enabling unambiguous detections of the Cold Neutral Medium (CNM) at these scales. By studying HI emission and absorption concurrently, we can capture the phase transition between the CNM and molecular gas. I will present the first localized detections of the CNM in LGLBS dwarf galaxies, contextualizing them with similar GASKAP-HI detections within the Milky Way and Magellanic System to systematically investigate variations across astrophysical environments. These findings leverage multi-wavelength data to enhance our understanding of local ISM conditions driving future star formation, paving the way for next-generation facilities like ngVLA and SKA.

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MeerKAT's detection of low surface brightness HII regions associated with highly variable 6.7 GHz methanol masers

Ms Mavis Seidu[1], Prof James Chibueze[2], Dr Bruno Letarte[1]

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Abstract

The effect of massive OB stars on their surroundings is of significant interest for study. The ability to detect or not detect a radio continuum around these stars is important for understanding how they evolve. This work focuses on five high-mass protostellar objects (HMPOs) in the Southern Hemisphere that are associated with highly variable 6.7 GHz class II methanol and class I methanol masers. Using the sensitive MeerKAT array at 1.28 GHz (~23 cm), we observed compact radio continuum emissions towards the HMPOs. On average, the integrated flux density is 1.869 ± 0.018 mJy and the peak flux is 1.30 ± 0.02 mJy/beam. The 23 cm observations were combined with high angular resolution ALMA archival data which revealed the presence of dense cores at the positions of the 6.7 GHz methanol masers and traced the surrounding gas. One of the sources (G354.50+0.35) showed signs of triggered star formation as the 23 cm compact radio continuum source was found at the border of an almost cometary HII region.

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The MaNGA Low-mass disks HUnt for CO Survey (MaLHUCOS): molecular content and global relations at low-stellar masses.

Dr. Marco Grossi[1], Dr. Edvige Corbelli[2]

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Abstract

Different scaling relations have been investigated to establish the molecular gas efficiency and the role of molecular gas in driving the global and local star formation rate of galaxies. However, in the low-mass regime, detecting cold gas is challenging, making scaling relations less well constrained. We selected 23 star-forming low-mass disk galaxies (M* < 5x10^9 M_sun) of type Sd or later from the MaNGA survey as a pilot sample to study their molecular gas content. The selected galaxies are not very metal poor, with metallicities equal or above ~1/3 solar. We used the James Clerk Maxwell Telescope to search for 12CO(J=2-1) emission that is detected in ~70% of the targets. We derive scaling relations between the molecular gas and the galaxy main properties to identify the parameters that most affect the gas content in our sample, and we compare the low-mass disks with the properties of more massive and metal-rich systems. While the molecular gas fraction (MH2/M*) appears to be anti-correlated with stellar mass following the trend of more massive galaxies, there is only evidence of a weak positive correlation between the molecular gas depletion time and stellar mass. Galaxies with a higher molecular gas fraction do also present a higher atomic gas fraction. Lastly, we investigate the role of environment on the global content of cold gas and on the efficiency with which it is transformed into stars in low-mass galaxies.

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Numerical modeling of the CO emission in Class 0 protostellar outflows

Dr Pedro Ruben Rivera-Ortiz[1], Dr Luis Zapata[1], Geovanni Cortes-Rangel[1], Dr Ary Rodríguez-González[2], Erika Alquicira[2], Bertrand Lefloch[3]

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Abstract

Protostellar jets and outflows are an essential agent of star formation feedback, which affects gas physics and chemistry at all scales, from the molecular cloud down to the central parental cocoon. We have used the axisymmetric chemo-hydrodynamical code WALKIMYA-2D to numerically model and reproduce the physical and H_2 and CO emission properties of the jet-driven outflows produced by: the intermediate-mass protostar Cep E, which was observed with the IRAM interferometer; and the low mass protostar IRAS04166+2706 observed with the ALMA interferometer. Our simulations take into account the observational constraints available on the physical structure of the protostellar envelope to provide constraints on the dynamics of the inner protostellar environment from the study of the outflow/jet propagation away from the launch region. We successfully reproduced the outflows' main qualitative and quantitative features and jet kinematics, naturally accounting for their time variability and the strong envelope-outflow interaction below 10^4 au scales. The distribution of CO abundance along the jet shows that the latter bears memory of the early dissociative phase in the course of its propagation. Analysis of the velocity field indicates that the jet material mainly consists of gas entrained from the circumstellar envelope and accelerated away from the protostar. Numerical modeling comparison with the CO observations have allowed us to peer into the outflow formation mechanism with unprecedented detail and to retrieve the history of the mass-loss events that have shaped the outflow.

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Joint ALMA+JWST analysis of the circumgalactic medium of MACS1931-26

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[1]The University of British Columbia. [2]European Southern Observetory

Abstract

The evolution of galaxies is affected by the diffuse gas around them known as the circumgalactic medium (CGM) through gas inflows and outflows. In this work, we report an investigation of the CGM and ISM of the brightest central galaxy (BCG) of a galaxy cluster, MACS1931-26 at z∼0.35 with one of the largest known H_2 reservoirs, elevated star formation, and strong radio AGN. We have detected cold H_2 towards MACS1931-26 using the [CI](2-1), CO(1-0) and CO(7-6) lines with the APEX 12-m and NRO 45-m telescopes. We complement these observations with archival ALMA CO data and model the gas and dust physical properties using a modified large velocity gradient (LVG) model. Our study shows that the gas in the BCG is highly excited, comparable to the local ULIRGs. However, the CGM gas is less excited, colder, less dense, and less virialized. The H_2 mass of the whole system derived using [CI](2-1) is larger than H_2 mass derived using CO(1-0), showing that a part of the gas in this system is CO-poor. Our recent observations of this object using JWST reveal warm H_2 concomitant with the cold H2 detected by ALMA. A joint analysis of the cold and warm H_2 with these two data sets would reveal any potential gas flow from the CGM to the BCG of this system which might fuel the enhanced star formation of this galaxy and correlate with the strong radio AGN in this system.

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MeerKAT reveals the replenishment of cold gas into star-forming galaxy NGC 5643.

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Abstract

The replenishment of cold gas into late-type galaxies is crucial to sustain their star formation rate densities over cosmic time, which still lacks observational evidence. The availability of the cold gas is determined by the delicate balance between the amount of material accreted from the inter-galactic medium and the amount of gas expelled from the galaxy.

MeerKAT L-band observations of nearby galaxy NGC 5643 (D_L~18 Mpc) trace the neutral atomic hydrogen (HI) from the innermost regions to its outskirts and environment. For the first time, we detect a massive (~5x107 $M_\odot$) tail of low-column density HI (~2x10^{18} cm^{-2}). Its kinematics and absence of nearby galaxies suggest that this gas is accreting onto the star-forming disk from the environment. Within the disk we are able to combine the radio continuum and HI observations with ALMA observations of the molecular gas, thus obtaining a complete picture of the baryon cycle in this galaxy. The difference in the H2/H1 ratio at the edge of the disk with respect to the inner SF regions of the disk provides new insights into the replenishment of neutral atomic gas into galaxies, its conversion into molecular gas and how this fuels star formation.

NGC 5643 provides a multi-faceted up-close example of cold gas flows in nearby galaxies. Multi-wavelength comparisons provide a more coherent view on the impact of feedback in the interstellar medium. Novel MeerKAT comparisons such as this preview SKA observations and science which will enable such studies over statistical samples of sources.

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Resolved Dust Emission and CO Isotopologues in Giant Molecular Clouds of the Andromeda Galaxy

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Abstract

The primary constituent of GMCs as the birthplaces of stars is molecular hydrogen (H2). However, it is not easily observable in the cold ISM. Instead, the next most abundant molecule, carbon monoxide (CO), is often used to map molecular gas. In Galactic neighbourhood studies of molecular clouds, the most successful method of tracing H2 and measuring the physical properties of GMCs has been from dust measurements combined with molecular line measurements. Outside the Galactic neighbourhood, studies rely on CO. Our SMA survey of GMCs in the Andromeda Galaxy (M31) has resulted in the first detection of resolved dust continuum emission of individual GMCs in an external spiral galaxy. I will present an updated overview of the full survey toward 100 GMCs. This survey probes dust continuum emission at 230 GHz and simultaneously obtained 12CO, 13CO, and C18O isotopologues at 15 pc resolution. To calculate the molecular mass of GMCs, we require α(CO) i.e. the conversion factor between CO luminosity and M_{mol}, which we can directly measure as the related ratio of CO luminosity and dust mass of clouds. Furthermore, α(CO) for both gas and dust is predicted to depend on metallicity, because UV radiation destroys molecules depending on the amount of extinction present, predicting that the CO to H2 ratio decreases at lower metallicities where UV can penetrate deeper. From MMT/Hectospec optical spectroscopy, we calculated metallicities of HII regions associated with these GMCs, enabling us to directly investigate the metallicity dependence of α(CO) across M31.

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Resolving the quenching of star formation in post-starburst galaxies

Dr Kate Rowlands

Space Telescope Science Institute

Abstract

One key problem in astrophysics is understanding how and why galaxies stop forming stars. The exact mechanisms that lead to the disruption of the gas supply, the relative importance of different quenching mechanisms, and the timescales involved are still poorly understood. Post-starburst galaxies are an ideal laboratory to study the galaxy transition process as they have undergone a recent, rapid shutdown in star formation. My recent work showed that post-starburst galaxies are not completely devoid of gas, which challenges the rapid quenching mode thought to form the quiescent population. I will present what the multiphase gas and dust properties of post-starburst galaxies reveal about the processes causing galaxies to transition from star forming to quiescent. Deep observations from JWST and ALMA are providing new insights into mechanisms of star-formation suppression and gas cycling in galaxies at a crucial point in their evolution. I will explore how future facilities such as ngVLA and SKA are key to understanding quenching at high redshift.

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The variation of H_2-to-HI content in galaxies over the past Gyr, and the fuelling of galaxies

Dr. Sambit Roychowdhury[1], Prof. Martin Meyer[2], Dr. Martin Zwaan[3], Dr. Carlos De Brueck[3]

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Abstract

The last Gyr is a very important time range for understanding cosmic structure formation and the ultimate fate of the Universe. During this time the star formation rate (SFR) density has continued to decline steadily as it has since the peak of cosmic star formation between z~2-3, the cosmic density of H_2 has also declined steadily, but the the cosmic HI density seems not to have varied much during this period. We know that the IGM/CGM needs to replenish the gas disks of galaxies and above mentioned variations of the cosmic densities must reflect the same. Now, the efficiency of conversion of H_2-to-stars has remained constant with redshift. Thus a fine tuning is required whereby infall from IGM/CGM maintains the HI reservoirs of galaxies but progressively less H_2 is formed in galaxy centres.

I will report our findings when trying to resolve the above by comparing the HI-to-H_2 ratio (1) across a large range in galactic properties, (2) in narrow redshift bins for the rapidly evolving regime of the past Gyr, (3) and for the **same set of galaxies** - something unprecedented beyond z=0. We have used the ALMA Pathfinder EXperiment (APEX) to observe the CO(J=2→1) emission line for z<0.09 galaxies (the last Gyr) in a 1 deg^2 field within the DINGO (deep HI survey on ASKAP) Pilot Survey region. I will present how the HI-to-H_2 ratio measured through stacking of the CO (and HI) spectra, varies across bins of redshift, M*, SFR, and environmental properties.

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2988

A giant barred-spiral starburst galaxy at the z=3 proto-cluster core

Mr. Hideki Umehata

Nagoya University

Abstract

We report (sub)kiloparsec scale observations of stars, gas, and dust in a bright dusty star-forming galaxy (DSFG), ADF22.A1, that is an AGN host galaxy and resides in the z=3 remarkable proto-cluster core. Spiral arms are detected in the rest-frame optical stellar emission, [CII]158um, and dust continuum, which reveal that ADF22.A1 is a Sb/Sc-like spiral galaxy with a forming-bulge. The rotation velocity 530 km/s and extent of 15 kpc was measured with [CII], which are comparable to the large spiral galaxies in the local universe. This requires a mechanism to effectively spin-up ADF22.A1 at the starburst and gas-rich phase, indicating the importance of the cold gas accretion from the cosmic web to supply gas and angular momentum at a proto-cluster core. Gas flows along a pair of dust lanes, which meets at the nucleus, has been discovered, suggesting that the gas in the disk transferred to the core through spiral arms and bars and led the active simultaneous growth of the SMBH and bulge. Thus the advent of ALMA and JWST has enabled us to tack gas flows in disks in a resolved manner at such a high redshift, offering new insights into how the most massive galaxies and central SMBHs form and evolve in the universe.

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Cold 'dark' gas in Cygnus X: The first large-scale mapping of low-frequency carbon recombination lines

Kimberly Emig

Observatoire de Paris. College de France

Abstract

Understanding the transition of atomic gas to molecular gas is critical to explain the formation and evolution of molecular clouds. However, the gas phases involved, cold HI and CO-dark molecular gas, are challenging to directly observe and physically characterize. We present a Green Bank Telescope 30 sq deg survey of the massive star-forming complex Cygnus X (d ~ 1.5 kpc) using carbon radio recombination line (CRRL) emission covering 274 - 399 MHz with an effective transition of C273alpha. Low-frequency CRRLs are key probes of the HI-to-H2 transition zone in clouds as they arise from cold (T ~ 20-100 K), C+ gas with typical densities of n = 100 - 1000 cm^3. We produce the first large-scale map of CRRLs, characterize the spatial distribution and spectral line profiles at 20 pc (45 arcmin) resolution, and compare these properties with those of CO. To first order, the intensities and velocities of these two tracers are well correlated. However, even at this spatial resolution, C273alpha and CO are characterized by a spatial separation of 20 pc and an absolute velocity difference of 1.7 km/s that is uniformly distributed. We suggest C273alpha likely arises from CO-dark molecular gas and is inflowing to the CO-traced gas. The median line-width of C273alpha emission, 2.8 km/s, implies Mach numbers of M = 4 - 10. Our findings demonstrate the importance of gas dynamics in forming molecular gas.

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The New Cryogenically-cooled Phased Array Feed for the 64m Murriyang Telescope at Parkes, Australia

Dr Anita Hafner

CSIRO, Marsfield Australia

Abstract

The 64m Murriyang Telescope at Parkes is an icon of Australian Radio Astronomy. Through its 6 decades of operation it has consistently been a powerhouse of discovery - including the first fast radio burst and half of all known pulsars - and has also played a pivotal role in perhaps humanity's most remarkable achievement: the first Moon landing. With ever-increasing sensitivity and versatility due to its expanding fleet of receivers, Murriyang will continue to be among the most scientifically productive radio telescopes in Australia. The next chapter in the story of Murriyang will feature CryoPAF: the brand new Cryogenically-cooled Phased Array Feed receiver, due to be installed later this year. Designed for ambitious pulsar and spectral line surveys, its low system temperature (~20K) and 72 beams on the sky will lead to orders-of-magnitude improvement in survey speed and sensitivity. In this poster I'll give an overview of the specifications of this exciting new instrument including the observing modes that will be available for proposals in the coming observing semesters.

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Molecular Complexity in Star-forming Regions of the Large Magellanic Cloud Probed by ALMA Observations

Dr. Marta Sewilo[1,2], Ms. Amanda Broadmeadow[2], Mrs. Roya Hamedani Golshan[3], Dr. Steven B. Charnley[1], Dr. Kazuki Tokuda[4,5], Dr. Jennifer Wiseman[1], Dr. C.-H. Rosie Chen[6], Dr. Remy Indebetouw[7,8], Dr. Thomas Moeller[3], Dr. Lee Mundy[2], Dr. Joana M. Oliveira[9], Dr. Peter Schilke[3], Dr. Jacco Th. van Loon[9]

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Abstract

The Large Magellanic Cloud (LMC) is the nearest laboratory for detailed studies on the formation and survival of complex organic molecules (COMs), including prebiotic species, in a low-metallicity environment - typical of earlier cosmological epochs. In the LMC, methanol (CH_3OH) and larger COMs have been found toward a handful of hot molecular cores - small, hot, and dense regions around forming massive stars. Methanol has also been found in multiple locations outside hot cores ("cold methanol"). Even though the detection of only six LMC hot cores has been reported in the literature to date, they show a surprisingly large variation in COM abundances; in contrast, the abundances of S-bearing species such as SO_2 and SO do not change significantly. Here, we report the results of a third in a series of investigations exploring the molecular complexity in star-forming regions of the LMC based on the high-resolution (~0.1 pc) observations with the Atacama Large Millimeter/submillimeter Array (ALMA) covering four ~2 GHz-wide spectral windows between ~241.5 GHz and ~260.6 GHz. We identified two hot cores in the star-forming region N83, both associated with CH_3OH and CH_3CN, but only one with larger COMs (CH_3OCH_3, $HCOOCH_3$, CH_3CHO, and NH_2CHO). We compare the chemical abundances of the newly identified hot cores to those of the other LMC hot cores, the only two known hot cores in the Small Magellanic Cloud (with even lower metallicity than that of the LMC), and Galactic hot cores, to elucidate the impact of the environment on hot core chemistry.

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Characterizing the atomic-to-molecular transition with carbon radio recombination lines

Pedro Salas[1], Kimberly Emig[2], Dylan Linville[3], Poojapriyatharsheni Jeyasingh[4], Anish Roshi[5], Loren Anderson[3], Allison Smith[6], Matteo Luisi[7], Trey Wenger[8], Leonardo Supan[9], Gabriela Castelletti[9]

[1]Green Bank Observatory. [2]Observatoire de Paris. [3]West Virginia University. [4]Lady Doak College. [5]Florida Space Institute. [6]National Astronomy and Ionosphere Center. [7]Westminster College. [8]University of Wisconsin at Madison. [9]Instituto de Astronomía y Física del Espacio

Abstract

The transition of atomic to molecular gas is central to the life cycle of molecular clouds -- the birth sites of stars. This elusive "dark gas" interface plays a key role in the formation of molecular clouds. Hence, characterizing the "dark gas" is an important goal in the study of galaxy evolution. This "dark gas" can be probed through carbon radio recombination lines (CRRLs) at radio and mm wavelengths. CRRLs are also powerful probes of the gas density, temperature and emission measure. Detecting these lines and using them to characterize the properties of dark gas is one of the goals of the Green Bank Telescope Diffuse Ionized Gas Survey at Low frequencies (GDIGS-Low). GDIGS-Low targets the inner Milky Way, 32>l>355 degrees and |b|<1 degree, at 90 and 40 cm. Preliminary survey results show multiple detections of CRRLs. In this contribution we present the survey and preliminary analysis of the "dark gas" properties derived from the multi-frequency CRRL detections in GDIGS-Low.

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Constraining the AGN Impact on the ISM in Simulated and Observed Galaxies Near and Far

Dr Pallavi Patil[1], Dr. Andreea Petric[2], Karolina Garcia[3], Yuanze Luo[1], Dr. Kate Rownlads[2], Prof Desika Narayanan[3], Dr. Dario Fadda[2], Dr. Erini Lambrides[4], Dr Mark Lacy[5]

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Abstract

The merger-driven evolutionary scenario predicts the presence of a critical transitional phase during which the recently (re)ignited Supermassive Black Hole (SMBH) is fueling at its peak and is actively injecting kinetic energy into the host's Interstellar Medium (ISM). This SMBH growth takes place behind thick columns of dust while the host galaxy is still experiencing substantial starburst activity. Although there is mounting observational evidence of AGN-driven impact on the ISM, we still do not understand how the AGN can regulate the galaxy growth by driving outflows and quenching the SF. In this talk, I will present a comparison of SOFIA FIFI-LS and Herschel PACS observations of nearby Star-forming galaxies and AGN with the prediction of multi-phase ISM tracers such as [CII], CO, and H2 estimated in simulated galaxies from SIMBA cosmological simulations. The radiative transfer modeling via Powderday and Slick allows us to look across a wide range of parameters, e.g., AGN fraction, obscuration, warm gas temperature, dust properties, and merger state. We extend our characterization of the AGN-ISM connection to the epoch of cosmic noon, where AGN is likely to have more dramatic impact on their host galaxies. Finally, I discuss the implications of such studies that would be beneficial for understanding the impact of AGN on their hosts over a significant range of cosmic time.

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Observations of HI and CO in Low-Mass Galaxies Hosting AGN

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Abstract

Active galactic nuclei (AGNs) have been proposed as a mechanism for shutting down – quenching – star formation in galaxies. With the discovery that AGNs can inhabit low-mass galaxies ($M_{stel} < 10^{9.7} M_{sun}$), we can study how the presence of an AGN affects a low-mass galaxy's gas reservoir and star formation processes. Previous HI single-dish observations have shown that low-mass galaxies with AGNs are typically HI-deficient. We select a sample of low-mass galaxies from the Sloan Digital Sky Survey IV Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey that have optical emission line ratios indicative of AGN activity. Out of this sample, we have HI interferometric observations of 10 of these galaxies from the Very Large Array. In addition, we have ^{12}CO(1-0) single-dish observations of eight of the galaxies from the IRAM 30m telescope. We do not detect significant amounts of HI or CO in any of the galaxies, and we place HI mass upper limits at $10^{7.1\text{-}8.8} M_{sun}$ and molecular mass upper limits at $10^{7.0\text{-}8.7} M_{sun}$. Based on these mass upper limits, we estimate that the atomic and molecular gas fractions of these AGN galaxies tend to be well below 10%. This suggests that the presence of an AGN could play a role in depleting the gas reservoir and quenching the star formation in low-mass galaxies.

Session

FM 2 A Coherent View of Atomic and Molecular Gas from Infrared to Radio Wavelengths

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Starburst heating and synthetic ion column densities in multiphase galactic outflows.

Daniel Villarruel, Dr. Wladimir E. Banda-Barragán

Yachay Tech University

Abstract

Stellar-driven galactic winds are outflows of energy and matter connecting the interstellar and circumgalactic media (CGM) with the intergalactic medium. They regulate the exchange of metals within these regions of star-forming galaxies. Galactic winds are also multiphase structures, which comprise a dense and cold gas phase embedded into a much hotter and diffuse phase. The cold phase is detected via emission and absorption spectra from the ions populating the outflow, while the hot phase is detected in X-rays. The production of ions within galactic winds depends largely on the background UV radiation field produced by star-forming regions, and this in turn depends on several factors, such as the interplay between radiative heating and cooling, the age of the starburst, the metallicity of the gas in the disc, the proximity of the outflowing gas to the central starburst region, among others. Here we study the influence of starburst UV heating on the production of multiple ion species in galactic winds. We utilise Starburst99 and Cloudy to generate different starburst UV backgrounds and incorporate them into hydrodynamical wind-cloud simulations via ion tables. In this talk, we show synthetic column densities of commonly-observed ion species, and compare them with galactic CGM observations.

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Properties of the Molecular and Atomic Gas in AGN in Mergers from ALMA and VLT/MUSE Observations

Ezequiel Treister[1], Michael Koss[2], Loreto Barcos-Muñoz[3], Franz Bauer[4], George Privon[3]

[1]Pontificia Universidad Católica de Chile, Chile. [2]Eureka Scientist. [3]NRAO. [4]PUC

Abstract

I will present results from our ongoing program to obtain optical and near-IR IFU spectroscopy and ALMA maps for a growing sample of dual AGN at z<0.1, with nuclear separations ranging from ~10 kpc to ~200pc. These high-resolution multi-wavelength studies allow us to understand the complex connection between black hole growth and galaxy evolution in this critical stage, and to study the parent population of energetic gravitational wave events that will be detectable in the future with planned missions such as LISA. Specifically, I will present the multi-wavelength properties of the gas in the atomic and molecular phases in newly discovered dual AGN, covering a range of nuclear separations, including a sample of late-stage major galaxy mergers at <1 kpc separations, requiring the highest spatial resolution observations currently achievable by ALMA.

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PRIMA: The PRobe far-Infrared Mission for Astrophysics

Alberto Bolatto[1], Jason Glenn[2], Matt Bradford[3], Margaret Meixner[3], Alexandra Pope[4], Laure Ciesla[5], PRIMA team[6]

[1]University of Maryland at College Park, USA. [2]NASA Goddard, USA. [3]Jet Propulsion Laboratory, USA. [4]University of Massachusetts at Amherst, USA. [5]Laboratoire d'Astrophysique de Marseille, France. [6]PRIMA

Abstract

PRIMA is a cryogenically-cooled, far-infrared observatory concept for the astronomical community in the 2030 decade, submitted to NASA. It includes both a sensitive wideband spectrometer (FIRESS) and a multi-band spectrophotometric imager and polarimeter (PRIMAger). The impressive advances in far-IR detector technology, together with the cooled primary, enable a sensitivity limited by the astronomical background --- orders of magnitude more powerful than anything previously deployed at these wavelengths. PRIMA's sensitivity unlocks the potential of the far-IR wavebands to advance astrophysics across a broad range of themes, from and AGN formation, to dust and interstellar medium evolution, to the formation of planets and planetary atmospheres. FIRESS covers from 24 to 235 um in two modes: a low-res (R~100) long-slit mode capable of fast mapping, and a high-res mode (tunable R<=4,400) on smaller fields. PRIMAger offers sensitive and rapid R=10 hyperspectral imaging with continuous coverage from 25 to 84 um and polarimetry in 4 bands from 90 to 235 um.

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Characterization of the ISM in the Milky Way with linear optical polarization

P Blay, J.C Ruiz, M. Gonzalez-Garcia

ESICT, Valencian International University - VIU, Valencia, Spain

Abstract

The light from the stars reaching our telescopes will pass through certain amount of interstellar matter that might alter its properties. The two main observational effects of the ISM on the stellar measurements are interstellar reddening (extinction) and polarization. We have collected a large sample of stellar linear optical polarization measurements, covering the whole galactic plane. For most of the stellar objects in the sample, their intrinsic polarization is expected to be null. However, as it is possible that some stars might show some degree of polarization themselves, in order to characterize the degree of polarization induced by the ISM in our sample, a cleaning procedure has been stablished by determining statistically valid representative values of the ISM induced polarization on each region. Then, we have identified outliers (stellar objects with intrinsic polarization) and clean them up from the sample. As a result, we have obtained a map of the induced polarization of the ISM across the Milkyway which can directly be compared to extinction measurements and the galactic magnetic field structure. Furthermore, clustering analysis of the polarization values (both degree and angle of polarization) is being used to identify and characterize interesting regions in the galactic plane such a star forming regions.

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Infall and outflow activities in star formation

Gang Wu[1], Christian Henkel[2], Jarken Esimbek[1], Dongdong Zhou[1]

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Abstract

The accretion and ejection of material are the two fundamental processes driving star formation. However, neither of these processes is yet well understood, as we still have limited evidence regarding the origin of tracers used to monitor them, as well as our limited knowledge of the accretion/ejection interface and their physical connection. Observing infall is crucial for comprehending the accretion process in star formation. Continuous efforts have been made to improve our capacity for detecting infall motions, aiming to achieve a comprehensive understanding of these motions in star-forming regions across a wider range of evolutionary stages and spatial scales. In this poster, we emphasize our efforts on a promising infall tracer, i.e. ammonia hyperfine intensity anomalies, which could serve as more effective infall tracers for relatively cold gas and large-scale motions. The launch and collimation mechanisms of jets remain subject to debate and the details of the interactions between jets and outflows are still unclear. One of the main reasons has been the inadequate angular resolution of current facilities needed to zoom into the launching and collimation zone. Therefore, we seek to utilize the so far highest resolution VLBI observations to study these critical aspects in the close vicinity of the protostars.

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Final category: FM 3 Follow-up observations of small bodies in the Solar System in the era of large discovery surveys

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Search and study of the Near-Earth Orbit within ground-based optical telescopes at NRIAG-Egypt

Dr Ahmed Moursi

National Research Institute of Astronomy and Geophysics (NRIAG)

Abstract

The development and research of near-Earth space (NES) have led to the awareness of the so-called space threats–asteroid hazards and problems associated with technogenic contamination of the so-called "space debris" (SD). The tasks of detecting and cataloging of near-Earth asteroids (NEA), investigating the evolution of their orbits, and studying their physical and mineralogical properties are extremely important. The tasks of studying, modeling, and preventing manmade threats to the implementation of space activities are also more urgent than ever before. Both of these tasks are united by an approach to their study – to research them, you need scientific tools in the form of a geographically distributed network of optical telescopes that cover all longitudes of the globe. Within our collaboration with the International Scientific Optical Network (ISON) for optical observation. We present an approach for finding and tracking small and fast near-earth asteroids (NEAs) and initiated observations from the Optical telescopes at the National Research Institute of Astronomy and Geophysics (NRIAG), Egypt. The aim of this work establish an observation program for NEAs tracking at NRIAG, to Create a database for astrometric observations of minor planets or irregular natural satellites, all of which would contribute to global knowledge of position data and be stored in the MPC.

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PHOTOMETRIC PROPERTIES OF ACTIVE ASTEROID 248370 (2005 QN173) FROM OBSERVATIONS IN SLOVAKIA AND TAJIKISTAN

Dr/ Gulchehra Kokhirova[1], Dr. Firuza Rakhmatullaeva[1], Dr. Marek Husarik[2], Dr. Oleksandra Ivanova[2,3,4], Dr. Sergei Borysenko[3]

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Abstract

We present the results of optical observations of the outburst of asteroid 248370 (2005 QN173), which occurred on July 7, 2021. Observations were carried out at the Skalnate Pleso Observatory in Slovakia and at the Sanglokh Astronomical Observatory in Tajikistan in July-August 2021. The object suddenly showed signs of cometary activity such as a compact coma and a long dust tail and was therefore classified as an active Main belt asteroid. The apparent and absolute brightness of asteroid in BVR bands was determined and it was shown that during the observation period the asteroid's brightness remained stable. The dust productivity parameter has been calculated, the values of which are typical of Jupiter-family comets at distant heliocentric distances. According to our estimates, the diameter of the asteroid is on average 5.3±2 km. Our photometric data confirm the active stage of the asteroid and are consistent with the results of other observations of this period.

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Rubin's LSST: opportunities for small-body science from a large-scale Solar System survey

Professor Zeljko Ivezic

AURA/University of Washington

Abstract

The Legacy Survey of Space and Time (LSST), the first project to be undertaken at the new Vera C. Rubin Observatory, will be the most comprehensive optical astronomical sky survey ever undertaken. Starting in 2025, Rubin Observatory will observe the sky visible from its location in Chile every clear night for ten years. Using this 60,000 terabyte image dataset, about 20 billion galaxies and a similar number of stars will be observed close to a thousand times. LSST data products will also include the largest catalog of Solar System objects to date, with orbital parameters and time-resolved multi-band photometry and astrometry for about 5 million Solar System objects. In addition to millions of main-belt asteroids, LSST will discover about 100,000 NEOs, about 40,000 TNOs and thousands of comets, and the majority of these objects will receive hundreds of observations in multiple bandpasses during the 10-year survey. The resulting dataset will enable a range of studies, from advancing planetary defense and understanding the structure and history of the Solar System, to discoveries of interstellar objects and searches for distant planets in the Solar System.

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THE INTERNATIONAL YEAR INITIATIVE FOR PLANETARY DEFENCE, 2029.

Ms. Doris Daou[1], Dr. Rudolf Albrecht[2], Dr. William Ailor[3], Dr. Sergio Camacho[4], Dr. Kelly Fast[1], Dr. Christian Koeberl[5], Ms. Romana Kofler[6], Dr. Detlef Koschny[7], Dr. Richard Moissl[8], Dr. Patrick Michel[9], Dr. Gonzalo Tancredi[10], Dr. Andrew Williams[11]

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Abstract

Near-Earth Objects (NEOs) are of great interest to the scientific community as well as the planetary defence communities. ESA, NASA and partners worldwide maintain a watch for NEOs, including asteroids and comets that can pass within Earth's vicinity, as part of an ongoing effort to discover, catalog, and characterize these bodies and to determine if any pose an impact threat.

On 13 April 2029, the ~370-meter asteroid (99942) Apophis will pass safely between the geostationary orbit and Earth. The asteroid will be visible with the naked eye to anyone under a dark sky. This is a once-in-a-lifetime event and is a unique occasion to dedicate the year 2029 to a world-wide campaign on raising awareness about asteroids, their scientific value, and the potential hazard they may present.

The International Year initiative for 2029 is intended as an opportunity to raise global understanding of asteroids and comets that might impact our planet in the future and how we might protect Earth and ensure human security considering possible impacts by these natural objects.

This initiative will mark the monumental leap forward in a global effort in planetary defence and portray it as a peaceful global scientific endeavor that unites all of us working together to defend our planet against the potential hazards of Near-Earth Objects. In this presentation, we aim to inform the community about the work that is underway and invite further partners to be involved and collaborate in the variety of planned efforts.

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Searching for Signs of Asteroid Activity in ATLAS Data

Omri Scannell

University of Cape Town

Abstract

This study investigates the presence of asteroid activity in photometric data from the ATLAS database. Focusing on known active asteroids, particularly (6478) Gault, our objective was to identify brightness spikes associated with their activity. Our analysis revealed a significant increase in brightness around MJD 58500 for (6478) Gault, consistent with documented activity periods, reaching approximately three times the predicted values. We developed a searching algorithm to identify and flag potential activity by iterating through asteroid apparitions and applying five tests to search for brightness spikes. Testing on a sample, including (6478) Gault and 81 other asteroids not listed as active, the algorithm was able to successfully flag solely (6478) Gault. This suggested that the algorithm can differentiate between active and non-active asteroids. Disabling certain tests led to false positives for one apparition of (162173) Ryugu and two apparitions of (3753) Cruithne, which were subsequently determined to exhibit no signs of activity. Our findings suggest the potential for algorithms like ours to automate the search for active asteroids, thereby enhancing the discovery rate and advancing our understanding of these intriguing celestial objects.

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Automated Rapid Follow-up Observations and Taxonomic Characterization of Near-Earth Asteroids using the robotic Lesedi Telescope

Ms Thobekile Sandra Ngwane[1,2], Dr Nicolas Erasmus[2]

[1]University of Cape Town. [2]South African Astronomical Observatory

Abstract

Near-Earth Asteroids (NEAs), a subset of minor bodies in the Solar System, result from resonant interactions with major planets, particularly Jupiter, leading to their escape from the main asteroid belt. The International Astronomical Union's Minor Planet Center (MPC) database, as of February 2024, lists approximately 34,000 discovered NEAs, with an average daily discovery rate of ~10 from dedicated survey programs (e.g. Catalina, Pan-STARRS, and ATLAS).

Our research leverages the robotic observing capabilities of the South African Astronomical Observatory's 1-meter telescope, Lesedi, equipped with the Mookodi instrument. This initiative focuses on executing rapid follow-up observations of newly discovered NEAs, often within the same night of their detection. This timely response is crucial as small asteroids, constituting an underexplored group, rapidly dim as they move away from Earth.

This work presents findings from our program, initiated in February 2023, focusing on multi-filter photometry and astrometric measurements of successfully observed NEAs, some identified as potentially hazardous asteroids (PHAs). Our astrometric data is crucial for refining orbital parameters, contributing to the final designation by the Minor Planet Center (MPC).

Additionally, g'r'i' photometry allows us to extract g' − r' and r' − i' colours, providing estimates of the spectral slope. This helps us determine the most likely Bus-DeMeo taxonomic type, which is an indicator of the likely composition of these NEAs. Our investigation into the composition, addressing likely structural integrity, of these smaller yet PHAs yields invaluable insights into the nature of potential future impactors. This research significantly contributes to our preparedness for planetary defence strategies.

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Are the diamagnetic cavities related to the outbursts in comet 67P/Churyumov-Gerasimenko?

Prof. Dr. Marcos Rincon Voelzke[1], Prof. Dr. Karl-Heinz Glassmeier[2], Dr. Willi Exner[2]

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Abstract

For the purpose of identifying and understanding a possible correlation between outbursts and the diamagnetic cavity of comet 67P/Churyumov-Gerasimenko, 34 images of outbursts (Vincent et al., 2016) from July to September 2015 are analysed. A systematic visual analysis revealed that in two cases an outburst occurred inside the interval duration of a diamagnetic cavity and at only one occasion the outburst took place a short time before the crossing of a diamagnetic cavity. In the other 31 cases, either the outburst occurred long before the entry into a diamagnetic cavity or after the exit out of it. The current nucleus rotation period at perihelion is about 12h 18m 10s. We present a model for the possible temporary movement of the diamagnetic cavity by the influence of outbursts. As the spacecraft can be assumed to be stationary in that time frame, we propose that the magnetic field components can change significantly within the data, which we analyse for similar component behaviour.

Reference Vincent, J.-B, et al., Summer fireworks on comet 67P, Monthly Notices of the Royal Astronomical Society, 462, 184-194, 2016.

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Exploring Capabilities: Characterising Solar System Objects with SAAO Telescopes

Dr Nicolas Erasmus[1], Thobekile Ngwane[2,1], Mandlenkosi Mnisi[2,1]

[1]South African Astronomical Observatory. [2]University of Cape Town

Abstract

In this presentation, I will provide an overview of some of the small-body follow-up observations conducted at the South African Astronomical Observatory's (SAAO) site in Sutherland, Northern Cape. I will showcase the instruments and capabilities available on the SAAO telescopes and introduce the SAAO's Intelligent Observatory (IO) program. This program enables fully automated follow-up observations through a robotic queue scheduled mode on select telescopes, ensuring efficient and rapid responses.

I will also touch upon future plans, including potential follow-up activities with the Southern African Large Telescope (SALT) and the utilisation of unexploited facilities hosted on-site.

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On the importance of combining photometric data sets for asteroid light curve inversion

Josef Ďurech, Josef Hanuš

Charles University

Abstract

The Rubin Observatory's Legacy Survey of Space and Time (LSST) will provide photometric measurements for millions of asteroids; typically, hundreds of individual measurements per asteroid spread over ten years. This sparse-in-time photometry can be used to derive the rotation period, spin axis direction, and convex shape model of asteroids with the light curve inversion method. Although the majority of LSST asteroids will be so faint that they will not have complementary data from other surveys, asteroids at the bright end of the magnitude range (the saturation limit of LSST is ~15 mag) will have, and already now have, observations from other surveys (ZTF, Pan-STARRS, Gaia,...). Adding these complementary photometric data to LSST data and inverting the whole data set together will significantly increase the success rate of unique shape and spin models.

We will demonstrate the importance of combining diverse photometric data sets on currently available data from surveys and estimate the number of asteroids for which LSST observations can be combined with photometry from other surveys.

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NEOMIR: ESA's space-based infrared mission for NEO detection and early warning

Dr Luca Conversi[1], Dr Javier Licandro[2], Dr Marco Delbo[3], Prof Alan Fitzsimmons[4], Prof Karri Muinonen[5], Dr Thomas Müller[6], Dr Marcel Popescu[7], Dr Paolo Tanga[3], Dr Richard Moissl[1]

[1]European Space Agency. [2]Instituto de Astrofísica de Canarias. [3]Observatoire de la Côte d'Azur. [4]Astrophysics Research Centre. [5]Department of Physics, University of Helsinki. [6]Max-Planck-Institut für Extraterrestrische Physik. [7]Astronomical Institute of the Romanian Academy

Abstract

Most current and planned NEO surveys are ground-based and carried out in the visible wavelength range. However, this approach has some limitations, such as (1) weather dependency, (2) that only a portion of the night sky is visible from any given location on Earth, (3) NEOs are difficult to detect at low galactic latitudes and (4) that visible-light surveys can only determine the motion and apparent magnitude of an object, but its physical properties (such as size) can only be inferred indirectly and therefore require additional observations for characterisation.

A space-based mission working in the thermal infrared and placed at the first Sun-Earth Lagrange point would overcome most of these issues: by regularly scanning an area not easily accessible from ground or other space-based NEO surveys, it will be capable of detecting and characterising new NEOs and - in the worst case of an imminent impactor - serve as an early warning system.

ESA is studying a NEO Mission in the Infra-Red (NEOMIR), designed with the aim of discovering the smaller NEO population, which can only be observed when the asteroids get closer to Earth. This is achieved by (1) pointing closer to the Sun and at all Ecliptic latitudes and (2) shortening exposure times and increasing cadence of revisit, ensuring that faster and therefore closer NEOs crossing the field of regard are not missed.

We will present the mission and spacecraft design, the status of the project as well as initial results on expected detection capabilities.

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Large photometric database and application to asteroid data from multiple space- and ground-based surveys.

Milagros Colazo, Dagmara Oszkiewicz, Przemyslaw Bartczak, Roman Hirsch, Edyta Podlewska-Gaca

Astronomical Observatory Institute, Faculty of Physics, Adam Mickiewicz University

Abstract

Nowadays, we are experiencing a revolution in astronomical surveys. Thanks to ground-based and orbiting telescopes, millions of observations of asteroids in various photometric filters are available. One way to take full advantage of the vast amount of data from different telescopes is to merge the databases that each one generates. The main challenge in combining these data sets involves processing information with distinct properties (for example, different random and systematic errors, some non-Gaussian, different filters, or observation conditions).

The main objective of our project is to develop tools for reading, processing, and analyzing large volumes of data. The initial step of our work involved creating a homogeneous massive photometric database containing observations from different surveys: SDSS, Gaia, TESS, SkyMapper, and ATLAS. We supplemented the original catalogs with additional information such as phase angles, ecliptic coordinates, computed fluxes, etc. The database currently contains around 70 million observations of over 500,000 asteroids. The codes used for database creation are generic enough to be easily reused as new databases emerge.

From this extensive database, we present preliminary results of phase curve parameters. Moreover, our large sample size enables us to provide statistical analyses of the obtained parameters. The ultimate goal of this project is to derive phase curve parameters corrected for shape and viewing geometry for a considerable number of asteroids. For the first time, this will allow the use of surface scattering properties statistically to address significant challenges in planetary science.

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A stellar flyby explains multiple small-body properties in the solar system

Prof Susanne Pfalzner, Amith Govind, Dr Frank Wagner

Forschungszentrum Jülich

Abstract

More than 3000 small bodies have been discovered beyond Neptune, which, together with the planets, formed from the primordial disc of gas and dust. Therefore, it was a surprise that most of these trans-Neptunian objects (TNOs) orbit on eccentric, inclined trajectories. Some process must have altered the TNOs' orbits after formation. Current models are challenged by explaining very distant objects like Sedna and TNOs moving on retrograde orbits close to the plane of the planets. We will demonstrate that a close flyby of a star can explain these extreme orbits. The observed complex correlation between the TNOs' colour and the inclination of their orbits seems a natural consequence of this flyby. The flyby would have also injected TNOs into the region of the planets, many on retrograde orbits. The giant planets would have captured a small fraction of these injected TNOs, explaining the similarities and differences in the colour distributions of both populations. The Vera Rubin telescope is expected to significantly increase the number of known TNOs and irregular moons. It will be able to test this flyby hypothesis in the near future.

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Detecting surface inhomogeneity of small bodies in the Solar System

Mr Mandla Mnisi[1], Dr Nicolas Erasmus[2]

[1]University of Cape Town. [2]SAAO

Abstract

Observations of asteroids from Earth have revealed a prevailing trend indicating global homogeneity of the surface composition of individual asteroids, despite the diverse spectral signatures correlated to surface composition, among the population as a whole. Nevertheless, exceptions exist, for example Psyche, a main belt asteroid exhibits significant optical albedo fluctuations and radar signatures suggestive of patches/area of metal-rich material on its surface (J.A.Sanchez et al.(2016)). Such peculiar asteroids potentially harbor exotic, valuable elements, driving NASA's Psyche mission to designate it as a primary target. The quest to discover more of these asteroids with surface inhomogeneity thus emerges as a compelling pursuit.

Mookodi, a recently deployed low-resolution spectrograph operating in the visible spectrum, is now installed on the South African Astronomical Observatory's 1-meter Lesedi telescope in Sutherland, South Africa. Originally designed for rapid-response characterization of transient astronomical events, Mookodi also proves well suited for automated time-series spectroscopic monitoring of variable sources. This work will present the results evaluating Mookodi's efficacy for detecting surface inhomogeneity of small bodies through time-series spectroscopic observations. We mainly show results using Pluto as a test case which has previously published ground-based time-series spectroscopic observations that have revealed varying methane concentrations across its surface(V.Lorenzi et al.(2016)). Our observations with Mookodi validate these findings, affirming its potential for detecting surface inhomogeneity on a Solar System object.

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Taxonomic classification of asteroids in the ATLAS database using machine learning

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Abstract

Based on their spectroscopic signatures, asteroids can be classified into their taxonomic types (e.g the Bus-DeMeo types, S, C and X). While spectroscopy offers more precise asteroid classification, information from photometry can also provide insights to a likely taxonomic type. In this study, photometric data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) was used to obtain two parameters for asteroids with independently determined and known taxonomic types to form a training sample: the c-o colour and the phase-curve slope parameter, G. The training set, with the two photometric features and known taxonomic types, was used to train a K-Nearest Neighbours Machine Learning (ML) algorithm. The trained algorithm was then able to take in previously unclassified asteroids and classify them based on their photometric features. The ML algorithm was used to produce a decision surface with regions for each type in the feature space, and percentage probabilities of the test asteroids belonging to each class. The S- and C-types in the training sample formed well defined regions on the decision surface, and the trained algorithm was able to classify test asteroids into S- and C-types reliably. In future, a larger training sample could produce more well defined regions on the decision surface, increasing the reliability of the classification and extending to taxonomic types other than just S-, C- and X-types. This work demonstrated a resource-efficient tool for the reliable approximation of asteroid taxonomy.

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The dust and gas production rates: monitoring of Long-period comets (LPC) and Dynamically new comets (DNC) with TRAPPIST telescopes.

Mr Said Hmiddouch[1,2], Dr Emmanuel Jehin[2], Mr Mathieu Vander Donckt[2], Pr Abdelhadi Jabiri[1], Dr Youssef Moulane[3], Pr Zouhair Benkhaldoun[1]

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Abstract

Although approximately two dozen potentially observable comets come to perihelion every year, only a small fraction of them are studied in detail. Nowadays it is increasingly difficult to obtain observation time on the always larger and fewer telescopes available. However, it is well known that comets vary unpredictably for a variety of reasons. Observing them on a limited number of nights could then provide a biased view of their evolution and composition. Gathering homogeneous physical data on as large a sample as possible is then very important for understanding the distribution of physical and chemical properties. This is one of the goals of the network of TRAPPIST robotic telescopes (E. Jehin et al. 2011), for which we use ~50% of its observing time for a photometric survey of bright comets in both hemispheres. We used both telescopes, to observe and follow bright comets of various dynamical histories along their orbits. These robotic telescopes are equipped with standard Johnson-Cousin B, V, Rc, and Ic filters, as well as narrow-band filters optimized for observing emission bands of volatiles found in comets (Farnham et al. 2000).

In this study, we present our findings from the photometric monitoring of a sample of long-period comets (LPCs) and the dynamically new comets (DNCs) observed between 2015 and 2024. Our work contributes to the understanding of the cometary behavior of these two dynamical classes originating from the Oort Cloud to help identify potential targets for future missions like the ESA Comet Interceptor mission (Jones et al. 2024).

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Error analysis for rotating-drift-scan charge-coupled device observation of near-Earth asteroids

Dr. Kai Tang[1], Anton Pomazan[1], Nadiia Maigurova[2], Yezhi Song[1]

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Abstract

The apparent velocities of near-Earth asteroids (NEAs) are usually high when they pass by Earth. Observing these fast-moving objects with long exposure times would cause their images to streak and significantly decrease the precision of astronomical measurements. The rotating-drift-scan (RDS) charge-coupled device technique is a promising approach to observe fast-moving NEAs during their close approaches to the Earth. By rotating the camera of a telescope, an NEA can be observed in the time delay integration mode. This allows the asteroid to be imaged as a point source, even with a long exposure time. This technique makes an impactful contribution to improving the NEA's orbit accuracy by extending the observation arc. A detailed statistical analysis of the astrometric error was conducted, revealing that RDS observations can achieve a competitive accuracy with a root-mean-square (RMS) error of 0.24" in right ascension and 0.32" in declination. The instability of the telescope is thought to be the main reason affecting the internal precision. Furthermore, the RDS technique excels at observing fast-moving NEAs, as well as newly discovered NEAs without accurate ephemerides. For NEAs with rates of motion exceeding 10 deg/day, the RMS of RDS observation residuals is 0.35" in along-track direction and 0.23" in cross-track. With this technique, a network of small-aperture telescopes would substantially benefit our global NEAs monitoring system to ensure Earth's safety from any asteroid impacts.

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Stellar Occultations by Bodies in the Outer Solar System

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Abstract

Stellar occultations are one of the most accurate, ground-based methods by which to assess physical characteristics of bodies in the outer Solar System. For example, in the trans-Neptunian region, occultation data have been used to determine object sizes and shapes at km-level accuracy, detect or place limits on microbar-level atmospheres, and discover and study rings down to km-level widths. Particularly compelling targets over the next few years include Pluto (which its thin, evolving, global atmosphere) and the trans-Neptunian objects and Centaurs for which rings have been proposed (Chariklo, Chiron, Haumea, and Quaoar). We will present recent results from stellar occultations by bodies in the outer Solar System, and we will consider the implications of large discovery surveys on future occultation efforts as well as how the technique can be used to increase their science return.

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THE CONTRIBUTION OF BVRI PHOTOMETRY IN CHARACTERIZING THE NEA POPULATION

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Abstract

Along with standard asteroid VIS/NIR spectroscopy, photometric color analysis represents a pivotal tool for asteroid characterization. Indeed, colors are also easier to obtain using medium-sized telescopes (1-2.5 m). We set up a database containing the B-V, V-R and V-I colors and additional information of about 1000 NEA with the aim to find out how far the photometric data may contribute to the understanding of the asteroid properties. We collect colors of 475 asteroid direct observations (Dandy et al. 2003; Betzler et al., 2010; Ye et al., 2011; Betzler et al., 2012; Erasmus et al., 2017; Lin et al., 2018; Hromakina et al., 2018, 2022; Ieva et al.,2018; Ieva et al. 2020; Birlan et al.2024) and we calculated colors from 577 spectra, normalized at unity at V filter (Perna et al., 2018, Devogele et al., 2019; C.A. Thomas et al., 2022; Tanga et al. 2022). We used three different methods to analyze our sample searching for grouping of objects characterized by the same behavior in the colors space: a linear combination of gaussian curves, the G-mode method (Barucci et al., 1987) and the clustering by fast search and find of density peaks (Rodriguez & Laio, 2014). The results of the three different methods are in very good agreement between each other and the analysis shows how the multicolor photometry is a precious tool in characterizing large amount of asteroid data obtained using faster and more frequent observations due to the greater availability of medium-sized telescopes.

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Observational activities and results of ESA's Planetary Defence Office

Marco Micheli, Luca Conversi, Maxime Devogèle, Dora Föhring, Rainer Kresken, Francisco Ocaña, Regina Rudawska

ESA PDO NEO Coordination Centre

Abstract

ESA's Planetary Defence Office (PDO) carries out NEO discovery and follow-up observations as part of its observation pillar.

Discovery activities are about to become operational with the commissioning of the "Flyeye", a metre-class wide-field telescope entirely dedicated to NEO survey activities.

Astrometric follow-up activities, on the other hand, have been carried out for the last decade, thanks to a well-established global network of facilities. Through a variety of telescopes, spanning a wide range of apertures, we can effectively react to various NEO follow-up needs:

- Smaller telescopes, strategically distributed all over the world, in every continent, allow very rapid response to urgent follow-up needs, such as imminent impactor alerts.
- Mid-size facilities with near full-time availability ensure our continued contribution to the overall follow-up effort.
- Agreements with larger 10-metre-class facilities, such as ESO's VLT, allow deep follow-up capabilities down to magnitude ~27, which are essential to properly monitor high-priority risk list targets.

We are also taking advantage of these diverse observational resources to test innovative observing techniques, such as timing calibrations, CMOS cameras, synthetic tracking, low elongation imaging and negative recovery observations. The goal is to ensure the capability to extract high-precision astrometry (and astrometric uncertainties) under the challenging observing conditions that are often required for NEO observations.

More recently, we are expanding our follow-up activities towards physical observations, while maintaining a specific focus on planetary defence needs, as required by our mandate. We are also maintaining a public archive of all the images obtained by our team, useful for precovery purposes.

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The Milky Way Globular Clusters: guests in the Oort cloud system on cosmological time scale.

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Abstract

As we know the actual location of the Solar system in the Milky Way is considered as calm region without large recent gravitational perturbations. But, if we assume, that a globular cluster (GC) with close passages near the Sun are not an exceptional event in the Solar System's lifetime, how strong will be the gravitational influence of GCs' flyby onto the Oort cloud system? The present epoch of the Gaia success gives us a possibility to predict the dynamical evolution of our Solar System in the global Galactic framework with high precision.

We integrated the orbits of GCs together with the Sun up to 6 Gyr lookback time based on Gaia DR3 observations. We used a high-order parallel dynamical N-body code phi-GPU, based on the fourth-order Hermite integration scheme with hierarchical individual block time steps. With the aim to get more realistic simulations we used pre-selected Milky Way-like time evolving potentials (Illustris TNG100), where the halo and disk mass and their sizes were changed dynamically in time.

Analyzing the individual GCs during of their evolution, we got several GCs that have close passages in all potentials in a close distance to the Sun (0-50 pc): Djorg, UKS1, NGC 1904, Pal 10, FSR 1758 and NGC 2808. For example, GCs BH 140, UKS 1, and Djorg 1 have a mean minimum relative distance to the Sun of 9, 19, 17 pc, respectively. We analyzed the gravitational energetic influence on the whole Oort cloud system from the closest selected globular cluster flyby.

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Evaluating the LSST's Capability to Detect Interstellar Objects that can be Followed-up with the Milankovic Telescope

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Abstract

The discovery of two interstellar objects (ISOs) passing through the Solar System, 1I/`Oumuamua and 2I/Borisov, indicates the existence of a galactic population with a number-density on the order of ~0.1 au^{-3}. We conduct a detailed simulation to assess the Rubin Observatory Legacy Survey of Space and Time (LSST)'s ability to detect interstellar inactive asteroids and active comets. We generate hundreds of realizations of synthetic populations covering a realistic range of relevant characteristics, including kinematics in interstellar space, distributions of size, albedo, shape, and rotational state, as well as cometary brightening behavior. These choices are motivated because the characteristics of the galactic population are still relatively unconstrained. We simulate a full-scale 10-year LSST observational campaign using the most recently recommended baseline cadence. We examine how the intrinsic characteristics of the true ISO population influences the detectability and the features of the detections relevant for tuning the linking algorithms, such as apparent rate of motion and observable arc length. Based on the output obtained from the simulations, we present a case study for follow-up possibilities for the Milankovic 1.4 m telescope at Astronomical Station Vidojevica in Serbia, which is already a part of the SER-SAG in-kind contribution to the LSST for the optical follow-up of bright LSST transients via the active follow-up program planned to be coordinated through the Astronomical Event Observatory Network (AEON).

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Determination of Nearly 32,500 Asteroid Rotation Periods from WISE Data

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Abstract

Large surveys often yield observations of individual objects that are either sparse or limited in duration. These observations may present additional analysis challenges but nevertheless contain a wealth of information. We used 22 um (W4) Wide-field Infrared Survey Explorer (WISE) observations of 4420 asteroids to analyze lightcurves and determined spin period estimates for 1929 asteroids. We fit second-order Fourier models at a large number of trial frequencies to the W4 data and analyzed the resulting periodograms. We found that three solutions accurately capture the vast majority of the rotational frequencies in our sample: the best-fit frequency and its mirrors around 3.78 and 7.57 rotations per day. By comparing our solutions to a high-quality control group of 752 asteroid spin periods, we found that one of our solutions is accurate (within 5%) in 88% of the cases. Encouraged by this result, we have extended the analysis to 32549 asteroids with the same technique applied to both the W3 and W4 bands.

Reference: A. L. H. Lam, J. L. Margot, E Whittaker, N. Myhrvold. Determination of 1929 Asteroid Rotation Periods from WISE Data. Planetary Science Journal 4, 2023. https://doi.org/10.3847/PSJ/acc5e4

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Investigating Asteroids Shape and Spin State from KMTNet and Gaia Light Curves

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Abstract

Recent advancements in large-scale surveys have led to the discovery of numerous asteroids, sparking significant interest in uncovering their physical properties. Shape models and spin properties are considered fundamental physical parameters of asteroids, providing crucial insights into their origins and evolutionary processes. Observational data obtained through these large-scale surveys are not only used for asteroid discovery but also for characterizing these physical properties. Indeed, data from large surveys such as Gaia, WISE, and ATLAS have revealed the shapes and spin properties of asteroids. However, most of these large-scale surveys suffer from sparse-in-time coverage, which limits the scope of the analysis results.

Korea Microlensing Telescope Network (KMTNet) has been conducting dense light curve observations of approximately 20,000 asteroids annually since 2019. Its distinctive advantage lies in the continuous 24-hour observation of a single asteroid, minimizing temporal gaps in light curves. However, because KMTNet began relatively recently, most asteroids have only been observed during one apparition, without observations from various geometries. Therefore, our analysis integrates dense light curves observed by KMTNet with sparse data from Gaia Data Release 3 (DR3), which was published on 13 June 2022, including data for 158,152 asteroids.

In this presentation, we will present preliminary results of asteroid shape and spin properties analysis using KMTNet and Gaia DR3 data, along with discussions on the enhancements achieved.

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Transitional objects among asteroids and comets monitored through archival images from large surveys

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Abstract

Transitional objects are bodies that share some characteristics with asteroids or comets. Asteroids in Cometary Orbits (ACOs) behave dynamically like comets but have not shown cometary activity; and Activated Asteroids (AAs) have a typical asteroidal orbit and have shown dust ejections at some point. We present the monitoring of a set of these objects using archival images as well as new observations. Two techniques were used to search for signs of activity: i) the surface brightness profile of the objects was obtained and compared with the profile of field stars, in search of a widening that indicates the presence of activity; ii) data on the reported magnitudes of these objects were obtained from our observations and from the Minor Planet Center database, in search of increases in brightness that could be due to activity. We analyze the surface brightness profiles of 133 ACOs and seven AAs. For the study of the reduced magnitude, we obtained data of all the existing ACOs at the time of the analysis (705). Ten ACOs presented some deviation in the surface brightness profile or in the reduced magnitude and one in both. A very small percentage of objects showed signs of activity, which would rule out a slow transition from active to inert. Four AAs were active in the images, three were coincident with the activity periods reported by other observers. The episodes of activity of these objects are very restricted in time and do not always occur in the same region of the orbit.

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NSOS-α: The First Korean Asteroid Survey Telescope

Dr. MYUNGJIN KIM, Dr. Hong-Suh Yim, Dr. Jaemann Kyeong, Dr. Youngmin JeongAhn, Dr. Hee-Jae Lee, Dr. Hong-Kyu Moon, Dr. Dong-Goo Roh, Dr. Jung Hyun Jo, Dr. Jang-Hyun Park, Dr. Youn Kil Jung, Dr. Sungki Cho

Korea Astronomy and Space Science Institute

Abstract

As of February 2024, more than 34,000 NEAs and 2,300 PHAs have been discovered. However, the discovery of NEAs larger than 140 meter class is only 50% less than the number estimated by the population model. In addition, most observation facilities in NASA NEO program are located in the Northern hemisphere. To address these issues, we are planning to build a 1.5-meter class telescope with a five-square-degree field of view aimed at discovering NEAs in Chile. The conceptual design of the telescope has been completed by a collaboration between KASI (Korea Astronomy and Space Science Institute) and NOIRLab (National Optical-Infrared Astronomy Research Laboratory) in 2022 and we plan to have a first light image in the beginning of 2027 at the CTIO. In this presentation, the telescope overview and the observation strategies for the NSOS-α project will be addressed. We also expect that there will be a high possibility of complementary synergy with the Vera C. Rubin Observatory, previously referred to as the Large Synoptic Survey Telescope (LSST).

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Near Earth Objects Follow-up Astrometry at Klet Observatory – 30 years of experience in Central Europe

Ms. Jana Ticha[1], Dr. Michaela Honkova[2], Dr. Milos Tichy[1,3]

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Abstract

Klet Observatory was one of the first observatories worldwide involved in early rapid Near Earth Objects (NEO) confirmatory and astrometric observations, joining the effort in 1994, and continues its operation up to the present. Our aim is to present an evolution of Klet Observatory NEO astrometric programme.

We have started early NEO astrometric follow-up based on direct information from the Minor Planet Center (MPC) and from discovery observatories. In 1996 we began to use the NEO Confirmation Page operated by the MPC.

We took our first steps with a 0.57-m reflector equipped by a small CCD camera from 1994. After several years of experience we decided to rebuild Klet Observatory's larger telescope. We kept the optical elements and built in its place a 1.06-m f/2.7 KLENOT Telescope, equipped with a sophisticated CCD camera FLI 230 with 2k e2v chip and a larger FOV. We eventually improved telescope control from sidereal tracking to off-set object tracking.

Work-flow development went from mainly manual simple image processing to sophisticated methods and more automated processes including artificial flat-field. Along the way, our astrometric catalog of choice changed from GSC-II, through USNO-A2.0, USNO-B1.0, UCAC-4, to Gaia eDR2 and finally to Gaia eDR3, as the respective catalogs were issued. Observation time accuracy was improved from 1 sec in 2002 to 10 msec in 2023.

Finally – the list of notable NEOs observed contains the first dangerous object 1996 JA1, the first monitored Earth impact 2008 TC3 and also the 5th observed Earth impactor 2022 EB5.

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Early-stopping SOMs as a tool to classify SSOs in space surveys

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Abstract

Self-organizing maps (SOMs) are unsupervised machine learning techniques that reduce the dimensionality of the original dataset while preserving its topological structure. Their implementation can be represented as a transformation of n data points each with p variables as clusters of similar data on a two-dimensional map.
This approach is widely used in astronomy due to the simplicity of the algorithm and the capability of identifying unknown features emerging from the variable space. In particular, we present its implementation as a classifier of stars, Solar System Objects (SSOs) and galaxies in space surveys with large amounts of data such as TESS.
We distinguish this approach from the previous studies on the matter by including an early-stopping method. By training the neural network on an input data set and, at the same time, testing its performance on an independent, randomly chosen, control set, it is possible to minimize the risk of falling into an over-fitting state and therefore losing the genericity which is required of this algorithm.
As a number of important space surveys will begin their operations in the coming decade, adding to those launched in the last few years, an algorithm capable of swiftly handling large amounts of data and discerning SSOs from galactic or extragalactic sources will be enormously valuable, for the main scientific objectives of the surveys as well as improving our knowledge of objects in the nearest regions of the sky.

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The Surprising Spectral Diversity of Low-Albedo Asteroids

Dr. Andrew Rivkin[1], Dr. Joshua Emery[2], Dr. Ellen Howell[3], Dr. Amanda Sickafoose[4], Dr. Matthew Richardson[4]

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Abstract

The scientific importance of carbonaceous chondrites has been recognized for decades, but understanding the nature and distribution of their asteroidal parent bodies is still underway. Sample returns from Bennu and Ryugu are in the process of remaking our paradigms, and remote sensing measurements provide necessary context from observations of hundreds of objects. As we move closer to the NEO Surveyor era, we need to understand the nature of low-albedo asteroids and the diversity of compositions that they represent, including how representative Bennu and Ryugu are of the larger population.

The L-band Main-belt and Near-earth object Observing Program (LMNOP) used the IRTF to make observations of 150 low-albedo asteroids from 2—4 μm, a wavelength range diagnostic for hydrated, organic, ammoniated, and other compositions associated with volatile materials whether primordial or formed via aqueous alteration. We will present the results of this survey, including implications for links between the low-albedo asteroid and comet/KBO populations, and the completeness or incompleteness of the meteorite collection.

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The Adler alert system for Solar System transients

Prof Colin Snodgrass[1], Dr Megan Schwamb[2], Dr James Robinson[1], Dr Steph Merritt[2], Dr Cyrielle Opitom[1]

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Abstract

The Adler system will be the Solar System counterpart to Sherlock, a classifier within the Lasair alert broker that identifies what type of astrophysical transient an object is likely to be. Currently under development in Edinburgh and Belfast, the Adler system is an in-kind contribution to the Vera C. Rubin observatory project funded by the LSST:UK project. It will provide tools that anyone can use to filter the public Solar System alerts that will come from the LSST. Adler will build up photometric models for each object in order to identify unusual brightness measurements in alerts, for example due to an outburst of cometary activity or debris from a collision, and will also apply morphological classification tools to identify possible activity (e.g. tails). The set of tools will first be available for use by the community on the Rubin science platform, before being integrated into Lasair to classify alerts as they arrive. This will allow users to generate their own customised list of alerts for behaviours and objects, or classes of object, that interest them, to generate target lists for follow up observations.

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Near Jupiter Comets: Activity and Characterization in the Rubin/LSST Era

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Abstract

Much like the Earth's occasional transient asteroidal companions, Jupiter also hosts a collection of bodies temporarily in close orbital association with it. The objects which encounter Jupiter, however, are the comets and Centaurs – significantly icier bodies which occasionally show activity. They range from temporary captures like 129P/Gehrels 3 or 111P/Helin-Roman-Crockett to transient co-orbitals like P/2019 LD2 (ATLAS) and P/2023 V6 (PANSTARRS) to impactors like D/1993 F2 (Shoemaker-Levy 9). Their varied orbits are matched by their significantly varied physical states. Given their multiple source regions and extremely rapid orbital evolution of objects, relatively little can be assumed with confidence for objects discovered in this region – they could be pristine and volatile rich or evolved and thus deeply depleted in the same orbit, and back-integrations cannot always distinguish between the two scenarios. If we are to understand how cometary activity begins in the Giant Planet region, and how that compares to activity closer to the Sun, we will need to find new ways to understand this intermediate population.

In this presentation, we will discuss the current crop of candidates for characterization and how they might help us prepare for a much larger sample in the Rubin/LSST era, many of which will be too faint for traditional characterization techniques. In particular, we will highlight what kind of science can be done with Rubin alone, how new dynamical studies might significantly assist with interpreting Rubin data, and what questions about this population might require a spacecraft mission to make progress in.

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Follow-up studies of active solar system objects in the LSST era

Dr. Ian Wong[1,2], Dr. Silvia Protopapa[3], Dr. Bryan Holler[4]

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Abstract

The Legacy Survey of Space and Time (LSST) at the Rubin Observatory will define the next decade of ground-based survey science. This 10-year survey will provide complete coverage of the southern sky, producing multi-band photometric measurements for millions of small bodies throughout the Solar System. While the enormous treasure trove of data will enable wide-ranging ensemble studies of small body populations, the temporal sampling provided by the regular observing cadence will establish LSST as a powerful tool for time-domain planetary astronomy. Of particular interest will be the detection and long-term monitoring of active objects, from active asteroids and short-period comets to active Centaurs and dynamically-new Oort cloud comets. Through synergies with contemporaneous high angular resolution imaging and spectroscopy from other ground- and space-based facilities, LSST will revolutionize the study of active solar system objects, building off the legacy of other ground-based surveys, such as Pan-STARRS and ATLAS. In this talk, I will summarize the unique capabilities of LSST in the realm of activity detection and monitoring, as well as discuss important considerations that will need to be addressed, such as sparsely-sampled rotational light curves. I will also provide a broad overview of various opportunities for coordinated follow-up observations, including the multicycle Target of Opportunity programs on JWST. As a demonstration of some of the science that will be enabled by follow-up observations of active objects, I will present the results of recent JWST Cycle 2 Director's Discretionary Time observations of the distantly-active Centaur Chiron.

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A contemporary view on M-type asteroids

Ivan Slyusarev, Irina Belskaya, Vasilij Shevchenko, Yurij Krugly, Oleksiy Golubov, Ihor Kyrylenko, Alexey Sergeyev, Olga Mikhalchenko

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Abstract

M (metallic)-type was introduced in the 1970s to classify asteroids that were believed to be parent bodies of iron meteorites. This type is well-separated from other asteroid composition types by featureless visible spectra and moderate albedos. With the accumulation of observational data obtained by different techniques, it became evident that large M-type asteroids may include diverse compositions similar to some types of metal-rich chondrites, mesosiderites, and iron meteorites. New color indices and visible spectra from numerous surveys (Gaia, SDSS, SkyMapper) together with geometric albedos (WISE, Akari), make it possible to identify all M-type asteroids among smaller main-belt objects (5-30 km). Additional information on the diversity of M-asteroids was obtained from sparse photometry (Pan-STARRS, Atlas, PTF) and polarimetry. Based on the analysis of available data for about a thousand of M-type asteroids, we found possible criteria for distinguishing two main sub-groups among M-type asteroids. We will discuss the general distribution of M-type asteroids in the main belt, their membership in families and pairs, paths of transition from the main belt to the near-Earth region, and their connection to iron meteorites.

The work was supported by the National Research Foundation of Ukraine (grant N 2020.02/0371 “Metallic asteroids: search for parent bodies of iron meteorites, sources of extraterrestrial resources”).

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Ground-Based Radar Observations of Near-Earth Asteroids

Lance Benner[1], Joseph Lazio[1], Marina Brozovic[1], J. D. Giorgini[1], Shantanu Naidu[1], Joseph Jao[1], Shinji Horiuchi[2], Ed Kruzins[2], Phil Edwards[2], Edwin Peters[2], Chris Phillips[2], Jamie Stevens[2], Lawrence Snedeker[3], Emmanuel Acuna[3], Seth Truitt[3], Justin Spring[1], Ronglin Liou[1], Mark Taylor[1], Clement Lee[1], Nereida Rodriguez-Alvarez[1]

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Abstract

Ground-based radar observations of asteroids provide a powerful means for characterizing a large number of asteroids, obtaining measurements of their sizes, shapes, rotation states, surface features, satellites or binary nature, masses, and densities. The Goldstone Solar System Radar (GSSR), part of NASA's Deep Space Network (DSN), is the world's most powerful planetary radar, conducting observations of dozens of asteroids per year. Complementing the GSSR, the Southern Hemisphere Asteroid Radar Project (SHARP) transmits from antennas at the Canberra DSN Complex and receives with the Australia Telescope Compact Array.

GSSR observations provide orbit determinations, by obtaining high-precision measurements of the ranges to asteroids. GSSR observations are integral to mission planning and enable up to century-long impact risk assessments. GSSR observations of the Didymos-Dimorphos binary were crucial to the mission design for the Double Asteroid Redirect Test (DART) and they obtained the first evidence that the DART impact had altered Dimorphos' orbit. GSSR observations are being leveraged for future missions, including OSIRIS-APEX's at Apophis.

A revised design has implemented for the GSSR klystrons, the vacuum tubes that enable the 450 kW of transmit power, and a new switching system has been installed that is projected to provide transmit-receive mode switching in less than 1 s. Looking ahead, the rebuild of the GSSR transmitter is planned, which will replace infrastructure that is as much as 40 years old.

Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

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Planetary Science with the SPHEREx 0.7 – 5.0 µm Solar System Object Catalog

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Abstract

The Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx; http://spherex.caltech.edu.), is a NASA astrophysics program mission that will launch in 2025 and perform a 2-year ***all-sky*** near-infrared spectral survey. The SPHEREx spectral survey provides a remarkable opportunity to spectrally categorize hundreds of thousands of solar system objects at WISE/NEOWISE sensitivity levels in 102 spectral bands between 0.75 - 5.0µm using a single well characterized, space-based remote sensing platform.

The resulting spectra could be used for everything from discerning new families of asteroids, comets, Trojans, Centaurs, and KBOs; to characterizing brand new interstellar objects; to mapping the zodiacal light with higher spatial resolution than has ever been done previously while searching for compositional structures; and to augmenting the science return from planetary encounter With great care of converting the millions of individual SPHEREx LVF images into calibrated spectra, the resultant data will be capable of:

- Determination of the size, albedo, and ***composition*** of ~10^5 asteroids.
- Discovery of newly active asteroids.
- Characterization from 0.7-5.0µm of Interstellar Objects.
- Spectral monitoring of the weather on Uranus, Neptune, and Pluto over weeks and years.
- Discovery, detection, and characterization of 1000's of Centaurs and Comets.

Providing the planetary science community with an accurate object spectral data catalog containing ~10^5 objects with IRTF/SpeX/Prism-like data will require the work of a dedicated team familiar with the SPHEREx mission, instrument calibration, and science data pipeline, time domain astronomical observations, and big dataset archiving at the PDS and IRSA.

Session

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1906

The Solar System Notification Alert Processing System (SNAPS)

Dr. David Trilling

Northern Arizona University

Abstract

The Solar System Notification Alert Processing System (SNAPS) is a broker that is ingesting ZTF and, soon, LSST data. I will briefly describe our architecture and science goals, and some current results and challenges. I will specifically address input (ZTF and LSST data) and output (database, alert stream, web-based data portal, API) that will enable follow-up observations of interesting objects.

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Constraints on the compositional gradient of the trans-Neptunian disk with visible and near-infrared colours of Neptunian Trojans

Dr. Bryce Bolin

Goddard Space Flight Center

Abstract

Neptunian Trojans (NTs) are trans-Neptunian objects in 1:1 mean-motion resonance with Neptune and are thought to have been captured from the original trans-Neptunian disk into co-orbital resonance with the ice giant during its outward migration. It is possible, that the colour distribution of NTs tests the location of any colour transition zones between the inner and outer disk. In support of this possible test, we obtained g, r, and i-band observations of 18 NTs, finding that the NT colour distribution is statistically distinct from other trans-Neptunian objects. The observed distribution of NT colours suggests that the protoplanetary disk colour transition zone was interior to ~30 au. In addition, we present the extension of our observations to the near-infrared and discuss the implications of near-infrared obsevations on the composition of Neptunian Trojans.

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A Lunar Comet/Asteroid Spectroscopy Telescope (LCAST) – *Automated Operations*

James Bauer[1], Charles Hibbitts[2], Silvia Protopapa[3], Andy Rivkin[2]

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Abstract

Over a single year hundreds of thousands of asteroids and ~350 comets are observed by the leading groundbased telescopes[1-2] down to 19m_V. These samples lack characterization over critical infrared wavelengths that are accessible only from above Earth's atmosphere and are diagnostic of the presence of basic volatiles and characteristic spectroscopic compositional features. A more detailed inventory of the changes and behaviors these bodies undergo during their passages through perihelion may provide constraints on key observables and insights as to which attributes are acquired over time and which are a consequence of their formational circumstances.

The LCAST[3] concept is for a pair of lunar-polar telescope stations of sufficient size (~2m), to be deployed by Artemis-type missions for characterizing the compositions of small body populations. An IFU imaging spectrograph (1-5mm) would observe the accessible small body populations with planned exposures at ranked priorities according to program science.

An effective observational strategy consists of sampling a large fraction of active bodies within the SNR limits on a weekly cadence, and inactive bodies on a monthly, over the full wavelength regime. LCAST would rely upon known positions of objects, referencing IAU Minor Planet Center's database copies[4]. Automation is necessary for operations to provide detailed characterization of hundreds of comets and thousands of asteroids. We will describe such a system, the data volumes downloaded through the relays, and the numbers of objects and observing cadence within the proposed design limits.

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[4]https://sbnmpc.astro.umd.edu/MPC_database/statusDB.shtml

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1931

Characterization of analogous objects to Earth's mini-moons: the case of 1990 UQ and 2022 NX1

Xavier Inosencio[1,2], Dr. Estela Fernández-Valenzuela[1], Dr. Marin Ferrais[1], Dr. Maxime Devogèle[3]

[1]Florida Space Institute. [2]University of Central Florida. [3]ESA Near-Earth Object Coordination Centre

Abstract

Rapid NEO characterization will become an important asset once the LSST survey and NEO Surveyor are operational. Here we present a work on characterization of two NEOs. The NEO 2022 NX1 is a very interesting object due to its slow and close approaches to Earth. The last one was on June 26, 2022 at 0.00543 au (well inside the Hill radius of Earth, 0.0098 au). However, due to the nature of its orbit, it is very difficult to study and, therefore, understand its physical properties. Shortly after its last closest approach in 2022, it became visible, allowing its discovery and obtaining a spectrum with GranTeCan (de la Fuente et al., 2023). The polarimetric properties of 2022 NX1, as determined by our VLT observation in August 2022, appear similar to those of another NEO, 1990 UQ, indicating that they should share very similar albedos. Therefore, determining 1990 UQ's albedo will allow us to use it as an analog of 2022 NX1. To achieve this goal, precise knowledge of its size is necessary. In this talk, we will present a new shape model of 1990 UQ that we derived from combining archival lightcurves, new lightcurves obtained with the TRAPPIST-North and -South telescopes, and radar observations acquired at the Goldstone observatory in May 2021.

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1983

Rubin Rocks: An online tool for assessing the dynamical evolution of near-Earth asteroids in the age of LSST.

Dr. Siegfried Eggl[1], Dr. Sarah Greenstreet[2,3], Samuel Cornwall[1], Prof. Mario Juirc[3]

[1]University of Illinois at Urbana-Champaign. [2]Rubin Observatory / NSF's NOIRLab, AZ, USA.
[3]Astronomy Department and the DiRAC Institute, University of Washington, WA, USA

Abstract

Near-Earth object (NEO) orbital distribution models are the key to understanding the dynamic nature of the inner solar system, since they provide, for instance, the steady-state fraction of NEOs originating from a combination of main-belt source regions. NEO population estimates based on such models are also crucial in designing adequate planetary defense strategies. Today, there are a number of high quality models based on various NEO surveys, e.g. [1-3]. However, despite valiant efforts, information embedded within those models is not always easy to access. To remedy this situation, we are presenting a web-based API that will greatly facilitate public access to the wealth of dynamical information present in current NEO orbital distribution models. This tool is specifically geared towards researchers interested in follow-up of large scale discovery surveys such as the Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) as it allows, for instance, for a rapid classification of source regions of potentially interesting follow-up candidates as well as their most-likely dynamical fate, lifetimes, smallest perihelia, etc. In short, our web service will allow asteroid hunters to "cherry-pick" from the large number of expected NEO discoveries produced by surveys such as the LSST.

[1] S. Greenstreet, H. Ngo, and B. Gladman. *Icarus*, *217* pp. 355, doi:10.1016/j.icarus.2011.11.010, 2012.

[2] M. Granvik, A. Morbidelli, R. Jedicke, et al. *Icarus*, *312*, pp.181-207, 2018.

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1989

GRSS: An open-source tool for high precision asteroid orbit determination and orbit propagation

Rahil Makadia, Dr. Siegfried Eggl

University of Illinois at Urbana-Champaign

Abstract

With increasingly accurate astrometry becoming available from large surveys, it is more important than ever to have reliable, publicly accessible tools that can leverage such datasets to study Near-Earth Objects (NEOs). We present GRSS, the Gauss-Radau Small-body Simulator, an open-source orbit propagator and orbit determination suite. The GRSS propagator is based on the IAS15 algorithm [1]. The force model includes relativistic effects from the Einstein-Infeld-Hoffman formalization of the N-body problem and zonal harmonic forces from the Sun and the Earth. Nongravitational effects such as Solar Radiation Pressure (SRP), the Yarkovsky effect and cometary outgassing can also be modeled [3]. The GRSS library is capable of fitting asteroid orbits using optical and radar astrometry via data from the Minor Planet Center (MPC) and radar data from NASA JPL. GRSS accounts for star catalog biases. The package underwent rigorous testing against state of the art propagators such as ASSIST [2] and the small-body orbit determination code used at NASA JPL. Through its user-friendly interface and easily modifiable source code, GRSS will facilitate the characterization of hazardous NEOs, especially for follow-up observations. The package is publicly available to the scientific community via the Python Package Index (PyPI). References: [1] Rein & Spiegel (2015) MNRAS 446, 2, 1424–1437, 10.1093/mnras/stu2164 [2] Holman, Akmal, Farnocchia et al. (2023) PSJ 4, 69, 10.3847/PSJ/acc9a9 [3] Marsden, Sekanina, Yeomans (1973) AJ 78, 2, 211-225, 10.1086/111402 [4] Makadia, Chesley, Eggl et al. (2023) ACM Conference, Abstract #2128

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2041

The New Horizons Search for Targets in the Outer Solar System: Follow-up Observation Results and Future Plans

Anne Verbiscer[1], Simon Porter[2], Wesley Fraser[3], J. J. Kavelaars[3], Susan Benecchi[4], Marc Buie[2], David Gerdes[5], Takashi Ito[6], Lowell Peltier[7], Tsuyoshi Terai[6], Fumi Yoshida[8], S. Alan Stern[2], Kelsi Singer[2], Pontus Brandt[9], Joel Parker[2]

[1]University of Virginia. [2]Southwest Research Institute. [3]National Research Council of Canada. [4]Planetary Science Institute. [5]University of Michigan. [6]National Astronomical Observatory of Japan. [7]University of Victoria. [8]University of Occupational and Environmental Health. [9]Johns Hopkins University Applied Physics Laboratory

Abstract

NASA's New Horizons (NH) team continues its ground-based surveys to find targets for its LOng Range Reconnaissance Imager (LORRI) along the spacecraft's trajectory. These surveys primarily leverage the Subaru Telescope Hyper Suprime-Cam's wide field-of-view, with >250 new trans-Neptunian objects (TNOs) reported to the MPC to date, finding more TNOs between 60-80 au than predicted by the Outer Solar System Origins Survey (Fraser+ 2024). NH's Student Dust Counter also detected more dust at >50 au than models predict (Doner+ 2024). These findings motivate deeper surveys (e.g. LSST, Roman) to find additional NH/LORRI targets and possibly confirm the existence of an unknown distant TNO population. NH/LORRI already observed several of these new TNOs and will come within 1.2 au of 2020 KV11 (H~7) in 2027. From the outer solar system NH can observe TNOs at solar phase angles substantially larger than the 2 degrees accessible from Earth. These unique vantage points enable determination of TNO shapes and rotation poles, properties that inform and constrain planetesimal formation mechanisms, from rotation (light) curves acquired at high phase angles. Modeling full solar phase curves enables derivation of TNO surface microtexture and scattering properties. Should these surveys find a close flyby target, we hope to conduct ground-based stellar occultation campaigns to characterize the TNO's size and shape and refine the astrometry prior to a flyby. Any such campaigns located in Africa will welcome the participation of the African Astronomical community, mirroring those carried out in South Africa and Senegal for Arrokoth (Buie+ 2020).

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Unveiling Cometary Composition: Importance of Spectroscopic Follow-up in the Era of Large Discovery Surveys

Dr K Aravind[1], Prof Shashikiran Ganesh[2], Prof Emmanuel Jehin[3]

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Abstract

In the current era of large discovery surveys, follow-up observations of small bodies, especially comets, in the solar system are paramount for advancing our understanding of their composition and behaviour. This work focuses on the importance of spectroscopic follow-up of comets, specifically highlighting observations of comet 46P, C/2020 F3 (NEOWISE) and 2I/Borisov, along with a few other Short-period and Long-period comets.

For comet 46P, spectroscopic observations spanning 19 dates reveal significant insights into the comet's activity trend and compositional characteristics. Comparative analyses with previous apparitions elucidate highly homogenous compositional features of the cometary nucleus, shedding light on its evolutionary history.

Furthermore, our investigation of comet C/2020 F3 emphasises the effectiveness of long-slit low-resolution spectroscopy in identifying major ionic emissions in its spectrum. This novel discovery underscores the importance of spectroscopic follow-up in unveiling the diverse chemical compositions present within cometary atmospheres.

Additionally, during the visit of the first interstellar comet, while the big telescopes around the world were studying the comet’s composition, we successfully performed systematic observations of the comet and determined the heterogeneity in the cometary nucleus along with an estimate for the nucleus size, with the help of a 1m/2m class telescope.

Through these case studies, we underscore the critical role of spectroscopic follow-up in the era of large photometric surveys and detections. Spectroscopic analyses provide crucial insights into the molecular and elemental compositions of comets, offering valuable data for understanding their origins and evolutionary processes. We also highlight the complementary nature of spectroscopy alongside photometric surveys.

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Spectroscopy of primitive asteroids with the Southern African Large Telescope

Sofiia Mykhailova, Tomasz Kwiatkowski

Institute Astronomical Observatory, Faculty of Physics, Adam Mickiewicz University, Poznań, Poland

Abstract

This work is focused on observational studies of primitive asteroids, using the 10-m Southern African Large Telescope (SALT), located in Sutherland, South Africa. Understanding of these objects has been challenging because of the limit of spectral information about their surface compositions. Most compositional studies have focused on visible-near-infrared (VNIR) wavelengths, but for primitive asteroids, VNIR spectra are often featureless. Many primitive (carbonaceous) asteroids exhibit a distinct near-ultraviolet (NUV) absorption feature at wavelengths shorter than 0.5 µm. Observed spectral differences suggest possible variations in the surface composition of primitive asteroid groups, potentially related to iron content or differences in their hydration history. Moreover, laboratory studies suggest that the NUV reflectance spectra can be used to detect the presence of hydrated minerals (and hence water) and organic minerals. Spectroscopy of the NUV spectrum part can also show a link with space weathering. Detecting hydrated minerals on asteroids or space weathering effects is crucial for understanding their history and the processes that have shaped them, which becomes more important in the epoch of space missions.
During the conference we will present spectra of several primitive asteroids in the 0.32-0.9 µm range. Preliminary analysis of the NUV absorption will be done for selected B-type asteroids observed during November 2023-April 2024. Additionally, we will discuss the observational strategy, including searching for solar analogue stars in the NUV range in the southern hemisphere.

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2264

LSST follow-up with VLT/CUBES

Dr Cyrielle Opitom[1], Dr Stefano Covino[2], Dr Fiorangela La Forgia[3], Prof Colin Snodgraa[1], Dr Alessandra Migliorini[4]

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Abstract

CUBES is the forthcoming near-UV spectrograph to be installed at the VLT in 2028. CUBES will cover the 300-400nm range at high spectral resolution (R~20,000) with an efficiency much higher than currently available high-resolution spectrographs covering the near-UV. It will also offer a lower resolution mode (R~7,000) with a larger entrance slit. The combination of high spectral resolution and efficiency of CUBES will enable ground-breaking results in various fields, from extragalactic astronomy to stellar nucleosynthesis.

CUBES will be particularly interesting for the observation of solar system objects, as the gas coma of comets or the exosphere of Galilean satellites contain a large number of features in the near-UV. The LSST survey is expected to discover comets at record distances from the Sun, allowing us to study how the drivers of cometary activity change during the orbit of a comet. Because of its high sensitivity around the 310 nm OH band, CUBES will lead to advances in detecting water from fainter or more distant comets than currently possible, revealing how much ice may be hidden in the main asteroid belt or up to which distance water contributes to the activity of comets. It will also enable measurements of isotopic ratios in a much wider range of comets than currently possible, providing constraints on their formation conditions

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2551

Southern Hemisphere Asteroid Radar Program (SHARP)

Dr. Shinji Horiuchi[1], Dr. Jamie Stevens[2], Dr. Chris Phillips[2], Dr. Philip Edwards[2], Dr. Lance Benner[3], Dr. Jon Giorgini[3], Dr. Joseph Lazio[3], Ms. Isabelle Savill-Brown[4], Dr. Ed Kruzins[5], Dr. Edwin Peters[5], Dr. Guifré Molera Calves[6], Dr. Nick Stacy[7]

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Abstract

Astronomical radar observations have been used to probe surfaces of all the solid planets and many smaller bodies in the solar system. This led to a growing interest in the use of radar to characterize near-Earth asteroids (NEAs) and determine their orbits more precisely. There is a three-fold motivation for performing radar observations of asteroids. First, asteroids represent primitive remnants of the early solar system and characterization of their properties such as shape, rotation state and existence of satellites can provide insights into their evolution and parent populations. Secondly, precise knowledge of asteroid orbits is essential to assess the extent that they might represent impact hazards to the Earth, and finally, they represent targets for spacecraft. Historically, Goldstone and Arecibo planetary radar capabilities have made significant contributions to tracking many asteroids. However, their coverage has been limited to the northern hemisphere sky and consequently have missed a fraction of NEAs during Earth flybys. To fill the gap, in recent years we have developed and demonstrated a Southern Hemisphere radar capability using the Canberra Deep Space Communication Complex (CDSCC), part of the NASA Deep Space Network (DSN), as transmitters and the Australia Telescope Compact Array (ATCA) and Murriyang, the Parkes 64m Radio Telescope, as receivers. This also provides the option for observing on dates and times when Goldstone can't, which is going to be even more important during the Goldstone downtime from 2026-2027. From the start of the project in 2015 to the end of 2023, we have detected a total of 35 near-Earth asteroids.

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Near-Earth asteroid follow-up and precovery with uncertainty analysis

Dr. Dmitrii Vavilov, Dr. Daniel Hestroffer

IMCCE, Observatoire de Paris

Abstract

Follow-up or precovery of asteroids, i.e. finding new or older observations of already discovered asteroid, is important to refine their orbits, update close approach information and even assess the impact probability with the Earth. Existing approaches generally look for an observation next to the predicted position from the nominal orbit, and mostly do not take into account the full coordinates' uncertainty distribution. We developed a computationally fast technique to predict the possible spherical coordinates of near-Earth asteroids in order to associate them with observations.

The technique is a modification of the Partial Banana Mapping method. For a near-Earth asteroid a Gaussian law for the equinoctial orbital elements approximates well the uncertainty region of the object at the epoch of the observation. We sample virtual asteroids on the main line of the curved uncertainty region, project all of them onto the celestial sphere, and evaluate the asteroid's brightness. We also estimate the probability of finding the asteroid on the image, and the uncertainty region's length (which shows the quality of the orbit) in order to establish a priority list among the images. The method was tested on the case of finding asteroid (506074) Svarog imagining it was recently discovered (the orbit is obtained with only 3 months of observations). In this case we assessed the precovery probability of about 10%, but found the object close to the constructed uncertainty region. However, the nominal position is outside of the image's field of view, which makes the conventional methods to fail.

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2637

The possible contribution of telescopes in Southeastern Europe to large asteroid surveys

Dr Nataša Todorović[1], Dr Gordana Apostolovska[2], Dr Elena Vchkova Bebekovska[2], Dr Dušan Marčeta[3]

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Abstract

The discovery of new asteroids will rapidly accelerate in the forthcoming years, thanks to large sky surveys (LSST predicts the discovery of 5 million new asteroids). However, determining the rotation and shapes of millions of asteroids (which is important for the reconstruction of the Solar system evolution) will lag behind, primarily because it requires long-term observations focused on only one target asteroid. A possible solution to this discrepancy could be the synchronization of the smaller available ground-based telescopes, with the massive survey programs.

We present some results and abilities of the Astronomical station Vidojevica in Southeastern Europe, where asteroid photometry has been successfully performed in the past seven years. The site is equipped with three telescopes (the largest mirror is 1.4m) and has close to 100 observing hours each month allocated to asteroids. In addition, asteroids are regularly observed at the Rozhen and a few other observatories in Southeastern Europe. The collaboration between these observatories can provide dense data, which, in synergy with sparse photometry from large surveys, would significantly contribute to obtaining new asteroid models.

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Minor Planet Center: preparing for the increased flux of discoveries expected from LSST

Federica Spoto, Matthew Payne

Center for Astrophysics, Harvard and Smithsonian

Abstract

The Minor Planet Center (MPC) is a NASA funded project that operates at the Smithsonian Astrophysical Observatory under the auspice of the IAU and is the single worldwide location for receipt and distribution of positional measurements of minor planets, comets and outer irregular natural satellites of the major planets (https://minorplanetcenter.net/).

The observed data, orbital elements, and MPC-generated products are publicly available through a variety of web-hosted files and services, as well as via the replication of a live, postgres database that is populated as part of the processing of each submission. The use of a database-centric system is essential to provide the increased capacity and processing speeds necessary to support the data from future surveys.

In this talk we will discuss the current data volumes processed by the MPC as well as the forecast data volumes from the upcoming Vera Rubin LSST survey and the NEO Surveyor mission.

We will then present the latest MPC developments designed to support these missions. Those include, but are not limited to (i) improving our processing pipelines, including the NEO Confirmation Page; (ii) improving the usability of our observation and orbit database tables; (iii) making our website more user friendly and improving our communication system.

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DePhOCUS: a Statistics-based Correction Scheme for astro-Photometric Observations

Tobias Hoffmann[1,2], Marco Micheli[2], Juan L. Cano[2], Davide Farnocchia[3], Peter Vereš[4], Petr Pravec[5], Björn Poppe[1]

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Abstract

The photometry of optical observations of asteroids received and distributed by the Minor Planet Center (MPC), also known as astro-photometric observations, often serve as the only available basis for the derivation of physical properties such as the absolute magnitude, which is a proxy to infer the size of the observed object, and its albedo with thermal observations. Magnitude information is acquired in different color bands, with respect to a reference star catalogs, and from different observatory sites. In order to combine measurements, photometry using different bands need to be converted to a common band (typically V-band). Current band correction scheme in use by MPC, JPL and ESA's NEO Coordination Centre use average correction values for the apparent magnitude derived from photometry of asteroids. By analyzing the photometric residuals of asteroids, we refine the previous correction scheme and additionally debiasing the observations based on their catalog and observatory. We describe a new statistical photometry correction scheme for asteroid observations with debiased corrections. Testing this scheme on a reference group of asteroids, we see a 51% reduction in the photometric residuals. Moreover, the new scheme leads to a more accurate and debiased determination of the H-G model and, in turn, leading to a more reliable inferred size, which is highly needed for asteroid population models. We discuss the significant shift in the corrections with this "DePhOCUS" debiasing system, its limitations, and the impact for photometric and physical properties of all asteroids, especially near-Earth objects.

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Robotic NEO follow-up observation pipeline based on open-source software

Tobias Hoffmann[1,2], Matti Gehlen[1], Gerhard Drolshagen[1], Thorsten Plaggenborg[3], Jutta Kunz[4], Toni Santana-Ros[5,6], Michał Żołnowski[7], Björn Poppe[1]

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Abstract

Observing Small Bodies in the Solar System is a crucial task in astronomy with many follow-up observations often necessary to refine orbit determination. Near-Earth Objects (NEOs), which have the potential to impact Earth, are of particular importance here. Telescopes with apertures ranging from 1 m to approximately 25 cm, also commonly operated by amateur observatories, are utilized for these follow-up observations.

The forthcoming NEO discovery surveys, facilitated by large-scale telescopes such as the Vera C. Rubin Observatory, NASA's NEO surveyor space mission, and ESA's Flyeye telescope, are expected to significantly increase the number of NEO discoveries. Consequently, a greater number of telescopes will be required at various locations for follow-up observations. However, observation planning, scheduling, and analysis remain significant challenges for many observers.

To address these challenges, we propose a fully robotic planning, scheduling, and observation pipeline that extends the widely-used open-source software, KStars/Ekos, designed for Instrument Neutral Distributed Interface (INDI) devices. This pipeline incorporates algorithms that automatically select high priority NEO candidates. It analyzes detectable objects at the given location and calculates and schedules optimal observing slots during the night. The pipeline recalculates the accurate position of the minor body just before measurement with the most recent data at the Minor Planet Center. We provide a comprehensive description of the pipeline's components and present a complete robotic hardware and software solution based on our methodology.

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The astorb database at Lowell Observatory: Enabling Science in the Era of Big Data

Dr Nicholas Moskovitz, Brian Burt, Robert Schottland, Lawrence Wasserman

Lowell Observatory

Abstract

With next generation surveys like LSST and NEO Surveyor, the volume of minor planet discoveries and physical characterization data will increase dramatically. Tools will be needed to help prioritize follow-up observations and to enable science investigations across different types of physical properties. The astorb database and associated website at asteroid.lowell.edu are being developed to serve these needs. astorb is an actively curated catalog that reflects the current census of minor planets in the Solar System with associated orbital and physical properties. Historically, astorb has focused on asteroids; work is ongoing to add comets to the data system. As new objects are discovered and added to the database, computed dynamical properties (e.g. planetary MOIDs, Tisserand parameter, delta-v for NEOs) and observational circumstances (e.g. trends in magnitude and ephemeris error) provide a means to prioritize objects for follow-up studies.

Included in the curation of astorb data are physical properties such as albedo and spectral type. These added data are compiled across many sources and provide one of the most comprehensive collections of asteroid physical properties in the world. Having both orbital and physical properties in a single database enables a variety of complex queries. An online query builder available through the project website (and via API) allows users to construct custom queries across many parameters, including conditions of upcoming observability to facilitate planning for follow-up observing programs. These features will continue to be developed and supported as future large-scale surveys begin.

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Photometric monitoring of near-Earth asteroids

Dr Yurij Krugly[1], Irina Belskaya[1], Oleksiy Golubov[1], Ihor Kyrylenko[1], Ivan Slyusarev[1], Vasilij Shevchenko[1], Raguli Inasaridze[2], Vova Ayvazian[2], Zahari Donchev[3], Tanyu Bonev[3], Kamoliddin Ergashev[4], Otabek Burkhonov[4], Shuhrat Ehgamberdiev[4], Vladimir Kouprianov[5], Joshua Haislip[5], Dan Reichart[5]

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Abstract

The ground-based optical telescopic observations of hazardous near-Earth asteroids (NEAs) remain the primary tool for accumulating data on physical properties of these asteroids. We carry out photometric observations of NEAs using telescopes located in a wide range of longitudes and latitudes: 0.6 and 2-m telescopes at Rozhen Observatory (Bulgaria), 0.7-m at Abastumani (Georgia), 0.6 and 1.5-m at Maidanak (Uzbekistan), and 0.4 and 0.8-m at CTIO (Chile). The observations are aimed at determining absolute magnitudes, color indices, rotation periods, albedos, composite types, sizes and shapes, and finding binary systems. These data will be used to compute densities of observed binary and bi-lobate asteroids as well as of bodies with known Yarkovsky effects. The orbital evolution of these observed asteroids will be modeled to recover the places of their origin and their possible dynamical connections with other asteroids. More than 40 NEAs were observed for obtaining lightcurves during more than 150 nights in 2023. Among them: 6 newly discovered NEAs; 29 potentially hazardous asteroids; 15 small asteroids with diameters below ~ 300 m (H > 20); 5 known binaries and 3 suspected ones; 6 contact binary candidates; the asteroids with detected YORP effect (1862 Apollo and 105140 2000 NL10) and suitable for detection of the YORP effect (184990 2006 KE89, 495615 2015 PQ291 and others). We will present determined physical properties for the observed NEAs.

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Assessing the scale of meteoroids entering the atmosphere based on well-known impacts

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Abstract

Everyday, the Earth's atmosphere is the barrier which protects us from numerous cosmic objects. Large meteoroids can be detected before entry, however, most objects are too small to be observed prior to their atmospheric impact. Thus, their interaction with the air particles gives us information of their physical properties.

To better estimate the size of the newly discovered Earth impactors, in this research we examine the multi-sensor data of several well-know meteoroids, with reconstructed trajectories, most of which have also left meteorites on the ground. By examining their data, we found that the luminosity was the most common measured property of the event. Thus, we have established a new relation between the emitted light and the kinetic energy of the object. This, along with the trajectory data, translates into the pre-entry mass and size.

This result aids in the cross-calibration of multiple mass estimation techniques, which are not limited to cameras, enhancing our understanding of the size and frequency of the minor body population.

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Prioritizing and Coordinating NEO Follow-up with NEOfixer in the Era of Large Discovery Surveys

Alex Gibbs[1,2], Carson Fuls[1,2]

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Abstract

Timely follow-up observations of near-Earth objects (NEOs) are critical to planetary defense and mitigation efforts since they reduce orbital uncertainty and allow predictions far into the future. With large new surveys coming online soon, the quantity of objects requiring follow-up observations is expected to grow enormously, while follow-up observing resources remain mostly unchanged. Because of this, we have developed NEOfixer to automate NEO target recommendations and coordination between follow-up observers.

Target recommendations are based on planetary defense priorities and customized for each user's specific telescope system. Coordination is achieved by adjusting recommendations based on the activity of other follow-up stations. NEOfixer provides a way to ensure that NEOs are neither under observed, by recommending targets most in need of observations, nor over observed, by downgrading reported targets of other stations. In other words, it will help make the most of limited follow-up resources in the era of large discovery surveys.

NEOfixer is already used by follow-up telescopes around the world to determine the most important and useful NEO observations they can make. We will present more details about how NEOfixer determines its recommendations and give a brief tutorial on how to start using NEOfixer. Finally, we will show the effect of incorporating NEOfixer recommendations at our site, I52, the most productive follow-up station in the world.

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Rapid detection and characterization of active small solar system bodies in the LSST era

Dr Henry Hsieh

Planetary Science Institute; Academia Sinica Institute of Astronomy & Astrophysics

Abstract

Our understanding of active small bodies in the solar system has advanced dramatically in the last few decades, thanks in large part to wide-field surveys such as Pan-STARRS, ATLAS, and the Catalina Sky Survey. These surveys dominate new active object discoveries at the present time, and have also enabled activity to be discovered at systematically fainter levels and greater distances than before. Rubin Observatory's Legacy Survey of Space and Time (LSST) expects to push activity detection limits to far fainter levels than current surveys, potentially increasing the rate of active object detection by an order of magnitude or more. This is of course extremely exciting from a scientific perspective, but also brings additional challenges in areas such as effective and efficient detection and confirmation of activity in unprecedentedly large data sets, pressure on follow-up facilities, and mechanisms for community notification and coordination to make the most efficient use of limited resources. I will discuss the opportunities presented by the expected deluge of active object discoveries, the challenges that will need to be addressed in order to take full advantage of those opportunities, current and planned efforts to address those challenges, and special considerations related to follow-up observations specific to active bodies.

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Enhancing LSST Solar System Discoveries: The Critical Role of 10-m Class Telescope Follow-ups

Dr Javier Licandro

Instituto de Astrofísica de Canarias, Tenerife, Spain

Abstract

The LSST is set to revolutionize our understanding of the Solar System by providing extensive catalogs of small bodies, encompassing near-Earth objects (NEOs), main belt asteroids (MBAs), Jovian Trojans, and trans-Neptunian objects (TNOs). With projected discoveries including approximately 100,000 NEOs, 5 million MBAs, 300,000 Jovian Trojans, and 20,000 TNOs, LSST will offer an unprecedented increase in the known populations of these celestial objects. Additionally, it will discover lots of events with short lifetimes that will need to be observed rapidly: impacts on Giant Planets; activity in main belt objects, Centaurs, etc.; collisions in the asteroid belts; interstellar objects like Oumuamua and Borisov; meter-size NEAs in impact trajectories with Earth; etc.

However, the sheer volume and faintness of LSST discoveries necessitate follow-up observations with 10-m class telescopes to fully characterize these bodies and unravel the complexities of the Solar System's evolutionary narrative. Such telescopes are pivotal for obtaining low-resolution visible and near-infrared spectra, and high-spatial-resolution and/or high-SNR images to derive broad-band colors, rotational properties and shape, and detecting binaries and activity indicators like outbursts or outgassing, providing nuanced insights into the composition and dynamic processes shaping these objects.

This review emphasizes the synergistic role of 10-m class telescopes in the LSST era, highlighting their indispensable contribution to time-domain science, especially for transient or ephemeral phenomena, including impacts with Giant Planets, unusual activities in main belt asteroids and Centaurs, the potential discovery of new populations of Solar System objects and interstellar objects like Oumuamua and Borisov.

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Fast-reaction follow-up and global networks of telescopes.

Dr Elisabetta Dotto

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Abstract

The Near-Earth Object (NEO) population provides crucial information on the origin and early evolution of the solar system as well as on the processes that governed the delivery of water and prebiotic material to our planet.

Furthermore, NEOs represent a well-known threat and even small-sized (tens/hundreds of metres in diameter) objects deserve our attention, as they have the highest statistical likelihood of actually impacting the Earth. However, such small asteroids become bright enough to be physically characterised from Earth only for very limited time spans, coinciding with close approaches with our planet, whereupon they could become unobservable for years or even for decades. Rapid-response physical observations of these bodies are hence necessary to keep up with the present trend of NEO discoveries toward small size objects.

Linking up NEO discovery, astrometric follow-up and physical characterization is therefore needed to improve our knowledge of the physical nature of small NEOs as well as to properly address NEO impact monitoring and mitigation. This can be achieved through a coordinated approach ensuring quick reaction time, guaranteed access to medium to large-aperture telescopes and the development of efficient methods for dynamical and physical characterization. The next step is to identify innovative scientific, technical and operational developments toward managing a global network of telescopes for rapid response.

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Dawning of a New Era: Understanding Ices in the Solar System with the James Webb Space Telescope

Noemi Pinilla-Alonso[1], Will Grundy[2], Heidi Hammel[3], Dan Hines[4], Bryan Holler[4], Jonathan I Lunine[5], Stefanie Milam[6], Yvonne Pendleton[7], John Stansberry[4,2,8], Ian Wong[6,9]

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Abstract

The trans-Neptunian objects (TNOs), along with the Oort cloud comets and the icy moons of the giant planets, constitute the primary reservoirs of ices in the Solar System. Decades of ground- and space-based observations of comets, as well as spacecraft exploration, have unveiled a myriad of molecular species (Mumma & Charnley 2011, Bockelée-Morvan & Biever 2017, Lippi et al.2021). At the same time, ices play a pivotal role as carriers of volatiles in protoplanetary disks, crucial for understanding the chemistry that ultimately dictates the organic composition of planets. Disk snowlines are pivotal in shaping the compositions of Solar System planets, moons, and small bodies (Bergin et al., 2015). The distribution of CHONS ices during the planetary formation in protoplanetary disks leaves a footprint in the composition of ice bodies. However, despite being a focal point of interest since the discovery of Albion in 1992, ices had remained elusive for decades, but not anymore!.

We are embarking on a new era in the study of ices in the Solar System, exoplanets, and disks, thanks to the advanced instrumentation aboard the James Webb Space Telescope. In this presentation, I will discuss some of the initial findings from various Webb observing programs ranging from small, red, cold classical bodies akin to Arrokoth, to the large dwarf planets, Eris, Makemake, and Pluto, ice giants with a warm heart. Hopefully, this presentation will catalyze discussions on how compositional characterization of small bodies in the NIR could naturally follow the discoveries in the forthcoming era of large surveys.

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Summary of the ESO-LSST workshop in Garching

Colin Snodgrass

Affiliation

Abstract

Summary of the ESO-LSST workshop in Garching

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Final category: FM 4 Bridging the final stages of massive stars to supernovae and transients

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Interacting Winds and Giant Eruptions in Massive Binaries

Prof. Amit Kashi

Ariel University

Abstract

Massive stars eject strong winds that affect their evolution. When in a binary system, their winds collide and emit radiation across the spectrum, providing an opportunity to study the stars and the interaction between them. There are many physical effects involved in the colliding wind problem, and its complexity requires 3D numerical simulations. I will present simulations of colliding winds in massive binary systems that include a detailed treatment of wind ejection, orbital motion, clumpiness, and other effects. These simulations are applied to different kinds of massive binaries, including LBV-WR, WR-WR, WR-O, and O-O systems. I will also showcase new simulations of accretion in a B[e]SG system, where both the companion and the primary star accrete material, and discuss the effect it has on shaping the outer ejecta. I will discuss the results of systematic simulations that were used to determine the general conditions that may lead to accretion onto the star with the weaker wind, and demonstrate new relationships between the mass accretion rate and the ratio of the stellar wind momentum and the Bondi–Hoyle–Lyttleton accretion rate. Additionally, I will present simulations of mass ejection during giant eruptions in LBVs, including interactions and accretion onto the companion star, and discuss the implications for the formation scenario of LBVs.

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DUST PROPERTIES AROUND ASYMPTOTIC GIANT BRANCH STARS: IRAS 20263+4245 UNDER IRIS, AKARI AND WISE SURVEY

DUST PROPERTIES AROUND ASYMPTOTIC GIANT BRANCH STARS: IRAS 20263+4245 UNDER IRIS, AKARI AND WISE SURVEY Lochan, Devendra Raj Khanal, Upadhyay

Tribhuvan University Amrit Campus. Government of Nepal

Abstract

DUST PROPERTIES AROUND ASYMPTOTIC GIANT BRANCH STARS: IRAS 20263+4245 UNDER IRIS, AKARI AND WISE SURVEY

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This work present the physical properties of dust across the far infrared cavity candidate region around an AGB star namely IRAS 20263+4245 was located at a distance 3038.60 pc. Physical properties have been studied at 60 μm and 100 μm in IRAS, 90 μm and 140 μm in AKARI and 12 μm and 22 μm in WISE survey. Presents work show the distribution of flux density, dust color temperature, dust mass, Planck's function, visual extinction and spectral distributions around the cavity.
The dust color temperature is found to be in the range of 23.92 ± 0.92 K to 28.46 ± 0.92 K using IRIS data, 13.91 ± 0.53 K to 19.74 ± 0.53 K using AKARI data and 305.15± 4.37 K to 327.26 ± 4.37 K using WISE data. The average value of dust mass and Planck's function using IRIS AKARI and WISE data. The average value of visual extinction using IRIS, AKARI and WISE data are found to be 1.69 $\times 10^{-11}$ mag, 1.12 $\times 10^{-10}$ mag and 5.06 $\times 10^{-11}$ mag.

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A Decade of Supernova Impostor Outbursts in NGC 4559

Dr Mojgan Aghakhanloo

University of Virginia

Abstract

We present the first photometric analysis of AT 2016blu, a supernova (SN) impostor discovered by the Lick Observatory Supernova Search in 2012. Optical and infrared photometry reveals that AT 2016blu experienced at least 19 outbursts from 2012 to 2022, characterized by irregular variability and multiple closely spaced peaks. We find that AT 2016blu's outbursts repeat approximately every 113 days. We propose these outbursts are driven by the interaction between two stars at periastron in an eccentric binary system, where the primary star is a massive luminous blue variable (LBV). The strength of periastron interaction between two stars may vary depending on the state of the LBV around the time of the periastron passage. If the LBV is in a quiescent state, characterized by a small stellar radius and low mass-loss rate, the interaction with its companion during periastron may be relatively weak. However, stronger interactions are expected when the LBV is in its outburst state with an inflated radius and/or higher mass-loss rate. The AT 2016blu's outbursts resemble the peaks of η Carinae leading up to its 19th-century Great Eruption, or the brief repeating peaks of SN 2009ip before its SN explosion. SN 2009ip provides the most direct link between SNe IIn and LBVs, challenging the current stellar evolution models. This similarity and the onset of eruptions in the past decade hint that AT 2016blu may also be headed for a catastrophe, making it a target of great interest.

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Runaway star candidates in the Magellanic Clouds: From Gaia Dr3 proper motions

Dr. Yikdem Mengesha Gebrehiwot[1], Dr. Gebregiorgis Abraha Fikade[1], Dr. Solomon Belay Tesema[2]

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Abstract

The Magellanic Clouds are on the virtue of merging with the Milky Way. As a result of the tidal interaction between the Milky Way and the Magellanic Clouds, numerous stars are scaping from their original associations. We investigated the relative proper motions of OB and AF spectral type stars from the 30 Dor region of LMC with respect to the field stars and the central cluster R 136. We imposed 10 acmin radiuses around each target star to identify the field stars and used different selection methods like parallax, color magnitude diagram and PM cuts, to minimize the foreground contamination of the field stars. By subtracting the mean PM of the filtered field stars from the PMs of the target stars, we calculated the relative PM of our target stars. From the relative PMs of the target stars and the distance to 30 Dor, we estimated the relative tangential velocities of our target stars. The relative PMs range is (0.11 +/- 0.16mas/yr < \mu_f < 0.36 +/- 0.27 mas/yr) for OB the spectral types and (0.16 +/- 1.08 mas/yr < \mu_f < 3.92 +/- 2.08 mas/yr) for the AF spectral types, which correspond to tangential velocity range of (27.73 +/-28.29 km/s < V_T < 88.58 +/- 36.13 km/s) for the OB spectral types and (37.48 +/- 256.78 km/s < V_T < 920.58 +/- 492.97 km/s) for the AF spectral types respectively. All except four stars are runaway star candidates and we also identified runaway star candidates from R136. We suggested possible runaway scenario for some of the runaways.

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Illuminating Our Universe with Gamma-ray Bursts

Dr. Nicole Lloyd-Ronning

Los Alamos National Lab

Abstract

The most luminous objects in our universe, gamma-ray bursts, can spectacularly outshine millions of galaxies while they are active. The emission from these objects - brightest in gamma-rays but covering the entire electromagnetic spectrum - is believed to come from dissipation processes in a relativistic jet, launched by a highly spinning black hole-accretion disk system left over after a cataclysmic event associated with stellar collapse or the merger of two compact objects. There are a number of fascinating and surprising mysteries that remain in understanding the progenitors of (and physics behind) these brilliant events. In this talk, we present a multi-code effort to model gamma-ray bursts across many scales in length and time. We will describe recent progress in unveiling the physical processes that power these extreme objects, from the launch of the relativistic jet, to the microphysics of the dissipation processes, to new exciting results on their circumstellar environments and progenitor systems. Finally, we will show how different intrinsic properties of these systems evolve as a function of redshift, and how we can use them to learn about massive stellar evolution over cosmic time.

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Collapsing self-gravitating massive stars and their EM transients

prof. Agnieszka Janiuk[1], dr Narjes Shahamat[2], Ms Dominika Król[3]

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Abstract

We investigate the fate of a collapsing stellar core, which is the final state of evolution of a massive, rotating star. Such stars explode as type I b/c supernovae, which have been observed in association with long gamma ray bursts. The core of the star is potentially forming a black hole, embedded in a dense, rotating, and possibly highly magnetized envelope. We study the process of collapse using General Relativistic MHD simulations, and we account for self-gravity, for the growth of black hole mass and its spin, as well as related evolution of the spacetime metric. We find that particular configurations of the initial black hole spin, the content of angular momentum in the stellar core, and the magnetic field, are favored for producing a bright electromagnetic transient. On the other hand, most of the typical configurations studied in our models do not lead to electromagnetic transient and will end up in a direct collapse, accompanied by some residual variability induced by changing accretion rate.
We also study the role of self-gravity in the stellar core and quantify the relative strength of the interfacial instabilities, such as Self-Gravity Interfacial and Rayleigh-Taylor instability, which may account for the production of an inhomogeneous structure, including spikes and bubbles, through the inner radii of the collapsing core (inside $\sim$ 200 rg). We find
that in self-gravitating collapsars the RT modes cannot grow efficiently. We also conclude that transonic shocks are formed in the collapsing envelope, but they are weaker in magnetized stars.

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Simulation-Based Inference of BNS Kilonova Properties: A Case Study with AT2017gfo

M.Sc. Phelipe Darc, Dr. Clecio R De Bom

Centro Brasileiro De Pesquisas Físicas

Abstract

Kilonovae are a class of astronomical transients observed as counterparts to mergers of compact binary systems, such as a binary neutron star (BNS) or black hole-neutron star (BHNS) inspirals. They serve as probes for heavy-element nucleosynthesis in astrophysical environments, while together with gravitational wave emission constraining the distance to the merger itself, they can place constraints on the Hubble constant. Obtaining the physical parameters (e.g. ejecta mass, velocity, composition) of a kilonova from observations is a complex inverse problem, usually tackled by sampling-based inference methods such as Markov-chain Monte Carlo (MCMC) or nested sampling techniques. These methods often rely on computing approximate likelihoods, since a full simulation of compact object mergers involve expensive computations such as integrals, the calculation of likelihood of the observed data given parameters can become intractable, rendering the likelihood-based inference approaches inapplicable. We propose here to use Simulation-based Inference (SBI) techniques to infer the physical parameters of BNS kilonovae from their spectra, using simulations produced with *KilonovaNet*. Our model uses Amortized Neural Posterior Estimation (ANPE) together with an embedding neural network to accurately predict posterior distributions from simulated spectra. We further test our model with real observations from AT 2017gfo, the only kilonova with multi-messenger data, and show that our estimates agree with previous likelihood-based approaches.

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DeepSTEP: A Deep learning tool for identification of Astrophysical Transients and artifacts from Images in S-PLUS Transient Extension Program (STEP)

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Centro Brasileiro De Pesquisas Físicas

Abstract

Transients are astronomical objects with variable luminosity, such as supernovae, kilonovae, among others. Identifying these transients in the sky is historically done by trained astronomers using visual inspection, facilitated by the use of image differentiation algorithms. These algorithms subtract from an image containing a transient candidate (search) and a previously captured image (template), searching for areas of concentrated flux that could indicate the presence of a transient. Most transient candidates for a given observation night are in fact false positives, the difference imaging process produces various types of artifacts. The most common example of an artifact is known as a “Bad Subtraction”. In this work, in order to reduce the number of Candidates that require visual inspections and speed up the Transient Detection process on S-PLUS Transient Extension Program (STEP) pipeline, we propose the use of a Convolutional Neural Network (CNN) to classify the images as Transients or Artifacts (Non-Transients). Our dataset consists of real transient candidates detected by our pipeline. The images produced by our transient detection pipeline are created using four channels (g, r, i, z) and each channel is observed with three different exposure times, resulting in a total of 12 different

images for each transient candidate observation. The CNN, named DeepSTEP, reduced the amount of Artifacts by 96.9% and maintained a true positive rate of 92.7%. This means that only 3.1% of the images classified as transient were actual Artifacts, demonstrating the ability of our model to filter the artifacts without losing transients.

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Using interferometry to model the effect of winds on atmospheric layers of red supergiants

Dr. Gemma Gonzalez-Tora

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Abstract

Red supergiants (RSGs) are evolved massive stars in a stage preceding core-collapse supernova. Understanding evolved-phases of these cool stars is key to understanding the cosmic matter cycle of our Universe, since they enrich the cosmos with newly formed elements. However, the physical processes that trigger mass loss in their atmospheres are still not fully understood, and remain one of the key questions in stellar astrophysics. In this talk, we propose a new method to study the extended atmospheres of these cold stars, reproducing the effect of a stellar wind to a well known stellar atmospheric model (MARCS). We then can compute the intensities, spectral energy distributions and visibilities matching the observations for the different instruments in the Very Large Telescope Interferometer (VLTI). Specifically, I will discuss the robustness of our results when comparing with brand new VLTI/MATISSE and GRAVITY data of the RSGs AH Sco, KW Sgr, V602 Car, CK Car and V460 Car. We find that our model can accurately match these observations comprising a large wavelength range of 1.8-5.0 µm, showing the enormous potential of this methodology to reproduce extended atmospheres of RSGs. This work is one of the first and most complete spectro-interferometrical studies of RSGs to date.

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Combined efforts: 1D vs multi-dimensional atmospheric model comparison for O and WR stars

Dr. Gemma Gonzalez-Tora

Astrophysical Reseach Institute, University of Heidelberg

Abstract

Massive stars (8>Msun) come in different colors and flavours. While hot O-stars have not yet left the main sequence stage, WR have already depleted their hydrogen and have become stripped He stars, presenting strong-broad emission lines. Regardless of their evolutionary stage, all massive stars present strong winds that can affect their evolution and death. Modelling stellar atmospheres with winds can be challenging due to their highly turbulent, inhomogeneous and time-dependent atmospheres. Current models that use simplified 1D, spherically symmetric and stationary approaches are boradly used due to their relatively low computational cost, but can greatly differ from more realistic multi-dimensional, radiation hydrodynamical (RHD) simulations. In this work, we compare both 1D and multi-dimensional modelling approaches on a combined effort to understand the shortcomings and strengths on the state of the art atmospheric modelling for hot massive stars.

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Binary progenitor systems for Type Ic supernovae

Martin Solar, Michał Michałowski

Adam Mickiewicz University

Abstract

Core-collapse supernovae (SNe) mark the death of massive stars (> 8 Msun), being one of the most important mechanisms that produce heavy elements and halt the star formation in the interstellar medium, so they have a profound impact on galaxy evolution. Details of these processes depend on SN progenitors, however, it is unclear if Type Ic SNe (without hydrogen and helium lines in spectra) originate from the core-collapse of very massive stars or from less massive in binary systems.
In order to constrain the respective progenitor lifetimes and initial masses, we study the molecular gas environments using high-resolution ALMA CO(2-1) observations, being the first statistically significant study of Type II and Ic SNe at scales comparable to giant molecular clouds.
We show that Type II and Type Ic SNe are located in environments with similar molecular densities.This implies that their progenitors have comparable lifetimes, and therefore, equivalent initial masses. Our results support a binary model for most Type Ic SN progenitors, arguing that the stripping of outer layers (lack of hydrogen and helium) is due to the interaction with a companion star.

This finding can be used to compute the SN metal production, and be implemented in sub-grid processes in order to improve the feedback and chemical mixing in numerical cosmological simulations.

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Transients and Fast Radio Bursts in simultaneous optical-radio data

Miss Kira Hanmer[1,2], Professor Paul Groot[1,3,4], Professor Benjamin Stappers[5]

[1]University of Cape Town. [2]South African Radio Astronomy Observatory. [3]Radboud University. [4]South African Astronomical Observatory. [5]University of Manchester

Abstract

As of September 2022, MeerLICHT syncs with MeerKAT and observes the same part of the sky simultaneously, weather-permitting. This means we get a simultaneous optical-radio view of the night sky. We are utilizing this link between the two telescopes to search for an optical counterpart to fast radio bursts (FRBs),in the hopes of narrowing down the possible causes of FRBs. We are also looking at other transients in simultaneous optical-radio data. We look through MeerLICHT transient candidates that were detected while syncing was taking place, and we then look at the corresponding MeerKAT data to see if we can find variability for those objects in the radio too. For the FRBs, when MeerKAT detects a new FRB at night, we check to see whether MeerLICHT was synced with MeerKAT at the time of the FRB. I will present the results that we have so far for both aspects of this simultaneous optical-radio work.

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CHARACTERISATION OF CORNISH-SOUTH ULTRACOMPACT HII-REGIONS SAMPLE USING THE MeerKAT

Mr. Calvince Juma

Technical University of Kenya

Abstract

Ultra-compact HII regions (UCHIIs) are dense, ionized areas that surround massive protostars. They form when UV radiation from these protostars ionizes nearby neutral hydrogen gas. UCHIIs are crucial to understanding massive star formation as they represent its earliest stages. However, studying them is challenging due to their short lifetimes, rarity, and large distances. Massive protostars are born in dusty environments, leading to high extinctions caused by dust grains. This makes it difficult to observe the protostars and their surroundings in optical and infrared wavelengths. Radio observations, which are less affected by dust extinction, can partially overcome this limitation. UCHIIs are particularly useful in studying massive star formation because they emit strong radio continuum radiation due to the presence of free electrons within the ionized gas. This allows their detection even at large distances by radio telescopes. This study used radio data from the MeerKAT (1.3GHz) and CORNISH-South (5.5 GHz) surveys to analyze Ultra-Compact HII (UCHII) regions. The lower frequencies of the MeerKAT survey allowed for the study of these regions with minimal interference from dust extinction. The radio spectral indices (α) of 79 UCHII samples were estimated. It was found that 91% of these sources had α values between -0.1 and 2 (between 1.3 GHz and 5.5 GHz), indicating thermal emission. The remaining 9% had α values less than -0.1, suggesting non-thermal emission. However, after further investigation, it was found that this could be due to the MeerKAT observation's higher sensitivity to extended emission compared to the CORNISH observation.

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Nucleosynthesis of Magnetorotational Supernova with Three-dimensional Explosion Models

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Abstract

Magnetorotational supernova is a promising scenario for hypernovae and long gamma-ray bursts, and it presents an intriguing astrophysical site for the synthesis of elements beyond iron. We present results of nucleosynthesis of magnetorotational supernovae based on state-of-the-art three-dimensional explosion models. In our magnetorotational supernova models, the strong magnetic fields tap the rotational energy of the protoneutron star and lead to earlier and more energetic (~3 foe) explosions than the typical neutrino-driven supernova. Compared to the reference non-magnetic model, the ejecta in the magnetic models have neutron-rich components with electron fractions down to ~0.25. Our post-processing nucleosynthesis calculations show that the magnetic models can produce significant weak r-process elements up to mass number~130. We find negligible differences in the synthesis of heavy elements between the magnetic models with initial field strength of 10^{10} and 10^{12} G, in accord with their similar explosion dynamics. The magnetic models produce about ~0.1-0.2 radioactive nickel, on the low end of hypernovae. The yields are publicly available for comparison with stellar abundance patterns and inclusion in modeling galactic chemical evolution.

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Probing supernova remnant VRO 42.05.01's progenitor properties with IRAM 30m observations

Maria Arias

Leiden Observatory

Abstract

VRO 42.05.01 is a supernova remnant whose unusual shell/wing morphology has been the subject of speculation throughout the decades, and been typically attributed to an ambient density discontinuity. We performed millimetre observations with the IRAM 30m telescope and mapped the molecular gas surrounding the remnant, with the aim of understanding the dense material's role in determining the shape of the source. We unexpectedly found evidence of the mass-loss history of the progenitor star before the explosion imprinted on the molecular material: sweeps in velocity space, and shocked gas with different characteristics (in terms of excitation ratios and velocity spreads) than those outlining the region of interaction between the supernova blast wave and the molecular gas. The regions of molecular cloud/stellar wind interactions are consistent with an equatorially enhanced wind. We propose that the star's pre-supernova properties, rather than the ambient medium, are responsible for its unusual morphology. This work showcases a new method to probe the properties of a supernova remnant progenitor via its imprint on the ambient dense ISM.

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Violent material ejection of a dying massive star inferred in SN 2023ixf

Prof Jujia Zhang

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Abstract

Type II supernovae (SN II), the Universe's most frequent stellar explosions, hold the key to understanding the formation of neutron stars and black holes and the volatile and mass-loss histories of massive stars. The initial light signals emitted by these explosions, known as flash spectra, offer vital clues to connecting SN II blasts with the later stages of massive stellar evolution.

The recent SN 2023ixf explosion in the nearby Messier 101 galaxy presents a unique opportunity to delve into this enduring mystery. By capturing middle-resolution spectra within 1-2 days of the explosion, we have imposed tight limits on the characteristics of the supernova's surrounding circumstellar material.

Considering the elevated mass-loss rate, significant wind velocities, and pre-explosion observations spanning two decades, evidence suggests that SN 2023ixf's progenitor may have been a briefly lived yellow hypergiant, transitioning from a red supergiant phase shortly before detonation.

Ongoing observations and inquiries into SN 2023ixf promise to establish it as a pivotal event in the chronicle of SNe II, ultimately illuminating the destiny of massive stars weighing 10 to 20 solar masses.

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The Supernova of the decade 2023ixf: progenitor properties from decades of observations

Monika Soraisam[1], Tamás Szalai[2,3], Schuyler Van Dyk[4], Jennifer Andrews[1], Sundar Srinivasan[5], Sang-Hyun Chun[6], Thomas Matheson[7], Peter Scicluna[8], Diego Vasquez-Torres[5]

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Abstract

Thanks to the wealth of archival data gathered by space- and ground-based facilities, the progenitor candidate of SN 2023ixf has been pinned down and found to be a red supergiant star. Infrared data spanning almost two decades have revealed the distinct variability of this object prior to its explosion. In this talk, I will present our results characterizing this variability, which is semi-regular over the final years before the progenitor's core collapse---the first time that such variability has been directly observed for any SN progenitor. We attribute the observed variability to pulsation, which is a typical occurrence for red supergiant stars. I will discuss the progenitor's stellar parameters that we infer from its pulsation properties. In particular, we derive a pulsation period of more than 1000 days, which implies a luminosity greater than 100,000 times that of the sun and an initial mass of around 20 solar masses, making it one of the most massive progenitors of Type II supernovae ever detected.

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Exploring the Red Supergiant wind kink. A Universal mass-loss concept for massive stars

Prof Jorick Vink, Dr Gautham Sabhahit

Armagh Observatory and Planetarium

Abstract

Red supergiants (RSG) are key objects in studying the evolution of massive stars and their endpoints, but uncertainties related to their underlying mass-loss mechanism have stood in the way of an appropriate framework for massive star evolution thus far. In this work, we analyse a recently uncovered empirical mass-loss "kink" feature and we highlight its similarity to hot star radiation-driven wind models and observations at the optically thin-to-thick transition point. We motivate a new RSG mass-loss prescription that depends on the Eddington factor, Γ, (including both a steep luminosity, L, dependence and an inverse steep mass, M_{cur}, dependence). We subsequently implement this new RSG mass-loss prescription in the stellar evolution code MESA. We find that our physically motivated mass-loss behaviour naturally reproduces the Humphreys-Davidson limit without the need for any ad hoc tweaks. It also resolves the RSG supernova "problem". We argue that a universal behaviour that is seen for radiation-driven winds across the HR diagram, independent of the exact source of opacity, is a key feature of the evolution of the most massive stars.

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Magnetorotational supernovae, violation of mirror symmetry and neutron stars kicks.

Dr Sergey Moiseenko, Ilya Kondartiev, Prof. Gennady Bisnovatyi-Kogan

Space Research Institute of the Russian academy of Sciences, Moscow, Russia

Abstract

We consider magnetorotational(MR) supernova explosion mechanism in the case of the magnetic field mirror symmetry violation. When initial magnetic field configuration consists of dipole+quadrupole or dipole with symmetrical initial toroidal field (quadrupole with initial antisymmetrical toroidal field) or offset dipole the MR explosion will be asymmetrical. The asymmetry of the MR supernova explosion leads to the kick of the forming neutron star. Results of our numerical simulations show the kick velocity of the neutron star could be up to 400-500km/s.

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Eruptive novae in symbiotic systems

Irin Babu Vathachira[1], Yael Hillman[2,3], Amit Kashi[1,4]

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Abstract

In this talk, I will present simulation studies undertaken to investigate how variations in white dwarf (WD) mass and binary separation affect the evolution of systems leading to nova eruptions. These simulations were performed for symbiotic systems hosting an asymptotic giant branch (AGB) undergoing mass loss via wind, where a portion of the wind is captured by the WD. The accretion rate onto the WD's surface was determined using the Bondi-Hoyle-Lyttleton (BHL) method, while incorporating orbital momentum loss caused by gravitational radiation, magnetic braking, and drag. Simulations spanned the evolution of systems producing consecutive nova eruptions until the AGB companion shed its envelope. The study covered a range of initial WD masses and binary separations, considering wind accretion from a 1.0 $M_\odot$ AGB companion over approximately 3×10^5 years. We find the accretion rate to increase and decrease throughout evolution correlated with the wind rate that is dominated by the AGB's thermal pulses. We additionally find the accretion rate to be correlated with the mass of the WD and with the binary separation of the system. Moreover, our results show that the orbital period may either increase or decrease during evolution, depending on the model, while the separation consistently decreases. Some eruptions exhibited weak non-ejective novae with WDs undergoing net mass gain, suggesting that a more massive WD, maintaining efficient accretion over time, could potentially serve as a type Ia supernova progenitor.

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Evolution and Final Fate of Solar Metallicity Stars in the Mass Range 7–15 Me. I. The Transition from Asymptotic Giant Branch to Super-AGB Stars, Electron Capture, and Core-collapse Supernova Progenitors

Dr Marco Limongi[1,2,3], Dr Alessandro Chieffi[4,5], Dr Lorenzo Roberti[6,7]

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Abstract

According to a standard initial mass function, stars in the range 7–12 M_e constitute ~50% (by number) of the stars more massive than ~7 M_e, but in spite of this, their evolutionary properties, and in particular their final fate, are still scarcely studied. In this paper, we present a detailed study of the evolutionary properties of solar metallicity nonrotating stars in the range 7–15 M_e, from the pre-main-sequence phase up to the presupernova stage or an advanced stage of the thermally pulsing phase, depending on the initial mass. We find that (1) the 7.00 Me star develops a degenerate CO core and evolves as a classical asymptotic giant branch (AGB) star in the sense that it does not ignite the C-burning reactions, (2) stars with initial mass M>=9.22 M_e end their lives as core-collapse supernovae, (3) stars in the range 7.50<=M/M_e <=9.20 develop a degenerate ONeMg core and evolve through the thermally pulsing super-AGB phase, (4) stars in the mass range 7.50<= M/$M_{e<=}$8.00 end their lives as hybrid CO/ONeMg or ONeMg WDs, and (5) stars with initial mass in the range 8.50<=M/Me <=9.20 may potentially explode as electron-capture supernovae.

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Heterogeneous Type II supernovae with short plateaus arising from low-mass RSG progenitors

Rishabh Singh Teja

Indian Institute of Astrophysics

Abstract

Massive stars heavier than 8 M⊙ terminate their lives as core-collapse supernovae (CCSNe). Depending on their mass, composition, environment and evolution history, they could lead to various sub-types of core-collapse supernovae. The most observed subtype of CCSNe is the Hydrogen-dominated Type II SN with a typical ∼100-day luminosity plateau observed in their light curve evolution. Within these extensively studied SNe sub-types, a handful has been observed to show a plateau duration shorter than typical ~ 100 days with varied luminosities. The origin of these short plateau type II SNe is widely debated with no consensus. In some recent modelling works, it is shown that they emerge from massive Red Super Giant (RSG) (>20 M⊙) progenitors, owing to higher mass loss. However, there is no substantial observational evidence supporting this. We present results on a few of these short plateau SNe, namely, 2018gj, 2020jfo, 2021wvw, and 2023ixf. The detailed hydrodynamical modelling and other observational signatures point towards an alternate progenitor channel. With the available small sample of well-studied short-plateau Type II supernovae, it appears that the low-mass RSG could be the most preferred progenitor of these events.

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Properties of the common GRBs of the Swift & Fermi catalogs

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Abstract

We conducted a statistical analysis on observational data from the Fermi GBM and Swift BAT satellites, spanning a 15-year period. Our investigation focused on comparing various parameters of gamma-ray bursts (GRBs), such as T90 duration, peak flux, and fluence, observed by either one or both satellites. For cases where both satellites observed a GRB, we directly compared parameter values using distinct statistical methods. Additionally, we fitted the T90 distributions of GBM and BAT data using a linear combination of lognormal functions. Our analysis revealed that two lognormal functions suffice for the GBM data, while three are needed for BAT. Contrary to prevailing beliefs, the number of lognormal functions required for fitting GRB duration distributions does not provide conclusive evidence regarding the number of central engine types responsible for GRBs.

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Massive Algols as whetstones for the progenitors of stripped-envelope supernovae and gravitational wave sources

Koushik Sen[1], Norbert Langer[2], Daniel Pauli[3], Goetz Gräfener[2], Abel Schootemeijer[2], Hugues Sana[4], Tomer Shenar[5], Laurent Mahy[6], Chen Wang[7]

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Abstract

All except one mass transfer episode in the isolated binary evolution channel occur at short timescales and, hence, are difficult to observe. This leads to many unconstrained assumptions in modelling mass transfer phases. The uncertainties percolate through our understanding of progenitors of stripped-envelope supernovae and gravitational wave mergers. As the only exception, the nuclear-timescale so-called 'slow Case A' mass transfer phase in short-period binaries has many Algol binaries as observational counterparts. Since a thermal timescale mass transfer precedes the slow Case A phase, in-situ constraints on stellar and binary physics assumptions, such as mass transfer efficiency, tidal strength and internal mixing, can be obtained through population synthesis studies of massive Algols. I will discuss the current state-of-the-art modelling and observations of these binaries and our identification of a novel outcome from this binary evolution channel, namely the 'reverse Algols'. We identified semi-detached binaries where the more massive star transfers mass to a less massive companion on a nuclear timescale. We also found that binary stripping can form Wolf-Rayet binaries on the main sequence with identified observational counterparts. Our population synthesis results predict ~5% of massive binaries (30-90 Msun) in the main sequence from the reverse Algol channel. We derived the predicted distribution of orbital periods, mass ratios, rotational velocities, and surface abundances of these binaries using a grid of ~100,000 detailed binary evolution models at a metallicity suitable for the Large Magellanic Cloud.

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An interaction creates an enriched nebula around a massive magnetic binary system

Dr Abigail Frost[1], Prof. Hugues Sana[2], Dr Laurent Mahy[3], Prof Gregg Wade[4], James Barron[5,4], Dr Jean-Baptiste Le Bouquin[6], Dr Antoine Mérand[1], Dr Fabian Schneider[7,8], Dr Tomer Shenar[9], Dr Dominic Bowman[10], Matthias Fabry[2], Dr Amin Farhang[11], Dr Pablo Marchant[2], Dr Nia Morrell[12], Dr Jonathan Smoker[1]

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Abstract

Understanding the effects of the interactions of stars in multiple systems is critical if we wish to understand the fates of massive stars, 90% of which are expected to exist in at least a binary system and 70% of which are expected to interact over their lifetime (Sana+ 2012). In this talk I will focus on massive stellar interactions as a catalyst for enrichment of their surroundings. I will present the case of the binary system HD 148937, a binary system consisting of two massive stars. This O-star binary system is a rarity amongst its class, displaying magnetism and harbouring a extended, complex bipolar nebula (Lim+ 2024) enriched with CNO process elements (Mahy+ 2017). Through a near-decade-long monitoring of the system with infrared interferometry and spectroscopy our team we constrain the orbit of the system in addition to the physical and atmospheric properties of its individual stars. We find that one star in the system appears significantly different to its companion despite their almost identical brightnesses - the primary star alone is magnetic and when placed on a Hertzsprung-Russell diagram appears ~1.5Myr younger than it's companion. Comparing of our results with hydrodynamical models, we determine that this star must have been formed through a merger and the surrounding nebula was also likely created during this event. Thus, the interactions of massive stars not only have the ability to affect their own fates through mass and rotation changes, but can also enrich their surroundings with the material of stellar interiors.

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Numerical Experiment of mass loss and mass accretion mechanics in Massive stars.

Miss Bhawna Mukhija, Dr. Amit Kashi

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Abstract

The evolution and characteristics of massive stars are significantly influenced by mass loss and mass accretion, through the stellar winds, accretion disks, and binary interactions. These mechanisms have a notable impact on the stellar envelope as they approach the main sequence, leading to substantial changes in their structure. I use numerical simulations to investigate how massive stars react to eruptive mass loss and accretion of material and analyze the resulting changes in their evolutionary track, energy transport, and internal structure.

In the talk I will present simulation results that show how mass loss leads to a decrease in luminosity in the evolutionary track, causing the star to become hotter and contract. This is not a monotonic process and includes several stages. I will also discuss simulations of accretion that lead to an increase in luminosity and radial expansion of the star toward cooler temperatures. A discrepancy exists between high and low accretion rates: for low accretion rates the star remains hot, whereas higher accretion rates lead to the cooling of the star.

For each simulation, I monitor the star's progression into the recovery phase as well. I will show a comparison of normal evolution without mass loss and accretion to evolution where either process takes place.

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MeerKAT-Based Multi-Wavelength Study of Supernova Remnant SN386 (G7.7-3.7)

Mr Patrick N. Mwaniki[1], Prof. James O. Chibueze[2], Dr. Dismas S. Wamalwa[1]

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Abstract

The supernova remnant SN386 (G7.7-3.7) presents a captivating subject for multi-wavelength observation. In this study, we investigated the structural characteristics of G7.7-3.7 at 1284 MHz, revealing intricate details of its morphology and emission mechanisms.

Our MeerKAT observations revealed G7.7-3.7 as an almost circular structure with filamentary features, manifesting in various regions. The western boundary exhibits a strong bright blowout, while the southern perimeter showcases extended bright filaments with feather-like structures, seemingly disconnected from the western blowout. Moreover, the eastern region presents a faint blowout with a centralized bright point source, while faint elongated filaments traverse the northwest, linking the eastern point source and the western blowout. Spectral index analysis indicates a steep spectrum, suggesting a synchrotron emission.

Furthermore, our multi-wavelength investigation unveils an intriguing enigma within the southern radio-bright blowout. This blowout exhibits a convergence of features, including a radio-bright blowout, a prominent X-ray arc, and two faint optical filaments aligned with the X-ray bright arc. We attribute the bright radio blowouts to weakened magnetic fields and heightened particle density in the blowout. Also, the supernova of G7.7-3.7 occurred in an environment of varying densities of the interstellar medium (ISM). Consequently, this environment facilitates X-ray emission and the formation of faint optical filaments due to collisions with the ISM.

Our findings shed light on the complex interplay of physical processes within G7.7-3.7, offering valuable insights into the dynamics and evolution of supernova remnants.

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Hot star winds

Dr. Andreas Sander

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Abstract

The properties, impact, and fate of hot stars cannot be understood without considering their winds. Revealed to be an almost ubiquitous phenomenon in the regime of massive stars, the winds hot stars arise vom a complex physical mechanism that still provides a major challenge for our understanding of massive stars. Different flavors of hot stars vary significantly in their winds with current evolution models still having problems to connect the zoo of observed phenomena. Moreover, the driving of hot star winds is inherently connected to the opacities arising from spectral line transitions, making the properties and strength of the winds strongly dependent on metallicity and changing them over cosmic time.

In this invited talk, I will review the current status in our understanding of hot star winds. Ranging from the observed spectral imprints to the theoretical efforts to predict their properties, I will present recent progress in our perception of hot star winds and the consequences for the evolution of massive stars. A particular emphasis will be given on current efforts and challenges towards a more realistic description of the radiatively-driven mass loss of Wolf-Rayet stars with the help of dynamically-consistent atmosphere models.

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Study of the fastest classical nova, V1674 Her: photoionization and morpho-kinemetic model analysis

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Abstract

We present the results of the investigation of the nova V1674 Her (2021), recognized as the swiftest classical nova, with t_2 ~ 0.90 d. The distance to the nova is estimated to be 4.97 kpc. The mass and radius of the WD are calculated to be ~1.36 $M_\odot$ and ~0.15 $R_\oplus$, respectively. Ov er the course of 1 month following the outburst, V1674 Her traversed distinct phases – pre-maxima, early decline, nebular, and coronal – displaying a remarkably swift transformation. The nebular lines emerged on day 10 making it the classical nova with the earliest observed commencement to date. We modelled the observed optical spectrum using the photoionization code CLOUDY . From the best-fitting model we deduced different physical and chemical parameters associated with the system. The temperature and luminosity of the central ionizing sources are found in the range of 1.99-2.34 × 10^5 K and 1.26–3.16 × 10^{38} erg s^{-1} , respectively. Elements such as He , O , N , and Ne are found to be overabundant compared to solar abundance in both the nebular and coronal phases. According to the model, Fe II abundance diminishes while Ne abundance increases, potentially elucidating the rare hybrid transition between Fe and He/N nova classes. The ejected mass across all epochs spanned from 3.42 to 7.04 × 10^{-5} $M_\odot$. Morpho-kinematic modelling utilizing SHAPE revealed that the nova V1674 Her possesses a bipolar structure with an equatorial ring at the centre and an inclination angle of i = 67 ± 1.5°.

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The features of interaction-powered supernovae explored by binary population synthesis

Mr. Takatoshi Ko

The University of Tokyo

Abstract

Several supernovae are brighter than normal supernovae due to interactions between the supernova ejecta and the surrounding dense circumstellar matter, displaying narrow emission lines. Type IIn supernovae feature narrow hydrogen lines, while Type Ibn and Icn show narrow helium and carbon lines, respectively. The dense circumstellar material around these stars is thought to have been formed by the massive mass ejection of the progenitor just before the explosion, but various scenarios have been proposed and are still under discussion. The mass-loss scenarios can be divided into two types: the single-star evolution scenario, in which a massive star loses the mass by itself, and the binary evolution scenario, in which a massive star interacts with a companion star to eject its mass. However, the progenitors of Type Ibn and Icn supernovae are compact and gravitationally constrained, and it is known that it is difficult to induce a large-scale mass loss by single-star evolution due to lack of energy, so the binary evolution scenario is preferred. In this study, we consider that Type Ibn and Icn supernova explosions are caused by the binary evolution of a massive star and a compact object, perform a population synthesis calculation of these supernovae, and compare their ratios with those obtained from observations. Then we also constrain the mass-loss of the progenitors of such supernovae and the evolution channels of such supernovae.

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Multi-wavelength and multi-messenger signatures of early-time particle acceleration in the remarkable core-collapse supernova SN 2023ixf

Matthieu Renaud[1,2], Fabio Acero[3], Pierre Cristofari[4], Justine Devin[1], Alexandre Marcowith[1], Vikram Dwarkadas[5]

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Abstract

Among the Supernova Remnants (SNRs) detected in gamma-rays, no indisputable evidence for the presence of PeV cosmic-ray (CR) particles being accelerated at their shock fronts has been found yet. It has then been suggested that these highest-energy CRs could actually be produced when the SN shock propagates at high velocity into a dense circumstellar medium (CSM) formed by the stellar progenitor wind, during the first weeks after the explosion. In such very young core-collapse Supernovae (cc-SNe), several multi-wavelength and multi-messenger signatures should then arise from the hadronic interactions: gamma-ray emission, high-energy neutrinos, and synchrotron emission from secondary particles. The remarkable cc-SN event SN 2023ixf in the nearby galaxy M101 at 6.8 Mpc, with the presence of a confined and dense CSM during the very early stages post-explosion, allows one to derive meaningful constraints on this paradigm. From a phenomenological modeling of particle acceleration, while accounting for the properties derived on the stellar progenitor and on the SN hydrodynamics, we will present the expected non-thermal emission from SN 2023ixf and confront it to the wealth of multi-wavelength and multi-messenger data, and discuss the general implications in terms of CR production in young cc-SNe.

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Dust Emission and Mass Loss from Evolved Stars in NGC 147 and NGC 185 Galaxies

Hamidreza Mahani[1], Atefeh Javadi[1], Roya Hamedani Golshan[2], Jacco Th. van Loon[3], Iain McDonald[4], Habib Khosroshahi[1,5], Hedieh Abdollahi[1], Mahdi Abdollahi[1]

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Abstract

NGC 147 and NGC 185, two of the most massive satellites of the Andromeda galaxy, exhibit similar mass and morphological characteristics but differ in their star formation histories (SFH) and interstellar gas content. By studying long period variables (LPV) and pulsating asymptotic giant branch (AGB) stars, which are excellent indicators of dust production, we have quantified and compared mass loss and dust production rates in NGC 147 and NGC 185 galaxies. Our results reveal a correlation between increasing luminosity, pulsation strength, intrinsic reddening of stars due to the self-extension, and heightened mass loss rates. Notably, the total mass return-rate of LPVs for NGC 185 is 1.3×10^{-4} $M_{\odot}yr^{-1}$,while NGC 147 exhibits a lower mass loss rate of 8.9×10^{-5} $M_{\odot}yr^{-1}$. The two-dimensional dust mapping of NGC 185 and NGC 147 reveals distinct spatial distributions of LPVs. In NGC 185, LPVs are predominantly concentrated in the central region, yet their dust production rate is notably lower than the current star formation rate of the galaxy, estimated at 0.005 $M_{\odot}yr^{-1}$. This suggests that additional gas required for ongoing star formation processes may be sourced from the mass loss of AGB stars or supernova events. Conversely, LPVs in NGC 147 are also observed in the outer regions of the galaxy. The lower gas production in NGC 147, coupled with potential tidal interactions with the Andromeda galaxy and the effect of M31's gaseous halo through ram pressure, may account for the lack of interstellar medium observed in NGC 147.

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3D hydrodynamic simulations of white dwarf-main-sequence star collisions.

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Abstract

Recently inaugurated telescopes, such as the MeerKAT radio telescope and the upcoming Rubin Observatory Legacy Survey of Space and Time (RO-LSST), will be able to detect millions of transient events in the night sky. Stellar collisions resulting in exotic objects, e.g., CK Vulpeculae, may be detectable among such transients, giving us an opportunity to investigate the different characteristics and parameter space for a broader combination of stars and environments. Simulations will play a key role in providing models that can be used by machine learning algorithms to more accurately classify transients events and suggest interesting targets for follow-up. In this talk, I will present 3D simulations of white dwarf-main-sequence star collisions using smoothed-particle hydrodynamics (SPH), coupled with a 34-isotope nuclear reaction network. I will present results for a broad parameter space and discuss the collision dynamics, energetics, mass-loss properties, and post-collision gas morphology that can be expected from these types of interactions within globular clusters and wide-field triples. Utilizing our simplified nuclear network, suggestions can be made towards the isotopic signatures that may be the key in distinguishing these collisions from other energetic transients.

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The Final Fates of Hydrogen-Rich Stars Around the PI Boundary

Mr Ethan Winch[1,2], Prof Jorick Vink[1], Dr Erin Higgins[1], Dr Gautham Sabhahit[1]

[1]Armagh Observatory and Planetarium. [2]Queen's University Belfast

Abstract

For decades, the detection of a Pair-Instability Supernova (PISN) has been observationally elusive, despite robust theoretical predictions of their existence in a specific mass range – the PI Gap. Previously it was theorised that this gap would exclusively exist above a certain mass (~ 50 M_{sol}) regardless of stellar evolution parameter inputs. However, with recent gravitational wave observations showing black hole masses within this gap, this has been questioned. We present a series of results showcasing Hydrogen-rich stellar evolution models using the software tool MESA where we systematically vary several stellar parameters such as initial mass, metallicity, and rotation, to build a theoretical prediction for the mass range above which stars are expected to go pair unstable.

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Looking into the world of interacting supernovae

Mrs Anjasha Gangopadhyay

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Abstract

The final evolution of massive stars leading to a supernova (SN) explosion, in particular the mass-loss mechanism, is an important open problem in astrophysics which generates a dense circumstellar medium (CSM) around the SN. Interacting SNe are characterized by the interaction between the SN ejecta and dense CSM, providing a key probe to the mass-loss history of the progenitor stars. The nature of the interacting SN progenitors is indeed highly debated, ranging from Luminous blue variable stars (LBV) to Wolf-Rayet (WR) stars. The interacting SNe form an interesting sequence in terms of the amount of the mass ejected before the SN; SNe IIn (H-rich CSM), SNe Ibn (He-rich CSM), and SNe Icn (C/O-rich CSM). Since some of the proposed mass-loss mechanism should be highly asymmetric (e.g., a binary interaction forming a “disk”), the CSM geometry also plays a very important role but this topic has rarely been investigated. The (heterogeneous) nature of the CSM (density, spatial extend, geometry, and so on) manifest itself to the observational signatures in the SN light curves and spectral profiles. In this talk, I will present a brief overview of the past history and recent trends of these SNe (photometrically, spectroscopically) and their relation to mass-loss mechanism through multi-wavelength studies. The talk will also discuss about the other groups of SNe which become interacting on a longer time scale. Thus, by connecting the new insight for different subclasses, I aim to discuss the nature of the mass-loss mechanism that can explain all the findings.

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Unravelling the asphericities in the explosion and multi-faceted circumstellar matter of SN 2023ixf

Dr Avinash Singh[1], Mr Rishabh Teja[2], Dr Takashi Moriya[3]

[1]Stockholm University, Sweden. [2]Indian Institute of Astrophysics, Bengaluru, India. [3]National Astronomical Observatory of Japan, Tokyo, Japan

Abstract

We present a detailed investigation of photometric, spectroscopic, and polarimetric observations of the Type II supernova SN2023ixf. The early detection of highly-ionized ``flash'' spectroscopic features, coupled with the blueward shift in colours and temperature, provides compelling evidence for a delayed shock breakout within a dense circumstellar matter (CSM). The temporal evolution of polarization SN2023ixf until the early nebular phase revealed three distinct peaks in polarization evolution, indicating an asymmetric dense CSM, an aspherical shock front, and/or clumpiness in the low-density extended CSM, and an aspherical inner He-core. The argument for an aspherical shock front is further strengthened by the presence of dual broad absorption features in the blue wing of the Balmer features in the spectral sequence post 16 d. Hydrodynamical light curve modelling indicated a progenitor mass of 10 solar-mass with a radius of 470 solar-radius and explosion energy of 2 foe, along with 0.06 solar-mass of 56-Ni. The early UV excess was derived from a confined dense CSM extending up to 5e14cm, with a mass-loss rate of 1e-2 solar-mass per year assuming a standard RSG wind of 10 km/s. In addition, SN2023ixf showed evidence of a late-plateau UV excess arising from an extended CSM spanning 5e14 - 1e16 cm with a mass-loss rate of 1e-4 solar-mass per year. The early nebular phase observations suggest an early onset of molecular CO formation in SNe II indicated by flattening in the Ks-band light curve and the attenuation of the red-ward emission of Halpha post 125 days

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Resolved spectroscopic binaries orbital and stellar parameters distributions.

Mr Dugasa Belay[1], Prof. Oleg Yu. Malkov[2], Dr. Seblu Humne Negu[1], Dr. Solomon Belay Tessema[1]

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[2]Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia

Abstract

Abstract

Resolved spectroscopic binaries (RSB) are double-lined spectroscopic binaries, visually resolved,usually with speckle or interferometric techniques. Published visual observations and radialvelocities allow a simultaneous usage and adjustment of both data sets for such systems. Besidesorbital parameters derived from visual and spectroscopic observations, RSB provide hypothesis-free orbital parallaxes and masses of both components, and, consequently, RSB are an invaluablesource of data in stellar astronomy. In this paper, we selected 40 resolved spectroscopic binaries from different sources. Then, we determined the missed orbital and stellar parameters for 40 resolved spectroscopic binaries selected from different sources. We conducted a statistical analysis of resolved spectroscopic binaries and developed the distribution of orbital and stellar parameters. Also, we instigated the numerical solutions for orbital and stellar parameters such as: radius, effective temperature, luminosity and orbital angular momentum.

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Roaring to softly whispering: late-time X-ray follow-up of the luminous FBOT AT2018cow

Dr Giulia Migliori

INAF-IRA

Abstract

In view of its proximity (d~60 Mpc), AT2018cow is the best studied Fast and Blue Optical Transient (FBOT), a class of transients characterized by luminosities and time scales that challenge traditional supernovae models. Its proximity (d~60 Mpc) enabled the most extensive FBOT multi-wavelength study to date, with observations in radio-mm, infrared, optical-UV, and, among few others dubbed luminous FBOTs (LFBOTs), soft-and-hard X-rays.

Here we report on X-ray observations sampling up to more than 3 years from its discovery, a pristine portion of the observational phase space of LFBOTs, which revealed the presence of a luminous, persistent, soft X-ray source of emission at the location of the transient. Modeling the soft X-ray emission in the context of the late-time panchromatic observations of AT2018cow, we find that either sub-Eddington accretion on an intermedate mass black hole (IMBH) or the manifestation of ~Eddington-like accretion processes on a lower-mass accretor are plausible scenarios. Most importantly, independently from the BH mass, our work provides support to the hypothesis that LFBOTs are accretion-powered transients, indirectly supporting the picture where the early, luminous and short-lived UV-optical emission of LFBOTs possibly originates at least in part from (partial) reprocessing of the high-energy X-rays by outflows launched by the super-Eddington accretion disk. If confirmed, LFBOTs would qualify as new laboratories of super-Eddington accretion physics.

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The complex circumstellar environment of supernova 2023ixf

Erez Arie Zimmerman, Ido Irani, Avishay Gal-Yam

Weizmann Institute of science

Abstract

Observing SNe shortly after they explode is key to probing their progenitor properties, the physics governing the late stages of the progenitor star existence, and the physics behind the explosion shock-breakout. As SNe are hot in their early stages, UV observations are critical to resolve these properties. In this talk, I will present early HST UV spectroscopy of the Messier 101 SN 2023ixf, the "Supernova of the decade". This first-of-its-kind spectral sequence of a SN showing narrow flash-ionization features resolves the early SN SED and extended shock-breakout, the physics of the CSM narrow line formation, and the distribution of metals in the SN immediate environment. Combining these data with other messengers, such as X-ray observations, we fully map the distribution of CSM around the SN progenitor system.

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Red supergiant mass loss and evolution

Dr Emma Beasor

University of Arizona

Abstract

dummy abstract

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Numerical Simulations of Silicon Shell Burning in Massive Stars

Dr Zsolt Keszthelyi, Prof Tomoya Takiwaki, Dr Koh Takahashi

National Astronomical Observatory of Japan

Abstract

The detection of neutrinos originating from SN1987A provided evidence that supports the neutrino heating mechanism to explain core-collapse supernovae. However, the seed instabilities leading to a neutrino-driven explosion remain unclear, with recent efforts aiming to explore convectively unstable layers in advanced burning stages of massive star evolution. To this end, we conduct numerical experiments to study silicon (Si) shell burning in supernova progenitors. First, we compute a base grid of one-dimensional stellar evolution models with various initial masses (9 - 30 Msun) and rotational velocities (0 - 150 km s^-1). We then select suitable progenitor models and map them into a multidimensional magnetohydrodynamic code. We study the impact of stellar rotation and magnetism in the Si shell. Our findings indicate strong mixing in three-dimensional simulations with complex flow patterns and convective entrainment. Based on the central temperature and central density evolution, we identify one-dimensional progenitor models that might potentially lead to electron-capture supernovae. In the future, we will also perform multidimensional simulations to study such cases.

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Estimating Eruptive Mass Loss in Massive Stars with MESA

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Abstract

Eruptive mass loss in massive stars has been observed but is not yet well understood. It is thought that episodes of eruptive mass loss are due to opacity peaks in the upper envelope of evolved massive stars that may cause the star to locally exceed the Eddington limit. Previous work in the literature either involve scaling formulae based on empirical mass loss rates rather than physical motivation or informative but computationally costly 3D simulations. We present estimated upper limits of eruptive mass loss rates derived from 1D MESA models for stars with masses between 10-100 solar masses at solar and SMC metallicities. Our model applies a physically-motivated energy argument to the envelope of massive stars to estimate eruptive mass loss by locating regions where the energy associated with locally super-Eddington luminosity exceeded the binding energy of the overlaying envelope. We find that, at a 10% model efficiency, eruptive mass loss of up to ~10^{-2} solar masses/year is driven by the Helium opacity peak and occurs in a vertical band on the HR diagram between 3.5 K < T_{eff} < 4.0 K. This predicted eruptive mass loss prevents stars of initial masses >20 solar masses from evolving to become red supergiants, offering a possible explanation for observations.

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Light Curve Modeling for Rapidly Evolving Transients Powered by Continuous Outflow

Mr. Kohki Uno, Professor Keiichi Maeda

Kyoto University

Abstract

Thanks to new-generation surveys, the number of discoveries of rapidly-evolving transients is dramatically increasing. In particular, Fast Blue Optical Transients (FBOTs), represented by AT2018cow, are a growing new population. FBOTs are observationally characterized by high luminosity and short-timescale evolution, but their mechanisms are yet to be clarified. We, here, propose a wind-driven model for FBOTs, which is a new framework to model observational properties of transients that are powered by continuous outflow from a central system, and apply the model to AT2018cow and other well-observed FBOTs. This model can explain their photometric properties which are not reproduced by a supernova-like instantaneous explosion. Furthermore, the model also predicts characteristic spectral features and evolution, especially for AT2018cow. The model shows that the peculiar features of AT2018cow and FBOTs are characterized by the large mass-loss rates ($\sim 20M_{\odot}{\rm ~yr^{-1}}$ and the characteristic radii of $\sim 10^{13}{\rm ~cm}$ for the launch of the wind. It would indicate that FBOTs may be related to events involving a red super giant (RSG), in which the RSG envelope is rapidly ejected by an event at a stellar core scale, and their central engine of FBOTs may be related to a relativistic object, e.g., a black hole. We then suggest that AT2018cow and FBOTs may be either a tidal disruption event of a low-mass RSG by a black hole (BH), or a BH-forming failed supernova.

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Getting all our Messengers in a row: Red supergiants and Multi-messenger efforts to prepare for the next Galactic Supernova

sarah healy[1], Shunsaku Horiuchi[1], Danny Milisavljevic[2]

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Abstract

Red Supergiants (RSGs), as the classical progenitors of core-collapse, are important for the development of stellar evolution theory. Galactic RSGs even more so as the progenitors of what is likely to be the next event where we can measure EM waves, gravitational waves, and neutrinos, giving us the most complete depiction of the explosion from the internal mechanisms via neutrinos to the structures of the surrounding material via EM waves. The era of big data provides new avenues to overcome the barriers that have limited previous Galactic RSG searches. Using Gaia parameters and all-sky survey catalogs, we developed a method that incorporates machine learning to both distinguish cool SGs from other bright late-type stars and to classify them. We tailored the resulting catalog to resolve objects through their evolution along the RSG branch and their transition off, including assessing our ability to take advantage of the inherent warning signal from the neutrino burst of supernovae. To maximize the future science potential of the next Galactic supernova, we increased the number of known Galactic RSGs, determined based on current and future detectors how completely we can observe each case, and with SNEWS's coincidence network, are preparing to provide directional information to the science community.

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Variability of Massive Stars in Open Clusters and Beyond

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

We present some results of long-term photometric monitoring of a number of star clusters carried out under the international Uzbek-Indian research project. The extensive photometric time series of 15 galactic open clusters were obtained during 3 years in 2021-2023. In addition to new data set, the time series were also obtained for 7 clusters in 2003. The complex analysis, together with the available data obtained by *TESS* mission, made it possible to discover a significant number of new variable stars and check the few known variables in these clusters. The extensive observational data we obtained from the project has a sufficiently high accuracy, range of magnitudes and cadence, which also allows us to search for variability phenomena on massive stars (greater than several solar masses). Along with monitoring of clusters, we also conducted 4-5 hour continuous (patrol) observations of each of 14 individual selected magnetic cataclysmic variables (MCVs) in different regions of the sky. In addition to monitoring clusters and MCVs, continuous (about 4 months) monitoring of the 2021 outburst of recurrent Nova RS Oph was also carried out. The resulting observational database and the current results of its analysis in combination with *TESS* and other data is discussed. In particular, the variables 1RXS J174320.1-042953 and YY Sex have been proven to be magnetic polars. Further careful processing and in-depth analysis of this material is currently ongoing together with our Indian partners.

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Pan-Chromatic Observations of Short Duration Transients

Dr. Walid Majid, Dr. Michael Shao, Dr. Daniel Hoppe, Dr. Russell Trahan, Dr. Robert Preston, Dr. Charles Naudet, Mr. Barzia Tehrani

Jet Propulsion Laboratory, California Institute of Technology

Abstract

Fast Radio Bursts (FRBs) are bright, milli-second duration transient radio pulses of unknown origin. Since their discovery in 2007, FRBs have been shown to have extragalactic origins and enormous energy outputs in the radio band alone. Compared to other radio transients, FRBs occupy a unique and extreme part of the radio luminosity versus time scale phase space, and as such hunting for FRBs and understanding their physical origin(s) have become a leading scientific goal in astrophysics. As neither the progenitors nor their emission mechanisms are known, simultaneous multi-wavelength studies of repeating FRBs would enable new tests of emission models.

A subclass of the current FRB population shows repeat radio pulses, providing an opportunity to study this phenomenon in more detail across a vast swath of the electromagnetic spectrum. In this presentation, we will describe the status of an extensive observing campaign of a nearby FRB in the radio, visible, and X-ray band using both ground-based and space-borne facilities. Radio and optical observations were carried out simultaneously using a novel hybrid radio/optical instrument now operating at the NASA Deep Space Complex in Goldstone, CA. X-ray observations were carried out using NASA's NICER instrument on-board the ISS. The planned observations with the new facility will enable precise measurements of the relative optical to radio energy flux of the bursts, a key observable for discriminating between the various proposed progenitors and emission mechanisms for FRBs.

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Detached Compact Object-Luminous Companion Binaries Discoverable by Gaia can Connect High-Mass Progenitors to the Compact Objects they Form

Dr. Sourav Chatterjee

Tata Institute of Fundamental Research

Abstract

The discovery of gravitational waves (GWs) from merging binary black holes (BHs) and neutron stars (NSs) have created unprecedented interest in improving our understanding of how high-mass stars evolve and form compact objects (COs). Recently, using detailed binary population synthesis and taking into account inherent detection biases and reddening effects, we have predicted that Gaia, by end of mission, should discover hundreds of BH binaries with luminous companions (LCs) through astrometry, photometry, spectroscopy, and their combinations. These predictions have started to come true through analysis of Gaia's third data release. These COs are complementary to those discoverable through the detection of GWs, X-ray, and radio emissions. Our results show that the distribution of properties for Gaia's detectable COs is identical to that of the intrinsic, showing little observational biases based on the CO properties. Furthermore, since Gaia itself provides the distance, magnitude, and colors for the LCs, it is relatively straightforward to constrain the metallicities and ages for the LCs, and in turn, infer those for the progenitors of the COs, a constraint that is hard to come by for COs discovered through other methods. Moreover, if indeed detected in large numbers as our study predicts, the mass and orbital properties of the CO-LC binaries can provide clues to constrain the supernova mechanism, a constraint highly useful to guide detailed modeling of high-mass stellar evolution.

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Finding Fast Radio Bursts with MeerKAT

Dr Mechiel Bezuidenhout

University of South Africa. North-West University

Abstract

Fast Radio Bursts (FRBs) are extremely bright, extragalactic, millisecond-duration bursts of radio emission of still-debated origin. Since their discovery in 2007, many surveys have been commissioned at radio observatories around the world to look for these bursts, resulting in a sample of almost 1000 known FRBs to date. However, the vast majority of these have been found using instruments that maximise their Field of View (FoV) at the expense of spatial resolution. Thus, only a few FRBs have positions that are well-enough constrained to associate them with host galaxies or multi-wavelength counterparts, making it very difficult to make conclusions about the kinds of environments that produce them.

This talk will introduce the MeerTRAP survey for fast radio transients using the MeerKAT radio telescope in South Africa. MeerKAT has a unique combination of high sensitivity (~4-5 times that of the comparable Murriyang telescope in Australia) and high spatial resolution, allowing for sub-arcsecond localisation of all FRBs found. To find FRBs, MeerTRAP employs a novel real-time single pulse search that operates commensally with other MeerKAT users. I will showcase the most notable of our ~50 FRBs found in 5 years' observing.

I will also discuss what our discoveries imply about the host environments of FRBs, the question of distinguishing repeaters from non-repeaters, and possible evolutionary links with long-period magnetars and other known neutron star populations.

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Pre-supernova evolution and final fates of binary stars

Fabian Schneider

Heidelberg Institute for Theoretical Studies

Abstract

Most massive stars are expected to exchange mass or merge with a companion during their lives. This implies that most supernovae (SNe) are from such post-mass-exchange objects. Here, I will summarize our recent studies on how envelope stripping, mass accretion and stellar merging influence the pre-SN structures of stars, their pre-SN location in the Hertzsprung-Russell diagram and the resulting explosion properties. In all binary products and single stars, we find similar CO core masses of likely black-hole formation. Binary-stripped stars may lead to characteristic black-hole masses across a large range of metallicity, seemingly in agreement with features observed in the chirp mass distribution of binary black-hole mergers. If confirmed by future observations, this could open a direct window to the otherwise elusive physics of pre-SN stellar evolution and SN explosions. SNe from binary-stripped stars are also on average more energetic and produce higher nickel yields compared to exploding single stars. Mass accretors and stellar mergers may explode as blue and cool supergiants with different interior structures compared to single-star models. Some mergers are predicted to explode as luminous blue variables while non-exploding merger models may give rise to ~50 solar mass black holes even at solar metallicity. I will argue that the central entropy of our models is a good proxy to predict the SN outcome regardless of the evolutionary history of the stars. It correlates closely with the neutron-star masses, nickel yields and explosion energies. Lastly, I will relate our findings to the missing red supergiant problem.

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SN 2014C: a metamorphic supernova exploded in the intricate and hydrogen-rich surroundings

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Abstract

SN 2014C has garnered significant interest due to its remarkable transition from a hydrogen-deficient Type Ib supernova (SN Ib) to a hydrogen-rich Type IIn supernova (SN IIn). This transition arises from the altered interaction between the supernova and the circumstellar material (CSM), providing an opportunity to investigate the mass loss process experienced by its progenitor leading up to the explosion. Given the unique photometric and spectroscopic data of SN 2014C, especially within the first month after the explosion, we have revealed the structure of its surrounding environment. Within the first 20 days, a fading Hα absorption indicates a limited amount of hydrogen in the outermost layer of the ejecta, while the variation of narrow Hα emission can be attributed to the interaction between the supernova and the H-rich CSM. The inferred distance between the progenitor and CSM, based on these interaction signals, is roughly one order of magnitude smaller than that derived from the nebular spectra. Furthermore, the rapid rise in the bolometric light curve of SN 2014C and the subsequent slow decline from peak luminosity suggest the presence of an additional energy source beyond the radioactive decay of ^{56}Ni, possibly arising from these interactions. Collectively, these findings suggest that SN 2014C exploded in a continuously distributed H-rich CSM, likely formed during the envelope-stripping process of a massive star in a binary system. It can also be inferred that massive stars in binary systems may explode at various stages of envelope stripping, resulting in a rich diversity of observational phenomena.

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Towards future multi-messenger detections of core-collapse supernovae harbouring choked jets

Angela Zegarelli[1], Dafne Guetta[2], Silvia Gagliardini[2], Silvia Celli[3], Irene Di Palma[3], Antonio Capone[4], Imre Bartos[5]

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Abstract

Over the last decade, the scenario of choked jets embedded in core-collapse supernovae (CCSNe) has attracted careful attention. The extended stellar envelopes of red supergiant (RSG) and blue supergiant (BSG) stars, both progenitors of Type II SNe, may constitute a challenge to the launch of a powerful jet able to burrow through their envelopes. As the jet carves its way through them, it dissipates its energy in a double-shock structure that forms at its head. The hot head material spills sideways, forming a cocoon that engulfs the jet and collimates it. If before choking the jet crossed a significant fraction of the stellar envelope, the cocoon is energetic enough to break out of the star, releasing ultraviolet (UV) and optical (O) emissions lasting over a few days. For a proper characterisation of RSGs and BSGs, the identification of both these electromagnetic signals is of paramount importance, because of the low probability for gamma rays to emerge.

I here discuss prospects in measuring UV emission, in view of the launch in 2026 of the satellite ULTRASAT which will operate in the UV band, complementing the performances of the currently active optical telescope ZTF. Furthermore, choked jets are also extremely interesting within the growing field of multi-messenger astronomy, being considered as possible contributors to the astrophysical diffuse neutrino flux, not yet associated with any existing source. In this regard, I discuss the possibility of exploiting multi-messenger detections on how to optimise combined detections between UV/O/neutrino telescopes.

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Transients in the gap - Luminous red novae, SN impostors, and intermediate-luminosity transients

Morgan Fraser

University College Dublin

Abstract

Historically, transients with luminosities fainter than supernovae but brighter than classical novae have been rarely identified. However, the present generation of all sky surveys have revealed that this region of parameter space actually is host to a diverse range of transients, including stellar mergers and common envelope ejections, non-terminal eruptions, pre-SN outbursts, weak SNe and more. Determining the physical nature of these transients is often challenging, particularly if they are dominated by circumstellar interaction. However, they can provide insights into poorly understood areas of massive stellar evolution, such as the common envelope phase, as well as late nuclear burning stages. I will provide an overview of the field as it stands, as well as future prospects with upcoming surveys and facilities.

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SN 2022jli: A Type Ic Supernova with Periodic Modulation of Its Light Curve and an Unusually Long Rise

Mr Thomas Moore

Queen's University Belfast

Abstract

I will present extensive multi-wavelength optical and ultraviolet observations of SN 2022jli, an unprecedented Type Ic supernova discovered in the galaxy NGC 157 at a distance of approximately 23 Mpc. The multi-band light curves reveal many remarkable characteristics. Peaking at a magnitude of g=15.11 ± 0.02, many facilities gathered high-quality, high-cadence photometry, revealing a remarkable 12.5-day periodicity superimposed on the supernova decline. This periodicity is observed in the light curve with seven separate filter and instrument configurations with amplitudes of ~ 0.1 mag. Such periodicity, over many cycles has not been observed before in any supernova to date. SN 2022jli displays an extreme early excess which fades over at least 25 days, likely due to shock cooling or companion interaction. We observe a long rise to maximum light (at least 59 rest-frame days), and broad peak with a decay tail with high cadence photometry over 200 days. In this talk I will present optical spectroscopic follow-up during the first 100 days, showing this is a hydrogen and helium-poor Type Ic supernova, with very little evolution and significant velocity structure in the line profiles. I will present light curve and spectral modelling and discuss the possible origin of the periodic variability in the light curve, including interaction of the SN ejecta with nested shells of CSM and neutron stars colliding with binary companions.

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Core-Collapse Supernova Progenitors from Light Curves and Stellar-Evolution Models

Dr Melina Bersten

Instituto de Astrofisica de La Plata(IALP), Argentina

Abstract

Supernovae (SNe) are excellent laboratories for testing many aspects of stellar-evolution theory with strong implications on many various areas of astrophysics. Their light curves are extremely sensitive to the properties of their progenitor stars or systems and their environments. With the increasing amount and improved quality of current data, new types of SNe or unexpected features in normal events are being detected. These discoveries challenge our standard knowledge of how massive stars explode, as well as the mechanisms that power these events. In this talk I will focus on the modelling efforts that we have been doing in order to understand the properties of normal and some peculiar objects. Particularly, I will show our results on a large sample of hydrogen-rich SNe. Our analysis indicates that most of the SNe II come from relatively low-mass progenitors (MZAMS < 10 Msun). This results have important implications on our knowledge of massive-star evolution. I will also present our recent hydrodynamic modeling of the famous SN 2023ixf.

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Luminosity Gap Transients and AT2019krl

Beth Fitzpatrick

University College Dublin

Abstract

The recent advancement of new surveys has led to the discovery of a wide range of optical transients with a luminosity between that of a classical nova and a supernova (-15 < M_V < -10). As they exist in this luminosity "gap", these events have been given the name "gap transients". Gap transients are an observational class with a number of physical mechanisms. These mechanisms serve as the defining characteristics of a number of subgroups: Intermediate Luminosity Red Transients (ILRTs), Luminous Blue Variables (LBV) eruptions, Luminous Red Novae (LRNe) and Failed Supernovae. Distinguishing between the different subclasses of gap transients is not an easy task, especially as some of these subclasses have few or no confirmed observations. The observational properties often look similar, occasionally exhibiting overlaps. AT2019krl, located in M74, is one such gap transient, discovered by the Zwicky Transient Facility (ZFT) on 2019 July 07. We have reanalysed this unusual transient, originally classified as an LBV eruption, with a more comprehensive data set of optical and near infrared imaging and spectroscopy. Late time images of AT2019krl suggest that it has faded to a luminosity below that of its progenitor. This would be remarkable behaviour for an LBV and suggests that the transient is in fact the first observational evidence of the theoretically predicted failed supernova.

Session

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1591

How to monitor the radio transient sky with the SKA telescopes?

Dr Sarrvesh Seethapuram Sridhar, Dr Shari Breen, Dr Nichol Cunningham, Dr Jimi Green, Dr Sharmila Goedhart, Dr Danny Price

Square Kilometre Array Observatory

Abstract

The SKA Low and Mid telescopes are next-generation flagship radio astronomical facilities that will revolutionize radio astronomy for decades. Both telescopes are complex instruments that can be configured to monitor a large sky area due to their multi-beaming and subarraying capabilities. Furthermore, the SKA telescopes can also respond quickly to external triggers following a transient event.

In this talk, I will discuss details of the SKA telescopes and their specifications, highlighting some of the areas where the increased sensitivity, spatial resolution, survey speed, and quick response to triggers from external facilities are particularly well suited to making significant contributions to transient science cases. I will also briefly discuss our operational model and provide details of how and when the community might expect to access the SKA.

Session

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1592

Establishing a mass-loss rate relation for Red Supergiants

Konstantinos Antoniadis[1,2], Alceste Bonanos[1], Stephan de Wit[1], Emmanouil Zapartas[3,1], Gonzalo Munoz-Sanchez[1], Grigoris Maravelias[1,3]

[1]National Observatory of Athens. [2]National and Kapodistrian University of Athens. [3]Institute of Astrophysics FORTH

Abstract

High mass-loss rates of red supergiants (RSGs) drastically affect their evolution and final fate, yet their mass-loss mechanism remains poorly understood. Various empirical prescriptions scaled with luminosity have been derived in the literature, yielding results with a dispersion of 2-3 orders of magnitude. We determine an accurate mass-loss rate relation using over 2000 RSG candidates, with UV to mid-IR photometry in up to 49 filters, in the Large Magellanic Cloud, and investigate the discrepancy reported in previous works. We determined the luminosity of each RSG by integrating the spectral energy distribution and the mass-loss rate using the radiative transfer code DUSTY. We established a mass-loss rate relation as a function of the luminosity and the effective temperature. Furthermore, we found a turning point in the mass-loss rate versus luminosity relation at approximately log(L/L⊙)=4.4, indicating enhanced rates beyond this limit. Yang et al. (2023) found this limit at log(L/L⊙)=4.6 in the Small Magellanic Cloud, hinting at a metallicity dependence. We show that this enhancement correlates with photometric variability. Additionally, we examined the effect of different assumptions on our models and found that radiatively driven winds result in higher mass-loss rates by 2-3 orders of magnitude compared to steady-state winds. Finally, we apply the same methodology to model a large sample of RSGs in different galaxies, such as the Small Magellanic Cloud, M31, and M33, to find if metallicity affects mass loss.

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1637

The population of high-mass X-ray binaries in the LMC detected during the first eROSITA all-sky survey

David Kaltenbrunner[1], Dr. Chandreyee Maitra[1], Dr. Frank Haberl[1], Dr. Georgios Vasilopoulos[2]

[1]Max Planck Institute for extraterrestrial Physics. [2]Department of Physics, National and Kapodistrian University of Athens

Abstract

The Magellanic Clouds are our closest star-forming galaxies with low Galactic foreground absorption. This makes them a unique laboratory to study the population of high-energy sources. The SMC hosts a large population of Be/X-ray binaries associated with high star formation activity 25-40 Myr ago. It has been proposed that the HMXB population in the LMC is associated with more recent star formation. However, due to the large angular extent and resulting insufficient coverage of the LMC, this association with SFR is not well established yet.

An essential asset for studying the HMXB population in the entire LMC was the launch of eROSITA. eROSITA scans the sky in great circles crossing at the ecliptic poles. Due to the vicinity of the south-ecliptic pole, sources in the LMC are monitored for up to several weeks during each all-sky survey, leading to a deep total exposure and the possibility of studying long-term temporal behaviour. This allowed us to discover several new HMXBs, verify candidate HMXBs and construct a complete, flux-limited catalogue. During my presentation, I will first focus on HMXB population properties in the LMC. Then I will discuss individual systems we discovered with eROSITA, such as a Be-WD and an SFXT candidate.

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1654

Neutron star X-ray binary jets with MeerKAT

Mrs Kelebogile Gasealahwe[1,2], Dr Itumeleng Monageng[1,2], Prof Rob Fender[3,1], Prof Patrick Woudt[1]

[1]UCT. [2]SAAO. [3]Oxford

Abstract

X-ray binaries are split into Black hole and Neutron star systems. The nature and properties of these systems provide a clear dichotomy, however, exploring the distinct differences has presented similarities in certain properties. The process of the disk and jet production in XRBs remains a large factor to understanding the two classes of systems and while this has been widely studied for BH XRBs, there is still a lot of ground to cover for NS XRBs. The sources SAX J1808.4–3658, Cir X-1, XTE J1701-462, Cyg X-2 provide a control sample of NS XRBs to investigate the jet outflows of such systems. The sources have been observed through the ThunderKAT project with MeerKAT and Swift, while Cyg X-2 has undergone extensive long term monitoring with AMI. The wealth of data allow us to present here the lightcurves of these sources where multiple flare events are observed for each source. We additionally include minimum energy measurements of these flare events and distinguish the spectral states of the outbursts. We place the sources on the radio : X-ray correlation plane to establish how the disk production and jet outflows relate during an outburst and compare this to Black hole X-ray binaries.

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1739

The impact of detailed metallicity evolution in galaxies on the pair-instability supernova rate

Dr Max Briel[1], Benjamin Metha[2]

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Abstract

Pair-instability supernovae (PISNe) are theoretically predicted stellar transient events, where pair-production followed by explosive carbon-oxygen burning completely disrupts the very massive star progenitor (M_ZAMS \sim 140-260 Msun). Together with pulsation PISNe at lower masses, this process is expected to shape the merging binary black hole mass distribution by limiting the formation of BHs above 50 \Msun with a pile-up below it. However, no unambiguous observation of a PISN has been made nor has a connection between a dearth and pile-up been found in the BBH mass distribution. PISN progenitors are required to maintain a large amount of mass to be bale to reach the low-density, high-temperature environment for pair-production, as such they are limited to low-metallicity galaxies.

We use the detailed stellar structures the binary population and spectral synthesis code suite, BPASS, to predict the associated PISN light curves and their observability in current and next-generation SNe surveys. Combining this with the detailed star formation history and metallicity evolution of the Illustris-TNG simulation, we create the most detailed population of PISN and their host galaxies to date. We show that treating low-metallicity star-forming pockets in higher-metallicity galaxies increases the PISN rate at present day by an order of magnitude, while stellar mergers allow PISNe to form at higher metallicities than isolated evolution. This has implications for the evolution of very massive stars.

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1765

GRB formation through reverse mass transfer: a positive metallicity relation

Dr. Max Briel, Prof. Anastasios Fragos

University of Geneva

Abstract

Most long gamma-ray bursts (GRBs) are observed at relatively high redshift, often taking place in low-metallicity galaxies. This apparent metallicity aversion can be interpreted as a condition for the progenitor massive star to retain a large angular momentum reservoir to power the GRB, which would be lost in winds otherwise. The necessary stripping of the hydrogen envelope of the GRB progenitor in such a scenario can be provided by interactions with a binary companion.
GRB 221009A, the brightest GRB observed to date, occurred at a redshift of only z=0.15. Since an event with similar properties would have been visible up to z=10, the question arises of why such GRBs are not observed at intermediate and high redshifts.
In this talk, I present a new, previously unexplored GRB formation channel in a massive stellar binary where mass transfer from an initially less massive companion back onto a hydrogen-poor primary leads to rapid spin up close to core-collapse. Using the binary population synthesis framework POSYDON, we model binary interactions using MESA over a wide range of metallicities and create a synthetic population of such "reverse mass transfer" GRBs.
This channel has a positive metallicity dependence, while being subdominant with respect to the traditional binary formation channels that prefer low metallicity. The modelling of such channel requires a detailed treatment of the mass transfer and its stability. At low redshift, solar and slightly sub-solar systems dominate the cosmic rate, when considering only the progenitors with the highest angular momentum reservoirs in the population.

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1768

New Observational Insights into the Astrophysics of Extremely Metal-Poor O Stars

Grace Telford

Princeton University. Carnegie Observatories

Abstract

Low-metallicity massive stars produce energetic radiation and supernova explosions that shape the evolution of low-mass galaxies, both locally and in the early universe. Theory predicts that these stars drive weaker winds than their higher-metallicity counterparts, with important implications for their evolutionary pathways and endpoints. Yet, open questions remain about the physical driver of metallicity-dependent differences in the nature of the explosions that end massive stars' lives. A fundamental limitation is that very few observations of individual massive stars below 20% solar metallicity (Z_sun) exist to validate stellar models in the very low-metallicity regime. I will present Hubble Space Telescope FUV spectra of three O stars in nearby dwarf galaxies spanning 3-14% Z_sun, which reveal that the two most metal-poor stars are both fast rotators driving weak stellar winds. Combined with with Keck/KCWI optical spectra, these observations provide novel constraints on theoretical stellar mass-loss prescriptions below 20% Z_sun, a crucial ingredient in evolution models for metal-poor stars. I will then describe the Treasury of Extremely Metal-Poor O Stars (TEMPOS), a new Large Treasury HST program that is assembling a comprehensive FUV and optical spectral library across O-star parameter space at ~5-10% Z_sun. These observations will provide the community with a much-needed empirical benchmark for the stellar models necessary to understand stellar evolution and feedback in metal-poor galaxies.

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1796

Spectroscopic analysis of metal-poor massive stars in the Magellanic Bridge

Elisa Schösser

University of Heidelberg

Abstract

The fate of massive stars depends severely on the strength of their inherent stellar winds. During most of their life, massive stars experience line-driven winds, which strongly vary with metallicity. Yet, robust constraints for the mass-loss rate of stars in metal-poor environments resembling early cosmic epochs are scarce. Until recently, stars with metallicities lower than those in the Small Magellanic Cloud (SMC) were only known in compact dwarf galaxies, with observations in such distant locations suffering from limited signal-to-noise ratios and spatial resolution.

Recently, we discovered three O stars and several early B-type stars in the Magellanic Bridge - a stream of gas and stars connecting the two Magellanic Clouds. Using newly acquired HST UV spectra combined with archival optical spectra, we measure for the first time the inherent iron abundances and characterize the stellar and wind properties of these stars with detailed, non-LTE quantitative spectroscopy. Thereby, we discovered the first nearby massive O star with a severely sub-SMC metallicity, reaching as low as 0.1 Zsol. Our approach involves utilizing detailed expanding non-LTE atmosphere models to generate synthetic spectra, which we then compare against optical and novel UV observations.

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1811

A new insight into the helium-layer stripping mechanism from the peculiar Type Ib supernova 2021efd interacting with hydrogen-poor circumstellar material

Master's student Niko Pyykkinen, Docent Hanindyo Kuncarayakti, PostDoctoral Researcher Takashi Nagao

University of Turku

Abstract

Stripped-envelope supernovae (SESNe) are explosions of massive stars that have lost a part of the hydrogen layer (IIb), the whole hydrogen layer (Ib) or both the hydrogen and helium layers (Ic). The mechanism leading to the hydrogen-envelope stripping is thought to be close binary interaction, in which the primary star fills the Roche-lobe potential and transfers its outer parts into the companion star and the interstellar space. However, the stripping mechanism for the helium layer has not yet been understood. I present photometry and spectroscopy of the unique Type Ib SN 2021efd showing a multi-peaked light curve. The observational properties are consistent with a picture of a Type Ib SN interacting with a clumpy hydrogen-poor circumstellar medium (CSM). From the light-curve modeling, I estimate the CSM density, which corresponds to the mass-loss rate of the progenitor of ~1e-3 Msun/yr. This value is too high for the usual mass-loss mechanism in massive stars, i.e. the line-driven wind mechanism. The dense and clumpy CSM suggests eruptive mass ejections as the possible He-layer stripping mechanism at least for this SN. If this mass-loss is related to late-burning processes in the core of massive stars, the expected time scale to remove the whole He layer (~1e3 yr) may support a mechanism that is related to the carbon burning phase. I discuss the possible parameters that trigger the He-layer stripping by comparing the ejecta properties of this SN with those of other typical Type Ib and Ic SNe.

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1835

Grids of Wolf–Rayet Stars Using MESA with the k–omega Model

zhi li

Yunnan Observatories, Chinese Academy of Sciences

Abstract

To explore overshoot mixing and rotational mixing beyond the convective core during the core He-burning phase in massive stars, we computed a grid of stellar models, both rotating and nonrotating, with the k − ω model at Z = 0.02, covering a mass range of 25–120 M_{sun}. Models with the k − ω model provide larger convective cores and a broadening of the main-sequence width. The diffusive-overshoot models with fov = 0.027 are, on average, closer to the k − ω models for massive stars at Z = 0.02, particularly for the stars with masses greater than 40 Me. The final masses of the Wolf–Rayet stars range from 9.5–17.5 M_{sun} and 10–23 M_{sun} for the rotating and nonrotating models, respectively. In the rotating models, the C/N ratio decreases slowly below 0.1 outside the convective core, resulting in a flatter element transition region. In addition, the lifetimes of the WNC phase are 1–4 × 10^4 yr, which is about 1 order of magnitude longer than that in the nonrotating models. The masses of the WNC stars are dominated by internal mixing processes and the maximum masses of the He-burning convective cores during the core He-burning phase are in the range of 15–35 M_{sun}. The expected WNC/WR ratios are 0.059 and 0.004 for the rotating and nonrotating models, respectively.

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1854

Nature or Nurture: revealing gamma-ray burst progenitor properties and environments through radio observations

James Leung

University of Toronto. Hebrew University of Jerusalem

Abstract

Long duration gamma-ray bursts (GRBs) now have a well-established connection with type Ic broad-lined supernovae (Ic-BL SNe). However, some aspects of this connection are still unclear. Why are GRBs only observed in a small subset of type Ic-BL SNe? How do Wolf-Rayet progenitors power their central engines long enough to produce ultra-long duration GRBs lasting more than 1000 seconds? The answers to these questions may lie in the interplay of both intrinsic (e.g., nature of the jet and/or cocoon) and extrinsic (e.g., system geometry and circumstellar environment) factors. In this talk, I will discuss how radio observations on all angular scales - from modern all-sky wide-field radio surveys to high-resolution Very Long Baseline Interferometry (VLBI) - have contributed to and will continue to help answer these questions. In particular, I will highlight two key results from recent multi-scale radio campaigns: (1) a 1500+ day long radio campaign of GRB171205A/SN2017iuk revealing key insights into the nature of the jet (structure/geometry) and profile of the circumstellar environment; (2) a 400+ day radio campaign following the most distant ultra-long GRB to date, GRB 220627A at z=3.08, revealing a secondary component in excess of standard afterglow predictions, pointing towards possible energy contributions from a magnetar remnant or sub-to-mildly relativistic supernova component. Finally, I will discuss the opportunities and challenges of radio-optical synergies in context of these studies during the LSST-SKA era.

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1885

SN 2023zaw: an ultra-stripped, nickel-poor supernova from a low-mass progenitor

Kaustav K. Das

California Institute of Technology

Abstract

I will talk about the spectacular SN 2023zaw -- a sub-luminous (M_r = -16.7 mag) and rapidly-evolving supernova ($t_{1/2,r}$ = 4.9 days), with the lowest nickel mass (~0.003 Msun) in any stripped-envelope supernova discovered so far. The photospheric spectra are dominated by broad He I and Ca NIR emission lines with velocities of ~10 000 - 13 000 km s^{-1}. The late-time spectra show prominent narrow He I emission lines at 1000 km s^{-1}, indicative of interaction with He-rich circumstellar material. SN 2023zaw is located in the spiral arm of a star-forming galaxy. We perform radiation-hydrodynamical and analytical modeling of the lightcurve by fitting with a combination of shock-cooling emission and nickel decay. The progenitor has a best-fit envelope mass of ~0.2 Msun and an envelope radius of ~50 Rsun. The extremely low nickel mass, ejecta mass (~0.5 Msun), and low explosion energy (~5 x 10^{49} erg) suggest an ultra-stripped SN, which originates from a mass-losing low mass He-star (ZAMS mass < 10 Msun) in a close binary system. This is a channel to form double neutron star systems, whose merger is detectable with LIGO. SN 2023zaw underscores the existence of an undiscovered population of extremely low nickel mass (< 0.005 Msun) stripped-envelope supernovae, which can be explored with deep and high-cadence transient surveys.

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1912

ALMA view on supernovae: uncovering the nature of massive star evolution toward their demise

Prof Keiichi Maeda

Kyoto University

Abstract

Thanks to recent inflating opportunities in transient surveys and rapid follow-up observations, a new, surprising picture has emerged on the nature of massive starts in their final phase; through observations of core-collapse supernovae (CCSNe) in the optical window, dense circumstellar matter (CSM) confined in the very vicinity of the progenitor has been discovered, indicating that the massive stars are much more dynamic in the last few years than widely accepted previously. To further constrain the nature of the CSM and thus the evolution of massive stars in the final centuries to even months toward the explosion, radio synchrotron emission, especially in the higher frequency, can provide unique and unbiased diagnostics. In this talk, I will present some results from our rapid follow-up observation of CCSNe with the ALMA, starting within ~5 days since the explosion; this is a new window that has become possible thanks to the great point-source sensitivity and ToO capability provided by the ALMA. I will especially focus on the following topics; sub-year timescale activity just before the explosion that changes the classical view of the single massive star evolution, and a case showing a rapid change in the mass-loss rate ~1,000 years before the explosion that confirms an important role of binarity in shaping the massive star evolution.

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1914

New massive runaway stars: supernova explosions or dynamical ejections?

Mar Carretero-Castrillo, Marc Ribó, Josep Maria Paredes

Universitat de Barcelona, ICCUB, IEEC-UB

Abstract

A significant fraction of massive stars are runaway stars, meaning that they have a high peculiar velocity compared to their surroundings. The runaway origin can be explained by kicks from supernova explosions or by the dynamical ejection of stars from clusters. Therefore, the binary status of the massive stars can play a crucial role in the runaway origin. Thanks to the extremely precise astrometric data from the most recent Gaia release, we identified new runaway stars in our Galaxy. We used a two-dimensional velocity space method using Gaia DR3 data for the first time, to identify O and Be-type runaway stars. We found 106 O-type runaway stars, 42 new discoveries, and 69 Be runaway stars, 47 new discoveries. We characterize the spatial distribution, the velocity dispersion, and the runaway percentages as a function of the spectral type. For O-type stars, the runaway percentage is 25.4%, while for Be-type stars, it drops to 5.2%. Such differences have implications in the runaway origin. In comparison to Be-type runaways, O-type runaways exhibit greater percentages and larger velocities, which further support the dominance of the dynamical ejection scenario over the binary supernova one. Not only our findings give insights in the pre-runaway stage, but also in the post-runaway stage. Our results open the door to identify new high-energy systems, such as binaries hosting compact objects, by conducting detailed multi-wavelength studies.

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2022

Still interacting after a decade: probing a stripped-envelope supernova progenitor's mass loss history and dust formation with James Webb Space Telescope

Dr. Samaporn Tinyanont[1], Dr. Ryan Lau[2], Prof. Mansi Kasliwal[3], Dr. Ori Fox[4], Dr. Schuyler Van Dyk[5], Prof. Ryan Foley[6], Prof. Danny Milisavljevic[7], Prof. Keiichi Maeda[8], Prof. Itsuki Sakon[9], Prof. Alex Filippenko[10], Tamas Szalai[11]

[1]National Astronomical Research Institute of Thailand. [2]NOIRLam. [3]California Institute of Technology. [4]Space Telescope Science Institute. [5]Infrared Processing and Analysis Center. [6]University of California Santa Cruz. [7]Perdue University. [8]Kyoto University. [9]Toyko University. [10]University of California Berkeley. [11]University of Szeged

Abstract

Massive stars shed a significant amount of mass prior to their demise. About 1/3 of massive stars that die in core-collapse supernovae lose all hydrogen and/or most of helium and produce stripped-envelope supernovae. The envelope-stripping mechanism and its timescale remain poorly constrained by observations, as the vast majority of stripped-envelope supernovae never interact with the lost envelope. Here, we present James Webb Space Telescope infrared spectroscopic observations of a notable exception. SN 2014C exploded as a hydrogen-poor SN Ib, but started to interact with its hydrogen-rich circumstellar medium (CSM) ~100 days post explosion. The interaction is still ongoing, almost 10 years later, allowing us to further probe the mass-loss history. The luminosity of SN 2014C at ~3500 days agrees well with the model light curve derived from Spitzer observations prior to 2019. This indicates that the CSM with which the SN is interacting is still the same component. This lengthy interaction indicates that the mass loss episode lasted ~1000 yr, the CSM extends to 0.13 pc and contains ~3 Msun. These CSM parameters are only compatible with binary-driven mass loss. Copious amounts of dust have formed in SN 2014C compared with earlier epochs, demonstrating that dust emission from interacting SNe is not all from pre-existing dust in the CSM. Finally, the spectra show several forbidden lines similar to what have been used to identify a central compact object in SN 1987A. We discuss the role that a compact object may play in the long-lasting emission from SN 2014C.

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2080

Magnetars as powering sources of GRB-SNe, and unsupervised clustering of cosmic transients discovered with the current deep time-domain optical sky surveys

Dr Amit Kumar

University of Warwick, UK

Abstract

The diversity in the observed properties of different types of supernovae (SNe) are crucial to understanding how the life of stars ends differently. Diversity among underlying powering mechanisms may play a vital role among other possible factors (e.g., progenitor, environment). Unique properties and scarcity of Gamma-ray bursts (GRBs) associated SNe (GRB-SNe) seek attention and are exciting for investigating their underlying powering sources. A magnetar with a spin period of 1 millisecond, mass of 1.4 solar masses, and radius of 10 kilometres has a rotational energy reservoir of nearly 2.2x10^53 ergs, hence can explain the light-curves of various types of SNe, including GRB-SNe. My talk will focus on how magnetars with different initial spin periods and magnetic fields can give birth to distinct types of transients and GRB-SNe and relativistic Ic-BL SNe occupy different parameter spaces for ejecta mass, initial spin period and magnetic field than those of SLSNe-I, FBOTs, LGRBs and SGRBs. I would also discuss the significance of employing machine learning algorithms, particularly with larger datasets facilitated by all-sky surveys, e.g., GOTO and LSST, to analyse and interpret the multi-dimensional parameter space proficiently.

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2160

GalRSG: A long-term monitoring campaign of Galactic Red Supergiants and the quest for SN explosions' premonitory signs

Dr Fabrizio Bocchino[1], Dr Salvatore Orlando[1], Dr Marco Miceli[2], Dr Oleh Petruk[1,3], Dr Andrea Pastorello[4], Dr Marco Limongi[5,6,7], Dr Alessandro Chieffi[8,9,7]

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Abstract

The studies of pre-supernova outbursts have received lot of attention because of their high diagnostic power for the nature of the supernova progenitor and the implications on the structure of the circum-stellar medium (CSM) in the immediate surrounding of the exploding SNe. So far, the study of the outbursts have been mostly confined to archive data of extragalactic SNe, resulting in a handful of cases in which SN precursors have been securely identified. These "a-posteriori" surveys have been proved very useful to characterize the diversity of the SNe "zoo", but they suffer a bias against the very rich $L <= 10^5 L_{sun}$ population of low-mass Red Supergiants (RSG) and they lack homogeneous pre-SN data. To overcome this limitation, we assembled a literature-based catalog of a coeval and co-distant sample of galactic RSGs in the Scutum-Crux region, which gives us the possibility to change the observational paradigm of pre-SN outburst studies. We launched a long-term monitoring campaign aimed to characterize the multi-color light curves of this large sample of RSGs, to detect late-stage outbursts and to compare them with very recent models of the final phases of low-mass RSGs before SN explosion, thus possibly predicting core collapse of specific objects before it occurs. We present this on-going project and some preliminary results.

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2212

Unraveling the progenitor characteristics of long-plateau core-collapse supernovae via light curve modelling

Ms Monalisa Dubey

Aryabhatta Research Institute of Observational Sciences (ARIES), INDIA

Abstract

The diversity in the light curve of Type II core-collapse supernova (CCSN) is mainly due to the variety in the characteristics of the progenitor, the morphology of the circumstellar medium (CSM), and the energy of the explosion. Using analytical (Nagy and Vinkó, 2016; Jäger et al., 2020) and hydrodynamical (MESA+STELLA) modelling of the light curves, the progenitor characteristics (like initial mass, explosion energy, ^{56}Ni mass, mass loss history, etc.) can be revealed. We perform analytical and hydrodynamical modelling in a sample of core-collapse SNe, which exhibits long plateau durations. Although hydrodynamical modelling is more robust and provides accurate results, analytical modelling is computationally less intensive. Our results indicate that the values of progenitor mass and explosion energy from analytical modelling are lower than those obtained from hydrodynamical modelling. The possible progenitors are red supergiants with masses greater than 20 $M_{\odot}$ with excessive mass loss rate ($dm \simeq 10^{-2}$ $M_{\odot}yr^{-1}$).

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2232

Commensal transient searches using SARAO data processing images in the LADUMA filed in the MeerKAT's UHF band.

Mr Moses Mlangeni, Prof Patrick Woudt

University Of Cape Town

Abstract

We present the findings of our commensal search using SARAO SDP images. Our investigation consisted of 43 images from the LADUMA field in MeerKAT's UHF band. Employing the Transient Pipeline (TraP), we identified source candidates within the LADUMA field, applying additional filtering methods to remove false positives. After-which, we conducted multiwavelength analysis on the potential sources, assessing radio variability through light curve inspection and radio image post-stamps. Our search spanned DES, Pan-STARRS, VizieR, SIMBAD, and MeerLICHT. Eight potential source candidates were discovered, showing radio variability. The radio variability in seven of the eight sources can be attributed to interstellar scintillation. Notably, SRC213653 exhibits intrinsic variability, displaying high variability at 0.816 GHz with 10 radio detections across 43 epochs, reaching a peak flux of 1.0411 ± 0.0430 mJy. We associate SRC213653 with the low-mass star LP 888-63, located at a distance of 23 pc from the sun and 0.107 arc-seconds from the MeerKAT's position. LP 888-63 is a M-dwarf companion to a white dwarf binary system, WD 0326-273. Multiwavelength associations of LP 888-63 reveal active flaring behavior across the electromagnetic spectrum. Optical photometry from TESS indicates a rotational period of 5.779 ± 0.5067 days. Considering the estimated radius of the star, it suggests LP 888-63 is a slow rotator, consistent with expectations for a typical low-mass star. Archive spectra exhibit Hα emissions, indicative of magnetic activity.

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2242

Luminous AGB Variables in Nearby Galaxies

Ms Etsegenet Alemu

Space Science and Geospatial Institute

Abstract

Stars with initial masses between 1 and about 10 M¤ go through an AGB phase, towards the end of which they become large amplitude, long period (Mira) variables and lose mass copiously. The mass-loss leaves them cocooned in a shell of dust and renders them optically invisible, but very strong infrared sources. As such they are easily detected at Spitzer wavelengths. These stars are of great interest for two independent reasons. First, they obey a period luminosity (PL) relation that makes them useful distance indicators. Secondly the whole process of mass loss and return of material to the interstellar medium is very poorly understood.

We examine the variable sources that have been found by the SPIRITS collaboration, selecting two galaxies to study in detail (15
galaxies have at least 50 transients and variables).

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The enigmatic double-peaked stripped-envelope SN 2023aew

Dr Tuomas Kangas

University of Turku

Abstract

I present an extensive data set and analysis of SN 2023aew, a double-peaked, type-changing stripped-envelope supernova (SN). SN 2023aew first resembled a SN IIb with hydrogen and helium lines, with a flattened light curve; it then dramatically rebrightened over 100 days after the explosion and started to resemble a SN Ic instead, with no hydrogen and weak or nonexistent helium lines. The spectral evolution in the Ic phase was slow, with low photospheric velocity, low temperatures and a post-peak appearance even during the rise toward the second (and more luminous) peak, during which the rising luminosity is predominantly caused by an increase in temperature, not radius. I discuss several scenarios for the origin of this peculiar SN, including multiple SNe, pre-SN eruptions, and one SN followed by a delayed source of energy. The latter of these is the most promising option, but the exact mechanism of energy injection and the reason for the delay remain unclear.

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Are single stars enough as progenitors of LGRBs

Rafia Sarwar

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Abstract

Stars more massive than $8M_{\odot}$ solar masses are ignited by nuclear-burning processes of chemical elements in their interior until the time of core exhaustion that marks the end of their life cycle. These massive stars strongly affect their surrounding environments through processes such as star formation, stellar winds, ionizing radiation, feedback mechanisms, and core-collapse supernovae. The final fate of evolved massive stars is classically linked to energetic and luminous transient sources, long-duration gamma-ray bursts (LGRBs). In this work, I present the revised and expanded single-star models using MESA along with new observational comparisons. My study demonstrates the impact of rotation during the evolution of these stars, leading to chemically homogeneous evolution followed by various types of supernova explosions. I also compare these theoretical models with the observed number of LGRBs to date with known redshifts. The comparison reveals a discrepancy between the population of single-star models and observations, most likely because the majority of massive stars are in binary systems, and single-star models alone are insufficient to explain progenitors of LGRB.

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The molecular environment of the LBV star AFGL 2298

Dr J. Ricardo Rizzo[1,2], Dr Cristobal Bordiu[3]

[1]Centro de Astrobiologia (CAB) CSIC/INTA. [2]ISDEFE. [3]INAF - Osservatorio Astrofisico di Catania

Abstract

Luminous blue variable (LBV) stars represent a short-lived stage in the late evolution of the most massive stars. Highly unstable, LBVs exhibit dense stellar winds and episodic eruptions that produce complex circumstellar nebulae, the study of which is crucial to understand the chemical and dynamical evolution of the Galaxy.

A particularly interesting object is AFGL2298. It is a heavily obscured Galactic LBV that hosts a highly structured circumstellar environment with hints of multiple mass-loss events in the last millenia. In this contribution, we present spectral line observations of AFGL 2298 at 1 and 3 mm performed with the IRAM 30 m radio telescope.

We report the detection of several carbon- and nitrogen-bearing species, such as CO, ^{13}CO, C^{18}O, C^{17}O, HCO$^+$, HCN, HNC, H^{13}CO$^+$, CN, N_2H^+, and C_2H. We identified three velocity components that clearly stand out from the Galactic background. The morphology, kinematics, masses, and isotopic ratios, together with a comparative study of the fractional abundances, lead us to suggest that two of these components (36 and 70 km s^{-1}) have a stellar origin. The other component (46 km s^{-1}) most likely traces swept-up interstellar material, and probably also harbours a photon-dominated region.

Our results are compatible with the hypothesis of former mass-loss events produced before the one that created the infrared nebula. The chemical abundances suggest the presence of ejected stellar material, and also swept up gas.

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Effects of winds on the optical and near-infrared properties of type Ib and Ic supernova progenitors.

Mr. Moo-Keon Jung, Prof. Sung-Chul Yoon

Seoul National University

Abstract

While the Hubble Space Telescope (HST) has enabled direct identification of Type II supernova progenitors in pre-explosion images, only three Type Ib/Ic supernova (SN Ib/Ic) progenitors or candidates have been confirmed so far: iPTF13bvn, SN 2017ein, and SN 2019yvr. In this study, we construct synthetic spectra of SN Ib/Ic progenitor models with a wide range of wind parameters using the non-LTE radiative transfer code CMFGEN. Our results show that strong emission lines and free-free emission from hot ionized wind significantly affect the optical and near-infrared (NIR) colors and magnitudes of SN Ib/Ic progenitors. Contrary to previous blackbody-based predictions, the optical/NIR luminosities of SN Ib/Ic progenitors are significantly lower, yet their detectable distance remains limited; SN Ib/Ic progenitors with standard mass-loss rates are detectable in HST images with a 1-hour exposure only if within ~20 Mpc. We conclude that most pre-explosion images of recent SNe Ib/Ic are not deep enough to detect their progenitors with standard mass-loss rates, and SN Ib/Ic progenitors and candidates reported so far may have extremely large mass-loss rates. Additionally, our analysis indicates that NIR observations have advantages in constraining the wind and physical parameters of SN Ib/Ic progenitors over optical observations. The James Webb Space Telescope and the upcoming Nancy Grace Roman Space Telescope are anticipated to have similar or better performance compared to HST in detecting SN Ib/Ic progenitors, potentially offering significant insight into SN Ib/Ic progenitors with deeper and wider NIR observations.

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Chemical enrichment from the first stars in cosmological simulations.

Dyna Ibrahim

University of Hertfordshire

Abstract

The first stars can be constrained by the chemical composition of distant galaxies. It is crucial to understand how and when the first stars formed to understand the formation and evolution of our Universe. The latest observational data reveal unprecedented information about the chemical enrichment of the early Universe, which seems to behave differently from the local Universe. The first stars, being very massive, enrich their metal-poor environment in an uncertain way. To predict the abundances of the first galaxies, we include nucleosynthesis yields from Population III stars up to 300Msun, including faint supernovae, Wolf Rayet and Pair Instability Supernovae into our state-of-the-art hydrodynamical cosmological simulations. Our code (based on Gadget-3) also includes the latest nucleosynthesis yields from population II stars (from Kobayashi et al. 2020) for all stellar mass ranges. We predict the chemical abundance evolution of galaxies for different elements from the early Universe to the local Universe. For example, we find that the N/O abundance gives a systematically larger value with nucleosynthesis yields from Population III stars, which is comparable with observational data of the GN-z11 galaxy. I also discuss the evolution of metallicity gradients and elemental abundances of the intergalactic medium. We constrain our model by comparing it with observational data from the James Web Space Telescope (JWST) and the Atacama Large Millimeter/submillimeter Array (ALMA).

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Diffuse emission sources and massive stars in the dwarf metal-poor galaxy IC 1613

Anastasiya Yarovova[1,2], Dr. Alexei Moiseev[2,3,1], Ivan Gerasimov[1,2], Dr. Milica Vučetić[4], Dr. Oleg Egorov[5,2,1], Dr. Dragana Ilić[4,6], Dr. Ilya Mereminskiy[3], Dr. Yury Pakhomov[7], Dr. Olga Sholukhova[2]

[1]Lomonosov Moscow State University, Sternberg Astronomical Institute. [2]Special Astrophysical Observatory, Russian Academy of Sciences. [3]Space Research Institute of the Russian Academy of Science. [4]University of Belgrade, Faculty of Mathematics, Department of Astronomy. [5]Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg. [6]Hamburger Sternwarte, Universitat Hamburg. [7]Institute of Astronomy of the Russian Academy of Sciences

Abstract

We present a study of the nearby low-metallicity dwarf galaxy IC 1613, focusing on the search for massive stars and related feedback processes, as well as for faint supernova remnants (SNR) in late stages of evolution. We obtained the deepest images of IC 1613 in the narrow-band Hα, He ii and [S ii] emission lines and new long-slit spectroscopy observations using several facilities (6-m BTA, 2.5m SAI MSU, and 150RTT telescopes), in combination with the multi-wavelength archival data from MUSE/VLT, VLA, XMM-Newton, and Swift/XRT.

We identify several faint shells, and further investigate their physical characteristics with the new long-slit spectroscopy observations and the archival multi-wavelength data. Based on energy balance calculations and assumptions about their possible nature, we propose that one of the shells, overlapping with X-ray emission source, is a possible remnant of a supernova explosion. During the study of MUSE data, we found P Cyg profiles in Hα line in two stars. We discuss their nature and classify them as Luminous Blue Variable candidate stars. Our analysis discards 5 of the 8 WR candidates, listed in the previous works, and finds no new ones, which means that the galaxy IC 1613 may have a lower rate of WR star formation than previously suggested.

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It‘s written in the massive stars: How stellar physics determines the formation of black holes and supernovae

Dr. Eva Laplace[1], Dr. Fabian Schneider[1], Prof. Philipp Podsiadlowski[2]

[1]Heidelberg Institute for Theoretical Studies, Heidelberg, Germany. [2]Oxford University, Oxford, UK

Abstract

In the era of all-sky transient searches and gravitational-wave (GW) observations, understanding the final fate of single and binary stars has become increasingly important. The formation of black holes (BH) and supernovae (SNe) is not a simple function of the initial mass of a massive star. Instead, it depends on the final core structure, often expressed in terms of the "compactness parameter", where high compactness indicates BH formation. This link is supported by observations of supernova progenitors, e.g. "missing" high-luminosity red supergiants. Additionally, the observation of a vanishing star, which could be a direct progenitor of a BH, is compatible with model predictions for a star with high compactness. Several independent groups have reported similar patterns in the compactness as a function of mass, despite making different assumptions, pointing to a common mechanism. With detailed stellar models, we investigate the origin of these patterns and show that these are determined by stellar physics, i.e., the timing and energetics of the last burning phases. We find that the final structure of massive stars is not random, but already "written" in their cores at the end of core helium burning. We show how binary mass transfer systematically modifies the final core structure of stars and thus the transients and black holes they produce. We discuss how uncertain stellar physics, such as mixing, mass loss, and uncertain nuclear reaction rates affect the final structure and fate of stars and the opportunities offered by observations to constrain these further.

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The Infrared Revolution: Supernovae with the James Webb Space Telescope

Prof Chris Ashall

Virginia Tech

Abstract

The recent Launch of the James Webb Space Telescope has transformed our understanding of supernovae (SNe) explosions. In this talk, I will present some of the most exciting JWST-SNe results from the MidInfared SuperNovA Collaboration (MIRSNAC). To date, MIRSNAC has been awarded over 180 hours of JWST time through 10 successful proposals spread over the first 5 cycles. I will present the first-ever JWST observations of type Ia SNe (SNe Ia) and core-collapse SNe (CC SNe). For CC SN, I will show observations of the SNe II: 2022acko and 2023ixf, the SN Ic: 2023dbc, and the SN Ib: 2024ahv. Where I will demonstrate how JWST data can be used to as a pathway to understand the formation, composition, and evolution of molecules and dust produced in the ejecta. For SNe Ia, I will present JWST observations of SN 2021aefx and SN 2022xkq, where I will show how JWST data can be used to accurately measure the mass of the primary white dwarf, as well as chemical asphericities within the explosion. Finally, I will project forward and discuss what future scheduled JWST-SNe observations will tell us.

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Variable massive stars

Dr. Alceste Bonanos

National Observatory of Athens

Abstract

I will review the variability properties of evolved massive stars, which are expected to be the progenitors of core-collapse supernovae. In particular, I will present the photometric variability properties of red supergiants, yellow supergiants, blue supergiants and luminous blue variables. I will also discuss spectroscopic variability discovered in certain red supergiants, the so-called Levesque-Massey variables. I will present two extreme red supergiants in the LMC: [W60] B90, which shows evidence for episodic mass loss events, and WOH G64, which recently underwent a spectacular change. Time-series photometry will soon be available for a large number of evolved massive stars in nearby galaxies from deep variability surveys, such as BlackGEM and LSST.

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GRB221009A: The brightest burst of all times, its supernova and host galaxy

Dr Antonio de Ugarte Postigo

CNRS / OCA. CNRS / LAM

Abstract

The gamma-ray burst of the ninth of October 2022 was the brightest ever recorded. It saturated most of the gamma-ray detectors in space and even affected the Earths ionosphere. On ground, Cherenkov detectors measured photons of up to 18 TeV, never seen before for these objects. It's brightness allowed amateur telescopes to observe it for days, and by major facilities for months. It was a very luminous GRB, but what made it truly extraordinary was the combination of this luminosity with its low redshift.

Here I will present a compilation of world-wide observations of this event, including extensive spectroscopic data from 8-10m ground-based telescopes, from space with HST and JWST, and multi-wavelength observations from radio to X-rays. I will give an insight to the physics of the event, its associated supernova, and host galaxy environment. Finally, I will place its significance in the context of extreme astronomical transients and will detail the lessons that this extraordinary event has taught us.

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Late-time evolution of the interacting supernova 2017dio

MSc Christina Humina[1], Doc. Hanindyo Kuncarayakti[1], PhD Claudia Gutiérrez[2,3], Prof. Seppo Mattila[1], PhD Takashi Nagao[1]

[1]University of Turku. [2]Institute of Space Sciences (ICE-CSIC). [3]Institut d'Estudis Espacials de Catalunya (IEEC)

Abstract

Type Ic supernovae (SNe) are explosive deaths of massive stars that have lost their hydrogen and helium layers before the explosion. SN 2017dio is a type Ic SN that exploded in a hydrogen-rich circumstellar medium (CSM). The hydrogen-rich CSM suggests that the CSM should not have originated from the progenitor, but from the companion, which further indicates a very complex mass ejection process. SN 2017dio is an extraordinary case as it is a challenge for stellar evolution theory on how to produce the progenitor of this kind of SN.

We present late-time spectra and light curves of SN 2017dio, which are dominated by the ejecta-CSM interaction. We study the late-phase properties by modelling the lightcurve and analysing the hydrogen emission line profiles, with the goal of determining the properties of the extended CSM. We identify an infrared excess in the light curves, which may have originated from infrared echo produced by pre-existing dust. By modelling this echo, we derive the CSM mass at even greater distances. Deriving the CSM properties at different distances allows us to study the radial distribution of the CSM, which tells us about the time evolution of the progenitor mass-loss history. This can shed light on the mass-loss mechanism and evolution of the progenitor system of SN 2017dio.

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The metamorphosis of SN 2019yvr: late-time interaction

Miss Lucía Ferrari, Dr. Gastón Folatelli

Instituto de Astrofísica de La Plata - CONICET

Abstract

Supernovae (SNe) are among the most energetic and luminous events in the Universe. A significant fraction of them is associated with the collapse of the iron cores of massive stars. Stripped-envelope (SE) SNe show little hydrogen (IIb), no hydrogen (Ib), and no helium (Ic) in their spectra, and the progenitor stars from which they arise are a matter of discussion, as they must have lost their outer layers through strong mass-loss processes.

In this talk, I will present the rare case of SN 2019yvr, which was initially classified as a Type Ib and evolved into a Type IIn-like SN at later times, showing signatures of interaction with hydrogen-rich circumstellar medium (CSM). This is interpreted as an exceptional case where the H-free progenitor explodes inside a H-rich CSM. It also constitutes one of the few SNe of its Type in having progenitor detections on archival Hubble Space Telescope images. I will describe the results of our study, in which we discuss observational evidence of late-time interaction and estimate key quantities such as the CSM inner radius, the mass-loss rate prior to explosion, and the progenitor pre-SN mass.

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Using UV and optical spectroscopy to show supressed mass loss rates of B-supergiants

Olivier Verhamme

Institute of Astronomy KULeuven

Abstract

Radiation-driven mass loss is an important, but still highly debated, driver for the evolution of massive stars. Current massive star evolution models mostly rely on mass loss rate prescription for massive stars which include a sudden increase in mass loss below an effective temperature of about 22 500 K (Vink et al. 2001). However, new mass loss rate predictions show no such bi-stability jump (Björklund et al. 2022). Instead, stellar mass loss decreases with decreasing stellar luminosity/temperature. This will heavily impact the evolutionary models we currently rely on for these stars.

By utilizing UV spectra from the ULLYSES program combined with X-shooter optical data it is possible to obtain mass-loss rate constraints, that are no longer degenerate to the effects of wind clumping, and derive novel empirical constraints on the mass-loss behavior across the temperature range of the presumed bi-stability jump.

We obtain stellar and wind parameters through spectral fitting using the 1D spectral synthesis code FASTWIND and genetic algorithm code Kiwi-GA. In my talk, I will show the results of this method on Large Magellanic Cloud B-supergiants. The discussion will focus on how we can show that there is no evidence for a bi-stability jump as implemented in evolutionary codes and on what this means for envelope stripping of massive stars.

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SNe Type II, stripped-envelope SNe, and superluminous SNe

Dr. Daichi Hiramatsu

Center for Astrophysics | Harvard & Smithsonian

Abstract

Supernovae are among the most influential events in every astrophysical scale. New wide-field and high-cadence transient surveys have enabled us to watch supernovae from the moment of explosion. Paired with rapid and continuous monitoring facilities, these observations have revealed unprecedented features that bridge our understanding of their progenitor systems to explosion mechanisms and power sources. In this talk, I will review the recent advancements in core-collapse supernova observations and theories, especially in the context of their classifications and a possible continuum between each class.

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Progenitors of different stellar explosions: can the environment give us further clues?

Dr. Christina Thöne

ASU-CAS

Abstract

The progenitors of many explosive transients such as GRBs, SLSNe and more exotic objects have still many open questions. Due to their scarcity and large distances, observing the progenitor directly is currently out of reach, so we have to rely on studying their environment at the best possible detail. It has become clear that the host populations of different transients might indeed be different regarding metallicity, star formation, stellar population age and dust, giving some hint of different progenitors. Past studies have also shown the importance to study local properties with IFUs. Here we present one of the closest long GRB hosts so, grand-design spiral, which is an unusual type of long GRB host. Its proximity allowed an highly detailed study of the GRB star-forming region, and also study its molecular and neutral hydrogen in unprecedented detail. The GRB site suggests some unusual star formation going on in this otherwise rather undisturbed, mildly star-forming galaxy, for which there is only a hint in the neutral gas distribution. We also compare the GRB site to the (small) sample of long GRB and SLSN environments and finally also take a comparison sample of seemingly similar (dwarf) galaxies to long GRB and SLSN hosts. Only selecting galaxies by low mass, low metallicity and young stellar population age, however, seems to result in a sample that is different from the properties we see in long GRB and SLSN hosts. Something else has to be in play to produce the progenitor of extreme stellar explosions.

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Unveiling Diverse Progenitors in Gamma Ray Bursts using Machine Learning

Dr Dimple Dimple[1], Prof K G Arun[1], Dr Kuntal Misra[2]

[1]CMI, INDIA. [2]ARIES, INDIA

Abstract

We present a machine learning (ML) approach to classify the progenitors of gamma-ray bursts (GRBs), the most energetic explosions in the universe. The traditional duration-based classification of GRBs has been challenged by recent observations of long GRBs with kilonovae (KNe) and short GRBs with supernova associations. We applied the PCA-tSNE/UMAP clustering algorithm to the prompt-emission light curves of GRBs from the Swift/BAT 2022 GRB catalog and identified five distinct clusters of GRBs. These clusters might represent variations within the collapsar model, where the core collapse of a massive star leads to a black hole and potentially a GRB. Differences in the mass, rotation, and composition of these stars could contribute to the formation of distinct clusters with varying ejecta properties and resulting GRB characteristics. Further, we found KN-associated GRBs clustered at two distinct locations in the maps, suggesting different progenitors. We propose that these clusters may represent subclasses of binary neutron star and/or neutron star-black hole mergers, with different mass ratios, spins, and ejecta properties. Notably, the distinct clustering of long GRBs associated with KNe aligns with previous findings, highlighting the potential of ML to unveil hidden patterns in astrophysics and contribute to our understanding of these events. Our study underscores ML's pivotal role in advancing our understanding of GRB progenitors and multimessenger astronomy.

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Asphericity in Superluminous Supernovae

Dr Rupak Roy

Manipal Centre for Natural Sciences, Manipal Academy of Higher Education, Manipal, Karnataka, India.

Abstract

Superluminous Supernovae (SLSNe) are rare and belong to the class of extremely luminous transients ever detected so far. The powering mechanisms, as well as the geometry of the SLSNe explosions, are yet not resolved. It is also not clear, among various types of SLSNe powering mechanisms (i.e., magnetar, Shock interaction, and Pair instability processes) which one creates more asymmetric explosions. Spectropolarimetric study of SLSNe are extremely important to probe the asymmetric properties of such explosions and hence their geometry. We performed spectropolarimetric observations of several SLSNe viz. SN2018bsz, and SN2018ibb using 10m SALT telescope, and have analyzed the data to explore the asymmetry in their explosions. Noteworthy, SN2018ibb is a probable pair-instability supernova, whereas SN2018bsz is most likely a interaction powered event. Here, we will discuss about the spectropolarimetric observations, polarizations of different lines in the observed spectra of these explosions, and hence asphericity and geometries of such explosions. We will also do a comparative study of these events with the asymmetric properties (i.e., polarization properties) of other cosmic catastrophes.

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TRAPUM search for radio pulsars in the Large Magellanic Cloud with MeerKAT: First discoveries.

Mr Venu Prayag

University of Cape Town. TRAPUM (Transients and Pulsars with MeerKAT)

Abstract

The Large Magellanic Cloud (LMC), at 50 kpc away from Earth, is one of our closest galactic neighbours. It has distinctive traits, including a lower metallicity, a higher rate of star formation, a larger abundance of supernova remnants, and a greater presence of high-mass X-ray binaries per unit mass compared to our Milky Way galaxy. Consequently, the LMC serves as an extraordinary astronomical laboratory for studying pulsar populations in an environment different to that of the Milky Way. As part of the TRAPUM project, using MeerKAT, we are conducting targeted searches for extragalactic radio pulsars within the LMC. MeerKAT achieves over 3 times the sensitivity of previous LMC surveys, enabling us to probe deeper than before. The additional sensitivity of MeerKAT has proven its worth and I will be presenting all of our new discoveries, keeping in mind that prior to this study, only 25 pulsars were known in the LMC.

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Broadband investigation of neutron star low-mass X-ray binary GX 349+2

Dr. Unnati Kashyap

Texas Tech University

Abstract

Compact objects are the ideal laboratories for studying signatures in the robust gravitational field regime. Low Mass X-ray binaries (LMXBs) are composed of compact objects, neutron stars (NS), or black holes (BH) and provide an excellent platform to compare the theoretical predictions with the observational signatures present in the surrounding environment of the central compact object, especially the X-ray emissions from the accretion disk. We report a broadband investigation of the Z-type NS LMXB GX 349+2 using AstroSat and NICER. The source exhibits large-scale variability in its normal branch (NB) /flaring branch (FB) vertex and flaring branch (FB) during AstroSat observations while showing a moderate evolution during NICER observations. We investigate the source variability, their energy dependence, and their correlation with the spectral states. The joint spectral modeling probes the source spectra to be of thermal and non-thermal origin. The origin of the thermal component is attributed to the accretion disk and a hotspot on the NS boundary layer or surface, well described by a disk blackbody and a blackbody component. A power law well represents the hard non-thermal coronal emission. As predicted by the gravitational redshift, we find a correlation between the line energy detected in NICER spectra and the inner disc radius. Using this correlation, we demonstrate the potential of a method to constrain the accreting compact object properties, including evolving continuum and line spectroscopy. We report the first detection of hard lag, providing evidence of the VLFN originating from the accretion disc in NS LMXBs.

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Dummy abstract for invited speaker D. Perley

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Abstract

Dummy abstract for invited speaker D. Perley

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Observational constraints on massive binary star evolution

Dr. Tomer Shenar

Tel Aviv University

Abstract

Binary interactions are commonplace among massive stars, giving rise observed phenomena such as X-ray binaries, stripped stars & supernovae, and gravitational-wave sources. Understanding the frequency and resulting products of these interactions at different metallicity environments is therefore crucial. The multiplicity properties of OB-type stars represent a fundamental input for stellar evolution and population synthesis models, dictating the future evolution of massive-star populations. In contrast, the multiplicity properties of evolved massive stars such as cool supergiants, luminous blue variables, Oe/Be stars, helium stars, and single-degenerate binaries are needed to calibrate, test, and bechnmark our models of single-star and binary evolution. In my talk, I will provide a summary of the observables of massive binaries across the mass and age range, and discuss some open problems in the field.

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Dummy abstract for invited speaker Y. Götberg

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Abstract

Dummy abstract for invited speaker Y. Götberg

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Understanding Red Supergiant Mass Loss Using UV and Optical Spectroscopy of Hydrogen-Rich Supernovae

Dr Azalee Bostroem

University of Arizona

Abstract

We are just starting to appreciate the extent to which interaction with circumstellar material influences the observations of type IIP/L supernovae. Post-explosion observations constrain the final moments of red supergiant mass loss, which appears to be much stronger than initially thought. However, the strongest signatures of interaction are most visible immediately after explosion and quickly fade or are at UV wavelengths. I will present two supernovae, discovered nearby and within a day of explosion, SN 2022acko and SN 2023ixf, which both have comprehensive UV (HST spectra) and optical datasets. I will show the earliest FUV spectrum of a type IIP supernova which shows no evidence of interaction with circumstellar material, although the rapidly rising light curve and late time spectra imply otherwise. In contrast, SN 2023ixf is strongly interacting in optical spectroscopy with narrow emission lines that evolve on sub-night time scales and in UV spectroscopy with features from interaction with circumstellar material up to 65 days after explosion. Understanding circumstellar interaction in the UV and optical is critical to interpreting the light curves from the Rubin Observatory and the Roman Space Telescope, neither of which include UV wavelengths or spectroscopy, and which will push our sample of type II supernovae to significantly higher redshift.

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Archival supernovae detected with the MeerLICHT telescope: A quest for precursors

Mr Orapeleng Mogawana[1,2], Prof Paul Groot[1,2,3]

[1]University of Cape Town. [2]South African Astronomical Observatory. [3]Radboud University

Abstract

The majority of massive stars end their lives by ejecting their outer envelopes in a core-collapse supernova explosion. A growing number of core-collapse supernovae (SN) present an outburst before their presumably final explosion. These SN precursors are probably related to the unknown phenomenon in the final stages of massive star evolution. By searching through data obtained in the MeerLICHT/BlackGEM Local Transient Program, where the nearby (d<200 Mpc) mass concentrations in our Universe are targeted on an hourly-weekly basis. We built a volume-complete sample of supernovae, detected in the earliest possible phases to present a search for supernova precursors in a sample of 127 observed supernovae and understand their frequency and appearance in the framework of massive star evolution.

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Polarization signature showing an elevated and asymmetric mass loss from the progenitor of SN2023ixf prior to the explosion

Dr. Manisha Shrestha

University of Arizona

Abstract

The progenitors of hydrogen-rich supernovae are red supergiants. However, the mass loss in the final years before a red supergiant's supernova explosion is not well understood and is difficult to observe directly. Interestingly, the circumstellar material (CSM) created by this mass loss can have an impact on the light curve, spectra, and polarization. In particular, polarimetric observations can constrain CSM geometry which cannot be resolved using traditional astronomical techniques. With these observations, we are starting to explore the structure and element distribution of these explosions shedding light on the mass loss of red supergiants in their final phase.

In this talk, I will discuss our polarimetry data analysis of SN2023ixf, the closest supernova in a decade, spanning from 2 to 100 days after its discovery. We detect significant intrinsic polarization during the light curve rise**,** a decrease in polarization during the plateau phase, and a rise when the light curve falls from the plateau, about 100 days after the explosion. Spectrophoarimetry data of H alpha shows that the outer regions of the supernova ejecta and CSM are aligned. Whereas the line polarization around the He II line shows a position angle shift from the continuum indicating a possibility of a different location for He II with respect to continuum emission. This analysis indicates an aspherical CSM and ejecta for SN2023ixf signifying an elevated and asymmetrical mass loss from the progenitor right before the supernova explosion. This study shows the power of the polarization technique in deciphering the mass loss process.

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How Low Can We Go: Minimum Spectroscopic Requirements for Supernova Subtype Classification

Willow Fortino, Dr. Federica Bianco

University of Delaware

Abstract

Millions of supernovae will be discovered with the Rubin Observatory Legacy Survey of Space and Time (LSST). As a result, spectrographs around the world will have to make difficult decisions about which supernova candidates receive spectroscopic follow-ups. This work identifies the minimum spectral resolving power, R = lambda / Delta lambda, as a function of signal-to-noise-ratio at which spectral classification of supernova subtypes becomes impossible. We developed a novel method for simulating future low-resolution spectra by degrading existing high-resolution data. We used an updated version of DASH (Muthukrishna et al. 2019), a convolutional neural network classifier, and a newly developed transformer-based classifier (Vaswani et al. 2017) to predict the supernova type of spectra at various resolutions. Our dataset includes 16 different supernova types including subtypes of Ia, Core Collapse and interacting supernovae. We hope that target observation managers associated with the LSST alert stream, as well as designers of future observatories, will benefit from knowing what spectral resolution is necessary to classify a supernova for arbitrary SNR.

Session

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The Life Story of Stripped-Envelope Supernovae as told through JWST Observations

Dr Melissa Shahbandeh

STScI

Abstract

Dust plays a crucial role in the evolution of the cosmos, yet its origins have long been enigmatic. This presentation focuses on the study of stripped-envelope supernovae (SESN) and the intricate physics involved in their dust production. Specifically, we delve into the observations made possible by the James Webb Space Telescope (JWST), which provide unprecedented insights into the formation of dust precursors such as CO and SiO in the aftermath of SESN explosions. By analyzing NIRSpec and MIRI spectroscopy data from nearby SESNs, we aim to unravel the poorly understood composition of SESN ejecta. I will present NIRSpec and MIRI early spectroscopy of a “once in a decade” nearby stripped-envelope supernova (SESN), SN 2023dbc, which, remarkably, has captured the emergence of dust precursors CO and SiO and allowed us to uniquely probe the poorly constrained ejecta composition of SESNe (DD-4436, DD-4520, GO-6213, PI: Shahbandeh). I will also present JWST observations of Type Ib SN 2024ahv (GO-4217, PI: Shahbandeh). Our findings challenge previous assumptions about dust production in SESNe, and provide critical insights into the physics governing dust production in these objects, advancing our understanding of their role in early cosmic dust enrichment.

Session

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Disentangling Newly Formed and Pre-existing Dust in SN 2017eaw

Jeniveve Pearson

University of Arizona

Abstract

The final life stages and violent deaths of massive stars are factories for dust formation. Some or all of the dust located in the circumstellar medium (CSM) around the progenitor may survive the explosion, while new dust can form in the cooling supernova ejecta after explosion. Dust formation in core-collapse supernovae is of particular interest as it may be responsible for a significant amount of early universe dust. However, disentangling pre-supernovae dust from the newly-formed dust is nontrivial and requires continued monitoring of the infrared luminosities of supernovae. The incredible depth and filter set of JWST's Mid-Infrared Instrument (MIRI) provides the opportunity to place robust limits on the scale and duration of dust formation in core-collapse supernovae. In this talk, I will discuss Cycle 1 and 2 JWST MIRI images of SN 2017eaw, a well-studied dusty supernova. The mid-infrared luminosity of SN 2017eaw decreased between the two epochs suggesting that a significant portion of the observable dust may predate the collapse of the star. These observations, alongside the rest of our JWST Cycle 2 supernovae sample, hint that pre-existing CSM dust may be a larger component of the dust observed in core collapse supernovae than previously believed and that additional mechanisms of dust formation may be necessary to explain all of the early universe dust.

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Rapid follow-up of gravitational wave events with a robotic meter-class optical telescope

Mr. Vishwajeet Swain[1], Mr. Ravi Kumar[1], Mr. Dhananjay Raman[1], Mr. Aswin Suresh[1], Mr. Tamojeet Roychowdhury[1], Mr. Yogesh Wagh[1], Mr. Judhajeet Basu[2], Mr. Harsh Kumar[1,3], Prof. Varun Bhalerao[1], Prof. G. C. Anupama[2], Prof. Sudhanshu Barway[2]

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Abstract

The GROWTH-India Telescope (GIT) is India's first fully robotic telescope, set up as a part of the international GROWTH network. The primary goal of GIT is rapid-response time-domain observations of gamma-ray bursts, novae, supernovae, fast optical transients, near earth objects, and, particularly, follow-up of EMGW sources. Our location allows us to fill a longitude gap between major observatories, providing critical continuous coverage for rapidly varying sources. To ensure rapid response, GIT monitors Kafka-based prompt GW alerts from General Coordinates Network (GCN) and automatically triggers neutron star mergers based on specific pre-defined criteria. Based on the localisation area, GIT may undertake observations in one of three modes: (a) tiling the entire localisation, (b) galaxy catalogue weighted observations (c) follow up of candidates reported by other telescopes. A custom dashboard allows us to monitor telescope operations. All data are automatically reduced, including image subtraction and photometry. A machine-learning pipeline trained on our data identifies transient candidates served on an interface for human vetting. The entire software for telescope operations, data processing, and transient identification was developed in-house by team of students. The system worked well in O4a, observing run of IGWN and has since been enhanced based on lessons we learned. I will present our workflows, lessons learnt, and key results from our follow-up efforts.

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The first polarimetric catalogue of Be X-Ray Binaries

Dr Pere Blay

Valencian International University - VIU / Telespazio UK / ESA-ESAC

Abstract

Be X-Ray Binaries are clue targets to understand the evolution of massive stars in binary systems both in terms of past interactions as well as likely progenitors of compact object binaries. Furthermore, the presence of a circumstellar disk in Be stars in not yet fully understood, but clearly related to the evolutionary stage of the early-type star. Polarimetric measurements directly yield the determination of the circumstellar disk properties. Comparison of the disk behavior of Be stars in binaries to that of the disk in isolated ones helps also to understand the evolution of such structure. In this line, a comprehensive campaign on measuring the polarimetric properties of Be stars in x-ray binary systems has been carried out. As well as to characterize Be X-ray binaries, this campaign also allows to identify peculiar targets for further analysis. We present here the first comprehensive catalogue of linear optical polarimetry in Be x-ray binary systems.

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Abstract

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New and future discoveries observing molecular and atomic lines

Prof Francoise Combes

Paris Observatory. Collège de France

Abstract

The Large Program MALS (MeerKAT Absorption Line Survey) has 1600 hours to observe in the two bands L and UHF, and produce the largest blind survey of the HI and OH lines, for redshifts between 0 and 1.8. The goals are to derive the cold gas evolution with redshift and relation to star formation, probe AGN feeding and feedback independant of obscuration, probe the variation of fundamental constants, among others. It has already obtained new detections of HI and OH in absorption in front of strong radio sources, and detected the most luminous known 1720 MHz maser line. I will describe the limitations due to RFI.

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Radio spectral properties of star-forming galaxies based on the SKA pathfinders' radio continuum surveys

Dr Fangxia An

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Abstract

The high-sensitivity and wide-field extragalactic radio continuum surveys, conducted using facilities such as MeerKAT, ASKAP, and eventually the Square Kilometre Array (SKA), mean that radio continuum observations are set to become a routine tool in exploring cosmic evolution. A well-determined radio spectrum of star-forming galaxy (SFG) is crucial for such studies based on rest-frame radio power, especially those at high-redshift where k-corrections are generally contingent on extrapolation. In this talk, I will introduce two of our recently completed projects based on the MeerKAT+VLA+GMRT data in the COSMOS field and the LOFAR+GMRT+VLA data in the ELAIS-N1 field. The MeerKAT data we used are from the MIGHTEE (MeerKAT International GHz Tiered Extragalactic Exploration) project and the LOFAR data are from the LoTSS (LOFAR Two-metre Sky Survey) project. I will present our measured radio spectral indices between the observer-frame frequencies of 150-400, 400-610, 400-1300MHz, 1.3-3GHz, and 610-5000MHz respectively and show the correlations between radio spectrum and physical properties of radio-selected SFGs. With these results, I will discuss the possible physical mechanisms that determine the radio spectrum of SFGs. I will also show how the adoption of these different radio spectral indices (from low- and high-frequency) in k-correction affects the study of far-infrared-radio correlation of SFGs, as well as implications for studies of cosmic evolution via radio continuum emissions.

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Radio astronomy on the Moon and the lunar-orbit Hongmeng project

Dr Yidong Xu

National Astronomical Observatories, CAS

Abstract

Radio astronomy are suffering from increasingly crowded RFIs at low frequencies on the ground, and even in the near space. Some science goals will only be enabled, or best achieved, by radio observations in the shielded zone of the Moon. After a brief overview of the science cases, and the current and future experiments, on the Moon, I'll focus on the "Hongmeng project", which is a proposed interferometer array made up of a formation of satellites in a lunar orbit. The scientific objectives include making high precision measurement of global spectrum, probing the cosmic dawn and dark ages; realizing ultra-long wavelength sky survey with a high resolution for the first time, opening up the last unexplored electromagnetic window; and monitoring the radio activity of the Sun and planets. In this talk I'll introduce the mission concept, the main science cases, as well as the current status of the Hongmeng project.

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A Supervised Deep Learning Approach for Enhanced Pulsar Observation through Combined RFI Detection and Restoration

Xiao Zhang[1,2], Ismaël Cognard[1,3], Nicolas Dobigeon[2]

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Abstract

Radio frequency interference (RFI) is a persistent challenge in radio astronomy, particularly in pulsar observations where precision and sensitivity are required. Conventional approaches to RFI mitigation involve the detection of potential RFI in dynamic spectra, often resulting in a loss of information as identified RFI-affected portions are excluded from subsequent data processing.

In our work, we reframe RFI mitigation as a combined detection and recovery effort, enabling the identification and recovery of RFI-affected regions within the dynamic spectrum. Our proposed supervised method utilises a deep convolutional network, exploiting advances from a well-established image denoising network. Through extensive experimentation, we have compared our approach with recent deep learning-based methods, demonstrating superior performance in both detection and restoration tasks. In particular, our method significantly improves the estimation of the time of arrival of pulsar signals, highlighting its potential impact on the advancement of precision radio astronomy.

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Upcoming challenges for radio astronomy spectrum management in the 2023-2027 ITU-R study cycle

Mr Boris Sorokin, Mr. Federico Di Vruno

Square Kilometre Array Observatory

Abstract

Following the World Radiocommunication Conference 2023 (WRC-23), the new study cycle of the radiocommunication sector of the International Telecommunication Union (ITU-R) in 2024-2027 introduces pivotal challenges and opportunities for radio astronomy in the spectrum management field. The WRC-23 outcomes could be grouped into outcomes of 2023 agenda items and preparations for the next WRC. The latter one was quite successful for the radio astronomy service, leading to the creation of two agenda items dedicated to radio astronomy protection – for the first time in several ITU-R study cycles. Conversely, other WRC27 agenda items, like the one connected with direct satellite-to-device communications, pose a great threat to radio astronomy observatories worldwide.

In this presentation, the overview of WRC-23 outcomes is presented to share the foreseen changes in radio interference background across the radio spectrum. The analysis of the agenda items for the next WRC is also presented, identifying the most pressing threats for radio astronomy, and discussing possible ways forward to get the most from both the new study cycle and the upcoming World Radiocommunication Conference 2027. A general overview of the ITU-R study cycle and process is also provided.

Finally, the importance of strategic planning and international cooperation in addressing spectrum management challenges, ensuring radio astronomy's continued ability to explore the cosmos unimpeded by interference is also highlighted and supported by introducing examples of successful international cooperation to secure the consideration of radio astronomy protection.

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Can you access the full radio spectrum? a realistic view on the use of a scarce resource!

Mr Federico Di Vruno

SKA Observatory. IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference

Abstract

This presentation will present a review of the use of the radio spectrum, starting from a historical review to the complex regulatory landscape we live in, all from the perspective of radio astronomy. We will discuss how the radio spectrum is divided and regulated internationally by the International Radiocommunication Union, touching items like: what is harm according to the ITU?, which frequency bands are protected for radio astronomy?, how do these protections apply?, and what do spectrum managers do?

Later we will discuss how national radio regulatory agencies apply the Radio Regulations and what can a radio astronomy observatory do to protect their radio spectrum environment. Ranging from how to interact with the national administration to what national policies can be implemented to safeguard observations.

This presentation will give a perhaps grim but realistic view of how the radio spectrum is used, and regulated, and what rights and tools do radio astronomy have over it.

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Radio frequency interference the menace: The band-2 of upgraded GMRT

Dr. Dharam Lal

National Centre for Radio Astrophysics TIFR

Abstract

The performance of radio interferometers can be severely affected by the radio frequency interference (RFI). The spectral domain of Giant Metrewave Radio Telescope (GMRT) for studying the astronomical objects extends from around 120 MHz to 1.45 GHz. Much of this spectral domain is also shared with communication industry, which is critical to society. For example, the band-2 of upgraded GMRT suffers severely from police wireless communications, air traffic controller, television signal, power line sparking, etc., which are all strong radio signals as compared to the extremely weak signal from the astronomical objects. The upgrade of GMRT made the (legacy) GMRT more sensitive; thus the threshold for detecting unwanted signal has moved to fainter levels, exposing it to greater number of RFI sources. We have made developments in RFI mitigation designed for all bands of the upgraded GMRT, e.g., the notch filter, tunable filter-bank, real-time RFI filter, etc., and here I would present our early results for the band-2 of upgraded GMRT. More specifically, its performance, comparisons between pre- and post-RFI mitigated data, and imaging results from our efforts to minimize the effect of interfering signals.

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The ultra-long wavelength sky model and reconstruction for the 3-D Galactic interstellar electrons

Dr. Bin Yue[1], Dr. Yanping Cong[2], Prof. Yidong Xu[1], Prof. Xuelei Chen[1], Dr. Yuan Shi[3], Dr. Shifan Zuo[1]

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Abstract

The ultra-long wavelength, or the ultra-low frequency, refers to the electromagnetic wave below 30 MHz in astronomy. This band, particularly below ~10 MHz, is largely unexplored because of the absorption and distortion by the Earth's ionosphere. Many projects, such as the DSL, FARSIDE, DAPPER, luSEE-Night, PRATUSH, and so on, have been proposed to explore this new electromagnetic window at the farside of the Moon, which is the best site for the ultra-long wavelength astronomy. To prepare for the upcoming era of ultra-long wavelength astronomy, we developed a sky model. We took into account the free-free absorption by electrons in the Galactic interstellar medium, making the model valid for frequencies down to ~ 1 MHz. We predict that at such low frequencies the morphology of the radio sky is very different from higher frequencies. Moreover, we proposed that, such absorption mechanism can help us to re-construct the 3-D distribution of free electrons in our Milky Way.

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The MeerKAT View of the Shapley Supercluster: Calibration, Mosaicing and Initial Science Results

Mr Keegan Trehaeven[1,2], Prof Oleg Smirnov[1,3], Dr Tiziana Venturi[2]

[1]Rhodes University. [2]Italian National Institute for Astrophysics (INAF). [3]South African Radio Astronomy Observatory (SARAO)

Abstract

The Shapley Supercluster is the most massive gravitationally bound structure in the nearby Universe, consisting of many galaxy clusters and groups at various evolutionary stages of merger activity. Using various SKA pathfinders, we study this prime example of the Universe's large-scale structure formation at unprecedented sensitivities. Recent MeerKAT (816MHz and 1283MHz), ASKAP (887MHz) and uGMRT (400MHz) observations are proving that a wealth of new science is available if sufficient sensitivity is reached. The core of the complex hosts an extremely faint ~ 1 Mpc inter-cluster radio bridge that is thought to trace the path of turbulence induced by merger activity, and many other non-thermal diffuse sources that probe the underlying dynamics and formation history of this chaotic environment. In particular, the MeerKAT data represents the state-of-the-art in GHz-frequency radio continuum science. However, tracing the merger in detail with high-resolution, robust spectral index and ageing maps requires ultra-deep continuum images of uniform sensitivity across the entire complex. We demonstrate using DDFacet and other radio interferometric data reduction software a novel technique of visibility-plane primary-beam-corrected mosaicing, including direction-dependent calibration and point source subtraction. This technique can be extended to large survey projects such as those planned for the MeerKAT+ and the SKA to, in principle, image the entire radio sky at an unprecedented sensitivity. Such fantastic data would not be possible without the careful characterisation and excision of RFI from each observation site. If the SKA is to push the boundaries of discovery even further, protecting its radio sky is critical.

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Large-scale Array for Radio Astronomy on the Farside of the Moon

Prof. Xuelei Chen[1], Prof. Feng Gao[2], Dr. Fengquan Wu[1], Prof. Yechi Zhang[2], Dr Tong Wang[2], Dr Weilin Liu[2], Prof. Yidong Xu[1], Dr. Bin Yue[1]

[1]National Astronomical Observatories, Chinese Academy of Science. [2]Beijing Institute of Space System Engineering

Abstract

On the farside of the Moon, the radio frequency interference (RFI) from the Earth is shielded. Furthermore, the absence of a thick ionosphere means that it is particularly suitable for low frequency observation. Comparing with an array on the lunar orbit, the lunar surface provides a stable platform, which makes it easier to maintain a large array. To detect the primordial fluctuations in the dark ages, which preserves most information about the cosmic origin, it is necessary to deploy arrays of extremely large scale. As a step towards that direction, we propose to build a relatively large array in the far side of the Moon, with a few hundred antennas, grouped into about 20 stations, with maximum baseline of 10 km. The stations are connected by power lines and optical cables. The array will make interferometric observation in the 0.1-50 MHz band during the lunar night, powered by regenerated fuel cells (RFCs). The whole array can be carried to the lunar surface with a heavy rocket mission, and deployed with a rover in 8 months. It has a sufficiently high sensitivity to observe many radio sources in the sky, though still short of the primordial fluctuations. We discuss the possible options in the power supply, data communication, and site selection.

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Managing Radio Frequency Interference at the Giant Metrewave Radio Telescope

Prof. Divya Oberoi, Mr. Pravin Raybole, Mr. Ankur Prajapati, Mr. Sanjeet Rai, Mr. Sureshkumar S., Dr. Shriharsh Tendulkar, Prof. Yashwant Gupta

National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, India

Abstract

Driven by the necessity to shield themselves from the intentional and unintentional radio emissions, many radio telescopes are located in sparsely populated areas, where it is feasible to establish large radio quiet reserves. However, there are also major facilities like the Giant Metrewave Radio Telescope (GMRT) which are located in comparatively populated areas where establishing a radio quiet zone is infeasible. Additionally, radio observatories across the world are moving towards wider bandwidths in their quest for higher sensitivity, further increasing the ever growing contention for radio spectrum. At the GMRT, we have successfully been following a co-existence model for limiting the radio frequency interference (RFI) in the GMRT frequency bands, by looking for ways to meet the needs of other stakeholders while maintaining low levels of RFI around the GMRT. This presentation will give glimpses of the various aspects of the efforts towards this end. In addition to comprehensive efforts directed towards (a) hardware based RFI filtering, (b) observing strategy based RFI avoidance, (c) statistics based real time RFI excision, key aspects of this effort include: (1) engaging with the policy makers for obtaining and ensuring continued RFI protection from intentional emissions (e.g. telecom services); (2) working with the local Government authorities to ensure a NOC from GMRT management for setting up new industries; (3) vigilant RFI monitoring to quickly become aware of new RFI sources; and (4) working with neighbors (industries, farmers etc.) to minimize unintentional RFI by identifying and suggesting EMC compatible products and devising shielding solutions.

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The added value of the Hellenic Radio Telescope THERMOpYlae in Radioastronomy: One step closer towards completion

Assistant Professor Nectaria Gizani[1], Assistant Professor Giorgos Veldes[2]

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Abstract

We present the Hellenic Project of conversion of a 30m telecommunication antenna into a capable radio telescope in the most southeastern point of Europe. We emphasize the THERMOpYlae's scientific added value in the very large baseline linked radio telescopes within the European content as well as globally. We will report on the progress of the completion, the RFI measurements of the site and the next steps of the commissioning.

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An alternate view of Radio Frequency Interference (RFI) using petabytes of data.

Dr Nadeem Oozeer[1,2], Mr Isaac Sihlangu[1], Prof Bruce Bassett[3]

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Abstract

In our unrelenting quest to unravel the mysteries of the cosmos, radio astronomers are embarking on the construction of increasingly sensitive radio telescopes, exemplified by groundbreaking instruments like MeerKAT, ASKAP, and the future SKA. However, this remarkable progress carries with it a caveat – the acquisition of a multitude of extraneous signals, commonly known as radio frequency interference (RFI), which taint the very essence of scientific radio data.

In this talk, I shall elucidate how a profound comprehension of the RFI landscape can empower astronomers to glean deeper insights from their radio datasets, consequently furnishing them with the assurance to accurately identify and flag their data.

I shall expound upon a nuanced probabilistic framework designed to characterize the intricate radio environment enveloping the SKA-mid telescopes, coupled with an exploration of innovative methodologies tailored to discern and isolate these unwelcome RFI intrusions. We will show how probabilistic models have been used to understand the RFI environment from analysis of over a peta-bytes of MeerKAT observational data.

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Excising and Characterizing Radio Frequency Interference in the UCLA SETI search

Prof. Jean-Luc Margot, Megan Li

University of California, Los Angeles

Abstract

UCLA SETI has been conducting a search for narrowband (3 Hz) radio signals with the L-band receiver (1.15-1.73 GHz) of the 100 m diameter Green Bank Telescope since 2016. We have captured radio emissions from 55,555 stars and planetary systems in the ~9 arcminute beam of the telescope and identified 82 million candidate signals to date. All detections were either automatically rejected or visually inspected and confirmed to be of anthropogenic nature. Frequency histograms of the detections reveal potent interferers. After injection of artificial signals in raw voltage data, the UCLA SETI pipeline recovers 94.0% of the injected signals over the usable frequency range of the receiver and 98.7% of the injections when regions of dense radio frequency interference (RFI) are excluded. Therefore, RFI remains a substantial challenge and the automatic removal of RFI in near-real-time is an important goal. With participation from over 30,000 volunteers at http://arewealone.earth, we have assembled a large training set containing over 70,000 dynamic spectra from approximately 20 of the most prevalent RFI sources. We are developing machine learning algorithms to automatically recognize and excise the most potent interferers.

Reference: J. L. Margot, M. G. Li, et al. A Search for Technosignatures Around 11,680 Stars with the Green Bank Telescope at 1.15-1.73 GHz. *Astronomical Journal* **166**, 2023. https://doi.org/10.3847/1538-3881/acfda4

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The RAMBO Project

Dr Zsolt Keszthelyi

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Abstract

Dozens of hot stars with OB spectral types have been identified to host large-scale magnetic fields. These fields are globally-organised and form a magnetosphere around the star, crucially impacting its mass loss, rotation, and consequently its evolution and final fate. Despite being enigmatic objects, magnetic hot stars are much less studied in radio frequencies than in other domains of the electromagnetic spectrum. We seek to remedy this issue with a new project called “The RAdio Magnetospheres of B and O Stars” (RAMBO). The main goal of the RAMBO project is to characterise radio magnetospheres, and in particular to evaluate very recent theoretical models about the origin of gyro-synchrotron and auroral cyclotron maser emission. There are two straightforward objectives: i) understand radio flux variability as a function of the rotation cycle by monitoring the radio-bright stars, and ii) detect expected radio emission from yet-undetected magnetic hot stars. We aim to use radio telescopes with a suitable frequency range of ~100 MHz to a few GHz (ASKAP, ATCA, JVLA, MeerKAT, LOFAR, uGMRT) and prepare for SKA, which will provide an order of magnitude higher sensitivity and thus enable us to double our target list. In this contribution, we will outline the project goals and discuss the first results using radio continuum observations with uGMRT.

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Unveiling Magnetic Fields From Star-Forming Regions to Diffuse ISM in M31

Amir Yarahmadi[1], Dr Fatemeh Tabatabaei[1], Dr Rainer Beck[2], Dr Aritra Basu[3]

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Abstract

Magnetic fields play an important role in the energy balance and structure formation in the interstellar medium (ISM)of galaxies. However, the origin of the magnetic fields on different spatial scales and the link between them are still pressing questions. The Andromeda Galaxy (M31) is an ideal laboratory to investigate the magnetic field from kpc scales down to scales of star-forming regions. To measure the field structure, we need high-resolution and high sensitivity data of polarized intensity as well as Faraday rotation (RM) measures. Thanks to the VLA, RM synthesis can be performed on scales of ~60-100 pc and also with high resolution in the Faraday spectrum. We propose L,S, and C band observations of two segments in the 10-kpc ring of M31 to 1) discriminate between the tangled and coherent fields as a function of scale, 2) study the 3-D structure of the coherent field, 3) understand the link between the field in star-forming regions and in the diffuse ISM, and 4) assess amplification theories of the magnetic field

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On the Alleviation of the Impact of Spaceborne RFI on Geodetic VLBI Results

Nlingi Habana[1,2], Leonid Petrov[2], Matthias Schartner[3]

[1]Science Systems and Applications, Inc.. [2]NASA Goddard Space Flight Center. [3]ETH Zurich

Abstract

We will present NASA efforts to mitigate the impact of radio interference from satellite on the VLBI program of monitoring Earth orientation parameters and determination of the terrestrial reference frame. Our approach is to construct a database of hazardous satellites, perform their observations, and develop mitigation strategies depending on the strength of the interfering signal and its frequency range. We present our database of all the potentially threatening satellites that is updated daily and used to map out the satellites in the sky. We will demonstrate results of actual tracking of a radio emitting satellites and show the impact of radio interference from them on VLBI analysis.

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Initiatives for the protection of astrometric and geodetic VLBI observations from unwanted radio signals

Dr. PhD-habil Vincenza Tornatore

Politecnico di Milano - DICA

Abstract

VLBI networks of radio telescopes distributed globally on the Earth's surface regularly observe cosmic electromagnetic radiation emitted by distant, compact objects such as quasars. It is essential the simultaneous operation of pairs of radio telescopes or of multiple telescopes when employed.

The products of the data processing are the coordinates of the telescopes and their kinematic movements for establishment and maintenance of the International Earth Reference Systems (ITRF), the Earth Orientation Parameters (EOP), the angular positions of galactic and extragalactic radio sources for the establishment and maintenance the International Celestial Reference Systems (ICRF) and also the positions of artificial transmitters in near-Earth Space. These products are used in a wide range of studies and applications in astronomy, Earth and environmental sciences. However, VLBI stations are increasingly exposed to unwanted signals from artificial transmitters, both from Earth and from the sky. It is difficult to predict the extent to which VLBI stations will be affected by current and future new active radio services before the end of this decade. To counteract the worsening situation for VLBI, activities are being undertaken in several directions: spectrum management and administration, new technical developments to mitigate interference to VLBI receivers, updating of technical specifications for VLBI and for the forthcoming new VGOS network. In order to rise awareness of the risks involved, some successful initiatives in support of geodetic and astrometric VLBI and VGOS have also been carried out and are ongoing at the level of international bodies such as IAU, IUGG, United Nations, ITU-R.

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Deblending of Radio Sources in the MIGHTEE Survey Using XID+

Dr Eliab Malefahlo

University of the Western Cape

Abstract

Stacking analysis has been a powerful technique for pushing scientific measurements below typical survey detection limits over the past decades. However, when applied to the deep, high-resolution MeerKAT International GHz Tiled Observations of the Extragalactic Sky (MIGHTEE) survey, we encounter challenges. Stacked flux densities are often overestimated due to radio source confusion and angular resolution mismatches compared to the near-infrared (NIR).

In this work, we apply a probabilistic deblending method termed XID+ to the confused MIGHTEE fields to blend them. Leveraging NIR galaxy positions as priors, XID+ models the flux distribution of these blended sources using Bayesian inference. The result is a set of robust, deblended radio fluxes along with their uncertainties at the precise positions of NIR galaxies.

By applying XID+ to MIGHTEE data, we aim to extract fluxes for sources below the nominal confusion limit. These refined measurements will enable us to derive reliable radio source counts and luminosity functions, reaching depths previously unattainable. Furthermore, we can apply our stacking techniques on the debblended fluxes. This approach highlights the need for sophisticated deblending techniques to fully exploit future, confusion-limited radio surveys.

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The Square Kilometre Array project economic potential: Perspective of an African partner country (Botswana).

Mr Kgomotso Thelo

Botswana International University of Science and Technology

Abstract

The Square Kilometre Array (SKA project) is an international effort to build the world's largest radio telescope, with a square kilometre of collecting area. It is among the biggest scientific projects ever undertaken. With the African continent being one of the hosts of the instrument, this presents an opportunity for economic benefit for Africa. This opportunity needs to be exploited and African partner countries must take deliberate steps towards this exploitation. Africa has not been at the vanguard of radio astronomy development, however the potential for growth is limitless. For Botswana in particular, the country is transitioning from a mineral led economy to a knowledge led as it gears towards high income status. With about 70% of Botswana covered by the Kalahari Desert and a vast majority of the land uninhabited and not valuable for agricultural purposes, this presents a case for radio astronomy proliferation. Several advantages for Botswana include;

- A geographical and meteorological advantage for astronomy due to its exceptionally clear skies, low humidity and high, flat and very extensive plateau.
- The low population density of the country means that Botswana has dark skies, largely free from light pollution, and in the radio, relatively sparse sources of radio interference from human activity.
- There is great potential to build on the nation's well-developed tourism industry to add high-value offerings in **astro-tourism**, taking advantage of our exceptionally clear and dark skies.

Botswana has taken active steps in human capital development, policy development and infrastructure as it poises for the SKA.

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1806

RFInder: Radio Frequency Interference data evaluation and reduction

Athanaseus Ramaila[1,2], Filippo Maccagni[3]

[1]Rhodes University. [2]South African Radio Astronomy Observatory. [3]INAF - Osservatorio Astronomico di Cagliari

Abstract

Radio Frequency Interference (RFI) poses a formidable challenge to radio astronomy as the proliferation of radio transmitters exacerbates the presence of terrestrial signals over astrophysical ones. Addressing RFI becomes then increasingly complex. To aid astronomers in grappling with this problem, **RFInder** emerges as a valuable solution. Developed as a Python library, RFInder harnesses the capabilities of Casacore to parse Measurement Set (MS) files, the standard format for radio astronomy data, to explore the presence of RFI in sensitive observations. RFInder detects and visualises instances of RFI within observations. Its outputs include interactive HTML and GIF files, providing detailed insights into the presence of RFI, the flagged visibilities attributed to RFI, and estimations of visibility noise. These visual representations empower astronomers to characterise RFI within their datasets, enabling them to gauge its impact on data quality and make informed decisions regarding further analysis and mitigation strategies. RFInder is a tool, available on the Python Packaging Index and GitHub, that integrates seamlessly into pipeline frameworks. CARACal, a data reduction pipeline, leverages RFInder as a component of its toolkit to manage RFI in various MeerKAT Large Survey Programs, providing a layer of quality control for the data processing. RFInder has shown to be a valuable tool for radio astronomers as it can help identify trends in RFI levels, such as whether RFI is increasing or decreasing and the presence of new RFI sources over time. RFInder empowers researchers to proactively address interference issues and safeguard the integrity of their observations, ensuring high-fidelity results.

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1818

Developments in NRAO-SpaceX Operational Data Sharing (ODS): Exploring Spectrum Coexistence with Satellite Operators

Chris De Pree[1], Anthony Beasley[1], Bang Nhan[1], Daniel Dueri[2], Matt Iverson[2]

[1]National Radio Astronomy Observatory. [2]Space Exploration Technologies Corp.

Abstract

NRAO has spent the past two years carrying out cooperative and coordinated experiments with SpaceX to determine the best path forward for spectrum coexistence in the 10.7-12.7 GHz part of the spectrum. Early experiments in 2021 involved placing a single Starlink User Terminal (UT) at various locations near the Jansky Very Large Array (VLA). Later experiments in 2022 involved the installation of ~60 UTs on the Alamo Navajo Reservation near the VLA. Since that time, NRAO has regularly taken data to explore and analyze the impact of Starlink satellite downlink transmissions on the VLA and Green Bank Telescope (GBT). Experiments in 2023 highlighted the importance of the distance from boresight on the strength and impact of Starlink downlink transmissions. NRAO is currently building an Operational Data Sharing (ODS) system that will inform the Starlink network of the current operating frequency, bandwidth, and pointing of NRAO telescopes. These data will be used by the Starlink network to mitigate the impact of satellite downlink transmissions on radio observations by directing the transmission of certain frequencies away from the boresight of the telescopes when those frequencies are being observed. Experiments performed in early 2024 indicate that this method of telescope boresight avoidance is a highly effective way for satellites and telescopes to coexist. We present recent results and implementation plans for the ODS software. These coexistence mechanisms may be applicable to other parts of the radio spectrum used for space to ground transmissions in systems.

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Exploring the protostellar synchrotron jet in W3(H_2O) via full-polarization observations

Elis Cristina Silva Sales[1], Dr. Ciriaco Goddi[1,2]

[1]University of São Paulo. [2]Radboud University

Abstract

Utilizing the Karl G. Jansky Very Large Array (JVLA), we conducted full-polarization observations on a protostellar synchrotron jet within the W3(H_2O) region, linked to a TW object and a highly polarized water maser source. Our goals are to: (i) intricately map the ionized jet structure and (ii) ascertain the 3D morphology and strength of the magnetic field by analyzing total intensity, spectral index, and polarization of the radio emission. Our methodology involves integrating spectral index and polarization maps to discern thermal (free-free) and non-thermal (synchrotron) emissions. Additionally, we analyze high-resolution radio data spanning multiple frequencies (S, C, X, Ku, K bands). The TW object serves as a valuable case study, shedding light on the magnetic field's role in protostellar jet launching. Moreover, the techniques devised in this study can be extrapolated to investigate magnetic fields through full-polarization observations across a broader spectrum of protostellar jets. This research contributes to advancing our understanding of the intricate interplay between magnetic fields and protostellar jet dynamics.

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1915

The Promise and Peril of Future Space-based Radio Astronomical Observations

Joseph Lazio

Jet Propulsion Laboratory, California Institute of Technology

Abstract

Radio astronomy emerged from Jansky's efforts to characterize "noise" sources interfering with transatlantic communications. Essentially ever since, radio astronomy observations have had to contend with interference, notably including communications transmitters but also from a variety of other services using the radio spectrum. Distinct from many other radio spectrum services, radio astronomers have much more stringent sensitivity requirements and desires to access large swaths of the radio spectrum.

Since before the *Apollo* missions, the surface of the Moon has been identified as a potential site for radio astronomical observations, and the 1971 World Administrative Radio Conference for Space Telecommunications, conducted under the auspices of the International Telecommunications Union, identified the Moon's far side as a potentially desirable site for radio astronomy based on considerations of "interference from terrestrial transmissions" and "unique opportunities for observations" not affected by the Earth's ionosphere.

The motivations for space-based radio astronomical observations have expanded since these early days of radio astronomy, today including aspects of space weather, studies of extrasolar planets, and cosmology and fundamental physics. If maintained in a pristine state, the far side of the Moon remains an attractive site for radio astronomy. However, achieving the ambitious scientific goals may require disturbing its current pristine state. I examine critically the promise and peril of future space-based radio astronomical observations, including from the far side of the Moon.

Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

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1929

New RFI Mitigation Strategies Enabled by the Upgraded Murriyang Receiver Fleet

Dr Jane Kaczmarek

CSIRO

Abstract

Murriyang, the CSIRO Parkes Radio Telescope, is in the process of upgrading its entire receiver fleet, eventually offering unrivaled broad, contiguous bandwidths spanning 704 MHz – 32 GHz. Additionally, the telescope has recently installed a cryogenically cooled phased array feed (CryoPAF) maximising sky coverage with up to 72 beams on the sky with a footprint of 2 square degrees. With such broad bandwidths and large fields of view, the Dish is even more susceptible to the increasing prevalence of radio frequency interference (RFI). Therefore, our modern instruments have been specifically designed to operate in the presence of RFI and we continue to work towards removing the interference whilst leaving the astronomical signal untouched. This talk highlights the work being done to mitigate RFI at the CSIRO Parkes Observatory from known transient sources (e.g. handsets, wi-fi & Bluetooth), persistent ground transmitters (mobile & tv towers) and satellites. The various techniques discussed include new algorithms, both for pre- and post-processed data, reference RFI signals and real-time beam-nulling towards known transient sources. Ultimately, the collaborative efforts invested in RFI mitigation are working towards making Murriyang RFI-free.

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1948

GRIDFlag : RFI flagging in the UV domain

Dr Srikrishna Sekhar

National Radio Astronomy Observatory

Abstract

We present a novel radio frequency intereference (RFI) flagging algorithm called GRIDflag that performs its flagging in the UV domain. RFI is becoming increasingly common, for observations spanning the ~ few MHz to ~ tens of GHz range due to the proliferation of new communication technologies and satellites, as well as other terrestrial emitters such as power lines etc. The presence of RFI presents a systematic noise floor that determines the sensitivity of the observation. Typically, the strong RFI is more straightforward to identify with traditional techniques. However, fainter RFI present in the data can be challenging to detect statistically, and is a systematic contaminant to the visibility data, ultimately determining the noise floor. Further, RFI also contributes to a baseline dependent closure error during calibration and self-calibration. This poses a fundamental limitation on the achievable sensitivity, as well as on the accuracy and reliability of the source morphology.

The GRIDflag algorithm operates by identifying RFI in the gridded UV plane. In a typical interferometric synthesis observation, multiple baselines will contribute points to the same UV cell. Given a sufficient number of points, the RFI affected points can be identified and flagged within a single UV pixel. It has been shown to be efficacious even in the presence of very strong RFI.

In this talk, we discuss in more detail the details of the GRIDflag algorithm, as well as it's applicability and limitations and future directions to increase effectiveness for upcoming telescopes (SKA, ngVLA).

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1952

Searching for 21-cm line absorption in wide-band spectra from a large-area survey

Dr. Hyein Yoon[1,2], Prof. Elaine Sadler[2,3,4], Dr. Elizabeth Mahony[4], ASKAP-FLASH team .[5]

[1]Departmant of Physics and Astronomy, Seoul National University, South Korea. [2]Sydney Institute for Astronomy, The University of Sydney, Australia. [3]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), Australia. [4]ATNF, CSIRO Space and Astronomy, Australia. [5].

Abstract

The ASKAP-FLASH (First Large Absorption Survey in HI) survey is designed to obtain continuous spectral line data in the redshift range from z = 0.4 to 1.0 along the sightline to background radio sources. Over the 1200 hours of the Full Survey, we anticipate acquiring around 300,000 spectra from 600 pointings for the next five years. Our ultimate goal is to identify a few hundreds of HI absorbers from a 25,000 square degree area of the southern sky using ASKAP's lowest frequency wide band, spanning 700 to 1000 MHz. Using the HI absorbers, we aim to determine the evolution of the cold gas in and around galaxies as a function of cosmic time, as well as probing the physical conditions and kinematics of gas in the central region of radio AGNs. Our recently completed Pilot Surveys are crucial tools for validating observations and improving data processing techniques in preparation for the Full Survey. We will discuss the technical challenges encountered during the two phases of Pilot Surveys, and then show how we identify true HI absorption from various artefacts. In addition to the spectra, we will also present high-quality wide-field continuum images obtained simultaneously.

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2010

Solar radio bursts studies in Malaysia: Contributions, Challenges & Prospects

Ms. Nurul Husna Mohammad Bokhari, Assoc. Prof. Ts. Dr. Zety Sharizat Hamidi, Assoc Prof. Dr. Nur Nafhatun Md Shariff

MARA University of Technology (UiTM), Malaysia

Abstract

Solar radio bursts represent a significant aspect of solar activity, with implications for space weather forecasting and understanding solar dynamics. Despite encountering challenges related to tropical climate conditions and some radio frequency interference, Malaysia has actively contributed to this research endeavour and provided observational data as part of the e-CALLISTO network since 2012. This study aims to explore the challenges and prospects of conducting solar radio burst research in Malaysia. Specifically, we seek to identify the obstacles faced by researchers in acquiring and analyzing observational data, as well as the potential opportunities for advancing solar radio burst studies in the Malaysian context. We conducted a comprehensive review of existing literature on solar radio burst studies, focusing on research conducted in Malaysia and relevant international contexts. Additionally, we present an overview of the latest research findings regarding the newly identified subtype SRB III (type VI). Our analysis reveals several challenges faced by researchers conducting solar radio burst studies in Malaysia, including moderate quality observational data and constraints posed by the tropical climate and local environmental conditions. Despite these challenges, we identify promising prospects for advancing solar radio burst research in Malaysia, including more collaboration with international observatories, development of more local observational facilities, and enhancement of solar physics research within the framework of the Malaysian National Space Policy. By addressing the identified obstacles and capitalizing on available opportunities, Malaysia has the potential to contribute significantly to the global effort to understand solar dynamics and improve space weather forecasting capabilities.

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2035

Managing Australia's Radio Astronomy Facilities in a crowded spectrum

Dr Douglas Bock, Dr Balthasar Indermuehle

CSIRO Space and Astronomy

Abstract

CSIRO, Australia's National science agency, operates the Australia Telescope National Facility (ATNF). The ATNF supports research in radio astronomy and is used by the international astronomy community. It also supports space-related activities, such as spacecraft tracking and communication, and bistatic and passive radar. The ATNF offers the Murriyang Parkes radio telescope, the Australia Telescope Compact Array, and the Australian SKA Pathfinder (ASKAP) to astronomers based on scientific merit. CSIRO's engineering technologies group develops radio astronomy receivers, digital signal processing systems and software to keep ATNF and other radio telescopes worldwide at the cutting edge of discovery in an increasingly crowded radio spectrum.

In 2014, CSIRO built the world's largest radio quiet zone, the Australian Radio Quiet Zone Western Australia (ARQZWA), around Inyarrimanha Ilgari Bundara - our Murchison Radio Observatory (MRO) deep in the Western Australian outback. The ARQZWA continues to provide the world's quietest radio environment from 50 MHz to 25.25 GHz at the site of ASKAP and the Murchison Widefield Array (MWA), and is where the SKA-Low telescope is being built. CSIRO represents Australia's radio astronomy service (RAS) and the space research service (SRS) interests at national, regional, and international spectrum management levels, with scientists and engineers in leadership roles, ensuring that radio spectrum remains available for science.

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The impact of direct-to-device satellite services on radio astronomy

Dr Balthasar Indermuehle

CSIRO Space and Astronomy

Abstract

The increasing availability of direct-to-device (D2D) technology from satellites has resulted in a global push by mobile operators across the globe to re-purpose terrestrial international mobile telecommunications (IMT) spectrum to make it available for satellite-based communication with mobile devices. Many governments view this as panacea to their declared goals of connecting every corner of their territories, and commercial pressure to enable these systems is therefore significant. Radio astronomy (RAS) observatories have always been built as far away as possible from civilisation centres to escape these same IMT signals, amongst other man-made sources of radio frequency interference (RFI). The permits and spectrum licenses issued by regulators across the globe for D2D systems therefore present an entirely new coexistence challenge for RAS. We report on our work providing input to consultations with national regulators and show our efforts to model the future impact these systems will have on RAS facilities across the globe. We examine the global regulatory context as outlined in the radio regulations at the International Telecommunications Union – Radiocommunications sector (ITU-R) and explore what actions RAS can undertake to accurately measure and mitigate these impacts in preparation for coexistence with these new D2D systems.

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2148

Unintended emissions from satellites: A new danger is lurking in the sky for radio astronomy

Dr Balthasar Indermuehle[1], Mr Federico Di Vruno[2]

[1]CSIRO Space & Astronomy. [2]SKAO

Abstract

The unprecedented proliferation of low earth orbit (LEO) satellites over the past few years and their anticipated increase in the very near future are highlighting a new danger to radio astronomy (RAS): Largely absent regulation on electromagnetic emissions for satellites have resulted in unintended electromagnetic radiation (UEMR) from satellites being detected in RAS observations, and some of these emissions are in bands that are protected for RAS by the radio regulations (RRs), the intergovernmental treaty framework negotiated by 198 nations at the International Telecommunications Union - Radiocommunications sector (ITU-R). We present an overview of these surprise measurements on a series of satellites that are found to emit UEMR in bands allocated to RAS, along with some new measurements undertaken in Australia. We explore possible avenues to mitigate these emissions, and report on avenues that have been explored by radio astronomers in collaboration with industry to prevent these types of emissions from causing interference.

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Battling RFI at the GMRT: Searches for HI 21cm emission from galaxies at z~0.2-3

Professor Nissim Kanekar

National Centre for Radio Astrophysics, India

Abstract

The weakness of the hyperfine HI 21cm line, the main tracer of the HI content of galaxies, has meant that we know little about the atomic gas mass of high-redshift galaxies and its evolution. Indeed, the evolution of the HI content of galaxies is one of the main open questions in galaxy evolution today. This issue is exacerbated by the presence of strong and variable radio frequency interference (RFI) at the low radio frequencies (<~ 700 MHz for z>~1) of the redshifted HI 21cm line. Stacking of the HI 21cm emission signals from a large sample of galaxies, observed simultaneously with a radio interferometer, can allow one to determine the HI properties of the galaxy population. However, the wide frequency coverage needed for such stacking studies implies that one has to overcome issues arising from terrestrial and space RFI. In this talk, I will describe results from HI 21cm surveys that we have been carrying out with the Giant Metrewave Radio Telescope (GMRT), aiming to detect the stacked HI 21cm emission signal from star-forming galaxies in the redshift range z~0.2-3.0, i.e. the period of cosmic noon and beyond, to characterize the HI properties of galaxies over the last 11 billion years. I will further describe the RFI environment at the GMRT between 300 MHz and 1300 MHz, and the approaches that we have taken to mitigate the effects of RFI on our data.

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2216

Milestone science with the local and the redshifted neutral hydrogen line (and limitations through RFI)

Prof Tom Oosterloo

Netherlands Institute for Radio Astronomy. Groningen University

Abstract

I will present a brief overview of the scientific impact of the radio astronomy done in the past using spectroscopy of neutral hydrogen, but will focus on current and future developments that can be expected with the new generation radio telescopes such as ASKAP, MeerKAT and the SKA. I will also discuss the impact RFI will have on this work and the scientific limitation this implies.

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2221

Present and expected science in radio continuum astrophysics (andlimitations through RFI)

Dr Kenda Knowles

Rhodes University

Abstract

Continuum radio astronomy is on the cusp of a scientific revolution in the SKAO era, already being seen by new results from SKA pathfinder and precursor instruments. I will present the work being done by members of the community to identify key current and future science goals in this field, the science resutls that have been moving us into the new era, and the optimal frequency coverage required. Finally, we will address the impact of RFI, both current and predicted, and discuss the existing excision and mitigation techniques and their limitations.

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2222

Astronomy in the MegaJansky era: the Transient Array Radio Telescope as a low-cost extendable platform for RFI monitoring

Mr Benjamin Hugo[1,2], Dr Tim Molteno[3], Mr Max Scheel[4], Mr Rickus Human[5], Dist. Prof Oleg Smirnov[2], Dr Nadeem Oozeer[1]

[1]South African Radio Astronomy Observatory (SARAO). [2]Rhodes University, South Africa. [3]University of Otago. [4]Electronics Research Foundation, New Zealand. [5]IXUS (Alphawave)

Abstract

The Transient Array Radio Telescope (TART) is a low-cost extendable interferometer platform. The telescope technology, from platform CAD drawings and digital signals backend to user software is Open Source licensed and provides an ideal platform for teaching, electronics, receiver and algorithm development.

Current iteration TARTs are small (few meters) 24-receiver interferometers constructed with off-the-shelve Global Navigation Satellite System (GNSS) receivers operating in the 1.5 GHz GNSS band, which provide near horizon-to-horizon sensitivity. Two demonstrators are installed at Dunedin, New Zealand and Rhodes University, South Africa. Next-generation TARTs, currently in development, will have up to 32 receivers and are planned to be installed in SKA partner countries, with interest from other developing nations.

The TART is an ideal low-cost platform for characterizing and active monitoring of transmission from the ubiquitous GNSS satellite constellations, which dominate -- by several orders of magnitude over galactic and extra-galactic astronomical sources -- the cm-frequency band between 1.1 and 1.5 GHz. Our demonstrator TARTs have already detected satellite emissions from uncataloged satellites and systems emitting in the GNSS band.

Telescope control and monitoring, as well as remote data acquisition, is made simple through RESTful API calls or via the interactive global TART web portal, where users are provided with open access to TART products from all registered TART telescopes around the world. The TART platform can be switched between single-channel visibility (interferometric) and high time-cadence spectroscopic ‘raw’ voltage modes. Interferometric data products can be reduced and imaged with standard radio interferometric tooling, including CASA.

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2300

RFI and the future of Radio Astronomy in Equatorial Africa

Prof Johnson Urama

University of Nigeria, Nsukka

Abstract

Africa lies astride the equator and extends almost equal distances (about 37 degrees) north and south of the equator. Equatorial Africa, here, refers to those countries in the continent that lie within about 20 degrees north and south of the equator. Majority of the countries in Africa (over 80%) lie in this equatorial region. Not much is known about modern astronomy here, and there is very little or no astronomical research facility, of any type, in nearly all the countries of this region. Light, and even radio-wave pollution, remains very low in virtually all parts of equatorial Africa; and this is a good advantage for the development of Astronomy here. Again, much of this region has access to the centre of the Milky Way Galaxy, making the region an excellent place for astronomical observations. This work highlights the state of astronomy, as well as the future prospects of radio astronomy, in this region.

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International spectrum management for radioastronomy

Dr. Vadim Nozdrin

International Telecommunication Union

Abstract

The rapid increase in demand for spectrum, largely driven by the deployment of commercial satellite and terrestrial radio technologies, exacerbates the problem of its scarcity. In these conditions, there is a growing need to regulate the use of radio frequencies at both the international and national levels to ensure protection against radio interference and the normal operation of existing scientific radio systems. Special attention is required to protect radio systems based on observations of naturally occurring radio emissions, particularly in radio astronomy. The responsibility for developing technical policies in the field of radio frequency spectrum utilization is entrusted to the International Telecommunication Union (ITU), a specialized agency of the United Nations, guided by the principle of its effective and rational use on a global scale. The existing international regulatory framework, based on ITU Radio Regulations and Recommendations, has provided sufficient protection for interference-free operation and development of radio astronomy stations. However, the increasing intensity of frequency use requires the development of new technical approaches and procedures aimed at combating new scenarios of interference in frequency bands used for radio astronomy measurements. This report comprehensively assesses the current regulatory landscape governing spectrum use for radioastronomy, considers the outcomes of the latest World Radiocommunication Conference for spectrum use in relation to radioastronomy, reviews ongoing research and deliberations of ITU-R Study Group, and explores the actions undertaken by the ITU Radiocommunication Bureau to protect radio astronomy sites.

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Simulation of the Earth's radio-leakage from mobile towers as seen from selected nearby stellar systems

Mr Ramiro Saide[1], Professor Michael Garrett[1,2,3], Professor Nalini Heeralall-Issur[4]

[1]University of Manchester. [2]Jodrell Bank Observatory. [3]Leiden Observatory. [4]University of Mauritius

Abstract

Mobile communication towers represent a relatively new but growing contributor to the total radio leakage associated with our planet. We investigate the total power contribution of mobile communication towers to the Earth's radio leakage, as observed from a selection of different nearby stellar systems. We developed a model of this leakage using publicly available data of mobile tower locations. The model grids the surface of the planet into small, computationally manageable regions, assuming a simple integrated transmission pattern for the mobile antennas. In this model, these mobile tower regions rise and set as the Earth rotates. In this way, a dynamic power spectrum of the Earth was determined, summed over all cellular frequency bands. We calculated this dynamic power spectrum from three different viewing points - HD 95735, Barnard's star, and Alpha Centauri A. Our preliminary results show that the peak power leaking into space from mobile towers is $\sim$ 4GW. This is associated with LTE mobile tower technology emanating from the East Coast of China as viewed from HD 95735. We demonstrate that the mobile tower leakage is periodic, direction-dependent, and could not currently be detected by a nearby civilisation located within 10 light years of the Earth, using instrumentation with a sensitivity similar to the Green Bank Telescope. We plan to extend our model to include more powerful 5G mobile systems, radar installations, ground based up-links (including the Deep Space Network), and various types of satellite services, including low-Earth orbit constellations such as Starlink and OneWeb.

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VLBI Science in an increasingly crowded radio spectrum

Dr. Tiziana Venturi

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Abstract

The present golden age of radio astronomy is jeopardised by the worsening of RFI in the radio spectrum. On one hand, the current radio astronomical SKA precursors and pathfinders are delivering breathtaking results, considerably broadening our knowledge in many astrophysical areas, from planets and stars in the Galactic Plane of the Milky Way all the way to the early stages of the life of the Universe. On the other, the advances in technology and data reduction strategies are challenged by the dramatic increase of RFIs of human origin, an by the colonisation of the sky by satellites.

In this presentation I will focus on the recent progress of milliarscecond scale radio astronomy, i.e. very long baseline interferometry (VLBI), and on its intermediate-scale developments, and I will highlight the impact of RFI on the VLBI research.

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Update on Activities of The US National Academies' Committee on Radio Frequencies (CORF).

Karen Masters[1], Kelsey Johnson[2], Bang Nhan[3]

[1]Haverford College. [2]University of Virginia. [3]NRAO

Abstract

The standing Committee on Radio Frequencies (CORF) of the US National Academies of Science, Engineering and Medicine (NASEM) considers the needs for radio frequency spectrum requirements and interference protection for scientific and engineering research, and represents the views of the U.S. scientists working in both the Earth Exploration-Satellite Service (EESS) and Radio Astronomy Service (RAS). CORF monitors and responds to radio frequency interference and allocation issues as they arise, for example by filing comments before the Federal Communications Commission (FCC). CORF was established in 1961, and is sponsored by NASA and NSF.

Representing the members of CORF, I give an update on committee activities, including items from the recent report from the National Academies detailing views on agenda items for the 2023 and 2027 World Radio Communication Conferences (WRC-23 and WRC-27).

Current Committee Members:

CHAIR: Nathaniel Livesey; VICE CHAIR Scott N. Paine.

MEMBERS Nancy L. Baker, Laura B. Chomiuk, Kshitija Deshpande, Dara Entekhabi Philip J. Erickson, Kelsey Johnson, Christopher Kidd, Karen Masters, Mahta Moghaddam, Bang D. Nhan, Frank K. Schinzel

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Studies on the impact of satellite constellations on SKA Band 5 with the Onsala Twin Telescope

Dr Hao Qiu[1], Federico Di Vruno[1], Gary Hovey[2]

[1]SKA Observatory. [2]Onsala Space Observatory

Abstract

10.6 GHz -10.7 GHz is an allocated frequency band for Radio Astronomy. Recent satellite constellations aim to provide broadband internet such as OneWeb and Starlink are known to operate between the 10.7-15 GHz frequency bands. This also presents a challenging environment for the operation of sensitive wideband receivers on radio telescopes such as the Band 5b for the upcoming SKA-mid telescope as adjacent frequency channels may be polluted. Recent spectrum management compatibility studies have limited the use between 10.7-10.95 GHz to protect the allocated Radio Astronomy frequencies. We present observation results of OneWeb satellites with the Onsala Twin Telescope at 10.7-12.7 GHz to follow up on the practical implementation of the new regulations and impact to observation data.

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Testing Metrics for Quality Assessment in the COSMOS HI Large Extragalactic Survey

Mr Rowyn Naidoo[1], Dr Nick Luber[2]

[1]University of Cape Town. [2]Columbia University

Abstract

The COSMOS HI Large Extragalactic Survey (CHILES) is a 1000-hour survey in the B-configuration of the VLA studying neutral hydrogen from z=0-0.45. One of the major challenges with modern large surveys, such as CHILES, is finding efficient yet robust methods for quality assessment of the data products. We have explored the use of kurtosis as a way to identify good and bad channels in data cubes. Kurtosis has a long history of being used for identifying radio frequency interference (RFI) in automated flagging routines, and seems to have promise in the image domain. We present the results of testing kurtosis as a metric for assessing image quality in the presence of both RFI and real sources and the implications for how it can be used to improve data reduction for large HI surveys.

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An Overview of Hardware RFI Excision Techniques in Radio Telescopes: A uGMRT Case Study

Kaushal Buch[1], Ruta Kale[2], Kishor Naik[1], Ajithkumar B[1]

[1]Giant Metrewave Radio Telescope, NCRA-TIFR, Pune, India. [2]National Centre for Radio Astrophysics, TIFR, Pune, India

Abstract

Radio Frequency Interference (RFI) poses a formidable challenge for the current and upcoming radio telescopes operating in the sub-Gigahertz and Gigahertz frequencies. Traditionally, RFI excision has been carried out offline on recorded data. While these software methods help in excising RFI, they lead to more data loss of astronomical data and do not work effectively for all types of RFI. With the advancement of semiconductor technology, signal processing hardware platforms like Field Programmable Gate Arrays (FPGA) provide a large number of resources and computational capabilities for real-time implementation of RFI excision systems. One of the major challenges in hardware implementation is the optimization required to meet the resource and timing requirements while dealing with finite precision arithmetic. A wide range of RFI excision techniques in time, frequency, and spatial domains have been implemented in the signal processing backends of various radio telescopes. We provide an overview of these techniques, including challenges in implementing, testing, and commissioning.

One such hardware RFI excision system has been successfully implemented for the Upgraded Giant Metrewave Radio Telescope (uGMRT). The system operates in real-time on Nyquist-sampled (800 MHz) time-series and is implemented on FPGAs. We describe various implementation tradeoffs and testing methods for this released system which is being regularly used for continuum, spectral line, and time-domain astronomy observations. We provide qualitative and quantitative improvements while describing the analysis to select optimal filtering parameters. Finally, we discuss the prospects for extending this system to upcoming major facilities like the Square Kilometer Array (SKA).

Session

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Radio astronomy re-discovered with LOFAR-VLBI and status of SKA-LOW pipelines

Dr Vijay Mahatma

University of Cambridge

Abstract

The LOFAR-VLBI pipeline is the state of the art collection of processing software that is routinely giving us high fidelity sub-arcsecond images of the radio sky at 144 MHz. I briefly describe the pipelines, how we deal with the complex ionosphere and beams, and how we may maximize our scientific potential by exploring a number of astronomical areas of interest. I also describe the future status of this organization, such as trying to create a strategy for polarization calibration at these frequencies for the first time. In the second part of my talk, I briefly describe the current status of the SKA Science Data Processor pipelines, and what we will try to implement in those pipelines in the future as the SKA Construction project comes to an end at the end of this decade.

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Radio astronomy spectrum coverage and technology of present and future receivers

Dr Giorgio Siringo

Atacama Large Millimeter/submillimeter Array - ALMA. European Southern Observatory - ESO

Abstract

Radio astronomy started in 1932 when Karl Jansky, trying to understand the origin of a peculiar type of antenna noise, identified the radio emission from the center of our Galaxy. Years later, Arno Penzias and Robert Wilson detection in 1965 of the cosmic background radiation marked a fundamental step in establishing radio astronomy as a powerful observational technique for experimental cosmology and observational astronomy in general.

Today, we have a large number of radio astronomy facilities, distributed in all continents, covering a large fraction of the electromagnetic spectrum spanning 6 orders of magnitude in frequency, from MHz to THz. Many radio telescope designs and observing techniques have been developed in the years, making radio astronomy capable of observing different astronomical objects and physical phenomena, producing results otherwise impossible with other techniques. Applications go from nearby objects in our Solar System to the first galaxies formed at the beginning of the Universe. Spectroscopic identification of different molecular species has boosted the development of astro-chemistry.

The growth of radio astronomy has been accompanied by developments of new radio receivers covering all the needs of astronomical projects, an ever-evolving world, with several laboratories around the Globe engaged in the design and development of new receivers.

Considering the rapid evolution of electronics and radio communications technologies, new receivers will be available at a rapid pace making radio astronomy capable of new observational astronomy capabilities. Radio-quiet sky protection is therefore critical and radio astronomy needs highest priority in spectrum sharing and radio frequencies allocation.

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Tackling RFI in Band 2 observations with the uGMRT

Prof. Abhirup Datta, Ms. Rashmi Sagar

Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore

Abstract

We have carried out several deep 150 MHz observations with the new uGMRT band 2 (120-250 MHz) system. Our observations suffer a lot due to RFI (Radio Frequency Interference) making with effective bandwidth of 100 MHz. There are significant RFI between 165 and 190 MHz. In fact, the observatory has introduced a notch filter to eliminate the RFI contaminated channels. Here, we outline the observations of a well studied part of the sky in other wavelengths, the European Large-Area ISO Survey-North 1 (ELAIS N1) field, using the uGMRT Band-2 (120 - 240 MHz). Our work aims at characterizing the foregrounds at this band and understanding the systematics for these observations. Our initial results show a radio image of the central field with the RMS noise of ~ 240 μJy beam^{-1} at ~ 180 MHz. We will present our initial results constraining the diffuse and compact foreground characteristics of the field at these frequencies. We will also present our way forward to get an upper limit on the redshifted HI 21cm signal from the CD/EoR signal at these redshifts. We will mention about our experience with more observing runs contributing to a total of 72 hours of data on EN1. We will discuss the impact of RFI over different night time observing runs. We will also present our experience with the performance of different RFI excision algorithms and packages.

We will also present our work with implementing an ML based RFI excision routine implemented on a FPGA accelerator.

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RFI mitigation software and limitations

Mr Benjamin Hugo

South African Radio Astronomy Observatory (SARAO). Rhodes University

Abstract

I present an overview of RFI mitigation in use at the MeerKAT radio interferometer, from the Science Data Processing pipeline, to that used in partially-automated reduction. Typically, various combinations of parameterized statistical flagging routines are employed, requiring successive rounds of iteration between flagging and calibration to excise most prominent RFI -- of which digital television, aircraft navigation, mobile communication, Global Navigation Satellite Systems, Wifi and Bluetooth are the most prominent sources of spurious and persistent RFI near the MeerKAT site, between 0.5 to 3.5 GHz. I discuss the shortcomings of these automated approaches as well as showcase the risks posed by, especially, Global Navigation Satellite System constellations, where digital saturation is regularly observed on the telescope, as well as on-site spurious RFI. These sources of RFI are, typically, in excess of 9 orders of magnitude brighter than the faintest populations of astronomical phenonima observed with sensitive radio instruments, such as MeerKAT.

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The host galaxies of fast radio bursts

Prof. Sandra Savaglio[1], Dr. Angela Gardini[2], Dr. Luciano Nicastro[3], Dr. Eliana Palazzi[3], Dr. Salvatore Quai[4,3], Dr. Andrea Rossi[3]

[1]University of Calabria. [2]Instituto de Astrofísica de Andalućia. [3]Osservatorio di Astrofisica e Scienza dello Spazio di Bologna. [4]University of Bologna

Abstract

Fast radio bursts (FRBs) are transient pulses of unknown nature, detected at radio wavelength only, with typically millisecond duration and 1-100 Jy fluxes. Although they are very frequent events, precise localization is possible only for a limited number, and all, but one, are of cosmological origin. Thanks to the host galaxy identification, it was possible to measure the redshift for just over 50 FRBs. In this talk, we will present the global properties of these galaxies, as published in the last few years. The redshift interval covered by the sample is $0.0 < z < 1.1$, with median and mean values $z = 0.160$ and $z = 0.209$, respectively. At least 77% of the hosts are star-forming and at least 40% are spiral galaxies. The median stellar mass of the hosts is $M^* = 10^{10.1} M_{sun}$, spanning the interval $8.1 < \log(M^*/M_{sun}) < 11.7$. While the sample is still small, these findings can still provide insight into the possible progenitors of FRBs. We expect that the new interferometric facilities being implemented will increase the number of well-localized events tenfold within a couple of years.

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Dark Matter in Dwarf Galaxies Using MeerKAT Radio Telescope

Miss Shibre Semane, Dr Geoff Beck, Dr Sphesihle Makathini

University of the Witwatersrand

Abstract

Dwarf spheroidal galaxies (dSphs) are prime targets in the search for dark matter due to their high dark matter content and faintness, minimizing interference from other astronomical phenomena. This study leverages the high survey speed and sensitivity of MeerKAT for deep radio observations , to explore dark matter in dSphs through indirect detection.

We hypothesize that faint radio synchrotron emissions from Weakly Interacting Massive Particles (WIMPs) annihilating or decaying within dSphs can offer crucial constraints on dark matter models.

In order to identify diffuse emission and distinguish between non-thermal astrophysical emission and a dark matter signal, we need a high-resolution and high-sensitivity radio telescope array and MeerKAT happens to be perfectly suitable for our purpose.

Our initial objective focused on analyzing MeerKAT observations of the Reticulum II dSph using the CARACal data reduction pipeline. We then utilized the DarkMatters Python code to predict the anticipated radio synchrotron emission from WIMP annihilation or decay within the dSph.

Initial results are encouraging, suggesting that MeerKAT holds the potential to provide significantly improved constraints on dark matter WIMP models compared to previous radio searches.

This highlights the effectiveness of dSphs as targets and underscores the importance of sophisticated modeling and simulation in dark matter exploration.

This not only aims to shed light on dark matter, but also to evaluate MeerKAT's potential as a tool for dark matter searches.

Further analysis and simulations of other dSphs are ongoing to solidify these findings and identify the most promising candidates for future MeerKAT observations.

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Preparations to a new RAS site

Dr. L. Viktor Tóth[1,2], Dr. Orsolya Ferencz[1]

[1]Eötvös Loránd University Budapest. [2]University of Debrecen

Abstract

A complex radio astronomical research site evaluation and selection work will be reported by the PI of the feasibility and preparatory studies. Fleshing up some details of our multidisciplinary efforts I will summarize the results of series of simulations and actual radio spectrum measurements to locate a site where terrain and clutter helps to keep a low RFI level. I will as well briefly discuss the work done to establish a good collaboration with the national frequency administrator, and local authorities as well as local NGOs. These are also important to guarantee a radio astronomy friendly environment for a space science ground infrastructure.

Recently this work led to the ITU registration of BEST-18M-RAS, a possible site to host a Hungarian radio telescope in the future.

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Regulatory processes at the national and international level, including local regulatory and hybrid measures to protect radio astronomy

Dr Bevin Vanderley

National Science Foundation

Abstract

This session will focus on regulatory processes for the current and future protection of radio astronomy to ensure that discoveries continue. Topics to be covered include a summary of how radio astronomy is regulated and discussion of limitations of the current regulatory environment, national and local radio astronomy protections and discussions of limitations, and other measures such as dynamic coordination and development of more robust receiver technology and interference excision techniques that may enable protection of radio astronomy beyond regulations.

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Understanding RFI properties at 550-850 MHz around the GMRT: Importance for high-*z* HI 21 cm science

Balpreet Kaur

National Centre for Radio Astrophysics, Pune, India

Abstract

Understanding galaxy evolution critically requires information on the evolution of the neutral gas content of galaxies across cosmic time. Unfortunately, the weakness of the 21cm transition, the main tracer of the HI mass of galaxies, makes it difficult to detect 21cm emission from individual high-redshift galaxies with today's radio telescopes and to thus determine their HI content. However, it is possible to measure the average HI mass of a population of high-z galaxies, with accurate redshifts and positions, by stacking their redshifted 21cm emission signals. We have followed the stacking approach, using the Giant Metrewave Radio Telescope (GMRT) 550-850 MHz receivers to carry out a 21cm emission survey of the COSMOS field. This has yielded only the second detection of the stacked 21cm emission signal from galaxies at z~1, and a measurement of the average HI mass of high-z star-forming galaxies. We are pushing forward with this project, aiming to obtain detections of 21cm emission from individual galaxies at z~1 in the COSMOS field, via a 600-hour GMRT integration on a single pointing. The main challenge to our GMRT 21cm surveys has been the worsening RFI environment in the 550-850 MHz observing band. In this talk, I will describe our completed and ongoing GMRT surveys, discuss the RFI environment in the 550-850 MHz observing band and the methods adopted to mitigate the effects of RFI on our data, and finally present our current 21cm emission results for star-forming galaxies at z~1 in the COSMOS field.

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Utilizing Flux Density for Radio Galaxy Observation Parameters at the African Millimeter Telescope

Mrs Sigrid Shilunga, Prof. Michael Backes

University of Namibia

Abstract

Radio galaxies, emitting substantial amounts of radio frequency radiation from their cores, provide valuable insights into supermassive black holes, galaxy evolution, and cosmic environments. The African Millimeter Telescope (AMT) that will be constructed in the Khomas Highlands in Namibia, poised to become a significant asset in millimeter/sub-millimeter wave astronomy, requires advanced methodologies for optimizing observations. The issue statement emphasises the importance of using flux density data to optimise observational circumstances, enhance distance computations, map position, and create optimal observation times for faint radio galaxies with the AMT. By employing the inverse square law, the study aim to calculate distances to radio galaxies, determine optimal observation conditions based on zenith angles, and establish observation periods for data acquisition. The research objectives include developing theoretical models, testing them with real-world data, and contributing to the global understanding of radio galaxy physics. Leveraging quantitative methods and data analysis tools, this study will derive insights into the relationships between flux density and observational parameters. This study aims to advance millimeter/sub-millimeter radio astronomy by providing practical tools for astronomers worldwide.

Keywords: Radio galaxies, flux density, observation period, AMT

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New and future discoveries observing molecular and radio recombination lines (and limitations through RFI)

Kimberly Emig[1,2], Francoise Combes[1,2], Michael Busch[3], Bin Liu[4], Brett McGuire[5,6]

[1]Observatoire de Paris. [2]College de France. [3]University of California, San Diego. [4]National Astronomical Observatories, Chinese Academy of Sciences. [5]Massachusettes Institute of Technology. [6]National Radio Astronomy Observatory

Abstract

The aim of this talk is to present state-of-the-art research in radio astronomy, focusing on the new and future discoveries observing molecular and radio-recombination lines. We give a brief overview of the current scientific advances and future science goals enabled through observations of these interstellar gas tracers. Advances in the field are made directly as a result of technological development, which we will describe. Finally, we discuss the impact and limitations of RFI on current and future science goals.

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InterPol: A Novel Simultaneous Polarized Imaging and Calibration Algorithm for Heterogenous VLBI Arrays

Dr. Paul Tiede

Center for Astrophysics | Harvard & Smithsonian

Abstract

Very Long Baseline Interferometry (VLBI) has paved the way for groundbreaking astrophysical discoveries, such as black hole jets, planet formation, and imaging of the shadow of a black hole. However, transforming the raw VLBI data into an interpretable image is a formidable challenge. VLBI imaging requires modeling an entire image from a sparse sampling of Fourier components and the complicated instrument response to the incident electric field. While the instrument response and image are traditionally analyzed separately for complicated VLBI arrays such as the EHT, separating instrument effects from source structure is complex. In this talk, I will present *InterPol,* a novel Bayesian simultaneous imaging and calibration algorithm implemented in the VLBI software Comrade. Interpol is able to reconstruct the full Stokes polarized image and instrumental response, including gains, gain ratios, and leakage and provide uncertainty quantification for both. By solving for the image and instrument from first principles, Interpol can model a larger class of instruments and produce images from data in a much earlier processing stage. We demonstrate Interpol on various VLBI arrays, including the VLBA, Event Horizon Telescope, and VGOS geodesy program, demonstrating improved image resolution with fewer image artifacts. Finally, we will use Interpol to forecast the capabilities of future VLBI instruments like the ngVLA, ngEHT, and Black Hole Explorer.

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Application of anomaly detection to MeerKAT radio data using machine learning techniques

Dr. Hanwool Koo, Dr. Michelle Lochner

University of the Western Cape

Abstract

As a mid-frequency Square Kilometre Array precursor, the MeerKAT radio telescope is a promising source of large sets of radio data. Developing an automated method for anomaly detection is becoming essential to discover more unknown phenomena for astrophysics or cosmology from the data with such an enormous volume. To do this, we explore anomaly detection techniques for time-frequency dynamic spectra of the radio data. We apply unsupervised machine learning techniques, coupled with active learning, for anomaly detection and evaluate our method using the simulated Single-dish PARKES data sets for finding the uneXpected (SPARKESX). We use these simulations to test anomaly detection methods that will be applied to real, unlabeled MeerKAT data. We also examine the possibility of detecting and removing anomalous radio frequency interference, which acts as the primary contaminant when hunting for genuine anomalies. We expect that applying machine learning methods will be a more efficient and reliable way to detect anomalous astrophysical signals with higher accuracy and in a shorter time than the classical methods.

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TABASCAL: Trajectory Based RFI Subtraction and Calibration

Mr Christopher Finlay[1], Prof. Martin Kunz[1], Dr Nadeem Oozeer[2], Prof. Bruce Bassett[3]

[1]University of Geneva. [2]Rhodes University. [3]University of Cape Town

Abstract

The next generation of radio interferometers such as the SKA, ngVLA, and uGMRT are increasingly more sensitive and therefore more susceptible to Radio Frequency Interference (RFI). We therefore present, TABASCAL, a new algorithm for the subtraction/excision of RFI from post-correlation radio interferometry data. TABASCAL takes advantage of estimated trajectories of RFI sources and the inherent differences in the time variability of antenna gains, RFI signal, and astronomical signal to jointly estimate these. A complete forward model is formed in a Bayesian framework allowing for the rigorous estimation of the astronomical signal with uncertainty estimates. We test TABASCAL on simulated MeerKAT data that is contaminated by both satellite and ground based sources of RFI where we manage to recover the astronomical signal within the estimated uncertainty. Comparisons are made to an idealised flagging approach on both a source extraction metric and power spectrum recovery, showing superior performance by TABASCAL on both these metrics.

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A FAST perspective on the dynamic universe

Dr Pei Wang

The National Astronomical Observatories of the Chinese Academy of Sciences (NAOC)

Abstract

The radiative mechanism of pulsars and the origin of Fast Radio Bursts (FRBs) are unknown and are currently major astrophysical puzzles. The study of pulsars and FRBs is a frontier field for the Five-hundred-meter Aperture Spherical radio Telescope (FAST), offering significant opportunities for breakthroughs in fundamental physics and astronomy. The FAST has so far detected more than 850 new pulsars and ten thousand of FRB repeating bursts, observing a decadal evolution of a repeating FRB. The presentation will focus on the recent observational progress and discoveries made using FAST. By exploring the dynamic Universe with FAST, it may expand the horizon of this new active frontier of radio astronomy.

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Advancements and Challenges in Astronomical and Geodetic Observations: The Impact of Broadband Radio Systems and Spectrum Congestion

Taehyun Jung

Korea Astronomy and Space Science Institute (KASI)

Abstract

Recent advances in radio astronomy technology have led to unprecedented opportunities for new discoveries in both radio astronomy and geodesy. Innovations like the broadband VGOS (3-14 GHz) and BRAND (1-15 GHz) receivers, alongside the Korean VLBI Network's (KVN) multi-frequency receiver capable of observing four bands simultaneously (18-26, 35-50, 85-116, 124-142 GHz), have significantly expanded our observational capabilities. Crucial development in Digital Base Band Converters (DBBCs) and ultra-highspeed recording technologies like Mark6 and Flexbuff further enhance this progress. The recently completed (2023) and commissioned 4th KVN telescope extends this range even further, offering observations from 6 GHz up to 270 GHz through a combination of three receivers and a quasi-optical system.

However, the growing use of technologies like 6G communications, Urban Air Mobility (UAM), and satellite internet services presents a significant challenge to radio astronomy and geodesy. South Korea operates valuable radio observing facilities like the Sejong space geodetic telescope (22-meter), the Seoul Radio Astronomy Observatory (SRAO) telescope (6.1-meter), and the Gwacheon National Science Museum's radio telescope (7.2-meter), alongside the KVN. Despite these contributions, the threat of radio frequency interference is a growing concern.

This presentation will firstly introduce the capabilities and scientific highlights of broadband systems, focusing on the KVN. Then, I will address the current challenges of radio frequency interference faced by Korean radio telescopes and discuss ongoing efforts to mitigate these threats.

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Fast radio transients in the era of “big” RFI

Franz, Kirsten,[1], Pei Wang[2], Marta Burgay[3], Laura Spitler[4], Kaustubh Rajwade[5], Clancy James[6], Yashwant Gupta[7], Gyula Jozsa[4]

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Abstract

Fast radio transients are signposts for sites of extreme astrophysics, as well as being valuable astronomical tools. Radio pulsars illuminate the extreme magnetospheres of neutron stars, while also providing valuable insights into the neutron star equation of state and observations of low frequency gravitational waves. Unveiling the origin of extragalactic fast radio bursts is currently a major focus of world-wide observational efforts. These sources also have the potential to inform our understanding of the large-scale structure and expansion of the Universe. Finally, radio observations of cosmic ray air showers give insights to high energy physics. Many scientific goals will require decades to finish, and it is therefore essential that the radio spectrum is protected for future astronomers. In this talk, several scientific highlights of fast radio transients are presented, as well as a discussion on the impact of ever increasing RFI on future scientific goals.

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The future of radio astronomy in an increasingly crowded spectrum: introduction

Gyula I. G. Józsa

Max-Planck-Institut für Radioastronomie

Abstract

Radio astronomy becomes existentially threatened by anthropogenic radio emissions. An example is the effort to provide global access to broadband internet with large satellite constellations, which might affect radio telescopes in the remotest areas. The radio astronomy community therefore has to make a continuous effort to protect radio astronomy and find ways to coexist with active users of the radio spectrum. To do so, it is important to engage with regulators, industry, and the public, but also to be aware of the state of the arts and the future of research in radio astronomy. Focus Meeting 5 aims to highlight the contributions of radio astronomy to science and society, and to discuss technical and regulatory solutions to coexist with modern radio communication systems. It also provides an opportunity to build new networks to engage with stakeholders in radiocommunication as a world-wide community.

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Technosignatures in the Age of Tech

Dr David DeBoer

University of California Berkeley

Abstract

The search for signals of possible extraterrestrial origin ("technosignatures") is one of humanities great quests. Understanding our place in the Universe and the possibility that we share it is the realm of science and technology; we study the potential for life to exist using powerful instruments to see if we can detect their presence. Much of its modern history (which has traditionally been called the search for extraterrestrial intelligence, or SETI) has centered around using state of the art radio telescopes to look for potential deliberate radio frequency transmissions. Radio astronomy has benefited greatly by the advent of high tech but is also beset by its nearly complete adoption around the globe as a source of radio frequency interference. Coexisting is certainly possible, and this presentation will give an overview of how this is done and how it may evolve.

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Final category: FM 6 History of Astronomy in South Africa: The Late Modern Period

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The fascinating story of the Cape Photographic Durchmusterung involving the different personalities of David Gill and Jacobus Kapteyn

Prof John Hearnshaw

University of Canterbury, Christchurch, New Zealand

Abstract

This paper discusses the origins of the Cape Photographic Durchmusterung, which was devised by Sir David Gill at the Royal Observatory at the Cape in November 1882 and commenced in April 1885 using a Dallmeyer 6-inch f/9 lens. Over 3000 plates of the southern sky were exposed, reaching about magnitude 9.5 in 30 to 45 minutes.

Gill corresponded with Jacobus Kapteyn in Groningen, the latter offering to dedicate several years of his life to reducing the plates, which entailed measuring the positions of nearly half a million stars between -18° and the pole as well as estimating the magnitudes from image diameters. The magnitudes of the CPD were beset with a multitude of problems, as the photographic blue-sensitive images were calibrated with visual magnitudes, with the result that very large systematic errors were made, as shown subsequently by J. Halm and E.C. Pickering.

Kapteyn estimated 6 or 7 years of work, but in the end it took 13. The third and final volume of the great catalogue appeared in 1900. The CPD represents a remarkable early collaboration between scientists in two institutions in different countries and continents. It reached a successful conclusion in spite of numerous difficulties, and the volumes were published with remarkably few typographical errors. This great early endeavour in using the new photographic technology applied to astronomy is in contrast to the concurrent programme of the Carte du Ciel, which took much longer to complete and was done so in a far less homogeneous manner.

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Herschel Family and Astronomy in South Africa

Dr. Alina Eremeeva[1], Prof. Nikolay Samus[2,1]

[1]Sternberg Astronomical Institute of Lomonosov Moscow University. [2]Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia

Abstract

William Herschel (1738-1822), musician, autodidact astronomer, was famous for his observational studies, among them, studies of the Galactic structure based on star counts in selected fields. His son, John Herschel (1792-1871), one of the founders of the Royal Astronomical Society, expanded his father's project to the Southern sky. With his father's 20-foot telescope, he came to South Africa in 1833 and established a perfectly equipped private observatory, where he fruitfully worked for five years. Reductions of the results then took a decade. The book of his life, "Results of astronomical Observations made during the years 1834, 5, 6, 7, 8, at the Cape of Good Hope; being the completion of a telescopic survey of the whole surface of the visible heavens, commenced in 1825, by John F.W. Herschel" was published in London in 1847. During his five-year stay in South Africa, John Herschel developed a plan of educational system for the Cape colony, suggesting a greatly improved social position of teachers, doubling their salaries and providing pensions. The scientific heritage left by William Herschel and John Herschel is still important for today's astronomy.

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The Astronomical Plate Archive of Leiden Observatory: the logbooks as a treasure trove of information on service observing by local staff

Dr. Christiaan Sterken[1], Dr. Arnout M. van Genderen[2]

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Abstract

The preservation of astrophotographic plates is a standing problem for almost all plate archives and repositories worldwide. Storage space is one problem, correct preservation is another matter, and even proper archiving of the logbooks and associated metadata is a challenging issue as only the most senior astronomers master the know-how for "reading" the data content of these extraordinary information carriers.

The Leiden Observatory plate archive is a collection that was started at the end of the nineteenth century, and contains at this moment almost 50 000 astronomical plates. The plates have been obtained with a number of telescopes and cameras in Leiden, and in South Africa (Johannesburg, Hartebeespoortdam). Thirty-one fields had been selected for variable-star searches, mostly in fields in the Milky Way, the Large and Small Magellanic Clouds, and the Large Sagittarius Star Cloud. Although some batches of plates have, over the years, somehow suffered from humidity and water, the bulk of the plates is in good condition.

The Franklin-Adams and Rockefeller telescope logbooks form a unique database that reveals most interesting aspects of the scientific management of these early modern remote observatories. This mine of information sheds light on a social aspect that is totally neglected in historical studies, in particular the role of service observers, *i.e.*, the large number of persons with scientific or technical training, who never appear in biographies, such as astronomical assistants and auxiliary staff. These logbooks should be saved, digitised and made available to the astronomical community.

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Hardships of the Geodetic Survey of South Africa: from Lacaille to Maclear

Dr. Christiaan Sterken

University of Brussels

Abstract

In 1751 Nicolas-Louis de Lacaille came to the Cape to measure the length of a degree of latitude, but despite precise surveying work and tedious data reduction, his results disagreed with those obtained in France: the shape of the Earth was different in the southern hemisphere than in the northern. In 1840 Thomas Maclear undertook the verification of Lacaille's arc of meridian, and reported in 1866 that Lacaille's baseline data were affected by deviations from the vertical due to mountain masses of, among others, Table Mountain. Maclear also extended Lacaille's chain of triangles from Cape Point to beacons over a distance of 500 km in a north-south direction. The measurement of the 13-km main base took five months. Maclear was assisted in his decade-long surveying by Charles Piazzi Smyth and William Mann, and occasionally by John Herschel. "Maclear's Beacon", is one of Maclear's triangulation points and is situated on the Eastern end on the plateau of the mountain.

For latitude determinations, Maclear used the zenith sector which Bradley had used to measure the aberration of starlight. Transporting this huge instrument from mountain to mountain through blizzards and dust storms was a true ordeal. Lacaille's measurement of a meridian arc became the basis of the South African trigonometric system and Maclear's chain of triangles became the backbone of the entire Geodetic system. This chain was later extended eastward and northwards. As such, the Republic of South Africa has been covered with trigonometrical control points for mapping and cadastral survey purposes.

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The Toppieshoek Restoration Project

Professor Elizabeth Jane Carruthers

University of South Africa

Abstract

This paper describes a project initiated by the Magaliesberg Association for Culture and Heritage (MACH) in collaboration with the Tshwane University of Technology (TUT). The project is unique in combining astronomical history and African archaeology.

The occurrence of two adjacent heritage sites on the university rural property, "Toppieshoek" is both fortunate and fortuitous. One site is the former Leiden University Southern Station Observatory, the other an Early Iron Age archaeological site dating from AD 350. The former recalls a time of scientific collaboration, the latter reveals the first arrival of Black immigrants into South Africa. Both are of major historical importance. Assisted by astronomers and archaeologists, the project's aim has been to initiate restoration of these sites for educational use and as a public legacy.

"Toppieshoek" is currently used for student recreation and for decades the heritage sites have been neglected. Once restored and appropriately conserved and used, they offer ideal opportunities for heritage appreciation and education at an institution focussed on applied technical education.

When the Leiden Observatory Southern Station closed in South Africa in 1978 two historically important telescopes were donated to the South African Department of Education. However, they were never put to their intended educational purpose.

The archaeological site was discovered by Arnout van Genderen, resident astronomer, in the 1970s. As a competent archaeologist himself, he recognised the significance of the artefacts in the Southern Station Observatory precinct and drew them to the attention of archaeologists at the University of the Witwatersrand.

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Harvard's Boyden Station in Bloemfontein

Dr. Sara Schechner

Harvard University

Abstract

Since only three-fourths of the sky are visible from Cambridge, Massachusetts (latitude 42°), the Harvard College Observatory (HCO) recognized the need for establishing an observing station south of the Equator. It also desired a high-altitude observatory with better atmospheric conditions. An opportunity to achieve both came in 1897 with a bequest from Uriah Boyden's estate. After testing out sites on Pike's Peak in Colorado and Mount Wilson in California, E.C. Pickering, the HCO director, sent an expedition to Peru under the leadership of Solon Bailey. In 1890, Arequipa was chosen as the site of Harvard's Boyden Station. The principal instruments were photographic telescopes—in particular the 24-inch Bruce Telescope-- whose glass plates were sent back to Cambridge for analysis.

As productive as Arequipa was, it had a cloudy season that could last four months. Therefore, as early as 1908, Pickering sent Bailey to explore alternative sites on the high plateau of South Africa. Bloemfontein had the most favorable weather and location. However, the financial straits of the HCO did not permit a move. In the 1920s, Pickering's successor Harlow Shapley found the money, and in 1927, the Arequipa instruments were disassembled, some refurbished, and then shipped to a new Boyden Station, established at Maselspoort, near Bloemfontein.

This talk will explore the opportunities and challenges of transferring Boyden Station from Peru to South Africa, the partnerships between the local government and American astronomers, and the research carried out by the transported instruments, which were paired with those in the northern hemisphere.

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Expanding the Universe from South and Southern Africa

Christiaan Sterken[1], Prof. Virginia Trimble[2,3]

[1]President IAU Commission C3 History of Astronomy. [2]University of California, Irvine. [3]Queen Jadiwga Observatory, Rzepiennik Bosupi, Poland

Abstract

The very first measurement of a stellar parallax was made from the Cape by Thomas Henderson in 1832-33, though he reported his measurement of Alpha Centauri only in 1839, two months after Bessel had announced his success with 61 Cygni. It is, therefore fitting that the first confirmation of Baade's

doubling of the cosmic distance scale (halving of the Hubble constant and doubling of the Hubble time) should have come from Andrew David Thackeray (1910-1978) also a Cape astronomer, speaking just after Baade at the 1952 IAU GA in Rome. Baade had failed to find RR Lyrae stars in Andromeda with the newly commissioned 200" telescope at Palomar; Thackeray had found the RR Lyraes tin the Magellanic Clouds, but much fainter than he expected. The presentation will focus on that story, but with some sidelights also on the work of Michael Feast finding unexpectedly faint examples of other types of variables (and yes there are joint Feast and Thackeray papers - one at least with Weeselink of the Baade-Wesselink method for finding Cepheid distances), and on the work of Samuel E. Okoye in establishing astronomy, especially radio astronomy, elsewhere in sub-Saharan Africa. I might try to include other relevant astronomers if I think of them between January and August 2024.

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The Carte du Ciel project and the crucial role played by the Cape Observatory

Dr. Ileana CHINNICI

INAF - National Institute for Astrophysics, Palermo Astronomical Observatory

Abstract

The Carte du Ciel project was launched in 1887 by the Paris Observatory under the direction of Admiral Ernest B. Mouchez. It was aimed at photographing the entire sky vault, reproducing on the plates stars down to magnitude 15, in order to obtain an accurate photographic sky chart as much as possible. The project was conceived and planned on a global scale and the photographic work was assigned to eighteen observatories, located in the two hemispheres. The original intent of producing a sky chart was, however, soon juxtaposed and supersed by the realization of a star catalogue, under the pressure and insistence of sir David Gill, director of the Cape Observatory, who was the true "éminence grise" of the project. This turn towards the catalogue implied to double the photographic work and to add a huge amount of complex activities, requiring staff and resources to measure the star coordinates on the plates, converting them from rectangular to equatorial, reducing them to the year 1900 and publishing the volumes. Gill played a crucial role in orienting the decisions of the International Permanent Commission and overcoming political difficulties to secure the completion of the catalogue work. In this talk, after a short descriptive introduction, I shall make a comparison between the two different approachs at Paris and Cape Observatories and show how the latter prevailed.

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The South African Observatories and Technological Change

Dr Ian Glass

SAAO

Abstract

Astronomical discovery in South Africa, as elsewhere, is often due to new technology. For example:

The earliest systematic sky surveys (1751-2), of the sky south of -23½° Dec, conducted from Cape Town, were dependent on a unique device developed by La Caille.

The first detected stellar parallax, due to Henderson (1831-2), was made possible by state-of-the-art instruments – mural circle, transit telescope and regulator clock, at the Royal Observatory, Cape.

The first large photographic catalogue of stars, the CPD, was made with a camera developed by Gill in the 1880s. Gill drove Howard Grubb to develop improved lenses and telescope mountings, important in the Carte du Ciel programme.

High precision stellar photometry was driven, at first by the Fabry photographic method, by locally–based astronomers. Later, Cousins's photoelectric UBVRI system gained worldwide acceptance.

The introduction of a large telescope (1.9m) enabled the discovery of RR Lyr variables in the LMC and the doubling of Hubble's distance scale of the Universe (Thackeray & Wesselink 1952).

The SAAO built Sutherland Observatory in 1971-2 to take advantage of good sky conditions. Noteworthy discoveries have been made with high-speed photometers (University of Cape Town) and infrared photometers.

CCDs and infrared arrays have increased the power of the existing telescopes. The SALT telescope (2010) has further increased faint-object detectability. Large-area detectors and on-line processing are revealing many rapidly changing objects.

A new South African radio telescope, the MeerKAT 64-element interferometer, is currently making some of the most interesting new discoveries.

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The challenging legacy of A.W. Roberts, South African variable star observer

Dr Keith Snedegar

Utah Valley University

Abstract

Between 1891 and 1920 Alexander William Roberts made some 70,000 visual magnitude estimates of southern variable stars from his observatory at Lovedale, South Africa. Never content with mere quantity, Roberts constantly sought to refine the quality of his measures and make them commensurate with emerging photometric standards. He utilized various instruments: an Oxford wedge photometer, a meridian photometer from Harvard, and a photometric telescope of his own design. Roberts's techniques were sufficiently refined for him to calculate orbital elements and absolute dimensions of some eclipsing binary systems from the analysis of their light curves. His observations also suggested that stars in close systems could be tidally distorted into oblate spheroids, as had been theorized by George Darwin and Jules Poincaré. However, as an independent researcher Roberts struggled to put the bulk of his data into publishable form. After his death his extensive papers went into storage at the Boyden Observatory, where they remained largely inaccessible until recently. Through its Endangered Archives Program, the British Library supported an effort to digitize Roberts's astronomical records beginning in 2018. Yet the creation of a digital archive is only an element in fully acknowledging Roberts's scientific legacy, which cannot be separated from his engagement with the racial politics of South Africa. He was fully alive to the impossibility of isolating the "purity" of his astronomy from its complicity in an unjust social and political order. Roberts's awareness of this predicament may well serve as an example for scientific workers today.

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Uncovering hidden logbooks of cometary observations: the case of comets Halley and Donati

Dr. Hong-Jin Yang[1,2], Mr. Hyojun Lee[3,1], Prof. Hyung Mok Lee[4]

[1]Korea Astronomy and Space Science Institute. [2]Korea National University of Science and Technology. [3]Korea National University of Science and Technology (UST). [4]Seoul National University

Abstract

Comets Halley and Donati were spectacular astronomical phenomena in 1758/1759 and 1858, respectively, observed worldwide, in particular from America, several European countries and their overseas territories. However, the task of uncovering hidden records of cometary observations still remains.

Korean chronicles have consistently documented astronomical phenomena for over two thousand years, including dozens of records related to these comets. Comet Halley's appearance was described with details such as position, brightness, tail length, etc. over a span of 25 days in the daily observational log of the Royal Observatory of Joseon Dynasty. Comet Donati, on the other hand, was recorded from September 13, 1858 in several royal documents until October 29 when low altitude made further observations challenging. Donati's tail changed rapidly, with the longest recorded tail on October 10 being over 10 times longer than on September 15.

Comet Halley was observed in a similar way by John Herschel at the Royal Observatory Cape of Good Hope in 1835, and the original data are conserved in the Herschel Archive at the Royal Astronomical Society. We compare Herschel's observations of daily position, brightness, and tail length with Korean historical records.

Donati's Comet was observed from the Cape of Good Hope between October 11, 1858 and March 4, 1859 by Sir Thomas Maclear. The original logs are conserved in the archives of the South African Astronomical Observatory in Cape Town. We discuss these data in relation to the uncovered Korean observations and introduce the Daily Log of Korean comet observations.

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Rescue Archiving: Lessons learnt at Boyden Observatory and elsewhere in South Africa

Mr Auke Slotegraaf

Centre for Astronomical Heritage (CfAH)

Abstract

Observatories are places where “data fossils” are created. These unique caches capture some aspects of the status of the Universe at a particular time. Typically, these data are photometric, spectroscopic, astrometric, and so forth. However, observatories are also dynamic spaces, evolving within physical landscapes where humans live and work. This interaction often inadvertently captures a wide array of data, encompassing not only ecological, cultural, and technological aspects but also historical, social, and even artistic dimensions.

Unlocking these data and turning them into knowledge, and perhaps even wisdom, is done using current best practices and techniques. It seems obvious that future techniques will unlock even deeper insights from the same data. But for that to happen, or until we invent a time machine, these valuable snapshots, our only empirical view into the past, need to be preserved.

The Centre for Astronomical Heritage (CfAH) is a small non-profit organisation with the big ambition to preserve South Africa’s astronomical heritage. At Boyden Observatory near Bloemfontein, our team, generously supported by the British Library’s Endangered Archives Programme, and drawing on experience gained at the South African Astronomical Observatory (SAAO) in Cape Town, assisted the staff with basic archival interventions to stabilise their collection. Work continues at both sites, driven by volunteers, to attend to materials at risk before, literally, time runs out.

This paper illustrates and discusses the progress made at Boyden and SAAO, highlighting practical methods for physical document preservation, collection management, and digitisation, useful for both non-specialists and volunteers.

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Economic considerations include direct collaboration between the Union Observatory in Johannesburg and Sydney Observatory in Australia during the First World War.

Mr Ian Tasker

Western Sydney University

Abstract

This presentation focuses on Robert T. A. Innes and his collaboration with Professor W. Ernest Cooke during the First World War. Innes, a British-born South African astronomer, had spent six years as an amateur astronomer in Sydney. Despite having had no formal training in astronomy, he was invited by Sir David Gill to the Royal Observatory, Cape of Good Hope, in 1894. He became the founding director of the Transvaal Meteorological Observatory in Johannesburg, which later became the Union Observatory; as a full-time professional astronomer, he was experimenting with blinking motion processes.

This paper highlights the correspondence between these colonial astronomers that needs more attention in existing scholarship and seeks to correct these omissions by exploring how Innes benefited from Cooke's access to a series of plates that began in 1899. During Innes's time in Australia, Henry Russell, a previous Sydney Observatory government astronomer, designed an astrograph for the International Astrographic Catalogue program, using a 34cm objective with a focal length of 3.43m (f/10), which allowed 1mm on the photographic plate to represent one arc minute in the sky. The 16x16cm plates covered an area of 2° square. Cooke believed these older plates were inferior, and some had fogging and would not reflect credit on the Observatory as stand-alone research products. Furthermore, he could not secure funds from the New South Wales government. Innes, who had become a professional South African astronomer, agreed that the Sydney zone should be blinked as processed data, and the Union Observatory published the results.

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Female Computers at the Cape Observatory (1890s-1930s)

Dr. Isabelle Lémonon-Waxin[1,2], Dr. Colette Le Lay[1]

[1]Centre François Viète (Nantes Université). [2]Cermes3

Abstract

At the end of the 19th century, many of the world's Western institutional observatories employed women as calculators: Greenwich, Paris, Harvard, etc. were among the best-known. The Royal Observatory of the Cape, run by his/her majesty's astronomer, is no exception. This presentation will analyse the integration and evolution of female staff at the Cape Observatory between the 1890s and 1930s, and will endeavour to circumscribe their practices. Were they confined to calculations, or did they have access to observations? Did the women have direct access to the plates taken by men or to the telescopes to take additional plates as needed? Did they take part in international programs such as the Carte du ciel? Could they become astronomers? What kind of limits were imposed on their careers because of their gender? These are some of the questions we will be tackling in the light of research already carried out for other observatories. This comparison will highlight the similarities and specificities of the Cape Observatory.

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A quest to preserve Bloemfontein's astronomical heritage: the development of the Boyden Observatory Museum.

Mr. Dawid Van Jaarsveldt

University if the Free State.

Abstract

Bloemfontein, a small city in the heart of South Africa, boasts two professional observatories, Boyden (Harvard College Observatory) and Lamont Hussey (Michigan State University). Boyden was transferred from Arequipa, Peru in 1927 and Lamont Hussey was built 1928. The rich history of these institutions unfolds in the Boyden Observatory Museum. Exhibits of "firsts" include: the first photographic atlas of the whole sky, published in 1903 by Harvard's Edward Pickering; the 13-inch Alvin Clark telescope with which the first pictures of Mars were taken in 1888; the Common 60-inch mirror, incorporated in the largest glass mirror telescope of its time in 1890; the Boyden Council - the world's first international observatory; and the Lamont telescope that took the first colour picture of Mars in 1939. In this presentation relevant historical research and logistics that formed part of the development of the museum are discussed.

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African Starlight and the Dismal Swamp

Dr. Clifton David Laney

Western Kentucky University. Brigham Young University. South African Astronomical Observatory

Abstract

The Royal Observatory at the Cape of Good Hope was authorized in 1820, but building it in an obscure, backward European colony with a small population and few skilled craftsmen was another matter. Even after the basic structure had been 'worried into existence' and the instruments sent from England installed in 1828, keeping the Cape observatory going and scientifically productive required heroic efforts through much of the 19th century.

Good work was done in traditional positional astronomy, but as the `new astronomy' of spectroscopy and astrophysics began to develop there were no significant funds or equipment, and for half a century a crushing burden of routine astrometric work overtaxed the small trained staff available.

All that would change when David Gill accepted `responsibility, acts of God and the King's enemies excepted' in 1879. Thoroughly aware of progress at major European observatories, many of which he visited to get ideas and establish contacts, Gill revolutionized what had become an astronomical backwater, leaving the Royal Observatory in 1906 with quadrupled staff, modern instruments and methods, and few traces of the days when the first permanent southern hemisphere observatory consisted of poorly constructed instruments and a virtually useless clock, housed in a prefabricated wooden hut. Spectroscopic and astrophysical work acquired a firm foothold, and innovations in astrometry had made the Cape a world standard in the field. The first scientific institute in sub-Saharan Africa, and the first permanent observatory in the southern hemisphere had come of age.

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Shanghai Sheshan Observatory's contribution to the Carte du Ciel project: past, present and future

Dr. Zheng-Hong TANG, Dr. Jian-Hai ZHAO, Dr. Yong YU, Dr. Mei-Ting YANG, Dr. Zheng-Jun SHANG, Dr. Liang-Liang WANG, Dr. Jing YANG

Shanghai Astronomical Observatory, Chinese Academy of Sciences

Abstract

The 40-cm telescope of Sheshan Observatory of Shanghai Astronomical Observatory (SHAO) started observation in 1901 and spent ten years to observe and complete the "Equatorial Catalogue", which was a partial application of the *Carte du Ciel* project, an international collaboration project headed by the Paris Observatory in which Sir David Gill, director of the Royal Observatory, Cape of Good Hope was one of the leaders.

During 2012-2017, SHAO carried out the project of "*Digitization of Chinese Astronomical Plates*" under the auspices of the Ministry of Science and Technology of China. In 2017, about 30,000 astronomical plates had been digitized and can be used by astronomers worldwide through the Chinese Virtual Observatory. In response to the IAU's resolution of expediting the digitization of historical astronomical plates, the proposal of "*Digitization of one million plates all over the world*" was submitted by SHAO and received support from the Shanghai Municipal Science and Technology Commission. Four new generation plate digitizers were developed during 2019-2022. In the past three years, SHAO has cooperated with Turin Astronomical Observatory (Italy) and the Astronomical Institute of Uzbekistan on digitizing more than 20,000 plates of the two Observatories. All plates had been sent back to Italy and Uzbekistan safely after digitization.

The South African Astronomical Observatory (SAAO) owns more than 18,000 photographic plates exposed since 1843, part of them belong to the *Carte du Ciel* project. SHAO and SAAO have signed an agreement in 2023 to cooperate on digitizing plates of SAAO in the near future.

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History of Astronomy in Namibia

Prof. Michael Backes

Department of Physics, Chemistry & Material Science, University of Namibia. Centre for Space Research, North-West University

Abstract

The history of astronomy at the Cape of Good Hope is well-known and -documented. Only a few know that also in (nowadays) Namibia, astronomical observations have a roughly hundred-year-long tradition:

Already during the early times of the South-African mandateship over (then) South-West Africa, there were vivid exchanges between professional astronomers from Germany and the (then) South-West African Scientific Society, including telescopes being stationed in what was to become Namibia. During the same period, the Smithsonian Institution operated a solar telescope in what was to become Namibia. During the 1950s the efforts of Prof. Cunno Hoffmeister made South-West Africa a beacon of discovery of variable stars of the Southern Hemisphere. Later, during the 1970s and 1980s, there were attempts by the Max-Planck Society, and ESO, respectively, to establish a major astronomical observatory on Mt. Gamsberg, and also the Southern African Large Telescope (SALT) was initially (i.e., during the 1990s) envisaged to be built there.

This presentation will review the history of astronomy in Namibia, highlighting successful projects as well as those that only were planned.

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The influence of Astronomy on the establishment of Early Scholarship in Surveying Education in South Africa

Dr Mulemwa Akombelwa, Prof Koos Landman, Mr Angus Forbes

University of KwaZulu-Natal

Abstract

Surveying education in South Africa began as a response to boundary disputes amongst the early settlers. The boundaries were demarcated by surveyors who did not have any formal training and were largely self-taught. The Cape Colony government in 1834 issued a decree requiring anyone wishing to practice as a land surveyor to take a qualifying examination before they could be allowed to practice. This led to the establishment of formal training for surveyors.

Although the development of the practice of Surveying is well documented, this paper examines the influence of astronomy on the establishment of survey scholarship in South Africa from the late 19th century to the present day. It will also examine the challenges and successes of the development process including future prospects of Surveying education in South Africa.

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Commentaries on Tangible and Intangible Cultural Heritage at the Cape

Professor Jennifer Whittal[1], Dr Ian Glass[2], Dr Christiaan Sterken[3]

[1]University of Cape Town. [2]South African Astronomical Observatory. [3]University of Brussels

Abstract

Tangible heritage such as public and private archives need to be inventorised and documented in freely accessible databases. Content should be indexed, preferably digitised and made available in Open Access mode.

Museums at scientific institutes need support to conserve and display their collections in optimal conditions, and get access to expert help for restoring historical instruments.

Historical buildings, such as astronomical observatories and geodetical or meteorological field stations should be considered as national heritage, and included in educational networks.

The Herschel/Maclear "Wynberg Stone", that was used in the triangulation of Sir John Herschel's Feldhausen Observatory located in nowadays Claremont, is thought to be the oldest surviving cadastral beacon in South Africa and is worthy of recognition as a national heritage monument, and complements the beacon monument at Buffelsfontein (Port Elizabeth), the southernmost point of a chain of triangles measured along the 30th meridian and ending near Cairo in Egypt. Other geodetic beacons also deserve preservation, as was done for Maclear's Beacon on Table Mountain.

Intangible heritage in the form of biographies and other symbols of international recognition of South African pioneer scientists is also sparse and more such items should be easily available.

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Final category: FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

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The LANCELOT project: Weak lensing and cosmic shear for future galaxy surveys in modified gravity

Mr. Oleksii Sokoliuk[1], Mr. Subhrat Praharaj[2], Dr. Simran Arora[2], Dr. Felipe dos Santos[3], Dr. Willem Elbers[4], Prof. Pradyumn Kumar Sahoo[2], Dr. Alexander Baransky[5]

[1]Main Astronomical Observatory, National Academy of Sciences of Ukraine. [2]BITS Pilani. [3]Universidade Federal do Rio Grande do Norte. [4]ICC, Durham University. [5]Kyiv Astronomical Observatory

Abstract

We present LANCELOT: LibrAry for N-body large sCale structurE simuLations in mOdified Theories of gravitation. This library not only incorporates various modified cosmologies but additionally includes massive neutrinos. For modified theories of gravitation, in the current work, we consider three cases: modified teleparallel gravitation $f(T) = T + \alpha(1-e^{-p\frac{T}{T_0}})$, it's non-minimal matter-torsion coupled extension with $f_1(T)=T$ and $f_2(T)=1+\lambda(T/T_0)^b$, Palatini-$f(R)$ gravitation with $f(R) = R - 2\Lambda\left(1-e^{-R/b\Lambda}\right)$ respectively. In the present work, we analyse the halo catalogue outputs of the LANCELOT project, use ray-tracing techniques on particle snapshots to obtain various cosmic shear and weak lensing observables, such as Integrated Sachs-Wolfe (ISW) effect angular power spectrum, power spectrum of shear-E and shear-B modes, tomographic measurements of xi_+ and xi_-. Obtained quantities are related to the observational data from KIDS survey to decide on the validity of each theory of modified gravitation.

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Evaluating the Efficacy of Physics-Informed Neural Networks for Astrophysical and Astronomical Data Simulations

Miss Johanne Ekue

National Institute for Space Research

Abstract

Our research aims to evaluate the efficacy of Physics-Informed Neural Networks (PINNs) in simulating astrophysical and astronomical data. By integrating domain knowledge from physics directly into the neural network structure, PINNs potentially offer a more accurate and efficient approach for handling complex space-related datasets. This study not only investigates the performance of PINNs in this context but also compares them with other established techniques. Our goal is to identify the most computationally efficient method, considering both accuracy and resource utilization, for processing and analyzing large-scale astrophysical and astronomical data.

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Theoretical predictions of nitric oxide detection in exoplanet atmospheres with Spectr-UF: simple numerical models for solving big observational problems.

Mr. Grigorii Tsurikov[1], Dr. Dmitry Bisikalo[2,1]

[1]Institute of Astronomy of the Russian Academy of Sciences. [2]NCPM – National Center for Physics and Mathematics

Abstract

Recent studies show that the presence of an N_2-O_2 dominant atmosphere on the terrestrial exoplanet should be one of the determining factors of biological and geological activity on this planet [1]. One of the indicators of such an atmosphere, the spectral features of which can be potentially detected with the LSS spectrograph (R = 1000) of planned for the launch space observatory Spektr-UF (WSO-UV) in the near UV range (203 – 248 nm) [2], is a nitric oxide molecule.

In order to make theoretical predictions of NO molecule detection using Spektr-UF, we consider several 1-D computational models: model of chemistry and diffusion in the upper atmosphere, model of electron precipitation in this atmosphere [3], and radiative transfer model. In addition, the capabilities of the telescope itself are taken into account. This work shows that planetary systems with active host stars of G-K spectral types are more appropriate for searching for NO since the influence of the activity of such stars contributes to the expansion of the atmosphere and an increase in the concentration of this molecule. In particular, it is evaluated that in a reasonable observation time with a signal to noise equal to three, it is possible to observe transmission signal in the NO γ-bands for typical super-Earths and sub-Neptunes near active host stars at distances up to 10 and 5 parsecs, respectively.

1.Sproß et al., Astronomy Reports, 2021, V65, №4, pp.275-296.

2.Tsurikov, Bisikalo, Astronomy Reports, 2023, V.67, №11, pp.1123–138.

3.Shematovich et al., Atmosphere, 2023, V.14,№7, 15p.

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A Topological Data Analysis of the CHIME/FRB Catalogues

Ms Shruti Bhatporia[1], Dr Anthony Walters[2], Prof Jeff Murugan[1], Prof Amanda Weltman[1]

[1]University of Cape Town. [2]Univeristy of Kwazulu Natal

Abstract

We use Topological Data Analysis (TDA), a mathematical approach for studying data shape, to analyse Fast Radio Bursts (FRBs). Applying the Mapper algorithm, we visualise the topological structure of a large FRB sample. Our findings reveal three distinct FRB populations based on their inferred source properties and show a robust structure indicating their morphology and energy. We also identify potential non-repeating FRBs that might become repeaters based on proximity in the Mapper graph. This work showcases TDA's promise in unravelling the origin and nature of FRBs.

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Enabling New Discoveries with Machine Learning

Dr Michelle Lochner

University of the Western Cape. South African Radio Astronomy Observatory

Abstract

The next generation of telescopes such as the SKA and the Vera C. Rubin Observatory will produce enormous data sets, far too large for traditional analysis techniques. Machine learning has proven invaluable in handling massive data volumes and automating many tasks traditionally done by human scientists. In this talk, I will explore the use of machine learning for automating the discovery and follow-up of interesting astronomical phenomena, both in the image and time domains. I will share an exciting recent MeerKAT discovery made with machine learning and discuss how the human-machine interface will play a critical role in maximising scientific discovery with automated tools.

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The Statistical and Computational Challenges in Astrophysical Imaging

Gordian Edenhofer

Max Planck Institute for Astrophysics. University of Munich

Abstract

In astrophysics, we often have to contend with noisy data that only indirectly probe the quantities we are interested in. Imaging is the process of extracting the quantities of interest from noisy data. Rigorous imaging is computationally and statistically challenging. Models in imaging typically entail millions to billions of degrees of freedom and as many noisy measurements. NIFTy is a fast and accurate Bayesian imaging framework. It provides the statistical and computational modeling infrastructure for astrophysical imaging and accelerates the inference through just-in-time compilation, vectorization, and offloading to accelerator hardware. NIFTy has a rich set of models and employs statistically rigorous inference algorithms for probing uncertainties in extremely high dimensions. It has been successfully used to map the 3D distribution of interstellar dust, resolve distant radio galaxies, and detect faint X-ray sources. Its latest iteration improves its integration with machine learning frameworks, enabling seamless interoperability between machine learning models and NIFTy. In my talk, I will provide an overview of Bayesian imaging frameworks, with a particular emphasis on NIFTy. I will discuss how we have built a community around NIFTy, present recent key scientific results, and conclude with a discussion of future directions for data-driven astronomy.

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Optimising Multiple Stellar Flybys Setup in 3D Hydrodynamics Mesh Code

Katarzyna Nowak

Centre for Astrophysics Research, University of Hertfordshire

Abstract

We investigate the stability of accretion discs around hypothetical supermassive stars (M > 1000 M_{SUN}) in dense young massive star clusters, which are proposed as candidates for polluters responsible for self-enrichment in globular clusters. These supermassive stars would form via runaway collision, simultaneously with clusters. Hence their discs are perturbed by stellar flybys, inspiralling, and colliding stars.

Stellar flybys on parabolic orbits are computed using Barker's equation. This is quite an expensive method when solved directly in 3D, which we combined with hydrodynamics mesh code PLUTO. Instead, we implemented linear interpolation to calculate the positions of typically 5000 perturbers in our simulations. This now works well with our 3D hydrodynamics disc models using an MPI set up with 480 processors.

We use this set up around a supermassive star to examine how its accretion disc reacts to those frequent encounters. We examine if the disc survives and remains dense enough to mase water lines. We then model kilomasers, which are generally associated with the forming super star cluster and compare it to an interesting candidate in the starburst galaxy NGC 253.

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BIPP: An efficient HPC implementation of the Bluebild algorithm for radio astronomy

Dr Emma Tolley[1], Shreyam Krishna[1], Dr Etienne Orliac[1], Simon Frasch[2]

[1]EPFL. [2]CSCS

Abstract

As a groundbreaking observational facility, The Square Kilometer Array (SKA) introduces new astrophysical, computational, and data analysis challenges. During its operation, the SKA will collect unprecedented amounts of data in the domain of 10 Exabytes, requiring the world's fastest supercomputers to process this data in near real time. We give a high-level overview of image synthesis in radio astronomy and the corresponding computing challenges, and a then present our HPC implementation of the Bluebild algorithm for radio-interferometric imaging: Bluebild Imaging++. Our library is a spherical imager that leverages functional PCA to decompose the sky into distinct energy levels. The library features interfaces to C++, C and Python and is designed with seamless GPU acceleration in mind. We evaluate the accuracy and performance of the library on simulated observations of the upcoming Square Kilometer Array Observatory and real data from the Low-Frequency Array (LOFAR) telescope. We find that the library offers accurate wide-field imaging with no need for a w-term approximation and has comparable execution time with respect to the interferometric imaging libraries CASA and WSClean. Futhermore, due to the energy level decomposition, images produced with BIPP can reveal information about faint and diffuse structures before any cleaning iterations.

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FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

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Numerical Modeling and Constraint of the Shadow of the Supermassive Black Holes

Dr. Yosuke Mizuno

Tsung-Dao Lee Institute, Shanghai Jiao Tong University

Abstract

Recently the Event Horizon Telescope has presented a ring-like emission structure of M87 at 1.3mm with unprecedented angular resolutions. These images show the asymmetric ring. To understand the physical conditions of black holes and accretion flows, we construct a large library of models based on general relativistic magnetohydrodynamic simulations and synthetic images produced by general relativistic radiation transfer calculation. We compare the observational data with this library and confirm that the asymmetric ring is consistent with earlier predictions of strong gravitational lensing of synchrotron emission from a hot plasma orbiting near the black hole event horizon. In this talk, I would like to present the recent progress of theoretical modeling by numerical simulations of magnetized accretion flows onto a black hole and a new approach based on machine learning.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

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Big Data in Astronomy: Surveys, Catalogues, Databases, Archives and VOs

Dr. Areg Mickaelian

Byurakan Astrophysical Observatory (BAO), Armenia

Abstract

I will review the current situation in astronomy from the point of view of accumulated Big Data, its storage and efficient usage for further discoveries. Astronomical Surveys are the most important sources for the revelation of new objects and their parameters define their efficiency; wavelength range, method, sensitivity, resolution, sky area, achieved limiting magnitude, completeness, etc. Many large surveys have defined the available data volumes in Astronomy, namely Fermi, INTEGRAL and others in Gamma-rays, ROSAT, Chandra, XMM in X-rays, GALEX and others in UV, DSS1/2, SDSS, Gaia and others in optical range, IRAS, AKARI, WISE, Spitzer, Herschel in IR, NVSS, FIRST, GB6 and others in radio. This is the Multi-Wavelength Astronomy. In addition, non-electromagnetic carriers of information make Astronomy Multi-Messenger. In VizieR, currently there are 24,797 catalogues, including such huge ones as Gaia DR3 with 1,811,709,771 objects or SDSS photometric catalogue with 1,231,051,050 objects. Catalogs giving variability or spectroscopy are also rather important. Many survey data are given in their own databases and many are combined in joint archives, such as MAST, IRSA and HEASARC. Virtual Observatories have been created to unify data into standards and common software and analysis systems to facilitate their usage and trigger many new research projects. Computational Astrophysics and Big Data are at present tightly involved in all Astronomy/Astrophysics; Data Reduction and Analysis; Astronomical Software Systems, Digitization of astronomical data, Astronomical Catalogues, Archives and Databases, Data Mining, Astrostatistics, Modeling, Simulations, Astroinformatics, Machine Learning, Deep Learning, Artificial Intelligence, Virtual Observatories, Laboratory Astrophysics and Data Science.

Session

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Imaging Spectral-Line Deep Fields in the SKA-Era: insights from CHILES and DINGO

Dr Richard Dodson[1], Dr Alex Williamson[1,2,3], Dr Pascal Elahi[2], Dr Jonghwan Rhee[4], Dr Martin Meyer[1], Dr DJ Pisano[5], Dr Qian Gong[6], Dr Kristof Rozgonyi[1], Dr Nick Luber[7], plus the CHILES & DINGO Teams[8]

[1]ICRAR/UWA. [2]Pawsey. [3]AusSRC. [4]ICRAR. [5]University of Cape Town. [6]Oak Ridge National Laboratory. [7]Columbia University. [8]Multi-institutions

Abstract

Deep Spectral Line imaging with SKA and the pathfinders is one of the greatest challenges for the next generation of instruments, as the data volumes are too large to store the raw visibilities required for forming the final image. The SKA will store only a day of spectral line data; deep imaging will then be formed from many days of observations. This assumes that the images have Gaussian residual errors and no systematic errors - which is rarely the case.

We are exploring this using:

The CHILES Jansky VLA legacy survey; an ideal test for SKA-Scale dataflow, as the total volume is about that of a single day of SKA observing. All the data was retained, fortunately, as the out-of-field sources introduce strong spectral- and hour angle-effects. Stacking daily images would have baked-in these effects, limiting the sensitivity. Processing will be discussed.

The DINGO ASKAP survey will not be able to retain the data and an alternative processing paradigm was required. We store the averaged uv-grids, which is the maximally efficient approach to baseline dependent averaging, whilst ensuring the correct application of all the gridding kernels. We will be able to flag localised data and still correctly reconstruct the images.

In addition we are exploring lossy compression on these residuals, using the ADIOS2/MGARD application embedded in the CasaCore libraries. We are achieving excellent performance, with a seven-fold improvement in processing time, a six-fold (lossless) or better (~20 for a lossy error bound of 5σ) reduction in storage requirements, with minimal impact on the results.

Session

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A first taste of MESA – an open source tool box for experiments in stellar astrophysics

Lieke van Son

Center for computational Astrophysics - Simons Foundation. Princeton University

Abstract

The recent detection of gravitational waves has highlighted the many uncertainties and gaps in our understanding of massive binary star evolution. Simultaneously, photometric surveys have been revolutionized by space-based missions like Kepler and TESS, and will further improve with the launch of PLATO in 2026. These observations provide asteroseismology benchmarks that offer new insights into stellar evolution and tidal theory. State-of-the-art simulations of their stellar progenitors are needed to interpret these observations.

MESA is one of the most widely used stellar evolutionary codes, with applications ranging from binary systems to planet structure, nuclear burning in the accretion layers of neutron stars, and asteroseismology. I will lead a 2-day workshop/hackathon called 'A First Taste of MESA', which aims to train young researchers, particularly PhD students and early-career postdocs, who are essential for advancing the field. This event will also provide an opportunity for local African students to become acquainted with astrophysical codes, an exposure they might not otherwise have.

Session

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Gamma Ray Bursts and their central engines studied by computational hydrodynamics methods

Prof. Agnieszka Janiuk[1], dr Gerardo Urrutia[1], dr Hector Olivares[2], Mr Joseph Saji[1]

[1]Center for Theoretical Physics PAS. [2]University of Aveiro

Abstract

I will present a a set of 2D and 3D, large scale numerical simulations of the gamma ray burst (GRB) central engines, their jets and outflows. The computational astrophysics group at CTP PAS in Warsaw is using general relativistic MHD codes with advanced microphysics, to address multi-scale evolution and physics of GRBs.

The engine of short GRB engines is modeled with code HARM_COOL. We quantify the interaction between GRB jets and neutrino-driven disk wind, for different types of compact binary progenitors. The central engine simulations consider r-process nucleosynthesis in the ejecta and the kilonova phenomenon, using the Skynet nuclear reaction network. The main properties of GRB: its energy distribution, cocoon expansion, angular structure, and collimation degree, are estimated from our simulations, by mapping the HARM results onto the larger grid with an adaptive mesh refinement (AMR) code MEZCAL.

Long GRB model is the multiscale evolution of collapsing star, and the jet breakout. We study specific configurations of magnetized collapsars, with various topology of magnetic fields and stellar rotation, that allow for the formation of an electromagnetic transient. To accomplish this, we use the GR MHD code BHAC. The capability of this code to read initial and boundary conditions from tabulated data allows us to use as input the realistic stellar models generated by the stellar evolution code MESA. We also benefit from its AMR capabilities, which in combination with the use of logarithmic spherical coordinates allow the treatment of the several-orders-of-magnitude separation in the length-scales.

Session

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AstroPhot: Fitting Everything Everywhere All at Once in Astronomical Images

Dr. Connor Stone

Université de Montréal

Abstract

We present AstroPhot, a fast, powerful, open-source, and user-friendly Python based astronomical image photometry solver. AstroPhot incorporates automatic differentiation and GPU acceleration, powered by the numerical library PyTorch. Everything: AstroPhot can fit models for sky, stars, galaxies, PSFs, and more in a principled forward optimization, recovering posterior information and covariance of all parameters. Everywhere: AstroPhot can optimize forward models on CPU or GPU; across images that are large, multi-band, multi-epoch, rotated, dithered, and more. All at once: The models are optimized together, thus handling overlapping objects and including the covariance between parameters (including PSF and galaxy parameters). A number of optimization algorithms are available including Levenberg-Marquardt, Gradient descent, and No-U-Turn MCMC sampling. With an object-oriented user interface, AstroPhot makes it easy to quickly extract detailed information from complex astronomical data for individual images or large survey programs. In this talk I will detail the powerful capabilities of the code, and demonstrate its ease of use. It should be of interest to all astronomers who process images and wish to extract the most insight from their data. Further, I will discuss how simultaneous fitting of ground based and space based data can enhance the science capabilities beyond what either could accomplish on its own!

Session

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Unlocking Astronomical Discoveries: Harnessing Zooniverse and Machine Learning for Large Data Sets

Lindsay House[1], Laura Trouille[2], Cliff Johnson[2,3], Samantha Blickhan[2], Chris Lintott[4], Lucy Fortson[5], Kameswara Mantha[5], Hayley Roberts[5], Sarah Huebner[5]

[1]University of Texas - Austin. [2]Adler Planetarium - Zooniverse. [3]Northwestern University. [4]University of Oxford - Zooniverse. [5]University of Minnesota - Zooniverse

Abstract

Processing our ever-expanding datasets in astronomy presents a significant challenge to our community. This is particularly true when trying to identify rare objects or events in these large data sets. Participatory research, or citizen science, particularly when coupled with machine learning, has emerged as a valuable tool for researchers. However, the availability of free, reliable, user-friendly, open-source platforms for creating participatory research projects remains limited. Zooniverse is a world-leading people-powered research platform with 2.7 million registered participants worldwide and over 90 active projects at any given time. Zooniverse has collaborated with hundreds of research teams from around the world on projects across diverse disciplines, such as astronomy, zoology, cancer research, climate science, arts and humanities. Currently, Zooniverse hosts over two dozen active astronomy projects, analyzing data from major observatories, space satellites, and planetary missions. These projects host a range of tasks, including galaxy classification, light curve analysis, identifying cyclones on Jupiter, and transcribing historical astronomers' journals. Zooniverse's DIY Project Builder platform (zooniverse.org/lab) empowers anyone to create their own crowdsourced research project for free. Using an intuitive browser-based interface, project builders upload content and data, establish discussion forums, export classification results, and invite collaborators. In this presentation, we will showcase the capabilities of the Project Builder platform, highlight how teams are utilizing Zooniverse to integrate machine learning alongside human effort, and share best practices for project development and public engagement. We eagerly invite discussions, feedback, and collaboration opportunities to support the astronomy community's research and public engagement endeavors.

Session

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Exascale Science with the AusSRC: Building on the Big Data Precursors

Dr Jordan Collier

Curtin Institute of Radio Astronomy (CIRA). Inter-University Institute for Data Intensive Astronomy (IDIA). Western Sydney University

Abstract

The Australian SKA Regional Centre (AusSRC) is Australia's portion of international SKA Regional Centre network, and a partnership between the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Curtin University, The Pawsey Supercomputing Centre, and The University of Western Australia (UWA). AusSRC aims to establish and build capability to support the Australian and international SKA science communities, thereby ushering in the next era of astronomical discovery and advanced data processing.

This presentation will cover the broad and diverse scientific projects that the AusSRC facilitates, with particular focus on our current support for the Australian SKA Precursors, the Murchison Widefield Array (MWA) and the Australian SKA Pathfinder (ASKAP), in themselves routinely producing big data, as well as our future plans to build on top of this to develop the capabilities essential to facilitating SKA science, including the simulation of SKA data at the exabyte scale.

Session

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FLAME: Fitting Lyα Absorption lines using Machine lEarning

Dr Priyanka Jalan[1], Dr Vikram Khaire[2], Dr M. Vivek[3], Dr Prakash Gaikwad[4]

[1]Computational Cosmology Group Center for Theoretical Physics, Polish Academy of Sciences Warsaw, Poland. [2]Indian Institute of Space Science and Technology, Thiruvananthapuram, Kerala 695547, India. [3]Indian Institute of Astrophysics, Koramangala, Bengaluru, Karnataka 560034, India. [4]Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

Abstract

We introduce FLAME, a machine learning algorithm designed to fit Voigt profiles to HI Lyman-alpha absorption lines using deep convolutional neural networks. FLAME integrates two algorithms: the first determines the number of components required to fit absorption lines, and the second calculates the Doppler parameter b, the HI column density NHI, and the velocity separation of individual components. For the current version of FLAME, we trained it on low-redshift forests observed with the Far Ultraviolet gratings of the COS aboard the HST. Drawing on this data, we trained FLAME on ~1M simulated Voigt profiles, forward-modeled to mimic absorption lines observed with HST-COS, to classify lines as either single or double components, and then determine Voigt profile fitting parameters. FLAME shows impressive accuracy on the simulated data by identifying more than 98% (90%) of single (double) component lines. It determines b values within 15 (18) km/s and log NHI cm2 values within 0.3 (0.8) for 90% of the single (double) component lines. However, when applied to real data, FLAME's component classification accuracy drops by ~10%. Despite this, there is a reasonable agreement between the b and NHI distributions obtained from traditional Voigt profile fitting methods and FLAME's predictions. Our mock HST-COS data analysis, designed to emulate real data parameters, demonstrated that FLAME could achieve consistent accuracy comparable to its performance with simulated data. FLAME's performance validates the use of machine learning for Voigt profile fitting, underscoring the significant potential of machine learning for detailed analysis of absorption lines.

Session

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905

The Galactica database: an open, generic and versatile tool for the diffusion of numerical simulation data in astrophysics

Dr Damien CHAPON

CEA Saclay - Research Institute into the Fundamental laws of the Universe (IRFU)

Abstract

The Galactica simulation database is a platform designed to assist computational astrophysicists with their open science approach based on FAIR principles. It offers the means to publish their numerical simulation projects, whatever their field of application or research theme and provides access to reduced datasets and object catalogs online. The application implements the Simulation Datamodel IVOA standard.

To give the scientific community the possibility to also access raw simulation data, Galactica integrates WebServices able to generate, on an "on-demand" basis, high-level data products that can be customized to meet specific user requirements. To that end, the Galactica central web application communicates with a high-scalability ecosystem of data-processing servers called 'Terminus' by means of an industry-proven asynchronous task management system. Each Terminus node, hosted in a research institute, a regional or national supercomputing facility, contributes to the ecosystem by providing both the storage and the computational resources required to store the massive simulation datasets and post-process them to create the data products requested on Galactica, hence guaranteeing fine-grained sovereignty over data and resources.

This distributed architecture is very versatile, it can be interfaced with any kind of data-processing software, written in any language, handling raw data produced by every type of simulation code used in the field of computational astrophysics. Its genericity and versatility, together with its excellent scalability makes it a powerful tool for the scientific community to disseminate numerical models in astrophysics at the exascale era.

Session

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Disentangling stellar atmospheric parameters in astronomical spectra using Generative Adversarial Neural Networks

Dra. Minia Manteiga[1,2], Dr. Carlos Dafonte[1,3], Dr Raúl Gómez-Santoveña[1,3]

[1]CITIC, Centre for Information and Communications Technologies Research, Universidade da Coruña, Campus de Elviña s/n, 15071 A Coruña, Spain. [2]Universidade da Coruña (UDC), Department of Nautical Sciences and Marine Engineering, Paseo de Ronda 51, 15011, A Coruña, Spain. [3]Universidade da Coruña (UDC), Department of Computer Science and Information Technologies, Campus Elviña s/n, 15071 A Coruña, Spain

Abstract

Finding representations of the data that can ease the extraction of useful information and improve algorithm performance in classification or parametrization problems has become crucial in the era of Big Data Astronomy. In this work, a deep network based on an encoder-decoder architecture has been designed where adversarial training, a modification of the traditional autoencoder, is used in the context of stellar spectral analysis. Concretely, we present a method for the chemical disentanglement of the information present in stellar spectra, with application to two spectroscopic surveys, APOGEE and Gaia/RVS. Our purpose is to find a projection of the stellar spectra, or latent space, in which the contribution due to the main stellar physical properties is eliminated to maximize the information related to the chemical properties which can then be better obtained or used, for instance, to locate chemical peculiar objects, unconditioned by physical parameters. In addition to the original application, the most direct outcome of our methodology is in the field of Big Data Astronomy, driven by the development of many important modern all-sky spectroscopic surveys. Our algorithm provides an important data dimensionality reduction while preserving, and even highlighting, the information of interest present in them.

Session

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935

Cosmological Hydrodynamical Simulations to probe the Evolution of Galaxies and their central Black Holes

Dr. Paramita Barai

INAF - Osservatorio Astronomico di Trieste (Italy)

Abstract

A complete understanding of the astrophysical processes in the Universe require a hybrid approach involving multiple techniques. Theoretical and numerical studies is a parallel attempt to understand how the Universe came to be as is observed by multi-wavelength observations.

Galaxy formation is highly non-linear, and involves a complex interplay of physical processes. Energetic feedback from stars and central Supermassive Black Hole (SMBH)s inside galaxies are extremely powerful and influence the fate of matter 100s of kpc to Mpc away. Tracking galaxy formation involves a wide range of physical scales: from star formation in molecular clouds on the pc scale, to millions of times larger tidal interactions between galaxies on Mpc scales. Numerical methods are ideal to tackle these sophisticated physics of galaxies and intervening gas. Cosmological Hydrodynamical Simulation, executed on massively parallel petaflop supercomputers, has emerged as a powerful tool to produce cosmic structures that are similar to the observed ones.

I will describe the performance and analyses of Cosmological Hydrodynamical Simulations, emphasizing on feedback from SMBHs at galaxy centers. These simulations are done with a modified version of the SPH code GADGET-3, and includes sub-resolution prescriptions for the physical processes of cooling, star-formation, chemical evolution, SN and AGN feedback. Especially we have sub-resolution models of thermal and kinetic AGN feedback, and switching between the feedback modes depending on the BH accretion rate. We investigate the growth of early supermassive BHs, and their impact on the host galaxies in terms of star formation quenching and the formation of outflows.

Session

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Dark Energy Explorers: Understanding Dark Energy with the Synergistic Use of Participatory Science and Machine Learning

Lindsay House[1], Karl Gebhart[1], Keely Finkelstein[1], Jose Saucedo[1], Laura Trouille[2,3]

[1]University of Texas at Austin. [2]Adler Planetarium. [3]Zooniverse

Abstract

In the age of large data astronomy, the use of machine learning (ML) is imperative. One method to ensure accurate results with ML is to use visual vetting. Dark Energy Explorers is crowd-sourced research, hosted on Zooniverse. To date, we have reached more than 16,000 individuals, representing over 80 countries. The goal is to visually vet sources from the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX). HETDEX is working to understand dark energy by mapping millions of galaxies at a lookback time of ~11 billion years. As an unbiased, spectroscopic survey one of the largest issues of HETDEX to tackle is minimizing false positives and contamination. Dark Energy Explorers has been successful with training the public to differentiate galaxies from artifact contamination to an accuracy of 98% as compared to an expert (House et al. 2023). In turn, DEE has improved the science impacts of HETDEX in combination with ML algorithms. Dark Energy Explorers and ML efforts have been successful in eliminating false positives from the source catalog (House et al. 2023) and have been able to remove almost 8,000 false detections with these efforts. The Dark Energy Explorers team has further used the project for public engagement in astronomy and ML through hosting Zoom nights with participants, facilitating discussions of the research publications, leading telescope tours, and creating classroom/educator resources. This talk will further explain how Dark Energy Explorers and ML have been successful in improving the science goals of HETDEX and public engagement.

Session

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A New High-Order Magnetohydrodynamic Code with a High-Order Constrained Transport Scheme

Professor Dongsu Ryu[1], Dr. Jeongbhin Seo[2]

[1]UNIST (Ulsan National Institute of Science and Technology), South Korea. [2]Los Alamos National Laboratory, USA

Abstract

We introduce a magnetohydrodynamic (MHD) code tailored for astrophysical applications. The code leverages a fifth-order finite-difference weighted essentially non-oscillatory (WENO) scheme for spatial discretization, coupled with a fourth-order strong stability-preserving Runge-Kutta (SSPRK) scheme for temporal integration. In particular, to match the high-order accuracy of the WENO scheme, we implement a novel constrained transport (CT) algorithm of high-order accuracy to enforce div(B) = 0. Here, we outline the MHD code and present its performance. We validate that with the new CT scheme, the code achieves the order of accuracy of the WENO scheme in wave decay tests, including a circularly polarized Alfven wave propagation test. Further, the code's high robustness and fidelity are demonstrated through tests involving complex flows.

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La Serena School for Data Science and the Spanish Virtual Observatory Schools, two initiatives based on hands on experience.

Prf. Dr. Amelia Bayo

European Southern Observatory

Abstract

The worlds of Data Science (including big and/or federated data, machine learning, etc) and Astrophysics started merging almost two decades ago. For instance, around 2005, international initiatives such as the Virtual Observatory framework emerged to standardize the way we publish and transfer data, enabling new tools such as VOSA (SED Virtual Observatory Analyzer) to come to existence and remain relevant today.

More recently, new facilities like the Vera Rubin Observatory, serve as motivation to develop efficient and extremely fast (very often deep learning based) methodologies in order to fully exploit the informational content of the vast LSST dataset.

However, fundamental changes in the way we explore and analyze data cannot permeate in the "astrophysical sociology and idiosyncrasy" without adequate training. In this talk I would present two specific initiatives that have been extremely successful and that are based on "learning by doing": La Serena School for Data Science and a series of schools organized by the Spanish Virtual Observatory.

The common denominator among the two kinds of schools is to present the students with real scientific problems that benefit from the concepts / methodologies taught. On the other hand, the demographics targeted by both initiatives vary significantly and can represent examples of two "flavors" to be followed by others.

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1019

Towards FAIR astrophysics simulations

Prof Susanne Pfalzner[1], Dr Stephan Hachinger[2], Dr Jolanta Zjupa[1], Dr Salvatore Cielo[2], Dr Frank Wagner[1], Prof Marcus Brüggen[3], Annika Hagemeier[1]

[1]Forschungszentrum Jülich. [2]Leibniz Supercomputing Centre. [3]University of Hamburg

Abstract

Scientific work needs to be reproducible, and this requires open access to the data. In the context of astronomical observations, the FAIR principles of research data, which stands for findable, accessible, interoperable, and reusable, are widely discussed. However, it is similar important that numerical simulations in astrophysics become FAIR and reproducible. Here we discuss that not only the relevant simulation codes need to be shared, but also the results data and diagnostic tools. Currently, the degree to which this data is shared differs significantly. Although code sharing has become more common, often only older or reduced versions are publicly available. Also, the actual result data and diagnostic tools are much less disseminated. This situation affects the reproducibility of researchers' work and other researchers' ability to reuse these research results. To address this,we review the requirements for data to become FAIRer in computational astrophysics and discuss supporting tools and access strategies to provide the relevant metadata. Finally, we suggest that open-source publishing standards in computational astrophysics agreed upon as the next steps towards FAIRer simulation data.

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Modelling WALLABY's: Challenges of, and Solutions for, Automated Kinematic Modelling of Galaxies in Large Surveys

Dr Nathan Deg[1], Dr. Nikhil Arora[1], Prof. Kristine Spekkens[2,1]

[1]Queen's University. [2]Royal Military College

Abstract

Current and upcoming untargetted HI surveys, like WALLABY, are resolving more galaxies than ever before. Deriving kinematic models for these galaxies is a key science driver for much of this work. But generating these models poses a great number of challenges as, regardless of the particular survey, the majority of detections in an untargetted survey will be marginally resolved and have a low S/N. We will present the challenges faced and lessons learned from the generation of the WALLABY pilot release kinematic models. We will also show how these have informed the automated pipeline being used for the full survey and how this pipeline can be used in other surveys as well as on mock observations from simulations, enabling detailed comparisons of the observations and simulations. We will also present early science results using these models, comparing the WALLABY results to those from simulations.

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Target selection for 4MOST WAVES using automated redshift bin classification

Gursharanjit Kaur, Dr. hab. Maciej Bilicki

Center for Theoretical Physics, Polish Academy of Sciences

Abstract

The WAVES survey of the 4MOST has a key science goal of studing the halo function by probing significantly lower galaxy and halo masses in the low-redshift Universe as compared to previous surveys. This will be achieved by measuring redshifts of 1.6 million galaxies with two flux-limited and redshift limited sub-surveys “wide” and “deep”. The WAVES-wide survey intends to target galaxies with Z band (central wavelength 0.88 μm) magnitude $Z \lesssim 21.1$ mag and a redshift $z \lesssim 0.2$. For the WAVES-deep, the conditions are $Z \lesssim 21.25$ mag and $z \lesssim 0.8$. The selection of galaxies with desired completeness for spectroscopic redshift measurements without a prior idea of the redshift is challenging. The general solution to such a problem is the photometric redshift estimation using the magnitude and color measurements of the target. However, such estimates typically have errors of $\sigma_z \gtrsim 0.02$ which might be too large for efficient target selection.

Our research intends to use machine learning classification to predict the probability of a source falling within the redshift limit as required by the WAVES survey, rather than estimate each object’s photometric redshift. We use supervised machine learning algorithms, our data being ugriZYJHKs broad-band photometry from KiDS+VIKING, as well as ancillary spectroscopic redshifts from overlapping wide-angle and deep surveys. Our current results indicate that we should be able to achieve the completeness of 90% of the targets with our methodology which is close to the survey success criteria.

Session

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The next generation of the HyperLeda database

Danila Makarov, Prof. Dmitry Makarov

Special Astrophysical Observatory of the Russian Academy of Sciences

Abstract

HyperLeda is the oldest database for the study of extragalactic objects, combining information from the literature and various sky surveys. One of the main features of HyperLeda, which distinguishes it from other numerous databases, is the integration of data from different sources into a unified homogeneous system. The main goal of our project is to develop an application that provides the ability to easily manage the data and add new information, as well as calculate the physical characteristics of galaxies.

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Anime.jl: Instrument Modelling for next-generation VLBI arrays

Dr Iniyan Natarajan

Center for Astrophysics | Harvard & Smithsonian. Black Hole Initiative, Harvard University

Abstract

The Event Horizon Telescope (EHT) is a global array of radio telescopes that has produced the first ever images of supermassive black holes using Very Long Baseline Interferometry (VLBI). We present an instrument modelling framework for millimetre (mm) and sub-mm wave observations with VLBI arrays, with a focus on the EHT and the next-generation EHT (ngEHT). We model instrumental and atmospheric propagation path effects at mm and sub-mm wavebands such as the instrumental contribution to the polarization state of the observed signal, the effects of wide passbands and simultaneous observations at different frequency bands, and ionospheric and tropospheric effects from first principles.

We also discuss how new algorithms for modelling VLBI observations would benefit from a conceptual redesign of the standard data formats currently used to store VLBI data sets. New data schemas and storage formats must take advantage of contemporary distributed parallel processing systems, support representation of multi-frequency data sets with easy access patterns, and should be accessible to modern programming languages such as Python and Julia.

We present Anime.jl, a software package for generating instrument models for simulation and calibration of radio observations. Anime is written in Julia, an open source, high performance language, ideal for high time resolution model synthesis due to the availability of highly optimised libraries for numerical and statistical computing. Anime also supports standard VLBI data formats and aims to serve as a platform for evaluating data schemas being developed for representing future VLBI data sets.

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Astronomaly at Scale: Searching for Anomalies Amongst 4 Million Galaxies

Mr Verlon Etsebeth[1], Dr Michelle Lochner[1,2], Dr Mike Walmsley[3,4], Ms Margheritta Grespan[5]

[1]University of the Western Cape. [2]South African Radio Astronomy Observator. [3]Jodrell Bank Centre for Astrophysics, Department of Physics & Astronomy. [4]Dunlap Institute for Astronomy & Astrophysics. [5]National Center for Nuclear Research, Poland

Abstract

Modern astronomical surveys are generating vast datasets with unprecedented detail, opening new avenues for significant scientific discoveries. To navigate this wealth of information, machine learning frameworks, such as Astronomaly, have emerged, aimed at anomaly detection. Here we assess the scalability of Astronomaly by analyzing nearly 4 million images of galaxies from the Dark Energy Camera Legacy Survey. Employing a deep learning algorithm, we extract valuable image representations which are subsequently fed into the Isolation Forest anomaly detection algorithm, augmented by Astronomaly's novel active learning method.

We show that the selection criteria for data significantly influence the balance between identifying rare phenomena, such as strong gravitational lenses, and introducing artifacts into the dataset. We demonstrate the necessity of active learning in pinpointing the most intriguing sources while mitigating the presence of artifacts, underscoring the inadequacy of relying solely on anomaly detection methods. Leveraging Astronomaly, our analysis uncovers 1635 anomalies within the top 2000 sources, post-active learning implementation.

Notable findings include 8 strong gravitational lens candidates, 1609 potential galaxy merger events, and 18 sources exhibiting highly unusual morphologies, the majority of which are previously unrecognized. These results underscore the efficacy of harnessing the human-machine interface to swiftly identify scientifically significant sources amidst extensive datasets. Through the synergy of advanced algorithms and human expertise, Astronomaly offers a potent tool for accelerating astronomical research and exploration.

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Lowering Barriers to Big Data in Astronomy: A Cloud Platform for the 21st Century

Thomas Dutkiewicz, Dr. Claire Murray

Space Telescope Science Institute

Abstract

The proliferation of “big data” in astronomy presents challenges and opportunities for the community. The Mikulski Archive for Space Telescopes (MAST) has already archived a petabyte of observations from TESS; we expect to archive another 20PB of data from the Roman Space Telescope over its 5-year primary mission. To fully harness these rich data resources, we need innovative cloud-based platforms that facilitate access, analysis, and collaboration in a scalable manner. The fundamental challenge is that we cannot just provide the cloud infrastructure; we must also teach users how to get work done in this novel environment. To that end, we present the Timeseries Integrated Knowledge Engine (TIKE), an AWS Jupyerhub platform providing direct access to cloud-hosted MAST data. The TIKE platform includes pre-installed software environments, documentation, and tutorials to rapidly onboard new users to cloud workflows. Since the platform works “out of the box”, requiring only an internet browser, it is ideal for teaching. Students don’t need to configure Python or even have a personal computer to begin learning. Although TIKE doesn’t yet support the most computationally intensive workflows, it is the first step toward our larger goal of changing the way researchers access and analyze data. Ultimately, our vision is to dramatically improve data accessibility for the broader astronomy community, not just those fortunate few with access to specialized computing environments. By fostering a collaborative community committed to making big data accessible, we will unlock new frontiers of astronomical discovery for everyone.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

1236

MESA workshop/hackathon

Shelley J. Cheng

Harvard University, Center for Astrophysics | Harvard & Smithsonian

Abstract

Massive stars are an important ingredient in understanding the evolution and structure of many astrophysical systems and objects, particularly compact objects and supernovae. Detections of Type IIn supernovae by programs such as the Carnegie Supernova Project have unveiled interesting pre-brightening signatures that are thought to be due to details of massive star evolution that are not yet well-understood. Additionally, detections of gravitational waves over the past decade by LIGO and VIRGO have provided observational signatures of compact object mergers that have challenged our present understanding of binary stellar evolution. Detailed simulations using stellar evolutionary codes such as MESA are crucial to contextualize these observations and further our overall understanding of stellar evolution. I will serve as a teaching fellow for a 2-day workshop/hackathon called 'A First Taste of MESA' lead by Lieke van Son to train early career researchers in MESA, which spans a variety of applications including asteroseismology, binary stars, planets, and compact objects.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

1237

Surrogate Modeling for Supernova Feedback toward Star-by-Star Simulations of Milky-Way-sized Galaxies

Keiya Hirashima[1], Kana Moriwaki[1], Michiko Fujii[1], Yutaka Hirai[2,3], Takayuki Saitoh[4], Junichiro Makino[4,5], Shirley Ho[6,7,8]

[1]The University of Tokyo. [2]University of Notre Dame. [3]Tohoku University. [4]Kobe University. [5]Preferred Networks, Inc.. [6]Flatiron Institute. [7]New York University. [8]Princeton University

Abstract

In galaxies, multiscale physics, such as star formation, stellar feedback, and inflow/outflow, work together and shape the entire evolution. Physical models for these phenomena have been improved in the past decades. Still, the highest resolution of Milky Way-mass galaxy formation simulations remains above 1,000 solar masses for one particle in smoothed-particle hydrodynamics simulations using a maximum of 10,000 CPUs. A smaller scale than the resolution is interpolated by so-called sub-grid models. Even if we use more CPUs, the other bottleneck prevents improving the resolution; the efficiency of parallel computing drops because of small timesteps caused by resolved small-scale structures such as supernova feedback. To overcome this problem, we have developed a surrogate model using machine learning to duplicate supernova feedback quickly (Hirashima et al., 2023). This model learns from three hundred 3D simulations of supernova feedback within isolated giant molecular clouds and predicts the physical quantities 100,000 years ahead, like Image-to-Image prediction. Our new approach reduces the computational cost to ~ 1 percent compared to directly resolving supernova feedback in the isolated cloud. We can use this model instead of integrating the expanding shells with small timesteps in galaxy simulations. By avoiding small timesteps, this method would improve the scalability of galaxy simulations and enable us to simulate the entire Milky Way galaxy, resolving individual stars and stellar feedback. In the presentation, we will report the fidelity and progress of the simulations with our new machine-learning technique

Session

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Estimating Eruptive Mass Loss in Massive Stars with MESA

Shelley J. Cheng[1], Dr Matteo Cantiello[2], Dr Jared Goldberg[2], Dr Evan Bauer[1], Professor Mathieu Renzo[3], Professor Charlie Conroy[1]

[1]Harvard University, Center for Astrophysics | Harvard & Smithsonian. [2]Center for Computational Astrophysics, Flatiron Institute. [3]University of Arizona & Steward Observatory

Abstract

Eruptive mass loss in massive stars has been observed but is not yet well understood. It is thought that episodes of eruptive mass loss are due to opacity peaks in the upper envelope of evolved massive stars that may cause the star to locally exceed the Eddington limit. Previous work in the literature either involve scaling formulae based on empirical mass loss rates rather than physical motivation or informative but computationally costly 3D simulations. We present estimated upper limits of eruptive mass loss rates derived from 1D MESA models for stars with masses between 10-100 solar masses at solar and SMC metallicities. Our model applies a physically-motivated energy argument to the envelope of massive stars to estimate eruptive mass loss by locating regions where the energy associated with locally super-Eddington luminosity exceeded the binding energy of the overlaying envelope. We find that, at a 10% model efficiency, eruptive mass loss of up to ~10^{-2} solar masses/year is driven by the Helium opacity peak and occurs in a vertical band on the HR diagram between 3.5 K < T_{eff} < 4.0 K. This predicted eruptive mass loss prevents stars of initial masses >20 solar masses from evolving to become red supergiants, offering a possible explanation for observations.

Session

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1243

How Important is Software to Astronomy?

Alice Allen

Astronomy Department, University of Maryland College Park, USA

Abstract

Software is by far the most used instrument in astronomy, and as robust research requires reproducibility and transparency, computational methods should be easily discoverable and open to examination. The Astrophysics Source Code Library (ASCL, ascl.net) makes the software that drives our discipline discoverable. The ASCL is a free online registry and repository for astrophysics research software. Containing over 3300 entries, it not only includes all the major codes that have enabled astro science, thus making it easy to find this software, it also advocates for open source and FAIR practices, and enables trackable formal software citation. Its entries have been cited over 14,000 times in over 200 journals, and are indexed by ADS and Web of Science. This presentation will cover how to use the ASCL and how it benefits the community.

Session

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1245

Bridging dimensions: numerical simulations of core-collapse supernova progenitors in 1, 2, 3D

Dr Zsolt Keszthelyi, Prof Tomoya Takiwaki, Dr Koh Takahashi

National Astronomical Observatory of Japan

Abstract

Our study leverages new computational capabilities to explore core-collapse supernova progenitors through numerical simulations across one (1D), two (2D), and three dimensions (3D). We focus on the silicon-burning phase in the late stages of massive star evolution. Employing a one-dimensional stellar evolution code, we study a dense parameter space. In this case, the computation of an order of 10^4 - 10^5 models can be suitably accomplished. Expanding into multidimensional simulations, we adopt 2D and 3D models to capture the interplay between complex phenomena such as convection, rotation, and magnetic fields, which are inherently three-dimensional and cannot be fully understood within the confines of 1D models. These higher-dimensional simulations offer a more realistic representation of stellar processes. However, the computational cost of more sophisticated 3D simulations is still prohibiting large parameter studies. Currently, we are able to compute an order of 10^2 2D models and up to about 10^1 3D models within computational feasibility. Our research aims not only to deepen our understanding of core-collapse supernova progenitors but also to bridge the gap between simulations and the wealth of data emerging from current and future astronomical surveys. By integrating observational data with simulation outputs, we confront the challenges of interpreting Big Data within the context of complex theoretical models. This synergy promises to refine our comprehension of stellar evolution, emphasizing the need for robust computational infrastructure and innovative data analysis techniques.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

1264

Big Data and Novel Processing Capabilities in Stellar Variability

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

The exponential growth of data in astronomy with the prospect of accelerating its flow makes astronomy not only one of the most productive branches of science, but also poses urgent challenges for fast (often in real time) and efficient processing and analysis of incoming data. Huge amounts of data obtained by *TESS*, *Kepler*, *Gaia*, *PanSTARRS*, *SAGES* and expected from *LSST* (Vera Rubin Observatory), as well as special photometric monitoring projects, provide excellent opportunities for studying stellar variability and searching for new variable objects. Here we present some results of long-term photometric monitoring campaign of a number of star clusters carried out under the international Uzbek-Indian research project. We obtained the extensive photometric time series database of 15 galactic open clusters during 3 years in 2021-2023. In addition to new data set, the time series were also obtained for 7 clusters in 2003. The complex analysis, together with the available data obtained by *TESS* and *Gaia* missions, made it possible to discover a significant number of new variable stars in different clusters and check the few known variables in these clusters. We also conducted ~4-5 hour continuous (patrol) observations of each of 14 individual magnetic cataclysmic variables (MCVs) in different regions of the sky. The resulting observational database and the current results of its analysis in combination with *TESS* and other data is discussed. Processing and in-depth analysis of this data using original pipelines and existed *BigData* analysis sofftware is currently ongoing together with our Indian partners.

Session

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1266

ASKAP software development: research software engineering for a radio telescope

Mr. Eric Bastholm[1], Dr. Paulus Lahur[1], Dr. Pascal Elahi[2], Mr. Matt Austin[1], Dr. Matthew Whiting[1]

[1]CSIRO, Space and Astronomy. [2]Pawsey Supercomputing Centre

Abstract

In this session, discover practical insights and lessons learned in development of a large scale, distributed, high performance computing (HPC) radio astronomy data ecosystem for the Australian Square Kilometre Array Pathfinder (ASKAP), a new-technology radio telescope, operated by CSIRO at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory in the Western Australian outback.

Building a functional data management and processing pipeline on an HPC platform for big data astronomy is a challenge that transcends the normal batch processing tasks that are more familiar in HPC data centres. Creating and maintaining a computing environment hosting a distributed data reduction application and various interconnected data sources and services to augment the real-time operation of a remote radio telescope is an ambitious goal. Success requires: development of effective software engineering practices that are compatible with the unpredictability of a research domain; adoption of proven software design patterns; good collaboration with the HPC platform provider; good collaboration with research scientists; consideration of scale early; establishment of sound development, build and test environments; and recognition that software engineering for a science research context is quite different to that of a typical industry context.

Using open-source components to accelerate and standardise development of the architecture and adopting design practices to facilitate extensibility and reusability of the codebase is a path to both effective agile design and development, and the ability to engage industry software engineers allowing *domain* specialists to work on *domain* problems.

Session

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ASKAP's high-performance processing: lessons from big data operations at scale

Dr Matthew Whiting[1], Dr Wasim Raja[1], Mr Matt Austin[1], Dr Paulus Lahur[1], Mr Eric Bastholm[1], Dr Mark Wieringa[1], Dr Max Voronkov[1], Dr Pascal Elahi[2], Dr Daniel Mitchell[1], Dr Stephen Ord[1], Mr Minh Vuong[1]

[1]CSIRO. [2]Pawsey Supercomputing Research Centre

Abstract

The Australian Square Kilometre Array Pathfinder (ASKAP) is a new-technology radio telescope and SKA precursor, operated by CSIRO at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. Its innovative receivers, with their wide field-of-view, generate very large data rates, necessitating high-performance computing to create the required calibrated images and catalogues, and deposit them in the CSIRO ASKAP Science Data Archive (CASDA) for use by astronomers.

The processing is performed through the ASKAP pipeline, a scripted workflow that interfaces with the Slurm workload manager to run large numbers of ASKAPsoft calibration, imaging and source-extraction tasks, all executed in near-real-time to keep up with the incoming data rate, allowing the telescope to efficiently survey the entire sky.

This talk will address several aspects of dealing with changing computational demands and infrastructure, reviewing some lessons learned from the point of view of a mature big data / big compute project. ASKAP is in its second year of survey operations, following several years of pilot surveys and early science, and we have built up concrete experience of the practicalities of running intensive, near-real-time processing on an HPC platform to produce science-ready data. This includes the recent move of our workflows to a new platform, made possible through the exploitation of containers and adaptation to the new infrastructure constraints of memory and compute resources. We have also been through the experience of scaling up our processing to deal with larger data sizes, and will speak to the role of large-scale simulations in paving the way.

Session

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CoLFI: Likelihood-free Inference with Neural Density Estimators

Dr. Guo-Jian Wang

Stellenbosch University

Abstract

In this talk, I will present how to constrain cosmological parameters with Neural Density Estimators (NDEs). Specifically, I will show three NDEs that we presented: the artificial neural network (ANN), the mixture density network (MDN), and the mixture neural network (MNN). I will show the principle of estimating parameters using these three NDEs. Then I will show a flexible code called CoLFI that we developed to constrain parameters using ANN, MDN, and MNN, which is suitable for any parameter estimation of complicated models in a wide range of scientific fields. CoLFI can obtain a high-fidelity posterior distribution using O(10^2) simulation samples, which makes parameter estimation faster, especially for complex and resource-consuming cosmological models.

Session

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1387

Exploring the High-Redshift Universe Using SKA and Other Upcoming Observational Facilities

Prof. Tirthankar Roy Choudhury

National Centre for Radio Astrophysics, Tata Institute of Fundamental Research

Abstract

Understanding the formation of the first stars in the Universe is an important unsolved problem in cosmology, which demands a multi-wavelength approach using different telescopes. For example, satellites like the JWST can directly detect the early galaxies, while upcoming radio telescopes like the SKA will probe the signal of hydrogen atoms. Interpreting the large and complex data sets from these observations would require theoretical models that are extremely detailed and, at the same time, computationally efficient. These models would then need to be combined with sophisticated statistical techniques to enable unbiased interpretation of the underlying physics. Although significant progress has been achieved towards building such theoretical frameworks, they have yet to attain the requisite level of sophistication necessary to fully harness the forthcoming high-quality datasets anticipated from state-of-the-art observational probes. In light of these challenges, the objective of this presentation is to highlight recent advancements in modelling the high-redshift universe, coupled with the evolution of Machine Learning-driven statistical techniques tailored to facilitate the comparison of theoretical models with observational data. The integration of such methodologies holds profound implications for enhancing our capacity to derive meaningful insights from forthcoming observational facilities.

Session

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1412

Emulating cosmological simulation dataset (CAMELS) with generative model

Dr Sambatra Andrianomena[1,2], Dr Sultan Hassan[3], Dr Francisco Villaescusa-Navarro[3]

[1]SARAO. [2]Department of Physics \& Astronomy, University of the Western Cape, Bellville, Cape Town 7535, South Africa. [3]Center for Cosmology and Particle Physics, Department of Physics, New York University, 726 Broadway, New York, NY 10003, USA

Abstract

We explore the possibility of using deep learning to learn from state-of-the-art hydrodynamic simulations of the CAMELS project. We train a generative adversarial network to generate new images with three different channels that represent gas density (Mgas), neutral hydrogen density (HI), and magnetic field amplitudes (B). We consider a case where the model is unconstrained and another case in which the images produced by the model are conditioned on cosmological parameters. The quality of each field map in each new example generated by the model looks very promising. More importantly, we find that the statistical properties of both the generated and simulated maps are in good agreement. Moreover, the cross-correlations between fields in all instances produced by the emulator are in good agreement with those of the dataset, implying the three fields in each new image describe the same physical region. Results also show that the matter density and amplitude of density fluctuations which condition the generative model can be recovered from the new images to a great precision, using a convolutional neural network based regressor trained on the CAMELS dataset. Our model, by speeding up computationally expensive cosmological simulations, can potentially help extract most of the information from different large scale surveys.

Session

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1414

Enabling unsupervised discovery in astronomical images through self-supervised representations.

Mr Koketso Mohale[1], Dr Michelle Lochner[2,3]

[1]University of the Western Cappe. [2]University of the Western Cape. [3]South African Radio Astronomy Observatory

Abstract

The next generation of telescopes such as the Square Kilometre Array (SKA) are expected to produce enormous amounts of high-resolution data. Machine learning, being data-driven, is increasingly being applied in astronomy. Unsupervised Learning, a sub-field of machine learning, is a more powerful approach for dealing with large and unlabeled datasets. The two most important unsupervised learning tasks are anomaly detection (detecting anomalous objects) and clustering (detecting groups of similar objects). However, these algorithms often fail to work with high-dimensional datasets, such as image datasets. This leads to a need for algorithms that reduce the dimensionality of resolved datasets, thereby obtaining what are called representations. We explore the use of deep learning techniques such as transfer learning and self-supervised learning to obtain deep representations of optical morphologies. We apply unsupervised learning on this representation space and show that we can obtain meaningful clusters as well as anomalies.

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Exascale Computation of Core-collapse Supernova with Flash-X

Dr. Anshu Dubey[1,2], Dr. Austin Harris[3], Dr. Bronson Messer[3]

[1]Argonne National Laboratory. [2]University of Chicago. [3]Oak Ridge National Laboratory

Abstract

Flash-X is the new incarnation of FLASH, which has served the astrophysics community along with several others for more than two decades. Flash-X continues that legacy. It was recently used on Frontier, the world's first exascale platform, as a part of the United States Depart of Energy's Exascale Computing Project. Specifically, Flash-X was used to run a core-collapse supernova simulation as a demonstration of the exascale capability for the ExaStar ECP project. The calculation exercised the integrated multi-physics of the code, including self-gravity, shock-capturing hydrodynamics, nuclear reactions, nuclear equation of state, and spectral neutrino transport. Each of these pieces of physics is necessary to produce simulations of these stellar transients that can be used to confront observations across photons, neutrinos, and gravitational waves.

Computing at scale on exascale platforms is extremely challenging due to heterogeneity in both hardware and software. While platform heterogeneity has been in the spotlight for a while, a similar challenge is presented by increasing diversity in solvers that applications such as core-collapse supernova simulation need to deploy has not been given needed attention. Therefore, Flash-X adopted the approach of co-designing the software architecture with an accompanying toolchain to provide an enduring solution to performance portability across a wide variety of applications and platforms that can be supported. The code and the toolchain are both highly composable with building blocks that can be permuted and combined in different ways. In this presentation we distill our experience in preparing Flash-X for multiphysics astrophysical simulations on exascale platforms.

Session

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1477

Application of Machine Learning to map stable regions around planets

Giovana Ramon[1], Mrs. Tiago Francisco Leal Pinheiro[1], Prof. Dr. Rafael Sfair[1,2]

[1]Sao Paulo State University (UNESP), Guaratinguetá-SP, Brazil. [2]Eberhard Karls University of Tübingen, Tübingen, Germany

Abstract

The number of exoplanets increases every year and the study of the stability of extra-solar planetary systems led to a question if they could host exomoons or exorings. These studies are typically performed numerically by solving a large set of computationally expensive N-body simulations. We propose to apply Machine Learning (ML) to predict maps of stable regions of S-type orbits around planets. To identify the stable regions we perform numerical simulations of a system formed by a star, a planet, and a particle, using the Rebound package and IAS15 integrator. Each system has nine features representing the initial conditions of the orbital elements of the planet, the particle, and the mass ratio of the system. The constructed ensemble characterizes the set for training and testing ML methods; thus, based on the dataset features, the model learns the behavior of stability regions and can predict the stability of a system. In total, we run $5x10^4$ numerical systems, where stable particles comprise around 12% of the sample, resulting in an unbalanced data set. The ML training with imbalanced classes can lead to classification biases and impair the algorithms' effectiveness. To solve this problem, we used resampling methods, hyperparameter and threshold tuning. We applied 5 different supervised models: Decision Tree, Random Forest, XGboost, LIGHTGBM and Histogram Gradient Boosting, achieving an accuracy of up to 98%, a recall and a precision of 91% and 93% respectively for stable particles. This approach reduces the invaluable time that would be spent in numerical simulations to a training of minutes.

Session

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Determination of the merger time in shell galaxies with IllustrisTNG

Tuğba EROL[1], Dr. Mustafa Kürşad YILDIZ[2,3], Dr. Ivana Ebrová[4], Dr. Michal Bílek[4]

[1]Erciyes University, Graduate School of Natural and Applied Sciences, Kayseri. [2]Erciyes University, Faculty of Science, Astronomy and Space Sciences Department, Kayseri. [3]Erciyes University, Astronomy and Space Sciences Observatory Applied and Research Center (UZAYBİMER), Kayseri). [4]FZU - Institute of Physics of the Czech Academy of Sciences, Prague

Abstract

Stellar shells are low surface brightness features generally in the shape of concentric arcs. Stellar shells observed in many giant elliptical and lenticular, as well as a few spiral and dwarf galaxies, presumably result from minor and intermediate radial mergers of galaxies. An essential factor in determining the merger time is the distance of the shells from the centre of the galaxy. Shells move away from the centre after they are created; therefore, the outermost shell indicates the lower limit of the merger time. Thus, we use the radius of the outermost shell to calculate the time of the merger. Based on the relation between the merger time and distance, the resulting merger time significantly changes if shells are further behind than the observed ones. Therefore, we need to look at galaxies from different angles and determine the distances of the shells. However, the visibility and radii of the shells change with the viewing angle; thus, we cannot see the shells behind the galaxy.We can only explore these effects in simulated galaxies. In our study, we investigate up to which precision the shell radii depend on the orientation of the galaxy with respect to the observer. We make use of the Illustris TNG50 simulation.We look at galaxies from 9 selected points of view angles and measure the distances of the shells. We calculate the merger time for each line of sight and evaluate how different orientation affects the results.We also learn about how shells evolved by creating an evolutionary scheme.

Session

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1512

Handling the Data Deluge from the Square Kilometre Array telescope

Dr Danny Price[1,2], Dr Jimi Green[1], Dr Shari Breen[1], Dr Nichol Cunningham[1], Dr Sarrvesh Sridhar[1], Dr Sharmila Goedhart[1]

[1]Square Kilometre Array Observatory. [2]Curtin University

Abstract

The SKA Low and Mid telescopes are next-generation flagship radio astronomical facilities that will revolutionize radio astronomy for decades. The data rates anticipated from the telescopes require that signal processing and data reduction are integrated into the telescope design and operational model. In this talk, I will discuss details of the SKA telescopes and their specifications, highlighting the expected data rates, supported data products, signal processing solutions, and challenges. I will also briefly discuss our operational model and provide details of how and when the community might expect to access the SKA.

Session

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1564

eXplainable AI for Radio Galaxy Morphology Classification

Dr Hongming Tang[1], Ms Shiyu Yue[2], Mr Zijun Wang[2]

[1]Department of Astronomy, Tsinghua University. [2]School of Physics and Astronomy, Sun Yat-sen University

Abstract

Radio galaxy morphological classification is one of the critical steps when producing source catalogues for large-scale radio continuum surveys. While many recent studies attempted to classify source radio morphology from survey image data using deep learning algorithms (i.e., Convolutional Neural Networks), they concentrated on model robustness most time. It is unclear whether a model similarly makes predictions as radio astronomers did. In this work, we used Local Interpretable Model-agnostic Explanation (LIME), an state-of-the-art eXplainable Artificial Intelligence (XAI) technique to explain model prediction behaviour and thus examine the hypothesis in a proof-of-concept manner. In what follows, we describe how LIME generally works and early results about how it helped explain predictions of a radio galaxy classification model using this technique.

Session

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1576

Comparing simulations and observations of disk galaxies.

Dr. Nikhil Arora[1], Prof. Stéphane Courteau[1], Dr. Connor Stone[2], Prof. Andrea Maccio[3,4]

[1]Queen's University. [2]Université de Montréal. [3]New York University Abu Dhabi. [4]Center for Astrophysics and Space Science, New York University Abu Dhabi

Abstract

Given their importance for constraining galaxy formation and evolution models, studies of galaxy scaling relations have enjoyed a rich history. In this talk, I will present a large dataset of observed spiral galaxies with resolved photometry and rotation curves from the MaNGA galaxy survey. Along with the ancillary data, numerous fundamental galaxy scaling relations can be constructed which are uniformly compared to similar relations from cosmological simulations such as NIHAO. Given the versatility of resolved observed data, we can now begin studying resolved galaxy scaling relations. I will also present spatially resolved scatters for the velocity-size-stellar mass structural relations using MaNGA and NIHAO samples. The scatter for these relations in the galactic interiors is a consequence of the diversity of inner RC shapes, while scatter in the outskirts is dictated by the large range of stellar surface densities, which is itself driven by sporadic star formation within galaxies. The detailed spatially resolved scatter analysis highlights the complex interplay between local and global astrophysical processes and provides a strong, novel constraint to numerical simulations. This new era of high-resolution, spatially resolved multiwavelength observations and state-of-the-art cosmological simulations will benefit from the multifaceted analysis discussed in this presentation.

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1604

3D Asymmetries and their application to Simulations and Surveys

Dr Nathan Deg[1], Dr Marcin Glowacki[2], Prof Sarah Blyth[3]

[1]Queen's University. [2]Curtin University. [3]University of Cape Town

Abstract

The large volumes of data now being generated by surveys and simulations requires new statistical tools and techniques to fully leverage their power. One area of particular interest is the characterization of galaxy morphology. The asymmetry statistic is one method of quantizing the disturbance/disruption of a galaxy, and has been used with great success in studies of images and spectra that probe the influence of interactions and environment on galaxy evolution. However, it has proved challenging to apply to interferometric surveys as typical detections from untargetted surveys are low resolution and have a low S/N. We have developed an extension of the asymmetry statistic that can be applied to 3D data products. We have also developed an improved method of quantifying the effect of noise, allowing for the asymmetry to be used at lower resolutions than ever before. We will present this new asymmetry measure and early results from its application to the Simba hydrodynamical simulations. We will also show how we can compare the results from our asymmetric Simba analysis (ASymba) to those from interferometric surveys like WALLABY.

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1667

New approach to constraint on the dynamics of extra solar ring systems

Mrs. Tiago Pinheiro[1], Giovana Ramon[1], Dr. Rafael Sfair[1,2]

[1]Sao Paulo State University (UNESP). [2]Eberhard Karls University of Tübingen

Abstract

No exoplanetary ring has been confirmed yet. However, observations in 2007 of the star J1407 revealed a prolonged dimming event, attributed to the passage of an inclined disk with a radial extension of 0.3 ua, potentially indicative of an exoplanetary ring system associated with an unseen secondary companion, J1407b. Another star, PDS110 in 2008 and 2011 underwent two similar eclipses with a depth of 26% and lasted 25 days each. A plausible explanation is the presence of a ring system around an unseen giant planet (PDS110b). In this work, we aim to constrain some orbital and physical parameters that are not well determined just by observational data. We applied two different approaches to study the stability of each system. We numerically integrated the three-body problem (star, planet and particle), exploring millions of different initial conditions for the PDS110b system and ruling out all that did not match with the observations. The most likely result shows an almost circular planet, with a mass > 35 Jupiter masses, a ring inclination < 60º, and a radius of [0.1–0.2] au. In the second approach, to reduce substantially computational efforts, we utilized Machine Learning algorithms to predict stable regions around J1407b. The performance of algorithms has an accuracy > 93% using a dataset with just 10% of the amount of numerical simulations if were applied the first approach. The results show J1407b has a mass > 50 Jupiter masses, an eccentricity ~ 0.3, the eclipse can be explained by prograde and retrograde rings.

Session

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High performance massively parallel direct N-body simulations on large hybrid CPU/GPU clusters.

Prof. Dr. Sci. Peter Berczik, Dr. Marina Ishchenko, Ms. Margarita Sobolenko

Main Astronomical Observatory National Academy of Sciences of Ukraine, 27 Akademika Zabolotnoho St. 03143 Kyiv, Ukraine

Abstract

Theoretical numerical modeling has become a third pillar of science, alongside theory and experiment (in the case of astrophysics, experiment is mostly replaced by observation). Numerical modeling allows one to compare theory with experimental or observational data in unprecedented detail, and it also provides theoretical insight into physical processes at work in complex systems. We are in the midst of a new revolution in parallel processor technologies and a shift in parallel programming paradigms that can help push today's software to the exaflop/s scale and help better solve and understand typical multi-scale problems. The current revolution in parallel programming has been largely catalyzed by the use of graphical processing units (GPUs) for general-purpose programming, but it is not clear that this will continue to be the case in the future. GPUs are now widely used to accelerate a wide range of applications, including computational physics and astrophysics, image/video processing, engineering simulations, quantum chemistry, to name a few. In this work, we present direct astrophysical N-body simulations with up to six million bodies using our parallel MPI/CUDA code on large hybrid CPU/GPU clusters (JUREAP/Germany and LUMI/Finland) with different types of mixed CPU/GPU hardware. We achieve about one third of the peak GPU performance for this code, in a real application scenario with single hierarchical block time-steps, high (4th, 6th, and 8th) order Hermite integration schemes, and a real core-halo density structure of the modeled stellar systems.

Session

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1735

CARACal: A Comprehensive Container-based Data Reduction Pipeline for Radio Astronomy

Athanaseus Ramaila[1,2], Oleg Smirnov[1,2], Benjamin Hugo[2,1], Simon Perkins[2], Mpati Ramatsoku[3,1], Lexy Andati[1], Paolo Serra[3], Filippo Maccagni[3], Dániel Molnár[3], Francesca Loi[3], Sarah White[4], Sphesihle Makhathini[5], Dane Kleiner[6], Erwin de Blok[6,7], Gyula Jozsa[8], Peter Kamphuis[9], Kshitij Thorat[10]

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Abstract

Recent advancements in radio interferometry software have reached a level of sophistication that enables astronomers to tackle calibration and imaging challenges presented by next-generation telescopes, notably the South African MeerKAT, LOFAR, ASKAP, and the Square Kilometre Array (SKA). We will present the **CARACal** pipeline (Józsa et al. 2020), which uses a platform-independent scripting framework ***stimela*** that allows the easy creation of astronomical data reduction pipelines using Python and any of the supported container technology of choice (Docker, Podman and Singularity/Apptainer). In this framework, radio interferometry-related tasks such as data synthesis, calibration, polarimetry, continuum and spectral line imaging are executed in containers. In CARACal, the ideal tools available for each task are used seamlessly to produce some of the best astronomical images in an automated manner. The pipeline is indeed leveraged across multiple MeerKAT Large Survey Programs and instruments (such as JVLA and GMRT) to generate science deliverable data products shortly after the conclusion of observations. It has enabled tens of publications across a wide range of astronomy applications, including radio continuum, polarisation and spectral line imaging. We have enhanced the pipeline by implementing distributed computing approaches across the workflow, which includes a comprehensive suite of remotely accessible imaging quality metrics.

The primary objectives of this initiative are to offer essential services to the Radio Astronomy community, which include: a) A user-friendly environment that facilitates easy access to cutting-edge radio interferometry packages. b) Streamline installation processes and facilitate production deployment to enhance usability across various computing environments.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

1846

Scientific Computing at Scale : How do we approach a petabyte scale problem?

Dr Srikrishna Sekhar

National Radio Astronomy Observatory

Abstract

Current generation radio interferometers (e.g., MeerKAT, JVLA) are producing data at rates of a few to tens of terabytes per day, with the rates predicted to go up substantially with the next generation of instruments (ngVLA, SKA). In order to keep up with the expected data, and to produce science ready data products on reasonable timescales, the data processing architectures must necessarily be highly parallel and scaleable.

In this talk, I will discuss two approaches to parallel computing at scale. The first is the approach adopted by the IDIA MeerKAT pipeline, deployed at the Institute for Data Intensive Astronomy (IDIA) facility in Cape Town, South Africa. The pipeline is an automated, parallel, scaleable full Stokes calibration and imaging pipeline designed to operate on the ilifu cluster using off-the-shelf software. The pipeline was designed to be scaleable and reproducible by interfacing with cluster workload managers (such as SLURM) and utilizing software containers (Singularity) to manage software versions and dependencies.

The second is the VIPER framework, being designed as the parallelization backbone of the next-generation CASA software package. VIPER utilizes DAGs (directed acyclic graphs) using Dask to manage the parallelization. These DAGs can then be deployed on a connected cluster, or a distributed cluster architecture using technologies such as HTCondor.

I discuss synergies between these approaches, as well as their applicable regimes with a view on the data processing requirements from next-generation instruments.

Session

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1848

ALeRCE: Machine Learning for multistream/multicadence alert streams

Guillermo Cabrera-Vives

University of Concepción. Millenium Institute of Astrophysics. Millennium Nucleus on Young Exoplanets

Abstract

ALeRCE (http://alerce.science/) is an astronomical alert broker aiming at the rapid classification of large etendue telescope alert streams, such as that provided by the Zwicky Transient Facility (ZTF), the Asteroid Terrestrial-impact Last Alert System (ATLAS), and, in the future, the Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST). ALeRCE contains an ever evolving set of machine learning algorithms that are constantly being improved enabling new avenues for scientific exploration across diverse astrophysical phenomena. This talk will focus on the models under production, models in development, and challenges lying ahead, including moving towards a multistream ecosystem dominated by LSST. We will pay particular attention to the challenges arising when dealing with distribution shifts in the data (e.g. models trained on simulations and applied to real data or changes in cadence).

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

1857

Probing Star Formation in Interacting Galaxies through Cosmological Simulations

Mr. Lawrence Faria[1], Dr. David Patton[2]

[1]Queen's University. [2]Trent University

Abstract

Mergers and interactions play pivotal roles in the evolutionary trajectory of galaxies, significantly influencing various dynamical and baryonic properties throughout their histories. Understanding the impact of these major and minor interactions on galaxy evolution is crucial for constraining galaxy formation and evolution processes. Observational studies have shown that interacting galaxies exhibit elevated star formation rates compared to their more isolated counterparts. Idealised high-resolution merger simulations indicate that this enhancement may result from a combination of enhanced fuelling or enhanced efficiency of star formation. In this talk, I will explore how cosmological hydrodynamical simulations provide a unique opportunity for us to study these processes as a function of time within a cosmological context.

Using reconstructed orbits of galaxy pairs in the IllustrisTNG simulation, we assemble a dataset of distinct pericentric encounters over which we track changes in galaxy properties relative to the pericentre. We find that star formation rates, gas fraction, and star formation efficiency are significantly centrally enhanced approximately 0.1 Gyrs after a pericentric encounter. We identify the enhanced star formation efficiency of hydrogen gas as the primary driver for the increased star formation following a pericentric encounter. This investigation helps to better link observational pair studies of interacting galaxies with the findings of high-resolution merger simulations.

Session

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1870

Black hole modelling and imaging with EHT data

Dr Iniyan Natarajan[1,2], Dr Paul Tiede[1,2], Dominic Chang[3,2]

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[3]Department of Physics, Harvard University

Abstract

This hackathon focuses on the analysis of data obtained from very long baseline interferometry (VLBI) black hole observations with the Event Horizon Telescope (EHT) at an observing frequency of 230 GHz. The EHT Collaboration has developed many software tools for modelling and imaging black holes en route to the publication of the first ever images of the supermassive black holes at the centres of the Milky Way and M87 galaxies.

Participants will learn to use two of the many modelling and imaging tools used within the EHT collaboration, namely, eht-imaging and Comrade. The eht-imaging library is a regularized maximum likelihood method written in Python for simulating, manipulating, and reconstructing images from radio interferometric data. Comrade is a Bayesian modelling and imaging framework written in the highly performant Julia programming language. Both tools can be used to investigate the morphology and astrophysics of a variety of astronomical sources.

Participants will be given a short introduction to the Julia programming language in which they will learn the basics of programming with Julia. They will then learn how to use Comrade and eht-imaging to analyse both synthetic and real observations of black holes with the EHT and will have the opportunity to work on short projects exploring these software packages during the Focus Meeting on Computational Astrophysics and Big Data.

Session

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2011

Turning SDO Noise Into Van Allen Radiation Belt Characterization Data

Dr. Spiridon Kasapis[1], Dr. Barbara Thompson[2], Dr. Raphael Attie[2], Dr. Gonzalo Cucho-Padin[2], Daniel da Silva[2], Dr. Juan Rodriguez[3]

[1]NASA Ames Research Center. [2]NASA Goddard Space Flight Center. [3]University of Colorado Boulder

Abstract

The Solar Dynamics Observatory (SDO), a solar mission in an inclined geosynchronous orbit, has been capturing images with its Atmospheric Imaging Assembly (AIA) instrument since its commissioning. These images often exhibit "spikes" – pixel regions with an unusually high number of digital counts, likely caused by energetic electron collisions with the detector system. To ensure data integrity, these spikes are typically removed from AIA Level 1.0 images. An analysis of historical data reveals the presence of over 100 trillion spikes over the past decade. This project aims to enhance the utility of SDO data by linking spike detection frequency with surrounding radiation environment parameters. Our investigation involves a detailed correlation study between SDO/AIA data and the radiation belt activity in SDO's orbit. By extracting “spike” data from SDO/AIA images, we have developed a comprehensive dataset, correlating it with geomagnetic indicators like Kp, Ap, and Sym-H, as well as electron and proton fluxes recorded by the GOES-14 satellite. The findings indicate a strong correlation between AIA spikes and GOES-14’s detection of electrons and protons, with Spearman's Correlation values of $\rho = 0.73$ and $\rho = 0.53$, respectively, at the equatorial meeting point of the two satellites. Additionally, a moderate correlation of $\rho = 0.47$ is observed with magnetospheric proton detector protons over a continuous 2-year data collection period. This significant correlation underscores the potential of SDO spike data in characterizing the Van Allen radiation belts, particularly in regions not covered by other satellites.

Session

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2051

Synergy of 3D Realistic Modeling of the Turbulent Dynamics of the Sun and Observations from SDO, Hinode, and IRIS Space Missions

Irina N. Kitiashvili[1], Alexander G. Kosovichev[2], Cristina M. Rabello Soares[3], Viacheslav M. Sadykov[4], Alan A. Wray[1], Junwei Zhao[3]

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Abstract

The current computational capabilities allow us to reproduce the turbulent dynamics of the Sun with a high degree of realism from the interior to the corona. At the same time, the variety of available observations allows us to probe the subsurface dynamics and observe a wide range of phenomena in the solar atmosphere, from the photosphere to the corona. However, interpreting observations remains challenging due to the non-linear coupling of the turbulent plasma dynamics with magnetic fields and radiation. Using the output from the realistic 3D radiative MHD simulations, we generate synthetic observables for different instruments to enable comparison of observations and models. This presentation will discuss examples of a synergetic analysis of the models, synthetic observables, and observational data from different space missions: SDO, Hinode, and IRIS. Specifically, we will discuss the center-to-limb variations of spectroscopic data, subsurface flow measurements by the ring-diagram analysis, effects of the local dynamo, the origin of small-scale eruptions, and dynamics of the solar corona.

Session

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2098

Big *Mock* Data: Understanding galaxies with simulation-based inference

Dr. Connor Bottrell

ICRAR/UWA

Abstract

The next generation of galaxy astronomy will be shaped by the unprecedented output from instruments like the Square Kilometer Array, Euclid space telescope, and Rubin Observatory. Most importantly, data from these facilities will be gauntlets through which competing models of galaxy formation will be tested. Running these tests demands an apples-to-apples approach that is efficient, sensitive, and goes beyond reductive scaling relations. In this talk, I will show that large samples of realistic, multi-wavelength mock images made from galaxies in cosmological simulations make it possible to (1) compare simulated universes to ours; (2) map observables to unobservables and (3) port these mappings to the real Universe. I will first show that deep contrastive learning supports comparisons of mocks and observations with minimal information loss. Next, I will show that simulation-based inference models can be trained on simple, image-based observables to significantly reduce the intrinsic scatter in key relations, such as the stellar-to-halo mass relation. Lastly, I will show that simulation-trained deep generative models can be used uncover substructures buried in noisy and blurry images across very different domains — from galaxies to planetary disks.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2179

Hackathon: Magnetohydrodynamics with PLUTO code.

Dr. Bhargav Vaidya

Indian Institution of Technology Indore

Abstract

Astrophysical code, PLUTO, is a freely available software designed for solving mixed hyperbolic/parabolic systems of partial differential equations, specifically focusing on high Mach number flows in astrophysical fluid dynamics (Mignone et. al. 2007). For about two decades, there has been significant development of the PLUTO code both in terms of adopting novel computing advancements and expanding its scope in terms of applications. This multi-physics, highly parallel code has been used to simulate several astrophysical environments ranging from the planetary atmosphere to AGN jets. Further, it has a hybrid Eulerian-Lagrangian framework for developing synthetic observations. I aim to develop a hackathon to drive students and professionals in the realm of MHD simulation with PLUTO code. This hackathon will concentrate on physical processes like instabilities and shocks in astrophysical environments. As a case study, the focus would be on heliosphere modelling, commonly referred to as space weather. This is an area inundated with data, particularly from recent missions like the Parker Solar Probe and Solar Orbiter. Despite this data influx, 3D multi-scale MHD and plasma simulations, crucial for understanding space weather phenomena, are lacking. Moreover, this topic holds relevance globally as countries are establishing specialised centres for Space Weather, such as SANSA in South Africa. The skills and experience participants will acquire can be applied to investigate various phenomena, including stellar and extragalactic jets, magnetospheric accretion, star-disk interaction, relativistic shock dynamics, and fluid instabilities.

Session

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2182

Polarisation and SED Modelling of Magnetised Relativistic AGN Jets using RMHD Simulations.

Mr. Reuben Immelman[1], Mr. Izak P. van der Westhuizen[1], Prof. Brian van Soelen[1], Dr. Jacques Maritz[2], Prof. Bhargav Vaidya[3]

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Abstract

Jets associated with radio-loud active galactic nuclei (AGN) produce synchrotron radiation which dominates the lower energies (from radio to soft X-rays). At sub-parsec and parsec scales, the impact of varying observational angles, jet kinematics and structure on the emission and polarisation from relativistic jets is not well understood. We aim to simulate the changes in the emission and polarisation due to varying observational angles of over-pressured, magnetized relativistic jets. A 3D RMHD simulation was set up with the PLUTO code. A domain size of 6 pc was used to model the parsec region. The simulation consisted of a uniform background medium with a less dense spine/sheath jet model injected at the base of the simulation. The spine and sheath had a radius of 0.033 pc and 0.1 pc and a maximum bulk Lorentz factor of $\Gamma_{max} = 10$ and $\Gamma_{max} = 3$, respectively. The jet was threaded by a helical magnetic field where the spine and sheath had a maximum magnetic field magnitude of $B = 50$ mG and $B = 5$ mG, respectively. Lagrangian particles were injected at the base of the jet with an initial power-law distribution, and were allowed to evolve with time. The synchrotron emissivity and absorption coefficients were calculated during runtime. The emission was simulated for various viewing angles, with light crossing time accounted for using a linear interpolation method. We present the modelled spectral energy distributions (SEDs) and linear polarisation fractions of an over-pressured magnetized relativistic jet simulated at different observational angles.

Session

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2266

Africanus II. QuartiCal - Scaling radio interferometric calibration from your laptop to the cloud

Dr Jonathan Kenyon[1,2], Dr Simon Perkins[2], Dr Landman Bester[2,1], Dist. Prof. Oleg Smirnov[1,2]

[1]Centre for Radio Astronomy Techniques & Technologies (RATT), Rhodes University. [2]South African Radio Astronomy Observatory (SARAO)

Abstract

Existing radio interferometers such as MeerKAT already produce huge quantities of visibility data. However, these quantities are modest in comparison to the expected output of future instruments such as the SKA, ngVLA and DSA-2000. Calibration of these visibilities is, and will remain, an integral component of data processing. Unfortunately, most existing calibration software was not designed for problems at this scale. In particular, support for distributed computing is limited and where it exists it is often implemented post-hoc. To address this, we introduce QuartiCal, a calibration package implemented in Python which leverages the Dask library for parallel and distributed computing. This approach allows QuartiCal to run in a wide variety of scenarios, from small problems run locally on a laptop to intermediate problems run on a single cluster node and even large problems run on an HPC system or in the cloud. The Dask-MS package was critical to these developments as it exposes the most common radio interferometer data format in a manner compatible with Dask. Typical Python concurrency limitations have been circumvented by implementing the most computationally demanding components of QuartiCal using Numba, a just-in-time compiler which allows for the speed of a compiled language without sacrificing the accessibility of Python. Our results include performance benchmarks and images produced using QuartiCal for calibration, establishing the package as a modern and robust alternative to legacy software.

Session

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2268

Africanus IV. Stimela2 – scalable and fully reproducible data reduction workflows, from on-premises to HPC to cloud

Distinguished Professor Oleg Smirnov[1,2,3], Dr Sphesihle Makhathini[4,1], Dr Landman Bester[2,1], Dr Jonathan Kenyon[1,2], Dr Simon Perkins[2]

[1]Centre for Radio Astronomy Techniques & Technologies (RATT), Rhodes University. [2]South African Radio Astronomy Observatory (SARAO). [3]nstitute for Radioastronomy, National Institute of Astrophysics (INAF IRA). [4]School of Physics, Wits University

Abstract

Modern radio interferometric data reduction pipelines are long, complex beasts, and, above all, highly heterogeneous ones – the best results are often achieved by pulling together a combination of disparate software packages of varied provenance. Given the diversity of our instruments and software groups, this is likely to remain the case in the future. This complexity is in essential tension with reproducibility, ease of development, deployment and use. Stimela2 is a workflow management framework that aims to square this circle. It provides a rich yet concise YaML-based syntax for (1) wrapping third-party software packages into “cabs”, comprised of an interface definition (schema) file, and a docker image (or a natively installed executable), and (2) chaining cabs into “recipes” that represent a workflow. Stimela2 can then execute these workflows using a variety of backends: (a) natively on the host OS (using locally-installed software), (b) using a container engine such as Singularity/Apptainer, (c) using a cloud-based Kubernetes cluster (e.g. EKS), (d) using some combination of (a) and (b) with the Slurm scheduler. The containerized backends (along with a registry of curated and versioned images) provide reproducibility and ease of deployment, the Kubernetes and Slurm backends provide scalability and compatibility with cloud and HPC architectures, while the “native” backend allows for rapid development of experimental workflows. Stimela2 also handles parameter validation (thus catching many user errors up front), modular and composable recipes (i.e. steps may be sub-recipes), and scatter/gather constructs for high-level workflow parallelization.

Session

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2269

Novel Computer Vision Applications for Big Data in Astronomy

Dr Minh Huynh, Dr Nikhel Gupta

CSIRO

Abstract

Big Data challenges associated with large radio surveys, such as the Evolutionary Map of Universe (EMU) conducted using the Australian Square Kilometre Array Pathfinder (ASKAP) telescope, will require non-traditional approaches. We have applied self-supervised algorithms for discovering new radio sources such as Odd Radio Circles. I will discuss how we use weakly-supervised deep learning techniques for detecting extended radio sources, along with the integration of novel semi/fully supervised object detection methods to identify, categorize and group complex radio galaxies with multiple components. These novel computer vision methods produce value-added catalogues of radio galaxies which are essential for astronomical and cosmological studies.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2280

Africanus III. Deconstructing a Radio Interferometric Imager to Foster Better Algorithms

Dr Landman Bester[1,2], Dr Simon Perkins[1,2], Dr Jonathan Kenyon[2,1], Dist Prof Oleg Smirnov[2,1]

[1]South African Radio Astronomy Observatory (SARAO). [2]Centre for Radio Astronomy Techniques & Technologies (RATT), Rhodes University

Abstract

Despite certain well-documented limitations, the CLEAN algorithm stands out for its speed, ease of parameter tuning, and maturity, making it the most popular deconvolution algorithm in radio interferometry by far. pfb-clean is an imaging library that breaks down the constituent parts of an imager into separate workers. Each worker corresponds to a Python function that consumes and produces Xarray Datasets backed by Dask graphs. Workers interface with measurement set-like objects, including those backed by cloud-native storage engines, using Dask-MS. In addition to the Python API, each worker also has an associated command line interface. This flexibility simplifies development and testing while enabling pfb-clean's integration into highly heterogeneous and reproducible pipelines, with support for both High-Performance Computing and cloud infrastructures. This presentation will focus on the algorithms and technologies that enable pfb-clean to rival CLEAN in terms of both speed and ease of use, while facilitating better image reconstruction. Specifically, we will discuss the role of the preconditioned forward-backward (pfb) algorithmic structure in generalizing the notion of major and minor cycles to arbitrary regularisers. Additionally, we will demonstrate how pfb-clean workers can be composed into tailor made imaging recipes using the stimela2 workflow management framework. Not only does this provide flexibility but also obviates the need to expose users to irrelevant parameters. Finally, we will show how pfb-clean integrates into the Africanus software ecosystem in a way that minimizes unnecessarily large intermediary data products while respecting the statistics of the data.

Session

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2283

Africanus I. Scalable, distributed and efficient radio data processing with Dask-MS and Codex Africanus

Doctor Simon Perkins[1,2], Doctor Jonathan Kenyon[2,1], Doctor Landman Bester[1,2], Doctor Benjamin Hugo[1,2], Distinguished Professor Oleg Smirnov[2,1]

[1]South African Radio Astronomy Observatory. [2]Centre for Radio Astronomy Techniques & Technologies (RATT), Rhodes University

Abstract

Next-generation radio interferometers such as the SKA, ngVLA and DSA-2000 will produce vast quantities of data, necessitating the development of new software frameworks to process this data in tractable amounts of time. Furthermore, the greater sensitivity of new instruments necessitates development of new techniques to address previously inconsequential and unknown imaging artefacts. This produces a critical tension in Radio Astronomy software development: highly optimised pipelines are desirable for producing science products in a realistic amount of time, but the design requirements for such pipelines are unlikely to be fully understood upfront due to increased sensitivity and the ambitious science goal of current and future instruments. Therefore, it is desirable for pipelines to flexibly incorporate new techniques. We achieve these goals by striking a balance between flexibility, ease-of-development and performance. Common packages in the PyData ecosystem such as NumPy, Numba, Dask and XArray are employed to rapidly implement new and existing algorithms. Dask-MS serves as a data access layer that produces and consumes XArray Datasets of Dask arrays backed by CASA Tables or modern, cloud-native Zarr datasets, allowing seamless migration to modern distributed formats. Dask arrays are consumed by algorithms in the Codex-Africanus algorithms library to transform data. Applications, such as QuartiCal and pfb-clean also consume these arrays to compute gain solutions or image visibility data, respectively. Numba is used to accelerate these algorithms up to C/C++ speeds, while Dask allows us to scale algorithms horizontally on both cloud and HPC architectures to address the Radio Astronomy Big Data problem.

Session

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2293

MeerKAT-VLBI: First steps to African VLBI Network

Mr Dionisio Nhadelo

University of Pretoria

Abstract

Very Long Baseline Interferometry (VLBI) at radio wavelengths provides extremely high angular resolutions that allows astronomers to investigate the details of black hole activity, star-formation processes, the molecular gas around stars and locate fast radio bursts. However, the most sensitive observations require large collecting areas and building massive radio telescopes is both expensive and for some science cases impractical. An alternative is to form a phased array of smaller elements to achieve the required sensitivity. The MeerKAT radio telescope has 64 filled-aperture receptors that are 13.5 m in size. Combined, they have an equivalent collecting area that is greater than a 100-m radio telescope, and therefore, MeerKAT can provide a sensitive part of any VLBI network. Recently, fringes were found between MeerKAT and other elements of the European VLBI Network, including the 25-m dish at Hartebeesthoek, paving the way to sensitive VLBI observations of southern-hemisphere radio sources. However, how the MeerKAT array is combined to form a single beam can have a significant impact on the science goals of a particular project. Here, we present novel simulations that allow us to determine the beamformed response of MeerKAT using different configurations of the individual antennas of the array. We present several suggested sub-arrays that are optimized for sensitive observations of individual targets and for wide-field VLBI experiments. Finally, we outline how a phased MeerKAT will be used to carry out VLBI experiments with radio telescopes within South Africa, and also with VLBI networks around the globe.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2412

Morphological differences in RMHD simulations of High and Low Lorentz factor AGN jets

Mr Izak Van der Westhuizen[1], Prof Brian Van Soelen[1], Prof Bhargav Vaidya[2]

[1]University of the Free State. [2]Indian Institute of Technology Indore

Abstract

Relativistic magnetohydrodynamic simulations (RMHD) have become a useful tool to investigate the kinematics and morphology of the relativistic jets associated with radio loud AGN. In this study we use the PLUTO grid based hydrodynamic code to simulate kpc scale jets. The jet simulations consist of a 3D kinetically dominated jet with a helical magnetic field, injected into a stratified background medium. We present two distinct cases, a high Lorentz factor (Γ=10) and low Lorentz factor (Γ=1.2) bulk jet velocity and investigate the difference in their resulting morphology. The synchrotron emission produced by the simulated jets is modelled using the PLUTO Lagrangian particle module. A sample of Lagrangian particles are continuously injected into the jet and are spatially evolved along the fluid streamlines. Each of these particles are given an energy distribution representative of non-thermal electrons in the jets. The energy distribution of each particle is then evolved with time taking into account advective effects, radiative cooling and diffusive shock acceleration. Using the energy distribution of the Lagrangian we calculate the I, Q and U Stokes parameters. The Stokes parameters are integrated along arbitrary lines of sight to produce intensity and polarization maps. The effects of absorption, relativistic transformation and light travel time is taken into account during integration. Finally, we also show the spectral energy distribution produced for these simulations.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2417

Scientific Exploration of Spectral Cubes and Particles using Immersive Technology: iDaVIE, paving the way to the SKA

Dr Lucia Marchetti[1,2,3], Dr Alexander Sivitlli[1,2], Prof Thomas H. Jarret[1,2], Dr Angus Comrie[2], Dr Fabio Roberto Vitello[4], Mr Cilliers Pretorius[2]

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Abstract

With the advent of the SKA and other exascale science facilities, data storage and visualisation present the scientific community with new challenges. The Inter-University Institute for Data-Intensive Astronomy (IDIA) Visualisation Lab at the University of Cape Town (https://vislab.idia.ac.za) is thus exploring new approaches to handle the exploration and detailed interrogation of multi-parametric astronomical datasets in preparation for the SKA era. In my talk, I will present our new Virtual Reality software suite for immersive data exploration named iDaVIE. iDaVIE combines virtual reality (VR) technology and custom-built software to work with particle and volumetric datasets, enabling user interaction and immersive exploration of 3D data. In particular, the IDaVIE-v suite (https://idavie.readthedocs.io/) aimed at volumetric rendering has been specifically designed to analyse HI spectral cubes from radio interferometers and it has already been used for several scientific publications. iDaVIE-v is now ready for its first public release and is already showing capabilities to serve the astronomy and general scientific community. In my talk, I will introduce the software and its current capabilities, show some recent examples in which it was used to analyse MeerKAT data and outline our plans for its future development and integration within the cloud based CARTA (https://cartavis.github.io) framework.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2427

Deep Neural Networks for Pulsar Searches

Connor Westcott[1], Joris Verbiest[2]

[1]Florida Space Institute. [2]Florida Space Institue

Abstract

Current methodologies for Pulsar searching involve a variation of Fourier Transforms or, increasingly, applications of Artificial Intelligence (AI). However, both struggle in the low signal-to-noise ratio (S/N) regime and with deleterious impacts of Radio-Frequency Interference.

We have implemented a Deep Neural Network in the form of a Denoising Auto-Encoder (DAE) to learn and remove noise from Pulsar filterbank observations and increase the S/N. Previous studies in the AI field have applied DAEs to electrocardiograms with relatively high S/N (Chiang et al. 2019). We are extending this approach to apply state of the art DAE to Pulsar filterbanks with an approximate S/N of 0.5.

The dataset we are using are simulated pulsar observations. Pulsar profiles were taken from the EPN database and ran through the PSRSigSim python package. The simulation resulted in two filterbanks: one noiseless and one with simulated Gaussian noise. The dataset consisted of 100 different pulsar profiles with different periods and dispersion measures. Noise for the dataset was increased in steps to produce sub-datasets of lower S/N. Noise was removed by training the DAE with inputs of a randomly selected sequence from the noisy and matching noiseless filterbank. The learning objective of the DAE set to recreate the noiseless sequence. As the DAE performance improved the S/N was lowered.

Our preliminary results show that the DAE is able to double the sensitivity compared to alternative methods. Specifically, our DAE was typically able to increase the S/N by a factor of four.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2506

Application of anomaly detection to MeerKAT radio data using machine learning techniques

Dr. Hanwool Koo, Dr. Michelle Lochner

University of the Western Cape

Abstract

As a mid-frequency Square Kilometre Array precursor, the MeerKAT radio telescope is a promising source of large sets of radio data. Developing an automated method for anomaly detection is becoming essential to discover more unknown phenomena for astrophysics or cosmology from the data with such an enormous volume. To do this, we explore anomaly detection techniques for time-frequency dynamic spectra of the radio data. We apply unsupervised machine learning techniques, coupled with active learning, for anomaly detection and evaluate our method using the simulated Single-dish PARKES data sets for finding the uneXpected (SPARKESX). We use these simulations to test anomaly detection methods that will be applied to real, unlabeled MeerKAT data. We also examine the possibility of detecting and removing anomalous radio frequency interference, which acts as the primary contaminant when hunting for genuine anomalies. We expect that applying machine learning methods will be a more efficient and reliable way to detect anomalous astrophysical signals with higher accuracy and in a shorter time than the classical methods.

Session

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2516

Simulating emission line galaxies for the next generation of large-scale surveys

Mr Wenxiang Pei

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

We investigate emission line galaxies across cosmic time by combining the modified L-Galaxies semi-analytical galaxy formation model with the JiuTian cosmological simulation. We improve the tidal disruption model of satellite galaxies in L-Galaxies to address the time dependence problem. We utilise the public code CLOUDY to compute emission line ratios for a grid of HII region models. The emission line models assume the same initial mass function as that used to generate the spectral energy distribution of galaxies, ensuring a coherent treatment for modelling the full galaxy spectrum. By incorporating these emission line ratios with galaxy properties, we reproduce observed luminosity functions for Hα, Hβ, [OII], and [OIII] in the local Universe and at high redshifts. We also find good agreement between model predictions and observations for auto-correlation and cross-correlation functions of [OII]-selected galaxies, as well as their luminosity dependence. The bias of emission line galaxies depends on both luminosity and redshift. At lower redshifts, it remains constant with increasing luminosity up to around 10^42.5erg^-1 and then rises steeply for higher luminosities. The transition luminosity increases with redshift and becomes insignificant above z=1.5. Generally, galaxy bias shows an increasing trend with redshift. However, for luminous galaxies, the bias is higher at low redshifts, as the strong luminosity dependence observed at low redshifts diminishes at higher redshifts. We provide a fitting formula for the bias as a function of luminosity and redshift, which can be utilised for large-scale structure studies with future galaxy surveys.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2536

ESA Datalabs: Addressing Big Data Challenges in Space Science

Sandor Kruk[1], Pablo Gomez[1], Vicente Navarro[1], Jan Reerink[1], Sara del Rio[2], Marcos Lopez Caniego[3], Miguel Angel Diego Alfageme[3], David O'Ryan[4]

[1]European Space Agency. [2]RHEA Group for ESA. [3]AURORA Technology for ESA. [4]Centro de Astrobiología (CAB/ESAC)

Abstract

Space science missions are projected to generate petascale data volumes in the near future. For example, the European Space Agency's (ESA) Euclid mission is projected to produce an astonishing 20 petabytes (Pb) of data over its operational lifetime. Analyzing and processing data on this scale requires specialised infrastructure and toolchains. ESA is developing the ESA Datalabs (https://datalabs.esa.int/) platform which provides the essential infrastructure required to access and analyse data from missions such as the Hubble Space Telescope, James Webb Space Telescope, Gaia, and Euclid. Leveraging software like JupyterLab, users can easily interact with mission data without the need for downloading it. ESA Datalabs fosters collaboration among scientists through team workspaces and provides a streamlined environment for users to create, deploy, and share their applications or processing pipelines. In this manner, ESA Datalabs provides an accessible and powerful framework for high-performance computing and direct access to the data in the ESA archives.

We describe the rationale for creating ESA Datalabs, main features, and the forthcoming steps in its development. We will showcase some new scientific applications and pipelines developed for the recently launched ESA Euclid mission. Additionally, we will present the power of ESA Datalabs in the context of large-scale analysis of the data stored in the ESA science archives using data mining and machine learning techniques, for various use cases, such as the large-scale identification of interacting galaxies in over twenty years of Hubble Space Telescope observations (O'Ryan et al, 2023).

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2606

Deep Learning Techniques for Strong Gravitational Lensing Studies

Ms Justine Crook-Mansour, Prof Mattia Vaccari, Dr Lucia Marchetti

University of Cape Town

Abstract

The study of galaxy-galaxy strong lensing (GGSL) systems has many useful applications, including constraining the mass distribution of the lensing galaxies, and estimating the Hubble constant. However, less than a thousand of these systems have been discovered to date. But in upcoming imaging surveys, such as those carried out with the European Space Agency's Euclid mission, we expect there to be more than a hundred thousand detectable GGSL systems. Due to the large volume of data, there is a need to develop more efficient, automated techniques to identify them. Over the past few years, the use of convolutional neural networks (CNNs) has proven particularly effective in this context, because of their rapid execution and ability to generalise to unseen data. In this work, we evaluated the ability of CNNs to identify GGSL events, using a data set of simulated images that have characteristics similar to those expected from surveys planned with Euclid. We investigated the effects of data preprocessing using pixel value clipping, normalisation, standardisation, and arcsinh stretching. For our best-performing model, we proceeded to tune a small subset of its hyperparameters. This project contributes to the development of accurate and efficient methods to detect GGSL systems using deep learning techniques.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2683

RCSEDv2: algorithm for automatic analysis of spectra with multicomponent emission lines using the NBursts full spectrum fitting technique.

Evgenii Rubtsov[1], Dr. Igor Chilingarian[2,1], Dr. Ivan Katkov[3,1], Kirill Grishin[4,1], Dr. Anastasia Kasparova[1], Victoria Toptun[5], Vladimir Goradzhanov[1]

[1]Sternberg Astronomical Institute, M.V. Lomonosov Moscow State University. [2]Center for Astrophysics – Harvard and Smithsonian. [3]New York University Abu Dhabi. [4]Université de Paris, CNRS, Astroparticule et Cosmologie. [5]European Southern Observatory

Abstract

RCSEDv2 is the second version of the RCSED catalog (Chilingatian et al, 2017) – A Value-added Reference Catalog of Spectral Energy Distributions (https://rcsed2.voxastro.org/). It is based on spectral and photometric data for more than 4 million extragalactic sources collected from several publicly available spectral (SDSS, LAMOST, Hectospec, 2dF, etc.) and photometric (SDSS, UKIDSS, GALEX, WISE, etc.) all-sky surveys in a wide wavelength range. To analyze them, we used the NBursts full spectrum fitting technique developed by the authors (Chilingarian et al, 2007), with additional capabilities for analyzing emission lines. Analysis of such large samples of objects is only possible in automatic mode, for which procedures have been developed for detection, classification and selection of emission lines templates with several possible action scenarios. The properties of the stellar components (age and metallicity) were determined using stellar population models (PEGASE, MILES, X-SHOOTER, etc.). If emission lines were detected in the spectrum, the following scenarios were checked: a single set of lines, a set of narrow lines with a broad lines component (NLR+BLR) and a double set of narrow lines (DP/outflow). The emission lines profiles were described both parametrically and non-parametrically. From the resulting fluxes, gas properties (metallicity and ionization parameter) were assessed using the IZI procedure (Blanc et al, 2015). As a result, for a large number of extragalactic sources, we obtained a complete and homogeneous set of analysis results, which can be used for further statistical analysis and study of the evolution of galaxies.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2791

Analysis of Zwicky Transient Facility alert stream data using the anomaly detection module of the Fink broker.

Anastasia Baluta[1], Maria Pruzhinskaya[2,3]

[1]Lomonosov Moscow State University, Moscow, Russia. [2]Laboratoire de Physique de Clermont, Clermont Auverne, France. [3]Sternberg Astronomical Institute, Moscow, Russia

Abstract

Big surveys like Zwicky Transient Facility (ZTF) make us rethink how we process data. Each night, ZTF generates about 200,000 alerts which signal the most recent changes in brightness recorded by the telescope. The inability to spectroscopically follow up on all alerts underscores the critical need for developing anomaly detection algorithms to identify the most rare and interesting objects from an astrophysical perspective.

Our project aims to search for and analyze anomalies in ZTF data streams, and soon, data from LSST. Due to the vast amount of information, real-time data access is facilitated through brokers like Fink. As a Fink scientific broker team we propose to develop and integrate an active anomaly discovery algorithm. This method involves human-machine interaction during the algorithm's operation, enhancing anomaly recognition.

For the past year through our anomaly detection methodology, we have successfully pinpointed several intriguing supernova candidates and variable objects deserving further investigation. Notably, we have detected SN2023mpt, a supernova exhibiting a precursor originating from a galaxy with low surface brightness, shedding light on the diverse nature of supernova progenitors. In total, we identified and submitted 30 supernova candidates to the Transient Name Server database, fostering collaboration and further observations from telescopes such as the 9.2-m SALT. By adding 10 new cataclysmic variables and 1 variable star of the FU Ori type to the Variable Star Index (AAVSO VSX) database, we contribute to expanding the knowledge base on variable celestial objects.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

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2860

Accelerating the Computational Modeling of Cosmic Gas with Deep Learning

Dr Robert Feldmann, Dr Mauro Bernardini

University of Zurich

Abstract

Cosmological, hydrodynamical simulations provide a principled approach to study the distribution of atomic hydrogen (HI) and other baryonic matter on the field level from cosmic scales down to the scales of individual galaxies. However, the high computational cost of running such simulations poses a severe limitation resulting in the adoption of simplified models with reduced complexity. In recent years, emulators based on machine learning techniques have shown promise in enabling a mapping between comparably inexpensive dark-matter-only simulations and gas fields. In this talk, I will present a novel architecture (EMBER-2) based on Deep Convolutional Neural Networks to predict baryonic fields, including HI, from dark matter data alone. Compared to previous works, this generative model is designed to provide simultaneous predictions for different fields, such as maps of gas temperature, velocity, and density, for any given input redshift. To achieve this goal, EMBER-2 employs a conditional Generative Adversarial Network architecture with context-based styling paired with modulated convolutions for fast, accurate, and memory efficient emulation. Trained on data from the Feedback in Realistic Environments (FIRE) project, in particular the FIREbox simulation suite, EMBER-2 not only demonstrates the ability to accurately reproduce gas and HI power spectra across a broad range of scales and redshifts but also to do so at a comparably low computational cost. Generative models such as EMBER-2 exemplify the synergy between cutting-edge AI techniques and more traditional astrophysical modeling, promising to enrich our understanding of the cosmos in the era of big data and beyond.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2904

Leveraging the synergies between next-generation surveys with the SKA and LSST

Miss Nomthendeleko Motha

University of the Western Cape

Abstract

The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) will be an unprecedented optical survey capable of revolutionising many fields of astronomy. The Square Kilometre Array (SKA) telescope will be similarly groundbreaking in the radio regime. We aim to develop techniques that combine the data from these two complementary instruments to maximise potential scientific gain.

The 21cm neutral hydrogen (HI) emission line is ubiquitous throughout the universe and extremely useful for obtaining precise redshift information using a radio telescope. However this line is intrinsically faint and difficult to observe for distant galaxies. In 2017, Harrison, Lochner and Brown developed a Bayesian technique to extract the redshift from a radio spectrum by fitting a standard model to the expected HI emission. We propose an extension of this work by introducing a new and realistic model of the HI line. Additionally, we incorporate photometric redshift estimates as expected from optical surveys such as the LSST, and expand the model using a Bayesian hierarchical modelling approach to include population information to further constrain redshift information.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2911

Leveraging the synergies between next-generation surveys with the SKA and LSST

Miss Nomthendeleko Motha

University of the Western Cape

Abstract

The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) will be an unprecedented optical survey capable of revolutionising many fields of astronomy. The Square Kilometre Array (SKA) telescope will be similarly groundbreaking in the radio regime. We aim to develop techniques that combine the data from these two complementary instruments to maximise potential scientific gain.

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Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2954

Enhancing Discovery in Large Surveys with Machine Learning

Mr Fernando Ventura[1], Dr Kshitij Thorat[1], Dr Anna Bosman[1], Prof Roger Deane[2,1]

[1]University of Pretoria. [2]University of the Witwatersrand

Abstract

With the advent of SKA precursors and pathfinders, the problem of the scientific analysis of extremely large volumes of data has assumed critical proportions. The vast quantities of data and the dramatic increase in recovered source complexity with these instruments' excellent imaging fidelity and dynamic range, make it challenging for traditional tools to keep up with the high source density and data volume such facilities and other large telescopes such as the Rubin Observatory will generate. The aim of this project is to identify unusual radio sources with high astrophysical value in large continuum surveys, such as the MeerKAT Galaxy Cluster Legacy Survey (MGCLS) or the MeerKAT South Pole Telescope (SPT) Survey. We use autoencoders, automated unsupervised neural networks that encode an input into latent space code form and then attempt to reconstruct input images. An automated approach to reliably finding source morphologies of interest in upcoming all-sky surveys is key to accessing new discovery space with astronomical big data. The use of machine learning is a promising approach to addressing many of the challenges these high-quality images present. Using manually labeled datasets of MeerKAT radio sources, in itself a valuable community resource, we demonstrate that autoencoders can significantly reduce the work required to locate astrophysically valuable sources.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2968

Science opportunities and challenges with next-generation ground-based gravitational-wave observations

Hsin-Yu Chen

The University of Texas at Austin

Abstract

Since 2015, ground-based gravitational-wave observations have constantly provided new insight into our universe. With successive upgrades to current facilities and the launch of new instruments, and hence a growing number of detections, we are prepared to address some fundamental questions in the Universe. In this talk, I will give an overview of the exciting opportunities that next-generation gravitational-wave facilities will provide with the large number of detections, and discuss the challenges and preparations toward the main science targets.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2992

The large-scale interaction between short GRB jets and disk outflows from NSNS and BHNS mergers

Dr Gerardo Urrutia

Centre for Theoretical Physics, Polish Academy of Sciences

Abstract

Short GRBs are produced by relativistic jets arising from binary NS-NS or NS-BH mergers. Since the detection of the first unambiguous off-axis GRB 170817A, we learned that energy distribution in the jet plays an important role in explaining the GRB emission. The structure and dynamics are modified during the first seconds of the jet interaction with a post-merger environment. Conventional studies often assume this environment as a simple homologous and symmetrically expanding wind. However, post-merger outflows exhibit complex dynamics influenced by the accretion disc evolution. Moreover, the r-process nucleosynthesis influences the thermodynamics and properties of the post-merger neutron-rich environment. During the talk, I will show the results of numerical simulations studying the impact of realistic post-merger disc outflow over the jet dynamics at large scales. Our results are substantially different from the typical model with symmetric homologous, specifically: a) the impact of the r-process on initial wind pressure leads to significant changes in the jet collimation and cocoon expansion; b) the angular structure of thermal and kinetic energy components in the jets, cocoons, and winds differ concerning simple homologous models, hence it would affect the predictions of GRB afterglow emission; c) the temporal evolution of the structure reveals conversion of thermal to kinetic energy being different for each component in the system (jet, cocoon, and wind); d) post-merger environments influence energy structure and material dispersion, altering the interaction between jets and disk winds.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

2994

Toward Effective Early Anomaly Detection via Machine Learning and Prompt Alert Follow-up for the Rubin Observatory

Dr Albertus Seyffert

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Abstract

The Rubin Observatory Legacy Survey of Space and Time (LSST) — set to commence in 2025 — promises roughly ten million flux difference alerts per night. This deluge simultaneously represents a potentially rich vein for astrophysical discovery (via anomaly detection) and a significant challenge when conducting such discovery with prompt alert follow-up in mind. In preparation for said deluge, a number of machine learning-based classification methods have been and are being devised that typically incorporate anomaly detection to some extent. To date, however, most of these methods effect classification and anomaly detection with complete simulated observations in hand, and those methods that are early time-focussed tend to be aimed exclusively at classification. Moreover, since anomaly admits no possibility for training, those methods that do conduct anomaly detection, necessarily do so at second order, and there is, as yet, no clear consensus on how such anomaly detection should be conducted.

We propose — and aim to implement — a two-layered classification scheme: a conventional machine learning classifier paired with an algorithmic monitor. The latter leverages Bayesian epistemology and time domain statistics derived from the former (in likelihood space) to assign (for each source) a likelihood to the anomaly class that is consistent from an epistemological perspective. To construct said monitor, we first characterise the behaviour of the classifier using synthetic observations that form part of the ELAsTiCC challenge training dataset. In this contribution, we aim to present our results to date and progress toward full implementation for the LSST alert stream.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

3017

Transient Classifiers in the Fink broker: preparations for the LSST era

Dr Bernardo Fraga[1], Dr. Clecio de Bom[1], Mr Andre Santos[1], Dr Emille Ishida[2], Dr. Anais Moller[3], Dr Julien Peloton[4]

[1]CBPF. [2]Laboratoire de Physique de Clermont. [3]University of Swinburne. [4]IJCLab

Abstract

The upcoming Legacy Survey of Space and Time (LSST) will detect tens of millions of transient objects every night, streaming these detections as alert packages to community brokers. These brokers are then tasked to select subsets of these alerts, enrich them, and redirect them to the scientific community of interest. Given the sheer volume and complexity of the data generated on a nightly basis, machine learning (ML) algorithms will be an essential part of a broker system. In this work, we present the models and methods for light curve classification developed within the Fink broker in preparation for LSST. For this, we use simulated data from the Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC), showcasing the performance of the binary and multi-class ML models available in Fink. These include tree-based models with tailored feature extraction, and deep learning algorithms. We introduce for the first time the CBPF Alert Transient Search (CATS), a deep learning algorithm designed specifically to deal with LSST-like data. The results show that Fink classifiers are able to handle well the extra complexity from LSST data. CATS is shown to have an average accuracy above 95%, while the best binary classifier achieves over 98% accuracy for the AGN class. Furthermore, Fink is able to ingest and process the vast majority of the alerts within the time window required by LSST, showing that it is well prepared for receiving Rubin data.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

3034

Synthetic survey catalogs for the Galactic Roman Infrared Plane Survey (GRIPS) using py-ananke

Dr. Adrien Thob

University of Pennsylvania

Abstract

The Gaia space observatory revolutionized our comprehension of the Milky Way, delivering precise photometric and astrometric measurements for nearly 2 million individual stars — an achievement surpassing its predecessor, Hipparcos, by orders of magnitude. With the imminent launch of the Nancy Grace Roman Space Telescope, our exploration of the crowded and highly obscured disc plane of our galaxy is set to reach unprecedented depths, thanks to the Galactic Roman Infrared Plane Survey (GRIPS). Our work harnesses the py-ananke pipeline to create a suite of synthetic surveys emulating GRIPS, accounting for factors such as dust extinction and observational uncertainties. Employing data from Milky Way-like simulated galaxies within the latte suite of high-resolution FIRE cosmological simulations, we generated those mock catalogs by strategically placing the solar viewpoint at varied positions to yield distinct surveys. Those mirror the specifications of GRIPS, encompassing the inner Galactic plane, with latitudes $|b| < 3°$ and longitude $|l| < 60°$, along with additional coverage in the bulge ($|b| < 10°$, $|l| < 10°$), and providing photometry in the planned F106, F158, and F213 filters of the Roman Wide Field Instrument. We present a comprehensive discussion of the catalogs and outline the available tools for accessing them. We anticipate that these synthetic surveys will prove indispensable in preparing for the GRIPS survey, serving as a robust testbed for the refinement of analysis and data reduction pipelines.

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3110

Rare, faint, time evolving, and morphologically diverse: how to approach a pessimal computer vision challenge and automate the detection of light echoes at scale

Dr. Federica Bianco[1,2], Dr. Xiaolong Li[3], Ms. Tatiana Acero Cuellar[1], Ms. Rodiat Ayinde[1]

[1]University of Delaware. [2]Vera C. Rubin Observatory. [3]John Hopkins University

Abstract

Light Echoes (LEs), the reflection of cosmic explosions on interstellar dust, can enable the discovery of unknown galactic supernovae, the tracing of the Milky Way dust structure, and insight into stellar physics. Despite their significance, LEs pose a formidable challenge in computer vision: they are faint and diffuse features that change over time, morphologically diverse, inheriting the properties of both dust and transients that originate them, and rare, with only ~100 examples detected to date. This makes it effectively a pessimal computer vision problem. The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST), which will observe the entire southern sky at ~day time intervals with high sensitivity and spatial resolution, is an ideal LE survey. However, the LSST's alert pipeline, optimized for point sources, will overlook LEs entirely, while the 20TB/night data rates require the development of an automated detection pipeline. We are developing deep-learning methods for the automated all-sky detection and study of LEs. Our work includes the development of novel deep learning models (Li+, 2022) and exploration of the potential of existing platforms (Segment Anything Meta AI, Kirillov+, 2023). Furthermore, we are augmenting our training dataset through a combination of traditional and AI-based simulation techniques, with the goal to ensure a diverse and realistic representation of LEs while adhering to fundamental physical principles. This talk will address unique challenges posed by LEs and underscore the challenges astrophysics encounters in the application of computer vision and AI models, due to the unique nature of our data.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

3135

ilifu: A cloud computing system supporting Astronomy and Bioinformatics

Rob Simmonds

IDIA / UCT

Abstract

The ilifu computing system is an OpenStack Infrastructure as a Service cluster that is operated by the Inter-university Institute for Data Intensive Astronomy (IDIA). Ilifu, which is located at the University of Cape Town, has been in production since 2016. It has over 600 active users and much of the Astronomy processing works on data from the South African MeerKAT telescope. In the past year we have added a web based gateway accessible through Edugain authentication and provides single signon to most of our services. IDIA also lead the development of the Cube Analysis and Rendering Tool for Astronomy (CARTA), which is hosted on ilifu, in addition to creating Virtual Reality (VR) tools that focus on providing visual analytics for radio astronomy data cubes. This talk will describe the tools and environment provided by ilifu.

Session

FM 7 New Horizons at the interface between Computational Astrophysics and Big Data

Final category: FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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Is Hemispheric Asymmetry in the Sunspot Cycle a case of nonextensivity?

Prof. DANIEL BRITO DE FREITAS[1], Dr. Leonardo F. G. Batista[2], MSc. Thiago M. Santiago[1], MSc. Paulo C. F. da Silva Filho[1], MSc. Cleo V. Silva[1]

[1]Federal University of Ceará. [2]Institute of Aeronautical Technology

Abstract

The appearance of dark sunspots over the solar photosphere is not considered to be symmetric between the northern and southern hemispheres. Among the different conclusions obtained by several authors, we can point out that the north-south asymmetry is a real and systematic phenomenon and is not due to random variability. In the present work, we select the sunspot area data of a sample of 13 solar cycles divided by hemisphere extracted from Royal Greenwich Observatory and USAF/NOAA Sunspot database to investigate the behavior of probability distributions using an out-of-equilibrium statistical model, a.k.a nonextensive statistical mechanics. Based on this statistical framework, we obtain that the nonextensive entropic parameter q has a semi-sinusoidal variation with a period of ~22 year (Hale cycle). Among the most significant results, we can highlight that the asymmetry index q(A) supports the dominance of the northern hemisphere over the southern one, a result already confirmed by other authors who used the same data but with different statistical methods. Thus, we conclude that the parameter q(A) can be considered an effective measure for diagnosing daily variations of the solar dynamo. Finally, our study opens a new approach to investigating solar variability from the nonextensive perspective.

Session

FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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Nonequilibrium radiation transport in the solar chromosphere

Dr Anusha L S

Indian Institute of Astrophysics, Koramanagala 2nd blcok, Bengaluru

Abstract

To understand the structuring and dynamics of the upper photosphere and the chromosphere of the Sun, we need to improve and extend the existing numerical radiation-magnetohydrodynamical (MHD) simulations. To describe the radiation in the chromosphere, the approximation of local thermodynamic equilibrium (LTE) is very inaccurate, and a state of equilibrium cannot be assumed in general. To calculate the radiation energy transport under these conditions, the population evolution equation must be evaluated, including all time-dependent terms. To this end, we have developed a non-LTE, non-equilibrium radiative transfer (RT) module to the well-known MHD code MURaM. In this module, we have developed a numerical method to solve the evolution equation for the atomic level populations in a time-implicit way, keeping all time-dependent terms in first order. We apply this method to compute radiative cooling/heating terms in non-LTE and non-equilibrium. With this, we show the effect of continuum cooling on a shock-heated solar chromosphere.

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TEMPORAL & SPATIAL CHANGES IN SOCIAL VULNERABILITY & REHABILITATION DUE TO 2015 EXTREME SPACE WEATHER EVENTS OVER ETHIOPIA

Ms. Rabyatalhabesha Bilal Assefa

Werabe University

Abstract

The vulnerability to extreme solar events is an issue of increasing concern, yet relatively few detailed studies of the impacts of these events have been carried out. As society becomes increasingly dependent on space-based systems, it is vital to understand how space weather, caused by solar variability, could affect, among other things, space systems and human space flight, electric power transmission, high-frequency radio communications, global navigation satellite system (GNSS) signals, as well as the well-being of passengers in high altitude aircraft. Severe magnetic storms resulting from coronal mass ejections are causes of failures of many geostationary orbit communication satellites, radio blackouts and power outages on Earth. The 2015 extreme space weather events, marked by unprecedented geomagnetic storms and aurora activity, exposed global vulnerabilities to disruptions in critical infrastructure, communication networks, and technological systems. The ability to predict space weather accurately could assist in preventing or minimizing impacts of severe magnetic storms on space-based services and systems and on ground power systems. A powerful solar storm generates electric and magnetic anomalies that can have severe and widespread effects: Radio communications can be distorted or blacked out. Research, telecommunications, navigation, and weather satellites can suffer hardware failures and computer errors. This proposal will help
to understand how social vulnerability rehabilitation evolves during and after extreme space weather events, taking into account societal preparedness, access to resources, and community resilience.

Session

FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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A Database of 3D Magnetic Loop Models as a Tool for Flare Analysis: Case Study of the GOES C6.2 Flare on 27 October 2003

Dr Valente Cuambe[1,2], Dr Joaquim Rezende[3], Dr Paulo Simões[4]

[1]Eduardo Mondlane University. [2]RAEGE-Az. [3]National Institute of Space Reseach (INPE). [4]CRAAM-Mackenzie, Escola de Engenharia, Universidade Presbiteriana Mackenzie

Abstract

We introduce a novel approach to solar flare analysis by developing and applying a database containing simplified 3D magnetic loop models. Focusing on the GOES C6.2 flare occurring on 27 October 2003 at the heliographic position S20E29, we utilised essential parameters of microwave emission to infer a comprehensive set of physical parameters characterising solar flares. The database, designed to encapsulate the general properties of known solar flares and adjusted for instrument resolution, facilitated a direct comparison between observed NoRP spectra, NoRH brightness maps, and model predictions. We analysed the flare across its gradual, impulsive, and decay phases using a weighted mean of the one hundred best-fit model parameters, refined through the Pikaia genetic algorithm. Our findings indicate consistent recovery of key physical parameters such as the energy spectral index ($\delta \sim 5.74$), photospheric magnetic field ($B \sim 2543 G$), and non-thermal electron density ($N \sim 10^9 cm^-3$), particularly at the burst maxima. However, the study also highlights challenges in accurately fitting geometric parameters due to the limitations of current instrument resolutions, affecting the precise determination of loop geometry. This research underscores the potential of integrating observational data with 3D modelling to enhance our understanding of solar flare dynamics while also pointing to the need for advancements in observational technologies for improved geometric characterisation.

Session

FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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MAGNETIC BRAKING OF RECENTLY STUDIED SOLAR TYPE BINARIES AND THEIR GYROCHRONOLOGY III

Dr. Ronald Samec

Faculty Research Associate, Pisgah Astronomical Research Institute Long researcher, Dark Sky Observatory, Appalachian State University, Department of Physics and Astronomy

Abstract

A statistical study was presented in a poster session in 2015 and 2018 at the IAU GA--a compendium of 218 solar-type binaries--each with a clearly decreasing orbital period. These systems gave strong evidence for a magnetic braking scenario which follows. *Solar type binaries have strong magnetic activity. It is believed that these systems, begin their existence as well detached fast rotating stars in groups that undergo gravitational interactions which leave them as binaries with several day periods. Since they are highly magnetic in nature, due to their convective envelopes and fast rotation, they undergo magnetic braking as plasma winds stream away from the stars on stiff rotating dipole fields out to the Alfvén radius. This action torques the binary, eventually bringing them into contact. They continue to coalesce and finally merge and undergo a cataclysmic event called a red nova, the aftermath of which is a single, earlier spectral type star (late G to A).*

Recently 6 solar type systems with decreasing periods were observed and analyzed via synthetic light curve modeling, These include DX CMi, SZ Scl, WISEJ0164147.0-120803, NSV6429576, V590 Cam, and GSC 06462-00195. Updated statistical results are compiled. An “age” is computed for each binary, δt, based on the difference in the current orbital period and the proposed initial period, δP and the rate of orbital decay, dP/dt,

$\delta t = -\delta P/(dP/dt)$.

The result is that the evolution of solar type binaries from formation to the present configuration averaging more than two magnitudes faster than theory suggests.

Session

FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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Estimation of Polar Magnetic Fields using Ca II K Polar Network as a Proxy

Ms. Dibya Kirti Mishra[1,2], Dr. Bibhuti Kumar Jha[3], Dr. Theodosios Chatzistergos[4], Dr. Ilaria Ermolli[5], Prof. Dipankar Banerjee[1,6,7]

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Abstract

The polar magnetic field in the Sun is an important aspect of the solar dynamo process for predicting future solar cycles. However, systematic measurements of this polar field have only been available since 1976 at the Wilcox Solar Observatory (WSO). Prior to 1976, there was a lack of direct information on polar magnetic fields, leading researchers to utilize various proxies such as polar faculae and polar filaments to infer polar field data. The use of polar faculae, however, introduced uncertainties due to manual counting methods, impacting the accuracy of polar field information. Recently, the polar network has emerged as a more reliable proxy for polar field information. This is attributed to its correlation with polar faculae, along with its observation in higher latitudes compared to polar faculae. In this study, we employed newly calibrated and rotation-corrected Ca II K data from the Kodaikanal Solar Observatory (KoSO) spanning the years 1907 to 2007 to detect the polar network automatically and estimate polar magnetic fields. In addition to KoSO data, we also utilized PSPT/Rome Ca II K data (1996-2022) to generate a continuous polar network index (PNI) series from 1907 to 2022. Our findings revealed a significant correspondence between polar faculae counts from the Mount Wilson Observatory (MWO) and the Polar Network Index (PNI) from KoSO Ca II K data. Additionally, a good correlation was observed between the PNI of PSPT/Rome and the WSO polar field during the overlapping period of analysis.

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Near-Surface Azimuthal Magnetic Fields and new solar dynamo model

Dr Andrei Tlatov

Kislovodsk Mountain Astronomical Station of the Pulkovo Observatory

Abstract

We consider variations of the azimuthal magnetic fields of the Sun in the 23 – 25 activity cycles according to observations with SDO/HMI, SOHO/MDI, and Kislovodsk/STOP telescopes. To identify azimuthal magnetic fields, the daily observations of LOS magnetic fields from the regions near the solar limb were analyzed. It is shown that with a sufficiently large averaging of the data, large-scale structures are distinguished, which can be interpreted by horizontal magnetic fields along the east – west direction. Azimuthal magnetic fields are visible at both low and high latitudes. Azimuthal fields at the same latitudes have opposite directions in the northern and southern hemispheres and also change sign in even and odd cycles of activity.

The mechanism of formation of global azimuthal magnetic fields and their role in the cycle of solar activity is discussed. The near-surface azimuthal magnetic field is closely related to the activity cycle. Apparently, the azimuthal field is formed from U-shaped flux tubes of active regions (AR). Due to the presence of the tilt angle AR during differential rotation, the subsurface magnetic fields are pulled in the azimuthal direction. The role of azimuthal magnetic fields in solar activity cycles is considered. A scheme for the generation of a magnetic field different from Babcock – Leighton dynamo models is proposed.

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Observational evidence that mergers in stellar multiple systems can create magnetism in massive stars

Dr Abigail Frost[1], Prof Hugues Sana[2], Dr Laurent Mahy[3], Prof Gregg Wade[4], James Barron[4,5], Dr Jean-Baptiste Le Bouquin[6], Dr Antoine Merand[1], Dr Fabian Schneider[7,8], Dr Tomer Shenar[9], Dr Dominic Bowman[10], Matthias Fabry[2], Dr Amin Farhang[11], Dr Nia Morrell[12], Dr Jonathan Smoker[1]

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Abstract

In stars like our Sun that have convective envelopes, the surface magnetic field is produced through a dynamo effect. Massive stars (M≥8Msun) have radiative envelopes that cannot actively sustain such a dynamo and yet ~7% of massive stars (e.g. Wade+ 2016) display strong, large-scale, surface magnetic fields, the origins of which are not understood. In this talk I will present the results of a 9~yr interferometric monitoring with multi-epoch spectroscopic data, which have allowed the characterisation of the magnetic massive binary system HD 148937. Only one star of the pair is magnetic, and using its distant companion as an independent clock, we have found a self-consistent scenario in which magnetism originated in only one star in the system due to a merger event, that the system was originally a hierarchical triple system, and two stars of this previous triple merged to create the magnetic star in the current system. This scenario is supported by the presence of a complex bipolar nebula surrounding the binary, which is enriched in CNO process elements. This constitutes observational evidence that magnetic fields in massive stars can be generated through interactions in multiple stellar systems. Given that the fraction of O stars that are predicted to experience a merger is ~8% (de Mink+ 2014), very similar to the ~7% fraction which are observed to have magnetic fields, mergers may be a significant originator of magnetic fields in massive stars.

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Probing Convective Dynamo Activity in Young Suns with the Chandra X-ray Observatory

Dr. Konstantin Getman[1], Prof. Eric Feigelson[1], Prof. Gordon Garmire[2]

[1]The Pennsylvania State University, USA. [2]Huntingdon Institute for X-ray Astronomy, USA

Abstract

Our analysis of Chandra X-ray data for over 27,000 young stellar members across various Galactic star-forming regions and open clusters suggests that, compared to the present-day Sun, the convective dynamo responsible for generating magnetic fields in young stars demonstrates much higher levels of surface activity: large spot areas, magnetic fluxes, baseline and flare X-ray luminosities, and magnetic loop sizes. The convective dynamo mechanism enables the production of X-ray super-flares (with X-ray energies E_X ranging from 10^{34} to 10^{36} erg) and mega-flares ($E_X > 10^{36}$ erg) in fully convective (Hayashi track) pre-main sequence stars, far surpassing the capabilities of the contemporary Sun. Moreover, it leads to frequent weaker X-ray flares ($E_X < 10^{34}$ erg) with an occurrence rate more than a million times higher than in older solar-type main sequence stars. These flares are expected to significantly impact the photoevaporation and dispersal of surrounding protoplanetary disks and young planetary atmospheres. Our research also provides tentative evidence for the transition from a convective to a solar-type tachoclinal dynamo as radiative cores develop around ages 10-25 Myr for solar-mass stars. A related effort involves near-simultaneous Chandra/HET/VLBA/ALMA study of surface magnetic fields, coronal mass ejections, and effects on protoplanetary disk chemistry in super-flaring pre-main sequence members of the Orion Nebula Cluster.

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Progress in Modeling and Predicting Solar and Stellar Cycle

Dr Alfio Bonanno

INAF Catania Astrophysical Observatory

Abstract

Understanding the solar activity cycle within the broader framework of stellar magnetic field dynamics is pivotal for comprehending the solar and stellar dynamos. A significant challenge in this pursuit lies in the presence of multiple branches in the relationship between stellar rotation and activity cycle period among main sequence stars. In this presentation, I will elucidate recent advancements addressing this challenge, drawing connections with mean-field dynamo theory and Direct Numerical Simulations (DNS). Additionally, I will explore the implications of these findings for tachocline theory and the prediction of solar and stellar cycles.

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ROTATION AND ACTIVITY IN EARLY-TYPE STARS

Dr Luis Balona

South African Astronomical Observatory

Abstract

Analysis of time series photometry of the Kepler and TESS missions suggests that rotational light modulation and flare activity continue along the main sequence to the hottest stars. This indicates that stellar surface magnetism and consequent activity may persist even in the presumed absence of convection. Results from the TESS mission also suggest increasing mass loss with increasing temperature. This is indicated by an increase in the amplitude of rotational light modulation from late to early B stars.

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Magnetic Field of Massive Stars

Dr. Swetlana Hubrig

Leibniz-Institut fuer Astrophysik Potsdam (AIP)

Abstract

Magnetic fields are considered to be key components of massive stars, with a far-reaching impact on their evolution and ultimate fate: a magnetic mechanism was suggested for the collimated explosion of massive stars, relevant for long-duration gamma-ray bursts, X-ray flashes, and asymmetric core collapse supernovae. Because multiplicity is a fundamental and defining characteristic of massive stars, inducing new processes and leading to numerous observational and evolutionary impacts, it must be taken into account in theoretical studies considering the origin of the observed magnetic fields. The origin of the observed stable, globally organised magnetic fields is still a matter of debate: it has been argued that they can be fossil, dynamo generated, or generated by strong binary interactions. Observational evidence is accumulating that the magnetism may originate through stellar mergers, both during the initial mass transfer and when the cores merge.

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Combined effects of disk-locking and magnetic fields on convective turnover times of low-mass stars

Luiz Themystokliz Sanctos Mendes[1], Natália Resende Landin[2], Luiz Paulo Ribeiro Vaz[1]

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Abstract

Convective turnover times are of key importance for determining the Rossby number of fully or partially convective stars, which in turn provides a measure of the magnetic dynamo efficiency in the mean-field dynamo theory and so is commonly used as a tool for better understanding the rotation-activity relationship of such stars. On the other hand, disk-locking is also another physical process that can affect the magnetic activity of low-mass stars. Here we report and discuss some preliminary results of convective turnover times obtained through an improved version of the ATON 2.3 rotating stellar evolution code, which takes into account the combined structural effects of a large-scale magnetic field, surface star spots and disk-locking on the evolution of low-mass stars starting at their pre-main sequence phase.

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Effect of the inclination angle of the solar rotation axis on disk-resolved indices from full-disk solar images in the Ca II K line.

M. Grégory Vanden Broeck, Mrs Sabrina Bechet

Royal Observatory of Belgium

Abstract

The chromospheric emission in the Ca II K line is a primary tracer of the magnetic activity of the Sun and other Sun-like stars. The Sun is observed from Earth from its Equator's point of view, whereas other stars are observed at all possible viewing angles. The chromospheric plages, main contributors to the Ca II K emission, are distributed between mid-latitude and the Equator. Therefore, we suspect that the inclination angle of the solar rotation axis has an impact on disk-resolved indices such as the plage area and intensity. These indices are strongly correlated to the S-index, a well-known index to study the magnetic activity of stars, and could help to better understand the magnetic activity of Sun-like stars. We have studied the effect of the inclination rotation axis on disk-resolved indices using the archives of synoptic full-disk images taken on-site at the Royal Observatory of Belgium with the Uccle Solar Equatorial Table (USET) since 2012.

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Connections Between Solar and Stellar Magnetic Phenomena Through Homologous White Light Flares

Paolo Romano, Alfio Maurizio Bonanno

INAF - Osservatorio Astrofisico di Catania

Abstract

Understanding the mechanisms governing the magnetic dynamics of solar and stellar atmospheres is crucial for deciphering the mysteries of eruptive events. In our previous studies, we investigated two homologous white light flares of X-GOES class that occurred on the Sun on Sept. 06, 2017, offering a unique opportunity to delve into the processes shaping magnetic field configurations and their impact on the lower layers of the solar atmosphere.

Exploring the peculiarity of two recurrent white light flares in the superactive region NOAA 12673, we highlighted the strong horizontal photospheric motions preceding the flares. The observed shear motion, coupled with high magnetic flux intensity, continuously supplies new energy to the magnetic system. By utilizing photospheric vector magnetograms as boundary conditions, we reconstructed the non-linear coronal magnetic field and identified 3D null points at low heights above the photosphere, which were associated with the occurrence of the flares.

Our findings suggest intrinsic connections between solar and stellar activities, emphasizing the relevance of magnetic reconnection at low altitudes in driving eruptive events. We propose that similar mechanisms may elucidate the activity observed in young G-type stars, as reported by the Kepler mission.

These results not only contribute to our understanding of solar dynamics but also offer valuable insights into potential analogies with stellar dynamos, paving the way for a comprehensive exploration of the interconnected nature of solar and stellar magnetic phenomena.

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Weakened Magnetic Braking: what it tells us about stellar dynamos

Dr. Travis Metcalfe

Center for Solar-Stellar Connections, WDRC

Abstract

Eight years ago, Weakened Magnetic Braking (WMB) was proposed to explain anomalously rapid rotation in old field stars observed by the Kepler mission. Since then, indirect evidence of this phenomenon has accumulated in the form of reliable rotation periods and ages for much larger samples of stars. More recently, direct evidence has started to emerge from spectropolarimetric inferences of magnetic field strength and morphology for a sample of field stars that span the transition to WMB. These measurements demonstrate unambiguously that solar-type stars enter the WMB regime at a Rossby number slightly below the solar value, suggesting that our own solar system is already in this regime. Time series observations and numerical simulations of the Sun and other cool stars provide important constraints on the underlying transition in stellar dynamos that ultimately leads to WMB, through the disruption of magnetic organization on the largest spatial scales. I will provide an overview of the direct evidence of WMB from spectropolarimetry, and I will summarize what these constraints tell us about the evolution of stellar dynamos beyond the middle of main-sequence lifetimes.

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Insights into the Initiation Process of Grand Solar Minima Suggested by High-Precision Carbon-14 Analyses

Dr. Hiroko Miyahara[1], Dr. Fuyuki Tokanai[2], Dr. Toru Moriya[2], Dr. Mirei Takeyama[2], Dr. Hirohisa Sakurai[2], Dr. Motonari Ohyama[3], Dr. Kazuho Horiuchi[4], Dr. Hideyuki Hotta[5]

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Abstract

In this presentation, we present the initiation process of Grand Solar Minima as suggested by high-precision analyses of carbon-14 content in tree rings. A series of Grand Solar Minima during the past millennium has contributed to the global cooling event known as the Little Ice Age, highlighting the societal importance of understanding the onset process of such minima. Over the past decade, we have conducted repeated measurements of carbon-14, particularly focused on the onset period of Maunder, Spoerer and Wolf Grand Minima. Our analysis reveals that solar cycles begin to extend starting two to three cycles before the onset of sunspot disappearance. The lengthening, reaching up to 16 years, was observed for both the Maunder and the Spoerer Minima. It suggests that the meridional circulation within the solar convection layer is the key to understanding the reduction of sunspots. In the case of the Wolf Minimum, we found three large-scale solar proton events during the transition time from the active phase into the minimum. We discuss the possible relationship between these large solar proton events and the weakening of solar magnetic activity.

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Superflares on Sun-like Stars and Its Implication to Solar Superflares

Professor Kazunari Shibata

Doshisha University

Abstract

Solar and stellar flares are the most violent consequence of solar and stellar dynamo, and play fundamental role on the environment and habitability of the Earth and planets. Superflares are gigantic flares with energy more than 10^33 erg which is 10 times more energetic than the largest solar flares in recent 30 years. If superflares occur on the Sun, our society on the Earth will suffer from serious disasters as a result of extreme space weather due to superflares. Hence whether superflares occur on the Sun and what are the origins and consequences of superflares are important problems for modern space weather research. Maehara et al. (2012) revealed that many superflares occurred on solar type stars (G type main sequence stars). They found that even slowly rotating stars similar to the Sun (called Sun-like stars) showed superflares, suggesting the possibility of solar superflares. Applying so called Sun-as-a-star analysis (Otsu et al. 2022), Namekata et al. (2022) discovered the first evidence of gigantic filament eruption from superflares on young solar type stars, implying the same physics for solar and stellar mass ejections. Ikuta and Shibata (2024) developed a simple model for this mass ejections, and presented further evidence that this filament eruption eventually become coronal mass ejections.

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Improving our knowledge of the near sub-surface layer: the special case of the leptocline.

Dr JEAN PIERRE ROZELOT[1], Dr Irina, N. Kitiashvili[2], Dr Ali Kilcik[3]

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Abstract

The discovery of the solar activity cycle was linked from the outset to the observation of the temporal variability of sunspots, which we know to be the result of complex processes associated with the dynamics of inner layers. Numerous recent studies have highlighted changes of the Sun's stratification, pointing the role of the leptocline, a shallow and sharp shear layer at around 8 Mm depth. After a brief history of the events that led to the detection of this layer, the physical properties are described. The leptocline, mainly characterized by a strong radial rotational gradient at high latitudes and self-organized meridional flows, is the cradle of numerous phenomena: opacity, superadiabicity and turbulent pressure changes; hydrogen and helium ionisation processes; sharp decrease in the sound-speed; probably an oscillation phase of the seismic radius associated with a non-monotonic expansion with depth. In addition, the leptocline may play a key role in the formation of the magnetic butterfly diagram. Probably also, the initial place of the solar wind escape. Such results, starting point of systematic further investigations of structure and dynamics ot this layer, will lead to a better understanding of the solar activity.

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On the predictability of the solar cycle using the rise rate of polar field: Exploration using observed data and models

Dr Bidya Binay Karak

Department of Physics, Indian Institute of Technology (BHU) Varanasi

Abstract

Prediction of the solar cycle is challenging but essential. The most robust and physically motivated polar precursor method employs the polar field at the solar minimum for predicting the amplitude of the next cycle. However, do we need to wait until the solar minimum to make a reliable prediction using the polar field? Using dynamo simulations and observations, we show that the correlation between the polar field and the amplitude of the next cycle becomes strong already a few years before the solar minimum. More interestingly, we find that the rise rate of the polar field is strongly correlated with the rise rate and the amplitude of the next cycle. By simulating the polar field using synthetic solar cycles in SFT model, we establish the robustness of this correlation. We reveal that the Waldmeier effect, i.e., a positive correlation between the rise rate and the amplitude of the cycle, has a physical link with the buildup of the previous cycle's polar field. Thus, the prediction of the amplitude of the solar cycle can be made just a few years after the reversal of the previous cycle's polar field, thereby extending the scope of the solar cycle prediction to much earlier than the usual time. Our prediction of Cycle 25 based on the rise rate of the previous polar field is 137 +/- 23, which is quite close to the prediction of 138 +/- 26 based on the Waldmeier effect computed from the first 2-year sunspot data of the ongoing cycle.

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ASO-S: the current status and early results

Dr. Li Feng, Dr. Weiqun Gan, ASO-S Team

Purple Mountain Observatory, Chinese Academy of Sciences

Abstract

The ASO-S mission was launched in October 2022. It has three payloads, a Full-disk MagnetoGraph (FMG) to measure photospheric magnetic Fields, a Hard X-ray Imager (HXI) to observe non-thermal signals from 30 to 200 keV, and Lyman-alpha Solar Telescope (LST) to take images of the Sun in Lyman-alpha and white light. The mission aims to simultaneously observe the magnetic fields, solar flares, and coronal mass ejections on a single platform. In this talk, the current status and early results of the ASO-S mission will be introduced. We will pay particular interests in white-light, hard X-ray and Lyman-alpha flares, prominences and filaments, CMEs and waves.

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The effects of surface fossil magnetic fields on massive star evolution

Dr Zsolt Keszthelyi

National Astronomical Observatory of Japan

Abstract

The presence of large-scale magnetic fields in some hot, massive stars with OBA spectral types challenges our understanding of stellar magnetism since these stars lack significant convective zones in their envelopes. Such magnetic fields, presumed to be of fossil origin—either remnants of star formation or products of early-stage magnetic instabilities or stellar mergers—play a crucial role in stellar evolution. Our study utilizes appropriate parametric prescriptions to model these fossil magnetic fields by integrating key physical mechanisms, such as magnetic mass-loss quenching, magnetic braking, and efficient angular momentum transport, into stellar evolution calculations. We have developed an extensive grid of models that cover various initial conditions (in mass, magnetic field strength, chemical mixing, and metallicity). This effort marks the first opportunity to systematically compare theoretical predictions with observations of magnetic hot stars, including those potentially observable in the Magellanic Clouds. This contribution aims to bridge the gap between theory and observation, shedding light on the role of magnetic fields in non-convective regions and their impact on the observable properties of massive stars. Our models offer new insights into the characteristics of magnetic massive stars, providing a theoretical framework for understanding the complex interplay between fossil magnetic fields and stellar evolution.

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Effects on spectroscopic analyses of solar-type stars from chromospheric activity

Thomas Nordlander

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Abstract

The evolution of our Galaxy is studied through chemical abundance measurements in stars of different ages, and with different kinematic properties. A puzzling finding is that red giant stars younger than 1 Gyr are found to be chemically enhanced at vance with chemical evolution models. In particular, barium has been found to be enhanced by as much as a factor 4 compared to solar. Similar effects in dwarf stars are found, but only for much younger ages. It appears that the level of chromospheric activity is connected to the inferred chemical abundances.

I will present recent work predicting the effects on spectroscopic analyses for active solar-type stars. The model makes minimal assumptions on the properties of cool magnetic spots on the stellar surface, and connects this to the chromospheric activity index through empirical relations. Results of this remarkably simple model are in fair agreement with observations, and indicates a way forward that should be adopted by large spectroscopic surveys.

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Analysis of BMR tilt from AutoTAB catalog: Hinting towards the thin flux tube model?

Ms. Anu Sreedevi[1], Dr. Bibhuti Kumar Jha[2], Dr. Bidya Binay Karak[1], Dr. Dipankar Banerjee[3]

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Abstract

The solar convection zone is characterised by the birth of the concentrated magnetic field regions known as Bipolar Magnetic Regions (BMRs), which are tilted with respect to the equatorial line. The thin flux tube model, employing the rising of magnetically buoyant flux loops twisted by the Coriolis force, is a popular paradigm to explain the formation of the tilted BMRs. In this study, we assess the validity of the thin flux tube model by analyzing the tracked (Hale and Anti-Hale) BMR data obtained through the Automatic Tracking Algorithm for BMRs (AutoTAB). Our observations reveal that the tracked BMRs exhibit the expected collective behaviors and the polarity separations of BMRs increase over their normalized lifetimes, supporting the assumption of the rising flux tubes from the CZ. Furthermore, we observe an increasing trend of the tilt with the flux of the BMR, suggesting that rising flux tubes associated with lower flux regions are primarily influenced by drag force and Coriolis force, while in higher flux regions, magnetic buoyancy dominates. Additionally, we observe Joy's law dependence for emerging BMRs from their first detection, indicating that at least a portion of the tilt observed in BMRs can be attributed to the Coriolis force. Finally, we observe that the lower flux regions exhibit a higher amount of fluctuations associated with their tracked tilt measurements, suggesting that they are more susceptible to turbulent convection. All these results hint towards the thin flux tube model as a viable theory for explaining the formation of BMRs.

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AutoTAB: Automatic Tracking Algorithm for Bipolar Magnetic Regions

Ms. Anu Sreedevi[1], Dr. Bibhuti Kumar Jha[2], Dr. Bidya Binay Karak[1], Dr. Dipankar Banerjee[3]

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Abstract

Bipolar magnetic regions (BMRs) provide crucial information about solar magnetism. They exhibit varying morphology and magnetic properties throughout their lifetime, and studying these properties can provide valuable insights into the workings of the solar dynamo. The majority of previous studies have counted every detected BMR as a new one and have not been able to study the full life history of each BMR. To address this issue, we have developed Automatic Tracking Algorithm for BMRs (AutoTAB) that tracks the BMRs for their entire lifetime or throughout their disk passage. AutoTAB uses the binary maps of detected BMRs and their overlapping criterion to automatically track the regions. Here, we provide a detailed description of the working of the algorithm and evaluate its strengths and weaknesses by comparing it with existing algorithms. AutoTAB excels in tracking even for the small BMRs (with a flux of $\sim 10^{20}$ Mx), and it has successfully tracked close to 12000 BMRs over the period of (1996–2023), providing a comprehensive data set that depicts the evolution of various properties for each BMR. The tracked BMRs exhibit the well-known butterfly diagram and 11 yr solar cycle variation, except for small BMRs, which appear at all phases of the solar cycle and show a weak latitudinal dependence. Finally, we discuss the possibility of adapting our algorithm to other data sets and expanding the technique to track other solar features in the future.

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Exploring the role of meridional circulation in the solar and stellar dynamos

Ms. Vindya Vashishth, Dr. Bidya Binay Karak

Indian Institute of Technology (BHU) Varanasi

Abstract

Meridional flow plays a pivotal role in generating the solar poloidal magnetic field by facilitating the poleward transport of the field from lower latitudes, where it originates through the decay and dispersal of tilted Bipolar Magnetic Regions (BMRs). A moderate meridional flow helps in driving the trailing polarity of a BMR towards the pole, enhancing the cross-equatorial cancellation of the leading polarity field. However, a strong meridional flow tends to transport both polarities of BMRs poleward, potentially resulting in a reduction of the polar field. Our aim is to first replicate and understand this phenomenon through a kinematic solar dynamo model and then to explore the role of meridional flow in solar and stellar dynamos, in particular in determining the toroidal field and cycle duration. We employ a 3D kinematic solar dynamo model, STABLE [Surface flux Transport And Babcock–LEighton], which realistically captures the Babcock-Leighton process, which is consistent with observations. In accordance with previous surface flux transport (SFT) models, in our dynamo model, we find an initial increase in the polar field strength at low meridional flow speed and further decline at higher speeds, which is confirmed in a wide range of parameters. Additionally, we reveal how the dependencies of cycle duration and toroidal field on the meridional flow differ from those predicted by axisymmetric flux transport dynamo models. Our research shows the impact of meridional flow on cycle strength, providing insights into modeling cycles of stars at different rotations.

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Dynamo modelling for cycle variability and occurrence of grand minima in Sun-like stars: Rotation rate dependence

Ms. Vindya Vashishth[1], Dr. Bidya Binay Karak[1], Dr. Leonid Kitchatinov[2]

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Abstract

Like the solar cycle, stellar activity cycles are also irregular. Observations reveal that rapidly rotating (young) Sun-like stars exhibit a high level of activity with no Maunder-like grand minima and rarely display smooth regular activity cycles. On the other hand, slowly rotating old stars like the Sun have low activity levels and smooth cycles with occasional grand minima. We, for the first time, try to model these observational trends using flux transport dynamo models. Following previous works, we build kinematic dynamo models of one solar mass star with different rotation rates. Differential rotation and meridional circulation are specified with a mean-field hydrodynamic model. We include stochastic fluctuations in the Babcock-Leighton source of the poloidal field to capture the inherent fluctuations in the stellar convection. Based on extensive simulations, we find that rapidly rotating stars produce highly irregular cycles with strong magnetic fields and rarely produce Maunder-like grand minima, whereas the slowly-rotating stars (with a rotation period of 10 days and longer) produce smooth cycles of weaker strength, long-term modulation in the amplitude, and occasional extended grand minima. The average duration and the frequency of grand minima increase with decreasing rotation rate. These results can be understood as the tendency of less supercritical dynamo in slower rotating stars to be more prone to produce extended grand minima.

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Onset and Evolution of Joy's Law

Dr Hannah Schunker

University of Newcastle

Abstract

The tilt of solar active regions described by Joy's Law is an integral component of Babcock-Leighton dynamo models for converting a toroidal field to a poloidal field. In thin flux tube models the Coriolis force causes what we observe as Joy's Law, acting on east-west flows as they rise towards the surface. To constrain the origins of Joy's Law, we measured the evolution of the average tilt angle from line-of-sight magneto grams of hundreds of active regions as they emerge. We found that at the time of emergence the polarities are on average aligned east-west, consistent with previous results, and that neither the separation nor the tilt depends on latitude. We do find, however, that EARs at higher latitudes have a faster north-south separation speed than those closer to the equator at the emergence time. Joy's Law becomes evident about two days after emergence. Our finding that active regions emerge with an east-west alignment is surprising since thin flux tube models predict that tilt angles of rising flux tubes are generated below the surface. We conclude that Joy's law is caused by an inherent north-south separation speed present when the flux first reaches the surface, and that the scatter in the tilt angle is consistent with buffeting of the polarities by supergranulation.

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Exploring the Dynamic rotational Profile of the Solar atmosphere: A multiwavelength approach

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Abstract

The global rotational profile of the solar atmosphere and its variation at different layers, although crucial for a comprehensive understanding of the dynamics of the solar magnetic field, has been a subject to contradictory results throughout the past century. In this study, we thereby unify the results for different parts of the multi-thermal Solar atmosphere by utilizing 13 years (2010 May-2023 August) of data in 7 wavelength channels of the Atmospheric Imaging Assembly (AIA) atop the Solar Dynamic Observatory (SDO). Using the method of image correlation, we find that the solar atmosphere, at all representative temperatures, exhibits a rotational profile that is up to 4.18% and 1.92% faster at the equator and comparatively less differential than that of the photosphere, as derived from Doppler measurements and sunspots, respectively. Additionally, we observe a significant increase in equatorial rotation rate and decrease in differential nature at different layers above the photosphere. We also find results suggestive of the possible presence of torsional oscillation in the solar atmosphere on the correlation of yearly rotation parameters with yearly averaged sunspot numbers.

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Mechanism of stellar activity-rotation relationship driven by turbulent angular momentum transport

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Abstract

This study explores the relationship between stellar surface magnetic fields and rotation rates. Previous observations (e.g., Wright+ 2011, 2018) have established a connection between stellar activity and rotation rates, with recent observations by Reiners (2022) indicating a parallel trend in surface magnetic fields. Observations suggest an anti-correlation between the magnetic field and Ro within the moderate Ro range ($0.1 < Ro < 1$), reaching saturation at extremely low Ro. Here, the Rossby number (Ro) is a crucial measure in assessing the impact of rotation on dynamics defined as the rotation period over convective turnover time. While global magnetohydrodynamic (MHD) simulations, such as those by Brun+ (2022), successfully replicate the anticorrelation in moderate Ro, the saturation phenomenon at extremely low Ro remains beyond the reach of current global simulations, and its driving mechanism remains unclear. To elucidate the saturation of the stellar magnetic field at extremely low Ro, We perform non-kinematic mean-field dynamo simulations by extending the solar case by Rempel (2006). Our findings reveal that the magnetic field strength is influenced by both stellar rotation rates and the assumed turbulent angular momentum (AM) transport process. Through detailed analysis, we demonstrate that the dependence of the magnetic field on Ro is intricately determined by the balance between AM transport by turbulence and the magnetic field. Notably, our results, in conjunction with recent insights into turbulence properties at low Ro (e.g. Käpylä 2023), align closely with observed magnetic field saturation patterns reported by Reiners (2022).

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The Structure and Stability of a Quasi-Keplerian Accretion Disc around a Compact Objects

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Abstract

Accretion discs play a crucial role in astrophysical systems, serving as reservoirs of matter that fuel the energetic processes observed in various compact objects such as black holes and neutron stars. The study of the structure and stability of these accretion discs is essential for elucidating the mechanisms governing accretion processes and the associated emission phenomena. In this study, we investigate the properties of a quasi-Keplerian accretion disc around a compact object with or without a dynamo, focusing on both its structural characteristics and its stability against perturbations. The stability of the quasi-Keplerian accretion disc against axisymmetric and non-axisymmetric perturbations are governed by an evolution equation for matter surface density $\sum(R,T)$. Through linear stability analysis and nonlinear simulations, we identify critical conditions under which instabilities may develop, leading to the formation of structures such as spiral waves, shocks, and vortices within the disc. We discuss the implications of these instabilities for the accretion process, including their potential impact on the accretion rate, energy dissipation, and the generation of observational signatures.

Keywords: Accretion discs, Compact objects, Quasi-Keplerian motion, Stability analysis, Numerical analysis, Dynamos.

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Algebraic Quantification of the Sun's Dipole Moment: Probing the Role of Babcock-Leighton Mechanism in Solar Activity

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Abstract

The solar dynamo theory explains the Sun's magnetic activity, involving the generation and recycling of the toroidal and poloidal fields. Recent observations suggest that the primary driver of the Sun's magnetic field variations is the Babcock-Leighton mechanism. Surface flux transport dynamo models leverage these concepts to replicate various characteristics of sunspot cycles. In this study, we propose an algebraic approach as an alternative method to explain the role of the Babcock-Leighton mechanism in sustaining the dynamo. By inputting sunspot properties from observational resources into our analytical model, we estimate the dipole moment at the sunspot minimum, thereby quantifying the contribution of individual active regions to the Sun's dipolar field. We find that this algebraic method reasonably estimates the dipole moment at the end of solar cycles spanning a century of observations. Furthermore, we extend our analysis to reconstruct the past solar cycle amplitudes and predict the ongoing cycle 25. By examining the dipole moment estimation during periods of minimum activity and its impact on solar cycle strength, we conclude that the Babcock-Leighton mechanism is a primary contributor to the generation of the Sun's poloidal field.

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Observation of multi-phase small-scale magnetic field amplification in a vortical structure in the lower solar atmosphere

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Abstract

High-resolution solar observations revealed the existence of small-scale vortices in the solar atmosphere. These vortices have been observed near magnetic flux concentrations, indicating a link between swirls and the evolution of the small-scale magnetic fields. Vortices were mainly studied with MHD numerical simulations of the solar atmosphere, revealing their complexity and dynamics, and their importance in understanding the interaction of magnetic fields with turbulent convective flows.

We present a complete and comprehensive description of the time evolution of a small-scale magnetic flux concentration interacting with the intergranular vortex flow and affected by processes of intensification and weakening of its magnetic field. We study observations taken with the spectropolarimeter CRISP and Imaging spectrometer CHROMIS at the Swedish Solar Telescope (SST). The data were recorded at quiet-Sun disk-center, consisting of full Stokes maps in the Fe I line at 617.3nm, in the Ca II line at 854.2nm, and spectroscopic maps in the lines of Hα and Ca II K lines. Performing height-dependent Stokes inversion, methods of local correlation tracking, and wavelet analysis, we can study several atmospheric properties during the event lifetime. We identify the convective collapse process as the initial mechanism of magnetic field intensification, generating a re-bound upflow within the magnetic flux concentration. This disturbance steepens into an acoustic shock wave that dissipates in the lower chromosphere, heating it locally. We observe also prolonged magnetic field amplification happening when the vortex flow disappears. We suggest that such magnetic field amplification can be due to changes in the local vorticity

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Solar Activity Nests as Observed with the Helioseismic and Magnetic Imager

Dr. Aimee Norton

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Abstract

Activity nests, also known as active longitudes, are locations where active regions repeatedly emerge over a period of months or years. In addition to commonly hosting flares and CMEs, activity nests are interesting because they inform us about the non-axisymmetric nature of the solar dynamo. In this work, I report on the active longitudes observed during Solar Cycle 24 and the start of Cycle 25 as studied using HMI/SDO magnetic synoptic maps. Lower-order m = 1, 2 modes dominate early and late in the cycle whereas m = 4, 6 modes appear at solar maximum. The physical mechanism that causes nests is unknown but could be due to an instability acting on the interior magnetic field or due to flow fields such as giant convection cells causing preferred locations of flux emergence. I discuss these issues as well as report on the average characteristics such as lifetimes, rotation rates and amount of magnetic flux contained in the observed nests.

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The Mg II h&k lines, the magnetic chromosphere, and the role of the local dynamo.

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Abstract

The Mg II h&k lines are amongst the best diagnostic tools of the upper solar chromosphere, currently observed on a regular basis with the IRIS satellite. This region of the atmosphere is of particular interest as it is the lowest region of the Sun's atmosphere where the magnetic field is dominant in energetics and dynamics, defining its structure. While highly successful in the photosphere and lower to mid chromosphere, numerical models have not produced Mg II lines that match observations in the upper chromosphere well. We present a number of large scale models with magnetic field topologies representative of the quiet Sun, ephemeral flux regions and plage. We find that a much improved correspondence with observations is found in magnetic field topologies and with magnetic field evolution where there is significant chromospheric mass loading. This comes in addition to the inclusion of small scale velocities, nonequilirbrium ionization and ion-neutral interactions. . However, he line widths of Mg II h and k in plage remain problematic. Understanding and modeling these effects and their relative importance is necessary in order to reproduce observed spectral features and will help clarify the role of flux emergence and thus the workings of the local dynamo in describing the solar magnetic field at small to medium spatial scales.

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Insights from Starspot Transit Mapping: Exploring the Relationship between Stellar Differential Rotation, Effective Temperature, Rotation, and Spot Flux Deficit

Prof Adriana Valio, Dr Alexandre Araujo

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Abstract

The investigation of stellar rotation is crucial in understanding stellar evolution, offering insights into factors such as age, angular momentum transfer, and magnetic fields. While detailed observation of sunspots on the Sun has enabled precise estimates of its rotation period and differential rotation, extending such analyses to stars remains a challenge. In this study, we introduce a novel approach by analyzing stellar differential rotation through starspot transit mapping, specifically targeting solar-type and M stars. Here, we present the relationships between rotational shear, effective temperature, average rotation period of stars, and the stellar flux deficit caused by the presence of spots. Utilizing spot transit mapping data collected from 13 slowly rotating stars (with periods exceeding 5 days) spanning spectral types from M to F, observed by the Kepler and CoRoT satellites, which differential rotation profiles were determined. Our findings unveil a negative correlation (-0.77) between rotational shear and the mean period of stellar rotation, suggesting a potential indicator of stellar age. Conversely, a mild correlation is observed between differential rotation and the effective temperature of the stars. Moreover, the stars analyzed here seem to fall into two categories according to their spot flux deficit: those with flux > 0.005 and those with flux < 0.002, which may be related to flaring activity. This study contributes valuable insights into the intricate interplay between stellar parameters and differential rotation, thereby advancing our comprehension of stellar evolution and magnetic dynamos.

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Using Long-Short Term Memory Models to Predict Solar Active Regions Emergence

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Abstract

To develop an early warning system for upcoming Space Weather events, we have observed and analyzed 61 emerging active regions (ARs), compiling a dataset that includes Doppler shift, magnetic flux, and continuum intensity measurements collected by the Helioseismic and Magnetic Imager (HMI) on board of the Solar Dynamics Observatory (SDO). By tracking 30.66x30.66-degree zones surrounding active regions, we have followed the evolution of these areas and generated acoustic power maps. These were then combined with magnetic flux measurements to serve as input for machine learning models. We conducted an analysis of time series data across 81 tiles within each 30-degree patch, which span both quiet-Sun areas and zones of imminent emergence. A Long Short-Term Memory (LSTM) network was trained to identify changes in acoustic power and unsigned magnetic flux that signal a decrease in intensity associated with emergence and formation of active regions. The model was trained using data from 40 ARs and tested on the 10 most recently observed ARs in our dataset. The LSTM model, featuring three layers with 64 hidden units each, was trained with a learning rate of 0.001 over 500 epochs. This work showcases the capabilities of LSTM modeling in predicting active region appearances up to 24 hours before they emerge, explores how the characteristics of the ML model affect its accuracy and underscores the value of applying machine learning techniques to predict active region emergence, confirming the effectiveness of using acoustic power maps as a forecasting tool.

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Effects of Rotation and Magnetic Fields on the Dynamics and Structure of Upper Convection Zones of the Sun and Solar-Type Stars

Irina N. Kitiashvili

NASA Ames Research Center

Abstract

The magnetic activity of the Sun and stars is largely driven by rotation, which shapes the dynamics, characteristic scales, and properties of flows in the convection zone. Therefore, the modeling community effort is concentrated on the reproduction of dynamics of the Sun and understanding interlinks between different scales of turbulence and the global flow dynamics and their coupling to magnetic fields. This presentation will primarily concentrate on recent modeling advances of the near-surface layers of the Sun and stars, which are usually excluded from most global MHD models. In particular, we will discuss the influence of rotation on the small-scale dynamo, thermodynamical structure, self-organization processes of convection, oscillations, and the formation of roll-like patterns in stars with shallow convection zones.

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Predictions versus Observations of Solar Cycle 25: Where do we stand?

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Abstract

Given the influence of solar activity on planetary environments and space-reliant technologies, it is desirable to have a prior understanding of the strength and timing of decadal-scale solar variability. However, efforts to predict the peak amplitude and timing of sunspot cycleshave not always converged. Nonetheless, there is growing consensus in the solar dynamo community about the fundamental mechanisms that drive solar cycle variability; this understanding has been relied upon for physical model based forecasts for solar cycle 25. I shall present an analysis of physical model based - as well as other alternative - efforts to predict sunspot cycle 25 and confront these forecasts with recent observations. I shall discuss whether current observations support any specific physical models of solar cycle variability.

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Effects of the Solar Dynamo on the Differential Rotation and Meridional Circulation

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Abstract

A recently developed 3D dynamical mean-field model of the solar dynamo showed that variations of the internal differential rotation and meridional circulation during the solar cycles are driven not only by the direct effects of magnetic stresses but also by changes in turbulent heat transport, inertial forces, and other factors. Helioseismic data from the ground-based network GONG and NASA space missions SoHO and SDO allow us to test the theoretical predictions. In particular, variations of the differential rotation (so-called 'torsional oscillations') and the meridional circulation, inferred in the solar convection zone from the helioseismic data, exhibit a radial and latitudinal migration pattern — the 'extended' 22-year cycle. It is intriguing that these variations can be traced over periods of both activity maxima and minima; therefore, the presence of magnetic active regions on the solar surface, which could drive these variations, is not crucially important for them. Our dynamo model successfully explains the observed variations and shows that they are associated with the dynamo waves traveling from the bottom of the convection zone to the surface. This study provides unambiguous evidence for Parker's dynamo wave theory of the solar activity cycles.

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solar-cycle irregularities as revealed from Kodaikanal multi wavelength archive and its implications to the dynamo models

Prof Dipankar Banerjee

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Abstract

Kodaikanal Observatory (KSO) has archived more than 100 years of solar images in three different wavelengths namely, white light, Ca K and H-alpha. Four sets of data consist of while light photoheliograms since 1904, the Ca-K line spectroheliograms since 1906, H-alpha spectroheliograms from 1912 to 1998 and K-pr prominences spectroheliograms from 1912 to 1998. The butterfly diagrams as produced from these different datasets reveal new trends and features to understand the irregularities of solar cycle behaviors. The pseudo magnetograms as produced while combining these multi wavelength resources reveals new information particularly the polar migration, multiple surges etc. I will highlight the importance of polar rush behavior corresponding to the past century in different cycles and its implications with timing of the polarity reversal and the strength of the next cycle.

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Solar Cycle Variation of Cross-equator Meridional flows in the Near-Surface Shear Layer from SDO/HMI and GONG Observations

Dr S. Paul Rajaguru[1], Dr. Ruizhu Chen[2], Dr Junwei Zhao[2], Dr Shukirjon Kholikov[3], Ms Anisha Sen[1]

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Abstract

Time-distance helioseismology provides sensitive probes of hemisphere asymmetric dynamics of large-scale flows. Cross-equator averages of travel times of acoustic waves propogating in the meridional direction carry information on the cross-equator residuals resulting from hemisphere asymmetric active region flows, zonal flows (changes in rotation), alignment of solar rotation axis as well as systematics in the North-South alignment of input data. Here, we compare measurements of cross-equator meridional flows throughout the near-surface shear layer (NSSL) from SDO/HMI and GONG observations covering the years 2010 - 2024. We find significant differences between Cycle 24 and the ongoing Cycle 25 and study such changes in terms of hemispheric asymmetry of active region magnetic fields. By way of comparing HMI and GONG observations, we are able to provide a detailed analysis of signals and systematics in the measurements. We disucss implications of our current measurements to the dynamics of flows and magnetic fields in the NSSL.

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Forecasting Solar Cycle 25: How well did we fare?

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Abstract

As Solar Cycle 25 peaks, a preliminary confrontation of forecasts made in the past can now be attempted. Besides the errors in a forecast, the time lag from forecast to cycle start / cycle peak is also an important factor to consider when qualifying success.

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Nonlinear time series analysis and simulations at different amounts of dynamo supercriticality suggest solar dynamo is not highly supercritical

Mr. Pawan Kumar[1], Mr. Aparup Ghosh[2,3], Dr. Bidya Binay Karak[1], Mr. Sanket Wavhal[1], Dr. Amrita Prasad[4]

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Abstract

The toroidal to poloidal part of the solar dynamo mechanism involves some nonlinearity and stochasticity, which disturb the dynamo loop. Hence, the memory of the polar field decreases in every cycle. On the other hand, the dynamo efficiency and, thus, the supercriticality of the dynamo decreases with the Sun's age. Previous studies indicate that the memory of the polar field decreases as the dynamo supercriticality increases. This work employs well-recognized time series analysis techniques and computes Higuchi's fractal dimension, Hurst exponent, and Multi-Fractal Detrended Fluctuation Analysis to the amplitude of the solar cycle obtained from dynamo models operating at near-critical and supercritical regimes. We show that the magnetic field in the near-critical regime exhibits strong memory, less stochasticity, intermittency, and breakdown of self-similarity. Conversely, the magnetic field in the supercritical regime has less memory, strong stochasticity, and a good amount of self-similarity. Furthermore, applying these analysis techniques to the reconstructed sunspot data of 85 cycles and comparing these results with the model, we conclude that the solar dynamo likely operates near the critical regime rather than the highly supercritical regime. Finally, we reproduce the observed solar cycle features, namely, grand minima and maxima, solar cycle amplitude, and skewness. All these findings suggest that the solar dynamo operates near the critical regime and may not be too far from the critical dynamo transition.

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Observational constraints from helio- and astero-seismology for dynamo models

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Abstract

Magnetic activity cycles occur due to the interplay between rotation, convection, and the magnetic field, which are key ingredients in dynamo models. While surface rotation, surface magnetic field and surface magnetic activity can be measured with photometric observations, spectroscopy or spectropolarimetry, the internal dynamics and structure of stars are better constrained with seismology.

For decades, helioseismology proved to be an invaluable technique to study the deeper layers of the Sun. Not only does it provide the most precise internal rotation of the Sun (down to ~0.3solar radius), but it can also allow us to study the meridional circulation or determine the depth of the convection zone that are needed in dynamo models. By studying the oscillations, we can also study magnetic activity cycles.
In recent years, there has been a significant transformation in our comprehension of stellar physics, largely propelled by advances in asteroseismology. Space missions like CoRoT, Kepler, K2, and TESS have been collecting exceptionally precise photometric data allowing us to infer the internal rotation of solar-like stars even down to their cores, their core magnetic fields, and their magnetic activity while obtaining a precise measurement of their internal structures.

We are fortunate to be living in an extraordinary era with space missions scrutinizing our Sun and observing millions of stars. In this talk I will show the advances done with helio- and astern-seismology to better constraint the dynamo models of the Sun and stars.

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Exploring variabilities in the polar field and solar cycle due to irregular properties of BMRs using 3D Babcock-Leighton type dynamo

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Abstract

Decay and dispersal of tilted Bipolar Magnetic Regions (BMRs) on the solar surface are observed to produce a large-scale poloidal field that acts as the seed for the next sunspot cycle. Thus, any variation in the polar field can lead to changes in the solar cycle. Previous studies indicate that the observed irregular variations in BMR properties, such as tilt, time delay in successive BMR emergences, location, and flux, can lead to changes in the polar field and the solar cycle. Our study demonstrates that our 3D kinematic dynamo model, STABLE, reproduces the robust feature of the SFT model, specifically the variation of the generated dipole moment with the latitude of the BMR position. Using STABLE in both SFT and dynamo modes, we perform simulations by varying the individual properties of BMR and keeping their distributions the same in all the cycles following the observations. Our comparative analyses suggest that randomness due to the distribution in either the time delay or the BMR latitude produces negligible variation in the polar field and the solar cycle. However, randomness due to BMR flux distribution produces substantial effects, while the scatter in the tilt around Joy's law produces the largest variation. Furthermore, our simulations also show that the magnetic field-dependent time delay of BMR emergence produces more realistic features of the magnetic cycle, consistent with observation.

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Magnetic Fields and Dynamo in Non-Convective Regions of Stars

Dr Laurene Jouve

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Abstract

In this talk, we will review some recent progress in understanding the dynamics of magnetic fields in stellar radiative zones. In these regions, a convective dynamo cannot be at play to constantly shear and twist the magnetic field to maintain its energy against Ohmic dissipation. However, there can still be strong interactions between magnetic fields and differential rotation and potentially leading to MHD instabilities. These instabilities are likely to transport angular momentum and chemical abundances in stellar radiative zones. They are also potentially able to produce sustained turbulence and thus dynamo action not relying on the convective motions. Recent applications devoted to intermediate mass stars on the main sequence and to red giant stars will be discussed.

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Tackling Systematics in Helioseismic Measurements of Solar Deep Meridional Flow

Dr. Ruizhu Chen[1], Dr. Junwei Zhao[1], Dr. S.P. Rajaguru[2,1], Dr. Shukirjon Kholikov[3,4]

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Abstract

The Sun's meridional circulation is crucial to understanding its dynamo and interior dynamics. However, the helioseismic determination of deep solar meridional flow is complicated by multiple systematic effects, because of which previous studies have provided inconsistent results. To find the cause of the discrepancies, we analyze 12+ years of HMI and GONG data and make meridional flow measurements employing various helioseismic routines utilized in prior studies. We conduct a comprehensive comparison of flow measurements and corresponding systematic effects across different methods, data sources, and processing procedures. Our objective is to identify the optimal measurement routine to remove the systematics and reconcile the meridional flow results from HMI and GONG by different methods.

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3D MHD Modeling of Solar and Stellar Dynamos

Dr Gustavo Guerrero

Universidade Federal de Minas Gerais

Abstract

A comprehensive theory elucidating the physical mechanisms driving solar and stellar magnetism and activity remains elusive. Nonetheless, significant advances have been made in recent decades, largely attributed to the use of sophisticated computer simulations. The global (3D and spherical) MHD simulations are designed to uncover the fundamental physics involved in the the development of large scale flows and magnetic field as a consequence of a highly turbulent rotating plasma. Yet, achieving a realistic parameter regime, or at least, a regime of asymptotic convergence in high-resolution simulations remains challenging now and in the near future. Despite these facts, global simulations have yielded valuable insights, allowing the formulation of theories that explain the origin of large-scale flows and magnetic fields. Furthermore, these simulations have enabled exploration of ideas to explain the widespread occurrence of magnetism across stellar objects of all types. In this talk I'll present recent findings and challenges from these global simulations. This includes advancements in our understanding of the energy transport and distribution across different spatial scales, as well as the phenomena of magnetic buoyancy. Additionally, I will discuss recent numerical results concerning global inertial modes found in these simulations, these findings shed light on the influence of these inertial modes on the global dynamics.

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Non-linear simulations of excitation and dynamics of inertial waves in the solar interior

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Abstract

Recent observations have revealed the presence of inertial waves on the surface of the Sun, hinting at their potential as an effective tool in understanding the dynamics of the solar interior. The dynamics of this interior is characterized by movements at different scales, such as differential rotation, meridional circulation, and turbulent convection, which in turn can impact the solar magnetic cycle and space weather.

Numerical simulations of the solar interior have faced challenges in reproducing the observations, and the study of inertial waves offers a new approach to unresolved questions. By comparing theoretical models of inertial waves with observations, it's possible to establish limits on the parameters of the solar interior. In addition, numerical models studying the presence of these waves in the Sun suggest that they could interact with magnetic fields in the tachocline, leading to periodic events of solar activity on the surface. It has also been found that these oscillation modes can interact with differential rotation, leading to instabilities that periodically exchange energy with differential rotation.

In this work, we study the excitation and nonlinear dynamics of the inertial waves in stellar interiors. We have conducted global numerical simulations using the EULAG-MHD code, considering a domain with thermodynamic stratification compatible with the solar interior. We explored the development and evolution of these waves in simulations with rigid rotation, as well as with imposed differential rotation. Our model presented distinct types of inertial waves that can propagate radially and exchange energy in different scales.

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Comparing sound-proof and compressible dynamics in global simulations of solar convection

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Abstract

Simulating the turbulent convection in the solar interior is a notoriously difficult task. The high disparity of physical parameters and the scale separation needed to be resolved imposes severe numerical constrains. In addition, a large time span is desired in order to provide meaningful predictions of solar phenomena. A recurrent option for overcoming the last issue is to consider "sound-proof" models, which artificially filter sound waves and allow a larger integration time step. Despite the large adoption of this approach by the community, it is not yet clear how such models differ from the actual compressible case.

In order to clarify the difference of these approaches, we perform global ILES simulations of the solar interior for anelastic, pseudo-incompressible and fully compressible cases using the hydrodynamical version of the EULAG-MHD code. This code has been used for several decades as a framework for geophysics and astrophysics fluid dynamics and MHD. However, in order to adapt the workflow to the newest computational capabilities, we performed programmatic improvements to the code base, aiming for a modern and friendly syntax. This results not only in a refactored version of EULAG but also in a tool which is capable of formatting, updating and generating modern FORTRAN code besides allowing sound-proof and fully compressible fluid dynamics. These improvements will also be briefly discussed.

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The COFFIES Drive Science Center - A Concerted Effort to Understand the Sun's Magnetic Activity Cycle and the Sources of Variability

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[1]Stanford University. [2]18 Institutions Around the World

Abstract

Solar magnetic variability is a Consequence of Fields and Flows in the Interior and Exterior of the Sun (COFFIES). The COFFIES project brings together the expertise required to advance our understanding of the origins of solar and stellar magnetism. The Center focuses on three primary themes that inform the study of the activity cycle: the Tachocline, the Near-Surface Shear Layer, and Flux Transport & Emergence. Co-Investigators from 13 US and 5 international institutions are working with a much larger group of active and interested researchers who bring skills in solar convection, dynamo theory, helioseismology, surface observations & analysis, and model development and integration. The Center (see COFFIES.stanford.edu) is funded by the NASA Heliophysics Division for five years to address goals that include 1) the causes of variability in large-scale motions throughout the Sun, 2) the relationship of fluctuating flows with differences in solar cycles, 3) the sources of flux emergence and patterns of activity during the cycle, and 4) the commonalities and differences between activity of Sun and other similar stars. COFFIES works diligently to overcome issues that impede the success of large, distributed science projects. We also support education and public outreach activities, provide mentoring and mentor training, and strive to deliberately enhance diversity, equity, inclusion, and accessibility in the COFFIES team and beyond

Session

FM 8 Advances and Challenges in Understanding the Solar and Stellar Dynamos

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2990

Unveiling Dynamo Waves in the Sun: a Helioseismic Approach

Dr. Krishnendu Mandal[1], Prof. Alexander Kosovichev[1,2], Dr. Valery V. Pipin[3]

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Abstract

Solar differential rotation exhibits intriguing cyclic variations, known as torsional oscillations, that hold clues to the Sun's internal dynamo. Measuring the magnetic field within the Sun is challenging, making torsional oscillations a valuable tool for dynamo studies. This work aims to identify specific signatures of these oscillations in helioseismic data. We employ a comprehensive forward modeling approach, simulating helioseismic data from a dynamo model that replicates solar-cycle variations. Our model simulations show a clear 11-year periodicity in the estimated frequency-splitting coefficients. We further demonstrate the feasibility of extracting the dynamo wave signal from simulated data, incorporating realistic noise levels. By analyzing observed data, we find similar dynamo wave patterns in the observational data from MDI, HMI, and GONG. This validates the earlier detection of dynamo waves and holds potential implications for the solar dynamo theory models.

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Roles of global MHD tachocline instabilities in producing recurrent and sympathetic emergences of active regions

Mausumi Dikpati[1], Aimee Norton[2], Breno Raphaldini[1], Scott McIntosh[3]

[1]NSF-National Center for Atmospheric Research, HAO. [2]Stanford University. [3]NSF-National Center for Atmospheric Research

Abstract

Observations indicate that the new active regions often tend to emerge in the proximity of existing active regions. Also, active regions are often seen to emerge at a similar heliographic longitude where their opposite-hemisphere counterparts emerge. Noting the former situation as "recurrent" emergences and the latter the "sympathetic" emergences, we explore the nonlinear evolution of global MHD instabilities of tachocline toroidal magnetic bands, from which the active regions most likely emerge to the surface, and derive their emergence locations in latitude and longitude. It was previously demonstrated that solar Rossby waves, nonlinearly interacting with magnetic fields, can create certain locations, which are most prone for initiating flux emergences. Here we study plausible model-conditions in various solar cycle epochs that could be responsible for "recurrent" and "sympathetic" emergences. We compare the model-outputs with synoptic magnetograms to derive successes and limitations.

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Using code coupling to study the turbulent transport coefficients in a system with tachocline

Guilherme Monteiro[1], Dr. Matthias Reinhardt[2], Dr. Maarit Korpi-Lagg[2], Dr. Gustavo Guerrero[1]

[1]Universidade Federal de Minas Gerais. [2]Aalto University

Abstract

A consistent form of understanding the physics of the magnetic field in stars is the study of Turbulent Transport Coefficients (TTC). In this regard, the Test Field Method (TFM) is one of the most notable tools to evaluate the of a system, providing the values of it's TTC and, as result, it's physical meaningfulness. Unfortunately, simulations with access to the TFM are unable to reproduce the tachocline, the region between the stellar radiative and convective zones. In our work, we have used MPI to stablish a coupling between two well know magnetohydrodynamic codes, the Eulag-MhD and the Pencil-Code. With Eulag, we are able to simulate a spherical shell that has an internal structure similar to the Sun, including the tachocline. Meanwhile, with the Pencil, we can perform the analysis of the turbulent coefficients using the TFM. We are specially interested in how the coefficients will be altered by the tachocline and how they permeate the stable stratified zone below it. We conduct a parameter study to understand the behaviour of the coefficients, and how they are influenced by numerical and physical variables. The results depicts tendencies, specially with rotation and η-test values.

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Magnetic Buoyancy Instability at High Wave Numbers in Global Dynamo Simulation

Luiza Alkmim, Gustavo Guerrero

Universidade Federal de Minas Gerais

Abstract

The understanding of sunspots at the solar photosphere is closely related to the understanding of the solar dynamo, yet no theory explaining sunspots is free of criticism. The most widely explored of these theories considers that sunspots correspond to the topmost portions of arched magnetic flux tubes (omega loops) emerging buoyantly from the bottom of the convective zone.

From results of our convective dynamo simulation that support the rise of magnetic fields from the bottom of the convective zone, we see that the emergence is given in the form of O-loops occurring at high longitudinal wave numbers. We argue that the penetrative turbulent convection excites the magnetic buoyancy instability, which is responsible for the rise of the O-loops seen in the simulation.

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Introducing the L4 Mission: A New Frontier in Heliophysics

Dr Jeong-Yeol Han

Korea Astronomy and Space Science Institute

Abstract

The L4 Solar Observation Mission targets critical solar phenomena from the Sun-Earth Lagrange point L4, providing an unparalleled vantage for observing the Sun and Heliosphere. This mission incorporates a suite of remote and in-situ observational instruments, crucial for studying the effects of space radiation and enhancing space weather forecast capability. This initiative will complement existing observations from L1 and L5 points, filling a significant gap in multi-point heliospheric observation. Our presentation will provide details of the L4 mission, with a focus on the conceptual designs of its main observational tools. These include an optical telescope for Chromosphere observation with H-alpha and photospheric magnetic field with magnetograph, along with an EUV telescope for investigating the solar corona. The combination of these instruments at the L4 point aims to revolutionize our understanding of the Sun and Heliosphere, crucial for the safety and efficiency of future space missions from Moon to Mars.

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Observations of Magnetic Fields and Activity Cycles in Solar-Type Stars

Dr. Stefano Bellotti

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Abstract

Observing the magnetic field evolution of Sun-like stars advances our understanding on how key dynamo ingredients, like stellar mass and rotation, influence internal dynamo processes. In this talk, I will review some techniques used to observe stellar magnetic cycles, such as those inferred from activity indices, like the chromospheric S-index, and the evolution of the large-scale magnetic field as reconstructed via spectropolarimetry. I will also present the current status of the cycle searches and the trends that have emerged. For instance, the correlation between S-index and large-scale polarity reversals of some stars, or the lack of defined cycles at young stellar ages and the inset of solar-like behaviour at later stages, with some specific cases exhibiting multiple, superimposed cycles. Finally, I will conclude with prospects in the field, especially in light of future space-based facilities like PLATO.

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Final category: FM 9 Measures of luminous and dark matter in galaxies across time

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Constraints on primordial black holes as constituents of dark matter based on over 20 years of OGLE observations of the Large Magellanic Cloud

Przemek Mróz

Astronomical Observatory, University of Warsaw

Abstract

The idea that dark matter may be composed of dark compact objects, for example primordial black holes, was revived following the discoveries of gravitational waves from mergers of massive black holes by the LIGO and Virgo detectors.

If such black holes existed in large numbers in the Milky Way dark matter halo, they would cause long-timescale gravitational microlensing events lasting years. Previous experiments that aimed to detect gravitational microlensing events from dark matter halo objects were not sensitive to such long-timescale events, and thus, not sensitive to such massive black holes.

I would like to present the results of the search for the long-timescale microlensing events amongst the light curves of 78.7 million stars located in the LMC that were monitored for 20 years (2001-2020) by the Optical Gravitational Lensing Experiment (OGLE) survey.

We did not find any events with timescales longer than 1 yr. The properties of all thirteen microlensing events with timescales shorter than 1 yr detected by OGLE toward the LMC can be explained by stellar objects located either in the LMC itself or in the Milky Way disk, without the need to invoke dark matter in the form of compact objects.

We find that compact objects in the mass range from 1.8e-4 to 6.3 M_{Sun} cannot compose more than 1% of dark matter, and those with masses from 1.3e-5 to 860 M_{Sun} cannot make up more than 10% of dark matter. The weaker limits extend up to 10^4 M_{Sun}.

Our limits are about an order of magnitude stronger than those inferred by all previous gravitational microlensing experiments that aimed to assess the contribution of compact objects in the relevant mass range to dark matter.

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A comprehensive view of the luminous and dark matter content of ultra-diffuse galaxies

Luisa Buzzo

Swinburne University, Melbourne, Australia

Abstract

Ultra-
diffuse galaxies (UDGs) have been in the spotlight since their (re)discovery in 2015. These galaxies challenge our u nderstanding of the field of galaxy formation and evolution as they have the sizes of giants, but luminosities of dw arfs.

Across a sequence of works, we build a comprehensive model to understand the origins of UDGs in the universe. At first,
we employ spectral energy distribution fitting techniques on photometric data from the optical to the mid-infrared to recover the stellar population properties and morphologies of
~90 UDGs distributed across environments (Buzzo+22b, Buzzo+24a). In addition, we use photometric data to study the large-scale structure of globular clusters (GC) in a very controversial group hosting supposedly dark matter-free UDGs to probe their formation histories (Buzzo+22a, Buzzo+23). Finally, we use IFU spectroscopy to study the luminous and dark matter content of UDGs to help elucidate the link between their globular cluster populations and dark matter content (Buzzo+24b, Buzzo in prep.).

Using these works, we find evidence for a stellar population dependence on the environment, GC-richness, dark matter content, and morphology of UDGs, hinting at the existence of two classes of UDGs: classical dwarf galaxies which have grown in size, often refereed to as 'puffed-up dwarfs', and giant galaxies with stunted star formation, also known as 'failed-galaxies'.

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MeerKAT Detection of a Radio Halo at *z=1.23*: ACT-CL J0329.2-2330

Dr SinenhlanhlaPrecious Sikhosana

University of KwaZulu-Natal

Abstract

At high redshifts, the surface brightness of radio halos and relics is affected by the inverse Compton (IC) energy losses (CRe IC scattering lifetimes scale as $(1 + z)^4$) and redshift dimming effects. It is, therefore, expected that their occurrence rate decreases at higher redshifts. Lindner et al. 2014 were the first to detect a radio halo at a relatively high redshift of *z=0.870.* The host cluster was the massive ACT-CL J0102-4915, known as El Gordo. Until recently, this had been the only radio halo detected at $z \geq 0.8$. Due to the scarcity of high redshift halos and relics, their statistical studies have been constrained to nearby galaxy cluster samples $z \sim 0.1 - 0.4$. Recently, DiGennaro et al. 2021a observed a *Planck*-selected sample of high redshift ($0.6 < z < 0.9$) clusters. In their study, they found a halo occurrence fraction of 50% and that the halos exhibited radio luminosities similar to those hosted by nearby clusters. They hence concluded that to observe such properties means that magnetic fields are amplified faster during the initial cluster formation stages. In this presentation, we report the MeerKAT *L* and *UHF*-band detection of the highest-redshift radio halo, hosted by ACT-CL J0329. We also present the spectral index map of the halo. J0329 is at redshift 1.23 and has a mass of $9.7 \pm 1.7 * 10^{14}$ M_{sun}. This radio halo detection, a first at $z > 1$, gives us insight into astrophysical processes that occurred when the universe was less than half its age (~8.5 billion years ago).

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PostNewtonian Dark Matter Halos

Prof. Ericson Lopez

Quito Astronomical Observatory of Ecuador, National Polytechnic School. Department of Physics, Science Faculty, National Polytechnic School. Quito Astronomical Observatory

Abstract

In this contribution, we are interested in enforcing results reported in other works, where the main statement is that the general relativity formalism is not necessary to describe the physics of the halo around spiral galaxies. Then, an inter-median formalism between the classical Newtonian and the relativistic Tolman Oppenheimer Volkoff ones is used to model a halo filled with perfect fluid and an equation of state obtained derived from the universal rotation curves of spiral galaxies. To keep the hydrostatic equilibrium the dark matter should have a nonzero pressure to compensate for the gravitational force of the mass contends in the halo. A state equation is demanded to accomplish this requirement and completes the set of space-time nonlinear gravitation field, equations obtained from general relativity.

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Fast radio bursts as a probe to constrain primordial mass black holes made of dark matter

Dr. Surajit Kalita, Prof. Amanda Weltman, Ms. Shruti Bhatporia

University of Cape Town, South Africa

Abstract

This abstract is based on our recent work JCAP 11 (2023) 059. Fast Radio Bursts (FRBs) can be used as a tool to understand different cosmological phenomena because of their distinct features, such as short pulse width, relatively high dispersion measure, etc. On the other hand, over the past decades, researchers have proposed different modified gravity models. In my talk, considering a generic modified gravity theory, I will show how it affects the properties of gravitational lensing in FRBs. Thereby, using a set of FRBs from the CHIME dataset, I will discuss how it can constrain the fraction of dark matter made up of primordial black holes in such a theory. I will further show that modified gravity adds a screening effect on gravitational lensing similar to the case when there is plasma in the path of the light ray acting as a scattering screen.

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The dynamical and morphological transformation of galaxies through cosmic time

Dr Caroline Foster[1,2], Mr Aman Khalid[1,2]

[1]School of Physics, University of New South Wales, Sydney, NSW 2052, Australia. [2]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D)

Abstract

In this talk, I will briefly discuss some of the existing observational and theoretical evidence for the morphological and dynamical transformation of galaxies through cosmic time. This transformation is thought to result from the complex interplay between the hierarchical merging of dark matter halos and baryonic processes. I will first show that measuring and contrasting the dynamical state of galaxies using gas and stars in and beyond the local Universe is an important test of our cosmological understanding of galaxy evolution.

I will discuss barriers to the accurate measurement of dynamical evolution in galaxies and suggest possible solutions. In particular, strategies for mitigating the `progenitor bias' in observational surveys will be outlined.

I will introduce the Middle-Ages Galaxy Properties with Integral field spectroscopy (MAGPI) Survey, a VLT/MUSE large programme designed to replicate the depth and spatial resolution of local integral field spectroscopy surveys at intermediate redshift (z~0.3). MAGPI provides a 3D snapshot of the dynamical state of both the ionised gas and stars in galaxies at the highest feasible lookback time. I will discuss and contrast visually identified kinematic morphologies of MAGPI galaxies with local comparable surveys, using MUSE-derived gas and stellar kinematic maps.

Presented results will focus on the dynamical state of galaxies in MAGPI in light of predictions from cosmological simulations.

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Isolated elliptical galaxies: Dark Matter, MOND, or something else?

Dr Richard Lane[1], Prof Tom Richtler[2], Dr Ricardo Salinas[3], Prof Michael Hilker[4]

[1]Universidad Bernardo O'Higgins. [2]Universidad de Concepción. [3]Gemini Observatory. [4]European Southern Observatory (ESO)

Abstract

In recent years, various studies have revealed an apparent discrepancy between the dynamical expectations from LCDM and the measured dynamics of isolated elliptical galaxies, with some of these galaxies appearing not to require any dark matter to explain their dymanics. In this talk I will give an overview of several of these galaxies, and pose the open questions: "Can LCDM explain the dynamics of these galaxies? Must we turn to MOND or some other form of modified gravity to explain them instead? Or is something else going on entirely?"

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Probing early type galaxy evolution in the rest-frame near ultraviolet

Dr. Roberto De Propris[1], Dr. Sadman Ali[2]

[1]BIUST. [2]NAOJ

Abstract

We use deep imaging in the rest-frame NUV (2300 Å) to measure the evolution of ultraviolet colours for early type galaxies in clu sters, using data from GALEX, the CLAUDS survey and the HSC-SSP survey. We find that early-type galaxies exhibit an UV upturn. The UV upturn appears to be ubiquitous and to be present in all environments: it is therefore a property of early-type stellar populations. Our observations show that the upturn has a sharp onset at z~0.7. This is only consistent with the presence of a secondary stellar population of stars with helium abundance above 40% formed at z>3. These stars evolve rapidly to the blue horizontal branch even at high metallicities and produce the excess UV light; they resemble the second parameter stars in Galactic globular clusters. At higher redshift we are able to use the NUV light to constrain the formation of early type galaxies. We find that the data require that galaxies form their stellar populations at z > 3 with star formation timescales < 0.7 Gyr. However the presence of the UV upturn suggests that the star formation and mass assembly had to happen in situ. Early type galaxies have similar star formation and chemical evolution histories as globular clusters despite the differences in mass and dark matter content.

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Drivers of kinematic asymmetry in the stars and gas of z~0.3 galaxies

Mr Ryan Bagge

University of New South Wales. The ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions

Abstract

Stellar and gas kinematics are sensitive to the underlying mass distribution within galaxies, hence they are useful to understand a galaxy's assembly and evolution. Similarly, gas kinematics can be sensitive to elements of galaxy evolution that stellar kinematics are not (e.g., gas flows, feedback, etc.). The dynamics of galaxies along the line-of-sight can be modelled as a point-symmetric function, but deviations from symmetry can be caused by mergers, interactions, and secular galaxy evolution processes. I will discuss how we use a sample of galaxies from the Middle Ages Galaxies Properties in Integral Field Spectroscopy (MAGPI), and a novel approach based on KINEMETRY, to investigate what drives the kinematic asymmetry in *both* the stars and gas. We find a similar distribution of stellar kinematic asymmetries in galaxies where we detect ionised gas, and those we do not; suggesting that whatever drives the asymmetry does not always lead to gas removal, or that the gas was already removed before the stellar asymmetries increased. We also find that when older systems (log (Age/yr)>9) have gas, they will display larger asymmetry in their gas, compared to their stars; whereas younger galaxies will display larger asymmetries in their stars. I will then offer some conclusions regarding our results, and how they highlight the wealth of information about galaxy evolution that is available when comparing the kinematics of stars and gas holistically.

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The GECKOS survey: Globular Clusters as kinematic tracers of Spiral Galaxies halos

Zahra Aliakbarzadeh

University of New South Wales

Abstract

Globular clusters (GCs) have proven to be invaluable kinematic tracers of the outer dynamics of galaxies and their mass distributions. Given their ancient origin and extensive distribution into galactic halos, GCs act as probes of the gravitational fields that govern their orbits about their host galaxy, extending even into dark matter-dominated areas. They are thus useful in probing the complex interactions between stellar and dark matter components, providing a deeper view of galaxy formation and evolutionary processes. In this presentation, I will discuss my plan for compiling the largest homogeneous spectroscopic survey of GC systems around spiral galaxies using data from the GECKOS Survey. GECKOS is a deep $(S/N> 40 \, at\, \mu = 23.5 \, mag/arcsec^2)$ and a high spatial resolution $(<200 pc)$ MUSE large programme targetting 35 edge-on Milk Way analogues in the nearby Universe. I will cover the photometric and spectroscopic analyses used to identify the point sources and to confirm bona fide GCs. Moreover, I will show preliminary results from the kinematics of confirmed blue and red GCs as tracers of the dynamics of the halo and disc stars at large galactocentric distances. A comparison of the GECKOS galaxies' GC systems' properties with those of the Milky Way will be briefly shown.

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A new study of the galaxy mass-spin relation using ALFALFA data

Prof. Ed Elson

University of the Western Cape

Abstract

The galaxy mass spin relation is a sensitive probe of the processes by which galaxies acquire mass in a Lambda-CDM universe. In recent years several measurements of the mass-spin relation have shown it to be well-described by an unbroken power law over several decades of stellar mass. While there is a consensus that the power-law index is close to 2/3, additional measurements of the relation based on larger samples and accurate measurements of galaxy properties are needed to better refine the relation. In this presentation, I will present the results of a study that has yielded what is arguably the best measurement of the mass-spin relation to date. Strong evidence is found for a galaxy's central concentration of stellar mass (as quantified by its I-band effective surface brightness) serving as an important secondary driver of its angular momentum content.

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Dynamical masses of brightest cluster galaxies

Ilani Loubser

Centre for Space Research, North-West University

Abstract

We analyse spatially resolved deep optical spectroscopy of brightest cluster galaxies (BCGs) located in 32 massive clusters with redshifts of $0.05 \leq z \leq 0.30$ to investigate their velocity dispersion profiles. We find a surprisingly large variety in velocity dispersion slopes for BCGs, with a significantly larger fraction of positive slopes, unique compared to other (non-central) early-type galaxies. It is not clear whether the full diversity in velocity dispersion slopes that we see is reproduced in simulations.

We then use the profiles to investigate the stellar and dynamical mass profiles in the centres BCGs based on a multi-Gaussian expansion and axisymmetric Jeans Anisotropic Methods. We explicitly include a dark matter halo mass component, which is constrained by weak gravitational lensing measurements for these clusters. We find a strong correlation between anisotropy and velocity dispersion profile slope, with rising velocity dispersion profiles corresponding to tangential anisotropy and decreasing velocity dispersion profiles corresponding to radial anisotropy.

We finally use the stellar and dynamical mass profiles, combined with a stellar population analysis to place constraints on their stellar initial mass function (IMF). We find that for the majority of these BCGs, a Salpeter (or even more bottom-heavy) IMF is needed to reconcile the stellar population and dynamical modelling results although for a small number of BCGs, a Kroupa (or even lighter) IMF is preferred. We conclude that there is substantial scatter in the IMF amongst the highest mass galaxies.

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Calibrating Mass Modeling Methods with Numerical Simulations of Galaxies

Ms. Zahra Basti[1,2], Dr. Nikhil Arora[1], Prof. Stéphane Courteau[1], Prof. Aaron Vincent[1,2]

[1]Queen's University. [2]Arthur B. McDonald Canadian Astroparticle Research Institute

Abstract

Understanding the nature of dark matter (DM) through its distribution in galaxies cannot be done without a comprehensive description of the baryonic matter. Yet, accurately mapping baryons in galaxies is significantly hampered by model degeneracies. In this study, we utilize the NIHAO zoom-in cosmological hydrodynamical simulations to assess the inaccuracies inherent in traditional galaxy mass models. We extract surface density profiles, rotation curves, and mass profiles from the simulations providing us with the ground truth. We model these gas and stellar distributions to derive a DM mass in a similar way to standard observational procedures. We use this process to explore the magnitude of the mismatches between the true and inferred DM distribution and their potential causes. While we find excellent agreement between the observationally inferred and the simulated DM mass profiles at larger galactic radii, the mass discrepancies near the centers of galaxies can be as large as 50%! These differences between modeled and actual mass distributions are crucial for accurately determining DM distribution across galaxies of all masses and sizes.

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Probing dark matter with bar dynamics

Dr Francesca Fragkoudi

Durham University

Abstract

The intimate link between the dynamical properties of bars and the dark matter halos of galaxies, combined with the advent of high resolution cosmological hydrodynamical simulations, provide us with a novel avenue for probing dark matter halos. I will present recent results on the properties of barred spiral galaxies in cosmological simulations, with an emphasis on the bar-halo connection and the effects of dynamical friction, which can shed light on the amount of luminous and dark matter in massive spiral galaxies. I will discuss these results in light of recent claims in the literature of a severe tension between observed fast bars and the LCDM paradigm. I will also present new results on why some galaxies host bars and others don't, and show how this links to the baryon-dominance of galaxies and observed empirical relations. I will wrap up by discussing how the aforementioned results can help shed light on the existence of dark matter and to differentiate between LCDM and modified gravity scenarios.

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Mapping HI and Dark Matter Distribution in Low and Intermediate Mass Galaxies through LADUMA

Dr Toky Randriamampandry, Prof Edward Elson

University of the Western Cape

Abstract

LADUMA, or Looking At the Distance Universe using MeerKAT Array, is one of MeerKAT large HI surveys aiming to resolve galaxies in HI up to redshift 1. This survey has already identified around 200 galaxies, primarily comprising low and intermediate mass systems, crucial for understanding galaxy formation and evolution.

Utilizing the widely-used 3D tilted ring model software, 3D BAROLO, we derived precise rotation curves, velocity dispersion curves, and HI distribution maps for these galaxies. By integrating the derived rotation velocities with optical images from the Dark Energy Legacy Survey, we explored the dark matter and baryonic contents of these galaxies.

This presentation will highlight our findings, including inferred dark matter profiles modeled with the Einasto profile, and provide insights into the kinematics and HI distribution of these low and intermediate mass systems, essential for advancing our understanding of galaxy formation and evolution.

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Dark matter halos and scaling relations of extremely massive spiral galaxies

Enrico Di Teodoro[1], Michael Fall[2], Patrick Ogle[3]

[1]University of Florence. [2]Johns Hopkins University. [3]Space Telescope Science Institute

Abstract

I will present recent results about the dynamics and the scaling relations of the most massive spiral galaxies in the local Universe, having stellar masses exceeding 10^11 MSun and optical discs up to 80 kpc in radius. Using a combination of new slit Halpha data and new high-resolution HI interferometric data, we derive accurate rotation curves for 50 of these massive systems and estimate both their masses (baryonic and non) and specific angular momenta. I will show how massive spiral galaxies lie at the upper ends of the Tully-Fisher relation (mass vs velocity) and the Fall relation (specific angular momentum vs mass), in both stellar and baryonic forms, with no significant deviations from single power laws. The connections between baryons and dark matter will be illustrated through the stellar-to-halo mass relation (SHMR). I will show that the SHMR for massive spirals rises monotonically with stellar mass up to the high-mass end, in contrast with the usual LCDM ansatzs that predicts the presence of a break at high masses. I will also highlight how that these massive systems have surprisingly little or no missing baryons and that, despite a possible complex evolution, they have preserved all their initial angular momenta. Our results depicts a scenario wherein discs grow by relatively smooth and gradual inflow, isolated from disruptive events such as major mergers and strong AGN feedback, in contrast to the more chaotic growth of spheroids.

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Probing dark matter (or its absence) with galaxy mergers

Florent Renaud

Strasbourg Observatory

Abstract

Since the discovery of the missing mass problem, the concept of dark matter has been built, constrained, and challenged using its direct dynamical effect, mainly at galactic scale. However, despite considerable efforts, we are still missing an holistic framework to solve this problem consistently at all astrophysical scales. This suggests to look for the indirect effects of the missing mass. In this talk, I will use a series of high resolution hydrodynamic simulations of interacting galaxies within the Lambda-CDM and the MOND frameworks to illustrate how tidal fields from different treatments of the missing mass impact the visible matter. I will focus on observables like the starburst activity and the formation of tidal dwarf galaxies triggered by the galactic interactions to show how these two paradigms leave distinct imprints on the baryonic contents, and how future observational programs could target interacting systems to help constrain the nature of the missing mass.

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Dark matter searches in dwarf irregular galaxies with gamma-ray observatories.

Dr. Viviana Gammaldi

Department of Information Technology, Escuela Politécnica Superior, Universidad San Pablo-CEU, CEU Universities, Campus Monteprincipe, Boadilla del Monte, Madrid 28668, Spain. Department of Theoretical Physics, Universidad Autonoma Madrid, C. Francisco Tomás y Valiente, 7, 28049 Madrid, Spain.. Instituto de Física Teórica, UAM-CSIC, calle Nicolás Cabrera 13-15, 28049, Campus de Cantoblanco, Madrid, Spain.

Abstract

I will review the state-of-the-art of dark matter (DM) searches in dwarf irregular galaxies (dIrrs). Dirrs have been proposed as new astrophysical targets of interest for DM searches in gamma rays, complementary to benchmark dwarf spheroidal galaxies, galaxy clusters and the Galactic center. DIrrs show high DM content (with respect to the luminous matter), relatively close distance and low gamma-ray background: all these characteristics make dIrrs interesting targets for DM searches. After the first proof-of-concept paper, dIrr galaxies have been studied by both satellites and ground-based observatories, such as Fermi-LAT, HAWC and HESS. I will review the main results obtained so far, as well as preliminary observational prospects for the next generation of Cherenkov Telescope Array.

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Dark matter searches among Fermi-Lat unidentified sources with Neural Networks

Dr. Viviana Gammaldi

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Abstract

Around one third of the point-like sources in the Fermi-LAT catalogs remain as unidentified sources (unIDs) today. Indeed, these unIDs lack a clear, univocal association with a known astrophysical source. If dark matter (DM) is composed of weakly interacting massive particles (WIMPs), there is the exciting possibility that some of these unIDs may actually be DM sources, emitting gamma rays from WIMPs annihilation. We propose a new approach to solve the standard, Machine Learning (ML) binary classification problem of disentangling prospective DM sources (simulated data) from astrophysical sources (observed data) among the unIDs of the 4FGL Fermi-LAT catalogue. Applying the Neural Network (NN) to the unIDs sample, we find that the degeneracy between some astrophysical and DM sources can be partially solved within this methodology. Furthermore, by including systematic uncertainty of observational parameters as features of the ML algorithms, the classification accuracy of well-classified sources is improved, e.g. from 86.2% up to 93.3% for NN. Nonetheless, we conclude that there are no DM source candidates among the pool of 4FGL Fermi-LAT unIDs.

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Alternatives to CDM, MOND or Axion-like particles

Prof Francoise Combes

Paris Observatory. Collège de France

Abstract

The standard model of cold dark matter faces problems at galaxy scales, especially the cusp/core challenge in their center. One of the best modified gravity model (MOND) faces problems in galaxy clusters. Solutions have been proposed, in terms of fluctuations of the gravity potential due to baryons irregularities for CDM, and dark baryons iin clusters for MOND.
An other scenario is based on axion-like particules, with a large de Broglie length, as large as the core. This latter model produces quantum fluctuations in the potential that lead to strong constraints to the axion mass. Simulations will be described to quantify these constraints.

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Revealing the Characteristics of Luminous Compact Blue Galaxies in the MIGHTEE COSMOS Field

Prof Solohery RANDRIAMAMPANDRY

University of Antananarivo Madagascar

Abstract

Luminous Compact Blue Galaxies (LCBGs) stand out as a unique type of star-forming that are small in size and exhibit a distinctive blue color. These galaxies undergo intense star formation, providing valuable insights into the underlying physical mechanisms governing star formation, galaxy evolution, and the nature of stellar populations.

In this study, we utilize the MIGHTEE Early Science radio catalog coupled with comprehensive multi-wavelength data to analyze a large sample of LCBGs in the COSMOS field, spanning redshifts up to z=1.2. Our study focuses on understanding the IR-radio relationship, investigating the evolutionary track of LCBGs on the star formation main sequence (SFMS), and exploring their connection with diverse cosmic environments.

In this presentation, we will highlight our recent findings, particularly focusing on how variations in star formation rates (SFR) among LCBGs correlate with their mass (M*) across different cosmic environments.

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Constraints of the Dark Matter Concentration in the Solar Neighborhood Based on GAIA DR3 catalogue

Dr. Roman Tkachenko[1], Dr. Vladimir Korchagin[1], Prof. Giovanni Carraro[2], Prof. Katherine Vieira[3], Mr. Artem Lutsenko[2]

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Abstract

Detecting and studying the properties of the dark matter is a stumbling block for the progress in physics and cosmology. One of the key points in the ongoing and planning experiments aiming to detect the dark matter particles is the knowledge of the concentration of the dark matter in the solar neighborhood. Based on Gaia EDR3 and RAVE DR5, Vieira et al. (2022, 2023) have recently demonstrated that the thick disk of the Galaxy makes a significant contribution to the total mass of the disk component of the Milky Way (MW). In light of this discovery, there is a need to re-evaluate the concentration of the dark matter in the solar neighborhood based on the known MW rotation curve. Thanks to the Gaia DR3, it is possible to accurately estimate the total density of baryonic matter near the Sun and, hence, more accurately derive the contribution of the DM halo to the disk rotation. To compute the density of the stars in the solar neighbourhood we use The Gaia Catalogue of Nearby Stars, avoiding Gaia photometry limitations and taking into account close binary systems. The re-evaluation of the local dark matter density in the solar neighbourhood is done by the decomposition of the rotation curve in the solar neighbourhood on the local stellar densities of the thin and the thick disks, the gravity of the bar/bulge, the contribution of the gaseous disks, and contribution of the dark matter halo.

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Comparative analysis of dark matter distribution in HI-rich galaxies

Ms Famenontsoa Lovanarivo Rakotondrainy

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Abstract

This study examines 27 galaxies from the Bluedisk survey, comprising high HI gas content galaxies and control galaxies matched for stellar mass, stellar mass surface density, redshift, and inclination angle. Using HI gas as a tracer of dark matter, our focus is to understand the dark matter properties in HI-rich galaxies and compare them with normal spiral and dwarf galaxies. By analyzing stellar surface brightness profiles and rotation curves, we constructed mass models to study the dark matter distribution. We used the Navarro, Frenk, and White (NFW) and pseudo-isothermal (ISO) models, to evaluate the dark matter content and velocity fractions in the galaxies. Our findings reveal varying model fits, with some galaxies favoring the ISO model, indicating a central density core, and others align with the NFW model, exhibiting a cuspy density distribution, while some galaxies fit both models. This comparative analysis sheds light on the relationship between dark matter dynamics and HI gas content, enhancing our understanding of galaxy evolution.

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Galaxy formation in alternative dark matter scenarios

Dr Giulia Despali

University of Bologna

Abstract

Despite years of experimental searches, understanding dark matter, a cornerstone of modern cosmology, remains elusive. Cold dark matter successfully reproduces observed structures in the Universe on large scales, but tensions persist at the scales of galaxies and below. A solution can come from alternative dark matter models that influence the dark matter distribution at the center of galaxies and satellites. For a variety of models, telescope observations often provide the only constraints on the nature of dark matter and thus new upcoming observations will be instrumental in studying dark matter, through the comparison with numerical predictions. I will discuss the most recent predictions and constraints on dark matter models alternative to CDM, such as warm, fuzzy, and self-interacting dark matter. I will focus on the regimes where CDM is still challenged and describe computational and observational results that may point in the direction of new physics.

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Mass, Charge and Spin of dark matter particles

Prof. Charles McGruder

Western Kentucky University

Abstract

We study the distribution of quasars on the celestial sphere according to ground-based SDSS and

space-based WISE and Gaia observations. All distributions as a function of galactic latitude, b, exhibit

a decrease in quasar frequency well outside the dust in and near the galactic plane. We prove that

the observed decrease in quasar frequency at high galactic latitudes is not accompanied by reddening,

meaning that it cannot be caused by dust. The scattering of light by the circumgalactic gas is negligible

because the Thomson scattering cross section is very small. We conclude the observed scattering of

light must be caused by dark matter in the galactic halo. We determine the mass and charge of dark

matter particles. If the dark matter particle is a fermion its mass, m_{DM} and charge $e_{DM} = \delta e$, where e is the elementary charge are: $m_{DM} = 3.2 \times 10^{-2}$ eV and $\delta = 3.856 \times 10^{-5}$. If however, the dark matter particle is spinless then: $m_{DM} = 0.511$ eV and $\delta = 2.132 \times 10^{-4}$. These values for the charge of a dark matter particle are orders of magnitude higher than the upper limit of the neutrino charge according to laboratory experiments. Consequently, dark matter particles are not charged neutrinos. Since dark matter particles are charged, they must emit and absorb electromagnetic radiation. However, $P_{DM} \sim \delta^2$, or: $P_{DM} \sim 1.487 \times 10^{-9} P_e$, where P_e is the power output of a single electron.

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An observational prediction for the fraction of molecular hydrogen in the halos of cold dwarf spherical galaxies

Dr Allan Ernest

Charles Sturt University

Abstract

Gravitational quantum mechanics (GQM) has been experimentally demonstrated for neutrons in the Earth's gravitational field [1,2]. When applied to the environments of large gravitational wells of galaxies, GQM predicts that ordinary particles should have much reduced in-situ optical scattering cross sections (depending on the wavefunction's eigenspectral composition) compared to those obtained from traditional laboratory scattering experiments or field-free calculations. GQM thus predicts that baryonic material (ionized, atomic, or molecular hydrogen) should comprise a much greater halo mass fraction than would have been previously deduced from observations using accepted (and erroneous) cross sections. This potentially removes a need for "exotic" dark matter particles beyond the Standard Model.

GQM yields equivalent halo "quasi-temperatures" related to the de Broglie wavelengths of the eigenfunctions that make up the particle-halo wavefunction. These agree well with that of observed halos on all scales [3]. GQM predicts the existence of recently discovered dark matter-free galaxies [4] whose halos lie in a narrow range of temperatures and are composed chiefly of HI. This HI-dominated mass-fraction is unambiguously measurable (from *internal* 21 cm transitions). Hence there is no mass deficit and no requirement for dark matter in these galaxies. GQM predicts some dwarf spheroidal galaxies have even colder halos and would be chiefly composed of *molecular* hydrogen. In this work we present suggestions for observationally testing this prediction from GQM.

[1] V. V. Nesvizhevsky et al., 2002. https://doi.org/10.1038/415297a

[2] T. Jenke et al., 2011. https://doi.org/10.1038/nphys1970

[3] A. D. Ernest, 2023. https://doi.org/10.3390/universe9090388

[4] P. van Dokkum et al., 2018. https://doi.org/10.1038/nature25767

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The universality of the HI-to-Halo mass ratio for isolated disk galaxies

Dr Marie KORSAGA

Université Joseph KI-ZERBO (UJKZ). Instituto de Astrofisica de Andalucia (IAA-CSIC). Observatoire Astronomique de Strasbourg (ObAS)

Abstract

One of the most active areas of research of the last decade is undoubtedly the study of the effects of baryons on the observed dynamics of galaxies. This particularly led to the establishment of some fundamental scaling relations, which characterise the dependence of the abundance of baryons on the properties of galaxies' dark matter (DM) haloes. Among these fundamental relations, the stellar-to-halo mass relation appears to be one of the most investigated.
In this talk, I will present the less commonly explored neutral hydrogen-to-halo mass relation constructed using high-quality rotation curves of isolated rotationally-supported disk galaxies, selected from the SPARC and LITTLE THINGS databases. I will discuss how we constrain the DM halo of these galaxies using a Navarro-Frenk-White cuspy density profile and a semi-analytic Dekel-Zhao density profile, how we investigate the scaling relations between the cold gas and DM halo parameters, and the effect of AGN on these relations.

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The many ways that dwarf galaxy rotation curves can fail as mass tracers

Dr Kyle Oman[1], Ms Eleanor Downing[2]

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Abstract

It is routinely assumed that galaxy rotation curves are equal to their circular velocity curves (modulo some corrections) such that they are good dynamical mass tracers. We take a somewhat unconventional, visualisation-driven approach to analysing 33 low-mass galaxies from the APOSTLE simulation suite exploring the limits of the validity of this assumption. Only 3 galaxies have rotation curves nearly equal to their circular velocity curves; the rest are undergoing a wide variety of dynamical perturbations. We used our visualisations to give an assessment of how many galaxies are likely to be strongly perturbed by processes in several categories: mergers/interactions, bulk gas flows, non-spherical DM halo, warps, and IGM ram pressure. Most galaxies fall into more than one of these categories; only 5/33 are not in any of them. The sum of these effects leads to an underestimation of the low-velocity slope of the baryonic Tully-Fisher relation that is difficult to avoid, and could plausibly be the source of a significant portion of the observed diversity in low-mass galaxy rotation curve shapes.

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Galaxy clusters in MOND: the case of ultra diffuse galaxies in the Coma cluster

Mr Srikanth Togere Nagesh

Observatoire Astronomique de Strasbourg

Abstract

Ultra diffuse galaxies (UDG), low-surface brightness objects with large effective radii, inside galaxy clusters have very low internal gravity which renders them ideal candidates for testing the Modified Newtonian Dynamics (MOND) paradigm as a possible alternative to dark matter. Freundlich et. al. (2022) studied the velocity dispersions of several UDGs in the Coma cluster and compared them with the predictions of MOND. While the agreement would have been excellent if these galaxies were isolated, there seems to be an apparent disagreement because of the so-called 'external field effect' (EFE) related to the gravitational influence of the cluster. The authors have proposed several scenarios that could possibly explain this discrepancy. Building on this work, I will be presenting results of numerical simulations of UDGs orbiting around the Coma cluster, in MOND. We look at some of their dynamical properties and compare them with observations and subsequently try to explain whether the UDGs are within the realm of reconciliation or beyond.

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DarkMatters: the complete multi-wavelength WIMP emission simulator

Dr Michael Sarkis[1,2], Dr Geoff Beck[2]

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Abstract

As new generations of astronomical observatories begin their searches of the dark sky, the quantity and the quality of data to search through will reach new heights. To keep pace with the vast amount of high-resolution data, we have created a modern software package that is able to quickly calculate accurate emission profiles from a wide range of WIMP phenomenological models. This package, named DarkMatters, contains a completely customisable suite of calculations that allow for simulations of multi-wavelength WIMP emissions from a wide range of astrophysical targets. This package will provide the user with a set of results that are accurate enough for high-resolution images and are in a format that is ready for comparison to real data. We have successfully used this package to search through MeerKAT L-band continuum data of a sample of radio-quiet galaxy clusters for WIMP emissions, showing that it is able to help set stringent astrophysical constraints on the WIMP parameter space. The package is currently being open-sourced to the community, and will hopefully serve as a useful tool in the ongoing search for the dark matter in the universe.

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Quantifying the inner halo response to active galactic nuclei feedback in galaxies

Dr. Nikhil Arora[1], Prof. Stéphane Courteau[1], Prof. Andrea Maccio[2,3], Mr. Changhyun Cho[2,3], Mr. Raj Patel[1], Dr. Connor Stone[4]

[1]Queen's University. [2]New York University Abu Dhabi. [3]Center for Astrophysics and Space Science, New York University Abu Dhabi. [4]Université de Montréal

Abstract

AGN feedback is recognized for its significant role in driving gas outflows and reshaping numerous galaxy properties such as star formation rates, gas and stellar content, etc. The energy output of AGN feedback induces abrupt changes in the galactic baryonic content, consequently altering the central gravitational potential. In this talk, I will highlight how AGN feedback influences the dark matter (DM) properties of galaxies through the expulsion of gas. By comparing cosmological simulations with and without AGN feedback from the NIHAO project, we quantify the amount of DM displaced via the central supermassive black hole and the physical scale over which AGN feedback affects the DM halo. It is found that simulated galaxies more massive than the Milky Way present a growing central DM suppression of 40% from z=1.5 to present day. The growth of the DM suppression is related to the mass evolution of the SMBH and the gas mass in the central regions. The spatial scale, or 'sphere of influence', over which AGN feedback affects the DM distribution decreases as a function of time for MW-mass galaxies as a result of halo contraction due to stellar growth. This investigation highlights a novel aspect in the intertwined evolution of central supermassive black holes and galaxies throughout the Universe.

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Hot Gas in Normal Galaxies

Dr. Dong-Woo Kim

Center for Astrophysics | Harvard & Smithsonian

Abstract

Using ~8500 galaxies in the Chandra Galaxy Catalog (Kim et al. 2023), we investigate the hot gas properties in normal galaxies, separately for early-type and late-type galaxies and nearby and distant galaxies. We build the hot-gas XLF of normal galaxies and explore, for the first time, the possible luminosity evolution of hot gas in galaxies in the last ~5 Gyr. We address the hot gas properties in conjunction with the stellar mass and the total mass.

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Caustics: a differentiable, GPU accelerated, gravitational lensing simulator

Dr. Connor Stone

Université de Montréal. Ciela Institute

Abstract

We present Caustics, a tool to accelerate the analysis of gravitational lensing systems for the next generation of astronomical data. Caustics will enable precision measurements of dark matter properties, the expansion rate of the Universe, lensed black holes, the first stars, and more. In this talk I will the benefits and challenges of how we used PyTorch (a differentiable and GPU accelerated scientific python package) to allow for fast development without sacrificing numerical performance. I will detail our development process as well as how we encourage users of all skill levels to engage with our documentation/tools. Caustics is already shaping new exciting discoveries in the search for dark matter, which I will detail in this talk.

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Multi-TeV dark matter density in the inner Milky Way halo: spectral and dynamical constraints

Mr Jaume Zuriaga-Puig[1,2], Dr Viviana Gammaldi[1,2,3], Dr Daniele Gaggero[4], Dr Thomas Lacroix[5], Dr Miguel Angel Sánchez-Conde[1,2]

[1]Instituto de Física Teórica, IFT UAM-CSIC. [2]Departamento de Física Teórica, Mod. 15, Universidad Autónoma de Madrid. [3]Universidad San Pablo - CEU. [4]INFN Sezione di Pisa. [5]N/A

Abstract

We develop a comprehensive study of the gamma-ray flux observed by H.E.S.S in 5 regions of the Galactic Center (GC). Motivated by previous works on a possible Dark Matter (DM) explanation for the TeV cut-off observed by H.E.S.S. in the innermost 15 pc of the GC, we aim to constrain the DM distribution up to a radius of 450 pc. Within our proof-of-concept analysis, we use DRAGON to model the Galactic diffuse emission and determine upper limits on the density distribution of thermal multi-TeV Weakly Interactive Massive Particles (WIMPs). The results agree with an enhancement of the DM density in the GC relative to the benchmark Navarro-Frenk-White (NFW) profile ($\gamma = 1$) and allow us to exclude profiles with inner slopes cuspier than $\gamma > 1.3$. We investigate the possibility that such an enhancement could be created by a DM spike associated with the supermassive black hole Sgr A*. We find out that the existence of an adiabatic DM spike, smoothed by the interactions with the bulge stars, may be consistent with the observed gamma-ray flux if the spike forms on an underlying generalized NFW profile with $\gamma \leq 0.8$, corresponding to a spike slope $\gamma_{spike} = 1.5$ and spike radius of 25-30 pc. We also investigate other kinds of DM spikes with similar results. Finally, we analyze the DM mass enclosed within the S2 star orbit, with less stringent results than the spectral analysis. Our work aims to guide future studies of the GC region, with both current and next-generation telescopes.

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Testing models for dark matter with high resolution imaging of gravitational lenses.

Mr Zane Lentz

University of Pretoria

Abstract

Using gravitational lensing we are able to probe dark matter by investigating its effects on emission from distant galaxies. In particular we investigated a set of anomalous lensing systems in which current smooth dark matter models cannot simply explain their observed fluxes. The LoFT data set is a set of 6 cusp lens systems in which we notice a clear flux ratio anomaly which may be due to a large population of low mass cold dark matter haloes being present within this system. Each of these lens systems have been observed with the VLA at frequencies between 12-18 GHz over a span of 3 months allowing for robust spectral analysis. This data will therefore allowed us to rule out any frequency and time dependent aspects that may be attributed to the observed flux ratio anomaly. Of the 6 systems within the LoFT data set 5 have been observed to have flat spectra in log space with no clear indications of frequency dependent absorption or scattering affects and although many systems seem to show signs of extrinsic variability on small time scales these have not shown to be significant enough to be attributed to the observed flux anomaly. With VLBI high resolution images we may be able to further test these claims by observing possible distortions to these systems. We can then put constraints on a new model to test if these systems' inconsistent flux ratios are correlated with low mass cold dark matter haloes.

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Galaxy-galaxy lensing: Probing Dark Matter Surrounding Galaxies

Vanshika Kansal, Dr Edward Taylor

Swinburne university of technology

Abstract

Weak lensing is a crucial tool in modern cosmology, pivotal to missions like Euclid, Roman, and LSST. However, conventional weak lensing (CWL) measurements are approaching a fundamental 'shape noise limit', arising from the random shapes/orientations of unrelated galaxies (e.g., Refregier et al. 2012; Niemi et al. 2015). To address these challenges, we pioneer precision weak lensing (PWL) methods to surpass the shape noise limit. Building upon the concepts initially proposed by Blain (2002) and Morales (2006), Gurri et al. 2020 & 2021 have demonstrated a comprehensive experimental design using Integral Field Spectroscopy observations of the lensed galaxy for PWL. This approach is particularly adept at assessing dark halo concentrations through investigations of galaxy-galaxy weak lensing at small (10-100 kpc) scales, exclusively feasible at low redshift. In these scenarios, CWL encounters challenges in attaining adequate SNR, even with missions like Euclid or Roman, as exemplified by Xu et al. (2023). My work extends Precision Weak Lensing (PWL) techniques and analysis in two complementary directions: 1.) Utilizing DEIMOS long-slit spectroscopy of background galaxies to map the shear field, enabling the determination of the mass distribution for the lens. 2.) Employing new observations of the lens galaxies to derive detailed dynamical models that provide predictions for the shear field. These predictions are then compared to independently obtained PWL measurements. My talk will unveil early findings from these approaches, illuminating progress in understanding cosmic structures through innovative PWL approaches.

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Obtaining Einstein-A coefficients and eigenstates for particles in Navarro-Frenk-White density-profiled gravitational potential wells

Mr Isaac Lobo, Dr Allan Ernest, Dr Matthew Collins

Charles Sturt University

Abstract

Gravitational quantum theory applied to the weak gravity regions of deep gravitational wells predicts that photon-particle interaction cross sections can vary significantly, depending on the eigenspectral composition of the particle's wavefunction. These often-reduced cross sections can potentially enable the nature and origin of dark matter to be understood without recourse to new particles or new physics, and without necessarily compromising the observations from nucleosynthesis and the cosmic microwave background. The present work calculates the Einstein-*A* coefficients relevant to these photon interactions to states in potentials derived from both the *1/r* central point-mass (CPM) and Navarro-Frenk-White (NFW) radial density profiles. The Wentzel-Kramers-Brillouin and Modified Airy Function approximation strategies were used to find the eigenfunctions appropriate to these potentials, and hence obtain the relevant Einstein-*A* coefficients. For states in the CPM potential, whose Einstein-*A* coefficients can be found analytically, the approximation schemes were found to be highly accurate. The results show that states with both high principal and angular quantum numbers in the CPM and NFW potentials would exert gravitational influence, but also have significantly low transition rate. Particles in these states would therefore behave like dark matter particles within these profiles and have lifetimes comparable to the age of the Universe. Given that such particles would occupy regions within the galactic halo and have masses comparable to the hydrogen atom, it is therefore predicted that dark matter rich galaxies may also be hydrogen rich galaxies. For galaxies with a particular halo temperature, notably some ultra-diffuse galaxies, this hypothesis can be tested.

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Dark Matter from quantized gravity – Schrodinger takes Newton to the dark side.

Dr Allan Ernest, Dr Matthew Collins, Mr Isaac Lobo

Charles Sturt University

Abstract

The applicability of quantum mechanics to gravity has been experimentally verified [1] and, when applied to large gravitational wells of galaxy halos, calculations show conclusively that ordinary particles can have much reduced optical interaction cross sections (e.g., Compton cross sections) compared to those obtained in laboratory-based scattering experiments [2,3]. Ionized, atomic, and/or molecular hydrogen particles in various eigenspectral compositions effectively replace the halo's dark matter-gas content, eliminating the need for "exotic" dark matter particles beyond the Standard Model.

A halo's inferred dark matter fraction depends on the "true" fractions of HI, HII and H_2 present and the halo particles' wavefunctional form, which depends on the effective "quantum temperature" relating to the eigenstates' average de Broglie wavelengths. For a predominantly HI halo the halo gas mass, obtained from the internal 21 cm line, is not subject to gravitational quantum darkness, the mass fraction is then unambiguously determined, and no dark matter is required to make up a halo mass shortfall [4]. Conversely, hot ionized halos can have reduced Bremsstrahlung or heavy ion transfer cross sections, causing their gas mass fraction to be underestimated, and requiring a need for dark matter when it may not be necessary. This presentation will elaborate further on gravitational quantum theory in weak gravity and its implications for dark matter.

[1] V. V. Nesvizhevsky et al., 2002. https://doi.org/10.1038/415297a

[2] A. D. Ernest, J. Phys. A: Math. Theor. 42, 115207, 115208 (2009)

[3] A. D. Ernest, https://doi.org/10.3390/universe9090388

[4] P. E. M. Pina et al., arXiv:2112.00017v2 (2021)

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The Kinematic Scaling Relations of the WALLABY Pilot Galaxies

Dr Nathan Deg[1], Prof Kristine Spekkens[2,1]

[1]Queen's University. [2]Royal Military College

Abstract

Scaling Relations tell the story of galaxies writ large. As statistical probes, they provide information on the DM content of galaxies, how they grow and evolve over time and environment, and what physical processes drive their evolution. In neutral hydrogen, the scaling relations of resolved and kinematically models typically suffer from relatively small sample sizes. This is changing with the WALLABY survey, which will detect hundreds of thousands of galaxies, and kinematically model tens of thousands of them. As a first taste of what will be possible, we will present the scaling relations derived from the 236 models of the WALLABY pilot data releases, including both the stellar and baryonic Tully Fisher relations. This is the largest sample of uniformly observed and analyzed models from an untargetted survey. This sample size allows for improved estimates of the slope and scatter of a variety of scaling relations relative to other surveys. As WALLABY continues, we will be able to compare these relations in different environments. Moving into the SKA era, it will also be possible to probe these scaling relations across cosmic time, providing some of the greatest constraints on galaxy formation to date.

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The fall of the dwarfs and the mass of the Local Group

Danila Makarov, Prof. Dmitry Makarov, Dr. Lidia Makarova

Special Astrophysical Observatory of the Russian Academy of Sciences

Abstract

Dwarf galaxies are ideal test particles for studying the Milky Way, the Andromeda Galaxy, and the Local Group as a whole. Analysis of the kinematics of satellites inside virial zones is the main way to estimate the mass of galactic systems on scales from 50 to 300 kpc. Objects outside the virial zones of the Milky Way and Andromeda provide an alternative and independent approach to estimate the total Local Group mass from the nearest Hubble flow at distances from 400 kpc to 1.5 Mpc. We show that this approach produces reliable estimates of the total mass of $M_{LG} = (2.42\pm0.12)\times10^{12}$ Msun despite the complex dumbbell shape of the Local Group. There is no mass increase with distance between 400 and 1400 kpc. The Hubble flow model is in remarkable agreement with the sum of the virial masses of the two main galaxies, $M_{MW+M31} = (2.49\pm0.43)\times10^{12}$ Msun, estimated from the kinematics of their satellites. We conclude that essentially the entire mass of the Local Group is clustered within 300-400 kpc around our Galaxy ant the Andromeda Galaxy.

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Populations of Subhalos Beyond the Virial Radius: Splashback vs. Field Subhalos in FIRE

Nondh Panithanpaisal

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Abstract

A Milky Way-mass galaxy is expected to be surrounded by numerous smaller halos, so-called subhalos, both inside and outside of its virial radius. Their orbits depend on a complex interplay between the global host potential and interactions with other substructures. Using the suite of FIRE cosmological simulations of galaxy formation, we show that the subhalos lying beyond the virial radius consist of two populations: 1) splashback subhalos that have once fallen into the host, and 2) field subhalos that are on their first infall. On average, field subhalos can be differentiated by their relatively high masses, net negative radial velocities, and larger distances from the host. On the other hand, splashback subhalos dominate the subhalo populations within 500 kpc, with slight host-to-host variation. More importantly, they have been significantly disrupted and have lost a significant amount of mass compared to their peak masses. Finally, we show that interactions with massive mergers are one of the mechanisms that could create splashback subhalos. To accurately model subhalo properties and their internal dynamics, it is crucial to distinguish between splashback and field subhalos. Our findings have implications for modeling faint dwarf galaxies at or beyond the Milky Way's virial radius, many of which could be splashback subhalos due to the presence of the Large Magellanic Cloud and can potentially be detected by upcoming surveys such as LSST.

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The depletion radius of dark matter halo--from theory to observations

Prof. Jiaxin Han

Shanghai Jiao Tong University

Abstract

A dark matter halo has traditionally been viewed as a virialized structure bounded by its virial radius. However, the growth of a halo means it is inevitably surrounded by a non-virialized envelope of freshly accreted material. The splashback radius is one recent development in characterizing this growth envelope, motivated by the microscopic process of mass accretion. In this talk I will present a new alternative boundary for the envelope called the depletion radius, stemming from the macroscopic effect of halo growth which causes the environment to deplete. This radius is defined as the separation between the growing halo and the depleting environment, and is located at the radius of the maximum mass infall rate according to continuity. I will show that the depletion radius is both an important physical boundary for halo evolution and a natural geometric boundary for halo models of the largescale structure. It can naturally explain the formation of the nonlinear bias around a halo and the fast and slow accretion dichotomy in halo evolution. When used in a halo model, it automatically solves the difficulty in modelling the halo exclusion effect, resulting in very simple and intuitive model components and a high accuracy across scales. Lastly, I will present our observational measurement of the depletion radius both for our Milky Way halo and for DESI galaxy groups.

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The Formation of Late-type Galaxies: Nature versus Nurture

Dr. Ji Hoon Kim

Astronomy Research Center, Seoul National University

Abstract

The central density relation (CDR) is one of the fundamental relations that dictate the physical properties of late-type galaxies; The dynamical mass surface density of a disk galaxy scales with its central surface brightness. While it may sound trivial, the dynamical surface density of late-type galaxies dominated by dark matter should not be related to luminous matter. In the standard galaxy formation picture based on LCDM, the distribution of late-type galaxy size at a given mass abides by the two following hypotheses or mixtures of them; SH (Same Halo) in which galaxy sizes depend on the spin of the parent dark matter halos, and DD (Density begets Density) in which the surface brightnesses depend on the density of the dark matter halos. However, these hypotheses cannot reproduce late-type galaxies that follow CDR and the baryonic Tully-Fisher relation at the same time. Using SPARC (Spitzer Photometry and Accurate Rotational Curves) and Cosmicflows4 data, we are studying the correlations between the angular momentum, the spin parameter, and the central surface brightness of late-type galaxies, while small and large environments of galaxies affect these correlations. While we found that low surface brightness galaxies (LSBGs) have slightly higher specific angular momentum than high surface brightness galaxies (HSBGs), the difference is quite marginal. We also found that LSBGs have higher spin parameters than HSBGs, but have a large scatter. Moreover, we found a severe inconsistency across various proxies for the spin parameters. The effect of the environment is still unclear.

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Dark Matter Across Galactic Scales: Current Challenges and Perspectives

Dr. Gauri Sharma

Observatory of Strasbourg, France

Abstract

Observations from new generation spectrographs, on Very Large Telescopes, has allowed us to study the resolved velocity profiles, or rotation curves, of galaxies at high redshifts (z=0.6-3.0). This enables us to answer some of the most intriguing open questions in modern astrophysics. These include: Is the nature of dark matter cold as presumed in the most successful ΛCDM cosmological simulations? What is the fraction of dark matter in high-redshift galaxies compared to locals? Do dark matter halos evolve along with galaxies over cosmic time? Do baryonic processes impact the distribution of dark matter and, if so, can they be constrained? In my talk, I intend to elaborate on each of these questions. Specifically, I will present a combination of previous studies and a new study of mine that utilizes data from KROSS, KGES and KMOS3D data, comprise ~300 disk-like galaxies, a largest sample up to date, spanning a redshift range of $0.5 < z < 2.5$. I will present accurate rotation curves, dark matter estimates, and scaling relations. Finally, I will engage in a discussion on how we can examine the assembly history of galaxies and disk-halo co-evolution using gas kinematics at high-redshift. This work provides significant insights into the early Universe and galaxy formation, highlighting the need for future advancements in our kinematic and dynamical modelling techniques.

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The CRISTAL survey: Resolving kinematics of typical main-sequence star-forming galaxies at 4 < z < 6

Lilian Lai Yee Lee

Max Planck Institute for extraterrestrial Physics

Abstract

Kinematics studies at z ~ 1- 3 have established the prevalence (~70%) of regular rotating disks of star-forming galaxies. However, there is yet to be a consensus on when disks settled, as high-resolution resolved studies are only available for a very small and heterogeneous set of galaxies at z > 4. The ALMA large program, CRISTAL, targeted the [CII] line in a sample of 19+ massive star-forming galaxies at 4 < z < 6, providing an unprecedented clear view of the dynamical state of z > 4 star-forming galaxies. In this talk, I will present a resolved kinematic study of CRISTAL galaxies, using various criteria to classify galaxies as rotational-dominated disks, candidate mergers, and dispersion-dominated systems. Detailed rotation curves, kinematic modelling, and constraints on the mass budgets of the disks will also be discussed. These findings have important implications for understanding the build-up of galactic structure and the evolution of disk turbulence and angular momentum at early cosmic times.

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Dynamical lineage of HI-rich field ultra-diffuse galaxies

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Indian Institute of Science Education and Research (IISER), Tirupati

Abstract

Ultra-diffuse galaxies (UDGs) are remarkable for their low surface brightness yet relatively large stellar extent given their dynamical mass in the dwarf regime. They exhibit morphological similarities with other low luminosity galaxies indicating a possible evolutionary connection. We investigate for a common dynamical origin of HI-bearing field UDGs with other low luminosity field galaxies, namely the low surface brightness galaxies (LSBs) and the dwarf irregulars (dIrrs). Obtaining the scaling relations between (i) central stellar surface density and exponential stellar disk scale length, (ii) stellar and atomic hydrogen mass, and (iii) stellar and dynamical mass for LSBs and dIrr populations separately, and superposing the data for UDGs on them, we note that UDGs evolve fairly akin to dIrrs. We next construct distribution function-based stellar-dynamical models of these galaxies. Comparison of the ratios of the modelled radial-to-vertical velocity dispersion ratio, and the rotational velocity-to-total stellar velocity dispersion also indicates that the stellar kinematics of UDGs and dIrrs are fairly similar. Finally, we conducted principal component analysis to identify the key parameters accounting for the variance in the structure and kinematical data for the respective galaxy populations. We observe that the total HI-mass mostly regulates the variance for the UDGs and dIrrs, while the ratio of radial-to-vertical velocity dispersion dominates the same in LSBs. We therefore conclude that field UDGs and dIrrs possibly share a common dynamical lineage.

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Towards statistical constraints on mass distributions of galaxies/groups from strong lens samples

Anupreeta More[1,2], Alessandro Sonnenfeld[3], Anton Jaelani[4], Priyanka Gawade[1], Surhud More[1,2], SuGOHI Team[5]

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Abstract

Strong gravitational lensing produces multiple images of a background source such as galaxies and quasars, typically, around the central few kpcs to 10s of kpcs of the lensing galaxy or a galaxy group. This is the regime where the interplay between baryonic processes and dark matter becomes prominent. From the Survey of Gravitationally-lensed Objects in Hyper Suprime Cam Imaging (SuGOHI), we have developed machine learning algorithms and used Space Warps, a citizen science project, to discover hundreds of strong gravitational lenses. I will present results on the constraints of mass distribution for a subsample of confirmed lens systems for galaxies out to redshifts of 0.8, thanks to the deep imaging of HSC Survey. I will also showcase results from a new neural network for automating the prediction of lens mass model parameters in order to prepare ourselves for the 10,000 lenses that are expected to be discovered from the next-generation ground-based surveys such as the Rubin LSST, successor to HSC.

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The dark matter distribution, gas, star formation, and turbulence properties in NGC 6822 as seen by MeerKAT

Dr Roger IANJAMASIMANANA

INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA (IAA-CSIC)

Abstract

The neutral atomic hydrogen (HI) is the main cool gas reservoir from which star-forming molecular clouds form. In addition, it is an excellent tracer of the luminous and dark matter distribution in galaxies. To investigate the relationship between the gas dynamics, turbulence, magnetic fields, and the local star formation, we recently obtained deep, high-resolution, high-sensitivity, full polarisation, 2 by 2 degree mosaic of the HI distribution in NGC 6822 with MeerKAT. This has allowed us to derive high-precision rotation curves through 3D kinematical modelling and model the luminous and dark matter distribution in this galaxy. Moreover, we have mapped the different HI phases of this galaxies by means of Gaussian decompositions of its velocity profiles. This enabled us to address questions related to cold HI formation and the onset of star formation. This kind of study was previously hindered by the lack of velocity resolution and signal-to-noise ratio to resolve the cold component of HI, so-called Cold Neutral Medium (CNM) as predicted by HI thermodynamics. With the narrow mode of MeerKAT and its superb sensitivity, we were able to map the CNM in this galaxy, an important step to get a more complete view of the processes leading to star formation in galaxies.

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An Exposition on Globular Clusters: Theory and Observation

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Abstract

In this paper, we discuss the collaboration and focus between the Geneva Lake Astrophysics and STEAM (GLAS) group and the West Africa Office of Astronomy for Development (WAROAD). In particular, this collaboration aims to provide upcoming scientists with data analysis tools and resources in astrophysics to observe, reduce, and analyze globular cluster data from the Stone Edge Observatory (SEO). Within our framework, each student is equipped to stack images using Jupyter notebooks, plot histograms, and statistics (mean, std), observe and download images using SEO, as well as leverage different filters for mosaicing, flux calibration, and data reduction (bias, darks, flats). We show some of our initial results. In particular, we present the mosaics of our chosen globular cluster (M3), our data reduction process, and statistics of our data, as well as our work on what we have done on asteroid photometry. We also include preliminary colour-magnitude diagram (CMD) of our globular cluster.

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Galaxy stellar and total mass estimation using machine learning

Jiani Chu[1], Hongming Tang[1], Dandan Xu[1], Shengdong Lu[2], Richard Long[3]

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Abstract

I will talk about a successful proof of concept test on galaxy stellar and total mass estimation using machine learning. Conventional galaxy mass estimation methods suffer from model assumptions and degeneracies. Machine learning, which avoids many of assumption, can be a potential method to predict galaxy properties. In our work, we use a general sample of galaxies from the TNG100 simulation to investigate the ability of multi-branch convolutional neural network (CNN) to predict the central (i.e., within 1-2 effective radii) stellar and total masses, and the stellar mass-to-light ratio M*/L. These models take galaxy images and spatially-resolved mean velocity and velocity dispersion maps as inputs. Such CNN-based models can in general break the degeneracy between baryonic and dark matter in the sense that the model can make reliable predictions on the individual contributions of each component. For example, with r-band images and two galaxy kinematic maps as inputs, our model predicting stellar mass M* has a prediction uncertainty of 0.04 dex. Moreover, to investigate which (global) features significantly contribute to the correct predictions of the properties above, we utilize a gradient boosting machine. We find that galaxy luminosity dominates the prediction of all masses in the central regions, with stellar velocity dispersion coming next. We also investigate the main contributing features when predicting stellar and dark matter mass fractions (f*, fDM) and the mass-to-light ratio M*/L, and discuss the underlying astrophysics.

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Massive disc galaxies with high surface brightness plus low surface brightness stellar disks, hosted by massive dark matter halo - a TNG50 simulation study

Dr. Suchira Sarkar, Prof. Kanak Saha

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Abstract

We study massive disk galaxies (stellar mass >=10^11 solar mass) from IllustrisTNG-50 simulation, and perform 2-D structural decomposition of the galaxies using their SKIRT synthetic SDSS images for z=0. We find a dynamically interesting sample of galaxies having a central high surface brightness (HSB) stellar disk, surrounded by an extended (scale length as high as 30 kpc) low surface brightness (LSB) stellar disk, similar to giant LSB galaxies. These massive, double-exponential disk galaxies are found to be hosted by dark matter haloes as massive as ~10^12 solar mass, and have extended gas reservoir, in agreement to observations of such galaxies. Their maximum rotation velocity, a measure of their total dynamical mass, lies in the range of ~(300-400) km/s. The stellar-to-halo mass ratio and the baryon-to-halo mass ratio of the sample lies in the range of ~(0.04 - 0.3) and ~ (0.07 - 0.3) respectively. This shows that cosmological simulations are able to form giant disc galaxies with HSB+LSB disks, in agreement with observations.

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Rotation curves of disk galaxies and General Relativity

Prof. Luca Ciotti

Dept. Physics and Astronomy - University of Bologna

Abstract

It has been suggested that the observed flat rotation curves observed at large radii in disk galaxies can be a manifestation of unexpectedly large General Relativity (GR) effects instead of the presence of Dark Matter halos, with obvious astrophysical consequences. After reviewing the basic theory behind the construction of rotation curves of disk galaxies in Newtonian gravity, I will present the results of a careful mathematical study of the problem, and will show that the derived (quantitative and rigorous) values of the effects of GR on the galactic rotation curves are (as expected on general grounds) so small that Dark Matter halos in disk galaxies are required in General Relativity as in Newtonian gravity.

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The choice of orbital anisotropy in dynamical studies of axisymmetric galaxies

Silvia Pellegrini, Leonardo De Deo, Luca Ciotti

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Abstract

Over recent years, the stellar kinematic properties of galaxies of the local Universe have been recovered for samples of ever-growing size, and with increasing detail, thanks to progress in the instrumentation and the completion of large spectroscopic surveys (as for example ATLAS3D, SAMI, MaNGA). At the same time, analysis tools and modeling techniques have also improved significantly. One standard tool to derive the internal dynamical structure of galaxies (including their total mass and dark mass distribution) from spectroscopic observations is provided by the Jeans equations; these however suffer from a closure problem: the unknown velocity moments are in general more numerous than the equations. To overcome this problem, a relation between the velocity moments is often adopted, through a phenomenological “ansatz". In the modeling of axisymmetric systems, a widely used ansatz is that of a relationship between the vertical and radial velocity dispersion components (as in the JAM modeling; Cappellari 2008). We present an investigation of the a priori requirements on this ansatz for the physical consistency of the solutions of the Jeans equations, and an analysis of the ansatz effects on the kinematical fields that one can use to be guided before computing them. The results are useful for the dynamical modeling, to avoid repeated and time-consuming tests in a part of the parameter space that is forbidden, or corresponds to unwanted kinematical properties.

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Dynamic relations of disc galaxies at the Universe's half-age

Dr Pavel E. Mancera Piña

Leiden Observatory

Abstract

According to our theories, the total mass and the angular momentum of galaxies govern most stages of their formation and evolution, imprinting clear signatures into their dynamical structure, morphology and ISM conditions. Therefore, understanding the relation between the observed properties of galaxies and those expected from their dark matter haloes is crucial to building an integral view of galaxies through cosmic time. At low redshift, accurate measurements of the halo mass and angular momentum of disc galaxies have been obtained, allowing us to characterise the dynamics of nearby systems. However, primarily due to the limitations of existing data, what happens at higher redshift remains largely unknown, preventing us from building a coherent picture of the evolution of galaxy dynamics.

In this talk, I will present recent results of a campaign to characterise the dynamical properties of disc galaxies at z~1-2, a critical epoch between the Universe's half-age and cosmic noon. For this, I have exploited
ultra-deep NIRSpec@JWST and KMOS@VLT data of a sample of galaxies, for which robust kinematic models have been derived. I will focus on the relations between stellar and dynamical masses and between stellar mass and stellar specific angular momentum, and discuss the evolution of the dark matter fractions and the angular momentum with respect to present-day galaxies. Finally, I will contrast these results against the expectations of the Cold Dark Matter model.

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Hundred strong lens models. Strong lensing efficiency and dark matter mass distribution.

Dr Guillaume Mahler

University of Liege

Abstract

Clusters of galaxies are the largest, more massive, gravitationally bound structures observ- able in the Universe emerging after photon decoupling, containing tens of galaxy groups and hundreds of galaxies. According to the hierarchical structure formation typical of a universe dominated by CDM, structures grow by accretion and merging with small halos (galaxies) assembling first, followed by medium halos (galaxy groups) and then large halos (galaxy clusters) forming around the denser nodes of the cosmic web. Strong gravitational lensing provides unique opportunities to investigate the mass distribution at the cores of galaxy clusters. Using 94 strong lensing models of 74 cluster fields from the Hubble Frontier Fields (HFF), Reionization Lensing Cluster Survey (RELICS), and Sloan Giant Arcs Survey (SGAS), modeled with three parametric approaches, we evaluate the lensing strength of each cluster. We assess how large scale mass, projected inner core mass, and the inner slope of the projected mass density profile relate to lensing strength. While we do not identify a strong correlation between lensing strength and large scale mass as naive assume usually, we reveal that the inner slope (50 kpc ≤ r ≤ 200 kpc) of the projected mass density profile is indicative of lensing strength and can set an upper bound on the possible lensing strength of a cluster. These should be tightly connected to the cluster's growth itself and I will show how it connects to subhalos mass fraction and cluster mass assembly.

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An ultra-deep and ultra-sharp view on gas-rich ultra-diffuse galaxies: a population defying CDM

Dr Pavel E. Mancera Piña

Leiden Observatory

Abstract

Ultra-diffuse galaxies (UDGs) are extreme systems with the mass of dwarf galaxies but effective radii as extended as massive spirals. Some UDGs host large gas (HI) reservoirs, which has enabled the study of their gas dynamics over the last few years.

One of these gas-rich UDGs appears to represent a challenge to the cold dark matter (CDM) model since the kinematics can only be explained by either a lack of dark matter or the presence of a halo with extremely low concentration, unexpected in CDM. These claims, however, are based on only one galaxy. Moreover, the system's inclination (which normalizes the rotation curve) remains uncertain because existing optical data are not deep enough to obtain robust estimates of the geometrical parameters.

I will present the results of a novel project conducting ultra-deep and ultra-sharp observations of a sample of 6 gas-rich UDGs. The observational campaign involves obtaining unprecedentedly deep optical imaging and high-resolution HI data exploiting the optical 10-m Gran Telescopio Canarias and the new MeerKAT radio-interferometer. The new data allow us to constrain the geometry of the stellar and gas discs accurately and derive robust kinematic models.

I will show that mass models obtained from rotation curve decomposition imply that the dark haloes of these UDGs have different structural parameters from those seen in CDM simulations. I will also present mass models in the context of self-interacting and fuzzy dark matter. I will highlight the aspects in which these theories better fit the dynamics of UDGs compared to CDM.

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Imposters among us: globular cluster kinematics and the halo mass of ultra-diffuse galaxies in clusters

Dr. Jessica Doppel[1,2], Dr. Laura Sales[3], Dr. Jose Benavides[3], Dr. Elisa Toloba[4], Dr. Eric Peng[5], Dr. Dylan Nelson[6], Dr. Julio Navarro[7]

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Abstract

The inferred dark matter content of ultra-diffuse galaxies (UDGs) has been found to vary widely. In particular, recent measurements of globular cluster (GC) kinematics of UDGs in the Virgo cluster suggests UDG dark matter contents that appear to exceed that of the Milky Way. We utilize the catalog of GCs added in post-processing to the TNG50 simulation to study the GC systems of the simulation's set of UDGs that reside in galaxy groups and clusters. We find that the simulation's UDGs reside exclusively in dwarf mass halos (M_200 < 10^11.2 M_sun). Considering only GCs that are gravitationally bound to the simulated UDGs, we find GC properties—namely abundance and kinematics—that agree well with many observed GC systems of UDGs and dwarf galaxies. In particular, we do not observe any bias towards over-massive or under-massive halos for these galaxies, confirming that GCs are a good tracer of their DM content. However, in performing mock observations of the simulated GC systems, we find that intra-cluster GC contamination can occasionally substantially increase the measured GC velocity dispersion to suggest the presence of extremely over-massive dark matter halos around our sample of UDGs. We caution that small sample sizes of kinematical tracers are particularly prone to severe uncertainties. Measurements of the stellar velocity dispersion of such UDGs should help to confirm their halo masses.

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Investigating the Applicability of Massive Photon Theory to Galactic Rotation Curves and its Implications for Dark Matter

mr munashe manyevere, Professor Gadziari Nyambuya

National University of Science and Technology Zimbabwe

Abstract

The enigma of dark matter continues to challenge the scientific community. Initial hints of its presence emerged from gravitational anomalies observed in the Coma Cluster by Zwicky et al. (1933), and later, compelling evidence came from the analysis of the Andromeda galaxy's rotation curve by Rubin et al. (1970). This work investigates the applicability of the Massive Photon Theory (Nyambuya et al., 2014-2023) to the rotational curves of spiral galaxies. We hypothesize that the proposed "dark field" generating the photon's mass within this theory could potentially explain the observed rotational anomaly and, consequently, represent the long-sought dark matter. Our theoretical framework suggests a specific range for the photon's mass, aligning with the predictions of the Massive Photon Theory. Based on these findings, we propose the intriguing possibility that dark matter may consist of massive photons. Further research and experimental verification are crucial to validate this hypothesis and deepen our understanding of the universe's composition

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Probing Inner Dark Matter Density Profiles with MUSE Kinematics and Strong Lensing

Catherine Cerny, Dr Mathilde Jauzac, Dr David Lagattuta

Durham University

Abstract

The shape of the density profiles for dark matter in the inner region of galaxies is currently a source of tension between observational models and cold dark matter (CDM) numerical simulations. While CDM simulations predict mass profiles that follow a steep power law, where the density increases in a 'cusp' in the inner region of the cluster, observations suggest that the profile instead flattens out, forming a constant density 'core' in the center. From an observational perspective, resolving the core-cusp problem will require robust models of the mass distribution for many different galaxies in order to examine the structure that leads to core-like density profiles. In this talk, I will discuss how I use dynamical modeling of brightest cluster galaxy (BCG) kinematics in tandem with strong lensing mass models to untangle the baryonic and dark matter distributions inside of several massive, non-rotating elliptical galaxies embedded in the center of galaxy clusters, or BCGs. I will show how the dark matter profile for many BCGs in clusters with strong lensing tends toward a more core-like inner structure, and comment on how the interaction between BCG and cluster mass models can be used to examine the cusp-core problem at multiple different scales.

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Observational constraints on dark matter in galaxies over the last 10 billion years

Sedona Price

University of Pittsburgh

Abstract

Dynamical tracers provide key measurements of galaxies' total masses, complementing other methods of determining stellar and gas masses and also providing some of the only possible constraints on their dark matter content. Until recently, the deep spectrally-resolved observations necessary for these measurements were only accessible out to relatively low redshifts. Thanks to new observatories and instruments, particularly near infrared multi-object spectrographs and sub-mm interferometers, galaxy dynamical masses can now be measured out to the peak epoch of cosmic star formation and even earlier epochs. In this talk, I will give an overview of dynamical mass constraints of galaxy-scale dark matter fractions from the present day out to z~3. I will also discuss comparisons between measurements from different dynamical tracers, and the modeling challenges and degeneracies that complicate our interpretations of observations.

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Globular cluster systems as tracers of galaxy assembly and dark matter halos in nearby galaxy clusters

Michael Hilker

ESO

Abstract

The globular cluster (GC) systems of present-day galaxies were assembled through the hierarchical merger history of their host galaxies. Characterizing the GC's photometric and spectroscopic properties offers the opportunity to disentangle the galaxy's assembly history and to derive its enclosed mass via dynamical modelling. GC subpopulations have been identified in the nearby Fornax and Hydra galaxy clusters via multi-colour photometry and spectroscopy and the phase-space analysis. In both clusters, blue, metal-poor GCs were identified in filamentary and patchy substructures occupying the intra-cluster space. Their low velocity dispersion within Fornax cluster substructures point to low mass progenitor galaxies contributing to the mass assembly of the cluster. In Hydra, the GC line-of-sight velocity dispersion in the halo of the central galaxy NGC3311 rises up to the cluster velocity dispersion. In the context of Jeans models, a massive dark halo with a large core is needed to explain this finding. However, spectroscopic observations of the diffuse stellar halo showed that the velocity dispersion does not simply rise but fills an increasingly large range of values with two well defined envelopes. The lower envelope is about constant at 200km/s. The upper envelope rises smoothly, joining the velocity dispersion of the outer GCs and cluster galaxies. We interpret this behaviour as the superposition of tracer populations with increasingly shallower radial distributions. A combination of different mass profiles, tracing the inner galaxy component (red nugget), the inner halo, the displaced outer cD envelope and the overall galaxy population, can account for the observed complex kinematic behaviour.

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Neural network prediction of mass model parameters for galaxy-scale strong lenses from Hyper Suprime-Cam Survey

Ms Priyanka Gawade[1], Dr Anupreeta More[1,2], Dr Surhud More[1,2], Dr Akisato Kimura[3], Dr Alessandro Sonnenfeld[4,5], Dr Masamune Oguri[6,7,8], Dr Naoki Yoshida[9,10,11]

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Abstract

Gravitational lensing is an important tool to probe the matter distribution in the Universe. Analysing strongly lensed systems, like a galaxy lensed by another foreground galaxy or a cluster, where we can get multiple distorted images of the background galaxy, provides us crucial information about the distribution of the total matter in the foreground lens. Conventional lens modelling techniques used to analyse the strongly lensed systems are in general time and resource consuming, require sophisticated lensing codes and expertise in the physics involved. To inspect the tens of thousands of lenses expected from upcoming advanced imaging surveys like Rubin LSST, we need fast and automated techniques. In our work, we construct a simple convolutional neural network to rapidly predict the lens mass model parameters of lenses from the ground-based imaging surveys and demonstrate this on existing data from HSC. We focus on the lens mass model parameters such as Einstein radius, axis ratio and position angle of the major axis of the mass distribution. The network is first trained on simulated data where we have added lensed features on top of real data. The optimised network is then use to predict the lens parameters of galaxy-scale lenses from HSC. We find good agreement with the Einstein radii of these lenses, and a poorer performance on the axis ratio and position angles of the mass distribution, when compared to conventional modelling methods. We present comparison between our predictions of 10 high quality HSC lenses with conventional modelling methods from the literature.

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Signatures of dark matter through gravitational waves in modified gravity

Dr Murli Manohar Verma

University of Lucknow

Abstract

It is shown that scalarons as an extra scalar degree of freedom in f(R) gravity model can be a potentially viable candidate for dark matter. Scalarons also introduce new scalar modes of polarization in gravitational waves, in addition to the already present two tensor modes generated in general relativity. The detection of such additional modes will remain open to observational tests in future. Further, since the scalaron mass is directly influenced by the background environment of dark matter distribution through a chameleon effect, it is discussed how these modes of GW polarization can predict the dark matter masses, which can be confirmed in galactic mass measurements. These investigations will be significant to set our future goals.

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Closer look at the edge-on low surface brightness galaxies with big disks

Mr. Damir Gasymov[1], Dr. Anna Saburova[1], Dr. Igor Chilingarian[2], Mr. Evgenii Rubtsov[1], Mr. Sviatoslav Borisov[3], Mr. Ivan Gerasimov[1], Mr. Fedor Kolganov[4], Dr. Anastasia Kasparova[1], Dr. Michal B'ilek[5], Dr. Ana Lalovi[6]

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Abstract

To understand the origin of formation of extended disks of low surface brightness (LSB) we present detailed studies of four galaxies with big edge-on LSB disks. The edge-on position of these systems is beneficial because it boosts surface brightness giving an opportunity to assess stellar population properties of the LSB disk spectroscopically. We observed these systems with the Russian 6-meter telescope and at the Keck observatory. We also performed deep photometric observations of one of the galaxies with the 1.4-m Milankovi\'c telescope which we combined with archival HSC and DECaLS data available for other systems. By analyzing spectroscopic data, we estimated the properties of the stellar populations in the HSB+LSB regions of these galaxies as well as the radial profiles of gas metallicity and kinematics. From the photometrical observations we obtained the structural parameters of the disks. We estimated the dark halo mass contribution both dynamically and by assessing the ratio of radial to vertical disc scalelenghts. The dark halo to disk mass fractions lie in the range of 1 to 4 for these galaxies according to these two different approaches, both of which rely on the assumption of marginal gravitational stability of the disks. The gas metallicity gradient in these galaxies is about -0.07..-0.13 dex per exponential disc scalelength, which is consistent with other disky galaxies. We propose the possible formation scenarios for these galaxies giving greater credibility to the scenario in which LSB disks were formed by minor wet-mergers which agrees better with both photometrical and spectral data.

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1672

Milky Way like potentials in TNG-50 and their application to GCs system evolution

Mrs Margaryta Sobolenko[1], Dr. Peter Berczik[1], Dr. Evgeny Polyachenko[2], Dr. Maryna Ishchenko[1]

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Abstract

It has been demonstrated that using time-variable Galactic potentials (TVPs) for the long-term (>3–4 Gyrs) examination of the globular clusters (GCs) orbital development is essential. The high-resolution cosmological simulation TNG50 gives us the opportunity to substantially increase the quality of constructed potentials. We used the list of preselected 198 MW-like subhaloes from TNG50 as the basic set. For further construction of the TVPs (up to 10 Gyr) we recovered basic subhaloes merging tree and analysed the sizes and masses of each of the components (dark matter, gas, stars, supermassive black holes). The preparation of the subhaloes sample included the deletion of the subhaloes with complex merging history, cutting the subhaloes at a radius 10^3 kpc, smoothing subhaloes with sharp falls in mass and size evolution. Previously implemented methods of describing the stars distribution with Miyamoto-Nagai disk and halo with gas distribution with Navarro–Frenk–White potential showed unsatisfactory results. Mainly because the gas component has a mass comparable with the mass of the stellar component, but the size of the gas component is comparable with the size of the dark matter component. We decided to calculate the summarised potential and acceleration using multipole expansions. In such a way, we reconstructed the TVPs for around 100 subhaloes. The evolution of each of the components strongly affects the dynamic behaviour of the galactic structures. Smooth and maximally alike TVPs give us a unique opportunity to investigate the GCs subsystem evolution.

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1723

Joint modelling of strong gravitational lensing and stellar dynamics.

Carlos Melo-Carneiro, Cristina Furlanetto, Ana Chies-Santos

Universidade Federal do Rio Grande do Sul (UFRGS)

Abstract

Strong gravitational lensing (SGL) and stellar dynamics are powerful tools for studying galaxy properties, such as their stellar and dark matter (DM) contents, the mass density slope, and cosmological parameters. Both SGL and stellar dynamics probe the same physical mass: the mass that bends light in SGL also binds stars within the galaxy's gravitational pull. While limitations of each technique are well-understood, their combined potential and the development of self-consistent models remain relatively unexplored. By combining these tracers, we can overcome degeneracies inherent to individual methods and obtain more reliable measurements of galaxy mass profiles. However, the reliability of these combined measurements and strategies for further improvement requires investigation.

In this work, we address these issues using the high-resolution cosmological hydrodynamical simulations llustrisTNG50. Through TNG50 we generate mock observational stellar kinematics and gravitational lensing data. We then explore how the self-consistent modelling of stellar dynamics and lensing can recover integrated measurements of total mass, stellar mass, and DM content of early-type galaxies.

We find that the combined model consistently outperforms the individual methods (dynamics or lensing alone), exhibiting smaller median fractional differences. Specifically, it recovers the intrinsic total mass within 2.5Reff with a 2% accuracy and the total mass density slope with a 5% accuracy. On the other hand, the parameters describing the DM halo are poorly constrained by all models. We also verify the impact of the number of kinematic constraints on the assessment of the interesting quantities and we find a minimal influence.

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1734

Linking galaxies with dark matter halos using weak gravitational lensing

Surhud More[1], Navin Chaurasiya[1], Shogo Ishikawa[2], Shogo Masaki[3,4], Daichi Kashino[4,5,6], Teppei Okumura[7]

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Abstract

We infer the connection between the stellar mass of galaxies and their dark matter halo masses and its evolution in two redshift bins between [0.3, 0.8] using photometry and weak lensing observations from the Subaru Hyper Suprime-Cam (HSC) survey. Within each redshift bin, we generate subsamples of galaxies in stellar mass threshold bins that range from log M* in [8.6, 11.2]. We select source galaxies that lie beyond the redshifts of the lens galaxies and measure the distortions imprinted on the shapes of these galaxies due to gravitational lensing. These weak lensing signals are measured with high signal-to-noise ratios in all bins.

We model these lensing signals and the abundance of galaxies using the halo occupation distribution formalism and constrain the average central halo masses of galaxies at a given stellar mass. We find that the galaxy-dark matter connection does not vary significantly between redshift bins we explore in this study. We compare our inference to those obtained using the abundance and clustering of these galaxies as well as the subhalo abundance matching measurements and demonstrate qualitative agreement. We also explore how uncertainties in the photometric redshifts of the lens galaxies can affect the determination of their stellar masses, and how they propagate in to systematic effects in the measured weak lensing signal, and thus the inferred stellar mass-halo mass relation. We present implications for determining the stellar mass halo mass relation using photometric data for future imaging surveys such as the Rubin Legacy survey of Space and Time.

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1862

Probing Star Formation in Interacting Galaxies through Cosmological Simulations

Mr. Lawrence Faria[1], Dr. David Patton[2]

[1]Queen's University. [2]Trent University

Abstract

Mergers and interactions play pivotal roles in the evolutionary trajectory of galaxies, significantly influencing various dynamical and baryonic properties throughout their histories. Understanding the impact of these major and minor interactions on galaxy evolution is crucial for constraining galaxy formation and evolution processes. Observational studies have shown that interacting galaxies exhibit elevated star formation rates compared to their more isolated counterparts. Idealised high-resolution merger simulations indicate that this enhancement may result from a combination of enhanced fuelling or enhanced efficiency of star formation. In this talk, I will explore how cosmological hydrodynamical simulations provide a unique opportunity for us to study these processes as a function of time within a cosmological context.

Using reconstructed orbits of galaxy pairs in the IllustrisTNG simulation, we assemble a dataset of distinct pericentric encounters over which we track changes in galaxy properties relative to the pericentre. We find that star formation rates, gas fraction, and star formation efficiency are significantly centrally enhanced approximately 0.1 Gyrs after a pericentric encounter. We identify the enhanced star formation efficiency of hydrogen gas as the primary driver for the increased star formation following a pericentric encounter. This investigation helps to better link observational pair studies of interacting galaxies with the findings of high-resolution merger simulations.

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1917

Probing Dark Matter with Strong and Weak Gravitational Lensing Mass Models: A Case Study of Abell 2744

Miss Nency Patel[1], Mathilde Jauzac[1], Anna Niemiec[2], Guillaume Mahler[3], David Lagattuta[1]

[1]Durham University. [2]LPNHE, CNRS/IN2P3. [3]University of Liège

Abstract

Gravitational lensing, arising from the warping of spacetime around massive objects, offers a unique opportunity to indirectly study the distribution of dark matter and hence study the properties of dark matter without making assumptions about the dynamical state of the lens. I will present a precise mass distribution of one of the clusters, Abell 2744. It is a non-relaxed system with one of the most complicated merger phenomena at a redshift z=0.308 as shown in Jauzac et al. (2016). It has been seen that behaviour of dark matter during extreme mergers of substructures can be extremely pronounced. Since, Abell 2744 is a very complex system with ongoing mergers, its dense and active environment is ideal to test the possible nature of dark matter. The mass model is made by combining space-based weak lensing (WL) with already existing strong lensing (SL) analyses (Lam et al. (2014); Richard et al. (2014); Jauzac et al. (2015); Medezinski et al. (2016); Mahler et al. (2018); Bergamini et al. (2023)). Many new multiple image systems were found using James Webb Space Telescope in overdense regions (Furtak et al. 2023), where none were found in the past with only limited depth HST imaging and/or ground-based imaging. Combining the latest SL model from JWST with WL measurements from HST, we obtain a high precision mass model which will allow us to obtain the subhalo mass function of the cluster, and compare it to previous analyses, and predictions from numerical simulations which include different types of dark matter.

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1950

Probing dark matter with vast new surveys of galaxy peculiar velocities

Prof. Matthew Colless

Australian National University

Abstract

The peculiar velocities of galaxies provide a direct probe of the amount and distribution of dark matter on large scales. Vast new surveys of redshifts and peculiar velocities are now under way that will increase the numbers of peculiar velocity measurements by nearly two orders of magnitude, from a few tens of thousands to nearly a million. This leap in sample size will make peculiar velocities a far more powerful and precise tool for studying the dark matter distribution, measuring the growth rate of structure, and testing the nature of gravity on the largest scales. I will review the various new peculiar velocity surveys, with a particular focus on the WALLABY HI survey that will measure Tully-Fisher distances for over 50,000 galaxies and the 4MOST Hemisphere Survey that will measure Fundamental Plane distances for up to 500,000 galaxies. I will describe improved methods for simultaneously fitting the parameters of both the distance estimator relation and the peculiar velocity field reconstructed from the accompanying redshift survey. I will conclude with forecasts for the precision with which cosmological parameters such as the growth rate of structure will be constrained by these surveys.

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1977

Bar-induced transformation of dark matter haloes

Mr Matthew Frosst, Dr Danail Obreschkow, Dr Aaron Ludlow

University of Western Australia / ICRAR

Abstract

We use idealised N-body simulations of equilibrium discs in live and static haloes to study how dark matter co-evolution impacts the assembly of stellar particles into a bar, and vice versa. Initial conditions correspond to a marginally unstable disc according to commonly used disc stability criteria, and are evolved for the equivalent of 10Gyr. An extensive convergence study ensures accurate modelling of the bar formation process. Live dark matter haloes lead to the formation of a strong bar simultaneously with a bar-like structure in the dark matter halo, but the disc remains unperturbed when evolved in a static halo. Neither seeded disc instabilities, nor longer (60Gyr) simulations result in the formation of a bar when the halo is static. When the live halo is replaced with a static analogue at different times the bar slowly dissipates, suggesting: (1) global disc-stability criteria must be modified for discs in co-evolving dark matter haloes; (2) the co-evolution of the disc and halo is critical for the assembly and long-term survival of bars; and (3) the evolution of the halo leads to a dark-bar structure that will further disrupt kinematic measurements of disc stars, particularly in the galactic centre. Any process that inhibits the transfer of angular momentum between the halo and disc will stabilise the system against bar formation, and can lead to the dissolution of the bar itself. This raises further questions about the puzzling stability of many marginally unstable, but unbarred, observed discs.

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1981

Assessing the effect of supernovae feedback at the center of dwarf halos of scalar field/fuzzy dark matter

Dr. Victor Robles[1], Luna Zagorac[2], Nikhil Padmanabhan[3]

[1]Rensselaer Polythecnic Institute. [2]Perimeter Institute for Theoretical Physics. [3]Yale University

Abstract

Reliable constraints to dark matter requires understanding how the supernovae feedback and the dark matter physics affect each other. While there are numerous work that study such interplay in the CDM framework, it remains unclear how astrophysics models affect the DM of a different nature. I'll present the first study on the gravitational impact of supernova feedback at the center of Scalar Field/Fuzzy dark matter halo structures. We conduct numerical simulations to explore a simple model to mimic the impact of SNe feedback for various strengths in a fuzzy DM dwarf halo, assuming a fundamental dark matter mass of 10^{-22}eV/c^2. I'll discuss how, in contrast with other DM alternatives, SNe feedback leads to central SFDM dark matter densities that continuously fluctuate in time, even after feedback has ceased. The time-dependent profile leads to an inevitable scatter in the determination of the density profiles. The scatter then translates to an uncertainty in the determination of the dark matter distribution at a particular time. We found that a consequence of this is that we can infer the true dark matter mass only within 20% accuracy. Comparing the Local Group dwarf galaxies with the implied range of viable Fuzzy DM halos from our simulations resulted in agreement with a boson mass of $1x10^{-22}$ eV/c^2.

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1988

Bar Formation Timescales In Galactic Disks

Mr Matthew Frosst, Dr Danail Obreschkow, Dr Aaron Ludlow

University of Western Australia / ICRAR

Abstract

High-redshift observations indicate that disks may assemble far earlier than anticipated; bars may also form rapidly in such systems. We use N-body simulations of idealised equilibrium disks in dark matter halos to study the secular assembly of bars in a diverse range of disk galaxies representative of a broad redshift range. We vary the disk-to-halo mass fraction, halo concentration, disk thickness, and velocity dispersions for highly resolved models over long (12Gyr) timescales, and measure their bar assembly histories. We find that previous criteria detailing the onset of bar forming instabilities poorly describe the susceptibility of a diverse range of disks to bar formation. The primary difficulties are that they do not account for interactions between the disk and halo, nor the stabilising effects of the disk velocity dispersion and thickness. We present a new method that accounts for the disk vertical and kinematic structure when determining the global stability to bar formation, yielding the tightest relationship with bar formation timescale to date. This suggests an intimate link between disk vertical structure and bar formation. Our results explain the unreliable success of previous disk instability thresholds, provide a natural explanation for the assembly of bars across a broad range of redshifts.

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1990

Inferences on the Nature of Dark Matter from Lensing Anomalies

Prof. jeremy lim, Mr. Alex Chow, Mr. Amruth Alfred

University of Hong Kong

Abstract

The first multiply-lensed SNIa discovered, iPTF16geu, introduces a stringent new constraint on lens models for galaxies: utilised as a standard candle, this SNIa provides measurements of the absolute rather than just relative magnifications of multiply-lensed images. At the same time, iPTF16geu affords additional constraints not available for its closest analog, multiply-lensed quasars, in the form of an Einstein ring (ER) – corresponding to the multiply-lensed images of the SNIa host galaxy – seen in full after the SNIa had faded away. Here, we show that a simple subtraction of the ER reveals the lensing galaxy to be a barred spiral, permitting an exacting model for its stellar component. Constrained solely by the SNIa image positions, lens models that incorporate this model stellar component are oftentimes able to near perfectly match the SNIa image positions, and dramatically improve upon the match in SNIa image magnifications, irrespective of the density profile adopted for the Dark Matter halo of the lensing galaxy. We address whether forcing positional agreement in lens models may affect inferences on the magnitude and perhaps even type of lensing (i.e., position and/or magnification) anomalies left by such models. By constructing lens models constrained in addition by either the SNIa image magnifications or ER, or both, we demonstrate how inferences of lensing anomalies depend on the constraints adopted for lens models – and, in turn, evaluations of what additional ingredients are needed by lens models to resolve these anomalies, with corresponding implications for inferences on the nature of DM.

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2006

The Dark Matter Density Inside Galaxies as a Probe of Halo Assembly

Prof. James Taylor

Waterloo Centre for Astrophysics. University of Waterloo

Abstract

If galaxy formation proceeds without altering the underlying mass distribution within a dark matter halo, than one can predict the density of dark matter within the visible part of galaxies to reasonable precision. The mean dark matter density should depend on halo concentration, which in turn is linked to the characteristic formation time of the system. Thus, the dark matter density within galaxies provides a possible measure of when they assembled most of their mass. We apply this test to galaxies from the SHIVir and PROBES surveys of local galaxy kinematics, and show that mass models for these galaxies show good agreement with the dark matter densities predicted from theory. Furthermore, there is 3-4 sigma evidence for a gradient in mean dark matter density with environment, as expected if this density truly does trace the mean formation time of each galactic halo.

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2007

AN INDIRECT SEARCH FOR DARK MATTER WITH A COMBINED ANALYSIS OF DWARF SPHEROIDAL GALAXIES FROM VERITAS

Dr. Donggeun Tak

Seoul National University

Abstract

In the current cosmological theory, the existence and contribution of Dark Matter (DM) is fundamental. The Weakly Interacting Massive Particle (WIMP; M∼1 TeV) is a DM candidate which can annihilate and/or decay into secondary particles, sequentially producing very-high energy gamma-rays (VHE; above 100 GeV). The signature of the WIMP signal has been searched with state-of-art observatories, but no signature has been detected. This lack of detection, together with recent theoretical developments, motivates searches for ultra-heavy DM (UHDM) above 100 TeV. The Very Energetic Radiation Imaging Telescope Array System (VERITAS; 100 GeV to 30 TeV) is a ground-based VHE telescope array which can look for or detect gamma-ray signatures. Since dwarf spheroidal galaxies (dSphs) are DM-rich regions, they are one of the best targets for studying indirect DM annihilation signatures. Compared to the previous DM search in dSphs(VERITAS collab., 2017), we significantly extend the observational dataset and improve our method of constraining the UHDM as well as WIMP annihilation cross sections. In this talk, I will summarize our recent results of an indirect search for DM with a combined analysis of over 630 hours of observations of 17 dSphs.

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2014

DYNAMICAL EVIDENCE THAT GALAXIES OF DIFFERENT MORPHOLOGIES OCCUPY DARK HALOS OF DIFFERENT MASSES

Michael Fall[1], Enrico Di Teodoro[2], Lorenzo Posti[3]

[1]Johns Hopkins University. [2]University of Florence. [3]Observatory of Strasbourg

Abstract

The dark halo masses of galaxies are usually assumed not to depend on galactic morphology. We have tested this assumption by direct dynamical determinations of the halo masses of 25 early-type and 15 late-type galaxies, most with stellar masses $M_s > 10^{11}\ M_{sun}$, and report the results here. For early types, we use radial velocities of extended globular cluster systems, while for late types, we use extended HI rotation curves. These kinematic tracers typically reach out to ~ 10 effective radii. The mass models we fit to the kinematic and photometric data for each galaxy include both the stellar component, with unspecified M/L, and the halo component, with unspecified mass and concentration, but with priors on these parameters appropriate for dark halos in CDM-type cosmologies. We find that early-type galaxies occupy halos an order of magnitude more massive than late-type galaxies at the highest masses. For early types, the stellar-to-halo mass ratio (SHMR) has the familiar inverted-U shape, rising to a peak near the Milky Way mass ($M_s \sim 5 \times 10^{10}\ M_{sun}$, $M_h \sim 10^{12}\ M_{sun}$), and then declining precipitously, while for late types, it rises monotonically, with no prominent features. This appears to contradict results from abundance matching but is actually consistent, given the relatively small number of very massive late-type galaxies. We summarize briefly the implications of our morphology-dependent SMHRs. Galactic spheroids form chaotically by cold inflows and/or mergers regulated mostly by AGN feedback, while galactic disks form more quiescently by smoother inflows regulated mostly by stellar feedback.

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2020

The Second Acceleration Scales in Brightest Cluster Galaxies

Dr. Yong Tian[1], Prof. Chung-Ming Ko[1,2], Prof. Pengfei Li[3], Prof. Stacy McGaugh[4], Shemile L. Poblete[1]

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Abstract

Emerging research has elucidated a Radial Acceleration Relation (RAR) in galaxies, forging a concrete empirical linkage between the observed and the baryonic accelerations, underscored by a characteristic acceleration scale. Distinctively, an augmented RAR on the scale of Brightest Cluster Galaxies (BCGs) has been identified, showcasing an acceleration scale seventeen times larger, attributed to gravitational lensing. This study conducts a comprehensive analysis of the interplay between acceleration and mass among dynamical and baryonic components in an ensemble of 50 BCGs. We assessed dynamical accelerations through stellar kinematic data, processed via the Jeans equation and Abel inversion, and gauged baryonic masses utilizing photometry from the Sloan Digital Sky Survey (SDSS). Capitalizing on the extensive integral field spectroscopy data provided by the Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey, we examined the spatially resolved kinematic profiles. Our research corroborates that the dynamical RAR inherent in BCGs is in concordance with the RAR deduced from gravitational lensing on cluster scales, marked by a notably higher acceleration scale. The outcomes imply inherent dissimilarities between BCGs, along with their host clusters, and isolated field galaxies.

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2037

The evolution of total mass density slopes, dark matter content, and orbital structure since z=0.3 from resolved integral field stellar kinematics from MAGPI

Professor Richard McDermid, Ms Caro Derkenne

Macquarie University, Sydney, Australia

Abstract

Studies of the internal mass structure of galaxies have observed a ‘conspiracy’ between the dark matter and stellar components, with the combined mass structure showing remarkable regularity and low intrinsic scatter across various samples of galaxies at different redshifts. Such homogeneity suggests the dark and stellar components must somehow compensate for each other in order to produce such regular mass structures. We test the conspiracy using a sample of 22 galaxies from the Middle Ages Galaxy Properties with Integral field spectroscopy (MAGPI) survey, which targets massive galaxies $z \sim 0.3$ through a MUSE/VLT Large Program. We present resolved, 2D stellar kinematics analysed with the Schwarzschild orbit-based modelling technique to recover intrinsic mass structures and dark matter fractions - the first such application of this technique at this ~4 billion year look-back time. We find that the variability of structure for combined mass (baryonic and dark) density profiles is greater than that of the stellar components alone, contrary to the 'conspiracy' expectation. Furthermore, we find no significant correlation between enclosed dark matter fractions at the half-light radius and the stellar mass density structure, indicating there is no simple relationship between the stellar mass slope and dark matter content. We compare these results to similar studies of local Universe galaxies, finding that there is little evolution in the detailed dynamical or mass distribution properties of massive galaxies over the past 4 billion years.

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2050

Exotic cluster lenses: a new tool in the search for dark matter

Dr. David Lagattuta

Durham Unversity

Abstract

Hyperbolic-umbilic (H-U) lenses are an “exotic” sub-class of gravitational lenses, characterized by extreme (>100x) magnifications, providing a detailed window into the resolved physical properties of distant source galaxies. Found in the innermost cores of galaxy clusters (<100 kpc from the center), H-U systems are also sensitive probes of mass, placing tight constraints on the central subhalo mass function of dark matter — a parameter tied strongly to the cosmological model. Though historically rare (with only a handful of samples known in literature), thanks to the sensitivity of modern instruments we have discovered several new examples -- increasing the number of known H-U systems by over a factor of ten. This represents the first statistically robust collection of these lenses ever compiled. In a recent paper, we demonstrated the power of studying H-U lenses with optical imaging and spectroscopy, revealing highly structured sources at z~3 that placed new constraints on large- and small-scale dark matter distributions. Furthermore, we also set the stage for extending the analysis using infrared data. In this talk we will discuss the current state of known H-U lenses and demonstrate improvements that advanced JWST imaging and spectroscopy will bring to the sample. With a newly-approved JWST Cycle 3 program targeting a sample of these H-U lenses, we anticipate measuring the subhalo mass function down to ~10^7 M_sun, providing a metric to clearly discriminate between Lambda-CDM and alternative dark matter models, giving us an unprecedented look at both high-redshift galaxies and the massive clusters magnifying them.

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2089

Testing models for dark matter with extremely high angular resolution imaging of gravitational lenses

Prof. John McKean

South African Radio Astronomy Observatory. University of Pretoria. University of Groningen

Abstract

Galaxy-scale gravitational lens systems can provide important constraints on various dark matter models (CDM, WDM, Fuzzy). Although this has been traditionally done using, for example, flux-ratio or surface brightness anomalies, the perturbations from dark matter sub-haloes can be directly imaged via extremely high angular resolution imaging (milli-arcsecond) at radio and mm-wavelengths. Here, we present the latest constraints and detections of low mass haloes provided from Very Long Baseline Interferometry (VLBI) observations of known radio and mm-bright lensed sources using the European VLBI Network (EVN) and the Atacama Large (sub)Millimetre Array (ALMA). From modelling the observed surface brightness distribution, we i) find evidence for complex additional mass structure on large-scales, ii) place constraints on wave-like (fuzzy) dark matter models and iii) have made the lowest mass detection of a likely dark matter sub-halo in a massive elliptical galaxy at high redshift. Based on these results, we present an overview of the constraints on dark matter models using strong gravitational lensing. Finally, we provide a brief overview of the expected dark matter constraints to be obtained with the Square Kilometre Array (SKA) and next generation Very Large Array (ngVLA) over the next decade.

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Beyond Bertschinger - Dark Matter Phase-Space for observed disk galaxies and Implications for DM detection

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Abstract

The radial pseudo-phase space density (PPSD) profiles of Nbody halos predict a single power law index amazingly close to the value predicted by Bertschinger's analytical model. This has remained a puzzle since the underlying dark matter (DM) density and dispersion profiles are clearly different for Bertschinger's model and Nbody simulations.

We show, for the first time, that in estimated PPSD-profiles of dark matter halos surrounding observed disk galaxies, the single power law nature of PPSD is broken. The observed PPSD profiles are shallower towards the centre and require a double power law description, introducing a new radial scale to dark matter halos. Further, we show the inner shallowness is tightly correlated with the concentration of the dominant visible component, the stellar disk. The inner logarithmic slope then becomes a shape parameter breaking the self-similarity and universality of DM halos phase-space. Our work brings a paradigm shift from the single power law Bertschinger's PPSD profile which held true for 40 years. Our work has implications for galaxy-halo (luminous-DM) connection as well as for DM detection estimates.

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The impact of spurious collisional heating on the spatial distribution and kinematics of stellar and dark matter particles in simulated galaxies

Dr. Aaron Ludlow

ICRAR-UWA

Abstract

Simulated galaxies and their dark matter (DM) halos are resolved by far fewer particles than there are stars and DM particles in real galaxies and, as a result, the particle trajectories may be deflected by incoherent fluctuations in the gravitational potential, an effect commonly referred to as “collisional heating”. I will present results from a suite of idealised simulations designed to study the effect of spurious collisional heating on the structure and kinematics of galactic discs, and show how simple amendments to analytic theory can be used to describe them. I will then discuss how gravitational scattering affects the kinematics and structure of galaxies in cosmological simulations. These simulations show that a number of global properties of galaxies are unaffected by spurious collisional heating (e.g. stellar, gas, black hole masses, star formation rates, etc) but, below a characteristic mass and radial scale, their structural and kinematic properties are affected (including their sizes, characteristic velocities, angular momenta, dark matter fractions, etc). A simple semi-empirical model can identify the characteristic mass and radius above which the structural and kinematic properties of simulated galaxies are robust to these insidious numerical effects. Spurious collisional heating must be accounted for if simulations are to a provide reliable account of the luminous and dark matter content of galaxies across cosmic time.

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From optical imaging to dark matter halo masses with simulation-based inference models

Dr. Connor Bottrell

ICRAR/UWA

Abstract

Galaxies and dark matter halos are linked by concurrent assembly. To first order, this link alone establishes a stellar-to-halo mass relation (SHMR) which is secondarily affected by the baryon cycle of inflows, conversion of gas into stars, and outflows. Nonetheless, the baryon cycle (coupled with halo formation time) supports a broad range of stellar masses and galaxy morphologies at fixed halo mass -- yielding an intrinsic scatter in the SHMR of approximately 0.2 dex, on average. In this talk, I will show that this scatter can be significantly reduced using luminosity, colour, and morphological information extracted from mock optical/NIR images to predict galaxy halo masses. Using a simulation-based inference model, HALOFLOW, trained on a large sample of mock Subaru HSC images of galaxies formed in cosmological simulations, we find that colour and morphological information alone is sufficient to predict 40% of the scatter in the SMHR. We examine whether a model trained on one simulated universe (and set of recipes for the baryon cycle) performs similarly on another simulated universe. Finally, we test our simulation-trained model to galaxies in the real Universe for which halo masses have been constrained using lensing and group dynamics.

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Unveiling cosmic insights: Exploring dark matter content of galaxies at cosmic noon through angular momentum analysis

Dr. Juan Manuel Espejo Salcedo

Max Planck Institute for Extraterrestrial Physics

Abstract

Unlocking the hidden mysteries of galaxies' non-visible matter content demands precise measurements of their kinematics. Among these, angular momentum stands out as a crucial quantity, encapsulating not just the dynamics but also the mass distribution within these systems. However, at cosmic noon, our understanding of specific stellar angular momentum (j) is often hindered by simplistic global approximations, leading to unreliable inferences regarding dark matter (DM) fractions. In this study, I present a comprehensive analysis of the angular momentum profiles of 41 star-forming galaxies during cosmic noon. Leveraging high angular resolution (adaptive optics assisted) Integral Field Spectroscopy (IFS) data from SINFONI/OSIRIS as well as HST photometry, I establish a uniform sample spanning the redshift range $1.5<z<2.5$. By scrutinizing the j versus stellar mass (M) relation and exploring the angular momentum retention factor, my research sheds new light on the DM content within these systems. This integrated approach not only enhances our understanding of galactic evolution but also offers crucial insights into the elusive nature of dark matter at a pivotal epoch in cosmic history.

Session

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2173

The HI mass of galaxies at cosmic noon

Professor Nissim Kanekar

National Centre for Radio Astrophysics, India

Abstract

The weakness of the hyperfine HI 21cm line, the main tracer of the HI content of galaxies, has meant that, until recently, we know nothing about the atomic gas mass of high-redshift galaxies and its evolution. Indeed, the evolution of the HI content of galaxies is one of the main open questions in galaxy evolution today. Stacking of the HI 21cm emission signals from a large sample of galaxies, observed simultaneously with a radio interferometer, can allow one to determine the average HI mass of the galaxy population. In this talk, I will describe results from HI 21cm surveys that we have been carrying out with the Giant Metrewave Radio Telescope (GMRT), that have yielded the first measurements of the average HI mass of star-forming galaxies at z>~1, during the era of cosmic noon. I will discuss the relations between the HI mass, the stellar mass, and the molecular gas mass in high-redshift galaxies, demonstrating that atomic gas dominates the baryonic gas mass of galaxies at z>1. I will also describe the evolution of the baryonic mass of galaxies over the last 9 Gyr, and will present the first estimate of the baryonic Tully-Fisher relation at z~1, allowing us to connect the baryonic and dark matter properties of high-redshift galaxies.

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Our Local Group: evolution of dwarf galaxies

Dr Lidia Makarova, Prof Dmitry Makarov, Maxim Chazov

Special astrophysical observatory, Russian Academy of Sciences

Abstract

The Local Group of galaxies contains more than a hundred members currently known. Their distance from us does not exceed 1 Mpc. The vast majority of these stellar systems are dwarf galaxies. The Local Group provides us a unique opportunity to study the formation and evolution of these satellite galaxies, since they are all well resolved into individual stars with the Hubble Space Telescope, including faint main sequence and red giant branch stars. The phenomenon of morphological segregation of galaxies within the Local Group is well known, where spheroidal dwarfs are distributed mainly within a virial radius of about 300 kpc from our Galaxy and from M 31, and irregular dwarfs are located relatively evenly within the group. This phenomenon is usually explained by the star formation quenching caused by proximity to the host galaxy. However, in recent years it has become clear that the picture of the formation and evolution of galaxies within the Local Group is much more complicated. In this work, we present the results of measuring of the star formation history of a sample of Local Group galaxies observed with the Hubble Space Telescope. We analyze the subsamples of satellite galaxies in the virial zones of the MW and M 31, and also isolated galaxies, especially those whose star formation has now quenched. We present guesses on the evolution of such dwarfs associated with the formation of the Local Group of galaxies.

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A new Dark Matter detection? Testing lens model complexity in Strong Lensing

Samuel Lange

Durham University

Abstract

Dark Matter (DM) is one of the most elusive objects in Physics today. The standard Cold Dark Matter model predicts lots of low-mass dark substructures, which are not found in most alternative models, thus detection of these can constrain the nature of the DM. Though challenging, detecting DM substructure is possible by modelling strong gravitational lenses, where local distortions of lensed source emission can provide indications of substructure in the lensing galaxy. Thanks to JWST, we now have high signal-to-noise (SNR) imaging data in multiple filters, which allow us to model the same mass across slightly different light configurations, providing compelling results when models agree.

One key issue for this technique is the accuracy of the mass model used: complexity such as twists, skews, and box- or disk-like distributions of mass in the lensing galaxy could easily provide false-positive detections where substructures compensate for the simplicity of the standard smooth power-law mass model. I will discuss a (possible!) new high-mass DM detection found in JWST imaging of the Strong Lens SPT2147 and compare, in a Bayesian framework, the evidence for this detection using the standard power-law lens mass model, versus when we include multipole perturbations which induce angular complexity.

It is essential now as we receive higher SNR data than ever before to consider the effects of our model assumptions – if we cannot correctly model the lens galaxy mass, how can we know if a DM signal is real substructure, or missing complexity from the primary model?

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Dwarf spheroidal galaxies as dark-matter laboratories

Carlo Nipoti

Università di Bologna

Abstract

The kinematics of stars in the dwarf spheroidal galaxies (dSphs) of the Local Group indicates that these systems are largely dominated by dark halos and are thus among the best astrophysical laboratories to study the structure of dark halos and the nature of dark matter. Taking advantage of material from our review Battaglia & Nipoti (2022) and of more recent results obtained by our research group, I will give an overview of the methods to measure the dynamical mass of dSphs and I will present state-of-the-art measurements of their dark-matter content and distribution, with a special focus on Fornax, Sculptor and Leo I. Finally, I will briefly discuss the prospects of using nearby dSphs as targets for indirect detection of dark matter via annihilation or decay emission, and to constrain the self-interaction properties of dark matter, also in light of the empirical anticorrelation between the central dark-matter density and the orbital pericentre of the classical dSphs.

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Observational biases on deriving dark matter abundances from rotation curves of distant galaxies

PhD Amanda Evelyn de A. Carvalho, Dr. Thiago Signorini Gonçalves

Federal University of Rio de Janeiro

Abstract

The ΛCDM model proposes that dark matter resides within a galaxy's halo, constituting the majority of the galaxy's total mass. Analysis of rotation curves, depicting how star and gas velocities vary with distance from the galaxy's center, confirms dark matter's dominance in the outer regions, as evidenced by the curve's flatness. However, recent studies of high-redshift star-forming galaxies reveal that the rotation curves at such epochs exhibit a decline at their outskirts, suggesting reduced dark matter abundances. Yet, observational factors such as cosmological surface brightness dimming may introduce biases into the observations.In our study, we utilize a sample of 19 Lyman Break Analogs to simulate their appearance at approximately $z \sim 2.2$. Comparison of observed and simulated rotation curves reveals increasing galaxy asymmetry with radius, notably in the outer regions where mergers and interactions disrupt the gravitational field. In addition, cosmological surface brightness dimming reduces signal-to-noise to below detectability thresholds in those regions, making galaxies seem smaller and more uniform. Therefore, we conclude that the heightened asymmetry in galactic outskirts combined with cosmological bias complicates directly correlating rotation curves with earlier dark matter abundance. We conclude that relying solely on ionized gas kinematics cannot precisely determine the galaxy's gravitational potential to derive its total mass and therefore the dark matter fraction.

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Radio-monitoring of the gravitational lens system MG J0414+0534

Mr Noko cedrick Monyebodi

University Of Pretoria

Abstract

Gravitational lenses can be used to investigate the mass structure of galaxies at intermediate to high redshifts. However, one of the most startling observational results is that the measured flux-ratios of quadruply imaged quasars tend not to agree with the predictions from simple smooth mass models for the foreground lens. This is generally thought to be evidence for the cold dark matter model of galaxy formation. Here, we investigate the flux ratios of the radio-loud quasar MG J0414+0534 at redshift 2.64 using the Very large Array between frequencies of 12 to 18 GHz. We find that the observed high frequency flux-ratios are essentially constant over this frequency range, ruling out a propagation effect. Therefore, the flux-ratio anomaly persists at high frequencies. In addition, we present an analysis of the time variability of the radio spectra of the four lensed images to investigate whether the flux-ratio anomaly could be due to a gravitational lensing time-delay. Our results indicate what will be achievable for fainter lens systems using the sensitivity and wide-bandwidths of the Square Kilometre Array and the next generation Very Large Array in the future.

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The Interplay between Galaxy Properties and their Environment as seen by the Next Generation Fornax Survey

Dr. Thomas H. Puzia[1], Dr. Yasna Ordenes-Briceño[1], Dr. Paul Eigenthaler[1], Dr. Matías Blaña[1], Dr. Bryan Miller[2], Dr. Evelyn Johnston[3], Dr. Matthew Taylor[4], Dr. Prasanta Nayak[1], Rohan Rahatgaonkar[1], Juan Pablo Carvajal[1], Dr. Tuila Ziliotto[5], Dr. Marcelo Mora[6]

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Abstract

The Next Generation Fornax Survey (NGFS) is a deep, panchromatic imaging campaign that covers the virial sphere of the Fornax galaxy cluster in optical (u'g'i', using DECam@CTIO) and near-infrared filters (JKs, using VIRCam@VISTA). The survey targets all baryonic structures down to point-source luminosities typical of globular clusters ($M_i \simeq -7$) and reaches surface brightness limits ($\langle\mu_i\rangle_e \simeq 28$ mag/arcsec^2) deep enough to detect ultra-diffuse and LSB dwarf galaxies. We will present the spatial distribution of a rich system of dwarf galaxies inside of Fornax' virial and exciting new results based on the H-alpha extension of NGFS, showing intriguing recent star-formation activity in galaxies. Furthermore, we will showcase our most recent findings related to the dynamical properties of satellite galaxies within the Fornax galaxy cluster. Our analysis has identified a distinct transition radius, demarcating two zones where satellites exhibit varying properties of tidal stress. Intriguingly, this substructure mirrors patterns observed in cosmological galaxy simulations. Furthermore, when examining diverse cosmic environments, we discern a comparable transition radius in the Virgo galaxy cluster, as well as among the satellite galaxies of both the Milky Way and Andromeda.

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Weighing dark matter in dwarf galaxies in the Perseus galaxy cluster

Teymoor Saifollahi

Observatory of Strasbourg, France

Abstract

It is known that the number of Globular Clusters (GCs) around galaxies can be used to estimate the total dark matter halo mass of galaxies in a wide range of mass and luminosity when other mass estimators fail or are not relevant. As a result, in the last 10 years and mainly using the Hubble Space Telescope, the total number of GCs around galaxies has been used to estimate the halo mass of some tens of dwarf galaxies within 100 Mpc.

Thanks to the recently launched ESA/Euclid mission, over the next six years, we will be able to estimate the halo mass of more than 10,000 dwarf galaxies within 100 Mpc. As a first attempt, as I present in this talk, we, the Euclid consortium, studied the GCs and estimated GC number counts of dwarf galaxies in the Perseus galaxy clusters observed during Euclid's Early-Release Observations (EROs).

During this talk, I briefly introduce the adopted methodology for identifying GCs (candidates) in Euclid optical and near-infrared images to produce GC catalogues. Then, I present our study on the GC properties and GC number counts of dwarf galaxies using the resulting GC catalogues. With the result of this analysis, we could derive halo mass and dark-to-stellar mass for dwarf galaxies. At the end of this talk, I present our findings on the dark matter content of dwarf galaxies and briefly describe our plans within the Euclid consortium for studying GCs around dwarf galaxies with the Euclid Wide Survey.

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Dark matter distribution in Milky Way-analog galaxies

M.Sc. Natanael de Oliveira[1], Prof. Dr. Karín Menéndez-Delmestre[1], Prof. Dr. Thiago Gonçalves[1], Dr. Nicolás Garavito-Camargo[2], Dr. Pedro Beaklini[3], Prof. Dr. Marco Grossi[1], Prof. Dr. Davi Rodrigues[4,5]

[1]Valongo Observatory, UFRJ. [2]Flatiron Institute. [3]National Radio Astronomy Observatory. [4]UFES. [5]University of Heidelberg

Abstract

Our current understanding of how dark matter (DM) is distributed within the Milky Way (MW) halo, particularly in the solar neighborhood, is based on either careful studies of the local stellar orbits, model assumptions on the global shape of the MW halo, or from direct acceleration measurements. In this work, we present a study of external galaxies with the intent of gaining insights into the DM distribution in MW-analog galaxies. For this, we carefully select a sample of galaxies similar to the MW. With a need for deep, highly-resolved atomic hydrogen (HI), our resulting sample is comprised of 15 galaxies observed from two approved VLA and GMRT programs. To perform our baryonic analysis, we use deep Spitzer mid-IR images at 3.6 and 4.5μm from the S^{4}G survey. Based on the dynamical three-dimensional modeling software ^{3D}Barolo, we construct rotation curves (RCs) and directly derive the gaseous and stellar contributions from their mass surface density profiles. Through a careful decomposition of the RCs into their baryonic (stars, gas) and DM components, we isolate the DM contribution by using an MCMC-based approach. Based on the Sun's location and the MW's R_{25}, we define the corresponding location of the solar neighborhood in these systems. We put forward a window for the DM density (ρ_{dm}=0.21-0.46 GeV cm^{-3}) at these galactocentric distances in our sample, consistent with the values found for the MW's local DM density, based on more traditional approaches.

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The dynamical scaling laws of rotation-supported galaxies

Dr Federico Lelli

INAF - Arcetri Astrophysical Observatory

Abstract

Over the past decades, mass models have been constructed for hundreds of nearby galaxies by combining near-infrared imaging, providing the stellar mass distribution, with HI observations, providing the gas distribution and circular velocity curve out to large radii. These detailed mass models revealed puzzling regularities in the relative distributions of baryons and dark matter (DM) across the galaxy population. For rotation supported galaxies, the observational evidence can be summarized by three empirical laws: (1) the baryonic Tully-Fisher relation that links the total baryonic mass with the flat rotation velocity at large radii, (2) the central surface density relation that links the baryonic surface density with the dynamical mass surface density at small radii, and (3) the radial acceleration relation that links the baryonic gravitational field with the observed centripetal acceleration at each radius. These empirical relations are extremely tight for usual astronomical standards and imply a close link between visible baryons and observed dynamics, even in the DM-dominated regime. Each one of the three empirical laws imply the existence of a distinct acceleration scale that plays a specific physical role in the DM problem; yet these acceleration scales turn out to have the same value within the uncertainties. I will discuss the implications of these observations for LCDM models of galaxy formation, as well as for Milgromian dynamics (MOND), which predicted most of these facts in advance. I will also discuss recent efforts to build mass models of galaxies at high z, which can potentially discriminate between the two paradigms.

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WISDOM: Weighing supermassive black holes with high precision using molecular gas

Prof Martin Bureau

University of Oxford

Abstract

I will show that molecular gas is the best tracer of the circular velocity of galaxies across the Hubble sequence (including early-type galaxies), thus allowing accurate spatially-resolved dynamical mass (and thus mass-to-light ratio) measurements. In particular, I will discuss how CO can be used to easily and robustly measure the masses of the supermassive black holes lurking at galaxy centres, the latest measurements yielding percent precision and probing as close to the black holes as the best mega-maser measurements. This opens the way to literaly hundreds of measurements across the Hubble sequence with a unique method, this for both active and non-active galaxies.

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Dark matter perturbations with causal bulk viscosity.

Mr Jaymie van der Merwe, Dr Anslyn John

Stellenbosch University

Abstract

The ΛCDM model is currently our best description of the universe. However, discrepancies between theory and observation have emerged. Bulk viscosity has been proposed as a possible extension to the ΛCDM model to account for these mismatches. There are two popular frameworks for studying bulk viscosity in cosmological fluids. These are the Eckart and Muller-Israel-Stewart (MIS) theories of dissipative, relativistic hydrodynamics. We study the effects of bulk viscosity on the formation of large-scale structure via the evolution of the dark matter density perturbations. We compare the two competing theories for dissipative hydrodynamics. We investigate changes to the hydrodynamic equations as well as the Einstein equations with the introduction of the bulk viscous pressure. We will then discuss the numerical solutions found for the growth of the dark matter perturbations. We compare our results from the two competing theories with those from the ΛCDM model. Future work is also discussed.

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Dark matter content of low mass (dwarf) galaxies

Dr Azadeh Fattahi[1], Ms Jemima Briggs[2], Dr. Rob Crain[1]

[1]Institute for Computational Cosmology, Durham University, UK. [2]Liverpool John Moores University, UK

Abstract

Dark matter content of dwarf galaxies has long been a matter of debate as a potential tension between observations and the predictions of the standard LCDM model. A key uncertainty in this debate is the predicted stellar mass-halo mass (SMHM) relation at the faintest end. In this talk I present new results on the SMHM relation, based on a new suite of cosmological hydrodynamical simulations, "Columba", focused on studies of dwarf galaxies. I will first introduce this new high resolution suite which consists of zoom-in simulations of spheres with r~5Mpc, selected from different regions of the cosmic web to capture the diversity of environments and yield a representative sample of dwarf galaxies.

I will show our results about the predicted shape and scatter of the SMHM relation and the effect of the environment on this relation. We find that the origin of the scatter in the SMHM relation stems from the concentration of their dark matter halos. Moreover, we find the dark matter halo concentrations in turn biases star formation histories and metallicities of the dwarfs which are directly observable quantities, hence opening a new avenue into studies of dark matter distribution in these low mass objects.

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Galactic halos in alternative dark matter models

Dr Azi Fattahi[1], Dr. Victor Forouhar[2], Dr. Alex Riley[1], Dr. Alis Deason[1], Mr Fergus Henstridge[1]

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Abstract

Alternative dark matter models have been proposed to alleviate various tensions in Lambda Cold Dark Matter (LCDM) predictions vs observations. E.g. warm dark matter (WDM) models change the predicted number of ultra faint dwarfs, or self-interacting dark matter (SIDM) models can create shallow dark matter density profiles in the center of dwarf galaxies.

In this talk we discuss a new avenue to explore and test the predictions of various dark matter models, namely stellar halos. Galactic halos are formed from the accretion and disruption of dwarf galaxies, hence their properties may alter in various dark matter models and bear signatures of the nature of dark matter.

Using cosmological hydrodynamical simulations of Local Group-like volumes, run with different dark matter models (CDM, WDM and SIDM), I show how general properties of Galactic halos change in these models. We find that WDM masse very little difference to Galactic halos. However, the stellar density profile and dynamical properties in SIDM and CDM have stark differences, which can be observable. Our results show a novel way of constraining the nature of dark matter.

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Stellar Mass Calibrations in Low-Mass Galaxies

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Abstract

The stellar mass of a galaxy traces the galaxy's cumulative history of growth. In the local universe, color-M/L relations and spectral energy distribution fitting are perhaps the most common methods for measuring stellar masses using optical photometry. While several works have tested the robustness of these methods, these tests have typically not extended to low-mass (<1e8 Msun) dwarf galaxies. This regime poses unique problems for stellar mass measurements: dwarf galaxies have complex star formation histories that are difficult to model, and many empirical calibrations rely on survey data that are incomplete at low masses. Here we test a number of stellar mass measurement techniques on simulated dwarf galaxies, and we identify some best practices for measuring dwarf galaxy masses in the nearby universe. This is of particular importance as we enter a new era of optical extragalactic surveys that will identify and characterize unprecedented numbers of low-mass galaxies across a range of environments.

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The role of dark matter halo angular momentum distribution on bar formation, evolution, pattern speed and dynamical friction.

Dr. Sandeep Kumar Kataria[1], Prof. Juntai Shen[1], Dr. Rimpei Chiba[2]

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Abstract

Various studies have shown that dark matter halo properties like concentration, triaxiality, spin, etc., play an important role in the dynamical processes of bar instability. We have investigated the role of inner (within disk region) halo angular momentum distribution on the bar formation and evolution processes. We have performed a series of high-resolution N-body experiments with Milky Way-type disk galaxies in LCDM scenarios. These models are initiated with similar disks while increasing the inner halo angular momentum of the surrounding dark matter halo. The bar triggers earlier for the model with a higher inner halo angular momentum than the lower ones, similar to studies claiming the role of halo spins. However, the bar secular evolution shows growth for all the models, irrespective of inner halo angular momentum, contradicting the role of high spin in bar secular dampening claimed in earlier studies. The model with the highest inner angular momentum shows pronounced box/peanut/x-shaped bulges compared to the lowest one. Finally, using multiple approaches like linear perturbation theory, test particle simulations and N-body simulations, we show that dynamical friction due to dark matter halo on bars reduces with net prograde rotation of dark matter halos. This can potentially explain the short bar with high pattern speeds in Low Surface Brightness galaxies having larger halo angular momentum.

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Dark matter properties of star-forming galaxies at z~1.5 and how they compare to the local Universe

Dr Ugne Dudzeviciute[1], Prof Mark Swinbank[2], Dr Annagrazia Puglisi[3], KURVS collaboration[4]

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Abstract

Galaxy rotation curves provide fundamental measurements of the baryonic and dark matter distributions within galaxies. Although kinematic studies of local galaxies have shown dark matter dominance, there is less direct evidence for this at higher redshift (z>1). Indeed, some recent studies suggest that dark matter contribution to the inner regions may be much lower in the distant Universe. However, assessing such properties at high redshift is complicated due to observational limitations and model assumptions. To address this, we have recently undertaken an ultra-deep KMOS survey (currently the deepest Halpha observations) of ~40 star-forming galaxies at z~1.5. Utilising HST and JWST imaging, we constrain their stellar profiles and perform pixel-by-pixel SED fitting to obtain spatially-resolved stellar mass maps and infer the baryonic contribution to the dynamical mass. Using forward modelling, which includes both baryons and dark matter, we extract the their individual dark matter profiles and explore how the dark matter profiles of z~1.5 star-forming galaxies compare to local galaxies and simulations. Within the uncertainties, a NFW profile can describe the observed rotation curves for majority of the galaxies, although the dark matter fraction within the disk radius decreases strongly with increasing stellar mass. For main-sequence galaxies, the dark matter fractions are consistent with those predicted by cosmological simulations, although the most massive galaxies have lower dark matter fractions than predicts, which may be related to the effects of AGN feedback that are not fully captured in the simulation sub grid physics.

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Constraints on the properties of νMSM dark matter using the satellite galaxies of the Milky Way

Dr Oliver Newton[1], Dr Mark Lovell[2], Prof. Carlos Frenk[2], Prof. Adrian Jenkins[2], Dr John Helly[2], Prof. Shaun Cole[2], Dr Andrew Benson[3]

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Abstract

Low-mass galaxies are powerful tools with which to investigate departures from the standard cosmological paradigm in models that suppress the abundance of small dark matter substructures. One of the simplest metrics that can be used to compare different models is the abundance of satellite galaxies in the Milky Way. Viable dark matter models must produce enough substructure to host the observed number of Galactic satellites. Here, we scrutinize the predictions of the neutrino Minimal Standard Model (νMSM), a well-motivated extension of the Standard Model of particle physics in which the production of sterile neutrino dark matter is resonantly enhanced by lepton asymmetry in the primordial plasma. This enables the model to evade bounds associated with non-resonantly produced dark matter. Independently of assumptions about galaxy formation physics we rule out, with at least 95 per cent confidence, all parametrizations of the νMSM with dark matter particle masses, $M_s \leq 1$ keV, independently of other model parameters and of the Milky Way halo mass. Incorporating physically motivated prescriptions of baryonic processes and modelling the effects of reionization strengthens our constraints and we exclude all models with $M_s \leq 3$ keV. Unlike other literature, our fiducial constraints do not rule out the putative 3.55 keV X-ray line hinted at by observations of dark matter-dominated systems, if it is indeed produced by the decay of a sterile neutrino. We find that the constraints from satellite counts are substantially weaker than the limits reported from X-ray non-detections.

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Dark matter searches through radio astronomy - imposing mass limits on on ALPs

Tristan Jade Wilkinson, Dr Geoffrey Beck

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Abstract

Axion-like particles (ALPs) are potential dark matter candidates which are proposed as a solution to a problem in the current Standard Model of Particle Physics - the lack of an expected violation of Charge Conjugation & Parity (CP) symmetries. ALPs are strong contenders for dark matter candidates as they interact minimally with both “standard” matter and light, and furthermore are low-energy and non-relativistic particles. ALP-photon couplings are expected to lead to radio photon decays, and these signals can be searched for by taking spectroscopic radio data from neighbouring radio sources (chiefly dwarf galaxies) and searching for expected ALP decay signals. Individual bounds can be imposed onto source data, and these local bounds can thereafter be combined and integrated with global bounds.

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Final category: IAUS 389 Gravitational Wave Astrophysics

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Self Interacting Dark Matter and its Effect on Gravitational Wave Signal

Associate Research Professor Lan Nguyen

University of Notre Dame

Abstract

In this talk, I present two gauge models for light-dark matter: one with an exotic positive charged lepton and the other one is a variant with right-handed neutrinos. The scalar self-interacting dark matters are stable without imposing new symmetry and should be weak-interacting. We study the impact of the self-interacting light dark matter on the formation of the dark halo, the observation properties of neutron stars, and its effect on the gravitational wave signal.

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Electromagnetic signatures of massive black hole binaries

Dr. Jordy Davelaar

Flatiron Institute. Columbia University

Abstract

Massive black hole binaries are thought to reside in the cores of numerous galaxies as a result of galactic mergers. As the massive black holes migrate inwards, they will eventually emit gravitational waves which are expected to be detected by LISA. A critical component to understanding where and how black holes merge and how they shape galactic evolution is host galaxy identification, which relies on electromagnetic (EM) observations. In my talk I will show two novel tell-tale EM signatures that would provide strong evidence for the existents of a black hole binary either before or during a merger. The first is when the binary is seen close to edge on, in that case the binary produces self lensing flares (SLFs) when one of the black holes moves in front of the background black hole. This causes the emission to be gravitationally lensed. This signal additionally can hold information on the size and shape of the emission morphology of the lensed black hole. Secondly, I will argue that when the binary is close to merger the accretion is disrupted turning the binary X-ray dark. I will argue that the upcoming time-domain surveys such as the Vera Rubin Observatories LSST might observe these dips and that they additionally could be observed in precursor emission from LISA sources.

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Gravitational waves from magnetically-deformed neutron stars

Dr. Arthur Suvorov

Manly Astrophysics, Sydney, Australia. Eberhard Karls Universtät, Tubingen, Germany

Abstract

The strong magnetic fields present in neutron stars, and in particular the magnetar class, can induce sizeable quadrupole moments. These moments result in the emission of continuous gravitational waves, the detection of which is within view with ground-based interferometers. Typically, however, estimations for the strain are made under the assumption that Maxwell's equations are valid. This may not be the case when the fields are super-Schwinger (>> 1e13 G), which can be readily achieved in a magnetar, or if the interior forms a type II superconductor. I will provide an introduction to the theory of magnetic deformations and discuss how quantum modifications to Maxwell's equations can alter the predictions for the gravitational waves, with an emphasis on how this may influence subsequent constraints set on the highly-coveted equation of state.

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A review on the frequency-domain of gravitational wave signals emitted during the post-merger stage of binary neutron star coalescences

Gabriela Conde Saavedra[1], Professor Odylio Aguiar[1], Professor Henrique de Oliveira[2], Professor Maximiliano Ujevic[3]

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Abstract

Ground-based detectors of gravitational waves have given information about the initial components in compact binary system mergers. Nevertheless, the characteristics of the final products, especially in binary neutron star coalescences, are still not detectable. Only numerical simulations are available to study the post-merger stage. From these simulations, it has been found that the frequency domain is very useful for characterizing the different remnants of these systems. Therefore, we will review the frequency ranges of the post-merger phase using data from several binary neutron star simulations taken from the CoRe Database. The study of these post-merger stages will be important for future gravitational wave detections.

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The criteria for dynamical timescale mass transfer and its application in double white dwarfs

Prof. Dr. Hongwei Ge, Prof. Dr. Zhanwen Han

Yunnan Observatories, Chinese Academy of Sciences

Abstract

The stability criteria of rapid mass transfer and common-envelope evolution are fundamental in binary star evolution. They determine the mass, mass ratio, and orbital distribution of many important systems, such as X-ray binaries, type Ia supernovae, and merging gravitational-wave sources. In the limit of extremely rapid mass transfer, the response of a donor star in an interacting binary becomes asymptotically one of adiabatic expansion. We built the adiabatic mass-loss model and systematically surveyed the thresholds for dynamical timescale mass transfer over the entire span of possible donor star evolutionary states. We confirm that new mass transfer stability plays an important role in the formation and properties of DWD populations as well as in the progenitors of SNe Ia and detectable GW sources. The results of our model support the observational DWD merger rate distribution per Galaxy and the space density of DWDs in the Galaxy.

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Constraining the Stochastic Gravitational-Wave Background Anisotropy with Constrained Simulations

Metin Ata

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Abstract

The stochastic gravitational wave background in the nanohertz band is dominated by merging **supermassive black hole binary systems** residing in the most massive galaxies. Cosmological simulations have played a crucial role in estimating the signal of the stochastic gravitational wave background detectable with **Pulsar Timing Arrays**. However, as these simulations start from random initial conditions, they do not represent the actual observed universe, but a statistical realization of a ΛCDM Universe.

I will present **Constrained Simulations** that are designed to match the real local Universe and present an estimate of the anisotropies observable with a Pulsa Timing Array.

This work paves the way for a wealth of cross-analyses of the **Large-Scale Structure** of the Universe and the Gravitational Wave background, studying the **whole chain of physical processes** starting from the formation of the dark matter halo down to the inspiral phase of the supermassive black hole binary system.

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Viscous torque in turbulent magnetized AGN accretion disks and its effects on EMRI's gravitational waves

prof. Agnieszka Janiuk, dr Fatemeh Hosein Nouri

Center for Theoretical Physics PAS

Abstract

The mergers of supermassive black holes (SMBHs) produce mHz gravitational waves (GW), potentially detectable by future Laser Interferometer Space Antenna (LISA). Such binary systems are usually embedded in an accretion disk at the center of the active galaxy. Plasma environment imposes measurable imprints on the GW signal if the mass ratio of the binary is around $q \sim 10^{-4}$ - 10^{-3}. The effect of the gaseous environment on the GW signal is strongly dependent on the disk parameters, so future low-frequency GW detections will provide information about the physics of accretion disks. We investigate this effect by modelling magnetized disks around primary massive black hole. Using GRMHD HARM-COOL code, we perform 2D and 3D simulations. In our numerical analysis, we study the angular momentum transport and turbulence generated by the magnetorotational instability (MRI). We quantify the disk's effective viscosity and its evolution over time, and compute the relativistic viscous torque on a low-mass secondary black hole. Hence we estimate the GW phase shift due to the gas environment.

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Detection of continuous gravitational waves from fast radio burst sites to understand their progenitor mechanisms

Dr. Surajit Kalita, Prof. Amanda Weltman

University of Cape Town, South Africa

Abstract

This abstract is primarily based on MNRAS 520 (2023) 3742. Since the discovery of fast radio bursts (FRBs), researchers have proposed several theories and models to explain their characteristics. One of the most recent models takes into account the Gertsenshtein-Zel'dovich (GZ) phenomenon, which suggests that a portion of gravitational radiation is converted into electromagnetic (EM) radiation when gravitational waves pass through a pulsar magnetosphere. This model can explain both repeating and non-repeating FRBs and the pulsar's characteristics remain unchanged over time. My talk focuses on the gravitational radiation produced by the pulsar mechanism and how proposed gravitational wave detectors can detect these waves. If these detectors detect any continuous GW signal from the site of FRBs, it will provide significant support for the GZ theory and disprove the merger-like theories.

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The BlackGEM array for gravitational wave follow-up

Prof Paul Groot[1,2,3], Dr Steven Bloemen[3], Dr Jan Van Roestel[4], Dr Paul Vreeswijk[3]

[1]University of Cape Town. [2]South African Astronomical Observatory. [3]Radboud University. [4]University of Amsterdam

Abstract

The BlackGEM Array consists of three optical wide-field telescopes, located at the ESO La Silla Observatory, that have a combined field of view of 8.1 square degrees. Each telescope is equipped with a six-slot filter wheel housing the Sloan set (u,g,r,i,z) and a wider q-band filter (440-720nm). BlackGEM started operations in 2023, and will directly and automatically react to gravitational wave triggers from LIGO/Virgo. In between triggers it performs a synoptic survey focused on the mass concentrations within 150 Mpc, and a deep drilling survey geared towards LISA-detectable systems. Deepest observations are obtained in the wide-band q-band where a five-sigma limiting magnitude of m_ab = 21.6 is obtained in 60s of integration. This depth ensures sensitivity to kilonova afterglows for neutron-star-involved events out to the current LIGO/Virgo detection horizon.

BlackGEM is run by a consortium of institutes, led from Radboud University, NOVA and the KU Leuven.

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Binary coalescences as sources of Ultra-High Energy Cosmic Rays

Dr. Jaziel Goulart Coelho

Universidade Federal do Espírito Santo (UFES)

Abstract

Binary coalescences are known sources of gravitational waves (GWs) and they encompass combinations of black holes (BHs) and neutron stars (NSs). Here we show that when BHs are embedded in magnetic fields (Bs) larger than approximately 10^{10} G, charged particles colliding around their event horizons can easily have center-of-mass energies in the range of ultra-high energies ($\gtrsim 10^{18}$ eV) and become more likely to escape. Such B-embedding and high-energy particles can take place in BH-NS binaries, or even in BH-BH binaries with one of the BHs being charged (with charge-to-mass ratios as small as 10^{-5}, which do not change GW waveforms) and having a residual accretion disk. Ultra-high center-of-mass energies for particle collisions arise for basically any rotation parameter of the BH when $B \gtrsim 10^{10}$ G, meaning that it should be a common aspect in binaries, especially in BH-NS ones given the natural presence of a B onto the BH and charged particles due to the NS's magnetosphere. We estimate that the number of ultra-high center-of-mass collisions ranges from a few up to millions before the merger of binary compact systems. Thus, binary coalescences may also be efficient sources of ultra-high energy cosmic rays (UHECRs) and constraints to NS/BH parameters would be possible if UHECRs are detected along with GWs.

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Monitoring young X-ray pulsars using NICER and searching for their gravitational wave emission

Dr Wynn Ho[1], Dr Lucien Kuiper[2], Dr Cristobal Espinoza[3], Dr Zaven Arzoumanian[4]

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Abstract

Gravitational waves have been detected from the inspiral and merger of neutron star systems, and such detections provided valuable insights into fundamental physics like the nuclear equation of state. Meanwhile, searches for gravitational waves from solitary neutron stars continue, where detections could yield far more than from mergers. Here I discuss our ongoing campaign to track the long-term evolution of the rotation rate of fast-spinning young neutron stars. These sources are only observable in X-ray and make use of the NICER instrument on the International Space Station. Our X-ray measurements enable the most sensitive searches of these neutron stars for gravitational waves that could be produced by stellar mountains or fluid oscillations. I describe some of the sources we monitor, a few results from our observations, including glitches and what they tell us about superfluidity, and what could be learned from gravitational wave detection. If available, results from searches of the latest gravitational wave data will also be presented on behalf of the LIGO-Virgo-KAGRA Collaboration.

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Hierarchal inference of the Massive Black Hole Binary population with an analytical model

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Abstract

Massive black hole binaries (MBHB) are predicted to form via hierarchical assembly through galaxy mergers following dark matter (DM) halo mergers and will be among the loudest and furthest detectable source (z>20) during the future Lisa Interferometer Space Antenna (LISA) mission. As a consequence, understanding their population distribution at high and low redshift gives direct insights of the merger history and abundances of the first galaxies.

We employ a simple analytical model based on an empirically motivated prescription that connects theoretically derived DM halo mergers to BH mergers, to generate a population of MBHBs.

The high flexibility of this phenomenological model allows us to explore the broad and still uncertain range of MBHB seeding and growth mechanisms as well as the different mechanisms behind the interplay between MBH and Galactic astrophysics. We compare the model to different state-of-the-art semi-analytical population models finding that it is in broad agreement with current predictions.

Finally, we present hierarchical Bayesian inference on a set of selected population hyper-parameters of our model to investigate how well we can constrain the MBHB population with LISA given a measured detection rate.

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Signatures of Dynamically-driven Black Hole Mergers through Stellar Collisions and Accretion in Dense Star Clusters

Fulya Kiroglu

Northwestern University

Abstract

Despite the rising number of binary black hole (BH) mergers detected as gravitational wave (GW) sources by LIGO/Virgo, the evolutionary origin of these events remains a mystery. Dense environments can produce qualitatively different properties of binary BH mergers compared to systems that merge in isolation, allowing us to disentangle the origins of GW sources. In this talk, I will present insights from N-body simulations of dense star clusters, emphasizing the frequency of collisions between BHs and massive stars. These interactions can lead to significant accretion of material tidally ripped away from stars, which can then spin up and/or grow the BHs significantly while also producing potentially observable transients. This would provide an alternative to stable mass transfer in binaries as a way of spinning up stellar BHs, assuming that they are born spinning slowly (as now considered very likely), with important implications for the interpretation of GW signals from merging BH binaries. Depending on the GC's properties, we find that as many as 50% of all binary BH mergers feature at least one BH component that was spun up through stellar collisions. Although mass accretion efficiency is highly uncertain, collisions with young massive stars may conceivably lead to highly spinning BHs which could be a key observable signature distinguishing them as dynamically-driven BH mergers. These findings hold particular significance as the upcoming observing run O4 for the LIGO-Virgo/Kagra collaboration promises to offer unprecedented constraints on the distribution of BH masses and spins in the coming years.

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The emission for optical and gamma-ray flares associated with binary black hole mergers

Dr. Hiromichi Tagawa

Shanghai Astronomical Observatory

Abstract

The debate surrounding the astrophysical origin of stellar-mass black hole (BH) mergers detected through gravitational waves (GWs) remains ongoing. Mergers occurring in the disks of active galactic nuclei (AGN) present promising environments for at least a portion of these events, with potential observational indicators within the GW data. A clue that could help uncover AGN merger environments lies in potential electromagnetic emissions from post-merger accreting BHs. In the context of BH mergers within AGN disks, we anticipate emission from shocks arising around jets launched by accreting merger remnants. We have predicted the properties of the emission generated during breakout and the subsequent adiabatic expansion phase of the shocks. We then apply this model to gamma-ray and optical flares, which are suggested to be potentially associated with GW events. Our findings indicate that the gamma-ray and optical flares could be accounted for by the breakout and shock cooling emission, respectively, when jets interact with circum-binary disks and winds. If this model holds true, the optical flares would exhibit moderate color evolution and variations among different events. I will present the recent findings on this topic.

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Detecting, interpreting, and harnessing gravitational waves from eccentric compact binaries

Dr Isobel Romero-Shaw

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Abstract

With the fourth observing run of the LIGO-Virgo-KAGRA detector network ongoing, the number of detections of gravitational waves from binary black hole mergers is rapidly reaching into the hundreds. However, despite this wealth of detections, it is still unclear how black holes become bound into tight binaries that merge within the age of the Universe. Binaries that form and merge in isolation are predicted to have different parameters than those that form under the influence of dynamical interactions with other objects.

Traditionally, we have looked to the masses and spins of these binaries to teach us about their formation. However, arguably the most robust indication of dynamical evolution is orbital eccentricity: while isolated binaries will have essentially circular orbits at detection, a fraction of dynamically-formed binaries should have measurably non-zero eccentricity. Gravitational waves from eccentric binaries have historically been challenging to detect and analyse. Yet in the last few years, a handful of the signals reported by the LIGO-Virgo-KAGRA collaboration, including that from the unusually massive binary GW190521, have been claimed by multiple groups to contain tantalising hints of orbital eccentricity. In this talk, I will demonstrate how evidence of eccentricity in gravitational-wave signals can be decoded and harnessed to reveal details of a binary's history, and even to probe the identities of external influences to its evolution. I will also discuss what we can learn about our population of binary black holes when we combine observations of their masses, spins, and eccentricity.

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Revisiting GW170817's jet on milliarcsecond scales: novel techniques reveal new constraints on key jet parameters

Dr. Kelly Gourdji

Swinburne University of Technology

Abstract

Short gamma-ray bursts (SGRBs) offer an opportunity to study extreme examples of transient jets, providing insight into both the jet physics and the merger progenitors. While SGRBs have traditionally been seen only on-axis and at typically high redshift, the advent of gravitational-wave merger (GWM) detections means that much closer, off-axis events can also be identified and studied. The prototypical example of this new category was the landmark detection of the multiwavelength counterpart to binary neutron star merger GW170817, which provided an unprecedented view of an SGRB. Its relative proximity enabled very long baseline interferometric (VLBI) observations that identified superluminal proper motion of the merger's relativistic outflow. This provided largely orthogonal information to the multiwavelength light curve that enabled degeneracies between models to be broken and hence much tighter constraints on key jet parameters. However, such VLBI data will often be of low signal-to-noise and includes systematic sources of uncertainty that are difficult to quantify. This complicates the estimation of jet parameters and especially the associated uncertainty. To address these challenges, we have developed a novel Bayesian VLBI modelfitting framework. In this talk, I present a reanalysis of GW170817 VLBI data using this framework and the resulting improved constraints on the key jet parameters. Crucially, we find that the afterglow model that was claimed to best fit the VLBI data in the original analysis is actually not the best fit to the full multiwavelength astrometry dataset when incorporating Hubble Space Telescope constraints on the kilonova position and fully exploring the model parameter space.

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Gravitational-Wave Searches for Cosmic String Cusps in Einstein Telescope Data using Deep Learning

Quirijn Meijer[1], Melissa Lopez[1], dr. Daichi Tsuna[2], dr. Sarah Caudill[3]

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Abstract

Gravitational-wave searches for cosmic strings are currently hindered by the presence of detector glitches, some classes of which strongly resemble cosmic string signals. This confusion greatly reduces the efficiency of searches. A deep-learning model is proposed for the task of distinguishing between gravitational wave signals from cosmic string cusps and simulated blip glitches in design sensitivity data from the future Einstein Telescope. The model is an ensemble consisting of three convolutional neural networks, achieving an accuracy of 79%, a true positive rate of 76%, and a false positive rate of 18%. On a dataset consisting of signals and glitches, the model is shown to outperform matched filtering, specifically being better at rejecting glitches. The behaviour of the model is interpreted through the application of several methods, including a novel technique called waveform surgery, used to quantify the importance of waveform sections to a classification model. These analyses help further the understanding of the morphological differences between cosmic string cusp signals and blip glitches.

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Can Neutron Star Tidal Effects Obscure Deviations from General Relativity?

Dr. Stephanie Brown

Oskar Klein Centre

Abstract

One of the main goals of gravitational wave astrophysics is to study gravity in the strong field regime and constrain deviations from general relativity. Any deviation from general relativity affects not only binary dynamics and gravitational wave emission but also the structure and tidal properties of compact objects. In the case of neutron stars, the mass, radius, and tidal deformability can all differ significantly between different theories of gravity. Currently, the measurement uncertainties in neutron star radius and tidal deformability are quite large. Despite this, little work has been done to explore how the large uncertainty in the nuclear equation of state might affect tests of general relativity using binary neutron star mergers. To explore the possibility that the neutron star equation of state uncertainties are obscuring deviations from general relativity, we first derive the $\ell \geq 2$ tidal love numbers in scalar-tensor theory, and then use them in parameter estimation of GW170817. Correspondingly, we test if physics beyond general relativity could bias measurements of the nuclear equation of state and neutron star radius.

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The effect of interstellar medium on LVK's black holes

Mr. Sohan Ghodla

University of Auckland, New Zealand

Abstract

Gravitational radiation alone is not efficient in hardening the orbit of a binary black hole (BBH). By employing a toy model for the interstellar medium (ISM) surrounding BBHs, here we will discuss the effect of this baryonic medium on BBH dynamics. Depending on the BBH's mass, we will show that a binary surrounded by an isotropic cold neutral medium ($T \approx 100$ K) with a time-averaged particle density of $\langle n_H \rangle = O(1)$ cm^{-3} can play a significant role in hardening the binary orbit over a $O(10^9)$ yr time scale. Additionally, this causes the black hole's mass to grow at a rate $\propto m^2$. We will thus explore the impact of the ISM on the LIGO-Virgo-KAGRA (LVK) observables. Given the uncertainty in the strength of the common envelope evolution and the fine-tuning it requires to reproduce the LVK's observation, in this talk, we will quantify the properties of the ISM under which the latter could play a major role in driving the LVK's BBH mergers.

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Deviations of the Binary Black Hole Merger Rate from the Star Formation Rate

Adam Boesky[1], Professor Floor Broekgaarden[2,3,4,5,6], Professor Edo Berger[2,7]

[1]Harvard. [2]Center For Astrophysics | Harvard & Smithsonian. [3]AstroAI at the Center for Astrophysics. [4]Simons Society of Fellows. [5]Department of Astronomy and Columbia Astrophysics Laboratory. [6]William H. Miller III Department of Physics and Astronomy, Johns Hopkins University. [7]The NSF AI Institute for Artificial Intelligence and Fundamental Interactions

Abstract

Gravitational wave detectors are now making it possible to measure how the merger rate of binary black holes evolves with redshift (z). We present an analysis of deviations between the isolated binary black hole merger rate and the scaled star formation rate density (SFRD)---a frequently used model in state-of-the-art research. To this end, we conduct population synthesis simulations using COMPAS with a grid of stellar evolution models and compare the simulated merger rate from each model to the scaled SFRD. We find that our simulated rates deviate from a scaled SFRD due to two main phenomena: (i) the formation efficiency of binary black holes is an order of magnitude higher at low metallicities than at solar metallicity, and (ii) binaries experience delays from formation to merger ranging from Myrs to Gyrs. Combined, these effects cause our simulated binary black hole merger rates to deviate from the SFRD with factors up to 3.5x at z = 0 and 5x at z ~ 9. Deviations are similar when comparing to a *delayed* SFRD, and even larger (up to ~10x) when the SFRD is scaled to the local merger rate. Interestingly, the binary black hole delay time distribution is redshift-dependent in our simulations, increasing the complexity of delay time effects on the merger rate redshift evolution. Our work demonstrates that scientists should move away from SFRD-based merger rate models and gives insight into how future measurements of the merger rate can help us learn about the formation pathways of gravitational wave sources.

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Seeding the Gravitational-Wave Forest: Rapid Detection of LISA Sources

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Abstract

In the mid 2030s, the Laser Interferometer Space Antenna (LISA) is expected to detect merging supermassive black-hole binaries, superimposed upon millions of white-dwarf (WD) binary systems in our Milky Way. Independent, slowly-evolving monochromatic signals constitute a forest of lines in the LISA frequency spectrum. Systematic characterization of this forest will require Monte Carlo methods such as NASA's Global Bayesian Fit, yet rapid detection of LISA sources may be facilitated by seeding the parameter space with results from matched-filter-like statistics. This presentation will discuss continuous-wave searches derived from Laser Interferometer Gravitational-wave Observatory data analysis, to cross-correlate Time-Delay Interferometry channels in the simulated LISA Data Challenge (LDC). This analysis spans a low-dimensional parameter space (frequency and sky location), yielding a statistical peak for each source. Two forms of the statistic can be combined to infer correlated information about amplitude and polarization. Preliminary LDC analyses are presented, showing WD verification binaries. Computational costs allow runs in a few days or less on laptop CPUs, and further speed-up with GPUs is feasible. This study focuses on WD signals: disambiguating galactic signals is a time-sensitive prerequisite for detecting coalescing black-hole binaries, which share some similarities. Fast characterization of super-massive and stellar-mass systems alike will be essential to multi-messenger astronomy: joint electromagnetic and gravitational-wave observations must be maximized over LISA's expected four-year mission duration. This project is funded by Laboratory Directed Research & Development (LDRD) 20230448ECR and this abstract is approved for release under LA-UR-24-21508.

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Astrophysical implications of gravitational wave interactions with matter

Prof Nigel Bishop[1], Dr Vishnu Kakkat[2], Prof Amos Kubeka[2], Dr Monos Naidoo[1], Dr Petrus van der Walt[1]

[1]Rhodes University. [2]Unisa

Abstract

The interaction of gravitational waves (GWs) passing through matter is normally treated as being very weak. In a series of recent papers, we re-investigated this issue using linearized perturbations within the Bondi-Sachs formalism. We found, as expected, that the effect is very weak when the matter is far from the GW source, but when close to the source the interaction can be very significant. We consider a GW source surrounded by a spherical shell of matter. The shell causes the GWs to be modified both in magnitude and phase; and if the shell is viscous, then the shear induced in the velocity field results in an energy transfer so damping the magnitude of the GWs and heating the fluid. All these effects can be significant if the shell radius is comparable to the GW wavelength. There are astrophysical scenarios for which the modification to the GW signal and/or the fluid heating is large enough to be measurable. These include GW damping and heating in core collapse supernovae (CCSNe), and quasinormal mode emission from the remnant of a binary neutron star (BNS) merger; if matter is present at a binary black hole merger, it can be heated sufficiently to cause an X-ray or gamma-ray burst; and primordial GWs may be completely damped.

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Advancing gravitational wave searches with southern hemisphere pulsar timing arrays

Dr Daniel Reardon

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Abstract

The Parkes Pulsar Timing Array (PPTA) is a major project on the Parkes 64-m radio telescope (Murriyang), with the primary aim of detecting nanohertz-frequency gravitational waves (GWs). A background of GWs (GWB) modulates pulsar arrival times and manifests as a stochastic process, common to all pulsars, with a signature spatial correlation. The PPTA commenced in 2004 and is the longest-running pulsar timing array (PTA) experiment. Now, 20 years later, the MeerKAT pulsar timing array (MPTA) has rapidly overtaken the PPTA as the most sensitive in the southern hemisphere. In this talk I summarise the 2023 search for an isotropic stochastic GWB using the third data release of the PPTA, and discuss the future role of the PPTA in supporting nanohertz-frequency GW discoveries. Using the results of a noise analysis of the MPTA, I will outline the future observing strategies required to optimise southern hemisphere sensitivity to a GWB. Parkes will continue to have an important role in observing the brightest southern pulsars that are often jitter-limited with MeerKAT. The MPTA observing strategy will leverage the multiple excellent receiver systems to best characterise chromatic noise processes (dispersion measure and scattering variations). Chromatic noise measurements will be supported by PPTA observations over an ultra wide continuous wide bandwidth.

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The Two-Point Correlation Function of the GRBs

Zsolt Bagoly[1,2], Istvan Horvath[1]

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Abstract

The Spatial Two-Point Correlation Function for GRBs with redshifts was determined by partitioning the data based on the origin of the redshift (afterglow or host galaxy). Our analysis which aimed at identifying potential correlations between GRB redshift and sky position revealed only one anomaly: the Faraway GRB Patch, where nine distant GRBs exhibited deviation from randomness at a 1% significance level. This suggests that the spatial distribution of GRBs can be decomposed into separate sky and radial components, each independently determinable. Using kernel smoothing techniques we determined the Sky Exposure Function and applied it. There's no difference between the random datasets Two-Point Correlation estimators and the estimators obtained from the real datasets (i.e. all data and subsets based on afterglow or host galaxy origins of redshifts) .

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Distribution of Gamma-Ray Burst distances

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Abstract

A little less than 600 precise distance observations of gamma-ray bursts have been made. Regretfully, after examining the trend of GRB sightings, we discovered that there are progressively less redshift measurements. Several studies have shown enormous structures in the universe based on GRBs, but in order to investigate the relationship between GRBs and traditional cosmological structures, we need to know the spatial position of a magnitude more GRBs. We analyzed the distribution of the GRBs' distances to estimate the distances of those GRBs without redshift measurements from the over 100 observed properties in the GRB catalogs. We provide a potential approach to calculate Swift GRB distances based on observed parameter values.

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Massive Algols as whetstones for the progenitors of stripped-envelope supernovae and gravitational wave sources

Koushik Sen[1], Norbert Langer[2], Daniel Pauli[3], Goetz Gräfener[2], Abel Schootemeijer[2], Hugues Sana[4], Tomer Shenar[5], Laurent Mahy[6], Chen Wang[7]

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Abstract

All except one mass transfer episode in the isolated binary evolution channel occur at short timescales and, hence, are difficult to observe. This leads to many unconstrained assumptions in modelling mass transfer phases. The uncertainties percolate through our understanding of progenitors of stripped-envelope supernovae and gravitational wave mergers. As the only exception, the nuclear-timescale so-called 'slow Case A' mass transfer phase in short-period binaries has many Algol binaries as observational counterparts. Since a thermal timescale mass transfer precedes the slow Case A phase, in-situ constraints on stellar and binary physics assumptions, such as mass transfer efficiency, tidal strength and internal mixing, can be obtained through population synthesis studies of massive Algols. I will discuss the current state-of-the-art modelling and observations of these binaries and our identification of a novel outcome from this binary evolution channel, namely the 'reverse Algols'. We identified semi-detached binaries where the more massive star transfers mass to a less massive companion on a nuclear timescale. We also found that binary stripping can form Wolf-Rayet binaries on the main sequence with identified observational counterparts. Our population synthesis results predict ~5% of massive binaries (30-90 Msun) in the main sequence from the reverse Algol channel. We derived the predicted distribution of orbital periods, mass ratios, rotational velocities, and surface abundances of these binaries using a grid of ~100,000 detailed binary evolution models at a metallicity suitable for the Large Magellanic Cloud.

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Leveraging direct and indirect multi-messenger observations of merging neutron star binaries

Dr Nikhil Sarin

Stockholm University

Abstract

A neutron star binary merges somewhere in the Universe approximately every 10 to 1000 seconds, creating violent explosions potentially observable in gravitational waves and across the electromagnetic spectrum. The transformative coincident gravitational wave and electromagnetic observations of the binary neutron star merger GW170817 gave invaluable insights into these cataclysmic collisions and fundamental astrophysics. However, despite our high expectations, we have failed to see any other event like it. In this talk, I will highlight what we can learn from other observations of mergers seen directly in gravitational waves or indirectly as a gamma-ray burst and/or kilonova. I will also discuss the diversity in electromagnetic and gravitational-wave emission we can expect for future mergers and showcase tools to help maximally extract physics from existing and future observations.

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The nanohertz-frequency gravitational-wave sky

Ryan Shannon

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Abstract

The detection and study of nanohertz-frequency gravitational radiation is the primary goal for pulsar timing arrays (PTAs). The most likely source of gravitational waves in this band is from supermassive black hole binaries (SMBHBs). A stochastic background produced from the entirety of the SMBHBs in the Universe is thought to be the first signal discovered by PTAs. Significant decades-long efforts using the world's largest radio telescopes have been seeking this long-sought signal. Last year was seminal for the community, with multiple international efforts announcing the results of the most sensitive searches to date. I first review how pulsar timing arrays can be used to search for gravitational waves and the science they prosecute. I then discuss the results on the 2023 searches, which showed tantalising evidence for a gravitational wave background. I will then outline the what is needed to make a compelling detection and study the nanohertz-frequency gravitational wave sky. I will introduce the MeerKAT pulsar timing array (MPTA), an 83-pulsar array that has been utilising South Africa's MeerKAT radio telescope for the last five years. I will motivate its strategy designed to maximise sensitivity to a background and assess the array's performance. I also present results from searches of the latest MPTA searches, and compare the surprising findings to those of the other longer-duration projects. I conclude by discussing post-detection science with PTA experiments, highlighting the vital role MeerKAT and the Square Kilometre Array will play in studying the gravitational-wave Universe.

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Where do neutron stars get their mass from?

Dr Marisa Geyer

University of Cape Town

Abstract

And how did the MeerKAT get its stripes? As in a children's book, observing intriguing phenomena such as large ranges in neutron star (NS) masses, is the easier part of a discovery. Understanding how such phenomena came to be, is far more ambiguous.

The Meertime Relativistic Binary programme running on the MeerKAT telescope in South Africa, is actively weighing neutron stars across many relativistic binary systems that contain a pulsating neutron star (or pulsar) and a white dwarf or main sequence companion. Optimal results through high precision pulsar timing are achieved by conducting dedicated orbital campaigns during superior conjunction at UHF and L-band frequencies.

I will highlight the results of studying a set of relativistic binaries and their implications for NS masses, including PSRs J1933-6211, J1614-2230 and J1902-5105. PSR J1902-5105, analysed as part of a student project collaboration, is the most massive NS yet found in MeerKAT data, and at the edge of challenging NS formation theories and the physics of their interiors.

PSR J1933-6211 is a relatively rare system where the analysis of both its kinematic and relativistic orbital parameters, allowed us to fully map its 3D orbital geometry and to obtain accurate mass estimates of both the pulsar and its companion. These measurements solved the mystery of the nature of PSR J1933-6211's companion, and in analogy to the PSR J1644-2230 binary strengthens the case for NS being massive not through accreting matter but *because, just like how the MeerKAT got its stripes, they were born that way.*

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The MeerKAT Pulsar Timing Array: Towards the detection of nanohertz-frequency gravitational waves

Doctor Matthew Miles[1,2], Professor Ryan Shannon[1,2]

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Abstract

The signal that is most sought after in pulsar timing array experiments is that of a stochastic gravitational wave background: the superposition of all nanohertz-frequency gravitational waves emitted in the observable Universe. Recently, a number of pulsar timing arrays have unveiled modest evidence of a spatially correlated signal. This signal, if correct, is thought to be representative of a background of gravitational waves from inspiralling supermassive black hole binaries. However, in order to make a definitive detection, it is necessary to observe pulsars over a longer timing baseline, monitor a larger ensemble of pulsars, time pulsars to higher precision, or all. Here, we introduce The MeerKAT Pulsar Timing Array. The array monitors a large number of pulsars (83), to high precision, and at the highest cadence of any extant pulsar timing array. In the pursuit of a definitive detection of nanohertz-frequency gravitational waves, it now joins the others in searching its dataset for signals indicative of a stochastic gravitational wave background, and entertains more exotic explanations for the surprising results found in this search.

In this presentation, we describe the process of analysing the highly sensitive data of the array, and present the detailed results of these searches.

Session

IAUS 389 Gravitational Wave Astrophysics

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Gearing up for efficient detection of gravitationally lensed gravitational wave sources

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Abstract

Gravitational lensing of gravitational waves (GW) offers exciting prospects to study astrophysics and cosmology. We expect to detect lensed GW within the next few years. We developed ranking statistics that improves the significance of pairs of lensed events by considering joint constraints from lensing properties. Additionally, we demonstrated that if the joint constraints are ignored then we may get more false positives.

Since lensed GW sources with electromagnetic (EM) counterparts will provide the best constraints on the Hubble constant compared to other lensed transients and can potentially be used for giving an early warning for the subsequent lensed GW counterparts. This can help in studying the pre-merger stages of such GW sources. Note the lensing magnification may boost their signals making them easier to detect. We estimate the lensing rates and determine, for example, that the lensed events with arrival times of more than a day could be predicted several hours ahead of time assuming angular resolution of 0.05 arcsec from the EM data.

We also present a neural network which analyses the Q-transform maps (QT maps) and the Sine-Gaussian Projection maps (SGP-maps). The network does not depend on results from GW parameter estimation (PE) and can be run even prior to the PE. We find that the efficiency of our model is higher compared to previous work. When combined with sky localisation constraints, we hope to get unprecedented accuracy in the predictions than previously possible. The network correctly classifies known (O2-O3) real GW events, consistent with non-detection of lensing.

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Effect of Gravitational Waves on Free Particles

Profesor Amare Abebe

Space Science and Geospatial institute, Entoto Observatory and research center

Abstract

The space-time is effectively flat outside the wave front (before and after the wave passes), and the particles under study are free except from the wave's gravitational pull. Rather than searching for specific characteristics of the gravitational field or gravitational energy. Once more, if the black hole or quickly spinning neutron star is left behind by the shock-driven expansion of a bright shell following the core collapse of a massive star, and if the core has a mass greater than or equal to two or three times that of the solar mass. The effectiveness with which this mechanism generates gravitational waves and detection, however, is yet largely unknown. An precise spherical collapse, for instance, won't result in any gravitational radiation. Our goal is to study the properties of free particles and collect data on the behavior (variation) of the gravitational field properties or the gravitational waves' underlying information. The method that we can utilize General Relativity (GR) to measure a warped geometry of space and time. The geometry of a local patch, whose size is selected to be small enough that tidal effects are insignificant, and the speed of light are the two objects in GR that are unaffected by gravity. Solving the Einstein field equation will allow us to examine light propagation in gravitational wave geometry and gain an understanding of how beam detectors operate.

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Latest results from LIGO / Virgo / KAGRA collaborations

Sylvia Biscoveanu

invited speaker

Abstract

invited speaker

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Formation of merging compact object binaries

Floor Broekgaarden

invited speaker

Abstract

invited speaker

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Future gravitational-wave detectors

Stefan Ballmer

invited

Abstract

invited speaker

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Electromagnetic counterparts of compact binary mergers

Kenta Hotokezaka

invited

Abstract

invited speaker

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Probing neutron star physics with gravitational waves

Jocelyn Read

invited

Abstract

invited speaker

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Testing general relativity with gravitational waves

Jonathan Gair

invited

Abstract

invited speaker

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Studying the southerly eclipsing millisecond pulsar J1748−2446A using MeerKAT

Senate Lekomola

University of Cape Town

Abstract

In this discussion we will be focusing on the changes of the dispersion measure (DM), rotation measure (RM) and scattering characteristics of PSR J1748-2446A. PSR J1748-2446A is a "spider" binary in Terzan 5 where the pulsar blasts the surface of its orbiting companion star away. We used data from the MeerKAT telescope at L-band frequencies to look at the complex eclipse of this spider binary. Our observations of PSR J1748-2446A revealed that its radio emissions experienced an increase in DM as it moved into and out of eclipse phases. We also observed a change in the rotation measure up to tenfold compared to the initial RM value. We noted distinctive pulse widening, which can be attributed to multi-path propagation effects in the signal, and for the first time for this pulsar, we quantified the scattering time. Because measured the changes in DM and RM, we estimated the magnetic field strength of the companion's material to be an order of magnitude greater than that of the Crab Nebula. We have also estimated RM values deep into the eclipse to be about 20 times the initial value. Our findings inform us that the companion material is an ionised and turbulent magnetised plasma, with electron densities and density variations much higher than the typical interstellar medium.

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Unequal-mass, highly-spinning binary black hole mergers in stable mass transfer formation channel

Dr. Aleksandra Olejak[1], Dr. Jakub Klencki[2], Dr. Xiao-Tian Xu[3], Dr. Chen Wang[1], Prof. Selma de Mink[1], Dr. Stephen Justham[1]

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Abstract

The growing database of gravitational wave (GW) detections with inferred parameters of merging black holes (BH-BH) contains non-obvious insights into their formation scenarios. Interactions in massive star binaries in the form of stable or unstable mass transfer are expected to accompany the formation of GW sources. Those interactions would leave characteristic fingerprints in the parameters (masses and spins) of detected BH-BH systems. Their identification could help in constraining poorly understood parts of stellar evolution. We show that stable mass transfer formation scenario followed by efficient tidal spin-up of stripped helium core may result in a characteristic pattern in effective spin vs mass ratio distributions of merging BH-BH, similar as reported for current GW detections. In particular, the progenitors of unequal BH-BH systems in the stable mass transfer formation scenario are more likely to efficiently shrink their orbits during the second Roche Lobe Overflow than the binaries that evolve into nearly equal mass component systems. That makes it easier for unequal-mass progenitors to enter the tidal spin-up regime and later merge due to GW emission. Our results are, however, sensitive to highly uncertain assumptions on angular momentum loss. We conclude that a significant fraction of unequal-mass BH-BH mergers among the future GW detections could indicate the contribution of a stable mass transfer formation channel. Such a population would be consistent with the mass ratio reversal scenario during the first, relatively conservative mass transfer, and low angular momentum loss during the second, highly non-conservative mass transfer phase.

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Hunting for Gravitational Wave Electromagnetic Counterparts: Introduction to the 7-Dimensional Telescope

Dr. Ji Hoon Kim[1], Professor Myungshin Im[1,2], Dr. Seo-Won Chang[1], Mr. Gregory Paek[2], Mr. Hyeonho Choi[2]

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Abstract

As the main observational facility of the Center for the Gravitational-Wave Universe at Seoul National University, the 7-Dimensional Telescope (7DT) is a multi-telescope system designed to identify electromagnetic (EM) counterparts of gravitational wave (GW) sources. Consisting of 20 50-cm commercial off-the-shelf telescopes along with 40 medium-band filters of 25 nm full width at half maximum, 7DT can obtain IFU-like data with low spectral resolution (R=30~70) spectra for all astronomical objects within a large field of view (~1.25 square degrees) only with two exposures. This multi-object spectral imaging capability along with flexible operation, real-time data reduction, and analysis enable 7DT to follow up GW events quickly and to discover EM counterparts with unmatched efficiency. As of February 2024, 12 of the 20 planned telescopes are deployed at El Sauce Observatory which is located at Rio Hurtado Valley in Chile and hosted by ObsTech SpA. We obtained the first light of 7DT in October 2023. Since then, we started its commissioning procedures including examination of bias levels, master flat production, and spectrophotometric standardization by calibrating CALSPEC data against Gaia DR3 XP spectra. In this talk, we present details of instruments and their set-up, operation procedures, commissioning procedures, and data characteristics of 7DT. We also present two real-time machine learning classifiers that distinguish transients from interlopers based on the image subtraction method and kilonovae from other transients based on their spectra. The design and planning for our three-layered surveys that started in early 2024 are also introduced.

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Simulations of coalescing compact binary populations based on X-ray surveys and their merger rates detectable with LIGO/VIRGO and KAGRA

Mr Lutendo Nyadzani

University of Johannesburg

Abstract

LIGO's detection of gravitational waves (GWs) in 2015 marked a pivotal moment in astrophysics. Subsequent observations have shed light on the masses and distances of the compact objects, yet their evolutionary pathways remain debatable. This project investigates different formation channels of double compact objects (DCOs) using ultra-luminous X-ray (ULX) sources as tracers. ULXs, emitting above the Eddington limit, pose questions about their power sources, potentially ranging from intermediate-mass black holes (IMBHs) to beamed emissions from stellar mass black holes or super-Eddington accretion onto neutron stars.

Our analysis integrates theoretical simulations with observational data to refine our understanding of these objects. We employ the COSMIC population synthesis code to simulate the evolution and formation of DCO systems, focusing on systems transitioning through the ULX phase and aiming to distinguish their formation mechanisms. We compare the simulated ULX populations with observational data in the X-ray and optical bands. Additionally, we estimate merger and detection rates of DCOs emerging from ULX progenitors, which is crucial for GW observatories like LIGO/Virgo and KAGRA.

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Stellar-mass binary black hole mergers from young massive clusters, open clusters, and isolated binaries

Dr. Sambaran Banerjee[1], Dr. Aleksandra Olejak[2]

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Abstract

In the first part, I shall recapitulate our recent endeavours in investigating the role of dynamical interactions in moderate mass star clusters in producing stellar-mass binary black hole (BBH) mergers over cosmic time. Dynamical BBH mergers are obtained from long-term direct N-body evolutionary models of ~10^4 M_sun, pc-scale young massive clusters evolving into moderate-mass open clusters. These models consistently include state-of-the-art stellar-remnant black hole and neutron star masses and natal kicks, (pulsation) pair-instability supernova, black hole spins, post-Newtonian treatment, and general-relativistic recoil kicks. The resulting BBH merger rate and its cosmic evolution are compared with those from the LIGO-Virgo-KAGRA observations. I shall then demonstrate a new, in-progress model grid that incorporates the effect of external, galactic tidal field on clusters. This homogeneous grid spans over galactocentric distances 1.0-8.5 kpc. While strong tidal field dissolves the clusters much faster, it also accelerates their core collapse, favouring interactions among the clusters' BHs, so that the BBH merger is not quenched. I shall demonstrate how various galactic star formation profiles modify BBH mergers' properties, e..g., their delay time distribution. In the second part, I shall present preliminary results from our population synthesis study of BBH mergers from isolated (field) binary evolution. The new aspect here is the explicit inclusion of interacting-binary tidal spin-up of Wolf–Rayet stars within the fast binary evolution code 'BSE'. We show that this naturally and without any post-processing results in a somewhat positively biased effective spin parameter distribution in present-day BBH mergers, as observed GW events suggest.

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Massive binary black hole mergers from Population II and III stars

Dr. Guglielmo Costa

Centre De Recherche Astrophysique De Lyon (CRAL)

Abstract

Population III (Pop III) stars are almost metal-free stars, born from the primordial gas in the Universe. The almost total absence of metals impacts their initial mass function distribution (predicted to be top-heavy), their evolutionary path, and their final fate. Moreover, they lose a negligible fraction of their mass via stellar winds during their life. Such properties make them ideal massive black hole progenitors. In this talk, I will present the new models of Pop III stars computed with the PARSEC stellar evolutionary code. Then, I will show the large sets of Pop III and Population II binary populations we computed with the SEVN code used to study the main formation channel of binary black hole mergers. We find only mild differences between binary BH (BBH) mergers properties born from Pop III and II stars, especially if we adopt the same initial mass function and orbital properties. Most BBH mergers born from Pop III and II stars have the primary BH mass below the pair-instability gap, and the maximum secondary BH mass is < 50 Msun. Moreover, we find that, unlike metal-rich binary stars, the main formation channel of BBH mergers from Pop III and II stars involves only stable mass transfer episodes in our fiducial model.

Studies like this are fundamental in advancing our understanding of binary black hole merger formation scenarios and enhancing our interpretation capabilities of data from gravitational wave detection from current and next-gen observing facilities.

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The effect from uncertainties within cosmological simulations on the binary black hole merger population

Sasha Levina[1], Floor Broekgaarden[2,3,1], Lieke van Son[4,5], Emanuele Berti[1]

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Abstract

The binary black hole (BBH) merger rate and properties across redshift depend on the metallicity-dependent star formation rate density (SFRD) over cosmic history. We probe underlying assumptions about the star formation rate history and cosmic enrichment in the IllustrisTNG cosmological simulations by analytically modeling the SFRD(Z, z) in TNG50, TNG100, and TNG300. We then use the rapid population synthesis code COMPAS to calculate the primary mass distribution of locally merging BBHs in each simulation. Understanding the merger rates and properties over varying redshift will be crucial to gaining insight into stellar and binary evolution processes, formation channels, and enrichment processes over cosmic history by testing how models align with observational data from future gravitational wave detectors.

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Predictions for the Maximum Masses of Black Holes below the PI Boundary

Mr Ethan Winch[1,2], Prof Jorick Vink[1], Dr Erin Higgins[1], Dr Gautham Sabhahit[1]

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Abstract

While the initial discovery of GW150914 resulted in the detection of black holes larger than initially expected, it was the GW190521 event which truly challenged astrophysical assumptions about stellar evolution and black hole progenitors, as the components of GW190521 were firmly within the traditional Pair-Instability (PI) mass-gap – a range of masses where no black holes were expected to be created due to PI supernovae (PISN). We investigate the possibility that this merger involved first generation black holes, and that the unexpectedly heavy 85 solar mass BH could be produced from fundamental stellar physics. We present the results of studies involving the stellar evolution code MESA, as we systematically vary several parameters of stellar physics (in particular mixing and mass loss) to test assumptions and build a population of potential black hole progenitors within the traditional PI gap.

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Ameliorating transient noise bursts in gravitational-wave searches for intermediate-mass black holes

Melissa Lopez

Utrecht University

Abstract

The direct observation of intermediate-mass black holes (IMBH) populations would not only strengthen the possible evolutionary link between stellar and supermassive black holes, but unveil the details of the pair-instability mechanism and elucidate their influence in galaxy formation. Conclusive observation of IMBHs remained elusive until the detection of gravitational-wave (GW) signal GW190521, which lies with high confidence in the mass gap predicted by the pair-instability mechanism. Despite falling in the sensitivity band of current GW detectors, IMBH searches are challenging due to their similarity to transient bursts of detector noise, known as glitches. In this work, we enhance a matched-filter algorithm using Machine Learning. In particular, we build a multi-layer perceptron network to perform a multi-class classification of the output triggers of matched-filter. In this way, we are able to distinguish simulated GW IMBH signals from different classes of glitches that occurred during the third observing run (O3). We correctly classify over 90% of simulated IMBH signals in O3a and over 70% in O3b in single detector data. Furthermore, we identify 58 real GW signals from several public GW catalogs, including GW190521, with probability of being a GW signal > 0.8.

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Forming merging double compact objects with stable mass transfer

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Abstract

Binary compact objects merging within the age of the Universe and emitting gravitational waves (GWs) are a possible endpoint of the evolution of binary stellar systems. A mass transfer episode between the two stellar companions through Roche-lobe overflow can provide the sufficient orbital tightening. In particular, a quiet, long lived phase of tightening of the system's orbit, the "stable mass transfer" channel, can prevent the system to prematurely merge unstably into a common envelope, allowing the binary to survive until the formation of both compact remnants and their inspiral phase. The conditions under which the stable mass transfer channel operates in place of the common envelope is still a matter of debate, as many population synthesis studies work under the assumption of arbitrary thresholds on the mass ratio of the systems. Using detailed models of binary interaction, we assess the potential of stable mass transfer. We present a semi-analytical solution for the conditions for stable mass transfer evolution and assess whether or not a stably evolved binary is able to merge in less than a Hubble time by computing the resulting orbital hardening. Our results imply that the conditions for the stable mass transfer channel are not a simple function of the mass ratio of the binary, but need to account for the angular momentum loss mechanism, the initial orbital parameters and the internal properties of the stars. The pairings of compact objects inferred by GW data are, by now, comprising double black holes, double neutron stars, neutron star + black hole pairs. We demonstrate that any pair, including coalescing white dwarfs and black holes merging with neutron star companions, can be formed via stable mass transfer; the channel is also able to reproduce most of the final mass ratios and total masses inferred from the third Gravitational Wave Transient Catalogue.

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Impact of 300 - 1000 MHz observations on the sensitivity of PTA data-sets

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Abstract

Pulsar Timing Array experiments (PTAs) have recently uncovered compelling evidence of ultra-long wavelength gravitational waves (GWs). The current significance of this evidence is likely to increase with a combination of data from different PTAs under the auspices of the International Pulsar Timing Array consortium (IPTA). The sensitivity of these data is impacted by applied noise models for white noise as well as time-correlated noise, which could be dependent/independent on the observing radio frequency. Wide-band observations of radio pulsars between 300-1000 MHz provide critical information on the slow time-correlated variations in ionised interstellar medium (IISM) for constraining not only frequency dependent time-correlated IISM noise models, but also significantly reducing any leaks to frequency independent time-correlated spin noise. Motivated by encouraging results in the recent joint analysis by the InPTA+EPTA data set, we examine the impact of low frequency data on robust noise models using simulations as well as analysis of recent InPTA data. We also evaluate the impact of these noise models on the mild-tension between the expected and reported spectral-index of an astrophysical origin of background. Our results suggest that

multi-band concurrent observations in the upcoming SKA telescope are needed to significantly reduce the noise floor in the data allowing a much larger probability of detection of individual supermassive black hole binary system, which is the next milestone for PTA experiments.

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HeII Outflows in the X-ray Outbursts of the Dipping BH X-ray Transient Swift J1357.2-0933 - Velocity Shifts during the Dips

Prof Phil Charles[1,2], Dr James Matthews[3], Mr Jaco Brink[4,5,6], Prof David Buckley[4,5], Prof Poshak Gandhi[1], Dr John Paice[7]

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Abstract

The short orbital period (~3hr) X-ray transient, Swift J1357.2-0933, exhibits two unique properties amongst all LMXBs: (i) during its outbursts, it displays regular optical dips whose recurrence periodicity is not related to P_orb, but which changes smoothly as the outburst progresses, from ~2 to 8 mins (Corral-Santana et al 2013, Science 339, 1048), and can even extend into quiescent intervals (Panizo-Espinar et al arXiv:2311.03460); (ii) time-resolved spectroscopy through these dips has revealed short-lived broad Balmer and HeII absorption features, the latter never having been seen before in an LMXB (Charles et al 2019 MNRAS 489, L47). This was successfully modelled as an intrinsically high X-ray luminosity irradiating the accretion disc surrounding a ~10Msun BH, thereby producing structure in the disc winds. Such an explanation implies an extremely high orbital inclination, which has also been inferred from independent analyses (e.g. Casares et al 2022 MNRAS 516, 2023).

Here we present further time-resolved spectroscopy through the dips of J1357.2, as part of its 2019 and 2021 outbursts. With better temporal and spectral resolution, we not only detect the Balmer and HeII absorption features again, confirming the behaviour seen in 2017, we also see them moving in radial velocity from ~ -1500 to -800 km/s *during* the dips themselves, behaviour also never seen before. This provides even more detail on the properties of the accretion disc wind, an essentially unique opportunity amongst all these systems.

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Exploring Peculiar Short GRBs: A Systematic Search within the Third Swift Catalog

Mr Nicolás Noriega[1], Mr Esteban Cardenas[1], Mrs Jennifer Chacón[2], Mr Jonathan Quirola[3], Mr Nicolás Vásquez[1]

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Abstract

GRBs are candidates for gravitational wave emitters, and peculiar GRBs could be a new object to study in multimessenger astronomy. In this study, we analyze four peculiar Gamma-Ray Bursts (GRBs), namely GRB070724A, GRB070429B, GRB090426, and GRB120804A, all detected by the Swift space telescope.

Those GRBs are the result of a systematic search from the Third Swift GRB catalog recalibrating Epeak and isotropic energy. Our investigation evaluates temporal estimators, such as emission time, spectral lag, and isotropic energy among others, extracted from data Swift GRB observations. Our findings reveal that the calculated temporal estimators offer diverse insights into the classification of the examined GRBs, hinting at the distinctive nature of these events, suggesting that these GRBs are candidates for being "peculiar" when compared to typical Gamma-Ray Bursts in the spectral plane, specifically in the Amati-like relations.

As the next phase in our research, we are contemplating an expansion of the analysis, entailing enhancements in data management and a comprehensive exploration of the spectrum of events, among other aspects.

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EMGW science with the *Daksha* high-energy transients mission

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Abstract

Daksha is a proposed Indian high-energy transient mission that will consist of two satellites covering the entire sky from 1 keV to >1 MeV. The primary objectives of the mission are to discover and characterise electromagnetic counterparts to gravitational wave source (EMGW); and to study Gamma Ray Bursts (GRBs). With its broadband spectral response, high sensitivity, and continuous all-sky coverage, it will discover fainter and rarer EMGW sources than any other existing or proposed mission. *Daksha* can make key strides in GRB research with polarisation studies, prompt soft spectroscopy, and fine time-resolved spectral studies. In addition to the main science goals, *Daksha* is a versatile all-sky monitor that can address a wide variety of science cases such as monitoring of X-ray pulsars, detection of magnetar outbursts and high energy counterparts to Fast Radio Bursts, solar flares, Earth occultation imaging of persistent sources, detection and characterization of Terrestrial Gamma-ray Flashes and probing primordial black holes through lensing. In this talk, I will present the overall mission details and the science case for *Daksha* with particular focus on *Daksha*'s contribution to EMGW science.

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The candidate binary SMBH in the blazar OJ 287: no longer in the PTA regime, but a LISA precursor

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Abstract

Binary supermassive black holes (SMBHs) are the loudest sources of gravitational waves (GWs) in the Universe in the frequency regime accessible by future space-based GW interferometers.
Binary SMBHs form and evolve in the course of galaxy mergers, and as the BHs undergo major episodes of accretion as well as ejection in form of winds and jets, they not only shape the galaxy core environment, but also represent important multi-messenger sources themselves.
Therefore, an intense search for wide and close systems of binaries is ongoing. The most compact systems, far beyond the final parsec in their evolution, can no longer be spatially resolved into two separate black holes, and we therefore rely on indirect methods to search for such binaries. The most common of these methods makes use of (semi-periodic) signals in lightcurves.

The blazar OJ 287 is one of the best-known candidates for harboring a compact binary system. Multiple binary models for OJ 287 have been explored in the past which make distinctly different predictions for the lightcurve variability mechanisms, as well as for the orbital parameters and the masses of the two black holes. Based on the project MOMO we have obtained multiple tight new constraints on the different binary models. We present the results of these tests. In particular, the low measured primary SMBH mass of 10^8 M_sun implies that OJ 287 no longer is a source for soon-to-come pulsar timing arrays (PTAs), but rather is a candidate precursor to coalescing binaries in the LISA sensitivity regime.

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Mitigating Parametric Instabilities with Mechanical Dampers in Current and Future Gravitational Wave Detectors

Audrey Couineaux[1], Valentina Mangano[2], Paola Puppo[2], Piero Rapagnani[3]

[1]Institut of Acoustic Graduate School (IAGS) - Le Mans université. [2]INFN Roma. [3]Università degli Studi di Roma Sapienza Dipartimento di Fisica + INFN Roma

Abstract

To enhance the sensitivity of gravitational wave detectors, it is crucial to reduce noise within the 10 Hz to 10 kHz frequency range. One effective method is to decrease shot noise by increasing the laser power. This allows the achievement of noise specifications expected for the upcoming observation runs of Advanced Virgo and Advanced LIGO detectors, as well as for third generation detectors. However, employing a high power laser may result in undesirable effects known as Parametric Instabilities (PI), impacting the instrument's efficiency. These instabilities occur in an optical cavity due to the interaction between some optical and mechanical modes of the mirrors with very high quality factors and when the light power is very high (hundreds of kW). To mitigate the effect, a system has been developed to prevent the triggering of instabilities. Small oscillators resonating at the critical frequencies and with a low quality factor are attached to the lateral surface of the mirrors. Due to coupling effect between the damper's mode and mirror's mode, the quality factor of the mirror's mode is reduced, and so allows for the reduction of the risk of triggering instabilities. We present the latest results of various types of dampers tested on a suspended small fused silica substrate placed in a vacuum chamber at room temperature, as part of the effort to set up dampers for the Advanced Virgo interferometer.

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Exploring the Impact of Ejecta Velocity Profile on Kilonova Evolution: Diversity of the Kilonova Lightcurves

Dr. Z. Lucas Uhm

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Abstract

A kilonova is a short-lived explosive event in the universe, resulting from the merger of two compact objects. Despite its importance as a primary source of heavy elements through r-process nucleosynthesis, its nature is not well understood, due to its rarity. In this work, we introduce a model that determines the density of a radially-stratified relativistic ejecta. We apply the model to kilonova ejecta and explore several hypothesized velocity profiles as a function of the merger's ejection time. These velocity profiles result in diverse density profiles of the ejecta, for which we conduct radiative transfer simulations using TARDIS with the solar r-process composition. Consequently, we investigate the impact of the ejecta velocity profile on the resulting lightcurve and spectral evolution through the line transitions of heavy elements. The change in the rate at which these elements accumulate in the line-forming region leaves its imprint on the kilonova lightcurve at specific wavelengths, causing the lightcurves to decay at different rates. Furthermore, in several profiles, plateau-like behaviors (slow and/or flat decline) are also observed. In conclusion, this work proposes potential scenarios of the kilonova evolution due to the ejecta velocity profile.

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Bayesian Inference of the Hubble constant from Cross-Correlation of Individual Gravitational Wave Events with Galaxies

Tathagata Ghosh[1], Surhud More[1,2], Sayantani Bera[3], Sukanta Bose[4]

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Abstract

Gravitational waves (GW) from the inspiral of binary compact objects offer a direct way to measure the luminosity distance to the event, which is essential for estimating the expansion rate of the Universe, called the Hubble constant. However, unlike binary neutron stars, the inspiral of binary black holes is not expected to be accompanied by electromagnetic radiation. Thus, a subsequent determination of its redshift using the traditional host identification method is not possible. Therefore, independent redshift measurements of such GW events are necessary to measure the Hubble constant. Current state-of-the-art methods that perform statistical host identification in existing galaxy catalogs are limited by the completeness of such catalogs. In this study, we present a novel Bayesian method, which is less sensitive to the completeness of the galaxy catalog, to infer the Hubble constant from the cross-correlation between galaxies with known redshifts and individual binary black hole merger events. We demonstrate the efficacy of our method with 250 simulated GW events distributed within 1 Gpc in colored Gaussian noise of Advanced LIGO and Advanced Virgo detectors operating at O4 sensitivity. We show that such measurements can constrain the Hubble constant with a precision of 15% or less (90% highest density interval). We also discuss the potential improvements that are required before applying this method to the real data.

Session

IAUS 389 Gravitational Wave Astrophysics

1307

Identifying the Heavy Element Signatures in Kilonovae: How Kilonova Ejecta Properties Affect Its Spectrum and Lightcurve.

Dr Donggeun Tak[1], Dr. Z. Lucas Uhm[2]

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Abstract

A merger of a compact binary system produces electromagnetic emissions through a delicate interplay of physical processes, involving r-process nucleosynthesis and interactions between heavy elements and photons via radiative transfer. This phenomenon is called kilonovae. Due to its complexity and rarity, comprehensive understanding of its spectrum and lightcurve has been limited. To enhance our understanding and establish connections between physical parameters and observables, we conducted a series of radiative-transfer simulations. Recently, we investigated how the properties of the ejecta influence the resulting kilonova spectrum. For each species, the relative strength of its line features in the kilonova spectrum depends on the ejecta temperature and its mass, leading to the formation of a distinct region in the parameter space, where the line signature of that species is notably evident in the kilonova spectrum. We also explored the origin and applications of this region. In this talk, I will summarize our recent works on identifying the heavy element signatures in kilonovae and discuss potential challenges and future perspectives in observing heavy elements and determining their masses.

Session

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1362

Uxploring Merger Jets: A Bayesian Study of GW170817, GW190425, and the Electromagnetic Signals in Short Gamma-Rat Bursts

Ms. En-Tzu Lin[1], Dr. Fergus Hayes[2], Dr. Gavin Lamb[3], Prof. Ik Siong Heng[2], Prof. Albert K. H. Kong[1]

[1]Institute of Astronomy, National Tsing Hua University. [2]SUPA, School of Physics and Astronomy, University of Glasgow. [3]Astrophysics Research Institute, Liverpool John Moores University

Abstract

The joint discovery of the binary neutron star (BNS) merger GW170817 and short gamma-ray burst GRB170817A has shed new lights on the investigation of such system. In this work, assuming all BNSs produce GRBs, we seek to constrain the jet geometry of short gamma-ray bursts through a multi-messenger approach. Our analysis incorporates observations from two binary neutron star merger events, GW170817 and GW190425, as well as the gamma-ray prompt emission of GRB170817A and its subsequent X-ray afterglow. Additionally, we consider the observed rate of short GRBs from Swift telescope's 10 years' operation to restrain the BNS merger rate.

Session

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Exploring the Impact of Magnetic Fields on Gravitational Waves from Binary Neutron Stars

Anushka Doke, Dr R. Prasad, Dr Prayush Kumar

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Abstract

We explore the impact of strong magnetic fields on gravitational waves produced during the last stages of the inspiral of binary neutron stars in eccentric orbits. While the number of detected neutron stars with strong magnetic fields ($10^{14\text{-}15}$ G) is relatively low, their magnetic fields can potentially reach up to 10^{18} G. Neutron star binaries formed through dynamical capture may possess strong magnetic fields and a substantial eccentricity during their late inspiral stage, prompting a thorough investigation into these systems. Such magnetic fields can influence orbital dynamics by inducing additional tidal deformation in the companion (modifications to tidal love numbers), radiating orbital energy (motion of magnetic dipoles), and inducing attractive or repulsive effects based on the relative alignment of the magnetic dipoles. To quantify these effects, we analyse the change in the gravitational wave cycles, accumulated dephasing, and energy loss rates of gravitational and electromagnetic radiation. Our results indicate that magnetic fields around 10^{16} G in binary neutron stars contribute significantly to these effects, with potential detectability by third-generation gravitational wave detectors. The detection and subsequent parameter estimation of such binaries could provide valuable insights into ultra-strong magnetic fields, magnetar binaries, and the potential formation channels of such systems.

Session

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1371

On non-detection of gamma-ray bursts in three compact binary merger events detected by LIGO

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Centre for Astro-Particle Physics (CAPP) ,University of Johannesburg

Abstract

The joint detection of gravitational wave (GW) event GW170817 and the short-duration gamma-ray burst (SGRB) event GRB 170817A, marked the beginning of GW multi-messenger astronomy and confirmed that binary neutron star mergers are progenitors of at least some SGRBs. An estimated joint detection rate of 0.3 - 1.7 per year between the LIGO Hanford, LIGO Livingston and Virgo GW network at design sensitivity, and the Fermi Gamma-ray Burst Monitor was predicted. However, to date, the GW170817/GRB 170817A joint detection has been the only event of its kind so far. Taking into account that SGRBs are narrowly beamed, we propose that previous mergers involving neutron stars, were orientated such that observation of the emitted SGRB along this narrow jet was not possible. To support this hypothesis this study aims to determine the inclination of the progenitor systems for previously detected Binary Neutron Star and Black Hole Neutron Star mergers through GW analysis. This analysis is performed using BILBY, a python based Bayesian inference library, to estimate the inclination of the progenitor binaries for GW170817, GW190425, GW190917 114630 and GW200115 042309. The results obtained in this study all seems to suggest that these binaries had inclinations greater than 30◦ with respect to the line of sight from Earth. From observations of GRB 170817A, we set 33◦ as the upper bound on the viewing angle of a SGRB. This then suggests that the observation of the emitted SGRB from these past mergers was not possible

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Bimodal black-hole mass distribution and chirp masses of binary black-hole mergers

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Abstract

In binary black-hole mergers from isolated binary-star evolution, both black holes are from progenitor stars that have lost their hydrogen-rich envelopes by binary mass transfer. Envelope stripping is known to affect the pre-supernova core structures of such binary-stripped stars and thereby their final fates and compact remnant masses. In this paper, we show that binary-stripped stars give rise to a bimodal black-hole mass spectrum with characteristic black-hole masses of about 9 and 16 solar masses across a large range of metallicities. The bimodality is linked to carbon and neon burning becoming neutrino-dominated, which results in interior structures that are difficult to explode and likely lead to black hole formation. The characteristic black-hole masses from binary-stripped stars have corresponding features in the chirp-mass distribution of binary black-hole mergers: peaks at about 8 and 14 solar masses, and a dearth in between these masses. Current gravitational-wave observations of binary black-hole mergers show evidence for a gap at 10-12 solar masses and peaks at 8 and 14 solar masses in the chirp-mass distribution. These features are in agreement with our models of binary-stripped stars. In the future, they may be used to constrain the physics of late stellar evolution and supernova explosions, and may even help measure the cosmological expansion of the Universe.

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1401

Dynamical Formation of Gravitational Wave Sources and Implications for Advanced LIGO

Dr. Sourav Chatterjee, Mr. Ambreesh Khurana

Tata Institute of Fundamental Research

Abstract

The discovery of gravitational waves from mergers of compact objects (COs) such as black holes (BHs) and neutron stars have reignited interest in understanding their astrophysical formation channels. Theoretical studies have established that dense star clusters are efficient factories for the formation of CO binaries, merging binary BHs in particular. Constraining the overall production of merging binary BHs over cosmic time requires constraints on formation times, and birth structural properties for star clusters. We show that if the progenitors of today's globular clusters had masses and radii similar to those of the observed young star clusters (YSCs), then after ~12 Gyr of evolution, the surviving clusters exhibit distributions of properties very similar to today's globular clusters. Star clusters can also create BHs in the so-called upper mass gap, similar to those in GW190521. We investigate how mass-gap and intermediate-mass BHs form depending on the initial binary fraction and the fraction of high-mass stars initially in binaries. Adopting the mass-radius distributions at birth from the YSCs and using constraints from cosmological simulations on cluster formation epochs, we estimate the redshift-dependent merger rate for binary BHs from star clusters.

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Studying GRBs with INTEGRAL/IBIS-PICsIT in Preparation for the Next GW-EM Counterpart Observations

James Rodi, Angela Bazzano, Pietro Ubertini, Lorenzo Natalucci

Istituto Nazionale di Astrofisica - Istituto di Astrofisica e Planetologia Spaziali

Abstract

With the advent of gravitational wave (GW) astronomy and the detection of GW170817/GRB170817A, observatories across the electromagnetic (EM) spectrum have been preparing for the next GW trigger with an EM counterpart. The INTEGRAL satellite is no exception. The high-energy detector plane of the IBIS telescope onboard INTEGRAL covers the ~200 keV - 10 MeV energy range inside the field of view and is also sensitive to impulsive events out to ~70 deg in the range up to 2.6 MeV. However, the sensitivity is reduced past ~ 10 deg to passive lead shielding. Here we present PICsIT temporal and spectral results from GRBs 221009A and 231115A as examples of PICsIT capabilities for a future GW-EM event.

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Spectral features of ions: Ho I-III, Er I-IV, Tm I - V, Yb I - VI, Lu I-VII

Prof. Sultana Nahar

The Ohio State University

Abstract

The broad emission bump in the electromagnetic spectra observed following the detection of gravitational waves created during the kilonova event of merger of two neutron stars in August 2017, GW170817, has been linked to the heavy elements of lanthanides (Z=57-71), and a new understanding of creation of heavy elements in the r-process. The initial spectral emission bump has a wavelength range of 3000 - 7000 A, thus covering the region of ultraviolet to optical wavelengths, and is similar to those seen for lanthanides. Most lanthanides have large number of closely lying energy levels which introduce extensive sets of radiative transitions that often form broad region of lines of significant strength.

The current study explores these broad features through photoabsorption spectroscopy of 25 lanthanides ions, Ho I-III, Er I-IV, Tm I-V, Yb I-VI and Lu I-VII. With excitation only to a few orbitals up beyond the ground configurations, most of these ions cover large number of bound levels with open 4f orbital and produce tens to about hundred thousands lines that may form one or multiple broad features in X-ray to ultraviolet, optical, and infrared regions. Spectrum of each of 25 ions is presented indicating presence, shape and wavelength region of these features. The present study aims at providing improved atomic data for energies and transition parameters and predict possible features. The data have been benchmarked with available experimental data. The study finds that number of ions under the present study are possible contributors of the emission bump of GW170817.

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1485

Einstein Telescope: Detection of Binary Black Hole Gravitational Wave Signals Using Deep Learning

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Abstract

Expanding upon our prior work (Alhassan et al. 2022), where we evaluated the performance of single sub-detector data (SSDD) from the Einstein Telescope (ET) for binary black hole (BBH) detection using deep learning (DL). In this study, we explore the detection efficiency of BBHs using data combined from all three proposed sub-detectors of ET (TSDCD), employing five different lower frequency cutoffs (F_{low}): 5 Hz, 10 Hz, 15 Hz, 20 Hz, and 30 Hz, while maintaining the same match-filter Signal-to-Noise Ratio (MSNR) ranges as in our previous work: 4-5, 5-6, 6-7, 7-8, and >8. The Deep Residual Neural Network model (ResNet) was trained and evaluated for the detection of BBH gravitational wave signals using both TSDCD and SSDD. Compared to SSDD, the detection accuracy from TSDCD has shown substantial improvements, increasing from 60%, 60.5%, 84.5%, 94.5% to 78.5%, 84%, 99.5%, 100%, and 100% for sources with MSNR of 4-5, 5-6, 6-7, 7-8, and >8, respectively. In a qualitative evaluation, the ResNet model detected sources at 86.601 Gpc, with an averaged MSNR of 3.9 (averaged across the three sub-detectors) and a chirp mass of 13.632 at 5 Hz. The results demonstrate a notable accuracy improvement for lower MSNR ranges (4-5, 5-6, 6-7) by 18.5%, 24.5%, and 13%, respectively, and by 5.5% and 1.5% for higher MSNR ranges (7-8 and >8). TSDCD proves suitable for near-real-time detection and can benefit from a more powerful setup.

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1486

Kilonova evolution --- the rapid emergence of spectral features

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Abstract

Kilonovae (KNe) are one of the fastest types of optical transients known, cooling rapidly in the first few days following their neutron-star merger origin. KN spectral features go through rapid recombination transitions, with features due to elements in the new ionisation state emerging quickly. Due to time-delay effects of the rapidly-expanding KN, a `wave' of these new features passing though the ejecta should be a detectable phenomenon. In particular, the combination of large time-delays and rapid evolution implies *that isolated line features will emerge as blue-shifted absorption features first, gradually evolving into more pronounced absorption/emission P Cygni features and then pure emission features.*

We here compile a temporal series of optical/near-infrared spectra of the gravitational-wave detected kilonova AT2017gfo from 0.5 to 9.4 days – combining data from Magellan, the ANU telescope, SALT, Gemini, VLT and HST. In the union of these datasets, we show that these 'reverberation-waves' are indeed observed in AT2017gfo. This reverberation analysis suggests that temporal modelling is important for interpreting individual KN spectra and that higher cadence spectral series, especially when concentrated at specific times, can provide strong constraints on KN line-identifications and test the validity of LTE.

Session

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Enabling gravitational wave astrophysics with the SKA

Dr Danny Price[1,2], Dr Sarrvesh Sridhar[1], Dr Nichol Cunningham[1], Dr Jimi Green[1], Dr Shari Breen[1], Dr Sharmila Goedhart[1]

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Abstract

The SKA Low and Mid telescopes are next-generation flagship radio astronomical facilities that will revolutionize radio astronomy for decades. With the SKA telescopes now officially in their construction phase, the first SKA gravitational wave follow-ups and pulsar timing programs are almost in sight. But when is the community likely to see their first SKA data?

In this talk, I will discuss details of the SKA telescopes and their specifications, highlighting some of the areas where the increased sensitivity, spatial resolution, and quick response to triggers from external facilities are particularly well suited to making significant contributions to gravitational wave astrophysics. I will also briefly discuss our operational model and provide details of how and when the gravitational wave community might expect to access the SKA.

Session

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1503

The formation of intermediate-mass black holes in dense environments: perspectives for current and future gravitational wave detectors

Dr Manuel Arca Sedda

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Abstract

Intermediate-mass black holes (IMBHs) constitute an elusive class of compact objects populating the 10^2-10^4 solar mass range.
Aside from the revolutionising discovery of an IMBH weighing 150 solar mass via emission of gravitational waves (GWs) by two stellar-size BHs conducted by the LIGO-Virgo Kagra collaboration, and the observations of a few IMBH candidates with masses > 50,000 solar mass, the IMBH mass range is vastly unconstrained.
The very existence of IMBHs is still questionable. Over the next decades, the Einstein Telescope (ET) and LISA could provide us with observations of
relatively closeby (redshift < 1) IMBHs in the 10^3-10^4 solar mass range. A detector capable of scanning the unexplored deci-Hz frequency band, thus sitting between ET and LISA,
will increase our chance to understand what IMBHs are, enabling us to exquisitely observe IMBHs orbited by a close stellar-size compact companion, a class of GW sources called intermediate-mass ratio inspirals (IMRIs).
In this review, I will discuss how future Decihertz Observatories could help us make the next leap in our understanding of the nature of BHs, solving the mystery behind the true nature of IMBHs.

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A standard siren measurement of the Hubble constant using gravitational wave events from the first year of the fourth LIGO/Virgo/KAGRA observing run

Prof Clecio Bom

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Abstract

We present a new constraint on the Hubble constant (H_0) from the standard dark siren method using a sample of 5 well-localized gravitational waves (GW) alerts reported during the LVK fourth observing runs (LVK O4a) in combination with standard dark sirens from the previous runs. Our methodology is based on the catalog method without using any assumptions on the Binary Black hole mass population. We use the complete probability density function estimation of photometric redshifts derived by a Deep Learning method using DECam data.

We combine the H_0 posterior for 5 new O4 sirens with the other 10 from previous observation runs, finding $H_0 = 70.4^{+6.9}_{-6.5}$ km s^{-1}Mpc^{-1}, in combination with GW170817, yielding a ~ 10% precision on H_0. This result represents a reduction in ~ 45% uncertainty from the combination of 15 dark+bright sirens compared with GW170817 Bright siren alone. This result shows that ~ 15 well-localized dark sirens can provide a competitive constraint compared to bright siren GW170817 given a precise photometric redshift estimation and an appropriate catalog.

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Spin Perspectives: Imaging Resonant Orbits of Sgr A*

Prof Jeandrew Brink[1], Miss Corlé van der Walt[1,2]

[1]University of the Free State. [2]Akademia

Abstract

Obtaining the spin magnitude and orientation of Sagittarius A* (Sgr A*) has important implications for formation scenarios associated with the Milky Way Galaxy and is a necessary step in any rigorous test of the No-Hair theorems of General Relativity. In 2022, the Event Horizon Telescope (EHT) collaboration synthesized the first image of Srg A*. This significant milestone has provided valuable insights into the behaviour of the black hole's spin magnitude and orientation.

This project aims to glean the dependence of the radio image on the black hole's spin axis orientation. The aim is to produce the lensed radio image of the resonant orbital structures predicted by Brink, Geyer and Hinderer restricted to the equatorial plane. The advantage of such a pseudo-analytic model is that it is rapid to compute on a laptop using analytic techniques, such as Carlson's integrals, to solve the null geodesic paths. The model will permit the parameter space to be fully explored systematically, with many spin orientations.

The hope is that the research will provide greater insight into the near-horizon dynamics of Sgr A*. These dynamics, characterized by periods of one to three hours and reliant on resonant phenomena, are expected to significantly influence the observed image as perceived from different spin orientations. The insights could permit us to explore possible strategies for jointly analyzing time and image domain radio data in a self-consistent manner to yield a deeper understanding of the mysteries hidden in the core region of our Milky Way galaxy.

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Decoding the Cosmic Orchestra: Reconstruction of Binary Black Hole Harmonics in LIGO Using Deep Learning

Dr. Chayan Chatterjee, Prof. Karan Jani

Vanderbilt University

Abstract

Gravitational wave signals from coalescing compact binaries in the LIGO and Virgo interferometers are primarily detected by the template-based matched filtering method. While this method is optimal for stationary and Gaussian data scenarios, its sensitivity is often affected by non-stationary noise transients in the detectors. Moreover, current searches do not account for the effects of precession of black hole spins and higher-order waveform harmonics, focusing solely on the leading-order quadrupolar modes. This limitation impacts our search for interesting astrophysical sources, such as intermediate-mass black hole binaries and hierarchical mergers. Here we show for the first time that deep learning can be used for accurate waveform reconstruction of precessing binary black hole signals with higher-order modes. This approach can also be adapted into a rapid trigger generation algorithm to enhance online searches. Our model, tested on simulated injections in real LIGO noise from the third observing run (2019-2020) achieved high-degree of overlap with injected signals. This accuracy was consistent across a wide range of black hole masses and spin configurations chosen for this study. When applied to real gravitational wave events, our model's reconstructions achieved between 85% and 98% overlap with those obtained by Coherent WaveBurst (unmodeled) and LALInference (modeled) analyses. These results suggest that deep learning is a potent tool for analyzing signals from a diverse catalog of compact binaries.

Session

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1562

A new channel to form near- and sub-solar-mass black holes and naked singularities

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Abstract

Existence of naked singularities is a topical and fundamental issue of physics. The formation mechanism of such objects, particularly those with near-solar-mass, is not yet clear. Since, recent gravitational wave events have suggested the existence of near-solar-mass collapsed objects which cannot be formed via stellar evolution, here we investigate a likely formation channel, and especially if a near-solar-mass cosmic object can be transmuted into a Kerr naked singularity by capturing primordial dark matter particles. If the dynamical ejecta is small during the transmutation, the said cosmic object could be transmuted to a Kerr naked singularity. On the other hand, if the dynamical ejecta is large, the same will be transmuted to a sub-solar mass Kerr BH. We show that many white dwarfs could transmute into Kerr naked singularities or a sub-solar mass Kerr BHs (depending on the amount of dynamical ejecta), while neutron stars may not, and mention plausible observational implications (https://arxiv.org/abs/2401.08462).

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Results of MASTER Global Robotic Network follow-up observations of LIGO/Virgo/Kagra gravitational wave alerts

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Abstract

Gravitational wave astronomy has been one of the most promising areas of study in the last decade. MASTER Global Robotic Network takes part in programm of electromagnetic electromagnetic support of the LIGO/Virgo/Kagra gravitational wave expepiments. Here we present the results of this support. This study deals with all observational sets: O1(September 2015 - January 2016), O2(November 2016 - August 2017), O3(April 2019 - April 2020), O4(May 2023 - present days). The main purpose of these observations is to perform the first-time accurate localization of gravitational-waves sources. The first success was discovery of a Kilonova during GW 170817 event. An optical transient, MASTER OTJ130948.10-232253.3/SSS17a was independently found by MASTER network. In numerous other observations, dozens of optical transients unrelated to gravitational waves were discovered and among them there is not a single obvious candidate for kilonovae. Nevertheless, this first gravitational-wave localization experiment in the history of astronomy is of exceptional importance for the development of future successful strategy for localization of GW events involving relativistic stars. Furthermore, the objects discovered during the inspection of huge error boxes were studied in particular detail by the telescopes worldwide and provided important information about such objects in the Universe as supernovae, novae, active galactic nuclei, dwarf novae and other explosive phenomena in the Universe. This study reports on the observations of the MASTER Global Robotic Network for all LIGO/Virgo/Kagra confirmed events from the O1, O2, O3 and significant alerts from first part of O4 observing runs.

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Nonadditive entropy of the gravitational wave signal from GW150914

Prof. Daniel Brito de Freitas

Federal University of Ceará

Abstract

We study the first gravitational wave, GW150914, detected by advanced LIGO and constructed from the data of measurement of strain relative deformation of the fabric of spacetime. We show that the time series from the gravitational wave obeys a nonadditive entropy and its dynamics evolve of the three associated Tsallis' indices named q-triplet. This fact strongly suggests that these black hole merger systems behave in a non-extensive framework. Furthermore, our results point out that the entropic indexes obtained as a function of frequency are useful statistical parameters to determine the dominant frequency when black hole coalescence is achieved.

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New spacetime resonance effect due to rotational frequency.

Miss Judiet Van der Mescht, Prof Jeandrew Brink

University of the Free State

Abstract

Orbital resonances around black holes may have observable signatures when testing relativity around supermassive black holes such as Sgr A* and in the gravitational waves emitted during an extreme mass ratio inspiral observable with LISA.

Hitherto careful analytic characterization of the parameter space where these resonances occur has been restricted to considering the resonances between the two libration type frequencies (ω_r and ω_θ) associated with the radial and longitudinal motions around the Kerr black hole. This work expands the body of knowledge of orbital resonances by carefully characterizing the parameter space where resonances occur if the rotational frequency (ω_ϕ) is also included. Including the rotational frequency in the analysis increases the locations in parameters space where resonant phenomena could be observed. It also completes the characterization in the sense that no additional parameters need be considered. If the locations in parameter space are described with Kepler type constants associated with the orbital geometry rather than the standard energy (E), azimuthal angular momentum (Lz) and Carter constant (Q) a very regular structure emerges. This leads us to predict a distinctive spin dependent frequency spectrum for any observable originating from resonant effects.

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Gravitational waves from the triple black holes systems

Mrs Margaryta Sobolenko[1], Dr. Peter Berczik[2], Wei Hao[3], Prof. Rainer Spurzem[4,5,6]

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Abstract

We believe that the successive evolution of stellar and supermassive black holes (SMBH) in a dense environment makes it possible to analyze the different types of triple (or even N-body) systems. Gravitational waves (GWs) from these systems can be produced sporadically or continuously. We studied the effect of different initial black hole masses and spins on merging timescales, and we found a qualitative picture of merging as a whole. In the case of merging triple SMBHs systems, it is also important to characterise the central density profile of the host galaxies. We started by studying the merging dynamics in the test triple systems with stellar-mass black holes and two different initial spatial configurations. N-body simulations were performed with the phi-GRAPE/GPU code. To check the numerical convergence, we tried different particle numbers 64k, 128k, 256k, 512k, 1024k. For sufficient triple merging evolution, we first explored the pure Newtonian runs. In many cases, these triple systems showed evidence of the von Zeppel-Lidov-Kozai mechanism. Some of these prominent cases (with higher eccentricity >0.9) were selected for further post-Newtonian simulations. Since the von Zeppel-Lidov-Kozai mechanism is part of the Newtonian dynamics and is suppressed in the post-Newtonian formalism, merging such a triple system was a difficult task. We have also studied the effect of black hole spins on the binary orbit and derived the GW emission for a black hole covering a large parameter space. These results can be easily scaled to triple black holes in observed galaxies (such as NGC 6240).

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Recent Results from the Indian Pulsar Timing Array (InPTA)

Dr. Mayuresh Surnis

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Abstract

The Indo-Japanese Pulsar Timing Array (InPTA) is a 45 member Indo-Japanese collaboration working on detecting nHz gravitational waves using the pulsar timing array (PTA) concept. Recently, we combined our data and resources with the European Pulsar Timing Array (EPTA) to provide compelling evidence of a stochastic gravitational wave background (SGWB). In this presentation, I will give an overview of the recent results from the InPTA. We are likely to make our second data release (InPTA DR II) in the coming months, which will have both narrow band and wide band timing analyses of low frequency data for more than a dozen pulsars covering more than a 5 year time baseline. Additionally, we are contributing in the data combination under the auspices of IPTA for IPTA Data release 3 and analysis of these data. Our unique simultaneous wide-band low frequency coverage allows us to model the variations caused by the interstellar medium with high precision. I will report on the plans for gravitational wave searches with the InPTA DR II data and brief updates on auxiliary science results from the InPTA.

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The impact of post-Newtonian effects on massive black hole binary evolution from 1000 to ~10 Rsch separations.

Prof. Dr. Sci. Peter Berczik, Ms. Margarita Sobolenko, Dr. Marina Ishchenko

Main Astronomical Observatory National Academy of Sciences of Ukraine, 27 Akademika Zabolotnoho St. 03143 Kyiv, Ukraine

Abstract

Supermassive black hole (hereafter SMBH) mergers are promising candidates for gravitational wave (GW) detections with the LISA mission (Amaro-Seoane et al. 2017) and the Pulsar Timing Arrays (Reardon et al. 2016; Desvignes et al. 2016; Arzoumanian et al. 2016; Verbiest et al. 2016). After galactic mergers, the SMBHs located at the center of the resulting merged galaxy are expected to form binary systems that would eventually coalesce and emit a burst of GWs. Begelman et al. (1980) famously described the three main phases of an SMBH merger. We study the effect of post-Newtonian correction terms (up to PN3.5) on the energetic interaction between a gravitational wave (GW)-emitting SMBH binary and incoming stars using three-body scattering experiments. We use the combination of phi-GPU and AR chain code to simulate with high accuracy the interactions between stars and an SMBH binary at separations from 1000 to ~10 Rsch. For all interactions, we study in detail the energy balance of the three-body systems, using both Newtonian and post-Newtonian expressions for the orbital energy of the SMBH binary, taking into account the GW emission from the binary. We find that at these separations, a purely Newtonian treatment of the binary orbital energy is insufficient to properly account for the SMBH binary orbital evolution. Instead, in addition to the GW emission, terms must be included in the PN corrections to describe the energy change of the binary during the stellar interaction.

Session

IAUS 389 Gravitational Wave Astrophysics

1696

MOBY – Modeling Binary Systems That End in Stellar Mergers and Give Rise to Gravitational Waves

Jelena Petrović[1], Monika I. Jurkovic[1], Bojan Arbutina[2], Atila Čeki[1], Gojko Đurašević[1]

[1]Astronomical Observatory of Belgrade, Serbia. [2]Faculty of Mathematics, University of Belgrade, Serbia

Abstract

The newest observations of gravitational waves, by the Virgo and LIGO telescopes, indicate that the observed radiation originates in mergers of black holes with masses up to about 100 $M_{\odot}$. Within the MOBY project, the progenitor evolution of such gravitational wave sources, related to the most massive double black holes is investigated.

The evolutionary models of rotating close (Case A) super-massive binary systems are calculated with the MESA (Modules for Experiments in Stellar Astrophysics) numerical code. The goal of the MOBY project is to produce an extensive grid of detailed evolutionary models of rotating super-massive binary systems with the initial masses between 100 $M_{\odot}$ and 250 $M_{\odot,}$ in order to reproduce double black hole systems with masses above 50 $M_{\odot}$ and constrain the initial and other physical parameters of possible progenitors of gravitational wave sources. Here we present the first examples of such rotating super-massive Case A binary evolutionary models calculated from the main sequence to the core collapse.

*The MOBY project is funded by the Science Fund of the Republic of Serbia within the PRIZMA call for the period 2024-2027.

Session

IAUS 389 Gravitational Wave Astrophysics

1697

Tick-Tock: a supermassive black hole binary?

Mr. Avinash Kumar Paladi[1], Dr. Lankeswar Dey[2], Prof. Gopakumar Achamveedu[3], Dr. Apurba Bera[4], Dr. Nirupam Roy[1]

[1]Indian Institute of Science, Bengaluru. [2]West Virginia University. [3]Tata Institute of Fundamental Research, Mumbai. [4]Curtin University, Australia

Abstract

Recently, Pulsar Timing Array (PTA) collaborations around the world have found evidence for a stochastic gravitational waves (GWs) background at the nanohertz frequencies. One of the possible sources for these low-frequency GWs are the supermassive black hole binaries (SMBHBs). Despite having several hundreds of SMBHB candidates, none of them are confirmed till date. In 2022, Ning Jiang et. al. proposed the Tick-Tock (SDSSJ143016.05+230344.4) galaxy to host a highly eccentric SMBHB based on the variability in its optical lightcurve and postulated that the binary will merge in the next few years. In this work, we use an accurate post-Keplarian model and Bayesian inference to authenticate the presence of a binary in this galaxy and determine its orbital parameters. High eccentricity of this source indicates that this galaxy has undergone a recent major merger and we are using high-resolution uGMRT HI observations to probe its merger history. If this galaxy is found to host an SMBHB as proposed, it can have major implications for PTA to search for the GW memory effect.

Session

IAUS 389 Gravitational Wave Astrophysics

1722

The second data release of Indian Pulsar Timing Array experiment

Dr. Prerna Rana

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Abstract

Pulsar Timing Arrays (PTAs) are expected to inaugurate the era of nano-Hertz Gravitational Wave astronomy, facilitated by the collaborative efforts of the International PTA (IPTA) consortium. This consortium will combine data from more than 100 milli-second pulsars (MSPs) and resources from different PTA experiments for its forthcoming Data Release 3 (IPTA DR3) to begin such an era. Integral to this global initiative is the Indian PTA (InPTA: Indo-Japanese collaboration), an active participant in the IPTA consortium, which made its first official data release (DR1) featuring observations from 14 MSPs, concurrently monitored across the 300-500 MHz (Band 3) and 1260-1460 MHz (Band 5) frequency bands of the premier Indian radio astronomy facility, the upgraded Giant Metrewave Radio Telescope (uGMRT). The InPTA DR1 dataset is already combined with the other PTA data in the forthcoming IPTA DR3 for the international effort of ultra-low frequency GW search. The next pivotal milestone for the InPTA collaboration is its second data release (DR2) of a 6.5-year long uGMRT data set of 29 MSPs, which will also include data set in frequency range 550-750 MHz (Band 4). This presentation will include the intricacies of InPTA's second data release, focusing on the precise estimation of pulsar Time of Arrival (ToA) and Dispersion Measures (DM) using the multi-band Narrowband and Wideband techniques. Additionally, details of the timing characteristics of our pulsar sample will be presented. Towards the end, a summary of the results along with uniqueness of the InPTA experiment in context of IPTA efforts will be provided.

Session

IAUS 389 Gravitational Wave Astrophysics

1748

Stable Mass Transfer: Explaining the observed BBH mass distribution features

Dr. Max Briel[1], Dr. Helosie Stevance[2], Prof. Jan Eldridge[3]

[1]Univeristy of Geneva. [2]University of Oxford. [3]Univeristy of Auckland

Abstract

With the remarkable success of the LVK consortium in detecting binary black hole mergers, it has become possible to use the population properties to constrain our understanding of the progenitor stars' evolution. The most striking features of the observed primary black hole mass distributions are the extended tail up to 100 solar masses and an excess of masses at 35 solar masses. Traditional isolated binary population synthesis has difficulty explaining these two features due to the dominance of pair-instability supernovae (PISN) in shaping the BH mass distribution. Additional formation pathways, such as hierarchical merger, are required to explain these features in rapid population synthesis codes.

We use the semi-detailed binary population synthesis code, BPASS, to provide the first self-consistent explanation for the $35 \Msun$ excess and the extended tail using isolated binary evolution without fine-tuning evolutionary parameter.
In this talk, we discuss how the $35 \Msun$ excess is a result of stable mass transfer, which only shows up when accurately modelling the donor's response to mass loss, and is not shaped by pulsation pair-instability supernovae. Moreover, we show that this detailed treatment of mass transfer stability together with super-Eddington accretion can lead to merging BBH mergers within the age of the Universe with masses in the pair-instability mass gap. We further discuss potential observational constraints and the redshift evolution of this stable mass transfer formation channel.

Session

IAUS 389 Gravitational Wave Astrophysics

1760

An upper limit on the spins of black holes formed through binary evolution

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Institute of Astronomy, KU Leuven

Abstract

As ground-based gravitational wave detectors progressively increase their sensitivity, observations of black hole mergers will provide us with the joint distribution of their masses and spins. This will be a critical benchmark to validate different formation scenarios, particularly through the identification of unique features that help distinguish them. In this talk I will show how black hole progenitors that have been stripped of their hydrogen envelope (as expected in binary evolution channels), set a mass-dependent upper limit on their net angular momentum and consequently, on the black hole spin. This limit arises from the requirement that the star remains below critical rotation at its surface, and implies that stripped stars above ~25 Msun cannot hold enough angular momentum at collapse to produce a maximally spinning black hole. For the case of merging binary black holes, this limit can translate to edges in the spin-mass distribution, with their location depending on whether the corresponding formation channel can produce one or two highly spinning black holes. We show that the chemically homogeneous evolution channel can populate this boundary, although current observations would favor the detection of systems with smaller spins which arise at higher metallicities. I will also discuss how this limit connects to observations of high-mass X-ray binaries, as well as its implications on the progenitors of gamma-ray bursts.

Session

IAUS 389 Gravitational Wave Astrophysics

1784

Search for alternative GW polarisation modes in the MeerKAT Pulsar Timing Array data.

Md Atiqur Rahman[1], Dr. Jaikhomba Singha[1], Dr. Marisa Geyer[1], Professor Ryan Shannon[2], Matthew T. Miles[2]

[1]High Energy Physics, Cosmology and Astrophysics Theory Group, University of Cape Town. [2]Centre for Astrophysics and Supercomputing, Swinburne University of Technology

Abstract

Pulsar Timing Arrays are now reaching sensitivity towards detecting angular spatial correlations described by Hellings and Downs (HD) curve, as expected from binary mergers of a cosmic population of Super Massive Black Hole Binaries. The remarkable sensitivity of the MeerKAT telescope has enabled the detection of HD curve in MeerKAT Pulsar Timing Array (MPTA) dataset spanning around 5 years. This HD signature results from the expected quadrupolar nature of the Gravitational Wave Background (GWB) – specifically the h_+ and $h_\times$ polarisation modes. In this work, we investigate alternative GW polarisation modes known as the Scalar Transverse (ST) modes, along with the h_+ and hx modes and consider the sensitivity of the MPTA and future Square Kilometre Array (SKA) datasets to these Scalar Transverse (ST) modes. This provides an excellent test for modified gravity theories. We will present our preliminary results using the MPTA dataset and simulations.

Session

IAUS 389 Gravitational Wave Astrophysics

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Understanding Noise Modelling of best-timed millisecond pulsars in MeerKAT Pulsar Timing Array Dataset

Jaikhomba Singha[1], Md Atiqur Rahman[1], Ryan M Shannon[2], Matthew T. Miles[2], Marisa Geyer[1]

[1]High Energy Physics, Cosmology & Astrophysics Theory (HEPCAT) Group, Department of Mathematics and Applied Mathematics, University of Cape Town. [2]Centre for Astrophysics and Supercomputing, Swinburne University of Technology

Abstract

The recent results from various Pulsar Timing Array (PTA) experiments have opened a new era of nanohertz gravitational wave astronomy. The PTA datasets show strong evidence for a common uncorrelated red noise signal along with good agreement with the spatial correlations of the Hellings and Downs (HD) curve, as expected from a Gravitational Wave Background signature. The MeerKAT Pulsar Timing Array (MPTA) also aims to detect such signatures in their recent dataset. However, since the MPTA dataset spans less than 5 yrs, it is more impacted by the noise-processes of the pulsars themselves, and dominated by the results from the best-timed millisecond pulsars in the sample. It is therefore necessary to understand the noise processes in these pulsars and its impact on the HD curve detection. Owing to the complexities of the various noise processes, a hierarchical approach of modeling noise has been used for the MPTA dataset. Additionally, most of the PTA millisecond pulsars are in relativistic binaries and it is thus important to use appropriate binary models to understand these systems completely. In this work, we investigate the validity of assuming simple power law models for various noise processes used in PTA analysis. Furthermore, we study the implications of using different binary models towards the HD curve detection sensitivity.

Session

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1794

Precision timing of the relativistic double neutron star binary, PSR J1757-1854 with MeerKATPSR J1757-1854 is a 21.5 ms pulsar in a tight eccentric orbit of 4.4 hr period, making it one of the most relativistic double neutron star binary systems known in our galaxy . It is known to have the highest gravitational wave (GW) luminosity and orbital decay rate due to GW damping. PSR J1757-1854 exhibits extreme relativistic properties enabling stringent tests of General Relativity. Here, we present the results from the ongoing monitoring program of this pulsar using MeerKAT at both L (900 - 1670 MHz) and S (1750 - 2625 MHz) bands. This includes new constraints on the pulsar's long-term timing and post-Keplerian parameters.

Jaikhomba Singha[1], Vivek V Krishnan[2], Marisa Geyer[1]

[1]High Energy Physics, Cosmology & Astrophysics Theory (HEPCAT) Group, Department of Mathematics and Applied Mathematics, University of Cape Town, South Africa. [2]Max Planck Institute for Radioastronomy (MPIfR), Bonn, Germany

Abstract

PSR J1757-1854 is a 21.5 ms pulsar in a tight eccentric orbit of 4.4 hr period, making it one of the most relativistic double neutron star binary systems known in our galaxy . It is known to have the highest gravitational wave (GW) luminosity and orbital decay rate due to GW damping. PSR J1757-1854 exhibits extreme relativistic properties enabling stringent tests of General Relativity. Here, we present the results from the ongoing monitoring program of this pulsar using MeerKAT at both L (900 - 1670 MHz) and S (1750 - 2625 MHz) bands. This includes new constraints on the pulsar's long-term timing and post-Keplerian parameters.

Session

IAUS 389 Gravitational Wave Astrophysics

1822

The physics of neutron-star mergers revealed by the detailed element-by-element composition of ancient kilonovae outflows

Prof. Ian Roederer

North Carolina State University

Abstract

Gravitational wave detections of neutron-star mergers are incredibly informative when accompanied by the detection of freshly produced r-process material in kilonova outflows. The kilonova associated with GW170817 revealed the presence of a few r-process elements, including strontium and tellurium. In contrast, more than 40 elements can be detected and measured in r-process-enhanced stars found in the Milky Way, reflecting the yields of a major r-process site in the early Universe, likely neutron-star mergers. I will present the detailed element-by-element accounting of the r-process material found in these stars. These results indicate that (1) the full range of r-process elements from selenium to uranium are produced (elements 34 to 92); (2) deviations from the inferred Solar r-process residual pattern are regularly found, particularly among the lighter elements (selenium through tellurium, elements 34 to 52); and (3) transuranic element production appears to be a common phenomenon, where nuclei with mass numbers >260 are regularly produced, boosting the prospects for detecting Cf-254 or superheavy elements in kilonova light curves and gamma-ray signatures associated with fission. Confronting models with these results reveals that highly constrained physical conditions, such as the electron fraction and entropy, may be possible if the nuclear physics can be sufficiently constrained by future experiments. Furthermore, two r-process sites must be co-located within mergers to explain the observations. I conclude by identifying future opportunities to improve our understanding of the physics of compact binary mergers through this interdisciplinary approach that draws from the multi-messenger, stellar, and nuclear astrophysics communities.

Session

IAUS 389 Gravitational Wave Astrophysics

1943

The Future of NANOGrav and the DSA-2000

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National Radio Astronomy Observatory, Charlottesville, VA USA

Abstract

In 2023, the pulsar timing array community announced strong evidence for the presence of a stochastic background of nanoHertz frequency gravitational waves. In North America, that evidence came from NANOGrav and included 15 years of data from the Arecibo and Green Bank Telescopes. While we can't yet say for certain what is causing the gravitational waves, our best guess is a population of slowly merging super-massive black hole binaries (SMBHBs) throughout the universe. No matter their source, the next decade should be incredibly interesting for this field, with a detailed characterization of the stochastic background, including it spectral shape and measurement of potential anisotropies, and the likely detection of individual SMBHBs. Yet the loss of the Arecibo telescope has strongly impacted NANOGrav's gravitational wave sensitivity. That loss can be almost completely mitigated, and in some ways overcome (e.g. sky coverage) with the construction and operation of the DSA-2000. Using approximately 25% of its time, NANOGrav will continue to play a leading role in nanoHertz gravitational wave science, as well as in a plethora of additional science that we get for "free" with high-precision pulsar timing, like tests of gravitational theories and robust masses of neutron stars.

Session

IAUS 389 Gravitational Wave Astrophysics

1971

New Optical Light-Curve Predictions of Electromagnetic Counterparts to Binary Black Hole Mergers in Active Galactic Nuclei

Juan Carlos Rodríguez-Ramírez[1], Clécio de Bom[1,2], Bernardo Fraga[1], Rodrigo Nemmen[3,4], Emille Ishida[5], Phelipe Darc[1]

[1]Brazilian Center for Research in Physics (CBPF). [2]Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Itaguaí (Brazil). [3]nstituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de Sao Paulo (IAG-USP). [4]Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Stanford, USA. [5]Laboratoire de Physique de Clermont, Universite Clermont-Auvergne

Abstract

Gravitational waves (GWs) from binary black hole (BBH) mergers dominate the measurements of the LIGO/Virgo/KAGRA (LVK) experiment during O1-O4 observing runs. So far, the astrophysical environments hosting these mergers are not yet established. If confirmed, electromagnetic flares accompanying BBH GWs can unveil their astrophysical origin and also have cosmological applications. The thin discs of active galactic nuclei (AGNs) are promising and perhaps the only possible environments where BBHs can form and at the same time produce significant radiation feedback. In this presentation, we introduce new physically motivated models for optical light-curves (LCs) associated with BBH mergers occurring in the thin discs of AGNs. We analyse hyper-Eddington winds as well as relativistic collimated jets launched by the merger remnant as the mechanisms that energise observable optical LCs. Among the possible flare solutions, we discuss those that could be better identified as EM counterparts to GW events. We also discuss current candidate EM counterparts and whether they can be explained (our ruled out) based on our predictions. The LCs models presented here find direct applications in localising AGNs as hosts of BBH mergers following GW alerts with optical time-domain surveys.

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2049

Joint Inference of Population, Cosmology, and Neutron Star Equation of State from Gravitational Waves of Dark Binary Neutron Stars

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[1]Inter-University Centre for Astronomy and Astrophysics, India. [2]Universität Hamburg, Germany. [3]Department of Physics & Astronomy, Washington State University, USA

Abstract

The detection of gravitational wave (GW) signals from compact binary coalescence has opened an independent way to probe the history of expansion of the Universe. GW directly provides the luminosity distance of the event but no redshift information. If their redshifts were available by alternative means, such as via electromagnetic counterparts, the Hubble constant could be estimated from the distance-redshift relation. However, although binary neutron star (BNS) mergers are expected to be accompanied by electromagnetic counterparts, like GW170817, a redshift measurement may not always be available. The presence of matter in neutron star (NS) affects the phase and amplitude evolution of the GW signal. As a result, the tidal deformability of NS breaks the mass-redshift degeneracy of the GW signal and hence can solely constrain the distance-redshift relation directly from the GW observation. Since GW observation also provides the luminosity distance, the Hubble constant can, therefore, be inferred. In our work, we demonstrate a novel Bayesian formalism to jointly infer cosmology, population, and NS equation state (EoS) using GW from dark BNS, i.e., BNS with no detected EM counterpart. In particular, we show the importance of the inclusion of NS EoS in our methodology in the context of inference of the Hubble constant. We demonstrate the efficacy of our methodology with a mock GW catalog of sources simulated for LIGO-Virgo detectors, operating at their design O5 sensitivity. This method becomes extremely useful in future observations, when detecting the electromagnetic counterparts of BNS mergers at high redshifts will be challenging.

Session

IAUS 389 Gravitational Wave Astrophysics

2084

B-DECIGO: a Space Gravitational-Wave Observatory for Multimessenger Astronomy

Dr. Masaki Ando

The University of Tokyo

Abstract

B-DECIGO is a planned space mission to form a gravitational-wave observatory by three spacecraft. It will detect gravitational waves from compact binaries at pre-merger phase, and enables to predict when and where the merger occurs. As a result, the moment of neutron-star merger, kilonova, and gamma-ray burst will be observed with large high-resolution electromagnetic telescopes. In addition, the light curve will be observed from the beginning of the merger event. In this talk, I would like to present the concept, design, and current status of the project.

Session

IAUS 389 Gravitational Wave Astrophysics

2113

Fermi GBM contribution in multimessenger astronomy, including the results from O4

Dr Suman Bala, Dr Adam Goldstein

Universities Space Research Association (USRA)

Abstract

The detection of gamma-ray burst GRB 170817A by Fermi-GBM, coinciding with gravitational wave GW170817, is one of the extraordinary discoveries in the history of multimessenger era. It is not only the first binary neutron star (BNS) merger detected by the advanced (LIGO-Virgo) GW detectors, it is the only GW detection with a confirmed electromagnetic (EM) counterpart. The Fermi Gamma-ray Burst Monitor (GBM) is an all-sky monitoring instrument sensitive to photon energies from 8 keV to 40 MeV. Its capabilities allow it to observe nearly 40 short gamma-ray bursts (GRBs) each year through on-board triggers alone. Fermi-GBM continues to look for similar multimessenger detections through on-board triggers as well as subthreshold searches for weak transients, performed both in high-time-resolution continuous data and in targeted follow-ups of gravitational-wave events. In this talk, I will present an overview of these searches and their recent results.

Session

IAUS 389 Gravitational Wave Astrophysics

2134

Identifying galactic compact binaries of neutron stars and black holes with LISA

alberto vecchio

University of Birmingham

Abstract

Approximately 10-100 galactic binaries of neutron stars and black holes are predicted to be detectable by the Laser Interferometer Space Antenna (LISA). This would provide valuable information about the star formation history of the Milky Way and local astrophysical processes leading to the formation of double compact objects. The observational challenge is to distinguish these systems from the overwhelming (by two to three orders of magnitude) majority of the detected galactic binaries, which will actually be double white dwarfs. We discuss the signatures that may enable the identification of neutron star/black hole binaries and the LISA capabilities to achieve this goal.

Session

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Improving DM estimates using low-frequency scattering-broadening estimates

Jaikhomba Singha

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Abstract

A pulsar's pulse profile gets broadened at low frequencies due to dispersion along the line of sight or due to multipath propagation. The dynamic nature of the interstellar medium makes both of these effects time-dependent and introduces slowly varying time delays in the measured times-of-arrival similar to those introduced by passing gravitational waves. In this work, we present a new method to correct for such delays by obtaining unbiased dispersion measure (DM) measurements by using low-frequency estimates of the scattering parameters. We evaluate this method by comparing the obtained DM estimates with those, where scatter-broadening is ignored using simulated data. We also present the measurements of the scatter-broadening time and the frequency scaling index from analysis of PSR J1643-1224, observed with the upgraded Giant Metrewave Radio Telescope as part of the Indian Pulsar Timing Array experiment. Finally, we apply our new technique of removing scattering and estimating DMs for PSR J1643-1224.

Session

IAUS 389 Gravitational Wave Astrophysics

2165

Bridging the micro-Hz gravitational wave frequency gap with the prospective Uranus mission

Dr Lorenz Zwick[1], Dr Deniz Soyuer[2], Mr David O'Neill[1], Dr Andrea Derdzinski[3,4], Dr Prasenjit Saha[2], Dr Daniel D'Orazio[1], Dr Alexander Jenkins[5], Dr Diego Blas[6], Dr Luke Kelley[7]

[1]Niels Bohr Institute, Copenhagen, Denmark. [2]University of Zurich. [3]Vanderbilt University, USA. [4]Fisk University, USA. [5]University College London, UK. [6]Universidad Autónoma de Barcelona. [7]UC Berkeley, USA

Abstract

The recently reported stochastic background of gravitational waves implies a population of inspiraling binary black holes emitting at microhertz and higher frequencies. We argue that ranging to deep-space missions to the outer solar system, such as the prospective flagship Uranus mission, could provide a way to detect these sources, using modest improvements on already-proven technology. We estimate achievable mission sensitivities and probable event rates using time-domain simulations.

Session

IAUS 389 Gravitational Wave Astrophysics

Poster upload

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2281

The prospects for Multimessenger studies for Galactic binaries with LISA

Prof Thomas Kupfer

University of Hamburg

Abstract

Galactic binaries with orbital periods less than 1 hour are strong gravitational wave sources in the mHz regime, ideal for the Laser Interferometer Space Antenna (LISA). At least several hundred, maybe up to a thousand of those binaries are predicted to be sufficiently bright in electromagnetic wavebands to allow detection in both the electromagnetic and the gravitational bands allowing us to perform multi-messenger studies on a statistically significant sample. Currently we know of three dozen of such systems.

In this talk I will give an overview of the current population of LISA detectable Galactic binaries and how we plan to discover a more statistical sample in the future. I will also present our efforts to estimate how electromagnetic observations can aid gravitational wave data from LISA and vice versa and how that might affect observing strategies in the electromagnetic bands for the upcoming years before LISA flies.

Session

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2331

Nano hertz gravitational wave background from stellar binaries

Prof. Tomasz Bulik[1], Dr Iwona Kotko[2], Dr Malgorzata Crylo[1]

[1]University of Warsaw. [2]Nicolaus Copernicaus Astronomical Center, Poland

Abstract

Nano-hertz gravitational waves are commonly associated with orbiting and merging supermassive black holes. We turn our attention to thee waves originating from wide stellar binaries. While the gravitational wave radiation from each binary is extremely weak there is a large number of such binaries in all galaxies. We estimate the level of the gravitational ave background from these sources with simple order of magnitude estimates and with a detailed simulation of wide binary populations in galaxies with the StarTrack population synthesis code and discuss the effect on the future data analysis from Pulsar Timing Arrays.

Session

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2333

StarTrack - what next?

Prof Tomasz Bulik

University of Warsaw

Abstract

StarTrack code was developed and maintained by prof Chris Belczynski who passed away on January 13 this year. The Star Track code is now kept as his legacy and used by a newly formed Star Track users group. I will present the status of the Star Track code and the possibilities of collaboration and joining the Star Tack user group.

Session

IAUS 389 Gravitational Wave Astrophysics

2429

Black Holes - Deep Dive - Applications of Resonant Structures

Prof Jeandrew Brink, Ms Corle van der Walt, Ms Judiet van der Mescht

University of the Free State

Abstract

Orbital resonances provide a useful tool for probing the nature of space time around black holes. An interesting application is Sgr A* , where attributing observed time variability to a resonant phenomenon led to spin prediction that agreed closely with that favoured by the best fitting MHD models found to be consistent with the Event Horizon Telescope (EHT) observations.

Next generation EHT results in concert with high precision timing observations of the Galactic Center (GC) with the MeerKAT telescope will greatly increase the data available for testing General Relativity around Sgr A*. Should the hypothesis that resonant phenomena are contributing to the observed time variability at the GC, be correct, it will provide a powerful new tool in characterizing the Sgr A* environment by combining both time domain and image domain observations. In this talk I review the argument for the Sgr A* spin determination from resonant phenomena. I argue for the ubiquity of resonant phenomena around quiescent Black Holes and highlight a number of new interesting mathematical results pertaining to orbital resonances that will permit the falsification of the said hypothesis.

Session

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2476

Formation Channels and Properties of Binary Neutron Star Mergers Across Redshift

Ana Lam[1], Dr. Floor Broekgaarden[2,3,4]

[1]Graduate Center, City University of New York. [2]Columbia University. [3]Center for Computational Astrophysics, Flatiron Institute. [4]Johns Hopkins University

Abstract

Upcoming gravitational-wave observing runs with ground based detectors are expected to rapidly increase the observed population of binary neutron star (BNS) mergers, providing unique insights into their physics and their associated kilonovae, r-process, and short gamma-ray bursts. To fully comprehend BNS observations, it is crucial to understand both BNS merger progenitors and their formation pathways. This task, achievable by comparing observations with population synthesis models, is challenging due to many underlying stellar evolution uncertainties. For example, the classic isolated formation channel involving a stable mass transfer episode followed by a “single-core common envelope” phase has been regarded as the dominant formation channel for BNS. We investigate whether this holds for BNS populations across several models that explore uncertainties in binary stellar evolution. Our tested models include variations in mass transfer, supernovae kick, common envelope prescriptions, and their impact on predicted BNS merger rates. We present our statistical analysis on multiple formation channels for BNS, their predicted merger rates, and the insights they yield to constraining stellar evolution uncertainties with particular focus on common envelope evolution. Furthermore, we demonstrate the metallicity dependence of these BNS formation channels and illustrate the redshift evolution of BNS merger rates. We find that other channels, including one involving a “double-core common envelope” phase, can also significantly contribute to the formation of BNS.

Session

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Revealing White Dwarf Spin Rates in Binary Systems with LISA

Ms Anke van Dyk[1,2], Prof David Buckley[1,3]

[1]South African Astronomical Observatory. [2]University of Cape Town. [3]University of the Free State

Abstract

This abstract explores the potential of the Laser Interferometer Space Antenna (LISA) as a transformative tool for unlocking the spin rates of white dwarfs in binary systems. White dwarfs, the remnants of low to intermediate-mass stars, often reside in binary configurations, where their spin rates play a crucial role in understanding binary evolution, mass transfer processes, and the progenitor history of Type Ia supernovae. However, directly measuring these spin rates has remained challenging, particularly in binary systems where traditional observational methods are limited.

LISA, with its unparalleled sensitivity and frequency range in the millihertz regime, promises to revolutionise our ability to probe gravitational wave signals from white dwarf binaries. By detecting the subtle modulations in gravitational waves caused by the rapid rotation of white dwarfs, LISA offers a unique window into their spin rates. Leveraging advanced data analysis techniques, such as matched filtering and Bayesian inference, LISA has the potential to extract precise information about the spin rates of white dwarfs in binary systems.

The implications of such measurements are profound. Accurate determinations of white dwarf spin rates enable us to constrain binary formation scenarios, understand the mass transfer dynamics in close binary systems, and shed light on the mechanisms driving Type Ia supernova explosions. Moreover, these measurements provide critical insights into stellar evolution processes and the formation history of compact binary systems.

Session

IAUS 389 Gravitational Wave Astrophysics

2524

Measuring strength and direction of gravitational waves with astrometric gravitational wave antenna

Dr Mariateresa Crosta[1], Federica Santucci[1,2], Dr Mario Gilberto Lattanzi[1], Dr Beatrice Bucciarelli[1], Dr Ummi Abbas[1], Dr Deborah Busonero[1], Dr Mario Gai[1], Dr Alberto Riva[1]

[1]INAF-OATo. [2]University of Turin, Physics Dept.

Abstract

A new concept for a GW antenna (AstroGraWAnt) stems from an all-differential general relativistic formulation of the astrometric observable, i.e. the angular separation of a pair of celestial objects. For, close pairs of point-like sources act as natural antenna "arms" to record the very tiny variations in their angular separations induced by passing gravitational waves. This novel astrometric GW detection, truly complementary to the extant approaches, provides a powerful tool to infer GW strength and pinpoint direction to GW sources with unprecedented precision (see https://www.nature.com/articles/s41598-024-55671-9).

The large amount of information accumulated over the 10+ years by Gaia, through an appropriate digital adaptation of the AstroGraWAnt measurement principle, can be exploited to catch possible GW signatures in the Gaia raw epoch data and, thus, further boost synergies with other GW detectors, especially with PTA . Furthermore, a ground-based version of AstroGraWAnt could complement efforts in surveying GWs and/or serve as a GW sentinel.

Session

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2542

Gravitational wave memory from the propagation of Long Gamma Ray Bursts and their detection by future space-based interferometers

Dr Gerardo Urrutia, Dr Agnieszka Janiuk

Centre for Theoretical Physics, Polish Academy of Sciences

Abstract

Gamma-ray bursts (GRBs) are produced during the propagation of ultra-relativistic jets within a post-merger ejecta or a pre-collapse massive star. It is challenging to study and observe the properties of the jet at the first seconds of propagation because the progenitor environment presents high opacity, however, non-photonic signals could improve our understanding of the jet propagation at early times. A promising candidate is a GW signal originating from ultra-relativistic blobs of matter that induce a metric perturbation, then GRB jets that accelerate to large Lorentz factors are potential sources of this kind of signal. In this talk, I will present numerical simulations of relativistic jets propagating through a massive, stripped-envelope star associated with long GRBs, breaking out of the star and accelerating into the circumstellar medium. We compute the gravitational wave (GW) signal resulting from the propagation of the jet through the star and the circumstellar medium. We show that key parameters of the jet propagation can be directly determined by the GW signal for off-axis observers. The amplitude of the GW signal is h+D $\sim$ hundreds to several thousand cm. Although this signal, for extragalactic sources, is outside the range of detectability of current GW detectors, it can be detected by future instruments such as LISA, BBO, DECIGO and ALIA. Our results illustrate that future detections of GW associated with GRB jets may represent a revolution in our understanding of this phenomenon.

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2592

Phase-resolved spectroscopy and circular spectropolarimetry of magnetic cataclysmic variables EF Eridani during the high state

Dr Zwidofhelangani Khangale

University of Cape Town

Abstract

We present high-spectral resolution phase-resolved spectroscopic observations of EF Eri obtained with SALT during the 2023 high state. Our average spectrum shows strong emission from the Balmer lines (H α and Hβ) and HeII 4686 Å as well as weak emission from the HeI (at 4712 Å, 4921 Å, 5017 Å, 5411 Å and 5875 Å) and the Bowen fluorescence (CIII/NIII) blend at 4650 Å. The emission lines red-ward of 5500 Å changes from pure emission to pure absorption at orbital phases between $\sim$0.75–0.95, and this is due to obscuration of the line-emitting region by the accretion stream. Doppler tomography of the strongest emission lines (HeII 4686Å and the Balmer lines) using both the standard and inside-out projections revealed the presence of three emission regions: from the irradiated face of the secondary star, the ballistic stream and the threading region, and the magnetically confined accretion stream. Our circular spectropolarimetry shows positive circular polarization reaching about 15% and varying with the orbital cycle of the binary. The circularly polarized spectrum shows the presence of a broad cyclotron feature which is consistent with a cyclotron hump whose peak wavelength vary with the orbital cycle. High speed polarimetry shows consistent results with circular polarization reaching about 15% and a pulse in linear polarization also observed.

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Finding cosmic anisotropy with networks of next-generation gravitational-wave detectors

Bryce Cousins[1,2], Dr. Arnab Dhani[3,2], Dr. Bangalore Sathyaprakash[2,4,5], Dr. Nicolás Yunes[1]

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Abstract

The standard cosmological model requires the assumption of isotropy and homogeneity, a principle that is generally well-motivated but is now in conflict with various anisotropies found using independent astrophysical probes. These anisotropies tend to take the form of dipoles; while some can be explained by kinematic effects such as Earth's motion, many others are not fully understood. One effect of a generic, non-kinematic anisotropy is a dipole in luminosity distance measurements. In this talk, I will demonstrate how such a dipole could be measured or constrained using one year of binary neutron star merger observations for six networks of gravitational-wave detectors that include ground-based, next-generation interferometers. Our findings indicate that next-generation observations of binary neutron stars could result in either comparable or improved constraints on a generic dipole when compared to other measurements obtained through electromagnetic observations.

Session

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Identifying heavy r-process elements in the spectra of two compact binary mergers

Dr James Gillanders

University of Oxford

Abstract

Direct observations of the rapid neutron-capture process (r-process), responsible for synthesising approximately half of all elements beyond the iron peak, remain remarkably elusive. The only direct observations we have for the nucleosynthesis of r-process material come from binary compact mergers (aka kilonovae), and to date, only two such events have been observed spectroscopically. Spectroscopic observations are key to unravelling the composition of the ejected material, since they can be used to identify absorption and emission features that can then be linked to transitions belonging to a specific atom or ion. In this talk, I will present the results of my work analysing the spectra of the two observed kilonovae – AT2017gfo and AT2023vfi – to constrain their ejecta properties, and to identify the species responsible for the observed spectral features. By utilising a mix of atomic data sets, combined with nucleosynthesis compositions derived from a hydrodynamical simulation of a binary neutron star merger, I have modelled the early spectra of AT2017gfo. From this work, I have found that these observations necessitate the presence of heavy lanthanide elements, in addition to the lighter r-process species. In follow-up work focusing on the later epochs, we empirically fit the features to constrain the ejecta properties, and shortlist candidate species for these late-time, quasi-nebular emission features. For AT2023vfi, I will present new work showcasing the most detailed analysis of the two JWST spectra that currently exists. I will also highlight the most likely candidate r-process species that are responsible for producing the observed spectral features.

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321D modelling of convection in progenitors of supernovae, neutron stars and black holes

Prof Raphael Hirschi

Keele University, UK. WPI IPMU, Japan

Abstract

Convection plays a key role in the structure and evolution of stars of all masses. Despite its importance, the treatment of convection in one-dimensional (1D) stellar models is still incomplete and cannot reproduce observational constraints (asteroseismic and spectroscopic). The Achilles' heel of current convective theory is its boundary treatment, both in terms of location and shape. Indeed, convective boundary mixing (CBM; e.g. overshoot) across the formal Schwarzschild (or Ledoux) boundary has to be added to 1D models to reproduce observational constraints such as the width of the main sequence. The continuously increasing computing power finally enables us to study stellar convection in great detail in 3D hydrodynamic simulations and to provide much needed guidance to improve the treatment of convection and CBM. This is especially important during the advanced phases of massive stars where no observational constraints are available. In this talk, I will start by presenting the predictions for the fate of rotating and non-rotating massive stars (supernova and remnant types) from the large grids of Geneva stellar models covering the entire metallicity range from zero to super-solar metallicity. I will then discuss how the latest results from 3D and 3D-guided 1D (321D) models of convection (and CBM) are likely to affect these predictions. I will in particular discuss how shell mergers can affect the black hole mass gap. I will end by describing the next steps on the 321D modelling journey.

Session

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Multiband extension of the wideband timing technique

Mr. Avinash Kumar Paladi[1], Mr. Churchil Dwivedi[2], Dr. Prerna Rana[3], Dr. Nobleson K.[4], Dr. Abhimanyu Susobhanan[5], Prof. Bhal Chandra Joshi[6,7], Dr. Pratik Tarafdar[8], Dr. Debabrata Deb[8], Swetha Arumugam[9], Prof. Gopakumar A[3], Dr. Krishnakumar M. A.[6], Dr. Neelam Dhanda Batra[10], Jyotijwal Debnath[8], Fazal Kareem[11], Prof. Paramasivan Arumugam[7], Dr. Manjari Bagchi[8], Adarsh Bathula[12], Subhajit Dandapat[3], Dr. Shantanu Desai[9], Prof. Yashwant Gupta[6], Shinnosuke Hisano[13], Divyansh Kharbanda[9], Tomonosuke Kikunaga[13], Neel Kolhe[14], Dr. Yogesh Maan[6], Dr. Manoharan P. K.[15], Dr. Jaikhomba Singha[16], Aman Srivastava[9], Dr. Mayuresh Surnis[17], Prof. Keitaro Takahashi[13]

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Abstract

The wideband timing technique enables the high-precision simultaneous estimation of pulsar times of arrival (ToAs) and dispersion measures (DMs) while effectively modelling frequency-dependent profile evolution. We present two novel independent methods that extend the standard wideband technique to handle simultaneous multiband pulsar data incorporating profile evolution over a larger frequency span to estimate DMs and ToAs with enhanced precision. We implement the wideband likelihood using the LIBSTEMPO PYTHON interface to perform wideband timing in the TEMPO2 framework. We present the application of these techniques to the data set of 14 millisecond pulsars (MSPs) observed simultaneously in Band 3 (300–500 MHz) and Band 5 (1260–1460 MHz) of the upgraded Giant Metrewave Radio Telescope (uGMRT) with a large band gap of 760 MHz as a part of the Indian Pulsar Timing Array (InPTA) campaign. We achieve increased ToA and DM precision and sub-microsecond root mean square post-fit timing residuals by combining simultaneous multiband pulsar observations done in non-contiguous bands for the first time using our novel techniques.

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Revealing EMRI/IMRI candidates by quasiperiodic ultrafast outflows

Dr. Michal Zajacek[1], Dr. Dheeraj R. Pasham[2], Dr. Francesco Tombesi[3], Dr. Petra Sukova[4]

[1]Masaryk University, Brno, Czechia. [2]Massachusetts Institute of Technology, MA, USA. [3]Physics Department, Tor Vergata University of Rome. [4]Astronomical Institute, Academy of Sciences, Prague

Abstract

We report the detection of the quasiperiodic ultrafast outflow (v~0.3 c) in the system ASASSN-20qc at z=0.056 (Pasham et al., 2024) for the first time. The outflow is revealed in the soft X-ray spectra as an absorption feature, which is periodically enhanced every ~8.5 days. The periodic nature of the ultrafast outflow is best explained by an orbiting perturber that is inclined with respect to the accretion flow around the primary supermassive black hole. In this way, the orbiting body pushes the disc gas into the funnel, where it is then accelerated by the ordered magnetic field (Sukova et al. 2021). As the outflowing denser gas intercepts our line of sight, it results in the enhanced absorption of the underlying thermal disc continuum. The observed period of 8.5 days, in combination with the inferred SMBH mass of 10^7-10^8 Msun, indicates a semi-major axis of the perturber of ~100 gravitational radii. The observed outflow rate to inflow rate ratio puts constraints on the influence radius of the perturber. For ASASSN-20qc, the influence radius of 3 gravitational radii suggests the presence of a massive perturber in the intermediate-mass black hole (IMBH) mass range. Quasiperiodic ultrafast outflows (QPOuts) are thus a novel phenomenon that can reveal new EMRI/IMRI candidates that otherwise do not exhibit significant periodic changes in the continuum flux density or the accretion rate since the perturbing body is at a relatively large distance with respect to the innermost stable circular orbit.

Session

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AI-Assisted Gravitational Wave Population Inference at Scale

Colm Talbot

University of Chicago

Abstract

Population-level analyses of the entire observed gravitational-wave transient catalogue provide a rich opportunity to probe the astrophysical processes of binary stellar evolution, cosmic expansion history, and fundamental physics. However, as the size of the population grows, it is becoming increasingly apparent that existing approaches to solve this problem do not scale well. In this talk, I will demonstrate a novel machine-learning method for performing simulation-based inference with the entire observed population built on existing gravitational-wave data analysis methods and concepts from information theory. Using this method, I will demonstrate that we can quickly and efficiently project the sensitivity of future gravitational-wave surveys to specific physical phenomena, and analyze large populations with minimal systematic uncertainty.

Session

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2677

Do neutron stars harbour black holes?

Dr Anslyn John

Stellenbosch University. National Institute for Theoretical and Computational Sciences

Abstract

Primordial black holes are theorised to have formed in the early universe. Many of these black holes will have evaporated due to Hawking radiation while a certain fraction may persist as viable dark matter candidates. A recent study investigated the possibility that main sequence stars could host primordial black holes. If these black holes had masses above 10^{-12} solar masses they would disrupt their host stars through accretion. Below this mass limit stars could evolve along the main sequence to form sub-subgiants or red stragglers with observationally distinct features. We explore the possibility that neutron stars may also contain primordial black holes in this mass range. We examine the permissible mass-radius relations and also investigate the stability of these stars.

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Compact object merger rates and masses over redshift from correlated initial conditions

Lucas de Sá[1], Antonio Bernardo[1], Dr. Lívia S. Rocha[2], Prof. Dr. Jorge E. Horvath[1]

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Abstract

We perform a first study of the impact of varying four components of the initial conditions in binary population synthesis (BPS) of compact binary mergers with COMPAS: the initial mass function (IMF), which is made metallicity- and star formation rate (SFR)-dependent; the orbital parameter (orbital period, mass ratio and eccentricity) distributions, which are taken to be correlated; the multiplicity fractions (binary and higher-order), which are modeled as primary mass-dependent; and the metallicity-specific star formation history (SFH). We employ a time-sensitive initial sampling procedure that allows us to distinguish the contribution of populations of different ages to the coalescences taking place at different redshifts. We obtain the evolution up to redshift 10 of the black hole-black hole (BHBH), black hole-neutron star (BHNS) and neutron star-neutron star (NSNS) merger rates; as well as their component mass distributions. We find that the varying initial conditions induce a strong increase of BHBH and BHNS merger production, as well as a stronger correlation between redshift and primary masses. In particular, the varying initial conditions result in BHBH mergers being predominantly formed without undergoing a common envelope phase for z~2. While the particular varying model tested here does not yield local merger rates compatible with observational constraints, our work is the first step in testing a larger set of 192 possible initial condition permutations.

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Radio view of PG 1302-102: a potential black hole binary candidate for gravitational wave emission?

Dr Sayan Basu

University of Witwatersrand

Abstract

Supermassive black hole binaries (SMBBHs) are predicted to be the results of hierarchical mergers of galaxies throughout the history of the universe. SMBBHs can provide important constraints on models of galaxy formation and evolution. Also, sub-parsec (pc) SMBBHs are expected to dominate the recently detected stochastic nHz gravitational wave (GW) background. However, it is challenging to directly detect SMBBH systems at sub-pc separations because of the limitations of the spatial resolutions of present telescopes. Given that, we present an updated multi-epoch radio light-curve and spectral index analysis of a SMBBH candidate, PG 1302-102 (z~0.278), in which previous optical/UV light-curves hypothesize the presence of two supermassive black holes with a sub-pc separation (~0.01 pc) and an orbital periodicity of ~5.2 years. Sources such as this may be well suited to future orbital tracking experiments through high-precision astrometry with an expanded Event Horizon Telescope. It is therefore important to fully characterize such sources on a continual, up-to-date basis in preparation for the future EHT binary supermassive black hole observational campaigns.

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Polarimetric insights to neutron star mergers

Dr. Giorgos Leloudas

DTU Space, Technical University of Denmark

Abstract

Neutron star mergers exhibit a highly asymmetric 3D geometry, characterized by multiple ejecta components with different chemical compositions and physical properties. It is therefore anticipated that their observables demonstrate a significant dependence on the viewing angle. Polarimetry provides an independent means to disentangle the different ejecta components (blue and red kilonova), with important implications for understanding the astrophysical formation of heavy elements. Additionally, independently and complementary to other diagnostics, polarimetry allows us to constrain the merger inclination angle, thus reducing the uncertainty in the determination of the merger distance and the Hubble constant via the standard siren method. ENGRAVE is well-placed to acquire polarimetric data for the next kilonova, facilitated by the advanced instrumentation and versatility of the VLT. Furthermore, our group possesses the capacity for a prompt reaction and analysis, especially critical for this science case, coupled with modeling expertise to interpret the data and contribute valuable insights to the comprehension of neutron star mergers.

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2810

Efficient mergers of intermediate mass black holes with supermassive black holes in galactic nuclei

Dr Taras PANAMAREV

University of Oxford. Fesenkov Astrophysical Institute

Abstract

We present a comprehensive study on the dynamical interaction of intermediate mass black holes (IMBHs) with supermassive black holes (SMBHs) and surrounding stellar system in galactic nuclei. Our primary focus is to demonstrate that an IMBH with a mass of 10^4 solar masses can be drawn closer to a SMBH of 4 million solar masses by dynamical friction, ultimately reaching a distance where gravitational radiation starts to dominate the merger process and leads to a merger within 100 Myr.

Using direct N-body simulations, we reveal that when an IMBH is initially positioned at 0.15 parsecs from the SMBH, it can be brought to the gravitational wave (GW) dominated distance within just 10 Myr in a Milky Way-like galaxy. This finding has important implications for our understanding of the interaction between IMBHs and SMBHs in galactic nuclei and the role of these mergers in the broader context of galaxy evolution.

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The Low-Frequency frontier. New approaches to seismic noise attenuation and their impact on observing capabilities of future gravitational wave detectors

Massimiliano Razzano, Lorenzo Bellizzi, Gabriele Demasi, Federico De Santi, Francesco Fidecaro, Alessio Fiori, Maria Antonietta Palaia, Lucia Papalini, Barbara Patricelli, Michele Vacatello

University of Pisa and INFN-Pisa

Abstract

Third generation ground-based gravitational wave detectors as the Einstein Telescope will expand our view of the Universe. In the meantime, upgrade programs as Virgo_nEXT are planned to boost the sensitivity of existing detectors in the post-O5 era. In this context, improving seismic noise attenuation is a necessary step to enhance the sensitivity at low frequencies. Improving low-frequency sensitivity will enable the detection of coalescences of higher-mass black holes and increase the number of expected multimessenger observations associated with the merger of neutron stars. We will present new studies to simulate and optimize new solutions for seismic attenuation systems for detectors, and explore how low frequency improvements will impact on the observing scenario and localization capabilities of transient gravitational wave sources.

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Mass measurements of binary pulsar systems

Dr Vivek Venkatraman Krishnan

Max Planck Institute for Radio Astronomy

Abstract

Binary pulsars with compact companions and short orbital periods are natural gravitational laboratories in space. Timing pulsars in such systems reveal relativistic effects that affect the orbital motion and the propagation of light across the binary. These measurements in turn provide precise measurements of the pulsar and companion masses. Such measurements have consequences across a variety of fields such as gravitational waves, binary evolution and the neutron star equation of state. In this talk, I will provide an overview of neutron star and white dwarf mass measurements from timing binary pulsar systems, including the recent splurge in measurements aided by the MeerKAT telescope. I will discuss what these measurements mean for the various science cases mentioned above, and outline what measurements can we expect in the near future.

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2848

Particle Swarm Optimization in Eccentric Gravitational Wave Searches.

Mr Syed Naqvi

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Abstract

Eccentricity plays a crucial role in the study of gravitational waves in astrophysics and data analysis, offering valuable insights into stellar interactions, tidal effects, and dynamic encounters within celestial bodies. This characteristic presents both challenges and opportunities in the accurate extraction of signals, waveform modeling, detection, and parameter estimation. Investigating eccentricity enhances our comprehension of astrophysical sources and advances the field of gravitational wave data analysis.

Our research focuses on the application of optimization algorithms, specifically particle swarm optimization (PSO) and differential evolution (DE), in the context of gravitational wave data analysis. We aim to address the challenges posed by incorporating eccentricity as an additional parameter in gravitational wave searches. While current searches predominantly rely on quasi-circular templates, the inclusion of eccentricity significantly increases computational complexity.

Our objective is to evaluate the effectiveness of PSO in detecting eccentric gravitational wave signals observed by ground-based detectors. By harnessing the capabilities of optimization techniques, we aim to enhance the sensitivity and accuracy of detecting these unique signals amidst the detector noise. This research contributes to the evolving landscape of gravitational wave astronomy, offering new avenues for understanding advanced data analysis methodologies.

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Calibration of neutron star natal kick velocities to isolated pulsar observations

Veome Kapil[1], Ilya Mandel[2,3], Emanuele Berti[1], Bernhard Müller[2]

[1]William H. Miller III Department of Physics and Astronomy, Johns Hopkins University. [2]Monash Centre for Astrophysics, School of Physics and Astronomy, Monash University. [3]The ARC Center of Excellence for Gravitational Wave Discovery -- OzGrav, Australia

Abstract

Current prescriptions for supernova natal kicks in rapid binary population synthesis simulations are based on fits of simple functions to single pulsar velocity data. We explore a new parameterization of natal kicks received by neutron stars in isolated and binary systems developed by Mandel \& M\"uller, which is based on 1D models and 3D supernova simulations, and accounts for the physical correlations between progenitor properties, remnant mass, and the kick velocity. We constrain two free parameters in this model using very long baseline interferometry velocity measurements of Galactic single pulsars. We find that the inferred values of natal kick parameters do not differ significantly between single and binary evolution scenarios. The best-fit values of these parameters are $v_{\rm ns} = 520$~km\,s^{-1} for the scaling pre-factor for neutron star kicks, and $\sigma_{\rm ns}=0.3$ for the fractional stochastic scatter in the kick velocities.

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Stochastic Gravitational Wave Background from a semi-analytic model of galaxy, AGN and black hole formation

Dr. Taira Oogi[1], Prof. Masahiro Nagashima[2], Dr. Motohiro Enoki[3]

[1]National Institute of Technology, Asahikawa College. [2]Bunkyo University. [3]Tokyo Keizai University

Abstract

Gravitational waves are a useful tool to probe the formation and evolution of black holes. Recently, Pulser Timing Array (PTA) experiments show evidence for a stochastic gravitational wave background (SGWB) at ~1nHz range, which can provide an independent constraint on the growth of supermassive black holes (SMBHs) at the center of galaxies from electromagnetic wave observations. We study the gravitational wave from SMBH binaries using a semi-analytic model of galaxy and SMBH formation, v^2GC. Our model is based on the Uchuu simulation, a state-of-the-art cosmological N-body simulation. The derived luminosity functions of galaxies and active galactic nuclei (AGN) and black hole mass functions (BHMFs) are in agreement with observations. Our model predicts that the SMBH binary formation rate peaks at ~6 yr^{-1} at z~2. The main contribution to the total amplitude of the SGWB comes from binaries with total mass above 10^8 M_{sun} at $0 < z < 0.5$. The SGWB predicted by our fiducial model is by a factor of 3 lower than that observed by the IPTA collaboration. We investigate the prescription to avoid the inconsistency, considering the uncertainties in the observed BHMFs and AGN luminosity functions. Our model variant with a higher mass accretion rate produces the higher amplitude of the SGWB due to the high black hole number density in the mass range of $\log M_{BH} > 8$, while it overestimates the BHMF at z=0. Our model suggests that the combination of the AGN surveys and the black hole observations (BHMF, SGWB) is important for the formation and evolution of SMBH.

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Formation of binary compact objects in young star clusters with PeTar and SEVN

Dr. Gaston Escobar[1,2], Dr. Giuliano Iorio[1,2], Prof. Dr. Michela Mapelli[3]

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Abstract

The currently-growing LIGO-Virgo data provides an excellent opportunity to investigate the demography of gravitational-wave sources and their production channels. Gravitational-waves detected by LIGO-Virgo are originated in the coalescence of two compact objects, as black holes (BHs) or neutron stars (NSs). Compact-object binaries that merge in less than a Hubble time may arise as the last evolutionary stage of interacting binary stars evolved in isolation. In addition, dynamically active and dense environments, such as star clusters, provide several mechanisms to produce or enhance these merger episodes via dynamical channels. Research in this topic is addressed performing population-synthesis simulations of binary systems and direct N-body star-cluster simulations. In this talk we will show our recently developed tool to compute both dynamics and binary evolution integrated together, which uses the group's population-synthesis code SEVN (Stellar EVolution N-body) within the state-of-the-art N-body code PeTar. SEVN uses a set of precomputed stellar tracks to interpolate the evolution of star properties on the fly. This is a change of paradigm in the field, since most population synthesis codes rely on fitting formulas to stellar evolution tracks run more than 20 years ago. We will show our results on the demography of binary compact objects, as binary BHs (BBHs) and BH-NSs, formed in young star clusters, and confront the results with those which use past stellar-evolution prescriptions.

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The NANOGrav Pulsar Timing Program: Observing, Analysis, and Astrophysics

Prof Maura McLaughlin

West Virginia University

Abstract

NANOGrav observes a network of 70 millisecond pulsars with the Green Bank Telescope and CHIME in order to measure correlated perturbations in pulse arrival times due to low-frequency gravitational waves. I will describe our observing program and our continually evolving procedures for fitting timing models and for characterizing sources of noise in the data. I will also discuss the transformative ancillary science that results from our data, including pulsar astrometry and tests of general relativity, and constraints on the neutron star equation of state, pulsar emission physics, and the interstellar medium, and present several new results based on the 15-yr data set.

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Simultaneous measurements of the Hubble parameter and binary black hole population properties using the gravitational wave background

Bryce Cousins[1], Dr Ka-Wai Adrian Chung[2], Kristen Schumacher[2], Dr Tom Callister[3], Dr Colm Talbot[3], Dr Daniel Holz[4], Dr Nicolás Yunes[2]

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Abstract

It is known that early- and late-universe measurements of the Hubble constant are in major disagreement, amounting to an issue known as the Hubble tension. This conflict has prompted the development of many novel approaches to measuring the Hubble constant, including the use of gravitational waves from individually-resolved compact object mergers as so-called "standard sirens." While the standard siren method has been well-explored, the gravitational wave background arising from unresolved mergers has not yet been considered as a means to study the Hubble tension. In this presentation, I will demonstrate how combining resolved binary black hole mergers with the astrophysical gravitational wave background can be used to not only constrain the Hubble parameter, but also the properties of the binary black hole population. This procedure serves as a means to probe the Hubble tension independently of conventional methods at potentially higher redshifts while simultaneously providing insight on the population of binary black hole mergers across cosmic time.

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Final category: IAUS 390 A Multi-Point view of the Sun: Advances in Solar Observations and in Space Weather Understanding

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Applied Machine Learning methods for the synthesis and inversions of the Stokes parameters in the solar context

Bachelor in Physics Juan Esteban Agudelo Ortiz[1], Bacherlo in Physics Germain Nicolás Morales Suarez[1], PhD in Physics and Astronomy Santiago Vargas Domínguez[1], PhD in Physics and Astronomy Sergiy Shelyag[2]

[1]Universidad Nacional de Colombia. [2]Flinders University

Abstract

The upcoming spectropolarimetric instruments such as DKIST, the development of new and more precise methods of magnetohydrodynamics (MHD) and the development of new numerical methods for solving the equations of radiative transfer, come both with more computational demands in power and time and with the generation of tons of data to be treated for future scientific investigation. The combination of this requirements come with the possible delaying of current going scientific investigations in terms of years. This difficulties call for the development of faster methods to treat this data. The rise of Artificial intelligence and, specifically, Machine Learning, has come with new methods to treat faster and efficiently large quantities of data in different study fields. There has been studies applied to the area of physics and astrophysics that has been trying to replicate what is done with numerical methods but using machine learning techniques, allowing processes to deminish processing time in orders of magnitude. Following this steps, and parting from previous works made on the area of synthesis and inversions using machine learning techniques applied on the sun, we aim to use data obtained from simulations such as MURaM and the associated results from applied radiative transfer codes such as NICOLE, to train Machine Learning arquitectures forward (synthesis) and backward (inversions) to study the aplication of this models on new simulation codes and observational data to be obtained in the future, contributing to the new paradigm of treating physical data with the use of artificial intelligence.

Session

IAUS 390 A Multi-Point view of the Sun: Advances in Solar Observations and in Space Weather Understanding

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Geomagnetic Storms due to solar activity during the Rising Phase of Solar Cycle 25

Dr Gebregiorgis Abraha Fikade[1], Dr Yikdem Mengesha Gebrehiwot[1], Dr Solomon Belay Tessema[2]

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Abstract

A geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there exists an exchange of energy from the solar wind into the space environment surrounding Earth. The largest storms that result from these conditions are associated with coronal mass ejections (CMEs) with magnetic field embedded in it arrives at Earth magnetosphere. Solar cycle 25 was begin in 2019 and geomagnetic storm occurred almost every month since the beginning of the cycle. This study examines the occurrences rate of geomagnetic storms during the rising phase of solar cycles 25. It also investigates the solar sources of the storm, is it CME or CIR. The Disturbed storm time (Dst), Sunspot Number (SSN), and Solar wind Speed (SW) data were used in the study. The study establishes that the magnitude of the rate of occurrences of geomagnetic storms increase. At the beginning of the phase 2019 and 2020 only weak storms were observed. Except the sever storm of November 14/2021, in the years 2020 and 2021 the storms are rated as comparable moderate and weak storms, As the solar cycle is nearing to its peak the year 2023 was observed as the most disturbed year so far with moderate and intense geomagnetic storms (Dst < -100 nT) occured and are mostly associated with coronal mass ejections (CMEs).

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On the distribution of Forbush decreases and their size classification

Dr Innocent Eya

University of Nigeria.

Abstract

A Forbush decrease (Fd) is a temporary reduction in the cosmic rays (CR) flux observed on Earth. However, there has been a debate on how to classify Fds based on their sizes, mainly due to the incompleteness in the distribution of Fd sizes occasioned by the scanty/unavailability of Fds of magnitudes less than 0.3%. The manual measuring of Fd from raw CR data made it difficult to identify numerous Fds of size < 0.3%. However, with recent advancements in algorithms, Fds of size up to 0.01% can be identified from any CR data, thereby uncovering the numerous Fds of far less than 0.3%. In this analysis, we utilized an automated Fd measurement algorithm on CR data from nine Neutron monitors covering the period from January 1999 to December 2006 to uncover the Fds in them. We found that the size distribution of Fds is uni-modal and objectively complete. The probability of having Fd in the second quarter-sides of the lower end and larger end of the size distribution is less than 5% at a 95% confidence level. Having more Fds is not likely to shift the peak of the distribution significantly. Based on this, we can confidently classify Fds based on their sizes. Fds of size ≥ 2% are considered large Fds, while those < 2% are small Fds. The distribution of the Fd size is best described by a power law, just like other natural phenomena. Moreover, we also analyzed the interplay of large and small Fds with solar activity parameters.

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How open data and interdisciplinary collaboration improve our understanding of space weather: A risk and resiliency perspective

Vincent Ledvina[1,2,3], Dr. Erika Palmerio[4], Dr. Ryan McGranaghan[5,6], Dr. Alexa Halford[7], Aidan Thayer[8], Laura Edson[3,7], Dr. Elizabeth MacDonald[3,7], Dr. Don Hampton[1]

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Abstract

Space weather refers to conditions around a star, like our Sun, and its interplanetary space that may affect space- and ground-based assets as well as human life. Space weather can manifest as many different phenomena, often simultaneously, and can create complex and sometimes dangerous conditions. The study of space weather is inherently trans-disciplinary, including subfields of solar, magnetospheric, ionospheric, and atmospheric research communities, but benefiting from collaborations with policymakers, industry, astrophysics, software engineering, and many more. Effective communication is required between scientists, the end-user community, and government organizations to ensure that we are prepared for any adverse space weather effects. With the rapid growth of the field in recent years, the current Solar Cycle 25 maximum, and the evolution of research-ready technologies, we believe that space weather deserves a reexamination in terms of a “risk and resiliency” framework. By utilizing open data science, cross-disciplinary collaborations, information systems, and citizen science, we can forge stronger partnerships between science, industry, and the public and improve our readiness as a society to mitigate space weather impacts. The objective of this talk is to raise awareness of these concepts as the solar maximum peaks, coinciding with an increasingly technology-dependent society, and introduce a unique way of approaching space weather through the lens of a risk and resiliency framework that can be used to further assess areas of improvement in the field.

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On the influence of solar-geomagnetic properties on small-magnitude, algorithm-selected Forbush decrease

Dr Evaristus Iyida

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Abstract

The precise computation of the magnitude and time of sudden reductions in galactic cosmic ray (GCR) intensity has remained an important stage in studying Sun-Earth-related phenomena. This paper discusses the analysis of daily-averaged cosmic ray (CR) data from three known Neutron Monitor stations located at altitudes above 1000 m, namely, CALG, CLMX and ESOI spanning from 1999 – 2006 using an algorithm-selected technique. We compare the catalogs of small-magnitude FDs as recorded by the three stations to demonstrate how GCRs respond to the passage of these properties. Our technique selected 202, 54 and 95 FD events with a magnitude less than 3 % respectively from CALG, CLMX and ESOI. Also, 30 of the FD events were detected simultaneously in the standard time by the three monitor stations irrespective of their altitudes and cut-off rigidity. For the 30 simultaneous FDs, the average values of the events are found to be -8.40, -6.60 and -7.40 for stations CALG, CLMX and ESOI respectively. A statistical t-test and the non-parametric, two-dimensional Kolmogorov–Smirnov (K-S) tests of the FD data show that 5 – 80 % of the observed variability in GCR flux intensity at the same time of FD could be attributed to solar-geomagnetic effects. We discuss these results in the context of FD events and their dependence on solar-geomagnetic properties.

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Rieger Periodicity Variation in Solar Mg II Spectral Emission During Various Cycles

Prof Pieter Kotze

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Abstract

The temporal variation of the approximately 155-day Rieger solar periodicity is investigated in the Mg II spectral emission as observed at 280 nm during the interval between 1980 and 2019. Daily mean values of Mg II at each annual interval are spectrally analysed using Lomb–Scargle and Morlet wavelet techniques to obtain the temporal behaviour of particularly the » 155-day Rieger as well as the » 27-day solar rotation periodicities. Results obtained indicate substantial power in the Rieger periodicity that varies on an annual basis. In particular, the power of the Rieger periodicity exceeds that of the 27-day period during the maxima of Solar Cycles 21 (1981), 22 (1992), and 23 (2001), with the power of the 27-day periodicity dominating during the minima of these cycles. In contrast to these findings, we observe a substantial increase in power of the Rieger periodicity in comparison to that of the » 27-day solar rotation period during the minima of Cycles 23 (2006, 2007) and 24 (2018, 2019).

During this time the solar magnetic field experienced a substantial diminishing in the strength of several spherical harmonics with extremely low solar activity during the minima of Cycles 23-24 and 24-25. Recent studies showed that the Rieger periodicity is related to the instability of magnetic Rossby waves due to the solar differential rotation and magnetic field in the dynamo layer. A possible explanation for Rieger periodicity behaviour is the peculiar characteristics of the solar magnetic field during Cycles 23 and 24 and the resulting Rossby waves.

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The Predicted of Artificial Space Objects towards the Peak of Solar Cycle 25

Ms Fazira Huwaidaa, Mr Achmad Rozykkin, Mr Muhammad Ikhsan

Sumatera Institute of Technology

Abstract

The quantity of space objects launched into space, particularly within the low earth orbit (LEO), has exhibited a consistent rise since the beginning of the space race, which has become a major concern in the space sector. Over two thousand fragments of objects larger than 10 cm have reentered the earth's atmosphere. The reentry objects are expected to transpire during the peak of solar cycle 25. This study addresses the escalating focus on the prediction of artificial reentry space objects during the peak of solar cycle 25 through the implementation of machine learning methods. According to the study's findings, the population of artificial reentry space objects has increased significantly. One of the findings is that the enormous atmospheric drag in LEO is stronger than in other orbits; therefore, space objects are more affected by the atmosphere. The solar cycle's current peak further exacerbates the problem. The intriguing findings pertaining to the relationship between artificial reentry space objects and solar activity. Our results showed a significant correlation with predicted reentry objects, shedding light on the intricate play between solar activity and reentry objects at the peak of solar cycle 25.

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Can the Geostationary Operational Environmental Satellite's (GOES) ultraviolet measurements predict the X-ray properties of solar flares?

Miss Abigail Mthethwa[1], Dr Martin Snow[2]

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Abstract

Solar flares are powerful phenomena with significant implications for space weather. Understanding their characteristics and predicting their behaviour is crucial for mitigating potential risks and ensuring the safety of space-based operations. This research project aims to investigate whether ultraviolet (UV) measurements obtained from the Geostationary Operational Environmental Satellite (GOES) can be used to predict the X-ray properties of solar flares. By analysing high-cadence UV solar spectral irradiance data from the GOES Extreme Ultraviolet and X-ray Sensors (EXIS) instrument, the study seeks to establish a reliable relationship between UV observations and X-ray flare behaviour. The ultimate goal is to develop a model that enables real-time prediction and interpretation of solar flares, empowering space weather forecasters to make accurate forecasts and take necessary precautions.

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What is the Effect of Solar Wind Disturbances on Small-Amplitude Simultaneous Forbush Events During Solar Cycle 23?

Professor Jibrin Alhassan[1], Dr. Ogbonnaya Okike[2], Professor Augustine Chukwude[1], Associate Professor Finbar Odo[1], Dr. Innocent Eya[3], Dr. Jude Ugwu[3], Dr. Evaristus Iyida[1], Dr. Romanus Ugwoke[4], Mr Firew Menteso[1,5], Dr. Dominic Obiegbuna[3], Dr. Orji Orji[1]

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Abstract

The transient and rapid reduction in cosmic-ray (CR) flux intensity commonly referred to as Forbush decrease (FD), is widely used as a mediator variable in searching for solar-terrestrial weather linkages. Whereas, a wide range of solar-terrestrial literature is replete with high-magnitude (amplitude ≥ 3%) FD-based analyses, the empirical connections between low amplitude (FD(%) ≤ 3) events and Sun-Earth variables are seldomly tested. It is recently observed that the shortage of such studies might be due to the daunting task of accurate detection/precise timing of FDs and other transient astrophysical events. Using a highly sensitive version of the FD detection algorithm, we selected 264, 267, and 206 low amplitude (FD(%) ≤ 3) FDs from the daily CR data of Hermanus (HRMS), Newark (NWRK) and Oulu (OULU) neutron monitor (NM) stations respectively, during solar cycle 23. A total of 80 simultaneous small-amplitude FDs were identified from the three stations with the aid of a simple coincident computer code. We find statistically significant correlations at a 95% confidence level between the planetary K-index (kp), disturbance storm time index (Dst), planetary A-index (ap), and the corresponding simultaneous weak FDs at each of the stations.

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ASTROPHYSICAL ANALYSIS OF CORONAL MASS EJECTIONS AND COSMIC RAYS DURING INTENSE GEOMAGNETIC STORMS

EDWIN AYABIE, DR HAMMED LAWAL, MUKHTAR MUHAMMED

AIR FORCE INSTITUTE OF TECHNOLOGY KADUNA

Abstract

One of the most important layers of Earth's atmosphere, the magnetosphere, is essential for absorbing charged particles such as cosmic rays and coronal mass ejections (CMEs). The goal of this study is to comprehend the astrophysical causes and phenomena of CMEs, with a particular emphasis on their appearance during strong geomagnetic storms. The study highlights the astrophysical relevance of CMEs by identifying patterns and trends connected to them through a meticulous extraction and analysis of data from the OMNI Web. Compared with the solar cycle's majority of mild CMEs, a notable subset in 2022 and 2023 showed significant consequences, providing important information about the astrophysical dynamics of these events in the context of strong geomagnetic storms.

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Ionospheric total electron content (TEC) over Ecuador using global positioning system (GPS) data

Prof. Ericson Lopez

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Abstract

The Total Electron Content (TEC) serves as a crucial parameter for assessing the state of Earth's ionosphere, a region that significantly influences the propagation of electromagnetic waves traversing it. Given the multitude of physical phenomena occurring in the upper atmosphere, accurately measuring TEC aids in understanding ionospheric morphology. Among the tools utilized for TEC measurement, the Global Positioning System (GPS) stands out. GPS, a satellite-based radio navigation system, offers real-time position verification with remarkable accuracy, typically within a few centimeters.

The significance of studying TEC lies in its ability to provide insights into the spatial and temporal variations of the ionosphere. Such understanding allows for the development of improved correction tools for satellite communication and navigation systems. This study aims to visualize the evolution of TEC intensity through color maps, utilizing data from 14 GPS receivers distributed across Ecuador. Pseudo-range observables collected from these stations were leveraged to depict TEC and its evolution throughout 2021-2023.

The findings of this study unveil an oscillatory pattern in TEC evolution, characterized by intensity peaks at certain instances, some of which approach or even surpass 100 TEC units (TECU). Conversely, local minima are consistently observed to remain above zero values, underscoring the dynamic nature of the ionosphere's electron content.

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PURELY FACULAR MGII INDEX

Miss Siphumelele Ndlovu[1,2], Dr Martin Snow[2]

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Abstract

The MgII index has emerged as a valuable metric for studying solar activity and its impact on the Earth's atmosphere. This index focuses exclusively on the contribution of facular regions, which are bright and transient solar features associated with enhanced magnetic activity. In this study, we utilize data from the Interface Region Imaging Spectrograph (IRIS), the Helioseismic and Magnetic Imager (HMI), and the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) to develop an improved MgII index that highlights the contribution of the facula. The IRIS provides high-resolution observations of the solar chromosphere and transition region, allowing us to analyze the spatial distribution and temporal evolution of facular regions. The HMI provides magnetic field measurements, enabling us to study the relationship between magnetic activity and the facular MgII index. Additionally, the SOLSTICE provides calibrated solar irradiance measurements, which we will use to correct the IRIS measurements. Our analysis will yield insights into the dynamics, variability, and potential connections of the facular MgII index with magnetic activity and solar irradiance. These findings contribute to a deeper understanding of solar phenomena and their implications for atmospheric and climate studies.

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The Firefly (4π) Constellation: Going Above and Beyond in the Heliosphere Exploration

Dr. Nour E. Raouafi[1], Dr. Thomas Berger[2], Dr. J. Todd Hoeksema[3], Dr. Angelos Vourlidas[1], Dr. Lisa A. Upton[4], Dr. Sarah E. Gibson[5], Dr. Jeffrey S. Newmark[6], Dr. Susan T. Lepri[7], Dr. Donald M. Hassler[4], James Kinnison[1], Dr. Manolis Georgoulis[1], Dr. George C. Ho[8], Dr. Nicholeen M. Viall[6], Prof. Louise Harra[9,10], Prof. Marco Velli[11], Dr. Adam Szabo[6], Dr. Marta Casti[12,6], Dr. Sofiane Bourouaine[13], Dr. Vamsee K. Jagarlamudi[1], Dr. Juliana T. Vievering[1], Dr. James P. Mason[1], Dr. Sami K. Solanki[14,15], Dr. Lyndsay Fletcher[16,17], Dr. Richard A. Harrison[18], Dr. Yukio Katsukawa[19], Dr. Kanya Kusano[20], Dr. Christopher J. Owen[21], Dr. Marco Romoli[22], Prof. Robert F. Wimmer-Schweingruber[23], Dr. John W. Leibacher[24,25,26], Dr. Thierry Appourchaux[25], Dr. Patrick Boumier[25]

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Abstract

Heliospheric exploration has soared to unprecedented heights in recent decades thanks to innovative spaceborne missions, ground-based observatories, and advancements in computing, models, and theory. However, the progress of inner-heliospheric research is hindered by observing limitations, preventing resolving long-standing problems such as understanding the solar dynamo, solar cycle, solar wind acceleration, and the impact of active region magnetic fields on space weather and Earth. These limitations stem from observing a dynamic 3D star from a single vantage point in the ecliptic. Holistic observations, encompassing the Sun and the inner heliosphere with full 4π-steradian coverage, will open new research avenues and bridge knowledge gaps in heliophysics and astrophysics. The Firefly Constellation mission concept aims to enable simultaneous observations of the Sun and inner heliosphere from multiple viewpoints, revolutionizing our understanding of the Sun's interior, solar atmosphere, and the inner heliosphere. The mission includes spacecraft strategically positioned in the ecliptic plane and at high solar latitudes, all equipped with a comprehensive payload including remote sensing and in situ instruments. We provide an overview of the Firefly mission, which is under consideration by the 2024-2033 Decadal Survey for Solar and Space Physics (Heliophysics), and its success could pave the way for groundbreaking discoveries, building upon the achievements of previous NASA missions.

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Parker Solar Probe: An Overview of the Mission Achievements and Future Prospects

Dr. Nour E. Raouafi

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Abstract

NASA's Parker Solar Probe is now entering the pivotal phase of its prime mission, marking an exciting milestone for this remarkable endeavor. Since its launch on 12 August 2018, Parker has successfully completed 18 out of its scheduled 24 orbits around the Sun, venturing as close as 11.4 solar radii from the Sun’s center. On 6 November 2024, it will fly by the planet for the seventh and last time, setting it up for the ultimate orbit with a perihelion of 9.86 solar radii on 24 December 2024. The mission's primary science goal is to determine the structure and dynamics of the Sun's coronal magnetic field, understand how the solar corona and wind are heated and accelerated, and determine what processes accelerate energetic particles. Throughout its journey, the mission has made remarkable advancements in its science objectives and crucial discoveries regarding previously unknown solar wind phenomena. As the mission progresses, the intensifying solar activity leading up to its cycle maximum has brought forth new and intriguing properties within the near-solar environment. These distinctive characteristics mark a significant departure from the relatively tranquil period observed during the mission's initial three years. I will present an overview of the mission's current status, its remarkable scientific achievements, and the exciting prospects awaiting us as we conclude this seven-year primary science phase.

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ACCELERATION RATE OF PROTONS DURING SOLAR FLARES

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Abstract

Solar proton events registered by the anticoincidence shield of the spectrometer on the *INTEGRAL* (ACS SPI) during 23-25 solar cycles were considered. The proton acceleration rate was estimated from the onset of >100 keV electron emission (hard X-ray (HXR) or microwaves) and the proton onset of ACS SPI count rate. It is shown that in solar flares the rate of proton acceleration is consistent with the range of electron acceleration times up to 100 keV from tens to hundreds of milliseconds, known from HXR observations. Consequently, solar protons >100 MeV and electrons >100 keV are accelerated by the same mechanism during the development of eruptive flares. The acceleration mechanism is a stochastic acceleration by multiple reconnection during developing "magnetic detonation" in eruptive flares. Eruptive flares and proton events can be classified by the rate at which electrons and protons are accelerated. In this case, proton events associated with ground level enhancements of cosmic ray intensity (GLE events with Ep > 450 MeV) are distinguished by the "early" < 20 min arrival of the first protons into the Earth's orbit relative to the onset of HXR radiation > 100 keV (proton acceleration rate > 1 MeV/ s). In "late" >20 min proton events, the acceleration rate is <1 MeV/s. In "early" proton events without GLE, there was not enough time to accelerate a sufficient number of Ep > 450 MeV protons. Rare "late" GLE relatively to the ACS SPI proton onset might be attributed to small acceleration rate.

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ASO-S and synergies with space- and ground-based assets

Dr. Beili Ying

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Abstract

The Advanced Space-based Solar Observatory (ASO-S) was successfully launched in October 2022, opening the era of comprehensive solar space observation in China. The ASO-S mission is equipped with three payloads: a Full-disk vector MagnetoGraph (FMG) to measure photospheric magnetic Fields, a Hard X-ray Imager (HXI) to observe non-thermal signals from 30 to 200 keV, and a Lyman-alpha Solar Telescope (LST) to take images of the Sun and the inner corona up to 2.5 $R_{\odot}$ in both the Lyman-alpha (121.6 nm) and visible wavebands. The primary objective of the ASO-S mission is to explore the interconnections between solar magnetic fields, solar flares, and coronal mass ejections, which can be summarized as the "1M2B" concept. After over a year of stable operation, the satellite has amassed a substantial volume of observational data, accessed through the following link: [http://aso-s.pmo.ac.cn/sodc/dataArchive.jsp]. This presentation will provide an overview of the satellite's performance, highlight some of the major scientific discoveries, and discuss the synergies between the ASO-S mission and other space- and ground-based instruments.

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Multifractal Domain and Machine Learning for the Analysis of Space Weather

Dr. James Wanliss, Dr. Stephen Ojo

Anderson University, SC

Abstract

Space weather can cause temporary and unpredicted electrical interruption in systems on and around the earth. Thus developing early warning systems and extension of forecasting time is critical in real-world applications. Appropriately tuned convolutional neural networks (CNNs) can realize long-term dependencies in physical data. We apply the PyTorch machine learning (ML) framework to several metrics of space weather with novel multifractal measure statistical functions as input. We find that different combinations of features and classifiers produce different results. We employ a grid search-based hyperparameter tuning method in a novel temporal CNN framework not heretofore demonstrated in space weather research.

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SEARCH FOR PHASE OF GALACTIC COSMIC RAY VARIATIONS IN THE 21-25 SOLAR CYCLES

Dr Alexei Struminsky[1], Dr Anatoly Belov[2], Dr Raisa Guschina[2], Dr Victor Yanke[2], Dr Irina Grigorieva[3]

[1]Space Research Institute. [2]Institute of Terrestrial Magnetism and Radio Wave Propagation (IZMIRAN). [3]Main (Pulkovo) Astronomical Observatory

Abstract

Traditionally, the sunspot minimum is associated with beginning of galactic cosmic rays (GCRs) modulation in the 11-year cycle. However, the beginning of a new sunspot cycle does not reflect all physical processes on the Sun that modulate GCRs in the heliosphere. To clarify the beginning of the GCR modulation cycle, we look for an unknown variation phase choosing other options of zero time. We compare the amplitude of zero harmonic GCR variations, calculated for 5, 10 and 20 GV rigidities in the 21 - 25 solar cycles, for 11 years after: (1) the last proton event of the previous cycle; (2) the maximum of polar solar magnetic field B_{pole} and (3) the maximum of GCR intensity. Choosing zero (3), the reversal of B_{pole} polarity practically coincides in time for the 21-25 cycles. “To the right” of the polarity reversal GCR variations are similar in pairs of cycles: (21, 23) $B_{pole}<0$ and (22, 24) $B_{pole}>0$, and there is no such similarity “to the left”. Apparently, GCR fill the heliosphere by the drift mechanism “to the right” and GCR are removed from the helospere by the convection "to the left". The role of low coronal holes (LCHs) and coronal mass ejections CME is important "to the left". The amplitude of GCR variations is almost the same in the 21st, 23rd and 24th cycles, but it minimum in the 25th cycle (slow CMEs and small area of LCHs) and maximum in the 22nd cycle (powerful flares and CMEs of 1989 and 1991years).

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Probing Ionospheric Irregularities Through Multi-Constellation Multi-frequency GNSS Observations at a Low-latitude Indian Location

Dr. Sampad Kumar Panda, Mr. Ram Kumar Vankadara

KL Deemed to be University, Koneru Lakshmaiah Education Foundation

Abstract

The ionospheric plasma irregularities can critically affect the operational reliability of global navigation satellite system (GNSS) signals by introducing signal fading and scintillations. Plasma irregularities and depletions at equatorial and low latitudes are generally observed during the post-sunset and even post-midnight hours. We present a detailed analysis of ionospheric scintillations at a low latitude Indian location considering multi-constellation and multi-frequency signals datasets for about two years under the solar cycle-25. The analysis is undertaken in terms of peak amplitude scintillation indices and percentage occurrence rate, along with the number of affected satellites and respective intensities to realize the varying impact of scintillation on different constellations during post-sunset and post-midnight hours. Moreover, the quantitative results from this study reveal the scintillation behavior under changing night-to-night, seasonal and solar activity conditions, over diverse constellations, and frequencies. We also probe the presence of irregularities by substantiating the relationship between the total electron content (TEC) depletion and scintillation intensities across all types of GNSS signals during the most geomagnetically disturbed days under the current solar cycle. An indirect method for trailing the presence of ionospheric irregularities and associated EPBs is adopted by capturing the characteristic depletion signatures by detrending the slant TEC with a specific window size that is in good agreement with the recorded amplitude and phase scintillation indices. This opens the scope for utilizing the most abundant traditional geodetic GNSS receiver observations across any region to understand and develop mitigation strategies for the effects of plasma irregularities.

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Models for Long-Term and Short-Term Flare Prediction

Dr Marianna Korsos

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Abstract

The integration of long-term and short-term solar flare predictions is a crucial component of space weather forecasting, given their potential impacts on Earth's technological infrastructure and astronaut safety. This presentation examines the importance of combining different long-term and short-term solar flare prediction methods to improve the reliability and precision of forecasts. Long-term predictions provide a broad understanding of solar activity, facilitating better preparedness for heightened periods of solar activity. In contrast, short-term predictions are based on recent solar observations and the rapidly evolving phenomena on the solar surface, offering warnings within hours or a daily timeframe. By merging long-term and short-term insights, a more robust and effective solar flare prediction framework can be established. This comprehensive approach enhances the accuracy of specific flare event predictions and significantly advances our grasp of solar dynamics.

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Fine Magnetic Structure, Formation and Eruption Mechanisms of Solar Filaments

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Abstract

Filaments or prominences are cold and dense plasma supported by coronal magnetic fields in the hot and tenuous corona. The eruption of filaments is an important solar source for producing coronal mass ejections in interplanetary space and causes geomagnetic storms. Therefore, the study of solar filaments is the most important topic in solar physics, and it has been studied intensively during the past several decades. In this talk, I will introduce our recent studies on the formation, magnetic structure, and eruption mechanisms based on multi-wavelength and multi-angle high-resolution ground-based and space-borne solar telescopes, and these results might shed some light on the full understanding of solar filaments.

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Solar Close Observation and Proximity Experiments (SCOPE) Mission Concept

Professor Jun Lin

Yunnan Astronomical Observatories, Chinese Academy of Sciences

Abstract

The region close to the Sun is a totally unknown world to us, many important processes and phenomena occurring there are completely imperceptible on the Earth, and it is still an “uninhabited zone” for the deep space mission. This work is to introduce an unprecedented deep space mission that will enter the “uninhabited zone”, solving the puzzles that have challenged the solar physics society for around a century. These puzzles are related to the mechanisms for the solar eruption, detection of the coronal magnetic field, as well as the mechanism of the corona heating. The spacecraft will reach to the location closer to the Sun than the Parker Solar Probe would reach on an orbit of larger inclination to the ecliptic plane than the Solar Orbiter. The associated scientific goals include: 1. Entering the central structure of the energy release driving the solar eruption, performing in situ measurements of physical properties of the structure, and solving the problem of mechanisms of solar eruptions; 2. Acquiring the true thickness of the reconnecting current sheet connecting a coronal mass ejection to the associated solar flare, and renovating the classical theory and the physical scenario regarding the large-scale of magnetic reconnection; 3. Acquiring the coronal magnetic field via in situ measurement, obtaining unique evidence for identifying mechanisms of the corona heating, observing closely the polar magnetic field and plasma, revealing the role of the polar magnetic field and plasma in governing the global behavior of the solar activity.

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The radiation effort at SANSA Space Weather center and as an ICAO-designated regional warning center

Dr Rendani Nndanganeni

South African National Space Agency (SANSA), PO Box 32, Hermanus 7200

Abstract

The South African National Space Agency (SANSA) has operated the Regional Warning Center (RWC) for Space Weather (SWx) in Africa since 2010. In 2018, South Africa, through SANSA, was designated by the International Civil Aviation Organisation (ICAO) as a Regional Centre for the provision of space weather information to international air navigation. SANSA is in a position to work together with all the affected sectors, and government, to make provision for space weather capability that addresses both national and regional requirements and mitigation measures against space weather risks.

Over the past 14 years, SANSA has developed the capability to monitor and forecast space weather as well as prioritize research projects that enhance the modeling ability of the center. Space weather can disrupt these technological systems, and infrastructure, including but not limited to satellite and airline operations, communications networks, navigation systems, oil and gas pipelines, and the electric power grid.

This presentation will discuss the effort that SANSA has made in terms of studying radiation exposure at aviation altitude and the ICAO regional status.

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First Light Observations and results from the Solar Ultraviolet Imaging Telescope (SUIT) on board Aditya-L1

Prof Durgesh Tripaathi, Prof A N Ramaprakash, SUIT Team

IUCAA, Pune

Abstract

The Solar Ultraviolet Imaging Telescope (SUIT) is one of the seven payloads on board Aditya-L1. It provides, for the first time spatially resolved, full disk images of the solar atmosphere in the wavelength range of 200-400 nm, covering the photosphere and the chromosphere, using 11 different science filters, with a spatial resolution of 1.4 arcsec. SUIT observations help us study static and dynamic features in the solar atmosphere. Moreover, for the first time, it allows us to measure and monitor the spatially resolved solar spectral wavelength in this wavelength range, which is central to sun-climate relations. This presentation will highlight some of the first results obtained from SUIT and discuss its capability for various science observations, also in combination with other existing and upcoming space missions.

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Measuring Magnetic Fields of Coronal Mass Ejection in Corona and Inner Heliosphere using Wide Field of View Spectropolarimetric Radio Imaging

Dr. Devojyoti Kansabanik[1,2,3], Dr. Angelos Vourlidas[2], Dr. Surajit Mondal[4], Prof. Divya Oberoi[3]

[1]Cooperative Programs for the Advancement of Earth System Science (CPAESS), Corporation for Atmospheric Research, Boulder, CO, USA. [2]Applied Physics Laboratory, Johns Hopkins university, LAUREL, MD, USA. [3]National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, India. [4]Center for Solar Terrestrial Research, New Jersey Institute of Technology, Newark, NJ, USA

Abstract

Measurements of the plasma parameters of Coronal Mass Ejections, particularly magnetic fields entrained in the CME plasma, are crucial to understanding their propagation, evolution, and geo-effectiveness. However, estimating magnetic fields inside the CME both at the corona and heliosphere is challenging. Several observational probes at radio wavelength can estimate CME magnetic fields in the corona and heliosphere. Spectralpolarimetric modeling of gyrosynchrotron (GS) emission from CME plasma has long been regarded as one of the most promising remote observation techniques for estimating spatially resolved CME plasma parameters. With the data from the Murchison Widefield Array (MWA) and the recently developed spectropolarimetric snapshot imaging pipeline optimized for this data (P-AIRCARS), spectropolarimetric detection of faint GS emissions has become possible. We present studies of spectropolarimetric modeling of GS emissions, demonstrating that degeneracies between several model parameters can be broken using polarimetric imaging. However, this methodology is only useful to measure CME magnetic fields up to ~10 solar radii. At higher coronal heights and inner heliosphere, CME magnetic fields can be estimated by measuring the Faraday rotation of linearly polarized galactic/extragalactic radio sources. We have recently started exploring the FR measurements due to CME using the MWA. The advantage of using the MWA is its wide FoV and lower observing frequency. Lower observing frequency provides sensitivity to smaller magnetic fields and wide FoV will provide simultaneous measurements along multiple LoSs enabling estimation of magnetic fields of CMEs. We present the challenges to achieve these goals and some initial results.

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Power-law Index in Flare Frequency Distribution: A Probe to Local Magnetic Field of Flare Source Region

Dr. Yijun Hou

National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China. School of Astronomy and Space Sciences, University of Chinese Academy of Sciences, Beijing, China

Abstract

Stellar flares are powerful energy release phenomena in the stellar atmosphere that can pose hazards to the life in surrounding planets. While flares are widely believed to be driven by magnetic reconnection, the quantitative connection between stellar flare properties and the magnetic field of the flare source region remains hitherto elusive. This is because, unlike for solar flares, observations of distant stars cannot spatially resolve stellar flare source regions or directly measure their magnetic fields. Here we try to establish such connection by studying the nearest star, our Sun, where flares can be exactly linked to their source regions. We investigate the flare frequency distribution (FFD) of a large sample of solar flares that originate from solar active regions (ARs) with different average magnetic field strength (B_{AR}). It is found that the power-law index (α) of FFD shows a strong linear correlation with B_{AR}, establishing a quantitative connection between local magnetic field and flare statistical property. In the context that stellar flares are cousins of solar flares, such α-- B_{AR} linear correlation for solar flares can also be utilized to derive the magnetic field of stellar flare source regions that cannot be directly measured through current observations.

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Partial Eruption of Solar Filaments: Configuration and Formation of Double-decker Filaments

Dr. Yijun Hou

National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China. School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, China

Abstract

Partial eruptions of solar filaments are the typical representative of solar eruptive behavior diversity. Here we investigate a typical filament partial eruption event and present integrated evidence for configuration of the pre-eruption filament and its formation. The CHASE Hα observations reveal structured Doppler velocity distribution within the pre-eruption filament, where distinct redshift only appeared in the east narrow part of the south filament region and then disappeared after the partial eruption while the north part dominated by blueshift remained. Combining the SDO, ASO-S observations, and NLFFF modeling results, we verify that there were two independent material flow systems within the pre-flare filament, whose magnetic topology is a special double-decker configuration consisting of two magnetic flux ropes (MFRs) with opposite magnetic twist. During the formation of this filament system, continuous magnetic flux cancellation and footpoint motion were observed around its north end. Therefore, we propose a new double-decker formation scenario that the two MFRs composing such double-decker configuration originated from two magnetic systems with different initial connections and opposite magnetic twist. Subsequent magnetic reconnection with surrounding newly-emerging fields resulted in the motion of footpoint of the upper MFR to the region around footpoint of the lower MFR, thus leading to eventual formation of the double-decker configuration consisting of two MFRs with similar footpoints but opposite signs of magnetic twist. These results provide a potential way to determine unambiguously the progenitor configuration of a partial-eruptive filament and reveal a special type of double-decker MFR configuration and a new double-decker formation scenario.

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Short term variations in the solar spectrum

Miss Tsholofelo Kadiaka

University of Johanessburg

Abstract

The Sun's brightness fluctuates over all time scale, ranging from seconds to centuries. Short-term variations (minutes to days) are caused by convective motions in the Sun's outer layers, but long-term variations (months or longer) are caused by changes in the global magnetic field. New solar irradiance measurements from the GOES satellite allows us to better understand these short-term variations in solar brightness. Visible light is measured by the sun position sensor, several ultraviolet wavelengths are measured by the Extreme Ultraviolet Sensors, and extremely short wavelengths are measured by the Xray Sensor. Different wavelengths sample different heights in the solar atmosphere, so understanding the frequency spectrum of these variations will help to constrain models of the outer atmosphere of the Sun.

In this Master's project, we will investigate the frequency spectrum of variations in the EUVS full-disk irradiance measurements caused by solar flares. Characteristic oscillation periods in the photosphere and chromosphere are five and three minutes, respectively. Simultaneous observations from all the EUVS channels before and after strong flares will map out density variations in the solar atmosphere. I am using python to analyse and visualize the data.

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Terrestrial Response to Solar Events; Investigation of Solar wind parameters during Solar Flare Occurrence in Solar Cycle 25

Dr Hammed Lawal[1], Prof Martin Snow[2], Mr Mukhtar Muhammed[1]

[1]Air Force Institute of Technology Nigeria. [2]South African National Space Agency

Abstract

A study of terrestrial response to solar events of solar cycle (SC) 25 was made. This work is to analyze the response of solar wind parameters to solar flares (SFs). Furthermore, we seek to investigate the relationship between SFs and Geomagnetic storms (GMs) by studying the behavior of the Earth's magnetosphere approximately five days before and after the occurrence of each solar flares of SC 25 using the Dst index to observe the magnetospheric disturbance. The solar flare data was obtained from solarham.com while the solar wind parameters were obtained from NASA OMNI website from May 7, 2021 to October 3rd, 2022. Our findings have revealed that even a weak X class flare can produce a weak/moderate GMs as long as it is geoeffective.

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On the Connection between Solar Surface MagneticFlux and the Total Solar Irradiance

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Abstract

Solar surface magnetic flux evolution plays a dominant role in the variability of total solar irradiance (TSI). Different proxies of magnetic activity have been introduced to correlate solar variability and TSI. We present the daily strong flux densities (SFDs) and weak flux densities (WFDs) defined with three magnetic thresholds calculated from the Solar Dynamic Observatory/Helioseismic Magnetic Imager. TSI measurements are from the radiometers of the Variability of Solar Irradiance and Gravity Oscillations experiment on the Solar and Heliosphere Observatory, and sunspot area (SSA) is from the National Oceanic and Atmospheric Administration. We characterize the influence of the magnetic flux density variation on the TSI using the Pearson, Spearman, and percentage bend correlations and wavelet analysis between the TSI and the flux density. The Pearson's correlation shows that the TSI is negatively and strongly correlated with SFD and moderately with SSA; Spearman and 20% bend correlation shows that the TSI is moderately correlated with SFD and weakly with SSA on solar maximum, but weakly correlated on solar minimum. However, the TSI is not correlated with WFD during solar maximum and minimum. The bootstrapping tests also confirm that the influence of SFD on TSI is more significant than that of SSA. Finally, a wavelet analysis supports the idea that the SFD and TSI have a causality linkage and that the SFD dominantly influences the TSI variability on the rotational timescale.

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Beyond Flatland: A Star of Many Dimensions

Dr. Sarah Gibson

NCAR/HAO

Abstract

The more we learn about the Sun, the more we can appreciate its essential complexity. Multi-wavelength observations reveal its structured coronal atmosphere, and ever-higher temporal and spatial resolutions expose its spectacular dynamics. Helioseismology penetrates its depths, and spacecraft views from off the Sun-Earth line yield the beginnings of a three-dimensional perspective. Underlying this complexity is solar magnetism – the consequence of a cycling dynamo and the cause of solar eruptions that originate in stressed and twisted magnetic fields. In this talk, I will highlight critical areas of solar physics, presenting recent advances and open questions associated with the generation, storage and release of magnetic energy and resulting space weather at the Earth. I will then look to the future, considering how sustained observations from the Sun's poles and from a truly global view on solar and heliospheric magnetic fields could change the paradigm of Sun-Earth investigations.

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Preliminary results from Solar Orbiter “Eruption Watch” campaigns

Clementina Sasso[1], Federico Landini[2], Giuliana Russano[1], Frédéric Auchere[3], David Berghmans[4], Éric Buchlin[3], Johann Hirzberger[5], Phil Hess[6], Säm Krucker[7], David Orozco Suárez[8], Susanna Parenti[3], Luciano Rodriguez[4], Hanna Strecker[8], Gherardo Valori[5], Angelos Vourlidas[9], Anik De Groof[10], David Williams[10]

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Abstract

We present preliminary results obtained in different Solar Orbiter coordination campaigns aimed to catch eruptive events. These campaigns involve all the remote sensing instruments on-board the spacecraft so to have the opportunity to follow the eruption from the onset till the outer corona. We want to perform a statistical analysis on the observed events and investigate the physical and dynamical properties of at least one case study eruption.

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Recurrent Eruption and Formation of a Flux Rope byFlux Cancellation

Dr. Alshaimaa Hassanin[1], Dr. Bernhard Kliem[2], Prof. N. Seehafer[2], Dr. Tibor Torok[3]

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Abstract

The primary mechanism considered for the creation of magnetic flux ropes in the solar corona, during its quasi-static evolution between eruptions, involves the cancellation of magnetic flux in the photosphere. This process is believed to not only form flux ropes but also energize them, often leading to their eruption. Flux cancellation occurs intermittently, involving dispersed flux patches, and is typically sustained over extended periods. During such periods, a sequence of homologous eruptions is sometimes observed, with one or more confined eruptions often culminating in a final full eruption, such as a Coronal Mass Ejection (CME). In our work (Hassanin et al. 2022), we present the first Magnetohydrodynamic (MHD) simulations of flux rope formation and eruption specifically addressing homologous eruptions. These simulations depict a series of eruptions, starting with a confined eruption followed by a CME. While our modeling of the confined eruption is still simplistic, beginning with a kink-unstable flux rope in a sufficiently strong ambient field, the end state reveals a reformed, weakly twisted flux rope, indicating a potential path to homologous eruptions. Prescribed photospheric flows at the PIL, coupled with enhanced magnetic diffusion at the PIL, energize this configuration, leading to a second eruption initiated by the torus instability. Surprisingly, the new flux rope, rather than the reformed one, carries the main part of the free magnetic energy and becomes unstable. Future simulations will aim to fully drive a series of homologous eruptions solely through flux cancellation, as suggested by observations.

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Sources of the slow solar wind and the role of the coronal magnetic field topology

Dr Lucia Abbo

INAF-Astrophysical Observatory of Turin

Abstract

In order to investigate the sources and the physical mechanisms for the propagation
of the Slow Solar Wind (SSW), it is essential to analyze and modeling solar data in the region which determines the large scale structure in corona and also the origin of the SSW (from the solar disk up to 5 solar radii).
It will be given an overview of recent results by Solar Orbiter observations together with other space missions (i.e. SPP and GOES) which have contributed to the study of the global corona together with the role of the coronal magnetic field topology in controlling the solar wind dynamics and composition. We discuss also the results by the Total Solar Eclipse data, the possible future observations by PROBA-3 and by Solar Orbiter from 2025 when is out-of-ecliptic plane.

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The Solaris Mission: A focused solar polar view from outside the ecliptic plane

Dr. Donald M. Hassler[1], Dr. Sarah Gibson[2], Dr. Jeffrey Newmark[3]

[1]Southwest Research Institute. [2]NCAR/HAO. [3]GSFC

Abstract

Solaris is a transformative Solar Polar mission concept to address crucial outstanding questions that can only be answered from a polar vantage. Solaris will image the Sun's poles from 75° latitude, providing new insight into the workings of the solar dynamo and the solar cycle, which are at the foundation of our understanding of space weather and space climate. Solaris will also provide enabling observations for improved space weather research, modeling and prediction, revealing a unique, new view of the corona, coronal dynamics and CME eruptions from above the ecliptic plane.

The Solaris mission design is an expanded/enhanced version of the mission design from the MIDEX Phase A study of the same name. Solaris includes both remote sensing and in-situ instruments that are essential to address fundamental questions that can only be answered from a polar perspective. Solaris' ~10 yr mission covers the solar cycle and achieves multiple solar polar passes using a simple, ballistic trajectory. Solaris is ready to go now, moving Heliophysics forward at a critical time when models and computing power are ideally suited to capitalize on new polar observations. Solaris uses existing technology and can stand alone as a single spacecraft mission targeting questions that cannot wait, or act as the first element of a dis-aggregated constellation mission.

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On The Connection Between Solar Surface Magnetic Flux Density and Solar UV Variability.

Mr Mbonteh Roland Ndunge

Addis Ababa University. Cameroon Astronomy and Space Research Organization.

Abstract

The sun is a beautifully magnetically driven giant ball of plasma with invisible magnetic field lines spreading throughout its surface. Solar surface magnetic field is generated by a process known as solar dynamo. The strength of solar surface magnetic flux or solar surface magnetic induction or simply solar surface magnetic flux density (B) is believed to be related with solar UV variability. The best known indicator of solar variability is the records of sunspot numbers allowing direct measurement of solar radiation across different wavelengths, including the large variations in UV, the results to be presented in this document basically rely on daily sunspot datasets of 2010 and 2014 respectively taken from the World Data Center SILSO, Royal Observatory of Belgium, Brussels and are available at the SILSO website (https://www.sidc.be/SILSO/datafiles). These datasets were accessed via the LASP Interactive Solar Irradiance Datacenter (LISIRD) (https://lasp.colorado.edu/lisird/), and for the datasets of solar surface magnetic flux, results from NASA Solar Dynamic Observatory (SDO)/Helioseismic Magnetic Imager (HMI) are used. Wavelet power spectrum, Robust Correlation coefficients and Correlogram toolbox are also used for further analysis. Moreover, the relationship between solar surface magnetic flux strength and solar UV variability will be characterized.

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pyCAT: a Next-Generation Re-Imagining of NOAA/SWPC's CME Analysis Tool

Mark Miesch[1], Manasi Gopala[2], George Millward[1], Charlotte Martinkus[1], Anders Englyst[3], Mike Marsh[3], Francois-Xavier Bocquet[3]

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Abstract

The first operational numerical model to leverage high-performance computing (HPC) resources at NOAA's Space Weather Prediction Center (SWPC) was the WSA-Enlil model, a composite semi-empirical/MHD model of the solar wind. The WSA-Enlil model was made operational in 2012 and is still used today to forecast the arrival time of coronal mass ejections (CMEs). One of the motivations of this transition to operations was the availability of multi-perspective coronagraph observations from NASA's STEREO mission (launched in 2006). However, to leverage these assets, there had to be a way to assimilate coronagraph observations into the WSA-Enlil model. This led to the development of SWPC's CME Analysis Tool (CAT), written in IDL. The CAT allows SWPC forecasters to fit multi-perspective coronagraph observations to idealized cone models of CMEs which can then be ingested into Enlil. NOAA/SWPC and the United Kingdom Met Office (UKMO) are now developing a modernized version of CAT called pyCAT that features an interactive browser-based front end, a python back end, and an event database managed by MongoDB. After initial development and deployment, we plan to make pyCAT available as an open-source application to promote Research to Operations and Operations to Research (R2O2R). In this talk I will describe the motivation, design, and expected use of pyCAT and encourage the community to participate as users and potentially contributors. The goal is a modern, containerized, user-friendly, extensible application for modeling CME events that can be progressively improved to leverage future advances in multi-perspective observing platforms and numerical modeling.

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Improving the Medium-Term Forecasting of Space Weather: A Big Picture Review

Dr Angelos Vourlidas

Johns Hopkins University Applied Physics Laboratory

Abstract

Our scientific understanding of the key solar drivers of Space Weather (SWx)—Coronal Mass Ejections (CMEs) and tier associated flares and solar energetic particles (SEPs)—has improved considerably in the last 20+ years thanks to a plethora of space missions and modeling advances. Yet, there has been relatively little progress in actionable forecasting of the geo-effectiveness of a given CME and associated phenomena. Why is that? What are the issues that are holding back progress in medium-term forecasting (hours to days) of Space Weather?

In this talk, I review the last 20+ years of research on solar drivers and identify lessons-learned and paradigm shifts in our view of the SWx-relevant solar activity. I also identify the main open questions and offer possible mitigation strategies for achieving actionable medium-term forecasting of SWx.

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APPLIED ARTIFICIAL INTELLIGENCE FOR SCIENCE & EXPLORATION ENABLED BY PUBLIC-PRIVATE PARTNERSHIPS

Dr Madhulika Guhathakurta

NASA

Abstract

The recent advances in Artificial Intelligence (AI) capabilities are particularly relevant to NASA science and exploration goals because there is growing evidence that AI techniques can improve our ability to model, understand and predict our environment using the petabytes of data already within NASA archives.

I will talk about the Frontier Development Lab (FDL) which is an AI research accelerator that was established to apply emerging AI technologies to space science challenges which are central to NASA's mission priorities and provide some examples. Various programs held over the past eight years have focused on AI based science opportunities within the fields of Heliophysics and Space Weather. The program is an 8-week concentrated R&D deep-dive process using the latest developments in machine learning and access to cutting-edge academic research - and enormous compute resources provided by FDL's commercial AI partners - as well as detailed industry partner case studies, showcasing the potential application of AI to space challenge domains.

FDL uses sprint methodologies championed by Silicon Valley start-up culture for faster results; places emphasis on interdisciplinary teams for better research quality and viability, and public-private partnerships to lower the costs of high-risk innovation within an expensive technology domain. FDL results will be shared that demonstrate the power of bridging research disciplines and the potential that AI/ML has for supporting research goals, improving on current methodologies, enabling new discoveries, while doing so in accelerated timeframes.

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The Magnetic Origin of Solar Campfires: Solar Orbiter and SDO Observations

Dr Navdeep Panesar[1,2], Dr Viggo Hansteen[3], Dr Sanjiv Tiwari[3], Dr. David Berghmans[4], Dr Mark Cheung[5], Dr Daniel Müller[6], Dr Frederic Auchere[7], Dr Andrei Zhukov[4]

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Abstract

Solar campfires are small-scale coronal brightenings, observed in 174Å images by EUI on board Solar Orbiter (SolO). Here we investigate the magnetic origin of different types of campfires, in quiet-Sun, using line-of-sightmagnetograms from SDO/HMI together with EUV images from SolO /EUI and SDO/AIA. We find that (i)campfires are rooted at the edges of photospheric magnetic network lanes; (ii)most of the campfires reside above neutral lines and 77%of them appear at sites of magnetic flux cancelation between the majority-polarity magnetic flux patch and a merging minority-polarity flux patch, with a flux cancelation rateof $\sim 10^{18}$Mx hr^{-1}; some of the smallest campfires come from the sites where magnetic flux elements were barely discernible in HMI; (iii) in the large majority of instances (79%), campfires are preceded by a cool-plasma structure,analogous to minifilaments in coronal jets; and (iv) although many campfires have “complex” structure, most campfires resemble small-scale jets, dots, orloops. Thus, “campfire” is a general term that includes different types of small-scale solar dynamic features. They contain sufficient magnetic energy ($\sim 10^{26}$–10^{27}erg) to heat the solar atmosphere locally to 0.5–2.5 MK. Our observations suggest that the presence of magnetic flux ropes may be ubiquitous in thesolar atmosphere and not limited to coronal jets and larger-scale eruptionsthat make CMEs; and magnetic flux cancelation, most likely driven bymagnetic reconnection in the lower atmosphere, is the fundamental process for the formation and triggering of most campfires. Finally, we compare jet-like campfires with those found in a Bifrost MHD simulation.

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Solar Orbiter/EUI Observations and Bifrost MHD Simulatons of Fine-scale Bright Dots in Emerging Flux Regions

Dr Sanjiv Tiwari[1,2], Dr Viggo Hansteen[1,2], Dr Bart De Pontieu[1], Dr Navdeep Panesar[1,2], Dr David Berhgmans[3]

[1]Lockheed Martin Solar and Astrophysics Laboratory, Palo Alto, CA. [2]Bay Area Environmental Research Institute, Moffett Field, CA. [3]5Solar-Terrestrial Centre of Excellence SIDC, Royal Observatory of Belgium

Abstract

Solar Orbiter's EUI/HRI_{EUV} observations of an emerging flux region (a typical EUV/X-ray bright point) in 174 A reveals the presence of numerous tiny bright dots. These dots are roundish with an average diameter of 675 km, a lifetime of 50 seconds, and an intensity enhancement of 30% from their immediate surroundings. About half of the dots remain isolated during their evolution and move randomly (<10 km/s). The other half show extensions, appearing as a small loop or surge/jet, with intensity propagation < 30km/s. Many of the bigger HRI_{EUV} dots are discernible in SDO/AIA 171A, have significant EM in the T-range of 1-2 MK, and are often located at polarity-inversion-lines observed in HMI LOS magnetograms. The Bifrost MHD simulations of an emerging flux region do show dots in synthetic Fe IX/X images, although dots in simulations are not as pervasive as in observations. The dots in simulations show distinct Doppler signatures - blueshifts and redshifts coexist, or a redshift of ~10 km/s is followed by a blueshift of similar or higher magnitude. Our results, together with the field geometry of dots in the simulations, suggest that most dots in emerging flux regions form in the lower solar atmosphere (at ~1 Mm) by magnetic reconnection between emerging and pre-existing/emerged magnetic field. The dots are smaller in Fe IX/X than in O V/VI, and Si IV lines ikely because only the hottest counterpart of magnetic reconnection events is visible in the hotter emission.

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High Precision, High Time-Cadence Measurements of the MgII Index of Solar Activity by the Extreme Ultraviolet Sensor Aboard the NOAA GOES-R Series

Prof Martin Snow[1,2], Dr. William McClintock[2]

[1]South African National Space Agency. [2]University of Colorado Boulder / LASP

Abstract

One of the instruments on the Geostationary Operational Environmental Satellites is the Extreme and Ultraviolet Sensor (EUVS). Channel C of EUVS measures the Magnesium II core-to-wing ratio with high signal-to-noise ratio at a cadence of three seconds. This presentation will describe the design of the instrument and give an overview of the data collected so far. Available data products range from the full-cadence operational data measured every three seconds to science-quality daily averages.

The instrument measures the spectrum of the Sun from 275 to 285 nm with a spectral resolution of 0.1 nm. It uses a diode array with a sampling width of 0.02 nm, providing five samples per slit width.

The first of these instruments became operational in January 2017 and continues through the present.

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Multi-point view of the Sun's magnetic field: Results of co-observations by SO/PHI on Solar Orbiter with telescopes observing along the Sun-Earth line

Prof. Sami Solanki

Max Planck Institute for Solar System Research, Goettingen, Germany

Abstract

SO/PHI (the Polarimetric and Helioseismic Imager on Solar Orbiter) is the first magnetograph ever to leave the Sun-Earth line. Consequently, it is not surprising that co-observations between SO/PHI and telescopes observing along the Sun-Earth line have provided a number of novel and unique results. Examples of such results are listed below.

- First synoptic maps of the solar magnetic field produced in only 16 days, compared with the standard 27 days, thus providing more up to date maps of the magnetic field

- First resolution, without imposing additional assumptions, of the 180 degrees ambiguity in the magnetic field vector

- First tracking of the magnetic field of active regions for longer than 10-12 days without significant interruptions

- First direct validation of far-side helioseismology and its calibration in terms of magnetic flux (important for longer term predictions of space weather)

- First stereoscopic determination of the Wilson depression of a sunspot

- First reliable measurements of facular brighteness near the solar limb, important not just for solar irradiance studies, but also for better characterization of exoplanets

- First measurements of both horizontal and vertical velocities in solar p-mode oscillations;

- Identification of a potential solution of the open flux enigma, i.e. why the heliospheric magnetic flux is a factor of >2 larger than the open magnetic flux measured on the Sun.

A selection of the most exciting such "firsts" will be presented. Additionally, it will be pointed out how combining SO/PHI data with Earth-based and near-Earth observational resources will continue to lead to breakthrough results.

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Introduction to the Solar Polar-orbit Observatory (SPO)Deng Yuanyong 1 2on behalf of the SPO team 1 National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, P. R. CHina2 School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, P. R. China;

Professor Yuanyong DENG

National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, P. R. China. School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, P. R. China

Abstract

Solar magnetic fields and related solar magnetic activities dominate the heliospheric environments from the near-Earth space, to the interplanetary space, and up to the interstellar boundary. The polar magnetic fields of the Sun and its dynamic processes are especially vital in the aspects of manifesting the internal dynamo of the Sun, and shaping magnetic fields in the heliosphere. But so far, high quality observations of solar polar region is quite limited, especially the accurate polarization and Doppler imaging.

The Chinese spacecraft of "Solar Polar-orbit Observatory (SPO)" has been designed to directly image the solar polar regions in an unprecedented way by traveling in a large solar inclination angle (≥ 80°) and a small ellipticity. Based on multi-band remote-sensing and in-situ easurements, the SPO will focus on: the origin of solar magnetic activity cycle and high-speed solar wind, and providing the necessary, complete, and self-consistent initial and boundary conditions for creating a data-driven global heliospheric numerical model that serves as the foundation for space weather prediction.

In this presentation, we will give an overview of SPO, including the scientific objectives, satellite and orbit, payloads, and so on.

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Energization of Alfvénic slow speed solar wind

Dr Yeimy Rivera[1], Dr Samuel Badman[1], Tamar Ervin[2], Dr. Enrico Landi[3], Dr. John Raymond[1], Dr. Katharine Reeves[1], Dr. Michael Stevens[1], Soumya Roy[1], Tania Varesano[4]

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Abstract

A complete theory of the solar wind requires an effective connection between where solar wind originates, how it forms, and how it evolves once it escapes the corona. Decades of remote and in situ observations have found that winds from different coronal sources behave differently – as characterized by their properties in the corona and at large heliocentric distances, i.e., bulk speed, density, temperature, heavy ion composition, Alfvénicity. Recent work suggests that the fast and slow wind are energized by different mechanisms – ions in the slowest wind are accelerated through the ambipolar potential while ions in the fastest speed wind require additional heating and acceleration by Alfvén waves. A distinct subset of the slow solar wind exhibits high Alfvénicity and distinct heavy ion composition signatures. The subgrouping suggests such streams have a distinct source and radial evolution profile compared to conventional fast and slow outflows. Through a conjunction with Parker Solar Probe and Solar Orbiter, combined with near-synchronous spectroscopic remote observations, this work examines the large-scale energetics in Alfvénic slow wind compared to slow solar wind from a current sheet crossing to understand if/how they differ. The talk will also discuss the importance of ongoing integrated remote and in situ observations from present/newly operational solar telescopes that are necessary for addressing open questions about our star and its space weather impacts.

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Solar wind near coronal streamer structures using 3D MHD simulations in spherical geometry

Dr Piyali Chatterjee

Indian Institute of Astrophysics

Abstract

We use 3D MHD model in spherical geometry to understand the dependence of solar wind properties near a coronal streamer by varying the magnetic field and in-situ volumetric heating. The model additionally includes anisotropic heat conduction along field lines, optically thin radiative cooling and a semi-relativistic correction to Lorentz force. Our final aim is to understand the coronal flux rope activation or CME initiation conditions in presence of the ambient magnetic field that has been stretched by the solar wind. This kind of topology is close to H-alpha polar crown filaments observed on the Sun during migration of poloidal flux of the new cycle to the solar poles.

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Analysis of coronal holes and their impact on space weather based on FengYun-3E X-EUVI data

Qiao Song[1,2,3,4], Xinhua Zhao[2], Shuhong Yang[5], Jing-Song Wang[1,3,4]

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Abstract

Coronal holes are open magnetic field structures commonly found in the solar corona and are generally considered to be the main source of high-speed solar wind. High speed streams from coronal holes, especially low-latitude coronal holes, may cause geomagnetic storms and are therefore important objects for the space weather research. The Solar X-ray and Extreme Ultraviolet Imager (X-EUVI) onboard the FengYun-3E satellite is China's first in-orbit solar imaging instrument, which can conduct high-cadence and full-disk imaging observations in the extreme ultraviolet (EUV) 195 Å channel of the Sun. By using the X-EUVI images and the corresponding automatic identification method, we analyze the low-latitude coronal holes, including their position and morphology changes over time, and combined with their geomagnetic influences, to study the relationship between the observational characteristics of coronal holes in EUV images and the geo-effectiveness. The results show that the X-EUVI EUV data can accurately reveal the coronal hole boundary, and also observe the smaller-scale features such as bright points in the coronal holes, which provides strong support for the study of overall planetary geomagnetic response of the coronal hole.

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Space Weather Effects on the Ionosphere of Earth

Dr Tshimangadzo Matamba, Dr Donald Danskin

South African National Space Agency (SANSA)

Abstract

During severe solar storms, the space weather conditions cause variation in the ionosphere of Earth. The total electron content (TEC) varies due to the changes of the driving forces of the solar wind during the storm. The South African National Space Agency (SANSA) near-real-time global navigation satellite system products are used to monitor the variation in TEC over Southern Africa. Depending on the phase of the geomagnetic storm, the variation of TEC is observed from the maps of TEC. The TEC is also compared with estimates from ionosondes and the quiet-time AFriTEC model.

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Exploring the Impact of Space Weather Elements on Telemetry Metrics in Low Earth Orbit for Small Satellites

Dr. Sara Khodairy, Prof. Ahmed Morsi

National Research Institute of Astronomy and Geophysics

Abstract

This research delves into the intricate relationship between space weather phenomena and the telemetry parameters of small satellites operating in the Low Earth Orbit (LEO). As small spacecraft become increasingly vital for various scientific, commercial, and communication purposes, understanding the influence of space weather factors on their telemetry metrics becomes crucial. This study employs comprehensive data analysis and modeling techniques to investigate the impact of solar radiation, geomagnetic storms, and other space weather elements on the performance and reliability of small satellites in LEO. By examining telemetry data from a diverse set of small spacecrafts, this research aims to identify patterns, correlations, and potential vulnerabilities, providing valuable insights for enhancing the resilience and operational efficiency of small satellites in the dynamic space environment. The findings contribute to the broader understanding of space weather effects on satellite technology and inform strategies for optimizing small satellite missions in LEO.

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Machine Learning-Based Dynamics of Interplanetary Coronal Mass Ejections Using Deterministic Models

Mattia Rossi, Sabrina Guastavino, Anna Maria Massone, Michele Piana

MIDA, Department of Mathematics, University of Genoa

Abstract

Interplanetary Coronal Mass Ejections (ICMEs) are large explosions resulting from solar activity that propagate through the interplanetary medium. ICMEs directed towards the Earth, though infrequent, are particularly relevant for space weather forecast. For most of them, the dynamics of the wave front can be approximated by an analytical one-dimensional Drag-Based Model (DBM) (see, e.g., Cargill 2004, Vršnak et al. 2010), however, for many ICME events, additional acceleration contributions (e.g., ICME-ICME interaction) may affect the dynamics, so as to render the DBM less effective.

Unlike purely data-driven Machine Learning (ML) or deterministic approaches, we propose a physics-driven ML approach similar to Guastavino et al. 2023 capable of predicting the ICME travel time: we formulate suitable extensions of the DBM to incorporate either a) in the training process by feeding neural networks with synthetic data generated by the model or b) directly in the loss function in the weight optimization process.

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Forecasting Geoffective Events and Evaluating the Most Predictive Features through new Classifier-Dependent Ranking Scheme

Emma Perracchione[1], Sabrina Guastavino[2], Katsiaryna Bahamazava[1], Fabiana Camattari[2,3], Daniele Telloni[3], Michele Piana[2,3], Anna Maria Massone[2]

[1]Politecnico di Torino, Dipartimento di Scienze Matematiche Giuseppe Luigi Lagrange, Torino, Italy. [2]MIDA, Dipartimento di Matematica, Università di Genova, Italy. [3]Istituto Nazionale di Astrofisica, Osservatorio Astrofisico di Torino, Pino Torinese, Italy

Abstract

This study addresses the prediction of geomagnetic disturbances by exploiting machine learning techniques. Specifically, the Long-Short Term Memory recurrent neural network, which is particularly suited for application over long time series, is employed in the analysis of in-situ measurements of solar wind plasma and magnetic field acquired over more than one solar cycle, from 2005 to 2019, at the Lagrangian point L1. The problem is approached as a binary classification aiming to predict one or more hour in advance a decrease in the SYM-H geomagnetic activity index below the threshold of -50 nT, which is generally regarded as indicative of magnetospheric perturbations. The strong class imbalance issue is tackled by using an appropriate loss function tailored to optimize appropriate skill scores in the training phase of the neural network. Beside classical skill scores, value-weighted skill scores are then employed to evaluate predictions, suitable in the study of problems, such as the one faced here, characterized by strong temporal variability. For the first time, the content of magnetic helicity and energy carried by solar transients, associated with their detection and likelihood of geo-effectiveness, were considered as input features of the network architecture. Their predictive capabilities are demonstrated through a mathematically-convergent new feature ranking algorithm which is taylored for the considered classifier, e.g. LSTM.

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Estimation of projection effects in near-limb solar manetic flux measurements: Advantage of Multi-viewpoint Observations

Dr. Sanjay Gosain

National Solar Observatory

Abstract

We demonstrate using controlled MHD simulations that the projection effects and foreshortening cause systematic biases in the magnetic flux measurements away from the disk center, which deteriorate as one approaches closer to the solar limb. However, we show that using multiviewpoint observations of the Sun can help in overcoming these systematic effects. We evalute the extent of such effects and how cross-calibration of multi-viewpoint observatories is crucial for such combined data analysis.

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Properties of Chromospheric Flow Channels Around a Sunspot

Prof Debi Prasad Choudhary[1], Dr Christian Beck[2], Dr Sanjay Gusain[2], Dr. Avijeet Prasad[3], Dr. Qiang Hu[4], Dr. Mehmet Mehmet[4], Dr Sushree Nayak[4]

[1]California State University Northridge. [2]National Solar Observatory. [3]Institutt for teoretisk astrofysikk, Rosseland Centre for Solar Physics. [4]University of Alabama Huntsville

Abstract

We report the properties of chromospheric flow channels connecting the leader spot of a decaying active region NOAA 12418 with the nearby moat and plage location. The observations were carried out on 2015 September 16 with the Interferometric Bidimensional Spectrometer and the Facility Infrared Spectropolarimeter at the Dunn Solar Telescope. Our observations consist of IBIS sequential scans in two chromospheric spectral lines of Hα at 656 nm and Ca II IR at 854.2 nm in its spectroscopic mode with a non-equidistant spectral sampling of 27 and 30 wavelength points, respectively. With FIRS we recorded vector spectropolarimetric data in a wavelength range from 1081.37 to 1085.28 nm. The ground-based data are complemented with the Milne-Eddington inversion results for the photospheric magnetic field derived from observations by the Helioseismic and Magnetic Imager on board the Solar Dynamics Observatory. We find that the flow channels originate at locations close to the umbral edge and fragmented portion of the sunspot umbra that was at one end of the magnetic field polarity inversion line of the active region. They carry the Inverse Evershed Flow and the longer filaments permanently exhibiting a strongly reduced intensity and flows along a large part of their length. In this paper we shall present details on the internal substructure of the temperature, magnetic and flow structure of these different flow channels. Here we study the contrast of structures of flow channels of the sunspot in this decayed active region.

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EVOLUTION OF SOLAR ENERGY FLARES AND CLIMATE CHANGE IN RELATIONSHIP WITH ACTIVE REGION STRUCTURE

Assoc. Prof. Dr. ZETY SHARIZAT BINTI HAMIDI

Universiti Teknologi MARA

Abstract

Understanding the relationship between the magnetic field and solar activity requires an examination of how different types of solar activity are triggered by the structure of the active region flare events. These changes will lead to a variety form of solar flares phenomenon and also the amount of magnetic energy that will be released per day. Here, it was found that the βγ of magnetic class in AR 12877 releases the highest magnetic energy amount of and the releasing of powerful solar flares depended more on the number of sunspots and the amount of magnetic energy than the magnetic class. The result also gives an overview where the duration of the flare did not have a relationship with the class of solar flare events. It was believed that the magnetic class of the active region played a crucial role in this case of study. The third aim is to analyze the radiation of these solar activities regarding the climate change phenomena by applying a Pearson correlation technique. As far as climate change observation is concerned, found that sunspot number and TCI have a positive correlation, r = 0.59 as both of the variables showed an increasing pattern that related to each other's. Amount of TCI is classified as low levels along with fewer sunspot numbers from 2019 until 2021 which resulted in the thermosphere cooling off since a small amount of plasma penetrated the atmosphere. One of the benefits of this study is that it can lead to knowledge for future work on climate change studies.

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GHOTI: The GOES-R High-cadence Operational Total Irradiance project; using the EXIS SPS as a TSI proxy.

Dr Steven Penton[1,2], Dr. Martin Snow[3], Mr. Stéphane Béland[1,2], Dr. Odele Coddington[1,2], Dr. Don Woodraska[1,2]

[1]University of Colorado - Boulder. [2]Laboratory for Atmospheric and Space Physics. [3]SANSA

Abstract

The GOES-R series of geostationary satellites include a redesigned instrument for solar spectral irradiance: the Extreme ultraviolet and X-ray Irradiance Sensor (EXIS). Our team uses the Sun Position Sensor (a set of high-cadence broadband visible light diodes) on GOES-16 and GOES-18 EXIS instruments to construct a high-cadence proxy for Total Solar Irradiance (TSI).

This has two advantages over the existing TSI measurements:

1) the measurements are taken at 4 Hz, so the cadence of our TSI proxy is much faster than existing measurements, such as the 6 to 24-hour measurements produced by SORCE or TSIS-1, and

2) from a geostationary position, the time series of measurements is virtually uninterrupted.

Our calibration of the GOES-R EXIS diode measurements includes thermal and sun-satellite distance corrections, while the irradiance calibration relies on TSIS-1 TIM TSI composites. Another measurement from GOES-EXIS that will be used is the Magnesium II core-to-wing ratio. The MgII index is a proxy for chromospheric activity and is measured by EXIS every 3 seconds.The combination of the two proxies is used to generate a model of the full solar spectrum similar to the NRLSSI2 empirical model.

We are in the final year of a four-year grant to develop the TSI proxy and the SSI model.

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Scientific Perspectives of Remote-sensing Observations by the Heliophysics L4 Mission

Dr. Yong-Jae Moon[1], Dr. Kyung-Suk Cho[2], Dr. Sung-Hong Park[2], Dr. Eun-Kyung Lim[2], Dr. Roksoon Kim[2], Dr. Donguk Song[2], Dr. Jongyeob Park[2], Dr. Eunsu Park[2], Dr. Harim Lee[1], Dr. Hyun-Jin Jeong[1], Dr. Jihye Kang[1], Dr. Jinhye Park[1], Dr. Kangwoo Yi[1], Dr. Il-Hyun Cho[1], Dr. Hyeonock Na[1]

[1]Kyung Hee University. [2]Korea Astronomy and Space Science Institute

Abstract

The Sun-Earth Lagrange point L4, which is called a parking space of space, is considered one of the unique places where solar activity and heliospheric environment can be observed continuously and comprehensively. The L4 mission affords a clear and wide-angle view of the Sun-Earth line for the study of the Sun-Earth connections from remote-sensing observations. The L4 mission will significantly contribute to advancing heliophysics science, improving space weather forecasting capability, extending space weather studies far beyond near-Earth space, and risk reduction from solar radiation hazards on human missions to the Moon and Mars. Our paper outlines the importance of L4 observations by using remote-sensing instruments and advocates comprehensive and coordinated observations of the heliosphere at multi-points including other planned L1 and L5 missions. We mainly discuss scientific perspectives on three topics in view of remote sensing observations: (1) solar magnetic field structure and evolution, (2) source regions of geoeffective solar energetic particles (SEPs), and (3) stereoscopic views of solar corona and coronal mass ejections (CMEs).

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Comparative Reseaeches of Two Distinct Cosmic Ray Events (Forbush decrease and GLE event) Caused by the Solar Eruptions during September, 2017 Xiao Xia Yu [1] , Shuang Nan Zhang [1] , Hong Lu [1] , Hong Bo Hu [1] , Ping Zhang [2,3] , and Wei Kang Gao [1] 1 Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, 100049, People's Republic of China xxyu@ihep.ac.cn 2 Department of Physics and Technology, Wuhan University, Wuhan, 430072, People's Republic of China 3 WHU-NAOC Joint Center for Astronomy, Wuhan University, Wuhan, 430072, People's Republic of China

Dr. Xiao Xia Yu

Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, 100049, People's Republic of China

Abstract

Two large solar eruptions on AR 12673 produced a Forbush decrease (FD) on September 8 and ground-level enhancement (GLE) event on September 10, 2017. The two contrast cosmic ray (CR) events occurring within two days, associated with two similar X-class solar flares (X9.3 and X8.2) and sharing the same active region on the Sun, provide us a rare opportunity to understand the dominant factors that determine the characteristics of transient CR events. Using a suite of modern-day instruments, using ground-based CR detectors, we continuously tracked solar eruptions from the Sun to the Earth, revealing the complete cause–effect chain of these two events. We conclude that different consequences on the ground arise from two effects of the eruptions near the Sun: (1) the geometric effect of CMEs and (2) the intensity effect of CME-driven shocks. The first eruption, which originated at the heliographic longitude of W34° on September 6, had its CME ejecta and CME-driven shock intercept the Earth, leading to the FD event. The second eruption, which occurred on September 10 at W88°, only had its far flank reach the Earth. The peak shock speed of 3344 km s^{-1} of the second eruption, much faster than 2175 km s^{-1} of the first eruption, is the dominant factor producing GLE event, even though the first eruption is better connected magnetically to the Earth and has a similar flare. The results indicate the production of GLE particles can be dominated by fast-enough CME-driven shocks. In addition, the Neupert effect was shown using HXR data from Insight and SXR data from GOES satellite .

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Observations of kink-and-dissconnection solar failed eruption: 3D perspective.

dr. Tomasz Mrozek[1,2], dr Zhentong Li[3], prof. Marian Karlický[4], dr Nicolina Chrysaphi[5]

[1]Space Research Centre Polish Academy of Sciences. [2]Astronomical Institute University of Wrocław. [3]Purple Mountain Observatory, Chinese Academy of Science. [4]Astronomical Institute ASCR. [5]Sorbonne Université, École Polytechnique

Abstract

We report first stereoscopic observations of HXR emission sources registered by STIX onboard Solar Orbiter and HXI on ASO-S. This is a case study of two-stage failed eruption. First, it was stopped due to kink instability. However, kinked structure started to reconnect in the X-point and second stage of eruption started. This eruption was failed few minutes later due to reconnection below the magnetic flux rope and confinement by overlying magnetic fields. We identified three X-ray sources located in the corona which are related to reconnection site, and to the magnetic cloud arrested by overlying fields. Combining stereoscopic X-ray observations from STIX and HXI (31.5 degrees vantage point separation) together with Differential Emission Measure (DEM) maps based on SDO/AIA observations we were able to locate X-ray sources sites in the corona in the 3D space. The completness of the observed features was achieved by adding radio observations from STEREO/Waves. Results and further perspectives of stereoscopic observations of CMEs initiation (or failure) will be discussed.

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Triple coronal Hard X-Ray source observed by STIX during a failed eruption of a filament.

dr. Tomasz Mrozek[1,2], dr. Marek Stęślicki[1], dr. Sylwester Kołomański[2], dr. Krzysztof Barczyński[3,4]

[1]Space Research Centre Polish Academy of Sciences. [2]Astronomical Institute University of Wrocław. [3]ETH-Zurich. [4]PMOD/WRC

Abstract

Solar Hard X-Ray (HXR) emission is observed typically in the form of localized, rather compact sources. Majority of previously observed HXR sources are flare related, however there is growing evidence, observational and theoretical, that we can expect HXR emission from places not directly related to primary energy release regions. From this point of view, failed eruptions are very promising. There are only a few observations, from past instruments, showing some evidence of HXR production in failed eruptions. Recently, the Solar Orbiter has been launched giving a completely new perspective for observation and analysis of coronal dynamic events. Apart from others, it carries onboard Extreme-Ultraviolet Imager (EUI) and Spectrometer/Telescope for Imaging X-rays (STIX) telescopes open an opportunity to understand the physics of failed eruptions. Here, we present a case study of a very well observed flare accompanied by a failed eruption. From the Earth (AIA) perspective the event was visible very close to the west limb of a solar disc. For Solar Orbiter it was a behind-the-limb event with occulted footpoints which gave us a very good view, especially in the HXR range, of emission coming from the solar corona. During a flare's impulsive phase, the eruption accelerated to the velocity of a few hundreds kilometers per second and after six minutes it stopped abruptly at the height of 100 000 km above the solar surface. The eruption reconnected with overlying coronal loops leading to occurrence of at least three HXR regions observed by STIX.

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Surface flows prior to active region emergence on the Sun

Dr Hannah Schunker[1], Camron Alley[1,2]

[1]University of Newcastle. [2]University of Adelaide

Abstract

Understanding the physics of how magnetic active regions on Sun form and evolve at the surface will improve space weather forecasting. On average, it has been shown that active regions prefer to emerge in converging flows. We identified a sample of 42 emerging active regions (EARs) associated with small magnetic bipoles at least one day before the time of emergence in the Solar Dynamics Observatory Helioseismic Emerging Active Region survey (Schunker et al. 2016, A&A. 595, A107). We then identified a contrasting sample of 42 EARs that emerge more abruptly. We computed the supergranulation-scale surface flows using helioseismic holography, and averaged the flow maps and magnetic field maps over all active regions in each sample over the emergence time. We found that EARs associated with a persistent pre-emergence bipole evolve to be, on average, lower flux active regions than EARs that emerge more abruptly. Our results show that there is a statistical dependence of the surface flow signature throughout the emergence process on the maximum magnetic flux of the active region.

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Quasi-periodic oscillations of flare loops and slipping motion along flare ribbons during a C-class flare

Ms. Yining Zhang[1], Prof. Ting Li[1], Dr. Jing Ye[2]

[1]National Astronomical Observatories, China. [2]Yunnan Observatories, China

Abstract

Quasi-periodic oscillations are commonplace in many flares. To date, the underpinning processes resulting in the quasi-periodic oscillations remain unknown. In this paper, we report a unique event that exhibits both the long-duration quasi-periodic intensity oscillations of the flare loops and the quasi-periodic slipping motion of ribbon substructures during a C9.1 class of SOL20150315-T01:15, using the observations from Solar Dynamics Observatories and Interface Region Imaging Spectrograph. The high-temperature flare loops rooted in the straight part of the ribbons display ``bright-dim" intensity oscillation, with a period of about 4.5 minutes. The oscillation starts just after the flare onset and lasts over 3 hours. Meanwhile, the substructures within the ribbon tip display the quasi-periodic slipping motion along the ribbons at 1400 \AA~images, with the similar period of the stationary intensity oscillation of flare loops at the straight part of flare ribbons. We suggest that the quasi-periodic pattern is probably caused by the interaction of the intermittent reconnection outflows and flare loops.

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Exploring the magnetic fields of the upper solar chromosphere via ultraviolet spectropolarimetry.

Prof. Javier Trujillo Bueno

Instituto de Astrofísica de Canarias

Abstract

Javier Trujillo Bueno and the CLASP2 international team.

The magnetic field is the main driver of the spectacular activity of the solar upper atmosphere (chromosphere, transition region and corona), but its determination is notoriously difficult. This is because the observables of the solar radiation that are sensitive to the magnetic field in such relatively hot and rarefied regions of the solar atmosphere are difficult to measure and interpret. Over the last decade novel theoretical investigations based on the quantum theory of atom-photon interactions indicated that key observables for diagnosing magnetism from the photosphere to the base of the corona are the linear and circular polarization signals that the scattering of anisotropic radiation and the Hanle and Zeeman effects introduce in ultraviolet spectral lines, such as hydrogen Lyman-alpha and Mg II h and k. This led an international team (USA, Japan and Europe) to pursue the development of the CLASP suborbital space experiments, which in 2015, 2019 and 2021 have provided unprecedented measurements of the Stokes profiles in such and other ultraviolet spectral lines, both in quiet and active regions of the solar disk. This talk provides an overview of the research advances enabled by these sounding rocket experiments, which have opened a new diagnostic window in solar physics: ultraviolet spectropolarimetry.

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Manifestation of 3D magnetic reconnection in circular ribbon flares

Dr. Bhuwan Joshi[1], Dr. Ramit Bhattacharyya[1], Dr. Avijeet Prasad[2], Dr. Prabir K. Mitra[3]

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Abstract

The observations of parallel ribbons and associated overlying large post-flare arcades have been the most conspicuous and classical signatures of a solar flare, leading to the widely accepted two-dimensional model of solar flares – the standard flare model. However, contemporary observations with high spatial, temporal, and spectral resolutions indicate the inevitability of exploring 3D magnetic structures involved in solar flares. Contextually, the observations of "circular ribbon flares" stand out where one of the ribbons presents an almost fully closed quasi-circular or quasi-ellipsoidal shape, evidencing the involvement of a typical fan-spine magnetic configuration which exclusively requires a 3D description. In this talk, we discuss observational features vis à vis theoretical understanding of solar flares in view of 2D and 3D models of magnetic reconnection. We present a few complex cases of circular ribbon flares exhibiting parallel ribbons, a coronal jet, and/or an erupting magnetic flux rope. Investigating various 3D topologies also enables us to probe similarities between the physical conditions that govern the onset of jets, confined flares, and CME-producing eruptive flares.

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1507

A frequency-dependent classification for DH type II solar radio bursts: Toward exploring near-Sun and interplanetary characteristics of coronal mass ejections

Dr. Bhuwan Joshi, Ms. Binal D. Patel

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Abstract

The exploration of type II solar radio emission at decameter-hectometer (DH) wavelengths, which sometimes extend even up to kilometer domain, provide a means of remotely studying and tracking Coronal Mass Ejections (CMEs) from the solar corona out to 1 AU and beyond. The present study focused on the following aspects of DH type II bursts: (1) solar cycle evolution, (2) flare-CME association, and (3) consequences in near-Earth region. To explore the insights of DH type II bursts in the light of the above objectives, we classified the observed events in three frequency domains: Low Frequency Group (LFG; 20 kHz < f < 200 kHz), Medium Frequency Group (MFG; 200 kHz < f <1 MHz), and High Frequency Group (HFG; 1 MHz < f < 16 MHz). Our analysis revealed that CME initial speed or flare energetics is partly related to the duration of type II burst and that survival of CME-associated shock is determined by multiple factors/parameters related to CMEs, flares, and state of coronal and interplanetary medium. The profile relating CME heights with respect to the end frequencies of DH type II bursts suggest that for HFG and MFG categories, the location for majority of CMEs (65% -70%) is in well compliance with ten-fold Leblanc coronal density model, whereas for LFG events, a lower value of density multiplier (3) seems to be compatible. We further extended our work to explore the properties of Earth-directed CMEs in detail, which bring insights of the interrelations between CMEs, ICMEs, and geomagnetic storms.

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Solar Orbiter & Parker Solar Probe: Multi-viewpoint messengers of the inner heliosphere

Dr Stephanie Yardley

Northumbria University

Abstract

ESA/NASA's Solar Orbiter and NASA's Parker Solar Probe are both currently in their nominal mission phases, providing unprecedented, close-up views of the dynamic processes occurring in the solar atmosphere and how these processes influence the inner heliosphere. Connecting high-resolution remote-sensing observations of the Sun to plasma detected in situ in the inner heliosphere using multiple vantage points provides invaluable insights into how the solar wind and solar transients drive variability in the heliosphere. This work highlights the synergies between these latest missions and other space-based observatories present in the heliosphere.

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Height-Dependent Variations in Temperature and Non-Thermal Velocity in Fan Loops

Dr Aishawnnya Sharma[1], Dr Durgesh Tripathi[2]

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Abstract

Non-thermal velocity is an important parameter to understand the underlying physical mechanisms responsible for the solar coronal heating. In this study, we investigate how temperature and non-thermal velocity change with height in fan loops, using observations from the Extreme Ultraviolet Imaging Spectrometer (EIS) on board Hinode. Our approach involves using the emission measure (EM)-loci method to estimate the temperatures of various coronal fan loops. We then calculate the non-thermal velocities after subtracting thermal velocities obtained using the EM-loci temperatures in Si vii 275.35 Å and Fe viii 185.21 Å lines. The EM-loci analysis reveals nearly iso-thermal structure (log T(K)=5.85–5.95) of the fan loops and we obtain the non-thermal velocities in the range of approximately 5–15 km s^{-1} and 11–29 km s^{-1} for Si vii 275.35 Å and Fe viii 185.21 Å, respectively.

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Multi-view and multi-point CME Catalog based in SoloHI observations

Cecilia Mac Cormack[1,2], Shaheda B. Shaik[3], Laura Balmaceda[3,2], Phillip Hess[4], Robin Colannino[4], Teresa Nieves-Chinchilla[2]

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Abstract

With the combination of in-situ instruments and high-resolution remote sensing observations, the Solar Orbiter (SolO) mission has become one of the most valuable missions to study the inner heliosphere. The Solar Orbiter Heliospheric Imager (SoloHI), onboard SolO, is one of the new generation of heliospheric imagers with a field of view of 40° to the east of the Sun. SoloHI presents higher resolution than the previous generation of heliospheric imagers on board the Solar-Terrestrial Relations Observatory (STEREO) mission (HI 1-2). With SolO predicted to reach a minimum perihelion of 0.28 AU and an inclination angle of at least 30 degrees above the ecliptic plane, SoloHI complements and fills gaps in the observations of other remote sensing instruments at 1 au.

In this work, we present a living catalog of SoloHI events compiled over a span of two years of SoloHI observations. We identify each CME and present all the available remote sensing and in situ observations from other spacecraft. We also describe the source active region and provide the primary details of it. Finally, we complement the observations with the results of the WSA-ENLIN+CONE model performed by the Space Weather Database Of Notifications, Knowledge, Information (DONKI) developed at the Community Coordinated Modeling Center (CCMC).

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Magnetic Field Properties of Solar Sources of Impulsive Solar Energetic Particle Events

Radoslav Bucik[1], Mark Wiedenbeck[2], Maher Dayeh[1,3], Samuel Hart[3,1], Tilaye Tadesse[4]

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Abstract

Impulsive solar energetic particle (SEP) events show unusual elemental composition with ^{3}He and ultra-heavy ions enhanced by factors up to 10^4 above the coronal abundance. This results from yet-unknown acceleration mechanisms during magnetic reconnection in flares or jets. We identified 20 high-energy, impulsive SEP events in solar cycle 24 with 10 MeV/nucleon ^{3}He abundance >10^3 times the coronal value using SIS on ACE. The AIA SDO observations determined the associated solar sources. We explored the influence of parent active region (AR) magnetic properties on heavy-ion enrichment and intensity. Specifically, we used the magnetic class and the area from the NOAA Solar Region Summary. Complex ARs tend to show a higher ^{3}He/^{4}He ratio. In addition, both ^{3}He/^{4}He and ^{3}He intensity moderately correlate with AR area. We also used SHARP (Spaceweather HMI Active Region Patches) parameters obtained from the JSOC/Stanford repository. These physical quantities, derived from vector HMI SDO data, provide various characteristics of ARs, such as the gradient of the field, magnetic flux, shear angle, or current density. The ^{3}He/^{4}He ratio shows the strongest correlation with the absolute value of the net current helicity (a measure of twist in the vertical field) and ^{3}He intensity with the fractional area with shear > 45 degrees (a measure of the extent of extreme magnetic shear). We discuss the implications of these results for ion acceleration in impulsive flares.

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A multi-view study of consecutive CMEs observed by SoloHI during March 2022

Cecilia Mac Cormack[1,2], Cristina Mandrini[3], Laura Balmaceda[4,2], Shaheda B. Shaik[4], Germán Cristiani[3], Phillip Hess[5], Robin Colannino[5], Teresa Nieves-Chinchilla[2]

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Abstract

With the new solar missions, we have integrated high-resolution instruments that are able to fill some pre-existing gaps by providing observations closer to the Sun and out of the ecliptic (e.g. Solar Orbiter). These observations are crucial to understand the CME evolution from their origin until 1 au. The Solar Orbiter Heliospheric Imager (SoloHI) onboard the Solar Orbiter mission provides higher-resolution white-light images that allow us to track specific features detected before the CME erupts through the solar corona and the heliosphere. Previous studies found a moderate to strong correlation between the kinematic properties of a CME and the magnetic properties of the active region (AR) where the CME originated. In this work, we perform a study on the magnetic evolution of the Earth-facing AR 12795 during the period March 24 - April 02, 2022. This single AR presents high magnetic activity and has produced four consecutive CMEs in late March. All the CMEs were detected by the SoloHI onboard the SolO mission. By combining SoloHI data with other remote sensing observations located at 1 au, we can perform a multi-viewpoint analysis that can describe the global picture of the early evolution of a CME from its origin. We present preliminary results of this analysis, performing a 3D reconstruction and correlating it with the flux emergence and magnetic evolution of the AR.

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Machine learning techniques for solar physics and space weather

Prof. Anna Maria Massone[1], Dr. Sabrina Guastavino[1], Dr. Emma Perracchione[2]

[1]Dipartimento di Matematica, Università degli Studi di Genova. [2]Dipartimento di Scienze Matematiche "Giuseppe Luigi Lagrange", Politecnico di Torino

Abstract

The study of solar flares and coronal mass ejections may offer a unique opportunity to better understand both, fundamental processes on the Sun, and their space weather impacts at Earth. This talk will describe machine learning (ML) and deep learning (DL) approaches that can be a crucial key to understanding these open science issues. More specifically, first results obtained within the two recently funded ARCAFF and AIxtreme projects will be illustrated. On the one hand, the 'Active Region Classification and Flare Forecasting (ARCAFF)' project, funded by the European Union within the Horizon Europe Framework Programme, aims to improve flare forecasting capabilities by developing DL models and exploiting the large amount of available space-based solar observations. On the other hand, the 'AI for predicting extreme weather and space weather events (AIxtreme)' project, funded by the the Italian Fondazione Compagnia di SanPaolo, aims to monitor and forecast space weather by combining deterministic models and advanced machine learning techniques in a new approach in which the physical knowledge typical of deterministic approaches, is included into the learning process typical of a learning machine.

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1725

Thermal and Magnetic Field structures of solar coronal holes: Genesis and space weather Effects

Prof. K M Hiremath

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Abstract

Coronal holes, with unipolar magnetic field structures are the lowest density plasma activity features that are mainly detected in either UV or X-ray radiations of the sun's atmosphere. These activity features are associated with rapidly expanding magnetic field structure and the acceleration of the high-speed solar wind in the heliosphere and beyond. Possible link of sunspot activity on the Earth's atmosphere and climate are well recorded in the literature. Recently, evidences are building up that coronal holes also trigger responses in the Earth's upper atmosphere, ionosphere and magnetosphere. In one of our studies (Hiremath et.al. 2015, New Astronomy, 35, 8), we find that, in addition to influence of sunspots, radiative emission of coronal holes also trigger and maintain Indian Monsoon rainfall. For this purpose, estimation of radiative flux and energy of the coronal holes at 1 AU during their evolution passage on the solar disk are necessary. Eight years of full-disk SOHO/EIT 195 Angstrom calibrated images that are used to measure latitudinal and day to day variations of thermal (radiative flux and energy) and magnetic field structures of near equatorial coronal holes on the sun and at Lagrange point L1 are estimated. These estimated physical parameters are not only useful for the instruments (such as SOHO and Aditya) stationed at Lagrange point L1 but also for models of space weather effects in the heliosphere and beyond. Lastly, genesis of coronal holes and their latitudinal variation of thermal and magnetic field structures also will be discussed.

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Longitudinal variation of ionospheric electron density over 10 years provided by Swarm satellites.

Dr. Amal loutfi[1], Prof. Aziza Bounhir[2], Frederic Pitout[3], Zouhair Benkhaldoun[1]

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Abstract

The electron density in the topside ionosphere, monitored by Langmuir probes on Swarm satellites, has been systematically analyzed to investigate the Equatorial Ionization Anomaly (EIA) over a decade (2013-2023). This analysis provides valuable insights into the behavior of ionospheric density during both quiet and disturbed days, as well as its variations with the solar cycle, and seasonal changes across different longitudes, latitudes, and local time sectors. Moreover, the study sheds light on the interhemispheric asymmetry of the Equatorial Ionization Anomaly in the African sector, offering a comprehensive understanding of this phenomenon in the region. Additionally, the latitudinal distribution of total magnetic field intensity at mid- and low-latitude regions in various longitudinal and local time sectors has been quantified, enhancing our knowledge of magnetic field variations in these regions.

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KAPPA package: Impact Multi-Ionization and Suppression of Dielectronic Recombination on the ionization equilibria for kappa-distributions

Dr. Elena Dzifcakova, Dr. jaroslav Dudik, Dr. Alena Zemanova

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Abstract

There is a strong theoretical support of idea that non-Maxwellian electron distributions are present in the solar corona and transition region. The kappa-distributions or distributions exhibiting high-energy tails change individual ionization, recombination and collisional excitation rates. These changes are reflected in the changes in the ionization equilibrium, populations of the energy levels and finally in line intensities. In the latest version of KAPPA package (software and database, http://kappa.asu.cas.cz/), the electron impact multi-ionization and density suppression of dielectronic recombination into calculations of the ionization equilibria were added. Calculated synthetic spectra for different values of kappa and plasma parameters allow us to search for diagnostic opportunities of non-Maxwellian distributions from observations. We also present the successful diagnostics of kappa-distributions based on the forbidden lines and diagnostic proposal based on the Fe XVII and Fe XVIII lines in soft X-ray spectral range. Latest results show that the quiet Sun spectra are consistent with a Maxwellian distribution but spectra of coronal loops, moss, and for the transient loop observed within active region are strongly non-Maxwellian with kappa 3 or 2.

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Exploring convolutional neural networks for classification and segmentation of evolving granular structures in the solar surface

MSc Saida Milena Díaz Castillo[1,2], Dr. Andrés Asensio Ramos[3]

[1]Institute for Solar Physics - KIS, Freibug, Germany. [2]University of Freiburg, Freiburg, Germany. [3]Instituto de Astrofísica de Canarias - IAC

Abstract

Solar granulation is the visible signature of convective cells emerging from the upper convective zone towards the solar surface. High-resolution images have revealed the complexity of the granulation, evidencing special phenomena such as exploding granules or granular lanes, which are known to be directly related to the emergence of small-scale magnetic flux. Unveiling the nature of magnetic emergence in granules requires extensive statistical studies. The development of new automatic tools has become crucial to perform statistics on a large amount of data expected by new/upcoming instrumentation: DKIST or Sunrise III.

In this contribution, we present the current advances of our classification algorithm of solar granulation based on neural networks including the exploration of recurrent modules for covering the temporal dimension. An initial model was tested using U-net architecture in a supervised approach using the continuum intensity of the IMaX instrument onboard the Sunrise I and their corresponding segmented maps. We study the performance of this approach to assess the versatility of the U-Net architecture for single-frame segmentation. We found an interesting potential of the U-Net to identify granules reaching matching in pixels greater than 80%, achieving high levels of accuracy in the identification of the intergranular network and allowing the effective separation of granular morphologies. We identify per-class accuracy levels of around 60% in single snapshots which are substantially reduced when temporal sequences are included as extra channels. Recurrent modules added within the deep layers seem to improve the prediction accuracy compared with the previous case.

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1787

Assessing Ionospheric Responses to Geomagnetic Storms with VLBI and VGOS

Arno Rüegg, Prof. Benedikt Soja

ETH Zurich

Abstract

Space weather impacts Earth's atmosphere, and accurate ionospheric models helps us study these effects. Traditionally, these models primarily use GNSS data, benefiting from its continuous, extensive global coverage. Very Long Baseline Interferometry (VLBI) provides an alternative method to measure the ionosphere's Vertical Total Electron Content (VTEC), which allows the potential utilization of VLBI observations to enhance ionospheric models, provided that the robustness and reliability of the derived values are sufficient. The launch of the VLBI Global Observing System (VGOS) and its four frequency band observations significantly enhances our ability to accurately measure VTEC.

Our research utilizes a new approach based on least squares adjustment designed for VTEC estimation from both legacy VLBI and VGOS data. We analyze operational 24-hour sessions, focusing on sessions at co-located stations where VLBI and VGOS data overlap, allowing for unique comparative studies. The VTEC values obtained through our method are examined for their consistency and accuracy. For validation, we compare our results with two independent GNSS-based datasets, namely Global Ionosphere Maps (GIM) and Madrigal TEC Maps (MTM). Initial comparisons show that VGOS sessions correlate better with GIM than VLBI sessions, indicating a higher consistency overall.

Furthermore, our algorithm supports the creation of long-term ionospheric time series, enabling the study of variations in relation to solar activity. Besides the long-term evaluations, also the short-term effects of space weather on the ionosphere will be analyzed and evaluated. Concretely, we will study the ionospheric response during geomagnetic storms using legacy VLBI and VGOS data.

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Si IV emission model of the response of the flare energy transport through the transition region

Dr. Elena Dzifcakova, Dr. Jana Kasparova, Dr. Jaroslav Dudik, Dr. Alena Zemanova

Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic

Abstract

Results of the Si IV emission modelling at the footpoints of flaring loops are presented. The radiation-hydrodynamical simulations were performed using the FLARIX code. We modelled time dependent plasma parameters (temperature, density, non-Maxwellian beam electron distribution function...) in the transition region. They are response to an electron beam transport of energy from reconnection site down to the chromosphere. We tested a wide range of the beam parameters. Consequently, non-equilibrium ionization states for non-Maxwellian distributions of silicon and Si IV emission were calculated with high temporal resolution. The results are then compared with Si IV emission observed by IRIS during the impulsive phase of solar flares.

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1907

SolarKAT: Imaging Pipeline for Solar Interference Mitigation in MeerKAT

Miss Victoria Samboco[1,2], Professor Ian Heywood[3,4,5], Professor Ian Heywood[5,4]

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Abstract

In radio astronomy, one of the biggest challenges is radio frequency interference (RFI) caused by different sources, whether artificial or natural. This study focuses on mitigating interference from a natural source, the Sun, which can completely corrupt the data. To address this issue, we developed SolarKAT, an imaging pipeline that effectively mitigates interference caused by the Sun in MeerKAT, recovering the viabilities rather than discarding them. This is achieved while preserving the flux measurements in the main field. SolarKAT is versatile and can be applied to general radio astronomy observations and solar radio astronomy; additionally, generated solar images can be used for weather forecasting. SolarKAT is deployed in Stimela. It is based on existing radio astronomy software, including CASA, breizorro, WSclean, Quartical, and Astropy.

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1944

Bridging the solar interior and the solar wind with radiative MHD modeling

Haruhisa Iijima[1], Takuma Matsumoto[1,2], Hideyuki Hotta[1], Shinsuke Imada[3]

[1]Nagoya University. [2]The National Astronomical Observatory of Japan. [3]The University of Tokyo

Abstract

We will present our recent works on the three-dimensional radiative magnetohydrodynamic (MHD) simulations to investigate physical links between the solar interior and the solar wind.

The thermal convection in the solar interior is a known primary driver of the magnetic activity observed around the Sun, such as the solar wind. Recent advancements in solar observations, both in space and on the ground, have gradually unveiled the energetic link between the solar interior and the solar wind. However, the complexity of the Sun's magnetic field topology and the significant differences of spatial and temporal scales have made it challenging to fully understand the physical origins of various interplanetary phenomena.

To investigate energetic connections between the thermal convection and the solar wind formation, we carried out large-scale radiative MHD simulations using the numerical code RAMENS. The typical numerical box spans from the upper convection zone to a few tens of solar radii away from the Sun. The simulated thermal convection (from granular to super-granular scales) generated the mixed-polarity magnetic patterns through the small-scale dynamo. The interaction between the dynamo-generated magnetic field and the thermal convection spontaneously produces a millionth-degree corona and a supersonic solar wind without relying on any empirical assumptions. Through analysis of the simulated system, we could show a quantitative significance of the interchange reconnection in the solar wind acceleration. We hope our model will supplement the spatial or causal gaps between multiple observations.

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1951

2,000 years of twinkling: lessons learned from a brief history of astronomical scintillation

Emily Kerrison[1,2], Prof Ron Ekers[2], Dr Vanessa Moss[2,1], Dr John Morgan[3,2], Dr Rajan Chhetri[3,2]

[1]University of Sydney. [2]CSIRO Space & Astronomy. [3]International Centre for Radio Astronomy Research, Curtin University

Abstract

Some time around 350BCE, the Greek philosopher Aristotle wrote about the 'fixed stars which twinkle and the planets which do not'. This is perhaps the earliest reference to the scintillation of compact astronomical objects, a phenomenon which is used today by many branches of astronomy, from the study of fast radio bursts to the tracking of space weather. But the path from this ancient remark to modern scientific applications is a twisted one full of challenged assumptions and (mis)communication. In this talk I shall discuss how the physics behind the scintillation of radio sources, first ionospheric, then interplanetary and interstellar, was gradually understood over the course of many years, with a focus on the angular size dependence of this phenomenon. As with the twinkling of stars noticed by the Greeks, this radio frequency scintillation was initially misinterpreted as an intrinsic effect where in fact we now know it is related to aspects of wave propagation through a turbulent medium which are not so intuitive, but once this is understood we have a powerful tool to probe the space weather environment without even having to go there.

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1994

Probing the dynamical properties of new sub-type III solar radio burst (type VI)

Ms. Nurul Husna Mohammad Bokhari, Assoc. Prof. Ts. Dr. Zety Sharizat Hamidi, Assoc Prof. Dr. Nur Nafhatun Md Shariff

MARA University of Technology (UiTM), Malaysia

Abstract

Solar radio bursts (SRBs), including the newly identified type VI within the sub-type III category, are intriguing phenomena occurring in the solar atmosphere. These bursts exhibit unique dynamical properties, yet their detailed characteristics and relationship with other solar activities have not been explored extensively. This study aims to investigate the dynamical properties of sub-type III solar radio bursts and uncover their underlying mechanisms of generation and propagation. Through meticulous analysis of observational data, we seek to understand the temporal evolution, spectral characteristics, and spatial distribution of these bursts. Additionally, we aim to explore potential correlations with other solar phenomena such as solar flares, coronal mass ejections (CMEs), and sunspot numbers. We conducted a comprehensive analysis of observational data from 2020 until 2024 acquired from e-CALLISTO, a worldwide network of solar radio spectrometers. Signal processing techniques that include time-frequency analysis and statistical methods were employed to identify patterns in burst morphology and variations in dynamical properties. Comparative analysis allowed us to explore potential correlations between the bursts and concurrent solar activities. Our analysis reveals intricate patterns in the dynamical properties of sub-type III solar radio bursts. We observe distinct temporal evolution, spectral signatures, and spatial distributions indicative of complex underlying processes. Additionally, our preliminary findings suggest complex interactions between SRB type VI and other solar activities, indicating possible links to magnetic reconnection processes and energy release mechanisms. In conclusion, this study enhances our understanding of the dynamical properties of SRB type VI and their implications for solar dynamics and space weather.

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1996

Space weather impact of three solar flares observed by the POEMAS telescope at 45 and 90 GHz

Prof Adriana Valio, Miss Karla Lopez Araujo, Mr Ruben M. Romero Ramirez, Mr Jose Luis Gamonal Valenzuela, Dr Douglas F. da Silva

Center for Radio Astronomy and Astrophysics Mackenzie, Mackenzie Presbyterian University, São Paulo, Brazil

Abstract

Solar flares are often associated with coronal mass ejections (CMEs), which when directed towards Earth, may impact the magnetosphere, causing geomagnetic storms and altering space weather conditions. This study investigates three solar flares observed by the POEMAS radio telescope (45 and 90 GHz) in 2012 to discern flare/CME characteristics influencing Earth's space weather. Flares on March 2nd and June 6th (GOES class M) were followed by partial CMEs, while the July 12th event (X1.4) featured a more energetic halo CME. Detailed analysis, utilizing GOES 15 X-ray data, RSTN-POEMAS radio observations, and gyrosynchrotron fitting of radio spectra, revealed complex dynamics. The accelerated electron distribution exhibited a hard spectral index of 2.0 for all three flares. Ratios of CME kinetic energy to soft X-ray energy were approximately 40, 50, and 10 for March 2nd, June 6th, and July 12th events, respectively, underscoring the distinct nature of solar flares and CMEs. Geomagnetic storm potential was assessed using Dst and Kp indices. Despite being fast and energetic, the March 2nd CME showed no detected storm at Earth's estimated arrival, possibly due to its partial halo nature and unique active region location. The CME on June 6th may have induced a mild storm about 3.5 days later, while the largest event (July 12th) led to a moderated geomagnetic storm less than two days later. This underscores the intricate nature of solar-terrestrial interactions. The study emphasizes the importance of research to refine our understanding of the dynamic interplay between solar activity and Earth's space environment.

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1998

Examining the Ability of Machine Learning Models to Predict SEP Events Utilizing Two Solar Cycles of Observations

Dr. Spiridon Kasapis[1], Dr. Irina Kitiashvili[1], Dr. Alexander Kosovichev[2], Dr. Viacheslav Sadykov[3], Pau Kosovich[2], Patrick O'Keefe[2], Vincent Wang[1]

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Abstract

Solar Energetic Particle (SEP) events, mainly originating from magnetic reconnection processes during solar flares or swift coronal mass ejections, pose significant radiation hazards to aviation, spacecraft electronics, and particularly, manned space flights. In this study, we utilize the SHARP-SMARP dataset, which combines data from the Solar Dynamics Observatory/Helioseismic and Magnetic Imager's (SDO/HMI) Space weather HMI Active Region Patches (SHARP) with data from the Solar and Heliospheric Observatory/Michelson Doppler Imager's (SOHO/MDI) Space Weather MDI Active Region Patches (SMARP) in order to predict SEP events. We employ a variety of machine learning methods, including Support Vector Machines (SVM) and Regression Models, to evaluate the predictive power of this integrated dataset in forecasting SEP events subsequent to solar flares. Our analysis indicates that despite an increase in the amount of data compared to studies focused solely on Solar Cycle 23, the peak forecasting accuracy achieved is 0.7 ± 0.1. This is in line with, but does not exceed, previously established benchmarks. A linear SVM strategy, designed to mirror actual operational scenarios (imbalance between positive and negative examples), exhibits a slight enhancement (+ 0.04 ± 0.05) in forecasting SEP events 14 hours in advance compared to earlier efforts. This finding highlights the necessity for more sophisticated models that integrate physical principles to enhance our understanding of the mechanisms driving SEP events.

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2042

Intersecting frontiers for ground- and space-based solar missions: symbiotic coordination between DKIST, PSP, and Solar Orbiter

Dr. Thomas Schad, DKIST Team

National Solar Observatory

Abstract

Three uniquely powerful solar and heliospheric facilities are now operational at the same time. The US National Science Foundation's Daniel K Inouye Solar Telescope (DKIST), NASA's Parker Solar Probe (PSP), and ESA's Solar Orbiter each represent frontiers in solar and space science, and each pursue richly tailored science missions. At the intersection of these missions, however, lies unparalleled opportunities for multi-vantage point solar science. This symbiotic relationship is especially pronounced during PSP's perihelia and Solar Orbiter remote science windows, which rally efforts amongst existing and new observational assets. Being the most advanced and largest solar polarimeter ever built, DKIST strengthens many of the driving multi-facility use cases by probing regimes previously inaccessible. In particular, DKIST opens new diagnostic windows into solar magnetism--spanning the photosphere, chromosphere, and corona---at unprecedented spatial, temporal, and polarimetric resolutions. In this talk, we report recent efforts to maximize the science potential of coordinated DKIST, PSP, and Solar Orbiter observations. Existing DKIST data from coordinated observations with Solar Orbiter and PSP will be reviewed alongside some first results achieved from these data sets.

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Global Solar Activity Data Portal for Studying 3D Dynamics and Activity of the Sun

Irina N. Kitiashvili[1], Vincent Wang[2], Matthew Vu[3], Arthur Foy[4], Shubha S. Ranjan[1], Ryan C. Spaulding[1], Donald G. Deardorff[1]

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Abstract

The main problems with understanding and predicting solar activity are tightly linked to limitations in describing the global evolution of the Sun from the deep interior to the corona. Because of the complexity of interactions in a wide range of dynamical, turbulent, and spatial scales and dramatic changes in thermodynamic and magnetic field conditions, only physics-based models can provide essential background to generate reliable solar activity forecasts. However, performing accurate model calibration and estimating uncertainties is often challenging due to the unavailability of a long time series of observations. To mitigate these limitations, we have developed the Global Solar Activity (GSA) Data Portal, which enables convenient access to a variety of modern and historical data. The portal supports a dynamic visualization for 1D time series (such as the sunspot number and solar irradiance) and quick-look visualization for 2D data sets (e.g., synoptic magnetograms, the solar internal rotation, and flows). The GSA portal includes a search engine that enables data retrieval from user-specified data sources and time intervals. In this presentation, we will discuss the current and upcoming capabilities of the data portal and its potential applications for space weather studies.

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2058

Simulating the Magnetospheric and Geomagnetic Impact of Coronal Mass Ejections

Prof. Dibyendu Nandi, Souvik Roy

Indian Institute of Science Education and Research Kolkata

Abstract

One of the striking manifestations of space weather are geomagnetic storms which occur when magnetic transients such as coronal mass ejections (CMES) impact the Earth's magnetosphere. Predicting the impact of a CME remains an outstanding challenge because in-situ observations near-Earth only provide a small time window and complex computational models are prohibitively time-intensive. We have developed a relatively simpler and time-efficient magnetohydrodynamic model named STORMI for exploring solar storm magnetospheric interaction. Based on fundamental physics and some idealizations, we demonstrate that the STORMI model simulated geomagnetic storm intensity index compares favourably with observations.

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Development of Solar Flare and Energetic Particle Prediction Portal (SEP^3)

Alexander Kosovichev[1], Viacheslav Sadykov[2], Vincent Oria[1], Irina Kitiashvili[3], Patrick O'Keefe[1], Aatiya Ali[2], Chun-Jie Chong[1], Paul Kosovich[1], Samuel Granovsky[1]

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Abstract

Solar activity is a primary factor determining the state of the Earth's space environment, geomagnetic and ionospheric disturbances, and radiation hazards. In the current state of knowledge, machine learning (ML) methods provide essential tools for processing data, investigating relationships among various physical properties and characteristics, uncovering hidden connections, and predicting hazardous solar events. The primary difficulty in developing and applying modern machine-learning tools in heliophysics is that the essential data are scattered among over a hundred data repositories developed by instrument teams of space missions and ground-based observatories. In addition, statistical and ML methods require long time series of homogeneous measurements. To facilitate ML-ready data preparation and access, we have developed an interactive database of solar flares integrating the most essential datasets (https://solarflare.njit.edu/). The database performs an initial data processing and is automatically updated. In addition, we are developing the Solar Energetic Particle Prediction Portal (SEP3, https://sun.njit.edu/SEP3), which hosts web applications that allow users to retrieve the database records. The Portal has a search page for browsing the events from the most widely used catalogs and a dedicated space to share the most recent achievements of the team. The interactive widget can display soft X-ray and proton flux time series from GOES satellites and the flare records. The data portal has been used to evaluate the forecasts of solar proton events and investigate machine-learning approaches to SEP prediction.

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Patrol ground-based telescopes for recording coronal mass ejections

Ivan Berezin, Andrey Tlatov

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Abstract

The possibilities of organizing the solar activity observation service for space weather forecasting are considered. At this stage, the most promising approach is the establishment of a ground-based observation network. Coronal mass ejections (CMEs) are the main factor determining strong geomagnetic storms and space weather conditions. Regular observations of CMEs are necessary for successful space weather forecasting. Observation, detection, and characterization of CMEs can be carried out at ground-based patrol telescopes. Prototypes of such telescopes were created at the Kislovodsk Mountain Astronomical Station.

We use observations obtained with the Solar Patrol Optical Telescope (SPOT) to investigate the association between the early filament rise and CMEs. The instrument is a spectroheliograph and allows us to record the full profile of the Hα line in each pixel of the solar disk with a time periodicity of about 60-80 seconds. We analyzed the observations of a number of eruptive filaments between 2017 and 2023 and showed that patrol telescope measurements of the Hα line profile with a spectral resolution R = 40,000 can be used to detect precursors of filament eruptions with an advance of several hours and to estimate the initial acceleration of CMEs.

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Calibrating GONG Farside Seismic Maps with SO/PHI Farside Magnetograms

Kiran Jain[1], Hanna Strecker[2], David Orozco Suárez[2], Mitchell Creelman[1], Amr Hamada[1], Valentin Martinez Pillet[1], Niles Oien[1], Alexei Pevtsov[1], Sushanta Tripathy[1], Thomas Wentzel[1]

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Abstract

Solar active regions are the primary driver of space weather. Since these regions are the sources of strong magnetic fields, a precise knowledge of the 360-degree Sun is crucial for developing data-driven global magnetic field models. While the observations of nearside active regions are available from various sources, we mostly rely on indirect methods for farside active regions. Global Oscillation Network Group (GONG) has been producing Carrington maps of seismically detected strong active regions for about two decades. These maps are computed using the technique of helioseismic holography applied to Doppler observations of the Sun's visible hemisphere. In this technique, the seismic signatures of the farside active regions are expressed as phase shifts between waves entering and exiting these regions. However, in the absence of direct magnetic field observations of the farside, these seismic signals are calibrated through approximate empirical relations. With the successful launch of Solar Orbiter (SO), magnetic field observations are now available from different vantage points, with full or partial farside hemisphere coverage. This provides a unique opportunity to calibrate the magnetic field strength of seismically identified active regions. Here, we present results on the calibration of phase shifts of the farside active regions with SO/Polarimetric and Helioseismic Imager (PHI) magnetograms as well as verify their locations and areas.

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A Detailed Sun-to-Earth Investigation of the Space Weather Conditions that Trigerred the Loss of the Starlink Satellites in February 2022

Ms Yoshita Baruah[1,2], Mr Souvik Roy[2], Dr Suvadip Sinha[2], Dr Erika Palmerio[3], Dr Sanchita Pal[4], Dr Denny Oliveira[5,6], Dr Dibyendu Nandi[7,1,2]

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Abstract

Coronal mass ejections (CMEs) and high-speed streams (HSSs) directed towards Earth are significant drivers of space weather. Upon reaching Earth fast CMEs and HSSs, characterized by strong southward-directed magnetic fields with respect to Earth's magnetic field, interact with the magnetosphere, triggering geomagnetic storms. These events deposit a considerable amount of energy into the magnetospheric system, primarily through Joule heating, causing the thermosphere to expand upwards. This expansion leads to increased density at Low Earth Orbit (LEO) altitudes, resulting in heightened atmospheric drag on satellites and affecting their orbital lifetime. In February 2022, 38 out of 49 Starlink satellites launched by SpaceX re-entered the atmosphere due to such a geomagnetic storm. Our study delves into the solar events preceding this incident, analyzing solar wind data from L1 to identify interplanetary structures near Earth associated with the geomagnetic storms. Through data-driven magnetohydrodynamic simulations, we examine the impact of CMEs on Earth's magnetosphere and assess their effect on the orbits of Starlink satellites using empirical methods and simulations, establishing a causal relationship across the Sun-Earth system. Our findings reveal that the geomagnetic storms affecting the Starlink satellites were relatively moderate in intensity. However, besides space weather and low-altitude insertion, certain physical characteristics of the satellites also contributed to their rapid de-orbiting and loss.

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Observing space weather events with the autonomous ASKAP radio telescope

Dr Vanessa Moss, Dr Aidan Hotan, Dr Emil Lenc, Dr Zoe Taylor, Dr Rajan Chhetri, Dr John Morgan, Dr Keith Bannister, Dr Mark Cheung, Dr Ron Ekers

CSIRO

Abstract

We present an overview of the work done to date in enabling space weather related observations to be carried out at radio wavelengths with ASKAP. The ASKAP radio telescope is an array of 36 x 12m antennas located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory in Western Australia, and is equipped with innovative phased-array-field receivers which greatly increase its field of view in comparison with single-pixel feeds. ASKAP is primarily a survey instrument carrying out a number of all-sky surveys, but has a modest amount of time available for novel and high-impact guest science.

Over the last year, this guest science has expanded to include technical demonstration of ASKAP's ability to conduct interplanetary scintillation (IPS) observations of the solar heliosphere, making use of its instrumental capabilities, its autonomous operations model and the new CRACO backend currently under commissioning for high time resolution observations on the order of milliseconds. We are currently in the process of broadening this work to be a more regular and sustainable part of ASKAP science operations, and keen to explore the possibilities for future collaborations and coordination with the broader space weather community.

In this talk, I'll introduce ASKAP, its current capabilities and autonomous operations (and implications for its ability to be responsive to time-critical events), and showcase a number of space weather related observations that ASKAP has conducted as part of its transition from commissioning to full-survey operations.

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Global effects on the ionosphere during the second most significant geomagnetic storm of the 24th solar cycle

Bhupendra Kumar

National Institute of Technical Teachers' Training and Research

Abstract

In solar physics, one of the most important scientific goals is to figure out how the sun, the space weather that causes storms, and the effects on Earth are all connected.

Changes in the ionosphere during severe geomagnetic storms caused a disturbance in the earth's magnetic field. Geomagnetic storms are extreme space weather events with significant effects on the ionosphere. The ionosphere reacts dramatically and unexpectedly to variable magnetospheric energy inputs resulting from solar disturbances in geospace. The influence of space weather events on the ionosphere must be understood in order to estimate the environmental impact on the functioning of terrestrial and space-based systems. In this paper, we studied the second most significant geomagnetic storm that occurred on June 23, 2015, and Dst (storm time ring current index) reaching -204 nT was recorded for the 24th solar cycle, which caused very significant and long-term changes in the ionosphere. We analyse a detailed summary of how the ionosphere's Total Electron Content (TEC) changes in both hemispheres (Northern and Southern) at various geographic latitudinal and longitudinal stations using data from receivers over 45 stations (26 from the Northern Hemisphere and 19 from the Southern Hemisphere) identified from the IGS network all across the globe.

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High resolution mapping of the inner heliosphere via ground-based, wide-field radio observations.

Dr John Morgan[1], Dr Guifré Molera Calves[2], Ms Angelica Waszewski[3], Dr Rajan Chhetri[1]

[1]CSIRO. [2]University of Tasmania. [3]Curtin University

Abstract

An outstanding problem in observational space weather is the difficulty of probing the region between that covered by white-light coronagraphs (out to a few solar radii), and in-situ observations made at L1. This region, comprising almost all of the volume of the Heliosphere within 1 AU, remains only sparsely sampled by in-situ observations with very few exceptions.

Interplanetary Scintillation (IPS) is one approach to probing this volume. Earth-based observations are made of compact astrophysical radio sources. Propagation through the interplanetary medium causes scintillation (similar to stars twinkling) and measurement of these scintillation signatures provide useful proxies for solar wind density and velocity (integrated along the line of sight). Observations from established IPS observatories have been shown to improve forecasts of solar wind density and velocity at L1, both for ambient solar wind and Coronal Mass Ejections (CMEs).

In this presentation I will focus on the use of a new generation of radio telescopes for IPS observations. With their unprecedented combination of sensitivity, wide field of view, and snapshot imaging capability, these instruments measure IPS for hundreds of sources in parallel, providing a high resolution grid of IPS measurements, sufficient to reveal the existing of smaller-scale structures in interplanetary space, as well as map the morphology of interplanetary CMEs.

Finally, I will describe how a broader range of ground-based radio observations here in Australia can provide complementary information on the inner heliosphere. Such observations include observations of interplanetary spacecraft, pulsars, linearly polarised sources, and direct emission from the Sun and CMEs.

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ML-based Ionospheric TEC maps for enhanced K-band VLBI

Marcel Iten[1], Benedikt Soja[1], Aletha de Witt[2], Matthias Schartner[1], Arno Rüegg[1], Hana Krásná[3], Marisa Nickola[2]

[1]ETH Zurich. [2]South African Radio Astronomy Observatory. [3]Technische Universität Wien

Abstract

Very Long Baseline Interferometry (VLBI) is a powerful technique in radio astronomy and geodesy that enables the precise measurement of the positions of celestial objects, positions on Earth, and the Earth's orientation in space. The International Celestial Reference Frame (ICRF) forms the basis for all positional astronomy and serves as the foundational reference frame for all Earth observations. Currently realizations of the ICRF are based on dual-frequency VLBI observations on the S- and X-band (2.3 and 8.4 GHz) and on single-frequency K-band (24GHz) observations. The higher frequency K-band observations show certain advantages like a higher resolution and a more compact active galactic nuclei (AGN) source morphology. However, the accuracy of K-band astrometric solutions is currently limited by the lack of dual-band observations. Dual-band observations are necessary to correct for ionospheric effects. For a high-quality data analysis, the ionospheric effect needs to be corrected based on external information.

We therefore develop a novel ionosphere model based on machine learning (ML) and apply it to correct ionospheric effects in VLBI K-band measurements. Vertical total electron content (VTEC) estimates from Global Navigation Satellite System (GNSS) as well as space weather indices serve as input data. An ML model based on fully connected neural networks learns the spatial relationship between location and VTEC. We achieve a mean accuracy of 2 TECU for global spatial interpolation during high activity solar conditions. Based on the corrected VLBI observations, a K-Band CRF is calculated to compare the impact of the ML ionosphere model and traditional ionosphere models.

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Advances in Polarimetric Imaging of the Sun at Low Radio Frequencies

Prof. Divya Oberoi[1], Dr. Devojyoti Kansabanik[2,3], Dr. Surajit Mondal[4], Mr. Soham Dey[1], Ms. Puja Majee[1], Mr. Deepan Patra[1]

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Abstract

Polarization of active solar radio emissions is well known to carry a host of information about the emission mechanisms giving rise to this emission as well as the nature and topology of the local magnetic fields, which have remained notoriously hard to measure at coronal heights. For the quiet Sun, thermal emission picks up weak circular polarization in the presence of birefringent coronal plasma and can provide a coveted estimate of average quiet coronal magnetic fields. Despite these strong scientific motivations, rather limited progress has been made on this front as polarimetric imaging at low radio frequencies is technically challenging. Only comparatively recently, the confluence of the following two things has made it possible - (1) availability of data from new generation instruments like the Murchison Widefield Array (MWA), a precursor to the low-frequency telescope of the Square Kilometre Array Observatory and (2) development of dedicated interferometric radio imaging pipeline optimized for solar observations with the MWA (P-AIRCARS; Kansabanik et al., 2022, 2023). We are now using this combination to explore the polarimetric properties of not only the well-known solar bursts (types II and III) but also the quiet Sun and coronal holes. This presentation will showcase the highlights from this work, focusing on a detailed characterization of the nature of the polarized sources detected, and the implications and puzzles they lead to. This is proving to be a very interesting line of enquiry, which is expected to yield significant science results as it matures.

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Time evolution of Thermal and Non-thermal Energies in two Solar Flares

Soumya Roy[1], Sophie Musset[2], Katharine K. Reeves[3], Durgesh Tripathi[1], Christopher S. Moore[3]

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Abstract

We examine two solar flares, specifically an X-class event occurring on October 28th, 2021, and an M-class event on November 29th, 2020, to understand the dynamic variations in thermal energy throughout their progression. Our analysis incorporates data from various sources such as the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO), the Hinode X-ray Telescope (XRT), and the Spectrometer/Telescope for Imaging X-rays (STIX). Utilising this data, we estimate the overall thermal energy for both flares by calculating the Differential Emission Measure (DEM) to track thermal energy changes over time. Additionally, we use spectra from the STIX instrument onboard the Solar Orbiter for the X-class flare to estimate the non-thermal component. We also explore the impact of volume estimates of the flare arcade over time on our thermal energy calculations, underscoring the importance of high-resolution imaging across various wavelengths and perspectives. We propose a method for precisely determining the Line of Sight (LOS) throughout the Field of View (FOV) using near-simultaneous observations from multiple viewpoints, resulting in a better estimate of the volume of the flare arcade. Furthermore, our investigation of the M-class event includes an analysis of the thermal structure of the fan in comparison to the overall thermal evolution of the flare. Our findings reveal that the thermal energy decay of the fan is slower than that of the flare loops, suggesting a distinct heating mechanism at play within the fan structure.

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Geo-effectiveness of CME-CME Interaction events: An ensemble study using SWASTi framework

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Abstract

The geo-effectiveness of coronal mass ejections (CMEs) is a critical area of study in the field of space weather, particularly regarding the lesser-explored domain of CME-CME interactions and their geomagnetic consequences. This study leverages the SWASTi framework to simulate a range of CME-CME interaction scenarios within realistic solar wind conditions.

The study concentrates on the dynamics of the magnetic flux, velocity, and density of CMEs, and their combined and individual impacts on the geomagnetic storm index (Dst). We observe that increases in the initial density and velocity of CMEs generally lead to heightened geomagnetic activity. Interestingly, the impact of magnetic flux at eruption on storm severity depends on the chirality of the interacting CMEs. This suggests that magnetic reconnection and flux cancellation can mitigate storm intensity. Our findings underscore the significance of the relative tilt of interacting CMEs and reveal that variations in CME properties across different longitudes can drastically affect geomagnetic storm intensity. Furthermore, we show that inhomogeneous ambient solar wind conditions significantly alters the nature of CME-CME interaction, and hence its geo-effectiveness.

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Synergy and Potential Science from coordinated observations with Aditya-L1 and other Observatories

Dr. Sankarasubramanian Kasiviswanathan

U R Rao Satellite Centre

Abstract

Aditya-L1, an observatory class mission is currently placed at L1 to observe the Sun and local environments continuously. While Aditya-L1 alone can carry out certain unique science, coordinated observations with other space and ground based observations would enhance the knowledge about the Sun and heliophysics.

In this presentation, the potential observational capability of Aditya-L1 will be presented. Few potential areas where coordinated observations of Aditya-L1 with other observatories will provide additional science will be brought out. Both Indian and international facilities is identified for the same. The plan for the coordinated observations would also be discussed. Future potential coordinated observations which are not covered above will also be highlighted.

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Co-ordinated observing plans for Aditya L1 and other space platforms

Dr Dipankar Banerjee

Aryabhatta Research institute of Observational sciences

Abstract

Aditya L1 mission is the first observatory class solar mission from the Indian Space Research organization, launched in 2nd September 2023. The L1 insertion took place on 6th January 2024. With a combination of four remote sensing and 3 in situ instruments covering multi-wavelength it provides a unique opportunity to have joint observations with other co temporal missions. The first results from Aditya payloads will be presented during the invited plenary talk, but I will focus on the possible joint observations from other vantage points from space and ground. There will be window of opportunity for proposing joint observational campaigns with Aditya by the end of this year. So possible synergy of some transient studies with complimentary payloads on Solar orbiter, IRIS and ASPICS on PROBA3 with a combination of imaging and spectroscopic capabilities will be highlighted.

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First robust detection of linear polarization from solar radio bursts

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Abstract

When studying the polarimetric solar radio emissions, the focus has exclusively been on circular polarization. This originated from the reasonable expectation that even in the unlikely event that linearly polarized emission existed, the significant differential Faraday rotation in the coronal plasma should obliterate it (e.g., Grognard & McLean, 1973). Hence, despite some reports of detections of linear polarization in the late 1950s and early 1960s, the consensus has been to reject any linear polarization found in the observed dynamic spectra as instrumental artifacts (e.g., Grognard & McLean, 1972). This belief is so deeply rooted that it is routinely used during calibrating solar polarimetric observations. The recently developed full polar radio interferometric calibration algorithm, P-AIRCARS (Kansabanik et al., 2022a, 2022b, 2023) does not rely on this assumption. It provides state-of-the-art high-fidelity and high dynamic-range spectropolarimetric snapshot solar radio images using data from the Murchison Widefield Array (MWA). We find robust imaging-based evidence for the presence of linearly polarized emission during active solar emissions. We have also confirmed its presence using simultaneous observations from the MWA and the upgraded Giant Metrewave Radio Telescope at overlapping frequencies. We find that the Rotation Measure associated with this linearly polarized signal is orders of magnitude less than that expected from the corona, which implies that the linear polarization must originate at much larger coronal heights. We also present our explorations of physical scenarios which can give rise to it.

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Precise Point Positioning Accuracy of LAUTECH: A Seamless Opportunity for GNSS Applications in Nigeria.

Dr Benjamin Ayantunji[1], Dr Adebayo Adewumi[2], Dr. George Alagbe[2], Mr Efua Ogobor[1], Mr I.A Azeez[3]

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Abstract

This manuscript presents the result of the precise point positioning accuracy of LAUTECH for seamless GNSS applications in Lautech, Nigeria. A dual-frequency ublox GNSS receiver module with a ublox antenna was setup in an open-sky environment at the LAUTECH GNSS laboratory (8° 10' 13.92080", 4° 16' 8.07241", 403.411 m) to log GPS and GLONASS satellite observation data at 1 Hz for 24 hours. The data obtained was converted to a RINEX observation format using appropriate software. Online PPP was done through the Natural Resources of Canada (NRCan) service using rapid and final IGS products. The result shows that less than 11mm horizontal and less than 36mm vertical coordinates in GPS+GLONASS hybrid mode of operation with 95% confidence level is realizable in LAUTECH with the low-cost ublox ZED F9P compact module. It was witnessed that the combination of constellations enhanced the PPP accuracy when compared to the results of GPS-only and GLONASS-only modes of operation. The results will be useful for PPP solutions for GNSS seamless applications in LAUTECH, Nigeria.

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Upstream Solar Wind Prediction up to Mars by An Operational Solar Wind Prediction System

Dr Jingjing Wang

National Space Science Center, Chinese Academy of Sciences

Abstract

Combining the upstream solar wind observations measured by Mars Atmosphere and Volatile Evolution (MAVEN), Advanced Composition Explorer(ACE) and Deep Space Climate Observatory (DSCOVR) from October 2014 to April 2021, we investigate the statistical properties of the background solar wind at Mars and Earth. By applying an operational solar wind prediction system (Wang et al., 2018, https://doi.org/10.1051/swsc/2018025) in Space Weather Prediction Center (SEPC), we simulate the solar wind conditions and carry out a comparative analysis with observations to study our model performance. We find that our model is able to simulate the solar wind conditions upstream of Earth and Mars, corresponding to the different heliocentric distances and different levels of solar activity. Furthermore, we apply an event-based evaluation by analyzing the high speed enhancements (HSEs), and find that the hit rate of HSEs is 70.38% and 66.37% for Earth and Mars, respectively. By predicting the HSEs at Earth (Mars), our model reaches a Mean Absolute Error (MAE) of 83.93 km/s (65.91 km/s) and 22.98 hr (21.65 hr) for maximum speed and arrival time prediction error, respectively. We also conduct a three-month case study, from November 2020 to January 2021, analyzing solar wind conditions upstream of Earth, Mars, and measured by Tianwen-1 (China's first Mars mission), for which our model is capable to predict the upstream solar wind conditions up to Mars.

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Characterising solar eruptions through data-constrained MHD simulations

M. Valeria Sieyra[1], Antoine Strugarek[1], Andreas Wagner[2,3], Avijeet Prasad[4,5], Alexis Blaise[1]

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Abstract

Solar eruptions are ubiquitous in the sun and are one of the leading actors of space weather. The multiview observations have provided not only a three-dimensional reconstruction of coronal mass ejections but also new insights into their initiation processes. Motivated by what drives eruptive processes and to better understand the coupling between active region magnetic topology and thermodynamical variables, we develop a numerical framework for modelling ARs evolution. We consider different extrapolation techniques based on an HMI magnetogram. Here, I will present the results of an eruption that occurred in NOAA AR 12241 on December 18, 2014. We find that a flux rope self-consistently develops and rises in all our simulations. With the aid of an algorithm that identifies and tracks this structure, we study how the different extrapolation cases influence the dynamics of the magnetic flux rope. Taking advantage of the 3D simulations, we also reproduce synthetic EUV emissions from different points of view that can be directly compared with observations. We also add test particles to the model to identify particle acceleration sites and predict the shape of the hard-X ray emission. This work takes us a step closer to understanding the eruptivity of a given active region and the processes involved during the eruption. Hence, it improves our predictive and forecasting abilities for space weather purposes.

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Characterization of the source regions of high-latitude CMEs

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Abstract

In recent decades, instrumentation dedicated to solar and heliospheric observations has proliferated, with ever-increasing temporal, spatial and spectral resolution. In spite of many of these efforts being oriented to gain knowledge about the threatening phenomenon of coronal mass ejections (CMEs), there are many pending questions on their nature and evolution. In this study, we focus on exploring relationships between CME properties and the characteristics of their source regions. To this end, we analyze the sources of high-latitude CMEs for which their morphological characteristics can be estimated with less uncertainties than typically possible. We rely on observations of different regimes of the solar atmosphere, provided by the STEREO, SOHO, and SDO missions. In the low corona and chromosphere, we characterize associated filaments and phenomena related to the eruption; while in the photosphere we investigate a number of magnetic parameters and neutral line properties. The joint analysis of source regions and CMEs enables studying how the magnetic properties and observable attributes of the source regions impact the morphological and dynamical characteristics of CMEs, which ultimately may lead to improved space weather forecasting capabilities and understanding of processes involved in the initiation and early evolution of CMEs.

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Investigating the origin of the fast solar wind by linking remote-sensing and in situ measurements by the ESA/NASA Solar Orbiter mission

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Abstract

I will present the results of a "Fast Solar Wind Connection" Solar Orbiter Observing Plan (Fast Wind SOOP) that took place in October 2023. Its scientific goal was to identify the release mechanisms of the fast solar wind by relating an observed coronal hole to the solar wind measured in situ at the spacecraft's location. We combined low-latency images by the Extreme Ultraviolet Imager onboard Solar Orbiter, Earth-perspective observations by the Solar Dynamics Observatory, and models from the Magnetic Connectivity Tool to decide the target pointing. This was chosen to be a low-latitude coronal hole, located at the predicted foot points of the fast wind that would be later measured in situ. Coordinated observation campaigns for spectroscopy and/or imaging from Earth were also conducted by Hinode, the Interface Region Imaging Spectrograph, and the Swedish Solar Telescope. I will present and discuss our analysis of remote and in-situ data and how we can use their combination to get a better understanding of the sources of the fast solar wind. Among other things, we observed an eruption in proximity of the coronal hole, associated to a type III radio burst, and a filament channel encircling most of the coronal hole, exhibiting an interesting pattern of strong upflows and downflows along its boundaries. Another instance of the Fast Wind SOOP will be run in early April 2024, and some preliminary results from this could also be available in time for the symposium.

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Multi-viewpoint Coronal Mass Ejection catalog: Testing the pipeline for a citizen science project.

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Abstract

Coronal mass ejections (CMEs) are the strongest drivers of variability in the heliosphere. Identifying events that could have an impact on spacecraft or planets is extremely important in order to protect the missions against damages and to predict catastrophic events that may imply danger for instruments, astronauts and our planet. For this reason, the operation stage of an investigation is crucial to detect solar activity and follow the CME evolution at different distances from the Sun. This task is extremely time consuming but does not require any specific expertise in the field. Therefore, this is a perfect opportunity to connect society with science and to raise awareness of space weather to the general population. With the large amount of observations and catalogs available online, and basic information on what to look for, everyone can contribute to a collaborative catalog. We perform multi-view and multi-point analysis to understand the global evolution of CMEs predicted to impact different spacecraft or planets. In this project we catalog six events that occurred in the first half of 2023. These events were detected by both, in situ and with remote instruments. The entire analysis was performed as a final project of a highschool student, and sets the basis for a larger project for the general public.

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The first multi-year analysis of TEC results obtained at Oukaimeden Observatory. Study of the solar and geomagnetic activities on TEC behaviour

PhD student MAROUANE EL BAHRAOUI[1], Dr. Mohamed Kaab[1,2], Pr. Zouhair Benkhaldoun[1], PhD student noura azebabad[1]

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Abstract

One of the main parameters that characterize the ionosphere is the electron density showing changes with respect of solar activity, geomagnetic activity, position, season, ...etc. The quality of radio signals passing through this mysterious area of our Earth's atmosphere is affected by the behavior and state of the electron density. Hence the need to understand its evolution as a function not only of time but also of solar and geomagnetic activity. One of the key parameters making it possible to identify this behavior and its connection with the degradation of radio signals used in radio telecommunications is the measurement of the total electron content (TEC). Variations in TEC can cause signal delays, phase distortions, and scintillations, impacting the accuracy and reliability of telecommunications systems. The aim of this study is to represent the first multi-year analysis of TEC results obtained from GPS station installed at the Oukaimden Observatory, located at an altitude of about 2700 meters on the High Atlas mountain range, about 78 kilometers south of Marrakech, Morocco. We are going to present the evolution of total electron content (TEC) with respect to solar and geomagnetic parameters: in this context, F10.7 solar flux and Interplanetary Magnetic Fields (IMF) as solar proxies and Kp and Dst indices as geomagnetic activity proxies are considered

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Investigation of Solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory

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Abstract

Thermospheric winds and neutral temperature are two key parameters for a good understanding of the behavior and dynamics of the ionosphere at altitudes of around $200\,\mathrm{km}$. In this work we present the first multi-year results of our analysis of the effects of solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory. These results are obtained by measuring the Doppler shift and the Doppler Broadening via an imaging Fabry-Perot Interferometer which provide measurements of the $630.0\,nm$ emissions caused by dissociative recombination of the O^+_2. Our analysis obtained during the period from January 2014 to January 2017 including observations from 966 nights, focuses on the evolution of these two thermospheric parameters as a function of two indices: the first ,namely $F_{10.7}\mathrm{cm}$, is used to caracterize the solar activity and the second , K_P index, is used to decribe the geomagnetic activity. A preliminary analysis conducted with the first set of data shows that the neutral temperature is strongly linked to solar activity during the solar cycle while neutral winds are much more linked to seasonal variation, rather than to the solar cycle.

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Investigation of Solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory.

PhD student Noura AZEBABAD[1], Assistant Professor Mohamed KAAB[2], Professor of Higher Education ZOUHAIR BENKHALDOUN[3]

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Abstract

Thermospheric winds and neutral temperature are two key parameters for a good understanding of the behavior and dynamics of the ionosphere at altitudes of around 200 km. In this work we present the first multi-year results of our analysis of the effects of solar and geomagnetic activities on thermospheric neutral temperature and neutral winds over Oukaimeden Observatory. These results are obtained by measuring the Doppler shift and the Doppler Broadening via an imaging Fabry Perot Interferometer which provide measurements of the 630.0nm emissions caused by dissociative recombination of the O^{2+}. Our analysis obtained during the period from January 2014 to January 2017 including observations from 966 nights, focuses on the evolution of these two thermospheric parameters as a function of two indices: the first ,namely $F_{10.7}$cm, is used to caracterize the solar activity and the second , K_p index, is used to decribe the geomagnetic activity. A preliminary analysis conducted with the first set of data shows that the neutral temperature is strongly linked to solar activity during the solar cycle while neutral winds are much more linked to seasonal variation, rather than to the solar cycle.

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Benefits of Multi-point Observations of the Sun

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Lockheed Martin Advanced Technology Center

Abstract

The Solar TErrestrial RElations Observatory (STEREO), launched in 2006, came back to the Sun-Earth line in the summer of 2023. Although one of the twin spacecraft, STEREO-B, went out of commission in 2014, STEREO-A still continues its orbit ahead of Earth and sends us excellent data, both remote-sensing and in situ. We discuss some of the highlights of scientific investigations that crucially depend on STEREO observations from extra vantage points in addition to Earth-based observations, emphasizing the usefulness of data from the Extreme UltraViolet Imager (EUVI). First, we gain deeper insights into how the plasma in coronal temperature is distributed in 3D, including how it is evacuated by coronal mass ejections (CMEs) and other processes as revealed in coronal dimmings. Second, we have far better knowledge about how intense and extensive CME-related eruptions are, including those that occur on the far side of the Sun as viewed from Earth. It is known that intense solar energetic particle (SEP) events can come from far side regions, and STEREO observations are indispensable for estimating the spatial scale of the shock waves responsible for particle acceleration. Third, STEREO observations have contributed greatly to the determination of front- or far-side origin of stealthy CMEs, some of which cause substantial geomagnetic disturbances. These benefits would be enhanced, especially in the context of space weather research or operations, if we have observatories at reasonably wide and fixed angles with respect to the Sun-Earth line.

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Statistical Study of Solar Wind and Interplanetary Magnetic Field Parameters in Forbush Effects and Interplanetary Disturbances (FEID) during Solar Cycles 23 and 24 from 1996 to 2019

Miss Onyinye Jerry-Okafor[1], Professor Chika Onuchukwu[1], Dr Nonso Okoli[2], Mrs Victoria Okoye[1]

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Abstract

The study examines the statistical analysis of Forbush Effects and Interplanetary Disturbances (FEID) parameters across the dynamic solar cycles 23 and 24 spanning from 1996 to 2019. Forbush Effects represent the transient decrease in cosmic ray intensity observed on Earth, associated with the passage of solar ejecta through the interplanetary medium. Interplanetary disturbances, encompass a spectrum of phenomena arising from the interaction between the solar wind and the Earth's magnetosphere. The selected FEID parameters under analysis include Bmax (maximum interplanetary magnetic field intensity), VmBm (maximum velocity of solar wind), Bzmin (minimum value of Bz), BzmtoBm (ratio of Bz minimum to B maximum value), and ABzmax (the maximum absolute value of Bz component). These parameters are essential in understanding the nature and impact of solar disturbances on the Earth's magnetosphere and space weather dynamics. Employing comprehensive statistical techniques, including time series analysis, correlation analysis, and trend analysis, the study aims to elucidate the temporal variations, interrelationships, and trends exhibited by the FEID parameters throughout solar cycles 23 and 24. By analyzing nearly two and a half decades of data, the research endeavors to discern potential patterns, irregularities, and cyclical behaviors within the FEID parameters, thereby contributing to a deeper understanding of solar-terrestrial interactions and space weather forecasting. In conclusion, this research underscores the importance of systematic statistical analysis in unraveling the complexities of solar-terrestrial phenomena and underscores the need for continued monitoring and investigation of Forbush Effects and Interplanetary Disturbances across solar cycles for enhanced space weather forecasting and mitigation strategies.

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IAUS 389 Gravitational Wave Astrophysics

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A closer look at Streamer Blowout Coronal Mass Ejections: Multi-view analysis of morphology and kinematics

Leonardo Di Lorenzo[1], Fernando López[2], Hebe Cremades[2], Laura Balmaceda[3,4], Dana-Camelia Talpeanu[5], Elke D'Huys[5], Marilena Mierla[5,6]

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Abstract

We investigate three coronal mass ejections (CMEs) that occurred in 2013 and exhibit characteristics of streamer blowouts (SBOs). They often exhibit a prolonged expansion phase, indicated by an increase in the width of the lower part of the streamer. The swelling can last for several hours or days and is followed by the slow eruption of a CME at the streamer location. Their frequency varies between 1 and 12 per month, depending on the solar cycle, SBO-CMEs have been scarcely studied. This leaves unanswered questions about their origin, characteristics, and correlation with solar atmospheric structures. Moreover, the nature of these events poses important challenges for their detection, for which multi-viewpoint observations at different coronal heights are crucial. Using observations from SOHO/LASCO, STEREO/SECCHI COR1 and COR2, SDO/AIA and HMI, and PROBA-2/SWAP, we meticulously describe the evolution of the three studied events from ~1 to 15 solar radii. We determine the morphology and kinematics of SBO-CMEs in terms of their three-dimensional (3D) location, velocity and acceleration. We focus on their early stages and evolution in the corona. In addition, we use a Potential Field Source Surface (PFSS) model to examine the magnetic field configuration in the region of the events. Our analysis aims to unravel the 3D morphology of SBO-CMEs in the low corona, their evolution into the middle corona, and their impact on the configuration of the surrounding magnetic field. The results provide a more comprehensive understanding of SBO events and shed light on their intricate nature.

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What Do We Know About the Sun's Polar Fields?

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Abstract

The high latitude magnetic field polarity of the Sun changes sign near the maximum of each activity cycle, and we are observing the reversal of Cycle 25 now. The flip happens when magnetic flux from early-cycle active regions migrates from low latitudes to high, changing the dominant polarity. Long-lasting following-polarity patterns move poleward and first erode, then reverse, and finally strengthen the new polar cap. The change is not instantaneous or smooth and varies from hemisphere to hemisphere and cycle to cycle. The details depend on the transport of surface flux elements and the remnant field from the previous cycle. Observations from Cycles 21-25 from the Wilcox Solar Observatory show how the two hemispheres differ and how the overall field strength changes in time. Higher resolution observation from the Helioseismic and Magnetic Imager instrument on the Solar Dynamics Observatory (HMI/SDO) provide more detail about the reversals in Cycle 24 and 25. But one pole or the other is obscured at any given time due to the inclination of the ecliptic, and both the magnetic field and surface dynamics near the poles are difficult to observe from the solar equator. Observations from another vantage point are critical.

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Sun Neural Radiance Fields: From Images to 3D Reconstructions of the Solar Atmosphere

Robert Jarolim[1], Benoit Tremblay[1], Andrés Muñoz-Jaramillo[2], Anna Jungbluth[3], Kyriaki-Margarita Bintsi[4], Miraflor Santos[5], James Mason[6], Angelos Vourlidas[6], Cooper Downs[7], Ron Caplan[7], Sairam Sundaresan[8]

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Abstract

Over the last 15 years, at most three satellites observed the Sun in EUV at any given time. Additionally, these satellites have been tied to the ecliptic plane, thus incapable of observing the solar poles directly. However, a complete image of the 3D Sun is required to fully understand the dynamics of the Sun (from eruptive events to space weather), to forecast EUV radiation to protect our assets in space, to relate the Sun to other stars in the universe, and to generalize our knowledge of the Sun-Earth system to other host stars.

To maximize the science return of multiple viewpoints, we propose a novel approach that unifies and smoothly integrates data from multiple perspectives into a consistent 3D representation of the solar corona. We leverage Neural Radiance Fields which are neural networks that achieve state-of-the-art 3D scene representation and generate novel views from a limited number of input images. We adapted a neural radiance field for the Sun (SuNeRFs) to generate a physically-consistent representation of the 3D Sun, with the inclusion of radiative transfer and geometric ray sampling that matches the physical reality of optically thin plasma in the solar atmosphere. SuNeRFs leverage existing multi-viewpoint observations and act as virtual instruments that can fly out of the ecliptic, view the poles, and be placed anywhere in the solar system at no additional cost.

This is an example of how deep learning can be used to significantly enhance observational capabilities by creating virtual observatories.

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Sunspot 3-Min Umbral Oscillations: A Statistical Perspective from GST Observations

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Abstract

The Sun's dynamic atmosphere presents a diverse array of magnetohydrodynamic (MHD) waves, especially within areas of intense magnetic fields such as sunspots, where the most notable and powerful waves emerge. These waves propagate across the sunspot region, causing significant oscillations in spectral intensity and velocity. Our study focuses on observing the oscillations in the sunspot umbra using data from the Goode Solar Telescope (GST) at the Big Bear Solar Observatory. We analyze intensity oscillations at the center and the wings of the Hα line, as well as the Doppler velocity of the Hα line. Employing a wavelet analysis tool helps us identify the periodicity of the intensity and velocity oscillations. Through statistical analysis, we ascertain the prevalence of 3-minute oscillations in the umbral region. To distinguish wave modes at various wavelengths, we conduct phase difference analysis, estimating the phase difference between intensity in different bandpasses (such as Hα line core, Hα±0.2Å, Hα±0.4Å, Hα±0.6Å, Hα±0.8Å, and Hα±1Å) and Doppler velocity oscillations. The statistical distribution of phase differences falls within the range of -180° to 180° for all bandpasses, with peaks at 0° for blue shift bandpasses, -47° for Hα, and 180° for redshift bandpasses. This suggests evidence of both upward and downward propagating waves in the chromosphere region, indicating that the characteristic 3-minute umbral oscillations are indicative of resonant modes within the sunspot.

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Highly precise spectropolarimetry with ZIMPOL at IRSOL and at GREGOR as a tool to study the structure and evolution of solar magnetic fields

Dr. Renzo Ramelli[1], Dr. Franziska Zeuner[1], Prof. Svetlana Berdyugina[1,2,3], Francesco Vitali[1], Dr. Daniel Gisler[1], Dr. Michele Bianda[1], Dr. Luca Belluzzi[1,2,3]

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Abstract

Observations with the ZIMPOL polarimeter at IRSOL and GREGOR telescopes benefit of recent instrumental developments that allow detecting polarization signals with an improved zero-level accuracy and a precision mainly limited by the photon noise. This opens the possibility to understand and study the structure and evolution of the most elusive magnetic fields in different solar features. This presentation overviews the instrumentation developments and the main observing programs carried out or planned with ZIMPOL at the Gregory Coudé Telescope at IRSOL in Locarno and at the GREGOR telescope in Tenerife.

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The Upcoming Age of New Space Coronagraphs: Perspectives for Joint Science with ASPIICS, CODEX, and Metis.

Dr Silvano Fineschi[1], Dr Andrei Zhukov[2], Dr Jeffrey S. Newmark[3], Dr Marco Romoli[4]

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Abstract

In 2024, the coronagraphs ASPIICS and CODEX will be launched on the formation flying PROBA-3 ESA mission and on the ISS with a NASA-KASI-INAF mission, respectively.

The 150-m separation between the formation-flying Coronagraph and Occulter satellites of PROBA-3 will allow long-duration, eclipse-like imaging of the inner corona, down to heliocentric heights of 1.1 solar radii. Besides the cold (1.e+4 K) He I D3 587.6 nm, and hot (2.e+6 K) Fe XIV 530.3 nm emission-lines, ASPIICS will image the visible-light, broadband polarized brightness (pB) of the K-corona.

CODEX will measure the K-coronal intensity ratios at 390 nm and 410 nm where the strong absorption lines are concentrated in the photospheric spectrum, i.e., Ca II lines and the G band. The shape of the continuous coronal spectrum can offer a direct measure of the coronal electron temperature.

The inner field-of-view of ASPIICS will complement that of Metis, already operational on Solar Orbiter since 2020. Additionally, The coronal electron temperature from CODEX will provide a critical physical parameter for the Metis Doppler-dimming diagnostics of the solar wind speed. The presentation will review the perspective opportunities for joint science with Metis, ASPIICS and CODEX.

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A realistic Population III IMF from radiation-chemo-magnetohydrodynamic simulations

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Abstract

Although Pop III stars still remain elusive, recent JWST observations of highest redshift galaxies (as well as observations of metal-poor stars in the Milky Way) are starting to reach the level where quantifying the shape of the Population III IMF has become quite crucial. There has been immense progress in self-consistently deriving a Pop III IMF from simulations of collapsing primordial molecular clouds, yet we lack a suite of simulations that includes all the relevant star formation physics (chemistry, turbulence, magnetic fields, and radiation feedback). In this talk, I will present results from our new suite of 3D simulations of Pop III star formation that include turbulence and magnetic fields, and where the chemistry is coupled to protostellar radiation. These simulations simultaneously include turbulence and magnetic fields with ionizing and dissociating feedback during Pop III star formation, reach ~au-scale resolution needed to resolve shocks and turbulent dynamo amplification, and expansion of H II regions, and thus produce the most complete Pop III IMF to date. I will show how the interplay between magnetic fields and radiation feedback sets the Pop III IMF, and how their roles fundamentally differ from Pop I IMF. This research opens a much-awaited avenue in studies of Pop III stars, as the IMF produced can act as a realistic starting point to understand the evolution of Pop III clusters, early metal enrichment, formation of black holes, and assembly of the first galaxies.

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Galaxy Clusters an ideal laboratory for Cosmological phase transitions in an expanding universe

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Abstract

Galaxy clusters in an expanding universe are the bigger structures that are being considered while considering the large-scale structure of the universe. These clusters are always influenced by the force of gravity which makes various galaxies to cluster and form various bigger structures. We have developed both statistical mechanical as well as thermodynamical theories to evolve the clustering problem and study its science to a larger extent which is in convenience with the observational agreements. We rate the clustering problem by an impact parameter which has a strong dependence on various thermodynamical parameters like temperature, number density and interparticle distance. The measuring correlation parameter discusses the symmetry of the structures and focusses on the symmetry change from one type of cluster like moderately dense systems to high clustered systems. We develop the theory of studying the latent heats evolved in the system during the phenomena of galaxy clustering problem.

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Supermassive Dark Stars, a possible solution to the too massive first galaxies JWST puzzle

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Abstract

James Webb Space Telescope (JWST) has already begun to revolutionize our view of the cosmic dawn epoch. Namely, it discovered an unexpectedly large number of extremely bright objects in the sky from the early Universe, whose light was emitted more than thirteen billion years ago. If these objects are early galaxies, their discovery would be in stark contrast with the expectation set by numerical simulations, which predicted such bright galaxies to have formed significantly later. For this reason those JWST objects are sometimes called ``cosmology breakers.'' In addition, JWST data further strengthens another problem in cosmology: the origin of the supermassive black holes that power the large number of very bright quasars observed when the Universe was younger than 900 Myrs. Combined, those two problems indicate that the current understanding of the formation of the first stars and galaxies is, at best, incomplete. However, this ``understanding'' is largely based on theoretical and numerical models that ignore the role Dark Matter can have on the formation of the first stars. As shown by us in 2010, stars powered by Dark Matter annihilations (Dark Stars) can grow to become as bright as a galaxy, and with masses in excess of a million suns. In this talk we present recent JWST evidence for Dark Stars and discuss the first three candidates identified: JADES-GS-z13, JADES-GS-z12, and JADES-GS-z11. Moreover, we show that five most distant quasars ever observed (GN-z11, UHZ1, J0313–1806, J1342+0928 and J1007+2115) are consistent with supermassive black holes seeded by Dark Stars.

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What is a Little Red Dot and what is not, MIRI SMILES edition

Dr. Pablo G. Pérez-González

Centro de Astrobiología (CAB), CSIC/INTA

Abstract

We discuss what the most comprehensive MIRI survey to date (in terms of area, bands, and area), SMILES, is telling us about the nature of Little Red Dots, which have been claimed to be massive galaxies, dusty starbursts, and obscured AGN at high redshifts. MIRI data do in fact cover the right spectral range to probe the peak of the stellar emission and/or hot/warm dust radiation, providing very relevant information about this interesting population of galaxies discovered by JWST.

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The ALMA-JWST synergy: constraining the properties of galaxies in the early Universe

Jorge Zavala

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Abstract

Physically characterizing the excitation conditions and the physical properties of galaxies at high redshifts requires multi-wavelength observations and multi-line diagnostics. This is critical to understand whether or not they set real limits on the physical processes fueling efficient star formation within ΛCDM and to constrain the onset of AGN activity. The synergy between ALMA and JWST stands out as the most promising way to achieve this science goal thanks to the ability of simultaneously detecting rest-frame UV, optical, and FIR lines, as well as probing unobscured and dust-obscured starlight. In this talk, I will first summarize the most recent results regarding the formation and evolution of massive and dusty galaxies. Then, I will present the results of our unique JWST+ALMA survey on a spectroscopically-confirmed galaxy at z=12, which includes the first MIRI spectroscopic observations at high-redshifts and the deepest ALMA follow-up to date. These observations probe critical rest-frame optical emission lines such as Halpha, Hbeta and [OIII]5007, and the bright FIR transitions [OIII]52um and [OIII]88um. The combination of these emission lines allows us to put tight constraints on the gas properties of this early galaxy and its dust content, shedding light on the formation and evolution of the first galaxies in the universe, their black hole accretion, and their metal abundance and buildup history. This pioneering study highlights the importance (and the necessity) of conducting multi-wavelength observations and showcases the unique synergy between ALMA and JWST.

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JWST Reveals Powerful Feedback from Radio Jets in a Massive Galaxy at z = 4.1

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Abstract

We report observations of a powerful ionized gas outflow in a z = 4.1 luminous (L1.4GHz ∼ 10^28.3 W Hz^−1) radio galaxy TNJ1338-1942 hosting an obscured quasar using the Near Infrared Spectrograph (NIRSpec) on board JWST. We spatially resolve a large-scale (∼15 kpc) outflow and measure resolved outflow rates. The outflowing gas shows velocities exceeding 900 km/s and broad line profiles with line widths exceeding 1200 km/s located at ∼ 10 kpc projected distance from the central nucleus. The outflowing nebula spatially overlaps with the brightest radio lobe, indicating that the powerful radio jets are responsible for the extraordinary kinematics exhibited by the ionized gas. The ionized gas is possibly ionized by the central obscured quasar with a contribution from shocks. The spatially resolved mass outflow rate shows that the region with the broadest line profiles exhibits the strongest outflow rates, with an integrated mass outflow rate of ∼ 500 M_⊙/ yr. Our hypothesis is that an over-pressured shocked jet fluid expands laterally to create an expanding ellipsoidal “cocoon” that causes the surrounding gas to accelerate outwards. The total kinetic energy injected by the radio jet is about 3 orders of magnitude larger than the total kinetic energy measured in the outflowing ionized gas. This implies that kinetic energy must be transferred inefficiently from the jets to the gas. The bulk of the deposited energy possibly lies in the form of hot (∼ 10^7 K) X-ray-emitting gas

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The JWST Revolution: Progress in studies of early galaxies and cosmic reionisation

Professor Richard Ellis

University College London

Abstract

It is only two years since the James Webb Space Telescope (JWST) commenced science operation yet, in studies of the first billion years of cosmic history, the progress has been astonishing. Although redshift frontiers have been extended beyond those reached with Hubble Space Telescope and large ground-based telescopes, the main advances have been possible due to the superb quality of the new data, particularly in the near and mid infrared spectral regions. Spectroscopically, JWST has transformed the observational landscape by measuring the chemical composition of interstellar gas to redshifts beyond z~10 and identifying likely signatures of early active galactic nuclei. Its superlative image quality is also advantageous, enabling studies of resolved kinematics and stellar populations in early systems, particularly when aided through gravitational lensing by foreground clusters. As a result we can now address long-standing questions including which sources likely governed cosmic reionisation - the transformation of hydrogen in the intergalactic medium from a neutral to an ionised state, the origin of supermassive black holes and their abundance in sub-luminous galaxies, and the role that dust may play in obscuring our census of early systems. We can also consider perhaps the most enigmatic question: whether JWST can locate “cosmic dawn” when chemically-pristine galaxies first emerged from darkness. I will review JWST’s numerous observational achievements in the context of these questions, and highlight some puzzles that have arisen which may lead to unforeseen discoveries.

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Combining spatial resolution 3D imaging spectroscopy with cosmological simulations to trace the chemical and accretion history in nearby galaxies

Dr Kathryn Grasha

Australian National University

Abstract

Measuring the chemical history of galaxies is critical to understand how galaxies form and evolve. This is usually done through observations of emission lines from ionized nebulae, where their bright emission lines enable the measurement of physical properties, such as the gas-phase metallicity, across galaxy disks and in distant galaxies. In this talk I will present the newest state-of-the-art stellar evolution models based on the latest models of chemistry elements in the early universe to the determine chemical abundance patterns, pressure, star-formation rates, heavy element enrichment, and the production and escape of ionizing radiation from the first galaxies. Using these self-consistent chemistry and stellar population synthesis models, we use the observed stellar mass and detailed metallicity gradients to identify a best-fit to our galaxies within the IllustrisTNG cosmological simulations to characterize the likely chemical and accretion history. Our work suggests that the combination of cosmological simulations and high spatial resolution metallicity gradient observations can provide an archeological probe of the gas accretion and merger history of face-on spiral galaxies. With this, we are able to disentangle the different physical mechanisms regulate gas inflows and outflows and the resulting effects on the star formation activity. This project will exploit the next generation spectroscopy with the James Webb Space Telescope to make fundamental new measurements of the formation of stars in the first galaxies, linking the low and high redshift universes.

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Very massive stars and nitrogen-emitting galaxies

Prof Jorick Vink

Armagh Observatory and Planetarium

Abstract

Recent studies of high-redshift galaxies with James Webb Space Telescope (JWST), such as GN-z11 at z = 10.6, show unexpectedly significant amounts of nitrogen (N) in their spectra. As this phenomenology appears to extend to gravitationally lensed galaxies at Cosmic noon such as the Sunburst Arc at z = 2.37, as well as globular clusters overall, we suggest that the common ingredient among them are very massive stars (VMSs) with zero-age main sequence (ZAMS) masses in the range of 100-1000 $M_{\odot}$. The He II in the Sunburst Arc might also be the result of the disproportionally large contribution of VMS to the total stellar contribution. We analyse the pros and cons of the previous suggestions, including classical Wolf-Rayet (cWR) stars and supermassive stars (SMSs), to conclude that only our VMS alternative ticks all the relevant boxes. We discuss the VMS mass-loss history via their peculiar vertical evolution in the HR diagram resulting from a self-regulatory effect of these wind-dominated VMSs and we estimate that the large amounts of N present in star-forming galaxies may indeed result from VMSs. We conclude that VMSs should be included in population synthesis and chemical evolution models. Moreover, that it is critical for this to be done self-consistently, as a small error in their mass-loss rates would have dramatic consequences for their stellar evolution, as well as their ionising and chemical feedback.

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X-Shooting ULLYSES: Massive stars at low metallicity

Prof Jorick Vink

Armagh Observatory and Planetarium

Abstract

Observations of individual massive stars, super-luminous supernovae, gamma-ray bursts, and gravitational wave events involving spectacular black hole mergers indicate that the low-metallicity Universe is fundamentally different from our own Galaxy. Many transient phenomena will remain enigmatic until we achieve a firm understanding of the physics and evolution of massive stars at low metallicity (Z). The Hubble Space Telescope has devoted 500 orbits to observing ∼250 massive stars at low Z in the ultraviolet (UV) with the COS and STIS spectrographs under the ULLYSES programme. The complementary X-Shooting ULLYSES (XShootU) project provides an enhanced legacy value with high-quality optical and near-infrared spectra obtained with the wide-wavelength coverage X-shooter spectrograph at ESO's Very Large Telescope. We present an overview of the XShootU project, showing that combining ULLYSES UV and XShootU optical spectra is critical for the uniform determination of stellar parameters such as effective temperature, surface gravity, luminosity, and abundances, as well as wind properties such as mass-loss rates as a function of Z. As uncertainties in stellar and wind parameters percolate into many adjacent areas of astrophysics, the data and modelling of the XShootU project is expected to be a game changer for our physical understanding of massive stars at low Z. To be able to confidently interpret James Webb Space Telescope spectra of the first stellar generations, the individual spectra of low-Z stars need to be understood, which is exactly where XShootU can deliver.

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Quenching and Quiescence of first galaxies

Dr Laure CIESLA

Laboratoire d'Astrophysique de Marseille

Abstract

Over the vast expanse of cosmic time, there exists a subset of galaxies that have ceased their star-forming activities. The significance of these red galaxies varies depending on the cosmic era and their surrounding environment. Central to extragalactic astrophysics are inquiries into the physical mechanisms that trigger the cessation of star formation within these galaxies, as well as the epochs when these mechanisms become efficacious. This review aims to delve into these questions, beginning with an exposition of the understanding gleaned from observations predating the James Webb Space Telescope (JWST) era regarding quiescent galaxies in early cosmic epochs. Subsequently, I will analyze the recent insights derived from JWST's observations of these celestial objects within the first billion years of the Universe's existence. These findings will be contextualized alongside predictions from simulations, facilitating a comprehensive examination of the evolving nature of galaxies across cosmic epochs.

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The role of AGN in regulating galaxy evolution in massive z~3-4 galaxies

Mx Monserrat Martinez-Marin[1], Dr Karl Glazebrook[1], Dr Themiya Nanayakkara[1], Dr Colin Jacobs[1], Dr Ivo Labbe[1], Dr Glenn Gkacprzak[1], Dr Casey Papovich[2]

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Abstract

An excess of massive quiescent galaxies (MQGs) is found in the early universe (z~3-4). MQGs at this epoch suggest their stellar content was already in place in the first 1.5 Gyr of the Universe. These findings indicate that MQGs must have experienced an event that caused rapid quenching. Although observational evidence is scarce, AGNs are the most suitable candidate for quenching these galaxies. In this talk, we present a sample of massive galaxies (10 <log($M\bigstar/M\odot$)< 11) at 3 < z < 4 from JWST NIRSpec and the ZFOURGE survey with K–band spectra of the Keck/MOSFIRE, VLT/KMOS. We find that a large fraction have strong [OIII]5007 and Hβ emission lines with large line widths (σ 100 – 450 km/s). These results show a significantly high AGN fraction in massive galaxies, ranging from 60–70%, pointing to the period between 3 < z < 4 being a time of heightened activity for the development of supermassive black holes in the massive end of the galaxy population and provide evidence for their role in the emergence of the first massive quenched galaxies at this epoch.

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Cosmic star formation and AGN history over 13 billion years

Mr Jordan D'Silva

University of Western Australia

Abstract

Star formation and the growth of super massive black holes are two of the main processes that shape the observed light distributions of galaxies. However, the interface of these two processes is not well understood, especially during the epoch of reionisation, as star formation and active galactic nuclei (AGN) activity are often treated separately.

JWST has already identified many star forming galaxies and AGN, hinting that star formation and super massive black hole growth is rapid within the first few billion years after the Big Bang. We investigated the union of these processes with spectral energy distribution fitting, simultaneously accounting for the stellar and AGN emission in spectroscopically confirmed extremely distant galaxies. We found that including an AGN component in the fitting can lower the individual stellar masses of high redshift galaxies by 4 dex and the resulting cosmic star formation density by 0.4 dex. Therefore, exemplifying that AGN is an important factor to consider when interpreting the light distributions of among the first galaxies to ever exist in the Universe.

Observations from the present to 12.5 billion years into the past have revealed that star formation and AGN activity are coeval. Whether this coevolution persists further into the past, when the Universe was less than a billion years old, remains to be seen. This talk will discuss how this work is a stepping stone to this goal and how we are using JWST to further our understanding of the high redshift frontier.

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Characterizing the ISM and Physical properties of the galaxies that drove Reionization.

Dr Laura Pentericci

INAF- Osservatorio Astronomico di Roma

Abstract

JWST is revealing an unprecedented number of high redshift galaxies, and allowing us to characterize for the first time their physical properties in great detail. In this talk I will review what we have learnt about the interstellar medium conditions in galaxies in the Epoch of Reionization thanks to the GTO and ERS programs that provided the first sets of spectroscopic observations. In particular, I will focus on the star forming and ionizing properties of high redshift sources, as well as on the investigation of the conditions that facilitate the escape of Lyman continuum photons from the galaxies into the intergalactic medium, with the main aim of understanding the contribution of galaxies in the reoinization process.

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Advancing Scientific Frontiers with JWST

Dr. Nancy A. Levenson

Space Telescope Science Institute. Johns Hopkins University

Abstract

I will present highlights of some of the discoveries and questions that are the result of the tremendous new capabilities of JWST. As a scientific community, we have already made progress across fields that span scales from exoplanets to cosmology. We have also found some puzzling results that require re-examination of our prior assumptions and are a rich source for future investigations. JWST is remarkably complex, and the mission is possible because of the work of thousands of people around the world. We hope to apply the lessons of our experiences to future ambitious astrophysics projects that we will pursue together.

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Webb Unmasks Galaxy Growth at z>3: MIRI Pierces Dust and AGN Shadows

Dr Belen Alcalde Pampliega

ESO

Abstract

JWST is at the forefront of revolutionizing our comprehension of the high-redshift Universe, stretching the boundaries of galaxy detection for the youngest and most distant cosmic entities. Yet, as we strive for a more comprehensive understanding of the high-redshift Universe, concerns arise about the consistency of early estimates of galaxy number density and their vast stellar masses with model predictions.

Our study delves into the harmonious synergy of NIRCAM and MIRI, unveiling insights into the characterization of approximately 300 galaxies at z>3, including 30 MIRI-detected, optically faint galaxies. By capitalizing on the distinctive capabilities of both instruments, we explore the importance of MIRI data in comprehending dust obscuration and refining measurements of redshift and stellar mass. Moreover, we examine the impact of incorporating MIRI data on the derived AGN fraction, unraveling the intricate interplay between dust, star formation, and AGN activity. These findings illuminate the intricate processes shaping high-redshift galaxies, emphasizing the crucial role of MIRI data in refining our understanding of AGN contributions.

In essence, our research underscores the transformative potential of the NIRCAM-MIRI synergy, providing a deeper characterization of the true nature of z>3 galaxies. This synergy enables us to further refine our insights into their stellar populations, star formation, and AGN contributions within the broader galaxy population.

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Physical properties of extreme emission-line galaxies at z~4-9 from the JWST CEERS survey

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Abstract

Extreme emission line galaxies (EELGs) are typically characterized by high equivalent widths (EWs) which are driven by elevated specific star formation rates (sSFR) in low-mass galaxies with subsolar metallicities and little dust. Such extreme systems are exceedingly rare in the local universe, but the number density of EELGs increases with redshift. Such starburst galaxies are currently presumed to be the main drivers of hydrogen reionization over 5.5<z<15, which motivates the searches for high-z EELGs. In this talk, I will present the study of the physical properties of a sample of ~1000 EELGs at 4<z<9 photometrically selected from the CEERS survey using JWST/NIRCam. We create synthetic NIRCam observations of EELGs using empirical templates based on ~2000 local metal-poor starbursts (MPS) to select EELGs based on color-color criteria. We study their properties based on SED fitting and flux excess in the photometric filters. We consider a delayed-tau model for the star formation history and find EELGs are young with a mean value of the time after the onset of star formation of 93Myr. We find that they have similar line ratios to local MPS with high log([OIII]/Hbeta)>0.4 which indicates that star formation may be the dominant source of ionization. We find an increase of EW([OIII]+Hbeta) with sSFR and SFR surface density, and a decrease with age and stellar mass. The sample of EELGs can reach high SFR surface density and high O32>5 which indicates they may have the conditions to facilitate the escape of ionizing photons.

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Explaining the evolutionary mechanism of JWST's massive quiescent galaxies using cosmic simulations

Dr Harry Chittenden

Centre for Astrophysics & Supercomputing, Swinburne University of Technology

Abstract

The James Webb Space Telescope (JWST) has identified an increasing number of early, massive galaxies which have assembled most of their stellar mass during the epoch of reionisation, and quenched by z~6. This presents a challenge to the widely accepted model of galaxy evolution, in that what should be exceptionally rare primordial galaxies are manifesting in abundance. The use of data from multiple cosmic simulations may explain the distinct evolutionary tracks of candidates for these massive quiescent galaxies and their progenitors.

In this work, I will present the historical properties of massive quiescent galaxies from reionisation-era simulations such as Thesan-1 and Cosmic Dawn III, offering a physical explanation of the primary driving mechanisms of rapid assembly and early quenching. As these rare, massive objects are identified and investigated, a machine learning model will be used to predict the abundance and properties of massive quiescent galaxies in greater volumes.

Comparing these results across simulations may assert whether the formation of these galaxies is sensitive to the chosen subgrid physics, while comparing these formation histories with empirical JWST data may provide valuable insight into addressing the missing abundance of massive quiescents in cosmological models. This work may be used to address any key future amendments to the model of cosmic reionsation.

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Supermassive Black Holes and Galaxies at Early Cosmic Epochs using Cosmological Simulations

Dr. Paramita Barai

INAF - Osservatorio Astronomico di Trieste (Italy)

Abstract

Supermassive Black Holes (SMBHs) at the centers of high-z quasars are observed to have grown to masses >= 10^9 Msun by redshifts z=6-7, when the Universe was only 1 billion years old. Recent JWST observations are additionally revealing the existence of central Intermediate-Mass BHs (masses ~ 10^7 - 10^8 Msun) at even earlier epochs z~10-12. The formation of such early massive central BHs and their interplay with the host galaxies involves unresolved questions. Energy feedback from the accretion of gas onto the central SMBHs is expected to affect the host galaxies and the environment from pc to Mpc scales. The BH feedback is often observed as powerful outflows in some high-z quasars.

I will present results from Cosmological Hydrodynamical Simulations investigating the early growth and feedback from such SMBHs at galaxy centers. These simulations are done with a modified version of the SPH code GADGET-3, and includes sub-resolution prescriptions for the physical processes of cooling, star-formation, chemical evolution, SN and AGN feedback. Especially we have sub-resolution models of thermal and kinetic AGN feedback, and switching between the feedback modes depending on the BH accretion rate. We investigate the growth of early supermassive BHs, as well as their impact on the host galaxies in terms of star formation quenching and the formation of outflows.

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Constraining star cluster formation using multiwavelength observations with JWST and HST

Ms Jianling Tang, Dr Kathryn Grasha, Dr Mark Krumholz

The Australian National University

Abstract

The physical processes that govern the formation and evolution of star clusters are encoded in the distributions of star cluster physical properties, such as their mass and age functions. These functions hint at the physics underlying how star clusters form, evolve, and die. The largest obstacle to measuring these functions from JWST and HST observations is that current analysis methods require us to discard light clusters, which are by far the most numerous, because they are susceptible to luminosity fluctuations due to their small numbers of stars. This talk will introduce a novel method that solves the problem of deriving cluster demographics from integrated light without the need to discard most of the data, yielding the largest and most complete description of star cluster demographics to date, derived from ~10,000 clusters in ~40 galaxies, spanning a wide range of star-forming environments. These results constrain the evolution and dispersion of star clusters and their dependence on properties such as host galaxy star formation rate and surface density. Our method also allows us to probe the initial cluster mass function using clusters so young that they are embedded in dust and only visible in the IR with JWST, a population that may reveal insights into the physics of cluster formation in the early universe and the origins of present-day globular clusters.

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The turbulent teenagehood of disk galaxies

Dr Florent Renaud

Strasbourg Observatory

Abstract

Between cosmic dawn and cosmic noon, fast-evolving external conditions strongly affect the formation and evolution of young galaxies. Processes like reionization and repeated mergers alter the gas phases and the star formation activity, leaving clear signatures on the chemical contents and stellar populations. Internal physics also evolves rapidly at these epochs, with the consumption of gas and the settling of disk(s). JWST has opened a new window on these galaxies, now scrutinized with an impressive level of details. When combined with the power of strong lensing, even the birth of the oldest star clusters can, finally, be probed. Yet, it remains difficult connect this first chapter of galaxy formation, with our understanding of the baryonic cycle from detailed and highly-resolved studies in the local Universe. In this talk, I will use a series of high resolution simulations of disk galaxies (isolated and in cosmological context), to present how theoretical efforts can accompany the results from JWST, and help their interpretation. I will show the cosmic evolution of the regimes of star and galaxy formation, driven by internal and external processes. I will conclude by illustrating how state of the art simulations can be used to propose formation scenarios, testable with the new generation of instruments like JWST.

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Fast forming and fast quenching massive galaxies: challenging galaxy formation models.

Prof Karl Glazebrook

Swinburne

Abstract

In recent years the discovery of massive (>10^11 Msun) quiescent galaxies at z>3 that form and quench and early epochs have led to new questions about our galaxy formation paradigms. How it is possible that galaxies could form so quickly and quench so rapidly in epochs when most galaxies should be minnows? I will review how we got to this point, first with the pioneering ground-based observations and subsequently with beautiful observations from JWST. Answers are not yet in, but an increasing number of more interesting clues are being revealed by ever more precise observations.

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The Discovery of Ancient Relics in an Evolved Galaxy at z~3

Dr. Katherine Whitaker

University of Massachusetts Amherst. Cosmic Dawn Center

Abstract

With the recent discovery of "The Sparkler," JWST has opened up uncharted parameter space in the distant universe: remarkable high resolution views of ancient globular cluster candidates. There exists another fascinating galaxy in the Abell 2744 lensing cluster at even higher redshift that is littered with compact red and blue star-forming complexes - "The Relic". In this talk, I will present the discovery of the Relic, a bright, quenched galaxy at z=2.67, existing merely a few billion years after the Big Bang. These compact star-forming complexes are potential GC candidates, with the red ones consistent with ancient relics, while the blue ones may be caught early in their formation (before possible disruption). Based on a photometric analysis that includes recently acquired ultra-deep medium-band photometry, I will overview the properties of stellar populations within these GC candidates and the impact the timescales marked within these first ancient relics have on bulge formation.

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JWST blue monsters: a glimpse of a polluted future for primordial galaxies?

Dr Laura Sommovigo

Flatiron Institute

Abstract

Over the last few years, the ALMA large programs REBELS and ALPINE, have allowed us to collect the first statistical sample of dusty galaxies around the Epoch of Reionization. Despite these surveys' targets being UV-selected, relatively young z=4-7 galaxies, several are found to be strongly dust-obscured (obscured SFR fraction \sim 90%) and surprisingly dust-rich (Md/Mstar \sim 1e-2). These results lead us to question whether known stellar sources are efficient enough to enrich the very early Universe of metals and dust. On a completely different note, the latest JWST observations are unveiling a growing population of super-early (z>10), relatively massive (Mstar = 1e8-1e9 Msun) and evolved galaxies, which show extremely blue spectra (βUV <−2.6) consistent with little to no dust attenuation. A possible explanation is that rather than being completely dust-free these massive galaxies have a multi-phase, spatially-segregated ISM, where unattenuated UV and IR continuum emission can coexist. We show that for the JWST-selected z>10 galaxy candidates, this spatially-segregated scenario somewhat contrasts with the lack of dust continuum detection where ALMA/NOEMA follow-ups have been attempted. Our favored explanation is that in these z>10 bursty sources, dust is produced but ejected due to radiation pressure shortly after. At later stages, this dust can be re-accreted and grow to produce the large dust budgets measured at z\sim 7.
Future JWST and deep ALMA observations are needed to validate this scenario and clarify whether dust production follows this tormented and cyclical path throughout the first Gyr of life of the Universe.

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Galaxy Relations at High-z with COSMOS-Web

Dr. Jeyhan Kartaltepe

Rochester Institute of Technology

Abstract

COSMOS-Web is the largest contiguous area survey mapped by the James Webb Space Telescope (JWST), covering a contiguous 0.6 deg^2 area with deep NIRCam imaging in four filters (F115W, F150W, F277W, and F444W) and a total 0.2 deg^2 MIRI area in parallel with F770W. We present here first results using the full set of COSMOS-Web imaging, just completed in April, including high redshift galaxy candidates, their masses and star formation histories, and their physical structure.

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Globular Clusters in Nearby to Distant Galaxy Clusters

Dr. Myung Gyoon Lee, Mr. Brian S. Cho

Seoul National University

Abstract

Globular clusters in the nearby universe were formed in the first chapter of our cosmic history, but they show only the current chapter. However, the JWST enables us to see the younger phase of the globular clusters in the distant universe. Galaxy clusters host both galaxy globular clusters and intracluster globular clusters. We present a wide field photometric survey of globular clusters in the nearby to distant galaxy clusters. We discuss the photometric properties of these globular clusters in relation with the structure and assembly history of their host galaxy clusters.

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New insights on the first protoclusters: from JWST to the ELT

Dr. Nicolas Laporte

Aix-Marseille University

Abstract

According to the current paradigm of galaxy formation, the first galaxies likely formed within large dark matter haloes. The fragmentation of these massive haloes led to the formation of galaxy protoclusters, usually composed of one to a few bright objects, surrounded by numerous fainter (and less massive) galaxies. These early structures could have played a major role in reionizing the neutral hydrogen within the first billion years of the Universe, especially if their number density is significant.

Taking advantage of the unprecedented sensitivity reached by the James Webb Space Telescope (JWST), galaxy protoclusters can now be identified and studied in increasing numbers beyond $z \geq 6$. Within the first year of observation, the number of known protoclusters at $z>6$ has strongly increased and spanned a huge range of redshift up to $z=10.6$.

In this talk, I will first describe the properties of a few protoclusters at $z>7$ (and up to $z\sim11$) identified in JWST data and recent spectroscopic follow-up conducted with ground-based telescopes (e.g., VLT and Keck). I will demonstrate that current observational limits will be surpassed by the arrival of ELT instruments, and I will present a case study with the new architecture of MOSAIC/ELT of one of the protocluster identified by JWST.

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Type Ia Supernovae From The First Generation Stars

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Abstract

Type Ia supernovae (SNe Ia) play a decisive role in many astrophysical processes and precision cosmology. SNe Ia discovered at low redshift ($z\lesssim2.5$) are presumed to be produced from the Population (Pop) I/II stars. Whether Pop III stars contribute to the SNe Ia is still being determined. Here, we show Pop III stars may produce a considerable portion of SNe Ia at high redshift, which can be observed by the James Webb Space Telescope (JWST). Assuming the initial stellar mass function (IMF) favors low-mass stars as from recent numerical simulations, we found that at redshift $\gtrsim 6$ SNe Ia from Pop III stars may dominate over those from Pop I/II stars by more than a factor of ~ 10. In an optimistic scenario, we may expect ~ 1 SN Ia event from Pop III stars at $z\approx 3$ and $\sim 4-10$ Pop III SNe Ia up to $z\approx 6$ for a survey area of $300 \;\rm arcmin^2$ and $3\;\rm yr$ survey time for JWST. The same survey may record more than ~ 300 SNe Ia at lower redshift ($z\lesssim 2.5$) with about one of them from Pop III progenitors.

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JWST's resolved view of galaxy formation and feedback in high redshift radio AGN

Dr Kenneth Duncan

University of Edinburgh

Abstract

Since the discovery of the first quasars, radio continuum observations have played a crucial role in the discovery and study of accreting super-massive black holes (SMBHs). With the bulk of SMBH accretion activity in the early Universe obscured by dust, radio continuum observations offer a complementary probe of obscured AGN activity in the earliest stages of cosmic history. Combined with JWST's ground-breaking ability to study resolved galaxy properties deep into the early Universe, these high-redshift radio AGN offer a chance to study the host galaxies of the most massive SMBH without the blinding effects of quasar accretion disks as well as the earliest stages of jet-driven feedback. I will review results from JWST's early observations of luminous high-redshift radio galaxies as well as an offer overview of the future potential for the combination of JWST with the current (MeerKAT, LOFAR, ASKAP) and next generation of deep radio continuum surveys.

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Challenging our understanding of high-redshift galaxy formation with JWST observations and cosmological radiation hydrodynamics simulations

Harley Katz

University of Chicago

Abstract

The insights gained from the first two years of JWST observations at high-redshift have transformed our understanding of early star formation and the interstellar medium (ISM) and challenged our most state-of-the-art models of galaxy formation. Interpreting these results and extracting the underlying physical properties of high-redshift galaxies thus remains a complex theoretical challenge. In this talk, I will first review the successes and failures of the current generation of cosmological radiation hydrodynamics simulations. I will particularly focus on the excess number of bright high-redshift galaxies, observations of extreme gas densities ($>10^5$ cm^{-3}) and temperatures (>25,000 K), galaxies with anomalously high N/O, and the detection of Balmer jumps and two-photon nebular continuum and what these features imply for the high-redshift ISM. Next I will introduce the RAMSES-RTZ code which self-consistently models non-equilibrium primordial, molecular, and metal chemistry coupled to on-the-fly radiative transfer and show how simply moving from idealized 1D photoionization models computed with CLOUDY or MAPPINGS to 3D turbulent H II regions that are representative of the local and high-redshift ISM fundamentally changes emission line ratios that are commonly used to diagnose the ionizing source, ionization parameter, and metallicity (e.g. [N II]/Ha, O32, R3, R2, etc.). Finally, I will present early results from MEGATRON, the first cosmological simulation that couples this new physics to early Universe galaxy formation at parsec-scale resolution and demonstrate how the improved physical modeling based on early JWST results changes our understanding of the early ISM and galaxy formation.

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Galaxy scaling relations at high redshift: insights from JWST+ALMA

Rebecca Bowler

University of Manchester

Abstract

Two years of data from JWST has resulted in the surprising discovery of extremely massive galaxies, very red sources and the increased impact of AGN within the early Universe. To understand the rapid mass and dust build-up of the first galaxies, multi-frequency observations from e.g. ALMA, covering the rest-frame far-infrared (FIR), have a key role to play. I will give an overview of the key scaling relations coming from such data (e.g. the ALMA REBELS large program), as well as recent approaches focusing on solving the open questions of dust temperature, composition and the prevalence of FIR signatures at the highest redshifts. The field is set to be further revolutionised by spatially resolved JWST+ALMA datasets, and I will end by discussing the exciting future prospects for such analyses.

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Unveiling the earliest phases of galaxy formation with JWST

Dr. Paola Santini

INAF - Osservatorio Astronomico di Roma

Abstract

The launch of JWST has opened a new window on the rest-frame optical emission of high-redshift galaxies, enabling robust stellar mass estimates for the first time at early epochs. I will present a sample of z>7 galaxies drawn from all major JWST extragalactic surveys observed so far, and show how scaling relations among their physical properties provide insight into the star formation histories and the physical mechanisms responsible for the evolution of the most distant galaxies.

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The stellar content of NGC 6822 with JWST

Mr Conor Nally[1], Dr Olivia Jones[2]

[1]University of Edinburgh. [2]UKATC

Abstract

We present the NGC 6822 GTO program, first results and combined NIRCam and MIRI CMDs. JWST MIRI and NIRCam imaging observations of the isolated metal-poor galaxy NGC 6822 were obtained in Cycle 1 (GTO Program ID 1234) producing an inventory of star formation and dust life cycles at high resolution. Similar to Spitzer studies of the Magellanic Clouds (SAGE), NGC 6822 is metal-poor ([Fe/H]=-1.2), making it a compelling target for studying stellar evolution as it is thought to have conditions similar to galaxies at the peak star formation epoch in the Universe. For the photometry, we use StarbugII which we developed for complex and crowded fields taken with JWST. With the high sensitivity instruments on JWST, we have deep spatially-resolved photometry of individual sources which are bright in the infrared, reaching 6 magnitudes deeper than any previous IR study of the galaxy. We detect to a depth just above the main sequence turn-off and see clear evidence for multiple aged populations within the post-main sequence stars and young stellar objects. We compare the results to the SMC, enabling us to assess the impact of galaxy interactions on the underlying stellar populations in galaxies whose physical properties resemble those at z=2, the peak star-formation epoch in the Universe.

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Towards a Complete View of Galaxy Build-up at Cosmic Dawn

Pascal Oesch

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Abstract

The first deep images with the James Webb Space Telescope (JWST) have transformed our view of the Universe. With its unparalleled imaging and spectroscopic capabilities, JWST immediately extended our cosmic horizon into uncharted territory, with galaxies confirmed to z~13 and candidates identified out to z~14-16, only ~250-300 Myr after the Big Bang. We are thus at the brink of finding the first galaxies that ended the cosmic Dark Ages and started the reionization of the Universe. Furthermore, JWST finally provides deep rest-frame optical observations to z~10 -- a huge leap from the previous limit at z~3. This finally allows us to select mass-complete samples of galaxies in the first 1 Gyr of cosmic history and measure their redshifts. In this talk, I will provide an overview of what we have learned about early galaxy build-up from the first two years of JWST data. In particular, I will highlight the build-up of the galaxy stellar mass function from z~9 to z~3 based on the first mass complete galaxy samples in different legacy fields. Additionally, I will present results from the public survey FRESCO that exploit JWST's remarkable new spectroscopic capabilities at near-infrared wavelengths. In combination with ancillary, multi-wavelength data, FRESCO overcomes several major limitations in our previous extragalactic census and provides an outstanding multi-wavelength legacy dataset for the community, enabling a wealth of galaxy science across the full cosmic history.

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Insights on the Connection between Ionization Parameter and Gas Density, and the Hardness of the Ionizing Spectra of High-Redshift Galaxies from JWST and Keck Spectroscopy

Naveen Reddy[1], Alice Shapley[2], Michael Topping[3], Ryan Sanders[4]

[1]University of California Riverside. [2]University of California Los Angeles. [3]University of Arizona. [4]University of Kentucky

Abstract

A key goal of JWST is to explore the connection between massive stars and the state of the ISM across cosmic history. I will provide a broad overview of some recent JWST observations of massive stars in the high-redshift universe, and the ionization state of the ISM in typical galaxies at high redshift. I will discuss the dependence of ionization parameter on metallicity and gas density. Recent analyses using Keck and JWST spectroscopy demonstrate the importance of gas density in setting the physical conditions of the ISM at high redshift, and suggest a redshift invariance of the connection between gas density and ionization parameter between redshift z~2 to z~6, and possibly up to z~9. I will further discuss efforts to constrain the hardness of the ionizing spectrum from ground-based rest-UV spectra and multiple rest-optical emission lines newly accessible with JWST. Finally, I will present novel constraints on the dust covering fraction of z~2-4 galaxies using multiple Balmer and Paschen lines detected with JWST.

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Using Neural Networks to detect Dark Star Candidates in the Early Universe

Sayed Shafaat Mahmud, Dr. Cosmin Ilie

Colgate University

Abstract

Dark Stars, hypothesized to have formed during the cosmic dawn era, are unique stellar objects that utilize dark matter annihilation as their primary source of energy against gravitational collapse. These stars can reach immense sizes, and shine as bright as a galaxy. As such, they can be the precursors to the many observed supermassive black holes at high redshift, which remains an open question in Astronomy.

With the advent of the James Webb Space Telescope (JWST), we are now observing photometric data of too many, too massive, galaxy candidates too early in the universe. Motivated by recent findings by Ilie et al. 2023 (PNAS), who identified the first three Supermassive Dark Star (SMDS) candidates, we developed a Neural Network (NN) to automatize finding SMDS candidates. The NN was trained using simulated SMDSs spectra and can identify candidates based on photometric JWST data. In addition to independently re-identifying the first three SMDSs candidates found by Ilie et al. 2023, we detect and discuss several more. Our study presents a novel application of neural networks, and our results demonstrate the potential of neural networks in accurately predicting the crucial parameters associated with Dark Stars. This study contributes to our understanding of early universe astrophysics and aids in the identification of elusive Dark Star candidates, which, in turn, could hold clues to the nature of the Dark Matter particle itself.

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Tracing Outflows from Stellar Feedback in the Early Universe with Lyman-α

Mr James Nianias

The University of Hong Kong

Abstract

Massive galaxies in the early universe must have undergone an especially intense episode of star formation, at which time they would have constituted the brightest Lyman-α sources in the universe – provided the Lyman-α emission is able to escape the galaxy and avoid absorption in the mostly neutral intergalactic medium. Here, we study gravitationally-lensed Lyman-α sources at redshifts up to 6.7 – 0.8 Gyr after the Big Bang – associated with compact and sometimes dim rest-frame UV continuum sources. VLT/MUSE observations show these sources to have Lyman-α line profiles consistent with outflows, but until now the nature of the associated continuum sources has been ambiguous: are we seeing feedback from star-forming regions in high-mass galaxies, or from initial bursts of star formation in low-mass galaxies? By combining rest-frame UV from HST (ACS/WFC) with rest-frame optical observations from JWST (NIRCam) to probe the star formation histories of some of these objects, we are now able to shed light on this question. We find most of these systems to be extremely young, with ages as low as 1 Myr and, crucially, no evidence of underlying older stellar populations. Of these young systems, some have total masses on the order of 10^5 $M_\odot$, comparable to individual globular clusters, and with sizes as small as ~ 10 pc. We consider how to place such objects in the context of hierarchical structure formation in the early universe: are we seeing the births of dwarf galaxies, or perhaps even the formation of progenitor globular clusters?

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Inside-out growth in the early Universe: a core in a vigorously star-forming disc

Mr William Baker

University of Cambridge

Abstract

How do the morphologies of the most distant high-z galaxies evolve? How do they build up mass and structure and what can this tell us about bulge growth, structure formation, and Early-type galaxy formation? These questions are of vital importance to both observations and simulations in understanding feedback process, galaxy quenching and star-formation.

I will address these questions using the JADES survey, the most extensive extragalactic survey with JWST. I will present spatially resolved photometric results for a spectroscopically confirmed, redshift 7.4 galaxy with a compact central core (proto-bulge) and a strongly star-forming disc. I will explore the stellar population properties of these components and show that the radial profile of the specific star formation rate of this galaxy is sharply rising (approximately 1dex within the central 1kpc) implying rapid inside-out growth within the first 700Myrs of the universe's existence. I will also show how, despite being 1000 times less massive than present day elliptical galaxies, the central stellar mass surface density is within 0.2-0.3dex of present day massive ellipticals, and that the expected size evolution of the galaxy would see it, by redshift 2, reaching the quiescent (early-type) population, suggesting it could be a progenitor to these well-studied massive quiescent (early-type) ellipticals.

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Dusty Star-forming galaxy at z=6.8 with deep JWST/NIRSpec and ALMA

Dr Jan Scholtz

Cambridge

Abstract

With the recent discovery of quiescent galaxies at z>3, studying of dusty star-forming galaxies at high redshift became more vital than ever, as they are thought to be precursors of quiescent galaxies. However, until the launch of JWST, studying the rest-frame of optical emission of these sources at redshifts higher than 3 was out of reach of astronomers, often solely relying on the ALMA observations of their FIR emission lines. In this talk, I will present one of the first JWST/NIRSpec IFS data of a massive dusty star-forming galaxy at the Epoch of Reionisation. COS-30 (Smit+18, Witstok+22), is a unique UV bright galaxy (LUV>2 L*) at z~6.8, previously only observed using ALMA ([CII]158 microns, [OIII] 88 microns), VLT X-Shooter (Lyman-alpha). Furthermore, this galaxy has a large amount of dust (log Mdust =7.7 Msol) and an excess of [OIII]88micron emission suggesting that this might be an AGN. In this talk, I will present deep high-resolution JWST/NIRSpec IFS observations of rest-frame UV and optical continuum and emission lines, in combination with deep ALMA [CII] and [OIII]88micron observations and NIRCam photometry. Using the deep and unique NIRSpec IFS (PRISM+R2700) observations, I will show the ISM conditions in this unique galaxy: excitation conditions (extreme star formation or AGN?), metallicity gradient, location of dust obscured (from ALMA high resolution observations) and unobscured star formation. Finally, I will answer the question: What is driving such an extreme production of dust in this galaxy and UV luminosity in this galaxy?

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Unveiling star formation and kinematics of high-redshift galaxies with GEKO

Miss Angelica Lola Danhaive, Dr Sandro Tacchella, Dr Hannah Ubler, Prof Roberto Maiolino

Kavli Institute for Cosmology (Cavendish Laboratory), University of Cambridge

Abstract

Studies of galaxy kinematics at z<3 have painted a picture where most star-forming galaxies exhibit disc-like kinematics that fuel an inside-out growth of galaxies and drive scaling relations between various properties such as star formation rate and metallicity. With the arrival of the James Webb Space Telescope (JWST) and the unprecedented sensitivity and resolution of its Near Infrared Camera (NIRCam), we are now able to push this analysis to higher redshifts well into the Epoch of Reionisation. NIRCam's grism mode yields 2D spectra of every galaxy in the field of view of the instrument, allowing for the study of the emission lines of distant star-forming galaxies on spatially resolved scales. Harnessing this powerful instrument, I have developed a novel tool, GEKO (Grism Emission-line Kinematics tOol), which forward models and fits grism data using Bayesian inference to recover galaxy kinematics and intrinsic emission line maps. In this talk, I will present GEKO and its first applications to Hα and OIII emitters (at redshifts z=5-6.5 and z=7-8 respectively) in the FRESCO survey, showing how the combination of this tool and the large surveys obtained with JWST will allow us to paint the first picture of galaxy kinematics and disc formation at high redshifts. Furthermore, I will present a z=1.62 dusty star forming galaxy found in both FRESCO and the KMOS3D survey to highlight the power of constraining the kinematics of different emission lines to gain a deeper understanding of galaxy properties, such as dust and star formation rate profiles.

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JWST Emission Line Survey: Probing emission-line galaxies into the Epoch of Reionisation

Mr Corey Pirie

Institute for Astronomy, University of Edinburgh

Abstract

The JWST Emission Line Survey (JELS) aims to identify and study ~1000 emission-line selected galaxies across cosmic time using the power of NIRCam narrow-band imaging. Our primary science driver is the detection of ~60 H-alpha emitters out to the Epoch of Reionisation at z>6. The H-alpha emission line is the best-calibrated star-formation indicator in the nearby Universe and narrow-band surveys have mapped the evolution of H-alpha emitters out to the peak star-formation epoch at z~2. At higher redshift, samples of star-forming galaxies and estimates of the star-formation rate density are almost ubiquitously based on rest-UV observations. This single approach carries a high risk of systematic effects, both in the populations of galaxies selected and in their derived properties. In this talk, I shall share results from JELS including the first derived H-alpha luminosity function and star-formation rate density measurement at z>6. In addition, I shall discuss the other science goals of JELS including i) constraining the faint end of the H-alpha luminosity function at cosmic noon, ii) resolving the ionised gas structures of star-forming galaxies at high redshift and iii) determining the relationship between UV and H-alpha emission and how this varies with host galaxy properties, in order to delineate the physical processes driving star formation at these redshifts.

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The chemical abundances of star-forming galaxies at 2 < z < 8 with EXCELS

Dr Fergus Cullen

University of Edinburgh

Abstract

Galaxy chemical abundances are governed by the interplay between star-formation, gas accretion and large-scale gas outflows, and are therefore among the most sensitive probes of the full 'baryon cycle'. Commonly at high redshifts (i.e. z > 1), the gas-phase oxygen abundance is used as a proxy for total metallicity. Now however, thanks to the exquisite sensitivity of JWST/NIRSpec, it is possible to determine multiple element abundances at these redshifts for the first time (e.g. O, N, C, Ne, S). In this talk I will present the EXCELS survey, a 72-hour JWST/NIRSpec program targeting roughly 400 galaxies in the redshift range 2 < z < 8. The majority of EXCELS targets are star-forming galaxies for which we have deep observations of their rest-frame optical spectra enabling, direct temperate-based, abundance estimates. For a subset of the EXCELS sample, deep rest-frame FUV spectra from the VANDELS survey enable measurement of stellar Fe abundances, tracing Type-Ia supernovae enrichment. I will discuss early results on the chemical abundance ratios in high redshift galaxies from EXCELS and present the scaling relation between galaxy metallicities and global physical properties such as stellar mass and star-formation rate.

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1522

Discovery of a recently (mini-)quenched galaxy at z=7.3 and more observational evidence for bursty SFHs in the first billion years

Mr. Tobias Looser

University of Cambridge

Abstract

Directly observing the first quenched galaxies - i.e. galaxies with no or negligible star formation activity at the epoch of observation - and determining the causes which quenched them (perhaps only temporarily), is of utmost importance to constrain models of galaxy formation and transformation. To date, quenched galaxies have been identified out to z<5; and are all found to be massive ($M_\star > 10^{10}$ $M_\odot$). I will present the discovery of an extremely recently (mini-)quenched, post-starburst galaxy at z=7.3. This galaxy exhibits a Lya drop, a Balmer break and complete absence of any emission lines. Its SFH consists of a short and intense burst terminating only 10-40 Myr before the time of observation. Crucially, this galaxy has a stellar mass of only $4–6\times10^{8}$ $M_\odot$. This is a significantly lower stellar mass than any known high-redshift quenched galaxy (redshifts 3<z<5), yet it is much larger than the maximum mass of reionization-quenched dwarf galaxies in simulations. The fact that the galaxy does not have any close companions rules out environmental quenching. This suggests that likely different physical mechanisms were dominantly responsible for quenching this galaxy. This galaxy lies in a pivotal mass range between 'bursty' and stable SFHs, and in which feedback from a primordial black hole or star formation might drive powerful outflows leading to (temporary) quiescence. In addition to this discovery, I will present more observational evidence for an extremely stochastic evolution of high-redshift and low-mass galaxies based on inferred SFHs of ~200 galaxies (0.6<z<11) from deep NIRSpec prism spectra.

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Temporal variability in the HERA observations that pose a challenge to observing light from the early universe

Mr Mekuanint Hailemariam[1], Prof Lerothodi Leeuw[1], Prof Miguel Morales[2], Dr David DeBoer[3]

[1]University of the Western Cape. [2]University of Washington. [3]University of California

Abstract

In an effort to learn about the origin of our universe, new telescopes devoted to studying the early universe are becoming operational. Among these are the James Webb Space Telescope (JWST) and the Hydrogen Epoch of Reionization Array (HERA) in the infrared and radio windows, respectively. Looking for the light from the early universe, the epoch when the very first stars and galaxies formed, is one of James Webb's primary scientific objectives, which is in line with HERA's mission. HERA is a staged experiment designed to characterize our cosmic dawn, the period of time between the formation of the first stars and black holes to the full reionization of the intergalactic medium, using the redshifted 21 cm line of neutral hydrogen. The bright extragalactic foreground emissions dominate the extremely faint 21-cm line emissions. Along with the foreground emissions, the antenna system's systematics makes it challenging to accurately measure the extremely weak signals. The systematics results in high or low power, bad bandpass shape, excess correlation, and temporal structure. To reduce or eliminate the effects and retrieve the original information from the epoch of reionization, the systematics need to be carefully studied. Our goal is to identify the source of the temporal structure and suggest strategies to reduce or eliminate it. We examine the temporal discontinuity and variability metrics to characterize the temporal structure. Furthermore, we use correlation metrics to analyze the temporal structure and investigate its link with two important failure modes: abnormal bandpass shape and high/low power.

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Understanding star formation histories in the early universe : Combining JWST observations, simulations, and SED modeling

Mr Soumyadeep Das

University of Hertfordshire

Abstract

We have combined data from the cosmological simulation suite Feedback in Realistic Environments (FIRE), with the state-of-the-art SED modelling code Prospector to study the star formation histories (SFHs) of high redshift galaxies. Early galaxies often exhibit smaller sizes, irregular morphologies, and 'bursty' SFHs; while at lower redshifts, the galaxy populations are dominated by more massive sources with stable, thin disks and 'regular' SFHs. The influx of JWST NIRSpec and NIRCam data have enabled studies of the transitional phase of these galaxies. Here we explore the minimum wavelength resolution required to reliably infer the spectral features of galaxies in the first gigayear after the Big Bang. We use noiseless spectra of high-redshift galaxy snapshots from FIRE, generated using the radiative transfer code SKIRT, and convolve them to various spectral resolutions: JWST NIRCam and HST photometry, and low- and high-resolution spectroscopy. We fit these datasets with Prospector, leveraging its ability to treat photometry and spectra on an equal footing and to use highly flexible non-parametric SFH models. We contrast the recovered SFHs to the true SFHs. Our preliminary findings highlight the importance of combining photometry and spectra for robustly constraining burstiness at high redshifts. We investigate whether the star formations in supposedly quenched galaxies at z>7 are indeed quenched, or are they simply in a period of low specific star formation. Our work augments the studies attempting to reconcile predictions of star formation and dust production from simulations with JWST observations, therefore advancing our understanding of early galaxy evolution.

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Finding and characterising the first massive quiescent galaxies with JWST EXCELS

Dr Adam Carnall

Edinburgh University

Abstract

I will discuss progress made over the past two years finding and characterising the first massive quiescent galaxies to appear in the Universe, around the end of the first billion years. In particular, I will introduce and present the first results from the JWST EXCELS Cycle 2 NIRSpec survey. I will present the discovery of two massive quiescent galaxies (M_* ~ 10^10.11 M_solar), physically separated by ~900 kpc and embedded within a larger structure at z=4.62. These galaxies were selected from the JWST PRIMER NIRCam imaging survey, and we have obtained high-SNR, medium-resolution 1-5 micron spectroscopy with EXCELS. These observations reveal a full suite of Balmer absorption features, and in one case a substantial 4000AA break, indicating these galaxies have quenched star-formation. We fit the available data to constrain their star-formation histories, showing both formed their stellar mass at z ~ 8 - 10. We consider the SFHs of these galaxies within the Lambda-CDM cosmological framework, concluding that they are right on the edge of what can be accommodated, even assuming 100 per cent efficient conversion of baryons to stars.

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Galaxy Structures from the Perspective of Stellar Mass Distribution within Galaxies

Dr. Moein Mosleh

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Abstract

How stellar mass assembles within galaxies is still an open question. We present measurements of the stellar mass distribution on kiloparsec-scales for ∼5500 galaxies with stellar masses above log(M*) > 9.8 up to redshift 2.0. We create stellar mass maps from Hubble Space Telescope observations by means of the pixel-by-pixel spectral energy distribution fitting method. These maps are used to derive radii encompassing 20%, 50%, and 80% (r20, r50, and r80) of the total stellar mass from the best-fit Sérsic models. The reliability and limitations of the structural parameter measurements are checked extensively using a large sample (∼3000) of simulated galaxies. The size–mass relations and redshift evolution of r20, r50, and r80 are explored for star-forming and quiescent galaxies. At fixed mass, the star-forming galaxies do not show significant changes in their r20, r50, and r80 sizes, indicating self-similar growth. Only above the pivot stellar mass of log(M*) ~ 10.5 does r80 evolve as r80∝ (1+z)^(−0.85±0.20), indicating that mass builds up in the outskirts of these systems (inside-out growth). The Sérsic values also increase for the massive star-forming galaxies toward late cosmic time. Massive quiescent galaxies show stronger size evolution at all radii, in particular, the r20 sizes. For these massive galaxies, Sérsic values remain almost constant since at least z∼1.3, indicating that the strong size evolution is related to the changes in the outer parts of these galaxies.

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Extremely Metal-Poor O Stars in Nearby Galaxies as Analogs of Ionizing Photon Producers in the Early Universe

Grace Telford

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Abstract

JWST is now revealing the low-metallicity galaxies that likely powered cosmic reionization at high redshift. Theory predicts that the winds and ionizing fluxes of their massive, O-type stars significantly diverge from those at higher metallicity, with implications for the contribution of low-mass galaxies to reionization. Yet, our understanding of this complex astrophysics is fundamentally limited because few observations of individual massive stars below 20% solar metallicity (Z_sun) exist to validate stellar models. I will present Hubble Space Telescope FUV spectra of three O stars in nearby dwarf galaxies spanning 3-14% Z_sun. These data reveal that the two most metal-poor stars are both fast rotators driving weak stellar winds, suggesting high ionizing photon production. I will then show Keck/KCWI optical spectroscopy of the HII region that is powered by the only O star in the extremely metal-poor galaxy Leo P. The shape and normalization of the star's ionizing spectrum are encoded by the observed nebular emission lines, providing a novel constraint on a stellar ionizing spectrum at just 3% Z_sun. Finally, I will describe the Treasury of Extremely Metal-Poor O Stars (TEMPOS), a new Large Treasury HST program that is assembling a comprehensive FUV and optical spectral library across O-star parameter space at ~5-10% Z_sun. These observations will provide the community with a much-needed empirical benchmark for the stellar models necessary to analyze feedback and ionizing photon production in early galaxies.

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Where is the floor? Studying the lowest metallicity galaxies with NIRSpec

Prof Michael Maseda, Isaac Laseter, Zach Lewis

University of Wisconsin-Madison

Abstract

Directly observing “PopIII” or zero-metallicity galaxies has long been a goal in our quest to find the first galaxies that formed in the Universe. While the observational signatures are relatively straightforward, namely a spectrum with emission lines solely attributable to ionized H and He with moderate contributions of nebular continuum emission to the rest-UV, these objects have remained elusive even with 2+ years of JWST observations. I will present spectroscopy on the lowest metallicity systems yet confirmed with JWST, including the most extreme Lyman-alpha emitters at M_UV = -15 (0.01 L*) detected with MUSE at z=3-7 as well as a photometrically-selected sample at z=4-9 from the JADES survey. While these objects show significantly lower metallicities than more UV-luminous objects at the same redshifts, we find a consistent metallicity floor at ~2% Zsolar when using updated strong-line calibrations based on [OIII]4363 detections. This indicates rapid chemical enrichment must be taking place in systems with light-weighted ages less than 5 Myr. We characterize these objects according to their specific star formation rate, which highlights the fact that not all galaxies at these extremely low metallicities are currently undergoing intense epochs of star formation - further indication of a cyclical nature to star formation at low masses in the early Universe, with implications for the galaxy mass-metallicity relation at high-z. In sum, while we have identified many plausible methods for selecting low-metallicity galaxies in the early Universe, detecting true “PopIII” galaxies will remain a tantalizing challenge for at least the near future.

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Illuminating the Young Universe with FIRE: What drives the evolution of the cosmic star formation rate density?

Dr. Robert Feldmann

University of Zurich

Abstract

Observations with the James Webb Space Telescope (JWST) have revealed a higher than expected ultraviolet (UV) luminosity density as well as the presence of luminous, massive galaxies already a few hundred million years after the Big Bang. The physical origin of these observational findings is not well understood but possibly related to an increased star formation efficiency at early cosmic times. In this talk, I will introduce FIREbox-HR, a new cosmological hydrodynamical simulation from the Feedback in Realistic Environments (FIRE) project, that offers insights into the star formation efficiency of galaxies during the first billion years of cosmic time. FIREbox-HR re-simulates the cosmic volume of the original FIREbox run with eight times higher mass resolution down to z ~ 6 enabling it to robustly model the abundance of galaxies across a broad range in luminosity (down to M_UV ~ -12), stellar mass, and halo mass during the Epoch of Reionization and late Cosmic Dawn (z ~ 6-15). In contrast to previous theoretical works, the UV luminosity functions and the cosmic UV luminosity density predicted by FIREbox-HR are in excellent agreement with observations out to the highest observed redshifts. Subsequently, I will discuss the implications of this finding for the star formation efficiencies of galaxies during the Epoch of Re-ionization and inferences that can be drawn for even earlier cosmic times. Future observations of UV faint galaxies at z > 12 will provide an opportunity to further test these predictions and deepen our understanding of star formation during Cosmic Dawn.

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1824

Unveiling proto-clusters of galaxies with JWST data

Doctor Stephane Werner

Durham University

Abstract

Galaxy proto-clusters are known to be forming structures at high redshifts and the progenitors of galaxy clusters. The manner in which the proto-cluster environment influences the properties of galaxies and their assembly remains an area of ongoing debate. To understand their evolution over time, it is essential to investigate these structures in their early stages of formation. The James Webb Space Telescope (JWST) capabilities provide valuable data of the high redshift Universe, allowing us to study galaxies that could not be seen before. Furthermore, the gravitational lensing effect caused by foreground clusters can magnify galaxies and together with JWST data can be a powerful tool to detect high redshift overdensities. In this work, we report on the analysis of proto-clusters candidates in SMACSJ0723.3-7327 field, also known as the 'Webb's First Deep Field'. The dynamics of these systems suggest they are considerably massive systems. We also explore how gravitational lensing affects the observed properties of proto-clusters' galaxies, finding that some proto-clusters' members are strongly affected by the presence of the foreground cluster. We also discuss that these proto-clusters in the same line-of-sight can possibly affect background galaxies, so the lensing analysis might go beyond considering only the nearest cluster. This sample can be very useful for future studies on how galaxies evolve in dense environments in the early stages of structure formation.

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Simulating the dynamics, growth and feedback of massive black hole seeds in the high-redshift Universe

Christian Partmann, Thorsten Naab, Natalia Lahen

Max Planck Institute for Astrophysics

Abstract

The origin of massive black holes at high-redshift as detected by JWST is still unclear. With cosmological zoom simulations of the high-redshift Universe as well as idealised galaxy simulations, we explore the dynamics and growth of black hole seeds.

Our solar-mass (~4 solar mass) resolution simulations of galaxy formation and evolution have a resolved three-phase interstellar medium and account for non-equilibrium heating, cooling, and chemistry processes. The stellar initial mass function is fully sampled between 0.08 – 150 star masses while massive stars can form HII regions and explode as resolved supernovae. With an accurate algorithmic regularization scheme, we follow stellar and dark matter orbits around MBHs and their coalescence with PN corrections up to 3.5 order, taking perturbations form the gas phase into account. With our scheme, we automatically resolve dynamical friction and various complex evolution paths of MBHs (sinking of MBHs, formation of binaries, triplets, free-floating MBHs, and dynamical or recoil ejections of MBHs). We model the MBH accretion from the multiphase interstellar medium with a sink particle prescription and include a momentum, energy, and mass-conserving wind feedback.

In my talk, I will present first results from these novel simulations and discuss the relative importance of MBH growth by stellar collisions, gas accretion and MBH mergers in the low mass, high redshift (z>6) progenitors of massive galaxies. I will discuss implications for recent high-redshift observations of massive black holes by JWST.

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Novel Chemical Abundance Measurements with JWST MIRI/MRS

Dr. Noah Rogers[1], Dr. Evan Skillman[2], Dr. Danielle Berg[3], Dr. Rick Pogge[4], Dr. Karla Arellano-Cordova[5]

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Abstract

Gas-phase chemical abundances are powerful tracers of star formation and galactic evolutionary mechanisms. To constrain the overall metallicity of the interstellar medium, many prior galaxy surveys have relied on strong-line abundance diagnostics, which relate the emission of intense optical collisionally-excited lines to the O/H abundance in a nebula. However, these diagnostics have been shown to have large variation and discrepancies when calibrated on empirical or photoionization model data. One alternative is to utilize the IR fine-structure lines, which are insensitive to the electron temperature and reddening, and which accurately probe gas-phase abundances/ionization conditions. We present new JWST MIRI/MRS observations of multiple extragalactic H II regions in the spiral galaxies M33 and M101 with prior direct T_e and abundance measurements from the CHAOS survey. We provide the first empirical calibration of Ne_{23}, a novel MIR abundance diagnostic that can infer O/H in high-metallicity or obscured environments from the MIR Ne fine-structure lines and H I recombination lines. We employ other intense fine-structure emission lines to directly calculate the gas-phase abundance of Ne, S, and Ar from all relevant ionization states. The total abundances of these alpha elements are compared to the optical abundance measurements to assess the validity of ionization correction factors that are commonly adopted for chemical abundance inferences in local and high-z galaxies.

Session

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1860

Formation of galaxies at cosmic dawn by feedback-free starbursts

Dr. Zhaozhou Li[1], Prof. Avishai Dekel[1], Prof. Kartick C. Sarkar[2]

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Abstract

JWST observations indicate a surprising excess of luminous galaxies at z≳10, consistent with an efficient conversion of accreted gas into stars. This is very different from the suppressed star formation by feedbacks at later times, demanding a potential paradigm shift for early galaxy formation. I will show that the high densities and low metallicities at this epoch guarantee a high star-formation efficiency by feedback-free starbursts (FFBs) in the most massive dark-matter haloes. FFBs are expected in high-z massive halos where the gas density exceeds 1e3 cm^-3, with a free-fall time of ≲1 Myr, below the time required for low-metallicity massive stars to develop winds and supernovae. I will discuss the conditions for FFB and the observable predictions for galaxy mass and luminosity functions, sizes, outflows, dust attenuation, etc. Tentative comparisons to early JWST results at high z seem to indicate qualitative agreement with the FFB predictions.

Session

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1866

The origin of unusual chemical abundances from the JWST.

Dyna Ibrahim

University of Hertfordshire

Abstract

To understand the formation and evolution of our Universe, it is crucial to understand how and when the first stars formed. The latest observational data reveal unprecedented information about the chemical enrichment of the early Universe, which seems to behave differently from the local Universe. The first stars, being very massive, enrich their metal-poor environment in an uncertain way. In order to predict the abundances of the first galaxies, we include nucleosynthesis yields from Population III stars up to 300Msun, including faint supernovae, Wolf Rayet and Pair Instability Supernovae into our state-of-the-art hydrodynamical cosmological simulations. Our code (based on Gadget-3) also includes the latest nucleosynthesis yields from population II stars (from Kobayashi et al. 2020) for all stellar mass ranges. We predict the chemical abundance evolution of galaxies for different elements from the early Universe to the local Universe. For example, we find that the N/O abundance gives a systematically larger value with nucleosynthesis yields from Population III stars, which is comparable with observational data of the GN-z11 galaxy. We also discuss the evolution of metallicity gradients and elemental abundances of the intergalactic medium. We constrain our model by comparing it with observational data from the James Web Space Telescope (JWST).

Session

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1886

How Do Galactic Disks Form in the Early Universe?

Dr. Vadim Semenov

Harvard University

Abstract

Early JWST observations have revealed a surprising prevalence of disk galaxies out to the extremely early universe, challenging our current understanding of galaxy formation. Concurrently, recent astrometric and spectroscopic surveys of nearby stars (such as Gaia, H3, APOGEE) provided us with a view of our own Milky Way (MW) assembly, also suggesting that the MW disk formed surprisingly early, within the first 1-2 Gyr of evolution. I will present the results from cosmological galaxy formation simulations (both large-volume IllustrisTNG and dedicated re-simulations zooming in on individual galaxies) where we investigate the formation of galactic disks in the early universe. The formation of galactic disks is strongly correlated with the assembly history of galaxies, with simulated MW analogs assembling their mass early and forming disks out of gas that is relatively metal-poor even for that early epoch. I will also present insights into the physics of disk formation linked with their co-evolution with the co-rotating circumgalactic medium, the co-formation of the hot gaseous halo, and the build-up of the stellar bulge as a result of frequent early mergers. Finally, I will present the results from cosmological zoom-in simulations with detailed modeling of ISM physics, turbulence-regulated star formation, and on-the-fly radiative transfer that highlight both differences and similarities of early galactic disks at the dawn of their formation and nearby star-forming galaxies.

Session

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1908

Shedding Light on the Bright End: Insights from JWST Confirmation of Pure-Parallel Survey Galaxies at z > 8

Dr. Sofía Rojas-Ruiz[1], Dr. Micaela Bagley[2], Dr. Guido Roberts-Borsani[3], Prof. Steven Finkelstein[2], Prof. Tommaso Treu[1], Dr. Pablo Arrabal Haro[4], Dr. Eduardo Bañados[5], Oscar Antonio Chavez Ortiz[2], Katherine Chworowsky[2], Dr. Taylo Alexandra Hutchison[6], Dr. Rebecca Larson[7], Dr. Nicha Leethochawalit[8], Dr. Gene Leung[2], Dr. Charlotte Mason[9], Dr. Takahiro Morishita[10], Prof. Rachael Somerville[11], Prof. Michele Trenti[12], Dr. Aaron Yung[13]

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Abstract

I will be presenting groundbreaking results derived from key JWST observations on some of the brightest galaxies found at redshift z > 8, or within the first ~600 million years after the Big Bang. These galaxies were photometrically selected from the largest Hubble Space Telescope (HST) pure-parallel Brightest of Reionizing Galaxies (BoRG) survey, covering over 200 independent sight lines, thus minimizing cosmic variance. Using these data, we identified an over-abundance of luminous galaxies, in contrast to previous studies imaging single deep fields with HST. One of the significant early surprises of JWST has been the analogous number density of bright galaxies from NIRCam photometric findings in deeper single fields relative to HST. I am able to directly constrain this abundance estimate using JWST NIRSpec spectra and confirm the high-redshift nature of over 50% of BoRG-selected candidates. I constructed the first rest-UV luminosity function at z > 8 built solely from spectroscopically confirmed galaxies from pure-parallel fields to characterize the bright end of the galaxy population. Additionally, I used the spectra to infer the stellar masses and, consequently, the stellar mass function. Understanding the build-up of stellar mass and the role of stochastic bursts of star formation in early galaxy formation is crucial and facilitated by these observations.

Session

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1947

The Technicolor/Mega Science JWST/NIRCam Programs: Probing Early Galaxy Evolution with 30 Space-Based Filters

Professor Adam Muzzin

York University

Abstract

"JWST in Technicolor" and "UNCOVER Mega Science" are two cycle-2 medium programs obtaining deep imaging in all 20 NIRCam medium and wide band filters as well as some narrow bands. In combination with existing deep HST data they have an unprecedented total of 29 and 30 space-based filters, offering us the opportunity to study the spectral energy distributions of large samples of galaxies up to z=10 with unprecedented spectral coverage and photo-z quality. I will present initial results from both projects including a measurement of the abundance of Extreme Emission Line Galaxies (EELGs) at high-redshift. Remarkably, these can be detected to z=10 with [OIII]/Hbeta excesses in the F480M filter. With the medium bands we find that many galaxies that appear to have Balmer breaks in wide band filters instead have strong line emission in a single medium band causing their masses to be overestimated. However, we do detect clear Balmer breaks to as high as z=6, suggesting some old stellar populations at very early times. I will also show examples of EELGs with strong line emission that are undetected in continuum emission. These ultra-faint galaxies have UV luminosities as low at -14 (without lensing), are prevalaent in the Epoch of Reionization, and are likely significant contributors to that process. Lastly, I will show maps of star-formation obtained by subtracting nearby continuum fitlers in 2D. These maps are notably cleaner than those obtained via grism observations demonstrating that medium-band imaging offers an interesting alternative to classic slitless grism programs.

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1956

Firefly Sparkle: Capturing the Assembly of a Milky Way type Galaxy at z=8.3

Lamiya Mowla[1,2], Kartheik Iyer[3], Yoshihisa Asada[4], Guillaume Desprez[5], Vivian Yun Yan Tan[6], Nicholas Martis[7], Ghassan Sarrouh[6], Victoria Strait[8], Roberto Abraham[9], Marusa Bradac[7], Gabe Brammer[8], Adam Muzzin[6], Camilla Pacifici[10], Swara Ravindranath[11], Marcin Sawicki[5], Chris Willott[12], Vince Estrada-Carpenter[5], Nusrath Jahan[13], Gael Noirot[5], Jasleen Matharu[8], Gregor Rihtarsic[7], Johannes Zabl[5]

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Abstract

The most distant galaxies detected by JWST are assembling in a Universe that is less than 5% of its present age. At these times, the progenitors of galaxies like the Milky Way are expected to be about 10,000 times less massive than they are now, with masses quite comparable to that massive globular clusters seen in the local Universe. We will present JWST observations of a galaxy (the 'Firefly Sparkle') at z_{spec}=8.304±0.001, strongly lensed by a massive foreground cluster of galaxies. This galaxy provides an unprecedented case study of a Milky Way-like galaxy in the earliest stages of its assembly in only a 600 million year old Universe. It is a network of at least ten massive star clusters cocooned in a nebulous diffuse arc. The mass distribution seems to be concentrated in the star clusters (~55% of the total mass), with individual cluster masses (M_*~$2x10^5 M_\odot$) straddling the boundary between low-mass galaxies and high-mass globular clusters. The central star cluster shows nebular-dominated spectra consistent with high temperatures (T_e~40,000K) and a top-heavy initial mass function ($0.78<\alpha<2.0$), the product of formation in a very metal poor environment. The Firefly Sparkle resides in an overdense environment of 3 spectroscopically confirmed galaxies, with the closest neighbor 2 kpc away. Combined with abundance matching, this suggests that JWST has captured the earliest stages of the assembly of a galaxy at z~8.3 that exhibits the hallmarks expected of a future Milky Way-type galaxy seen during its most gas-rich stage of formation.

Session

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1974

Inferring the properties of early galaxies from JWST

Joel Leja

Penn State

Abstract

The last two years of JWST have revealed many surprises in the first billion years of the universe: overly bright / massive / old galaxies, luminous and numerous black holes, and a range of complex photoionization conditions. The confluence of new instruments, new galaxy and black hole characteristics, and the (potential) for new emergent physics creates both challenges and opportunities for modeling and learning from these exciting data. I will provide an overview of some of the modeling efforts ongoing in the latest JWST surveys of the early Universe, highlighting the known and unknown physics of these early systems, and the altered methodologies required to extract useful information from the available data.

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1975

J-HIVE: A Machine Learning Interface for Analyzing and Exploring One Million Galaxies from JWST

Dr. Kartheik Iyer[1], Dr. Lamiya Mowla[2], Dr. Mubdi Rahman[3], Jonathan Kemp[2], Julia Sherman[2], Alejandra Rodriguez[2], Eric Ludwig[4], Juan Alfonzo[5]

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Abstract

JWST observations have brought forth a wave of high-impact discoveries that are fundamentally altering our picture of galaxy formation at high redshift. However, these represent only the highest SNR 'tip of the iceberg' in terms of science that can be done with these data, and these analyses are often limited to the most seasoned astronomers equipped with advanced reduction tools. To explore the entirety of JWST's extragalactic treasure trove and lower the barrier to entry, we present a live demo for J-HIVE - a database of morphological and spectral energy distribution (SED) based physical properties of galaxies from all extragalactic imaging fields from its first two years of operation. Using public JWST imaging reduced by the DAWN JWST Archive (DJA), we will eventually include over 1,000,000 sources over 1 degree^2. This will be complemented with an interactive web-based explorer that clusters galaxies by morphological and SED similarity, enabling more efficient parameter exploration, outlier identification, sample selection, and removal of systematics. The J-HIVE explorer will (i) homogeneously identify novel subpopulations, (ii) cross-compare data from different fields to reveal potential systematics and unique galaxy groups, and (iii) refine labels using sparse ancillary data like spectroscopic redshifts to address biases in photometric redshifts. Users can download data cutouts and fits, and conduct analyses via cloud-based notebooks. This initiative promises lasting value for various JWST science endeavors, sets standards for future Roman and Rubin observations, and offers a rich dataset for training and testing machine learning methods.

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1978

Bursty star formation reconciles theoretical predictions and JWST high-z UV luminosity functions

Guochao (Jason) Sun[1], Claude-André Faucher-Giguère[1], Christopher Hayward[2], Xuejian (Jacob) Shen[3,4], Andrew Wetzel[5], Rachel Cochrane[2]

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Abstract

JWST observations have revealed number densities of UV-bright galaxies at z >~ 10 that exceed the predictions of most theoretical models, causing a 'crisis' for theorists. Various potential explanations have been proposed, including extreme solutions such as a top-heavy initial mass function and even deviations from LCDM. I will show that the UV luminosity functions (UVLFs) predicted based on simulations from the Feedback in Realistic Environments (FIRE) project — which are based on pre-launch simulations and were not tuned in any way — are in excellent agreement with those from JWST observations. The reason is that the bursty star formation that naturally arises due to the stellar feedback model implemented in FIRE flattens the bright end of the UVLF. There is thus no need to resort to such extreme applications.

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1979

Lens Finder Maps to Test Claimed Redshifts of Candidate High-z Galaxies

Prof. Jeremy Lim[1], Mr. Alex Chow[1], Prof. Thomas Boradhurst[2]

[1]University of Hong Kong. [2]Ikerbasque Professor

Abstract

Galaxies having photometric redshifts as high as z ~ 20 have been inferred from deep observations toward relatively nearby galaxy clusters with JWST. These observations take advantage of gravitational lensing to boost the brightness of galaxies lying far behind the galaxy cluster: here, we demonstrate how gravitational lensing also can be utilised to test the claimed redshifts of such galaxies. Taking as an example SMACS J0723.3-7327, we construct a lens model for this cluster anchored on five spectroscopically confirmed systems at $1.38 \leq z \leq 2.21$ that are multiply lensed, along with 12 other systems with proposed image counterparts sharing common colors, spectral energy distributions, and morphological features, but having unknown redshifts. Based purely on their image configurations, we solve for the geometrical redshifts of the 12 candidate multiply-lensed galaxies to find that they span $1.4 \lesssim z \lesssim 6.7$. Based on this lens model, we create a lens finder map that defines regions over which galaxies beyond a certain redshift are predicted to be multiply lensed. Applying this map to three galaxies claimed to be at $10 \lesssim z \lesssim 20$, we find no image counterparts at locations (with an uncertainty of ~0".5) where they ought to be sufficiently magnified to be detectable – suggesting instead that these galaxies lie at $z \lesssim 1.7$–3.2. The creation of reliable lens finder maps for more cluster fields is urgently needed to test and constrain redshifts inferred from photometry for a rapidly increasing number of candidate high-z galaxies found with JWST.

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1992

Nature of Extreme Emission-Line Galaxies throughout Cosmic History

Prof. Jeremy Lim, Mr. Keanu Wong

University of Hong Kong

Abstract

Extreme Emission-Line Galaxies (EELGs), which display large equivalent widths as measured primarily in optical emission-lines, are undergoing an especially vigorous episode of star formation. At high redshifts, EELGs may correspond to low-mass galaxies experiencing their first intense episode of star formation; alternatively, some EELGs may be caught during a phase of rapid stellar assembly to form massive galaxies in the early universe. In either case, EELGs may be important contributors to the re-ionisation of the universe. Here, we present a simple and efficient technique to select EELGs from archival broadband images taken by JWST. With this technique, we are able to identify large numbers of EELGs spanning the redshift range $1 \leq z \leq 9$; i.e., as early as just ~0.5 Gyr after the Big Bang. We compare the SEDs of the broadband-selected EELGs to the SEDs of EELGs found through spectroscopic observations to: (i) weed out interlopers; (ii) provide additional confidence on the selection of genuine EELGs at their inferred redshifts; and (iii) categorise the variety of SEDs displayed by all these EELGs. We show that the spectroscopically-selected EELGs have spectra indicative of photoionised gas with a relatively low metallicity, closely resembling the spectra of green pea galaxies in the local universe. We perform SED fitting to determine the stellar mass and probe the star-formation history of the EELGs found. Finally, we compare the luminosity functions of EELGs with those of UV-selected galaxies to better place EELGs among the more general population of star-forming galaxies at different epochs in cosmic history.

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2060

Stacking high-z galaxies' spectra from JWST/NIRSpec to explore the connection between Lyman alpha emission (or absence thereof) and rest-frame UV and optical properties.

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Abstract

Understanding the epoch of reionization is one of the frontier goals of modern astronomy. Lya emission from the high-redhsift galaxies has proved to be a useful tool for probing cosmic reionization. The launch of JWST has enabled the ultraviolet and optical spectroscopic studies of Lya emitters (LAE) in the epoch of reionization. In this contribution, we present the results based on the stacking analysis of JWST/NIRSpec spectra of galaxies taken as part of the JWST GTO program JADES. The samples consist of > 250 galaxies at redshifts of ~ 5-10. We divide the entire samples of >250 galaxies within five different sub-samples of galaxies based on the strengths of Lya emission and redshifts, and create composite spectra. We then estimate physical quantities such as dust-extinction, UV continuum slope beta, electron temperatures, ionization parameter, and escape fraction of Lya and LyC. This analysis shows that LAEs and non-LAEs are significantly different in terms of ionization conditions though their metal content is very similar. There are signatures of stellar He II in z>6.5 LAE, but no He II or CIV detection in non-LAEs. It also appears that the existing dust-extinction laws are not valid at these epochs. The LyC escape fraction for LAEs is higher than the non-LAEs. We interpret these results via comparison with the local galaxies data and theoretical models.

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2144

Cue: A Fast and Flexible Photoionization Emulator for Modeling Nebular Emission Powered By Almost Any Ionizing Source

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Abstract

The complex physics governing nebular emission in galaxies, particularly in the early universe, often defy simple low-dimensional models. This has proven to be a significant barrier in understanding the ionizing sources powering this emission. I will present Cue, a highly flexible nebular emulator trained on Cloudy, designed to interpret nebular continuum and line emission across a wide range of abundances and ionizing conditions of galaxies at different redshifts. Unlike typical nebular models, our model does not require a specific ionizing spectrum as a source, instead approximating the ionizing spectrum with a 4-part piece-wise power-law. This flexibility allows us to either marginalize over or directly measure the incident ionizing radiation, thereby directly interrogating the ionizing source in distant galaxies via their nebular emission. Our emulator demonstrates a high accuracy at the level of 5% and a run time around 6 ms for each prediction. I will demonstrate the use of Cue on a variety of simulated and real JWST data. For example, Cue reproduces the emission lines and ionizing production efficiency of GS-NDG-9422, a peculiar z=6 galaxy with a claimed top-heavy IMF, with an more orthodox ionizing continuum consistent with a combination of normal low-metallicity stellar populations and a low-luminosity AGN. Additionally, I will show the inferences of Cue applied to ~46-hour JWST/NIRSpec spectroscopy of z~2 galaxies (PI: Belli, ID 1810), specifically identifying the dominant ionizing sources in normal galaxies at the cosmic noon - are these consistent with single stars, binary stars, or a mixture of other ionizing sources?

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2152

Detecting the power spectrum turnover with SKAO & other surveys

Mr Yolanda Dube

University of the Western Cape

Abstract

Pathfinder surveys like MeerKLASS and SKAO are poised to explore previously uncharted scales of the universe, offering an unprecedented opportunity to detect features within the power spectra, notably the power spectrum turnover at large scales. This project focuses on assessing the turnover detection capability of these pathfinder surveys and elucidating how the turnover scale can effectively constrain cosmological parameters. Utilizing both Fisher and Markov Chain Monte Carlo (MCMC) methods, we conduct inference analyses to delineate parameter constraints. Our findings demonstrate that SKAO exhibits significantly tighter constraints compared to MeerKLASS.

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JWST NIRCam and NIRSpec/IFU observations of ALMA [OIII] 88 μm observations of galaxies in the reionization epoch

Dr. Takuya Hashimoto

University of Tsukuba

Abstract

Recent ALMA studies have detected rest-frame far-infrared emission lines (e.g., [OIII] 88 μm and [CII] 158 μm) in star-forming galaxies at redshift (z) ~ 6-9 (e.g., Hashimoto et al. 2018 Nature, 557, 392). These observations indicate that [OIII] 88 μm is often brighter than [CII] 158 μm in high-redshift normal star-forming galaxies, which may indicate their high escape fractions of ionizing photons (Ura & Hashimoto et al. 2023, ApJ, 948, 3). To investigate detailed properties of high-z ALMA [OIII] 88 μm emitters, JWST observations were made with NIRCam and NIRSpec IFU (GO-1840, PIs: J. Alvarez-Marquez & T. Hashimoto). In the NIRCam observations, six broad- and/or medium-band filters were used to trace rest-frame UV to optical stellar continuum emission, while NIRSpec IFU (R~2700) observations provide information on rest-frame optical emission lines such as [OII], Hβ, [OIII], Hα. The powerful combination of JWST and ALMA in this project has revealed a matured stellar population in the core region of the most distant protocluster, A274z7p9OD, at z = 7.9 (Hashimoto et al. 2023, ApJL, 955, 2). We also present our results of gas-phase metallicity from a direct-temperature method based on a joint analysis of the optical and far-infrared [OIII] lines, which will form the basis for similar studies combining JWST and ALMA data.

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2270

Co-evolution within a highly star-forming galaxy group at z~3.7 witnessed by JWST/NIRSpec IFS

Dr. Bruno Rodríguez Del Pino

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Abstract

Recent Integral Field Spectroscopic (IFS) observations with the NIRSpec instrument aboard the JWST have revealed a complex interplay of galaxy interactions and internal feedback in a galaxy group at z~3.7. Analyses of the rest-frame optical emission lines have shown a clear gradient of more than 0.2 dex in the gas metallicity from the south to the north-west of the most-massive system, suggesting ongoing accretion of low-metallicity gas from the inter-galactic medium that would be contributing to the mass-assembly of the system. The even higher gas metallicity in the lower-mass companion at the north also indicates that the accretion of low-metallicity gas is favored in the most-massive system, already suggesting a different evolution in the metallicity of satellites and centrals at high redshift. The gas kinematics of the most-massive galaxy are consistent with rotation in a dark-matter dominated system. Moreover, this galaxy is host to a metal-enriched, nuclear ionized outflow that reaches up to ~1.2 kpc and could be contributing to the observed metallicity gradient. This study demonstrates the potential of IFS observations with NIRSpec to shed more light on the formation of galaxy groups and the assembly of stellar mass in the first Gyrs of the Universe.

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2285

Between the Extremes: A JWST Spectroscopic Benchmark for High Redshift Galaxies Using ~500 Confirmed Sources at z>5

Guido Roberts-Borsani[1], Tommaso Treu[2], Alice Shapley[2], Adriano Fontana[3], Marco Castellano[3]

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Abstract

Early JWST spectra have challenged our understanding of high-z galaxy evolution. Whether a number of apparently-exotic objects represent anomalies or typical sources remains an open question, requiring an observational benchmark for interpretation. I will present an ambitious compilation and analysis of 482 confirmed sources at z=5-13 with JWST/NIRSpec, used to construct representative composite spectra stacked as a function of redshift, UV magnitude, and stellar mass, and report on their average properties. The spectra display blue UV continuum slopes characteristic of dust-poor systems, with a steady trend towards bluer values at higher redshift. The trend is mirrored by increasing UV line emission over the same redshift range, indicating a high prevalence CIII] among normal galaxies which are C/O-enriched and show strong ionizing spectra. Similarly, ratios of optical line emission (O32, R23 and Ne3O2) reveal elevated values compared to z~0 galaxies, characteristic of subsolar metallicities with radiation field strengths not found in the local universe. Within our sample we also identify 64 LAEs, which we stack separately to galaxies without Lya emission. The former displays enhanced C III], C IV, and He II UV line emission, bluer UV slopes, inverse Balmer jumps, and enhanced optical line ratios. The intrinsic differences point to higher Lya escape in sources with stronger ionizing fields, younger stars, and more pristine ISMs. These unprecedented templates represent a new benchmark for high redshift studies, serving as a reference point out to the earliest times and allowing more direct comparison of galaxy evolution across cosmic time.

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2286

The youngest sibling of the Milky Way: JWST reveals a barred spiral galaxy at z~3

Dr. Luca Costantin

Centro de Astrobiologia (CAB), CSIC-INTA

Abstract

Understanding the cosmic evolution of the barred galaxy population is fundamental to quantifying their impact on the internal secular evolution of galaxies and dating the formation of the first dynamically cold stellar disks in the Universe. In this context, the new imaging capability provided by JWST is revolutionizing the study of high-redshift disk galaxies, unveiling for the first time their complex morphologies.

In this talk, I will discuss the discovery of ceers-2112, the furthest barred spiral galaxy observed to date, recently published in Nature (Costantin et al. 2023, Nature, 623, 499). Ceers-2112 is located in the EGS field, targeted as part of the CEERS ERS program. The combined analysis of HST/ACS+WFC3 and JWST/NIRCam images place the galaxy at redshift z = 3.03, thus this bar was already formed when the Universe was only 2 Gyr old. The morphological analysis of the stack NIRCam images undoubtedly discloses the presence of a bar component. Considering that stellar bars typically form in 1 Gyr, this discovery proves that mature stellar (and not only gaseous) disks are in place as early as ∼12 Gyrs ago (z ∼ 5), challenging the current understanding of galaxy evolution. I will put in context this discovery in the recent view of disk galaxy formation that is emerging from the first morphological studies of high-redshift galaxies obtained with JWST observations.

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Poster upload

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2297

A merger-driven scenario for clumpy galaxy formation in the epoch of reionization: Physical properties of clumps in the FirstLight simulation

A merger-driven scenario for clumpy galaxy formation in the epoch of reionization: Physical properties of clumps in the FirstLight simulation Yurina Nakazato

The University of Tokyo

Abstract

Recent James Webb Space Telescope (JWST) observations with superb angular resolution have revealed the existence of clumpy galaxies at high redshift through the detection of rest-frame optical emission lines. We use the FirstLight simulation to study the properties of (sub-)galactic clumps that are bright in [OIII]5007Å line with flux greater than ~ 10^{-18} erg s^{-1} cm^{-2}, to be detected by JWST. For 62 simulated galaxies that have stellar masses of (0.5 − 6) × 1010 M⊙ at z = 5, we find clumps in 1828 snapshots in the redshift range z = 9.5 − 5.5. The clumps are identified by the surface density of star formation rate. About one-tenth of the snapshots show the existence of clumpy systems with two or more components. Most of the clumps are formed by mergers and can be characterized by their ages; central clumps dominated by stellar populations older than 50 Myr, and off-centered clumps dominated by younger stellar populations with specific star formation rates of $\sim$ 50 Gyr^{-1}. The latter type of young clumps is formed from gas debris in the tidal tails of major mergers with baryonic mass ratios of $1 \leq q < 4$. The merger-induced clumps are short-lived, and merge within a dynamical time of several tens million years. The number density of the clumpy systems is estimated to be $\sim$ 10–5 $cMpc^{-3}$, which is large enough to be detected in recent JWST surveys. We also discuss the wavelength dependence on the change in the number of clumps by considering dust attenuation.

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2312

Embarking on a Cosmic Odyssey: Deciphering Galaxies' Evolutionary Secrets

Dr Sreeja Kartha, Mr Ujjwal Krishnan, Mr Robin Thomas, Mr Akhil Krishna

CHRIST University, Bangalore

Abstract

The evolutionary trajectory of galaxies is intricately shaped by a combination of mergers, tidal interactions, and secular processes, all of which profoundly influence their star-formation properties and structural dynamics. Hence, star formation emerges as a cornerstone metric for deciphering these evolutionary narratives. Leveraging the UltraViolet Imaging Telescope (UVIT) on-board AstroSat, our investigation zooms into nearby galaxies, scrutinizing star-forming regions with a high angular resolution of ~1.4 arcseconds. Our meticulously curated sample comprises 15 nearby galaxies with UVIT observations, encompassing a diverse array of multiwavelength datasets. This selection encompasses galaxies traversing diverse evolutionary paths, from those undergoing secular transformations to those exhibiting ongoing interaction and in post-interaction phases. Through meticulous analysis of resolved-scale star formation properties within each subgroup, we systematically unravel the intricacies of galactic evolution. Leveraging insights gleaned from MeerKAT observations, we delve deeply into the nuances of the gas-star formation cycle, elucidating the underlying mechanisms governing star formation efficiency at fine spatial scales. Furthermore, the synergistic integration of ALMA and UVIT data uncovers additional layers of complexity, shedding light on the drivers of galaxy evolution. Our investigation extends further with the integration of JWST data, providing crucial insights into the interplay between star formation and polycyclic aromatic hydrocarbon (PAH) molecules. Notably, our JWST study reveals a compelling correlation between heightened star formation activity and the prevalence of smaller ionized PAH molecules. In this presentation, we amalgamate findings from our diverse studies to elucidate the multifaceted factors influencing galaxy evolution, leveraging UVIT data in conjunction with esteemed multiwavelength observatories.

Session

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2392

The Stellar Mass Function in the first 1.5 Gyr of Cosmic History with JWST: Rapid Build-up of Dust-Obscured Giants at z ~ 4 - 5.

Andrea Weibel

Université de Genève

Abstract

With its unprecedented sensitivity at wavelengths from 1 – 5µm, the James Webb Space Telescope (JWST) has opened a new window on the rest-frame optical emission of galaxies at z > 3, enabling us to perform a complete census of the galaxy population at z ∼ 4 – 9. Combining multiple public NIRCam imaging programs, spanning a total area of ∼500 arcmin^2, we compile a sample of >30,000 galaxies at these redshifts.

We measure galaxy stellar mass functions (SMFs) at z ∼ 4 - 9 and show that they are broadly consistent with existing literature results.

However, we find a rapid evolution of the high-mass end of the SMF from z ∼ 5 to z ∼ 4 which is entirely driven by UV-red galaxies that were largely missing from HST-based LBG samples. This points to a rapid build-up of massive dust obscured as well as quiescent galaxies in this redshift range.

The total galaxy mass density grows by a factor ∼25x in the ∼1 Gyr of cosmic time from z ∼ 9 to z ∼ 4. While this growth is slow from z ∼ 9 to z ∼ 7, it speeds up at later times. In particular, the contribution of UV-red galaxies rises steeply, so that they dominate the cosmic stellar mass density above 10^8 solar masses at z ∼ 4.

Our results emphasize the importance of rest-optical selected samples in inferring accurate physical properties and studying the mass build-up of galaxies in the first 1.5 Gyr of cosmic history.

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2403

Exploring High-Redshift AGN and Host Galaxies with JWST: Observational Highlights and Implications

Dr. Masafusa Onoue

Kavli Institute for the physics and mathematics of the universe (Kavli IPMU). The Kavli Institute for Astronomy and Astrophysics (KIAA)

Abstract

The first year of observations with the James Webb Space Telescope has significantly advanced our understanding of the early universe. In this talk, I will provide an overview of the observational results on high-redshift AGN from the initial JWST cycles. Some of the highlights include discovery of Seyfert-class AGN at z>4, both unobscured and obscured, and the successful detection of starlight from host galaxies down to what has been impossible with HST observations. I will then discuss what JWST reveals about the interaction between supermassive black holes and host galaxies, and the connection between AGN activity and massive galaxy formation. I will close by discussing synergies between JWST and upcoming large projects such as Euclid and LSST.

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2415

Divide et Impera: Galaxy Assembly in the Early Universe from NIRSpec/IFU Observations of ALMA/REBELS Galaxies

Dr. Mauro Stefanon

Universitat de Valencia

Abstract

The discovery in JWST data of numerous bright galaxies at Cosmic Dawn, along with the identification of potentially "Universe-breaking" massive galaxies, is reshaping our understanding of galaxy formation, and raise questions about how rapidly galaxies assembled their mass in the early Universe.

In parallel with follow-up studies, significant progress can be achieved by characterizing the brightest and most massive galaxies observed when the universe was ~200-400 million years older, likely the most immediate descendants of the tantalizing objects observed at z>10. In this talk, we will present the first results from a NIRSpec IFU R100 program targeting 12 bright, especially high-mass galaxies at just approximately 750Myr of cosmic time (6.5<z<8.5). Remarkably, this sample also benefits from [CII] and dust continuum estimates from the recent ALMA large program REBELS, making this a unique sample in the panorama of high-redshift studies.

Leveraging the JWST's high spatial and spectral resolution across a broad wavelength range, from the rest-frame UV to rest-frame optical, we can reconstruct spatially-resolved maps of their stellar and gas content. These maps enable us to interpret them in terms of in-situ mass assembly, merger-driven star formation, and star-formation history. We will also provide a brief outlook on their formation histories as inferred from gas-phase metallicities, but will leave most of the discussion to a companion, more in-depth presentation.

These results will ultimately allow us to assess the star formation efficiency in massive galaxies at early epochs.

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Investigating star formation in Illustris TNG galaxy mergers

Andras Peter Joo[1], Bendegúz Koncz[1], Andreas Burkert[2], L. Viktor Tóth[1], István Horváth[3]

[1]Eötvös Loránd University Budapest, Department of Astronomy. [2]Universitäs-Sternwarte, Ludwig-Maximilians-Universität München, Germany. [3]University of Public Service, Budapest

Abstract

Cosmological magneto-hydrodynamical simulations such as IllustrisTNG describe the first chapters of our cosmic history. In our study, we focus on the evolution of the physical and chemical properties of galaxies in a series of mergers. We processed the catalogue data and the merger tree files of the TNG100-1 and the TNG300-1 simulations and investigated the evolution of progenitor galaxies, their merger companions (next progenitor) and their common descendants. We calculated the galaxies' average star formation rate (SFR), metallicity and mass at different redshifts between $0 < z < 15$ and found that the SFR of the descendant galaxies is increasing through the mergers. We traced both the large-scale structure and mass build-up in events involving dwarf galaxies. We reconstructed the observed cosmic star formation rate density variation through a large time interval ($12 > z > 0$) and confronted the model predictions with recent JWST observations. We discuss how the dwarf galaxies influenced the mass increase of galaxies from both observational and computational approaches. Our results show that a high fraction of galaxy mergers is connected to superclusters, especially at lower redshifts.

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Dwarf galaxy mergers: comparing JWST results with the IllustrisTNG simulation

Andras Peter Joo, Bendegúz Koncz, L. Viktor Tóth

Eötvös Loránd University Budapest, Department of Astronomy

Abstract

Numerical simulations play a significant role in understanding galaxy formation and evolution. With the help of these simulations, we can make predictions or compare the results with measurements, to test their capabilities. Galaxy mergers are the main impellent of galaxy evolution, recent studies using JWST data have shown that minor mergers drive the evolution of massive quiescent galaxies with $\log(M/M_{Sun}) > 10.5$ at $0.5 < z < 3$. These galaxies have companions with mass ratios of <1:10, but many progenitors with a median stellar mass ratio of 1:900 represent about 30% of the total mass of the infalling material. With the help of the IllustrisTNG cosmological simulation, we show how the massive quiescent galaxies evolve in cosmic times. We use the merger tree of the TNG300-1 simulation to demonstrate how the dwarf galaxies influenced the mass increase of these galaxies in the early Universe, and we compare our results with the measured JWST data.

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2500

The FENIKS Survey: Spectroscopic Confirmation of Massive Quiescent Galaxies at z > 3

Dr. Jacqueline Antwi-Danso[1,2], Prof. Casey Papovich[3], Prof. Kate Whitaker[2], Prof. Adam Muzzin[4], Prof. Joshua Speagle[1], Dr. David Setton[5], Prof. Danilo Marchesini[6], Prof. Karl Glazebrook[7], Dr. Themiya Nanayakkara[7], Prof. Ivo Labbé[7], Dr. Cemile Marsan[4], Prof. Kim-Vy Tran[8], Yasha Kaushal[9], Dr. Ruben Diaz[10,11], Dr. Taylor Hutchison[12]

[1]University of Toronto. [2]University of Massachusetts, Amherst. [3]Texas A&M University. [4]York University. [5]Princeton University. [6]Tufts University. [7]Swinburne University of Technology. [8]Harvard University. [9]University of Pittsburgh. [10]Gemini Observatory, NSF's NOIRLab. [11]Universidad Nacional de Córdoba. [12]NASA Goddard Space Flight Center

Abstract

The measured ages of massive, quiescent galaxies at $z \sim 3-4$ imply that massive galaxies quench as early as $z \sim 6$. While the number of spectroscopic confirmations of quiescent galaxies at $z < 3$ has increased over the years, there are only a handful at $z > 3.5$. We report spectroscopic redshifts of one secure ($z = 3.757$) and two tentative ($z = 3.336$, $z = 4.673$) massive ($\log(M_*/M_\odot) > 10.3$) quiescent galaxies with 11 hours of Keck/MOSFIRE *K*-band observations. Our candidates were selected from the FENIKS survey, which uses deep Gemini/*Flamingos-2* $K_b K_r$ imaging optimized for increased sensitivity to the characteristic red colors of galaxies at $z > 3$ with strong Balmer/4000 Å breaks. The rest-frame UVJ and $(ugi)_s$ colors of 3/4 quiescent candidates are consistent with 1 − 2 Gyr old stellar populations. This places these galaxies as the oldest objects at these redshifts, and challenges the notion that quiescent galaxies at $z > 3$ are all recently-quenched "post-starburst" galaxies. Our spectroscopy shows that the other quiescent-galaxy candidate is a broad-line AGN ($z = 3.594$) with strong, redshifted Hβ+[O III] emission with a velocity offset > 1000 km/s, indicative of a powerful outflow. The star–formation history of our highest redshift candidate suggests that its progenitor was already in place by $z \sim 7-11$, reaching $\sim 10^{11} M_\odot$ by $z \simeq 10$. These observations reveal the limit of what is possible with deep near-infrared photometry and targeted spectroscopy from the ground and demonstrate that secure spectroscopic confirmation of quiescent galaxies at $z > 4$ is only feasible with *JWST*. I will also present early results from a *JWST*/NIRSpec program targeting abundance indicators in these galaxies.

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[CII]-Selected Sample of Extremely High SFR Sources in the z>6 Universe: First Results from the New CISTERN Program

Dr. Rychard Bouwens

Leiden Observatory

Abstract

One of the most significant surprises in the first year of observations with JWST is the number of luminous and seemingly massive galaxies in the very high-redshift universe. As search efforts with JWST proceed, it is essential to also make use of surveys in the far-IR to identify very massive galaxies in the early universe obscured by dust. One such survey program -- CISTERN -- has just started with ALMA in cycle 10 and systematically targets ~200 of the brightest QSOs+galaxies known in the z>6 universe and searches their neighborhoods for especially high SFR galaxies using the dust-insensitive [CII] line. Already ~50% of the highest SFR galaxies at z>6 have been identified this way, but the samples remain small. By significantly expanding the number of bright sources targeted with ALMA, CISTERN expects to triple existing samples of high-SFR galaxies at z>6. Thanks to the large sample size, pure SFR selection, and insensitivity to dust (superior even to JWST), it should serve as a key z>~6 reference sample. Observations from this program will commence in March 2024 and finish in early May. In my presentation, I will share some of the early results being obtained from this program, contrasting the demographics and likely ISM characteristics of our ~75-source [CII]-selected companion samples from ALMA with parallel efforts with JWST to identify very high SFR sources at z>~6.

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Early galaxy formation and its large-scale effects in the JWST era

Dr Pratika Dayal

University of Groningen

Abstract

Galaxy formation in the first billion years mark a time of great upheaval in our cosmic history: the first sources of light in the Universe, these galaxies ended the 'cosmic dark ages' and produced the first photons that could break apart the hydrogen atoms suffusing all of space starting the process of cosmic reionization. At the forefront of astronomical research, the past few years have seen cutting-edge instruments such as JWST and ALMA provide tantalising glimpses of such galaxies chaotically assembling in an infant Universe. I will show how this data has provided an unprecedented opportunity to pin down the reionization state of the Universe, understand the physical properties of early galaxies, shed light on their dusty nature and study the key physics driving their formation and evolution. Time permitting, I will try to give a flavour of how 21cm emission from the first billion years can provide a powerful testbed for Dark Matter models beyond "Cold Dark Matter".

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Baryons and dark matter in massive galaxies at z=4-5 from the synergy between JWST, ALMA, and VLA.

Dr Federico Lelli

INAF - Arcetri Astrophysical Observatory

Abstract

Galaxy dynamics play a prime role in the formation and evolution of galaxies, being driven by the combined gravitational potential of baryons and dark matter (DM). At early cosmic epochs (z>4), however, the relative distributions of baryons and DM in galaxies are poorly constrained. The TRICEPS survey is investigating with unprecedented details the internal dynamics of 16 massive galaxies at z=4-5, exploiting a unique JWST+ALMA+VLA synergy. JWST imaging from NIRCam and MIRI probe the stellar mass distribution at sub-kpc resolutions, ALMA data of the [CII] line trace the cold gas distribution and kinematics at similar spatial scales, and VLA data of the CO(1-0) line provide the molecular gas mass. The TRICEPS galaxies probe the top end of the star-forming main sequence, having stellar masses between 10^{10}-10^{12} Msun and star-formation rates between 100-5000 Msun/yr. In all TRICEPS galaxies, our ALMA data reveal a regularly rotating [CII] disk, allowing for the derivation of an accurate rotation curve. In most cases, the rotation curves rise steeply at small radii, pointing to a central mass concentration, possibly due to stellar bulges and/or supermassive black holes. At the time of writing, NIRCam and MIRI images have been obtained for four TRICEPS galaxies and the entire galaxy sample will be observed by the end of June. The JWST images are being combined with [CII] and CO(1-0) data to construct full mass models, revealing the nature of the mass concentration at small radii and measuring the DM content at large radii.

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Harnessing JWST-VLT synergy to probe dwarf galaxy outflows at early epochs.

Dr Alice Concas

European Southern Observatory

Abstract

JWST has recently unlocked the ability to measure gas-phase metallicity and the mass-metallicity relation (MZR) in low-stellar-mass galaxies (log(M/M⊙)<10) above z~2. Recent results, obtained from the first JWST cycles, suggest the need for massive momentum-driven outflows and increased metal removal efficiency in high-z dwarfs. These findings align with state-of-the-art cosmological simulations based on the ΛCDM model, where feedback from star formation and/or AGN activity drives large-scale gas outflows that can escape the shallow gravitational potential of low-mass galaxies.

In this talk, I will demonstrate how we can search for direct evidence of ionized gas outflows in the early universe through the kinematics of the ionized gas (traced by Hβ, [OIII], Hα, [NII], and [SII]). This pushes outflow studies down to the extremely low-mass regime, thanks to gravitationally lensed objects. I will first present the results obtained by the KLEVER survey with VLT/KMOS for galaxies at z2, showing that gas outflows are ubiquitous in high-mass AGN-host galaxies but surprisingly uncommon in low-mass ones. Next, I will introduce the GOLDEN (Gas Outflows in Lensed Dwarfs with ERIS and NIRISS) project, which is following up on lensed dwarf galaxies at z3 recently identified by JWST/NIRISS with high-resolution spectroscopy from VLT/ERIS. Finally, I will highlight possible synergies between JWST and ground-based spectroscopy.

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Unbiased UV continuum slopes at 6.5<z<13 from combined PEARLS GTO and public JWST NIRCam imaging

Mr Duncan Austin

University of Manchester

Abstract

In this talk, I will present UV continuum properties from the EPOCHS sample of 1011 high-redshift galaxies spanning 6.5<z<13 across 179 sq arcmin of public and PEARLS GTO NIRCam imaging from JWST Cycle 1. I will show the bias corrected UV beta-MUV relation, from which I find that the MUV=-19 galaxy population becomes extremely blue at z>11. The EPOCHS sample indeed contains a subsample of robust ultra-blue galaxies with beta<-2.8 and high Lyman continuum escape fractions which may be important contributors to the reionization of the Universe at early times. From the EPOCHS beta-stellar mass scaling relation, I find a large population of faint, low mass, red galaxies at 6.5<z<11 and a non-detection of these sources at z>11. The steep slope of beta-stellar mass at z>11 implies that at early times type II SNe are the major dust producers and that low mass <10^8 solar galaxies with smaller gravitational potential wells lose this dust in outflows induced by SNe feedback. Wolf-Rayet (WR) stars are most likely the culprits of the dust produced in low mass galaxies at z=9 since dust production in the winds of AGB stars takes longer than the rapid build up implied by the observed red beta slopes. Using standard IMFs there are too few WR stars around to produce this dust abundance assuming their production rates match those observed in the local Universe, implying that a more top heavy IMF would be required by z=9.

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A detailed look at the structure of 2 < z < 6 quiescent galaxies from rest-frame UV through mid-IR with JWST

Dr Zhiyuan Ji

University of Arizona

Abstract

One of the key revelations of HST was the extremely compact morphology of quiescent galaxies (QGs) at z ~ 2. How the structure of QGs evolves in earlier times remains largely unknown. At z > 2.5, HST is limited to rest-UV (< 4000Å), making the selection of robust QGs and the characterization of their structures very challenging. JWST has opened a new window to view early QGs in exquisite detail. I will present our recent studies of early QGs using ultra-deep, multi-band (>20 filters) NIRCam and MIRI imaging from JADES and SMILES in GOODS-S. These JWST data make the selection of z > 3 QGs highly robust. The unprecedented resolution of JWST imaging, for the first time, allows us to perform detailed analysis of structural properties of early QGs from rest-UV through mid-IR. We find that (1) QGs at z > 3 are extremely compact with stellar mass surface densities > $10^{10} M_{sun}/kpc^2$, (2) from UV to near-IR, early QGs become smaller and more spheroidal, (3) the structure of early QGs is rather complex: characterizing their rest-optical and NIR light distributions usually needs more than one Sersic profiles, (4) the dust emission is required to reproduce the observed mid-IR SEDs of the earliest QGs and, surprisingly, (5) the morphology of QGs is usually more extended in mid-IR than it is at shorter wavelengths. Our studies provide the unprecedented, panchromatic view of the detailed structural properties of high-redshift QGs, demonstrating the revolutionary role that JWST is playing in advancing our understanding of galaxy formation in the early Universe.

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2664

The Chemical Enrichment and Assembly Histories of Massive Quiescent Galaxies over Cosmic Time with JWST

Aliza Beverage

UC Berkeley

Abstract

The existence of a population of massive quiescent galaxies beyond z~2 has spurred questions about how they form so rapidly and what shuts down their star formation so abruptly. Stellar metallicities, ages, and elemental abundance ratios provide crucial insights into galaxies' star formation and assembly histories. Unfortunately, measuring the chemical properties of distant quiescent galaxies has proven to be challenging. Recent ultra-deep spectroscopic surveys have finally opened a new window into studying this population. In this talk, I will present an overview and first results from our JWST Cycle I SUSPENSE program, which acquired ultra-deep spectra of 20 massive quiescent galaxies at z=1-3. Using full-spectrum stellar population fitting, we find that massive quiescent galaxies at higher redshifts have lower [Fe/H], enhanced alpha-abundances, and earlier formation times than today's massive elliptical population, implying short star-formation timescales and rapid quenching by z~4. Such extreme elemental abundances are unlike any that are found at z~0, suggesting that the massive quiescent galaxy population has evolved significantly over the last 11 billion years.

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2703

BoRG-JWST : A Reference Sample of Luminous z>7 Galaxies from Independent Sightlines with NIRSpec Spectroscopy

Guido Roberts-Borsani[1], Tommaso Treu[2], Sofia Rojas[2], Micaela Bagley[3], Takahiro Morishita[4], Steve Finkelstein[3], Michele Trenti[5]

[1]University of Geneva. [2]UCLA. [3]University of Texas, Austin. [4]Caltech/IPAC. [5]University of Melbourne

Abstract

A major finding of early JWST has been the apparent over-abundance of luminous sources at z>9 compared to expectations. The accuracy of those photometric derivations and the characterization of those samples' global properties depends heavily on (i) the area of the sky probed, and (ii) the number of contaminants masquerading as high-z sources – whether such samples and their properties are representative of the general population thus remains to be seen. One alternate strategy is to select samples based on uncorrelated and independent pointings, thus mitigating cosmic variance biases and environmental effects. To this end, I will present first results from the BoRG-JWST survey, the combination of two JWST/NIRSpec Cycle 1 programs aimed at spectroscopically verifying and characterizing >20 luminous sources at z>7 with the prism, selected from over 300 independent HST sightlines with the aim of determining (i) the true abundance of galaxies at the bright-end of the LF, (ii) the underlying stellar and nebular properties of representative samples, and (iii) the true Lya fraction at high redshift from independent measurements. The program is 90% complete, revealing a plethora of high-z confirmations – and the only confirmations of pure-parallel selected Reionization-era sources to date – and 0.6-5.3 micron spectroscopy over >100 additional sources at z~2-4 and z~5 for community science. With complementary observations from ALMA, this unique sample of confirmed high-redshift sources will prove invaluable as a benchmark for deep-field analyses of the global properties and abundances of galaxies in the first billion years of the universe.

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JWST NIRSpec IFU observations of metal-rich, massive galaxies in the Epoch of Reionisation

Lucie Rowland

Leiden Observatory

Abstract

The REBELS (Reionisation Era Bright Emission Line Survey) ALMA large program has obtained, to date, the largest number of [CII] and dust continuum observations of massive galaxies at z~6-8. In this talk, we will present results from a now complete JWST NIRSpec IFU program (GO-1626, PI Stefanon) targeting 12 of these galaxies at 0.6-5.3 um, providing spatially resolved maps of their stellar mass, star formation, metallicity, and ionisation properties. Due to the incredible sensitivity of the NIRSpec prism, all key optical emission lines between [OII] and [SII] are detected for the majority of the sample, enabling metallicity constraints from a range of different calibrations as well as information on the extinction, ionisation parameter and the source of ionisation from traditional BPT diagnostics. One surprising finding of this dataset is the near-solar oxygen abundances for several of these galaxies. The focus of this presentation will be an extension of the mass-metallicity relations at high-z to higher stellar masses, in comparison to the typical galaxies observed in e.g., JADES and CEERS. These relations provide fundamental information on how stellar mass is assembled in galaxies, and how star formation enriches and dilutes the interstellar medium. In addition, robust ALMA dust continuum detections of the same galaxies will enable us to connect spatially resolved metallicity information with dust emission to gain insight into the build-up of dust in the early Universe. This talk will complement a separate presentation of the same data set where the focus will be on resolved star formation histories.

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2719

Leveraging JWST Imagery for Digital Science Communication in Ethiopia

Mr. Lealem Kinfe

Ethiopian Space Science Society

Abstract

The James Webb Space Telescope (JWST) holds the key to unraveling the mysteries of the universe, providing a unique opportunity to ignite public passion for science, especially in Ethiopia. This presentation delves into how JWST's captivating imagery can be harnessed for digital science communication, reaching a broad audience through social media and the internet.

By translating complex astronomical concepts into accessible language and incorporating local cultural contexts, the program aims to cultivate a deeper understanding of the universe's origins and evolution. It aspires to inspire the next generation of Ethiopian scientists and engineers, sparking their fascination with space exploration. Having experience in creating digital and printable materials for science communication, I will use these images to craft an article explaining the pictures and phenomena captured by the JWST for the majority of the population to access easily.

This initiative leverages the power and reach of digital platforms to overcome limitations and reach a wider audience compared to traditional media, which could be prohibitively expensive for science communication due to substantial payments required from broadcasters. Given that a majority of the population now uses social media, presenting science through eye-catching images of the cosmos with JWST, along with a touch of educational content, holds significant potential. The program's success will be measured by increased online engagement, website traffic, and participation in astronomy-related events. This effort not only aims to educate and inspire but also to foster a culture of scientific curiosity and innovation within Ethiopia.

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2722

The production and escape of ionizing photons in the era of JWST

Dr. Anthony Pahl[1], Alice Shapley[2], Michael Topping[3], Charles Steidel[4], Naveen Reddy[5], Yuguang Chen[6], Gwen Rudie[1], Leonardo Clarke[2], Ryan Sanders[7], Gabriel Brammer[8,9], Emily Kehoe[2], Trinity Bento[2]

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Abstract

The ionizing photon production efficiency (xi_ion) and the escape fraction of ionizing radiation (f_esc) are key inputs for reionization models. However, the evolution of these quantities over cosmic time and their relationship with galaxy properties and observables remain open questions. In this talk, I will present a comprehensive analysis of early JWST/NIRSpec spectroscopic galaxy samples to investigate the evolution of xi_ion from z~2-7, a redshift range unexplored in galaxy ensembles prior to the advent of JWST. I will discuss the impact of these early JWST xi_ion measurements on reionization models. In addition, I will summarize our recent findings examining f_esc as a function of galaxy properties at z~3 within the Keck Lyman Continuum Spectroscopic survey (KLCS). Of particular interest is the connection between f_esc and the shape of the Lyman alpha profile. While a strong correlation has been demonstrated at low (z~0.3) redshift, this connection remains untested at high redshift. I will present our analysis of f_esc and Lyman alpha profile shape within the KLCS dataset, highlighting the apparent evolution of these trends compared to those observed at z~0.3. These findings will be discussed in the context of the growing sample of reionization-era galaxies observed with JWST, including those with measurements of Lyman alpha kinematics. It is crucial to consider models of reionization in the context of f_esc analyses at cosmic noon, considering direct f_esc measurements in the epoch of reionization remain impossible even with the observational capabilities of JWST.

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2734

Catching Galaxies Napping with JWST : Stochastic Star Formation Histories in Post-Starburst Galaxies at Redshift > 4

Dr. Gourav Khullar[1], Prof. Rachel Bezanson[1], Dr. David Setton[2], Prof. Michael Gladders[3], Dr. Brian Welch[4], Dr. Taylor Hutchison[4], Dr. Sedona Price[1]

[1]University of Pittsburgh. [2]Princeton University. [3]University of Chicago. [4]NASA Goddard Space Flight Center

Abstract

This talk will lay out the discovery and characterization of mini-quenched (or napping) galaxies at high redshifts, and the characterization of their stochastic star formation histories.

JWST spectroscopic surveys are discovering mini-quenched galaxies when sampling the first billion years of the Universe's evolution. These spectra show a UV upturn, weak Balmer break, and weak or non-existent emission lines, all indicating a lull period in star formation, a recent star formation episode, and significant mass assembly in the past. This channel of mass assembly has serious implications for how compact galaxies at high redshifts form and evolve, and deserves a detailed characterization of global and local properties of stellar populations.

In this talk, I will unpack the physical conditions of the stellar populations in napping/mini-quenched galaxies at z > 4 with the UNCOVER survey (JWST Cycle 1 GO program; PIs: Bezanson, Labbe) using spectrophotometric stellar population synthesis modeling. I will also show our team's work with post-starburst strong gravitationally lensed galaxies (e.g., COOL J1241+2219 at redshift 5, JWST Cycle 1 GO 2566: PI: Khullar), in order to identify old stellar populations and comprehensively characterize local star formation histories with IFU spectroscopy. Finally, I will place these studies in the context of unpacking galaxy assembly in a diversity of mass ranges at high redshifts, especially using samples of gravitationally lensed galaxies.

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2864

I Zw 18: Dust Life Cycle at Very Low Metallicity

Dr. Alec Hirschauer[1], Dr. Nicolas Crouzet[2], Dr. Nolan Habel[3], Dr. Laura Lenkic[3], Mr. Conor Nally[4], Dr. Olivia Jones[5], Mr. Giacomo Bortolini[6], Dr. Martha Boyer[1], Dr. Kay Justtanont[7], Dr. Margaret Meixner[3], Dr. Göran Östlin[6], Dr. Gillian Wright[5]

[1]Space Telescope Science Institute. [2]Leiden Observatory. [3]Jet Propulsion Laboratory. [4]University of Edinburgh. [5]UK Astronomy Technology Centre. [6]Stockholm University. [7]Chalmers University of Technology

Abstract

A James Webb Space Telescope (JWST) imaging survey of I Zw 18, an archetypal extremely metal-poor (XMP), star-forming blue compact dwarf (BCD) galaxy, has been conducted. With a metallicity of only ~3% solar, I Zw 18 is an excellent analog for galaxies at high redshift, including during the epoch of peak star formation. The study aims to understand the origins of dust and dust-production mechanisms in the metal-poor environments typical of the early Universe by characterizing its evolved star population. The JWST data provide a comprehensive infrared (IR) view of I Zw 18, utilizing four filters each of NIRCam and MIRI photometry. The analysis reveals a recent starburst spatially concentrated in the northwest SF region, an intermediate-aged population of oxygen- and carbon-rich AGB stars spatially concentrated in the southeast SF region, and an older underlying population of red supergiant (RSG) stars populating the galaxy's halo. Additionally we detect YSOs which trace the massive star formation taking place in I Zw 18, as well as evidence for a possible recent gravitational interaction with its companion system known as Component C. As I Zw 18 is among the furthest galaxies for which observations with JWST's magnificent spatial resolution are capable of resolving individual stars, these important results set the standard for future stellar populations studies of star-forming systems, including those at XMP levels of enrichment.

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JWST/NIRCam WFSS: Current Status and Prospects as a Powerful Redshift Machine

Dr. Fengwu Sun

University of Arizona

Abstract

I will present an overview of the JWST NIRCam wide-field slitless spectroscopy (WFSS). This observing mode is highly efficient in spectroscopically confirming galaxies in the Epoch of Reionization through rest-frame optical emission lines (e.g., [OIII] and Halpha). In addition to the latest progress in calibration, the following studies will be highlighted in my talk:

1) Discoveries and characterization of galaxy overdensities at z=5-9 in both the GOODS-S/N fields. Coma-progenitor-like galaxy protoclusters are highly abundant when the Universe is only 1 Gyr old, and they host ~50% of cosmic star formation rate density (CSFRD) at this epoch.

2) The prevalence of Damped Lyman-alpha absorption (DLA) among z=7-9 galaxies. With ~200 NIRCam spectroscopic redshifts at z>7, we show that the photo-z's are on average higher than spec-z's by ~0.2, which is exactly caused by the softened Lyman-alpha break attenuated by both neutral IGM and DLA.

3) Spectroscopically complete determination of infrared luminosity function. With ASPIRE JWST (62hrs) + ALMA (100hrs) survey of 25 independent sightlines, we obtained a robust determination of obscured CSFRD at z=4-6 without uncertainty from photometric redshifts or cosmic variance. Our derived obscured CSFRD is 3x higher than those determined with GOODS-S/HUDF ALMA data, which is likely biased low because of strong cosmic variance.

I will also introduce our Cycle-3 treasury programs (COSMOS-3D & SAPPHIRES; ~1000 JWST hours in total) as co-PI / key co-I. These wide-area NIRCam WFSS surveys will open new windows to probe the most massive galaxies and AGN and their environments in the early Universe.

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Modelling the properties of star-forming galaxies at high redshifts

Anirban Chaqkraborty, Tirthankar Roy Choudhury

National Centre for Radio Astrophysics - Tata Institute of Fundamental Research

Abstract

Early JWST observations have indicated an unexpected surplus of UV-bright galaxies at z ≥10, which appears to challenge the predictions of standard galaxy formation models in ΛCDM cosmology at these redshifts. To address this, several cosmological as well as astrophysical interpretations have been advanced. However, these proposed scenarios carry noteworthy consequences for other large-scale processes in the early Universe, particularly cosmic reionization, as high-redshift galaxies are believed to be the primary ionizing sources during the Epoch of Reionization (EoR). To investigate this, we developed a semi-analytical model that explains the galaxy UV luminosity function (UVLF) over 6<z<15, and also jointly tracks the time evolution of the global neutral hydrogen fraction (Q_{HI}) in the IGM. The model self-consistently accounts for the suppression of star-formation in low-mass galaxies due to reionization feedback, and is constrained by comparing theoretical predictions with the new UVLF data from HST and JWST, recent Q_{HI} measurements, and the CMB scattering optical depth. Our analysis shows that a rapid enhancement in the star-formation rate efficiency and/or UV luminosity per stellar mass formed is necessary for consistency with recent JWST UVLF estimates at z ≥ 10. This model aligns well with existing EoR constraints when the escape fraction is assumed to be halo-mass dependent, requiring increased Lyman-continuum leakage from low-mass galaxies. We also examined the relative contribution of galaxies having different luminosities towards the ionizing photon budget. This framework has recently been integrated into semi-numerical simulations, enabling us to investigate the interplay between galaxy evolution and reionization more precisely.

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Observational Benchmarks of Chemical Evolution from Extreme Emission Line Galaxies

Danielle Berg

The University of Texas at Austin

Abstract

The advent of the James Webb Space Telescope has opened our first window onto detailed abundance studies of high redshift ($z > 6$) extreme emission line galaxies. The coming years will provide the first spectroscopic samples of these galaxies in the epoch of reionization with which we can constrain their chemical compositions and histories and resulting conditions that shaped the escape of ionizing photons. As we build our samples of high-ionization nebular emission lines and absorption profiles of outflowing gas, we can begin to understand how the time-dependent nature of elemental production affects our interpretation of different epochs of galaxies and the resulting strung-together evolutionary story. I will present recent observations of the dynamic ISM and the lessons we are learning about chemical evolution, star formation histories, and feedback prescriptions.

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Quasars, LAEs and Ionized Bubbles in Lyman-alpha forest Calibrated Radiative Transfer Simulations of Reionization

Mr Shikhar Asthana[1], Dr. Girish Kulkarni[2], Prof. Martin Haehnelt[1]

[1]University of Cambridge. [2]Tata Institute of Fundamental Research

Abstract

Much of our improved understanding of cosmic reionization is being driven by the wealth of JWST data flooding in as well as rapidly improving radiative transfer simulations. I will present new results from fast GPU-based radiative transfer simulations with the code ATON utilizing the SHERWOOD suite of hydrodynamical simulations. We have augmented ATON to include helium, expand across multiple frequency bins, and simulate the contribution of both galaxies and AGN to the ionizing emissivity for a wide range of reionization histories extending from $z=15-20$ to the end of reionization at $z\approx5$. Our simulations are all calibrated to reproduce the latest Lyman-alpha forest opacity observations. I will focus on examining the morphology of ionized bubbles and its association to LAEs, and the thermal state of the Intergalactic Medium in QSO assisted models of reionization, with a view to interpret JWST observations of reionization-epoch galaxies and AGN.

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Can Active Galactic Nuclei Explain the Overabundance of Highly-Luminous, z>10 Objects Observed by JWST?

Sahil Hegde, Michael Wyatt, Professor Steven Furlanetto

University of California, Los Angeles

Abstract

The first wave of observations with JWST have revealed a striking overabundance of luminous galaxies at early times (z>10) compared to theoretical and empirical models of galaxies calibrated to pre-JWST data. Early JWST observations have also uncovered a large population of supermassive black holes (SMBHs) at z>6. Due to the extended appearance of many of the high-z objects observed thus far, the contribution of active galactic nuclei (AGNs) to the total luminosity has been assumed to be negligible. In this work, using a semi-empirical model for assigning AGNs to galaxies, we show that such active galaxies can be simultaneously consistent with the observed morphology of high-z objects, and provide enough luminosity to solve the overabundance problem. We first demonstrate that low-luminosity AGNs can be hidden in such galaxies and be missed in common morphological analyses, using simulated objects and real observations. This sets an upper bound on the allowed BH luminosities in our model. We then build a semi-empirical model for the AGN+galaxy luminosity function (LF), constructed by connecting dark matter halo masses to galaxy and SMBH masses and luminosities, accounting for dispersion in the mapping between host galaxy and SMBH mass and luminosity. Beginning with a galaxy LF calibrated to low-z data, we demonstrate that reasonable choices for the parameters in our model can both reproduce JWST observations of the UVLF at z=11, 14 and remain consistent with the range of BH luminosities allowed by the morphology.

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Evolving sizes of Lyman-alpha emitters from z~2 to z~6: a JWST and HST comparative study

Dr Ana Paulino-Afonso

Institute of Astrophysics and Space Sciences

Abstract

The James Webb Space Telescope (JWST) has opened new frontiers in understanding the early universe, complementing and extending the legacy of the Hubble Space Telescope (HST). Here, we present a study that explores galaxy evolution by comparing the sizes of Lyman-alpha emitters (LAEs) across the crucial redshift range from z~2 to z~6. Using a comprehensive dataset from the COSMOS field, we analyzed 3045 LAEs with HST to establish a baseline for their compactness, averaging ~1 kpc in size. The addition of JWST observations enriches this analysis, allowing us to trace the size evolution of LAEs during a key period in the universe's history. Our results reveal a consistent compactness in LAEs across UV and optical wavelengths, challenging existing models of early galaxy expansion and evolution. This study not only demonstrates the power of combining JWST and HST data to advance our understanding of the universe's earliest galaxies but also contributes directly to the symposium's aim of exploring the physical and chemical properties of these ancient structures.

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The Emergence of Thin And Thick Disks Across Cosmic History

Dr Takafumi Tsukui[1,2], Dr. Emily Wisnioski[1,2], Prof. Ken Freeman[1,2], Prof. Joss Bland-Hawthorn[1,2]

[1]Australian National University Reserach School of Astronomy and Astrophysics. [2]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D)

Abstract

Archaeological studies of the Milky Way suggest two chemically and geometrically distinct disk components, thin/thick disk. The earliest disk formation may have occurred as early as z~4. The physical origin driving the properties of the two disks and the prevalence of such dichotomy is still an open question, as cosmological simulations suggest that a chemically distinct structure like the Milky Way's is rare. To address these questions, we analysed edge-on disks carefully selected from JWST images from CEERS, JADES, and PRIMER surveys. Measuring the thickness of the disk through the 3D disk modelling, we found that disk thickness has decreased significantly over the recent 5 billion years, after correcting for sample selection bias and observing bands. This result is concordant with ground-based IFU surveys showing a decline in the velocity dispersion of the ionised and molecular gas disks, especially over the last 5 billion years. Furthermore, the majority of galaxies in the past 10 billion years exhibit excess light, which cannot be described with a single disk component and requires a second disk component. We will discuss the thick and thin disk formation throughout cosmic history, linking our results with the kinematical studies of gas disks by recent ALMA, JWST, and ground-based IFU surveys and local studies of the thin/thick disk dichotomy.

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Unraveling Cosmic Dust Origins: JWST Revelations from Supernovae

Dr Melissa Shahbandeh

STScI

Abstract

Dust has seeded the Cosmos with galaxies, stars, and planets since the Universe was young. Despite its critical role, the origins of this cosmic dust have remained shrouded in mystery. AGB stars were originally considered primary candidates for dust production, but large dust reservoirs have been observed to exist before AGB stars had time to produce them. Core-collapse supernovae offer an alternative explanation, but before JWST, we had no instrument with both the sensitivity and wavelength coverage required to test this theory. This presentation focuses on JWST observations of several CCSNe that span from dust precursors formation to massive dust accumulation decades post-explosion. Previously, measurements of molecular dust precursors and dust reservoirs over five years post-explosion have only been achievable for SN 1987A. I will present JWST early spectroscopy of a once-in-a-decade nearby stripped-envelope supernova, 2023dbc, which, remarkably, has captured the emergence of dust precursors CO and SiO and allowed us to uniquely probe the poorly constrained ejecta composition of SESNe (DD-4436, PI: Shahbandeh). I will also discuss late-stage observations of SN 2004et and SN 2017eaw (GO-2666, PI: Fox), all four of which are nearby extragalactic Type IIP SNe. Our MIRI analysis of these two late-stage SNe reveals the highest dust mass observed since SN 1987A. SN 2004et is particularly notable, because its dust reservoirs rival those of SN 1987A, despite being significantly younger. These observations have helped us constrain geometry, origin, and heating mechanism of dust and support the theory that supernovae were key to early Universe dust.

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Inside the bubble: the most distant Lyman-α emitting galaxies reveal early sites of reionization

Dr Joris Witstok

Kavli Institute for Cosmology, University of Cambridge. Cavendish Laboratory, University of Cambridge

Abstract

Unless situated in sufficiently (re)ionised regions, Lyman-α emission from galaxies in the Epoch of Reionization experiences strong absorption by neutral intervening gas. Observations of Lyman-α have therefore been widely used from inferring the sizes of the first ionized 'bubbles' to studying the cosmic evolution of the neutral hydrogen fraction of the intergalactic medium (IGM). In this talk, I will present an overview of the physical properties and environments of the most distant Lyman-α emitting galaxies (LAEs) identified by *JWST*/NIRSpec, up to redshift $z \sim 9$. Around half of the reionization-era LAEs are found to coincide with confirmed large-scale galaxy overdensities, suggesting Lyman-α transmission is strongly enhanced in such overdense regions, and underlining the importance of LAEs as signposts of the first ionised bubbles. We find our sample of faint LAEs and their direct neighbours are generally not able to explain the sizes of the ionised regions required to reconcile the high Lyman-α escape fractions, suggesting lower-luminosity sources likely play an important role in carving out these bubbles. Finally, I will place these findings in the context of strong Lyman-α absorption at the redshift frontier ($z > 9$) far exceeding that expected only by the IGM, which may have a significant impact on the estimation of photometric redshifts. These observations demonstrate the combined power of *JWST* multi-object and slitless spectroscopy in acquiring a unique view of the early stages of galaxy evolution and cosmic reionisation.

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Little Red Enigmas: the origins red galaxies and AGN at high redshift

Prof Ivo Labbe

Swinburne university of technology

Abstract

The first deep imaging observations with JWST have revealed a large number of compact red sources at high redshift previously invisible with HST, Spitzer, and ALMA. For many sources, the JWST imaging observations are ambiguous: some could be very massive galaxies at z>5, implying an unexpectedly rapid channel of early galaxy growth, others could be affected by emission lines or AGN activity. Deep subsequent spectra has revealed a substantial population of galaxies with prominent red continuum and broad line nebular emission ("Little Red Dots"), likely highly obscured AGN. Yet detailed examination of their panchromatic SEDs seems to defy a simple explanation; these are not your garden-variety AGN. Key properties, such as black hole mass and galaxy host stellar mass remain uncertain, frustrating implications for black hole seed scenarios and early massive galaxy growth. I will discuss several examples from the cycle 1 Treasury program UNCOVER and follow up cycle 2 programs and potential ways to better understand this enigmatic population.

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Unlocking the secrets of star formation through LADUMA HI galaxies

Ms Leyya Stockenstroom[1], Dr Jacinta Delhaize[1], Prof Matt Jarvis[2]

[1]University of Cape Town. [2]University of Oxford

Abstract

One of the mysteries of universe is the drop of cosmic star formation density over 2<z<8. Since HI is the raw fuel of star formation, it is importan for us to study how HI mass and Star Formation Rate (SFR) evolves at higher redshifts. Now, thanks to the sensitivity of the MeerKAT telescope, the Looking At the Distant Universe with MeerKAT Array (LADUMA) allows us to detect fainter and more distant HI than was preciously possible. We will present the detection of 21cm emission in ~200 galaxies in LADUMA out to z~0.2, along with a multiwavlength characterisation of the host galaxies. We perform Spectral Energy Distribution (SED) fitting on their extracted photometry and use this to examine the relation between HI mass and star formation history. This paves the way for similar work in the high redshift regime of LADUMA, thus providing a low redshift result for direct and consistent comparison.

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The Magnetic Field Structure of the Large Magellanic Cloud: Insights from Atomic Gas Data and Foreground Emission Separation

Dana Alina[1,2], Jean-Philippe Bernard[3], Ka Ho Yuen[4], Alexander Lazarian[4], Meruyert Iskakova[5], Armanay Mukanova[1], Aruzhan Akimkhan[1]

[1]Nazarbayev University, Astana, Kazakhstan. [2]IRAP, Toulouse University, France. [3]IRAP/CNRS, France. [4]University of Wisconsin-Madison, USA. [5]University of Washington, USA

Abstract

The Large Magellanic Cloud (LMC) is the closest galaxy to the Milky Way and is one of the interesting targets for the analysis of galaxy evolution. Observations of polarized dust emission provide insights about dust properties and plane-of-the-sky magnetic field direction. However, polarization data of external galaxies is altered by the polarized emission of the foreground material.

To separate the polarized signal from the LMC from that of the Milky Way, we used data from the Galactic All-Sky Survey (GASS) to estimate the contribution of the foreground emission. We employed a technique that allows us to probe the interstellar magnetic field via turbulent properties of the atomic gas. We also used atomic gas data to accurately estimate the column density of the gas and to derive the foreground intensity. This allowed us to remove the foreground emission and reveal the outer spiral density structures and central molecular regions of the LMC.

Furthermore, we will discuss how the newly arrived GASKAP data improves the results, offering the potential for more detailed insights into the interstellar medium of the LMC and other galaxies.

Our study demonstrates that neutral hydrogen data is crucial in studies of other galaxies and it provides a coherent view of the atomic and molecular gas in the LMC and sheds light on the properties and magnetic field structure of the LMC. Our results have important implications for our understanding of the formation and evolution of galaxies, and demonstrate the power of multi-wavelength observations in studying the interstellar medium.

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HI View of the Norma Galaxy Cluster with MeerKAT

Mr Koketso MOPHAHLANE[1], Dr Mpati Ramatsoku[1,2], Prof Oleg Smirnov[1,3]

[1]Rhodes University. [2]The Italian National Institute for Astrophysics (INAF). [3]South African Radio Astronomy Observatory (SARAO)

Abstract

We exploit the higher sensitivity of the MeerKAT telescope to probe HI properties of galaxies in the Norma cluster to examine environmental effects responsible for the quenched population in the cluster core. The Norma cluster is an ideal laboratory for this study since it is a rich and massive cluster of nearby galaxies.

The HI data cube used covers a velocity range of 483 - 11,113 km/s, with a noise rms sensitivity of 0.09 mJy/beam and an angular resolution of ~ 14.65'' × 9.28''. A total of 25 reliable HI sources were detected over the entire velocity range. The HI detections reveal two major galaxy overdensities located at v_{rad} ~ 2096-7646 km/s and v_{rad} ~ 10,000 km/s. The first is associated with the Norma cluster gravitational potential and indicates a substructure in its velocity distribution; the other is a population of background galaxies. In this work, the Norma cluster has 13 cluster members detected in HI and 130 galaxies from optical surveys. The spatial distribution of cluster members covers a field that is 2/3 × R_A, where R_A = 2.02 Mpc at cz = 4871 km/s. From the phase-space diagram, 6 galaxies detected in HI are found in the virialised region, while the rest of the detections are infalling for the first time. The results demonstrate that the initial phase of galaxy-ICM interactions might be responsible for morphological transformation and enhanced of star formation activity.

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Spectral Stacking of MHONGOOSE Data - Searching for Neutral Hydrogen Clouds in the Cosmic Web

Simone Veronese

ASTRON. Kapteyn Astronomical Institute

Abstract

The investigation of the large-scale distribution of neutral hydrogen (HI) within the cosmic web is fundamental in comprehending the intricate processes governing galaxy formation and evolution. Evidently, the star formation rate observed throughout cosmic history necessitates galaxies to continually replenish their gas reservoir. Theoretical simulations predict that this replenishment primarily occurs via accretion of pristine gas situated within the Inter Galactic Medium (IGM). Nonetheless, the detection and comprehensive characterization of these HI clouds have proven to be formidable endeavors, due to their faint luminosity, compact nature, and sparse distribution. By applying the spectral stacking technique to data from the MeerKAT Observations of Nearby Galactic Objects: Observing Southern Emitters (MHONGOOSE) survey and to state-of-art cosmological simulations, I found a substantial difference in the amount of neutral gas surrounding the mock galaxies and the observed galaxies. In particular, the gas detected via spectral stacking the cosmological simulations is not found in the MHONGOOSE data, suggesting that simulations overpredict the column density of the neutral medium in the outskirt of galaxies. In the talk I will also focus on the limitation of the stacking technique and the need of deeper observations in order to detect the emission of the pristine gas predicted to fueling the star formation over cosmic time.

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Exploring redshift-space distortions by combining SKAO and DESI spectroscopic surveys.

Mr Simthembile Dlamini

University of the Western Cape

Abstract

Redshift-space distortions (RSD) play a crucial role in the study of large-scale structure formation via the measurement of the growth rate. Future spectroscopic surveys offer a promising opportunity to investigate RSD with unprecedented accuracy. In this talk, I will explore the potential of combining upcoming spectroscopic surveys with the SKA and DESI to improve the precision of the growth rate. Combining these surveys can mitigate cosmic variance and enhance the statistical power of RSD measurements. I will present results from Fisher forecasts demonstrating the potential improvements achievable by combining future spectroscopic surveys. Our analysis reveals enhanced precision in measuring the growth rate of large-scale structures, leading to a deeper understanding of the fundamental properties of gravity.

This talk will draw upon the insights presented in the following paper [1] and will also cover my ongoing work, which is an extension of the paper's findings.

[1] S. Dlamini, S. Jolicoeur, and R. Maartens, Constraining the growth rate on linear scales by combining SKAO and DESI surveys, arXiv:2310.17959.

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The 21-cm forest as a simultaneous probe of the dark and bright of the universe

Dr. Yidong Xu[1], Mr. Yue Shao[2], Prof. Yougang Wang[1], Ms. Wenxiu Yang[1], Prof. Ran Li[1], Prof. Xin Zhang[2], Prof. Xuelei Chen[1]

[1]National Astronomical Observatories, CAS. [2]Northeastern University

Abstract

The nature of dark matter and the first luminous objects of the universe are two of the indomitable urges of human beings. The 21-cm absorption lines from neutral hydrogen in and around galaxies at cosmic dawn, known collectively as the 21-cm forest, are proposed to simultaneously probe the small-scale structures governed by the dark matter particle mass and the early heating history regulated by the formation of first galaxies. By measuring the 1-D power spectrum of the 21-cm forest on high-redshift quasar spectra, the upcoming Square Kilometre Array will be able to shed light on the nature of both the dark matter and the first galaxies.

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Testing dark matter with HI observations of dwarf galaxies

Pavel E. Mancera Piña

Leiden Observatory

Abstract

The nature of dark matter remains a mystery despite the overwhelming evidence of its existence at galactic scales and its relevance for structure formation in the Universe. Obtaining observational constraints on the properties of dark matter has been one of the most urgent subjects in astrophysics for about a century. The nature of dark matter can be constrained by tracing its distribution within galaxies, as this will differ depending on the dark matter properties. Studying gas-rich dwarf galaxies is a powerful tool to this end. The gas reservoirs of these systems allow us to trace their kinematics on a robust observational basis and out to large distances from their centres. This, coupled with the relatively low baryonic densities, put us in a position to study the signature of the dark matter haloes on the overall galaxies' dynamics and compare the data against theoretical expectations.

In this talk, I will present an overview of recent efforts to test the nature of dark matter using gas (HI) observations of dwarf galaxies. In particular, I will show the comparison between accurate rotation curves of a set of nearby gas-rich dwarf galaxies and the predictions from three of the leading dark matter candidates: cold dark matter, self-interacting dark matter, and fuzzy dark matter.

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The Neutral Hydrogen in and Around Gas-rich Early-type Galaxies at High Resolution

Ms. Krislyn Sourivong[1], Ms. Debra Durham[1], Dr. Danielle Lucero[1], Dr. Lisa Young[2], Mr. Tim Proudkii[3], Mr. Jimmy O'Hara[1]

[1]Virginia Polytechnic Institute and State University. [2]University of Illinois Urbana-Champagne. [3]California Institute of Technology

Abstract

We present new high resolution (5”-11”, ~1-2.1 kpc at an average distance of 40 Mpc; D+C+B) JVLA imaging of the HI in and around 21 gas-rich early-type galaxies. These observations were carried out as part of an ongoing project which aims to use high resolution HI and CO (as a proxy for H_2) imaging of a sample of 35 gas-rich early-type galaxies to stress-test empirical and theoretical models of molecule formation. We find that the HI in early-types tends to be low surface density (<5 Msol/pc^2; with a few exceptions). However, in many cases unresolved higher density clumps are detected within the radius where molecular gas is observed. The targets have a wide range of HI morphology (rings, disks, tidal tails). The new HI data comprises the highest resolution HI data for a large sample of early-type galaxies to date. Since this type of data is not currently available for a large number of early-type galaxies, the dataset will have a legacy value for the community as well. We intend to release these images to the astronomical community in the near future. Ideally, to do a proper analysis of the HI-H_2 transition in early-type galaxies one would want (1) matching resolution HI and CO imaging and (2) imaging at sub-kiloparsec (GMC scales). Although it is possible to achieve the second criteria with ALMA, to observe the HI at sub-kiloparsec scales for a large sample of early-type galaxies will only be feasible with SKA phase one and beyond.

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Connecting HI to multiphase ISM at all redshifts

Dr Celine Peroux

European Southern Observatory, Germany

Abstract

These are incredibly exciting times for extra-galactic astrophysics; above all for studies of galaxy formation and growth of structure. New observatories and advanced simulations are revolutionising our understanding of the cycling of matter into, through, and out of galaxies. In this talk I will first provide an overview of the cosmic evolution of cold gas and future propects with both SKA-pathfinders and the full array itself. I will then focus on the relation of atomic gas HI to the multiphase interstellar and circumgalactic media on galactic scales. Together, these results provide an increasingly accurate description of the baryon cycle which plays many crucial roles in transforming the bare pristine Universe left after the Big Bang into the rich and diverse Universe in which we live today.

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Using LADUMA to study the dark matter properties of galaxies

Mr Craig Smith

University of the Western Cape

Abstract

The LADUMA survey will directly detect many galaxies in HI line emission, many of which will be observed with an HI interferometer for the first time. The project aims to dynamically model two particularly interesting LADUMA galaxies. The HI total intensity maps show the galaxies to have very interesting morphologies. However, their HI velocity fields suggest their kinematics to be rotation-dominated. The HI data cubes will be used to generate 3D tilted-ring models of these galaxies in order to measure their rotation curves. Accurate rotation curves will allow us to generate the first mass models of these galaxies in order to constrain the properties of their dark matter. Basic data products that have been generated from the HI data cubes are presented here, as well as a measure of the rotation curves for these galaxies.

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Connecting HI to multiphase ISM and feedback in simulations

Prof Romeel Dave

University of Edinburgh. University of the Western Cape

Abstract

Galaxy formation is driven by a complex interplay between galactic inflows and outflows known as the baryon cycle. Emerging HI data provides a unique tracer of these poorly-understood processes, but only yield a glimpse into particular stages of the baryon cycle. Galaxy formation simulations are an invaluable complement to contextualize HI data together with other multi-wavelength tracers within a hierarchical structure formation scenario. I will discuss recent efforts towards understanding the role of HI from the ISM to the CGM and beyond using state-of-the-art simulations, and how new HI data is already providing novel and stringent constraints on the processes moving gas in and out of galaxies. I will particularly focus on the role of SKA precursors such as MeerKAT in elucidating the nature and origin of HI in a variety of cosmic environments.

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The star formation histories of galaxies in different stages of pre-processing in the Fornax A group

Ilani Loubser

Centre for Space Research, North-West University

Abstract

The Fornax A group, on the outskirts of the Fornax cluster, is an ideal system to study pre-processing and quenching in group environments. To constrain quenching time-scales, we need to probe the stellar populations of galaxies and devise parameters that can describe the specific Star Formation Rate (sSFR) of a given galaxy over different time-scales. This allows a view into the change in the SFR.

We study the recent star formation histories of 10 galaxies in the Fornax A galaxy group. The galaxies are gas-rich, and their neutral atomic hydrogen (HI) was studied in detail with observations from the MeerKAT telescope. This allowed them to be classified into different stages of pre-processing (early, ongoing, advanced). We use long-slit spectra obtained with the South African Large Telescope (SALT) to analyse stellar population indicators to constrain quenching time-scales and to compare these to the HI gas content of the galaxies. The Hα equivalent width, EW(Hα), suggest that the pre-processing stage is closely related to the recent (<10 Myr) sSFR. Our results suggest that only three galaxies underwent significantly different histories from secular evolution during the last Gyr. The fact that most galaxies are on the secular evolution sequence implies that pre-processing has a negligible effect on these galaxies compared to secular evolution. We find EW(Hα) to be a useful tool for classifying the stage of pre-processing in group galaxies. The recent sSFR and HI morphology show that galaxies in the Fornax A vicinity are pre-processing from the outside in.

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Simulations of SKA observations of radio continuum and HI 21-cm line emission from M51 analogs

Dr Masoumeh Ghasemi Nodehi[1], Dr Fatemeh Tabatabaei[2,3,4], Dr Elizabeth A. K. Adams[5,6], Dr Mark Sargent[7,8]

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Abstract

Galactic gas contains atomic hydrogen (HI), which is crucial to numerous astrophysical phenomena. Studying the HI atomic gas in and around galaxies is very important to investigate the physical conditions under which massive star formation is quenched throughout cosmic time and to examine the feeding and feedback scenario in the conventional models of galaxy history. The first practical chance to investigate the unexplored field of HI in higher redshift galaxies is provided by sensitive SKA measurements. We model the HI maps of high-z galaxies whose SFR and current HI emission properties resemble those of neighboring galaxies like M51. In order to explore the possibilities of suggested surveys for mapping HI at high-z in this galaxy, the simulations utilize SKA configurations and sensitivities. Furthermore, throughout the redshift range of $0.15 < z < 3$, the study also models the evolution of thermal and non-thermal radio continuum (RC) emission on kpc scales. This study aims to investigate: a) the thermal and non-thermal emission structures on kpc scales; b) the evolution of the synchrotron spectrum and thermal portion at mid-radio frequencies; and c) the detection capacity of RC emitting structures using the SKA1-MID reference survey.

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Radial motions and radial gas flows in local spiral galaxies

Enrico Di Teodoro[1], Josh Peek[2]

[1]University of Florence. [2]Space Telescope Science Institute

Abstract

Disk galaxies need to accrete fresh gas from the environment to sustain their star formation. Numerical simulations predict that most accretion comes the intergalactic medium and that should induce strong radial flows in the gaseous disk. To test this scenario, we determined radial velocities and mass flow rates in a sample of 54 local spiral galaxies by modelling high-resolution and high-sensitivity data of the atomic hydrogen emission line. We found that, although radial inflow motions seem to be slightly preferred over outflow motions, their magnitude is generally small. Most galaxies show radial flows of only a few km/s throughout their HI disks, either inwards or outwards, without any clear increase in magnitude in the outermost regions, as we would expect for continuous radial accretion. Over the entire sample, we estimated an average inflow rate of only 0.1 Msun/yr in the outskirts of the Hi disks, which is about 10 times smaller than the average star formation rate of 1.4 Msun/yr. Our study suggests that there is no clear evidence for systematic radial accretion inflows that alone could feed and sustain the star formation process in the inner regions of local spiral galaxies at its current rate, leaving open the gas accretion puzzle. New high-sensitivity and high-resolution HI data from the SKA pathfinders over the next years will be pivotal to solve this puzzle.

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Mass Modelling of galaxies Over a Billion Years of Cosmic Time

Yara Simango[1,2], Dr. Natasha Maddox[1], Prof. Daniel Pisano[3]

[1]University of Bristol. [2]University of Cape Town. [3]University of CapeTown

Abstract

Galaxies require a large supply of hydrogen gas to maintain their star formation rates. How this gas is distributed and how it is accreted onto galaxies is one of the most fundamental, but unanswered questions in galaxy evolution. Observational data of the galaxy NGC 45 provided by the IMAGINE survey are used to quantify the mass, structure and column density distribution of HI gas in and around the galaxy. The main objective was to examine the dependence of the HI gas properties on environmental characteristics to determine the conditions driving the existence of this extended material. The IMAGINE observations were taken with the Australia Telescope Compact Array (ATCA) and are sensitive enough to yield clues on gas flows in and out disk, and accretion from the intergalactic medium. Infrared data from WISE photometry also available for NGC 45 give details about the stellar mass component of the galaxy. Then mass modelling is performed using 3D Barolo software to determine the galaxy compositions separated into stellar, gaseous and dark matter components. The results from this low redshift well resolved galaxy will then be used to move to more distant and unresolved galaxies, such as those that will be observed by SKA and precursor telescopes, to investigate the effect of spatial resolution and cosmic time on the mass modelling results.

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HI probing the environments surrounding FRB host galaxies

Dr Karen Lee-Waddell

Australian SKA Regional Centre

Abstract

Fast radio bursts (FRBs) are tantalising mysteries as they are particularly peculiar astronomical events arising from unknown origins. As more FRBs are detected and localised to host galaxies, we are starting to constrain the environments that could trigger these millisecond pulses. Several FRBs have been localised to extragalactic systems that are close enough for neutral hydrogen (HI) observations and further detailed analysis. I will present recent results for nearby, non-repeating FRB host galaxies. In most systems, there are clear indications of on-going tidal interactions, in agreement with leading theories that environments with enhanced stellar activity may be the mechanism behind the formation of FRB progenitors. Nevertheless, there is at least one system -- in which the FRB was detected during Widefield ASKAP L-band Legacy All-sky *untargeted* surveY (WALLABY) observations -- where the host galaxy appears undisturbed and is relatively isolated.

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HI galaxies behind the outer Galaxy detected by FAST

Dr. Tao Hong, Prof. Jinlin Han, Mr. Weicong Jing

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

Detection of HI galaxies in the Zone of Avoidance (ZoA) behind the Galactic disk can improve our understanding of the dynamics in the local Universe. Sensitive observations can detect faint HI galaxies, which are key for determination of the HI mass function (HIMF) at the fainter end. In this talk, we present the results of a pilot survey for the extragalactic HI galaxies from the piggyback spectral data of the Galactic Plane Pulsar Snapshot (GPPS) survey by using the Five-hundred-meter Aperture Spherical radio Telescope (FAST). With an integration time of 5 minutes, together with the sensitive 19-beam L-band receivers, the FAST line survey reaches a sensitivity of 0.42 mJy at the velocity resolution of 6.4 km s^{-1}, for spectral lines. More than 1000 HI galaxies are detected in the region of 150° < l < 200° and -1.5° < b < 1.5°, the farthest galaxy lies at the redshift of z = 0.087. The ongoing FAST GPPS survey will provide much more new HI galaxies in the ZoA even though their optical and near-infrared counterparts may not be available.

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New lessons revealed by wide-field HI surveys

Prof Jing Wang

Kavli Institute for Astronomy and Astrophysics, Peking University

Abstract

Wide-field HI surveys conducted in the past five years have revealed exciting new perspectives on the role of HI in galaxy formation.

The WALLABY (pre-)pilot survey captures snapshots of first-time-infall, HI-rich galaxies evolving within massive groups and clusters. These snapshots offer contiguous imaging with moderate resolution, providing valuable insights into galaxy evolution within these environments. We are able to statistically characterize the shrinking of HI disks due to different detailed physical mechanisms. Distinct environments including the Eridanus, Hydra, and NGC 4631 group (>30 sq deg each in fov) facilitate extensive testing of our methodology and coherent scenario setup. Beyond these local-universe environments, the blind survey (~400 sq deg in total) allows statistically analysis of SFR-HI relation of individual galaxies in close galaxy pairs.

Leveraging the existing ALFALFA dataset, new scaling relations between HI mass, stellar mass, halo mass, and SFR have been revealed using stacking methods. These relations constrain galaxy evolution models, providing insights into the interplay between these key galactic properties.

Going deeper with FAST in the regions previously partly surveyed by ALFALFA has uncovered new tidal structures and diffuse HI, suggesting more active interaction between galaxies and their gravitational and gaseous environment than previously thought.

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MeerKAT UHF intensity mapping survey

Dr Wenkai Hu

University of the Western Cape

Abstract

As a prevalent and widely distributed component of galactic gas, neutral atomic hydrogen (HI) plays a crucial role in comprehending various astrophysical processes, including star formation histories, galaxy interactions, and the tracing of cosmic large-scale structures. However, the sensitivity limitations of telescopes pose challenges to directly measuring line signals from distant individual galaxies, particularly at low redshifts. This limitation can be overcome by employing Line intensity mapping, thereby extending the survey capabilities to higher redshifts.Over the past two years, significant progress has been made in the detection of the HI cross-correlation power spectrum through the HI intensity mapping survey utilizing the L-band receiver of MeerKAT in single-dish mode. Additionally, the detection of the small-scale HI auto-correlation power spectrum has been achieved using MeerKAT in interferometric mode. To further our understanding of the HI power spectrum on large scales and to facilitate the measurement of large-scale structure, we initiated an HI intensity mapping survey employing the UHF-band receiver of MeerKAT in single-dish mode starting in late 2022.In this presentation, I will outline our efforts to glean scientific insights through the processing of the MeerKAT UHF intensity mapping data. I will delve into the advancements achieved in the new MeerKAT LIM project, shedding light on the progress and implications of our research endeavours.

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Exploring Circumgalactic Gas with WALLABY

Professor Lister Staveley-Smith

ICRAR/UWA

Abstract

The WALLABY survey has commenced its goal of mapping extragalactic neutral hydrogen (HI) across 14,000 sq degrees of the southern sky to a redshift depth of z=0.1. We showcase some of the most recent results, including insights into the large-scale HI environment of nearby galaxies and groups. We show an example of the interplay of ram pressure and tidal forces in the peripheries of large groups and dynamically young clusters, and note the implications for galaxy evolution. WALLABY will be an important starting point for deep targeted observations with the SKA. It also has important synergies with large-area multi-wavelength surveys such as 4HS, DELVE, HSC, WAVES. In the molecular bands, large ALMA surveys of WALLABY targets will also lead to improved understanding of the baryon cycle.

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Probing for optical and HI diffuse gas in MHONGOOSE galaxy UGCA 250

Mr Mikhail de Villiers

University of Cape Town. South African Astronomical Observatory

Abstract

MHONGOOSE is an HI Nearby Galaxies Legacy Survey of MeerKAT probing the HI in and around local disk galaxies with an unprecedented combination of high spatial resolution and sensitivity. It will deepen our understanding of the relation between gas and star formation, the baryon cycle, as well as the relation between the distribution of dark and baryonic matter within these galaxies. UGCA 250 is an edge-on, late-type spiral (Sd) galaxy part of this survey. This work looks for signatures of extraplanar gas associated with this galaxy with the aims of characterising the kinematics of the disk as well as its extensive gaseous layers. This is achieved due to the ability of MeerKAT to probe the innermost regions as well as the most extended regions associated with this galaxy. We perform kinematic analysis on the full depth MHONGOOSE radio cube using tilted-ring modelling and Gaussian decomposition. This is supplemented with high-resolution RSS longslit data from SALT, allowing for the detection of extraplanar gas in both its neutral and ionised states. We find interesting kinematics in both the optical, which involves gas and stellar kinematics, and the radio.
The end result is a multi-wavelength characterisation of the gas associated with this galaxy. Thus, we probe for multi-phase planar and extraplanar diffuse gas associated with this galaxy. This work illustrates how sensitive HI observations with MeerKAT can be combined with high-resolution spectroscopic SALT data to achieve a complete kinematic study of a nearby galaxy.

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Exploring the young stellar objects within the "Arclike" molecular cloud in the Vel OB1 association

Ms. Anahit Samsonyan, Dr. Yelena Nikoghosyan, Dr. Naira Azatyan, Mr. Derenik Andreasyan

Byurakan Astrophysical Observatory

Abstract

Star formation regions nestled within molecular clouds are fascinating astronomical objects that play a crucial role in the formation and evolution of stars in our galaxy and beyond. These regions are typically characterized by the presence of dense and cold interstellar medium and and harbor a diverse population of young stellar objects (YSOs) at various stages of evolution, which are the objective of active investigations. As a rule, the identification of young stars is based on their one of the main observational signs, namely, infrared excess.

The main purpose of our research is to study and determine the principal characteristics of young stellar population within the "Arclike" molecular cloud, including mass, evolutionary age and age spread, spatial distribution, luminosity and mass functions. We used near-, mid-, and far-infrared photometric data to identify and classify the YSOs. Their main parameters were determined by the radiation transfer models. We assume that the "Arclike" structure was created from the shock wave of the supernova explosion about 2-2.5 Myr ago, which causes the formation of star-forming knots around two IRAS sources, 08546-4254 and 08563-4225. Additionally, we constructed a colour-magnitude diagram and K-band luminosity functions to compare the parameters of stellar objects with the results of the radiative transfer models. The cluster around IRAS 08546-4254 associated with the RCW34 HII region. Using Gaia data, we approximated the region's distance to be around 2 kpc, aligning with previous investigations.

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The angular momentum-mass relation for LADUMA data

Mrs Narusha Isaacs-Klein

University of the Western Cape

Abstract

The study explores the intricate interplay between angular momentum and mass within the context of the LADUMA dataset. Employing observational techniques and analytical methodologies, this research delves into the fundamental relationship between the angular momentum of cosmic structures and their corresponding stellar masses, elucidating potential implications for our understanding of galaxy formation, evolution, and the underlying mechanisms governing the cosmic large-scale structure. By elucidating this intricate connection, the study offers valuable insights into the intricate dynamics that shape the cosmos, contributing to the broader field of astrophysics and deepening our comprehension of the universe's intricate tapestry.

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Looking to the future of simulations of HI

Dr Kyle Oman

Institute for Computational Cosmology, Durham University

Abstract

Atomic hydrogen gas is a key reservoir of fuel for star formation in galaxies across cosmic history and provides an excellent tracer of the dynamical mass in galaxies out to large radii. The Square Kilometre Array (SKA) precursor observatories in South Africa (MeerKAT) and Australia (ASKAP) are already giving hints of the incredible observations of atomic hydrogen that we can expect from the SKA when it is completed in about 2030. We are also undergoing a quieter but equally exciting revolution in how we make theoretical predictions for atomic hydrogen in galaxies. Up to now, we have had to resort to labelling atomic hydrogen in cosmological galaxy formation simulations in a post-processing step, subject to uncertain calibrations and assumptions. The next generation of simulation projects are starting to implement non-equilibrium cooling physics, enabling on-the-fly calculation of neutral and atomic gas fractions. We will soon have for the first time fully self-consistent, detailed, spatially-resolved predictions for the atomic hydrogen content, structure and kinematics of galaxies across cosmic history. I will give an overview of the state of the art in simulation-based predictions for atomic hydrogen measurements. I will also outline my hopes for the role that the SKA will play in the hunt for dark matter, and how I am building up to this with the SWAN Universe simulations project that I am co-leading to make direct mock-survey predictions for the WALLABY survey at ASKAP.

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Detection of diffuse HI emission in the circumgalactic medium of local galaxies

Sanskriti Das[1], Mary Rickel[2], Adam Leroy[2], Nickolas Pingel[3], D.J. Pisano[4], George Heald[5], Smita Mathur[2], Amy Sardone[2]

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Abstract

The circumgalactic HI might hold the clue to the missing accretion: the mismatch between the HI accretion rate and star formation rate of local (z~0) galaxies. If it traces the neutral fraction of a predominantly ionized CGM, it could also host missing galactic baryons. Using the Green Bank Telescope, we probed the 21-cm emission from HI in the CGM of several local galaxies out to 100 kpc impact parameter at an unprecedented sensitivity of 10^16 cm^-2. We detected HI of diverse spectral shapes, velocity widths, and column densities. Interferometric maps from the Westerbork Synthesis Radio Telescope cannot explain >50% of these single-dish detections. This excess circumgalactic HI along major axes pointings co-rotates with the HI disks and is an inflow/fountain along the minor axes pointings. Whether it accounts for the missing baryons and missing accretion is subject to individual targets.

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Exploring the Dark and Low Surface Brightness Universe through HI with WALLABY

Miss Tamsyn O'Beirne

Swinburne University of Technology

Abstract

Dark galaxies are isolated, dark matter dominated systems without optical counterparts that are predicted by ΛCDM simulations to have a primordial origin, yet observations have shown they're extremely rare. Although they're invisible at optical wavelengths, those that are gas-rich can be traced by neutral atomic hydrogen (HI). In our search for dark galaxies using the pilot data from Widefield ASKAP L-band Legacy All-sky Survey (WALLABY), we found dozens of candidates and dark clouds amongst almost 700 low surface brightness galaxies (LSBGs), ~70% of which hadn't been previously catalogued. We find the LSBGs to be HI-rich with low specific star formation rates, with the non-isolated sources tending to have smaller HI masses and diameters than their isolated counterparts. Amongst these sources we identified an 'almost' dark cloud which resides in the interacting group Klemola 13. For the first time we identify an extremely faint optical counterpart to this source with a mean g-band surface brightness of 27.0 ± 0.3 mag/arcsec^2, and find almost half the total HI gas to be beyond the optical limits of the galaxies. We conclude that the 'almost' dark cloud is a tidal remnant from interactions within the group and will be strongly influenced by ram pressure stripping. The detection of the large number of dark sources and LSBGs in the pilot data showcases the potential of the full survey to detect this extreme class of object, providing a glimpse into the future of studying the HI-rich low surface brightness Universe in the SKA era of radioastronomy.

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Resolved HI studies of nearby galaxies

Prof Erwin de Blok

ASTRON Netherlands Institute for Radio Astronomy

Abstract

The last two decades have seen a great increase in the number of high-quality and high-fidelity neutral hydrogen (HI) observations of nearby galaxies. Much of this has been made possible by the advent of the Square Kilometre Array precursors and pathfinders. These have produced observations of unprecedented sensitivity and resolution, while also making wide-field surveys a reality.

I will give an overview of some of the recent highlights of recent and ongoing HI surveys of nearby galaxies focussing on what they tell us about gas accretion and the link between gas and star formation. Recent observations have also reached sufficient column density sensitivity and resolutions to make detailed comparsions with simulations possible. Finally, I will briefly discuss some of the prospects of the upcoming facilities that will deliver a comprehensive picture of the baryon cycle in nearby galaxies.

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MIGHTEE-HI: A view of the cosmic web through the lens of HI galaxies

Miss Madalina Tudorache

University of Oxford

Abstract

Traditionally, studies of the cosmic web in observations are done using optical/near-infrared data. However, there is a plethora of information hidden in the other wavelengths - especially in radio. In this talk, I will discuss how we can use HI galaxies from the MIGHTEE-HI survey to draw links between the low density gas in the cosmic web and how the galaxies that lie within it grow using its material. Firstly, I will discuss the relationship between the spin vector of a galaxy and the direction of the filaments of the cosmic web in which it may reside. The result I will emphasise is that the neutral gas fraction relative to the stellar mass of a galaxy can be related to the alignment of the galaxy spin vector and the nearest filament, such that galaxies which are misaligned have higher HI mass fractions compared to their stellar mass. I will then discuss how we can use star formation histories (SFHs) from photometric bands, as well as spectroscopy and how can that help in the understanding the link between the neutral gas fraction and the spin-filament alignment. Moreover, I will explore how we can use the SFH-derived parameters in an HI-selected sample to obtain relations between star formation and stellar mass/HI mass. Furthermore, I will discuss some preliminary results of an elongated HI structure formed of 14 dwarf galaxies found in the local Universe which seemingly traces the cosmic web, as well as the implications it has for galaxy evolution models.

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Gas cycle and star formation in turbulent and magnetized media as seen from high resolution MHD numerical simulations

Prof. Diego Falceta-Gonçalves

University of Sao Paulo

Abstract

Star formation is governed by the complex interaction of gravity, magnetic fields, and turbulence in the ISM. The distribution of the gas within the cloud and the properties of star formation, such as the star formation rate (SFR) and efficiency (SFE), and the initial mass function, is currently understood as dictated by the ISM turbulence. The role of turbulence and magnetic fields in regulating star formation rates and efficiency is still not clearly understood. In this work, SFE and SFR have been studied by means of a number of high resolution self-graviting magneto-hydrodynamical (MHD) simulations covering a good range of observed turbulent and magnetization levels of molecular clouds. We show that magnetic fields are relevant on the statistics of velocity distribution but play a minor role on the evolution of core mass functions and consequence SFR/SFE. Turbulence, on the other hand is a major parameter, and the SFE/SFR as a function of the turbulence energetics and time evolution is provided. Our findings not only help the understanding of star formation but may serve as sub-grid template for future cosmological and galaxy evolution models.

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Revealing hidden structures and the neutral hydrogen mass functions of galaxies through MeerKAT blind systematic surveys of the Zone of Avoidance.

Mrs Sambatriniaina Rajohnson

University of Cape Town

Abstract

Our research is dedicated to shedding light on the uncharted regions of the sky obscured by the dust and stars of our Milky Way: The Zone of Avoidance (ZOA), particularly in the Vela region. This unexplored area hosts the enigmatic Vela Supercluster (VSCL) at cz ~ 18000 km s^{-1}, featuring potential merging walls and an inner core obscured in the innermost ZOA. Its location is essential for resolving the longstanding cosmological debate regarding the amplitude and volume of bulk flow measurements. With the excellent HI resolution and sensitivity of MeerKAT, we pursued a two-phase mapping of the morphology and inner structure of VSCL, focusing on identifying its gas-rich spirals using two blind systematic HI surveys. The two surveys jointly cover a total area of ~300 deg^2 within 263° < l < 284°, |b| < 6.7°, and are sensitive to M^*_{HI} galaxies throughout the probed volume (cz < 25000 km s^{-1}). This presentation highlights the exciting new findings from the distribution of over 1500 newly discovered HI-rich galaxies when linked to known structures near the Galactic Plane, validating hypothesized structures from decades ago and unveiling previously unknown ones. Among these discoveries are prominent signatures of two walls that connect to the previously identified higher latitude VSCL (16000 < cz < 23000 km s^{-1}). We use HI mass functions at these wall distances to evaluate their overdensities. The accomplishments of these interferometric surveys illustrate their remarkable capabilities to trace large-scale structures at extremely low latitudes, overcoming challenges posed by high obscuration and continuum background.

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HI absorption and AGN feedback

Prof Raffaella Morganti

ASTRON. Kapteyn Institute Groningen

Abstract

Since the 70's, HI absorption against extragalactic radio active galactic nuclei (AGN) has helped us to study the presence and kinematics of cold gas in the nuclear regions of galaxies.
In this talk I will summarise some of the recent results illustrating the variety of structures that can be traced using HI. They span from (circum-nuclear) disks of regularly rotating gas, to infalling clouds and to - the most surprising finding - fast and massive outflows. They all play an important role in the onset, life and impact of radio AGN.
While most of the results so far have been obtained by pointed observations aimed at characterise the presence and properties of HI around different type of AGN, the field is now moving toward blind surveys taking advantage of telescopes with wide field-of-view and/or wide instantaneous band. Some of these surveys (especially from the SKA precursors) are also expanding the search for HI-21cm in sources in the high redshift Universe.
I will summarise the latest results from these new large surveys, which are giving a taste of what will be possible with SKA1.

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New insight into dynamically important large-scale structures from the SARAO MeerKAT Galactic Plane Legacy Survey

Prof Renée C. Kraan-Korteweg

University of Cape Town

Abstract

The deep SARAO MeerKAT Galactic Plane Legacy Survey (SMGPS) covers the whole southern Milky Way along a narrow strip of $\Delta b \sim 3\circ$. While primarily aimed at exploring the inner Galaxy, the SMGPS provides a unique opportunity to trace the large-scale distribution of galaxies through the spectral 21cm line emission of galaxies in this fully opaque region of Milky Way. Various dynamically important structures, such as the Local Void, the Great Attractor, and the extent of the Vela Supercluster, remain poorly mapped at low Galactic latitudes. However, their mass overdensities are crucial in reconciling the decades-long cosmological controversy about the amplitude and volume within which bulk flows arise. The SMGPS is sensitive to galaxies throughout the probed volume (z < 0.08, i.e. V_{hel} < 25,000 km/s) down to 6 x $10^9 M_\odot$, and 3 x $10^8 M_\odot$ at the GA distance. Some of the tantalising new results will be presented, such as a clear delineation of the Local Void at these low latitudes, a surprisingly prominent connection to the core of the Great Attractor, two walls that link to Vela Supercluster, as well as the unexpected identification of a very extended HI galaxy disk that defies the well-established HI mass-diameter relation by more than an order of magnitude.

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Radial acceleration relation with resolved stellar mass measurements over 1 Gyr

Andreea Varasteanu, Dr Anastasia Ponomareva, Prof Matt Jarvis

Oxford University

Abstract

The radial acceleration relation (RAR) is a fundamental relation linking baryonic and dark matter in disc galaxies through the observed acceleration derived from dynamics to the one from baryons. Notably, this relation exhibits small scatter, thus providing key constraints for models of galaxy formation and evolution. However, it has only been extensively studied in the local Universe.

In this talk, I will provide new measurements of RAR that, for the first time, span 1 Gyr of cosmic history by making use of the homogeneous, unbiased sample of HI selected galaxies detected by the MIGHTEE survey.

I will present an analysis of the RAR by introducing a novel approach of resolved stellar mass modelling from spectral energy distribution fitting across 9 photometric bands, which is essential for measuring the acceleration due to baryons, using the deep optical and near-infrared data available in the MIGHTEE fields. I will combine this alongside the dynamical modelling based on high quality HI rotation curves to determine the RAR.

Furthermore, I will address the fundamental nature of the RAR and discuss its potential evolution with redshift by tapping into the full capabilities of upcoming HI surveys. The results promise to deepen our insights into the interplay between baryons and dark matter across cosmic epochs.

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HI-MaNGA: (21cm-HI) single-dish observations of MaNGA Survey Galaxies

Prof. Karen Masters[1], Dr David Stark[2]

[1]Haverford College. [2]STScI

Abstract

I give an overview of the HI-MaNGA project, initiated to obtain complementary information about the cold gas (neutral hydrogen 21cm line) content of MaNGA sample galaxies.

Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) was part of the fourth incarnation of the Sloan Digital Sky Surveys (SDSS-IV) and obtained spatially resolved spectral maps for 10,000 nearby galaxies. MaNGA data provide a census of the stellar and ionized gas content, and dynamics of these galaxies, which were selected to form a representative sample. Adding HI information is crucial for a number of applications, but especially understanding the physical mechanisms that regulate gas accretion, star formation and the quenching of star formation.

Since 2016, we have made use of over 2500 hours of filler time on the Robert C. Byrd Green Bank Telescope (GBT) to observe over 4000 galaxies in the MaNGA sample at 21cm. When added to existing data from the ALFALFA (Arecibo Legacy Fast Arecibo L-band Feed Array) HI survey this provides total HI masses (or upper limits) for over 70% of the MaNGA sample, rotation widths for about half, and helpful information to guide proposals for future resolved 21cm observations.

I review the program, including hi-lights of published results to-date (e.g. Sharma et al. 2023: “HI Rich but Low Star Formation galaxies in MaNGA”, Frank et al. 2023: “The HI Content of Red Geyser Galaxies” and Goddy et al. 2023 “A comparison of the baryonic Tully–Fisher relation in MaNGA and IllustrisTNG”).

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Verifying Cosmological Simulations: Searching for Extended HI Emission in the Fornax Cluster

Miss Nabeelah Adam

University of Cape Towm

Abstract

Galaxies seldom evolve in isolation. Their properties are impacted by their environment. Galaxy clusters are the most massive, densest, gravitationally bound structures in the universe comprising thousands of galaxies within a region of a few cubic megaparsecs; they have frequent, high-speed interactions that disrupt their outer disks. The Fornax cluster is the most massive galaxy cluster within 20 Mpc in the southern hemisphere, thus is an ideal target for studying the effect of the cluster environment on galaxies. The MeerKAT Fornax Survey (MFS) is currently mapping the HI in the cluster over 12 deg^2 down to an HI column density of 10^18 1/cm^2 to detect the diffuse HI, and to study the effect of the cluster environment on galaxies.

Complementary observations of Fornax have been conducted with the Green Bank Telescope (GBT) down to a similar HI column density. The GBT observations are well-suited for detecting extended, diffuse HI emission. Combined, we will have a comprehensive understanding of the HI distribution in the Fornax cluster down to faint levels of emission.

Due to MeerKAT's advanced observational capabilities, conducting comparisons with numerical modelling of cluster environments is possible. The TNG50 cosmological simulations have produced HI maps of Fornax-like cluster halos (mass enclosed within a sphere of radius R200, within which the average density is 200 times the critical density of the universe) that predict to find extended HI well beyond the satellites in the halo.

The comparison will serve as a test of the TNG50 cosmological simulations.

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Cold gas formation within an HI shell in the Magellanic Bridge from GASKAP-HI observations

Shin-Jeong Kim, Naomi McClure-Griffits, Antoine Marchal

Australian National University

Abstract

We will present a new study that investigates the multi-phase structure of a 9 pc scale HI shell located in the Magellanic Bridge using data from the GASKAP-HI survey. Associated with the H-alpha ring DEM-171, this shell is an ideal laboratory to study the effects of dynamical events such as supernovae or stellar winds from massive stars on the HI gas properties. We decompose the HI emission spectra into multiple Gaussian components using ROHSA, which enables us to map out the cold neutral medium (CNM), lukewarm medium (UNM), and warm neutral medium (WNM) that makes up the shell. The higher CNM gas fraction (~50%) and existence of UNM gas indicate that the HI shell undergoes a phase transition in the ISM, leading to the CNM formation, likely due to the gas compression. Additionally, exisiting star clusters and young stellar objects (YSOs) catalogs support the scenario that the expansion of the HI shell can trigger subsequent star formation within the shell. This analysis illustrates the stellar feedback on the multi-phase cycle and star formation activity within the Magellanic Bridge.

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Detections of 21-cm absorption from blind surveys with FAST

Dr Yougang Wang

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

We will present a HI 21-cm absorption catalogue from a blind search of the extragalactic HI absorption lines at z<=0.35 with the drift scan observation of the Five-hundred-meter Aperture Spherical radio Telescope (FAST). We carried out the search using the data collected in 1616.9 hours by the ongoing Commensal Radio Astronomy FasT Survey (CRAFTS) and the FAST All Sky HI Survey (FASHI), which spans a sky area of 7456.8 deg^2 and covers 85533 radio sources with a flux density greater than 12 mJy. We use a matched-filtering approach to detect HI absorbers and detect 14 previously identified HI absorbers and 20 newly discovered HI absorbers, comprising 15 associated systems, 10 intervening systems, and 9 systems with undetermined classifications. Statistical analysis reveals that associated systems tend to by hosted by red (g-r>0.7) galaxies at lower redshifts, whereas galaxies hosting intervening HI absorptions are typical found at higher redshifts and are of a bluer (g-r<=0.7) type. Additionally, it has been demonstrated art associated HI 21-cm absorptions connected to compact radio sources display higher N_{HI} values compared to those linked with extended radio sources.

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Galactic Winds and Outflows in Cold Gas

Prof Deanne Fisher

Swinburne University

Abstract

Galactic winds are the key mechanism that regulates galaxy growth and are a necessary ingredient to all models of galaxy evolution. Observations show that the majority of gas leaving the disk in galactic winds is in the cold phases, making HI a key tracer of outflows. Among the most pressing open questions regarding outflows are (1) understanding how cold gas survives the hot winds and (2) how much gas in the cold phases (atomic & molecular) is entrained in the wind. Indeed, characterizing the HI that surrounds galaxies, and its role in the baryon cycle is a key science driver for the SKA. I will discuss results from recent observations of the GECKOS project. GECKOS is a multiphase program of 35 galaxies that including a VLT/MUSE Large Program, ALMA observations and data from both WALLABY-ASKAP and MeerKAT. Using GECKOS we resolve outflows down to individual filaments leaving the disk. Our observations measure the total cold gas mass (atomic+molecular+ions) in the wind filaments, which places direct constraints on the drivers of the wind. I will show evidence that cold gas outflows are ubiquitous in starburst galaxies, suggesting the importance of future observations of how they regulate star formation. I will show that the location of shocks are critical to determine where the cold gas survives the breakout from the disk. These results directly inform multiphase theories of galactic winds, and helps set expectations for work with the SKA.

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The MALS view of cold atomic gas in and around galaxies at 0<z<0.6

Neeraj Gupta

IUCAA

Abstract

The MeerKAT Absorption Line Survey (MALS; https://mals.iucaa.in/) is a large project (1655 hrs) to blindly search for HI 21-cm and OH 18-cm absorption lines with the primary goal to better characterize the cold atomic and molecular gas in and around galaxies at 0≤z≤1.8. The L-band (900 - 1670 MHz) phase of the survey is completed and the observations with UHF-band (580 - 1015 MHz) phase are in progress. Through these we have recently reported: (i) the detection of the most luminous known 1720 MHz OH maser line, (ii) the discovery of the first extragalactic Hydrogen radio recombination line at cosmological distances, and (iii) the variability of the HI and OH 21-cm lines at z = 0.247 and 1.173. In this talk, I will present key results from the survey with focus on (i) new constraints on the filling factor of cold neutral medium (CNM; 100K) gas within the MW galactic halo based on sensitive spectra towards ~20,000 bright AGN detected in MALS, and (ii) the first constraints on the CNM cross-section of galaxies at 0<z<0.6 and its relationship with the evolution of star formation rate density.

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HI galaxy signatures in the SARAO MeerKAT Galactic Plane Survey: Probing the richness of the Great Attractor wall across the inner Zone of Avoidance.

Nadia Steyn[1,2], Em. Prof. Renée Kraan-Korteweg[2], Sambatriniaina Rajohnson[2], Dr Sushma Kurapati[2]

[1]International Centre for Radio Astronomy Research (ICRAR), University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. [2]Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa

Abstract

Presenting the first HI results extracted from the South African Radio Astronomy Observatory (SARAO) MeerKAT Galactic Plane Survey (SMGPS) – a narrow strip ($\Delta b \sim 3°$) along the southern Milky Way. Our primary goal consisted in tracing the Great Attractor (GA) wall across the innermost Zone of Avoidance. We reduced a segment of data spanning the longitude range $302° \leq \ell \leq 332°$ for the redshift range $z \leq 0.08$. The superb SMGPS sensitivity (rms = 0.3–0.5 mJy/beam per 44 km/s channel) and angular resolution (~31" × 26") lead to a detection limit of $\log(M_{HI}/M_\odot) \geq 8.5$ at the GA distance (V ~ 3500–6500 km/s). A total of 477 galaxy candidates were identified over the full redshift range. A comparison of the few HI detections with counterparts in the literature (mostly HIZOA) found the HI fluxes and other HI parameters to be highly consistent. The continuation of the GA wall is confirmed through a prominent overdensity of N = 214 detections in the GA distance range. At higher latitudes, the wall moves to higher redshifts, supportive of a possible link with the Ophiuchus cluster located behind the Galactic Bulge. This deep interferometric HI survey demonstrates the power of the SMGPS in improving our insight of large-scale structures at these extremely low latitudes, despite the high obscuration and continuum background.

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WALLABY: Ultra Diffuse Galaxies in HI

Dr Bi-Qing For

International Centre for Radio Astronomy Research/University of Western Australia

Abstract

There are many pathways to form an ultra-diffuse galaxy (UDG). The mechanisms that dominate the formation pathways in different environments are still an active research. Atomic neutral hydrogen gas (HI) plays an important role in this regard. It is also known that the gas content of galaxies in the group environment is more diverse as it depends on the evolutionary stages of the group. To understand if such variation is also observed for UDGs in groups, we conduct a pilot study of HI content of UDG candidates in the Eridanus supergroup using the WALLABY data. In this talk, I will present the results of the pilot and ongoing studies. In the case of Eridanus supergroup, we find that the actual numbers of UDGs for the Eridanus and NGC 1332 subgroups are consistent with the predicted abundance of UDGs and the halo virial mass relation, except for the NGC 1407 subgroup, which has a smaller number of UDGs than the predicted number. Different group environments suggest that these UDGs are likely formed via the satellite accretion scenario.

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Gas, gas, everywhere…Building the Framework for Neutral HI Detections in the SKA Era

A/Prof. Michelle Cluver

Swinburne University of Technology

Abstract

Courtesy of the Precursors and Pathfinders, we have glimpsed the coming radio-driven revolution! We are headed for the proliferation of neutral gas detections in the era of the SKA, and with it, the need to account for their role (both minor and major) in our models of galaxy evolution. The synthesis of multiwavelength data plays a central role in this endeavour, particularly in examining the role of neutral gas in the baryon cycle of galaxies in different environments. In this talk, I will discuss the importance of having a multiwavelength “scaffold” for HI observations in the local Universe, with a particular emphasis on redshift surveys, such as the 4MOST Hemisphere Survey, and imaging surveys such as LSST, WISE, and eROSITA. Finally, I will highlight the challenges we already face with MeerKAT and ASKAP in converting our immensely powerful multiwavelength datasets into knowledge, given the scale of information and the complexity of the processes we seek to understand.

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Mapping the impact of supernova feedback in the neutral atomic hydrogen across the Milky Way

Dr. Juan D. Soler[1], Prof. Sergio Molinari[1], Prof. Ralf Klessen[2], Prof. Patrick Hennebelle[3], Prof. Naomi McClure-Griffiths[4], Prof. Henrik Beuther[5], Dr. Marc-Antoine Miville-Deschênes[6], Dr. Davide Elia[1], Dr. Eugenio Schisano[1], Dr. Alessio Traficante[1], Dr. Philipp Girichidis[2], Prof. Simon Glover[2], Prof. Rowan Smith[7], Dr. Mattia Sormani[2], Dr. Tine Colman[3]

[1]Institute for Space Astrophysics and Planetology (IAPS). [2]University of Heidelberg. [3]CEA/Saclay. [4]Australian National University. [5]Max-Planck Institute for Astronomy. [6]CNRS. [7]University of St Andrews

Abstract

The diffuse neutral atomic hydrogen (HI) is the matrix within which molecular clouds reside and the medium that soaks up the energy injected by stellar feedback. I will present a systematic study of the anisotropy traced by the filamentary structure identified in the 21-cm-wavelength HI emission across the Galactic plane using the HI4PI, the Galactic Arecibo L-band Feed Array HI (GALFA-HI), and the HI/OH/Recombination-line (THOR) surveys. We found that the Milky Way's disk regions beyond ten kiloparsecs and up to roughly 18 kiloparsecs from the Galactic center display HI filamentary structures predominantly parallel to the Galactic plane. We also found that the HI filaments are mostly perpendicular or do not have a preferred orientation with respect to the Galactic plane for regions at lower Galactocentric radii. Using the insight from numerical simulations, we interpret these results as the imprint of supernova feedback in the inner Galaxy. We discuss the implication of this result for our understanding of the Galactic ecosystem and the potential of interferometric observations in studying the energy and momentum input from stars across the Milky Way.

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The MeerKAT Fornax Survey: removal of HI from galaxies in the Fornax cluster

Dr Filippo Maccagni, Dr Paolo Serra

INAF - Osservatorio Astronomico di Cagliari

Abstract

I will show science results from the MeerKAT Fornax Survey. Our goal is to perform a detailed study of the nearby Fornax galaxy cluster in order to understand how galaxies lose their cold gas and stop forming stars in low-mass clusters ($M_{vir} < 10^{14}$ M_{sun}). We are doing so through very deep (down to ~10^{18} cm^{-2}) and high resolution (up to ~ 1 kpc and 1 km/s) MeerKAT observations of neutral atomic hydrogen gas (HI) in a 1x2 Mpc^2 region centred on Fornax.

Our survey started in October 2020 and is now 88% complete. The data analyzed so far focus on the central region of the Fornax cluster and reveal for the first time the ubiquitous presence of tails and clouds of HI. Some of the HI is clearly being removed from Fornax galaxies as they interact with one another, with the intra-cluster medium and/or with the large-scale gravitational potential. I will present a sample of galaxies with long, one-sided, star-less HI tails (of which only one was previously known) radially oriented within the cluster and with measurable internal velocity gradients. The properties of these tails represent the first unambiguous evidence of ram pressure shaping the distribution of HI in the Fornax cluster. I will also discuss additional results on how interactions within the Fornax environment shape the HI mass function on the HI content of dwarf galaxies and on how the HI sustains the nuclear activity of some cluster members and neighboring galaxies.

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ORCHIDSS: An ESO 4MOST Community Survey to unlock the full HI potential of the SKA and its precursors

Dr Kenneth Duncan

University of Edinburgh

Abstract

Galaxy evolution is regulated by the continuous cycle of gas accretion, consumption and feedback. Crucial in this cycle is the availability of neutral atomic (HI) and molecular hydrogen. Thanks to the new generation of surveys with SKA pre-cursors, our inventory of HI is no longer limited to the local Universe and the incomplete picture this provides. However, even the deepest planned surveys will still be biased to detecting only the most extreme HI sources at $z > 0.5$. I will present an overview of the Optical Radio Continuum and HI Deep Spectroscopic Survey (ORCHIDSS), a spectroscopic survey specifically designed to address this critical challenge and maximise the scientific potential of deep extragalactic continuum and HI surveys with MeerKAT and the SKA. As 4MOST surveys commence in 2025, ORCHIDSS will begin to collect optical spectroscopy for ~200,000 radio continuum detected objects from the deep MeerKAT surveys with the goals of: providing the most reliable measurement of the evolution of the cosmic HI density, mass function and fundamental scaling relations from $z=1.4$ to now; directly measuring the effects of AGN and star-formation driven feedback on regulating the neutral gas reservoirs of galaxies across cosmic time; and providing a dataset with enormous legacy value for studying star-formation and accretion activity into the SKA era. The science enabled by the combination of 4MOST and MeerKAT can also play a crucial role in informing the scope and expectations of future SKA and coordinated multi-wavelength surveys.

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Exploring the Ophiuchus Supercluster with SARAO MeerKAT Galactic Plane Survey

Mr Austun Louw, Dr Sushma Kurapati, Dr D.J. Pisano, Prof Renee Kraan-Korteweg

University of Cape Town

Abstract

The Ophiuchus Supercluster is one of the brightest X-Ray clusters in the Local Universe. Part of the Ophiuchus cluster extends into the Zone of avoidance, making the fraction of the cluster that coincides with the Zone of Avoidance (ZoA) difficult to observe in optical and Infrared wavelengths. The reason for this is because of the obscured dust and thick stellar emission caused by the Milky Way. In this project, we use the HI 21-cm emission observations that were taken as part of the SARAO MeerKAT Galactic Plane Survey to study the large-scale distribution of galaxies in the Zone of Avoidance over the Galactic longitude range $-30^{o} < l < 55^{o}$ and Galactic latitude range $-1.5^{o} < b < 1.5^{o}$). We will be looking at galaxies with a redshift velocity from 7500 km/s up to 23000 km/s. We will also be looking for any connection between the Great Attractor and the Ophiuchus Supercluster when exploring the distribution of galaxies in the Zone of Avoidance.

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Unveiling the dynamics and cluster environmental impacts on the Abell 3408 galaxies using MeerKAT.

Mr Xola Ndaliso

University of the Witwatersrand

Abstract

Significant advances in observational capabilities are continuously transforming our understanding of the dense environment of galaxy clusters and its impact on individual galaxies. Discerning between intrinsic and externally-induced properties of galaxies is a key diagnostic in the field of galaxy evolution. We present MeerKAT spectral line data observations of the redshift z ~ 0.042 galaxy cluster Abell 3408. A total of 64 galaxies are detected in HI in this X-ray-luminous galaxy cluster (L500~ 2.76±0.50×1e43 ergs/s). We model the HI morphology and kinematics of the individual galaxies. Galaxies closer to the cluster centre exhibit higher degrees of asymmetry compared to those further away (i.e. $\gtrsim$ 1 Mpc) from the cluster centre, with the latter showing more uniform disk dynamics. Furthermore, a significant fraction of the HI-detected galaxies fall below the 1σ scatter of the MHI - M$*$ scaling relation, suggesting significant HI deficiency i.e. DEFHI ≥ 0.3 for the galaxies closer to the cluster X-ray core. This comprehensive analysis of the Abell 3408 galaxy cluster provides valuable insights into the impact of the cluster environment on individual dynamics of galaxies and galaxy morphology. The statistical power of many tens of spatially resolved HI galaxies is set to dramatically enhance our understanding of the morphology-density relation in clusters from an HI perspective.

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The Neutral Hydrogen and Mass Distribution in Two Dwarf Irregular Galaxies in the MeerKAT MHONGOOSE Large Survey Project SampleThe University of WitwatersrandGalaxies: dwarf; Galaxies: irregular; Galaxies: kinematics and dynamics, Galaxies; dark matter

Dr Brenda Namumba[1], Dr Ianjamasimanana Roger[2], Prof Roger Deane[3]

[1]University of Witswatersrand. [2]Instituto de Astrofísica de Andalucía. [3]University of the Witwatersrand

Abstract

The gas and stellar kinematics of galaxies are among the fundamental properties used to infer the distribution of dark matter and understand the dynamical structure of galaxies. We present, for the first time, high-sensitivity and high-resolution models of the kinematics and distribution of neutral hydrogen (HI) in two irregular dwarf galaxies, ESO444-G084 and KKS2000-23. The observations were obtained with the MeerKAT telescope as part of the MHONGOOSE survey, one of the eight MeerKAT Large Survey Projects. Our derived total HI masses of ESO444-G084 and KKS2000-23 are consistent with the results of single-dish telescopes and the kinematic data reveal symmetric HI discs. Approximately 90% of ESO444-G084's mass is dark matter, which is reflected in its high dark-to-luminous mass ratio. A large number of resolved HI data are now available through the MHONGOOSE survey and we plan to apply our analysis to a larger sample of irregular galaxies to constrain their kinematic parameters and their dark matter content. This growing sample serves as an important nearby reference of cold-gas content in dwarf galaxies that remain out of reach for higher redshift studies and as a comparison for the increasing mass resolution of cosmological hydrodynamical simulations.

***Note: acknowledges the contribution of the MHONGOOSE team**

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Galaxy evolution in the diverse environment of the Shapley Supercluster through HIobservations.

Mr Lwandile Gwebushe

Rhodes University

Abstract

The Shapley Supercluster, the largest known supercluster in the local Universe, offers a unique opportunity to study ongoing mass assembly processes. Comprised of numerous Abell clusters and interconnected galaxy groups, this region showcases a diverse range of galactic environments. Despite the availability of extensive multiband data, the absence of HI observations has hindered a comprehensive understanding of galaxy dynamics. Our project seeks to fill this gap by utilising the capabilities of MeerKAT to conduct HI observations within the Shapley Supercluster. HI serves as a crucial indicator for studying galaxy evolution, providing insights into dynamics such as motion direction, star formation abundance, and environmental influences. By complementing existing datasets with HI observations, we aim to unravel the intricate interplay between galaxies and their surroundings. Through the analysis of redshift distributions and X-ray observations, we affirm the Shapley Supercluster's status as a physically bound system undergoing mass assembly processes. Our focus lies on exploring how galaxy evolution is shaped by environmental factors, ranging from isolated galaxies to those within massive clusters.

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HI Polar Ring Galaxies in the SKA era: Lessons from the detection of the potential polar rings NGC 4632 and NGC 6156

Dr Nathan Deg[1], Prof Kristine Spekkens[2,1]

[1]Queen's University. [2]Royal Military College

Abstract

Polar Ring Galaxies (PRGs) are some of the most visually striking galaxies. They hold clues about galaxy formation, evolution, and interaction rates. In this talk, we will present the two potential HI PRGs among the WALLABY pilot data release 1 galaxies. These are gas rich galaxies, and their an anomalous HI component that appears to be polar. Careful consideration of the geometric detectability of such structures suggests that 1-3% of WALLABY galaxies will host an HI polar ring. Moving to the SKA era, we expect to detect thousands of these objects in both the local Universe and at higher redshifts, enabling studies of PRGs across cosmic time and environment. In particular, PRGs in the SKA era will provide new probes of galaxy formation and mergers. Moreover, the increased sensitivity of the SKA will allow for detailed studies of the outskirts of PRGs, which will allow us to determine the dominant formation mechanism of these beautiful galaxies.

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High Redshift HI & H2 With CHILES

Julia Blue Bird

National Radio Astronomy Observatory (NRAO) - Socorro, NM, USA

Abstract

Measurements of hydrogen are important in our understanding of the Universe. Following reionization at $z \sim 6$, most of the hydrogen outside galaxies is in an ionized state. Within galaxies, hydrogen passes through a neutral phase as it cools and collapses into molecular hydrogen and then to stars. We know that cosmic star formation peaks at $z \sim 2$ and sharply declines to the present, yet we know very little about gas reservoirs in individual galaxies that lead to star formation through these redshifts. The COSMOS HI Large Extragalactic Survey (CHILES) is a 1000-hour program, using the Karl G. Jansky Very Large Array, that images HI in a redshift range of $0 < z < 0.5$. We present images of HI gas in galaxies at high-redshift combined with observations of CO (tracing H2) and analyze atomic + molecular hydrogen gas in a small sample of galaxies three, four, and five billion years back in time.

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Are gas-rich Ultra-Diffuse Galaxies and field dwarfs distinct populations?

Khadeejah Motiwala[1], Dr Ananthan Karunakaran[2], Dr Kristine Spekkens[1,3], Dr Nikhil Arora[1]

[1]Queen's University, Canada. [2]University of Toronto, Canada. [3]Royal Military College, Canada

Abstract

The formation mechanisms of gas-rich Ultra-Diffuse Galaxies (UDGs) in low-density environments are not yet understood. For instance, some UDGs may be "failed" L* galaxies, while others appear to be the spatially extended tail of the low surface-brightness dwarf galaxy population. To constrain competing models, we explore the differences between UDG and dwarf galaxy populations using an extensive HI follow-up survey of optically-selected UDG candidates from the Systematically Measuring Ultra-Diffuse Galaxies (SMUDGes) catalogue. For each detection, the HI line provides distance (and therefore size) information that allows us to classify each SMUDGes candidate as either an actual UDG or a foreground dwarf. We also compare the SMUDGes observations with two state-of-the-art cosmological simulations: Numerical Investigation of a Hundred Astrophysical Objects (NIHAO), which forms UDGs through bursts of star formation at early times, and ROMULUS, which forms UDGs using major mergers at high redshift. Although formation scenarios for UDGs with these simulations are remarkably different, the present-day, global properties of the simulated galaxies are consistent with our observed sample. Furthermore, in both simulations and observations, we find that our UDG and dwarf samples follow similar scaling relations such as gas richness vs. optical size. Taken together, our results suggest that optically-selected, HI-rich field UDGs and dwarfs are not distinct galaxy populations in the present day Universe, either observationally or in simulations.

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Parsec-scale properties of HI 21-cm absorbers

Dr. Aditya J.N.H.S.[1], Prof. Elaine Sadler[1], FLASH team[2]

[1]The University of Sydney. [2]The University of Sydney & CSIRO

Abstract

Currently we are conducting LBA and VLBA follow-up continuum observations of

33 HI 21-cm absorbers detected in ASKAP-FLASH pilot surveys. The observations will

allow us to make pc-scale maps of the background radio emission arising from the AGN.

A comparison of DESI optical and VLBI radio positions of the AGN core will allow

us to distinguish the absorber as either AGN-associated or as an intervening system.

Further, these observations will allow us to estimate the gas covering factor, and thereby,

the true optical depth of the absorbing gas. In this talk I will discuss the details of

these science cases, and present preliminary results from the follow-up observations.

Particularly, I will present the case of MRC 0531-237 (at z=0.851), which has the highest integrated optical depth detected till date. Further, I will present VLBI HI spectroscopic studies of two local systems; one with recent eMERLIN results, probing few X 100 pc-scale vicinities of a merger hosting an AGN, where HI inflow is likely fuelling the AGN core for a second episode of jet activity. And, another system being probed by VLBA+GBT(HSA) observations, where the jet expansion is likely constrained by dense ambient gas; ineffective mechanical feedback and jet frustration scenarios. I will present the gas densities, compare results with existing simulations, and analyse their jet-gas interactions.

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Environmental processes driving the low-column density gas in and out of galaxies

Dr Filippo Maccagni

INAF - Osservatorio Astronomico di Cagliari

Abstract

The MHONGOOSE survey is bringing the study of the neutral atomic hydrogen (HI) in nearby galaxies (< 30 Mpc) to the next level: thanks to deep (55 hours) high spatial (>7'') and spectral (1.4 km/s) resolution observations over a wide field of view (1.5 degrees), we are able to study the kinematics of the HI gas in star forming galaxies down to M(HI)=10^6 Msun and column densities ~10^{18} cm^{-2}. In this talk, I will focus on the interaction history of the massive (M(HI)~10^{10} M_{sun}) star-forming galaxy NGC1566 (D_L=18 Mpc) and the impact on its star formation (SF). For the very first time, we identified that a past tidal interaction with a massive companion has left several HI debris clouds in the Dorado group. The low-column density (a few times 10^{18} cm^{-2}) HI filaments connecting the disk of NGC1566 with nearby dwarf galaxies (M(HI) ~10^{6-7} M_{sun}), suggest that more minor interactions are still on-going, actively contributing to the accretion of HI onto the star-forming disk. Lastly, I will focus on the lowest HI-mass (M(HI)~1.6x10^6 M_{sun}) object we found in Dorado. This novel detection allowed us to identify a gas-rich low-surface brightness (M_{star} ~2x10^6 M_{sun}) galaxy whose recent infall into the group is changing the physical condition of the HI and triggered a new episode of star formation in its center.

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Charting the SKA Era: Representation Learning for Neutral Hydrogen Mapping with *TPCNet*

Dr. Hiep Nguyen[1], Mr. Haiyang Tang[2], Dr. Matthew Alger[3], Dr. Antoine Marchal[1], Dr. Cheng Soon Ong[2,4], Prof. Naomi McClure-Griffiths[1]

[1]Research School of Astronomy and Astrophysics, The Australian National University, Canberra, ACT 2611, Australia. [2]School of Computing, The Australian National University, Canberra, ACT 2601, Australia. [3]Google Australia, Pyrmont, Australia. [4]Data61, CSIRO

Abstract

We introduce *TPCNet*, a neural network predictor combining convolutional and Transformer architectures, for neutral atomic hydrogen (HI) spectral analysis. Trained on synthetic datasets, our models predict the amount of optically-thick cold neutral gas from emission spectra based on the learned relationships between the desired output parameters and observables (optically–thin column density and peak brightness temperature). *TPCNet* outperforms its deep Convolutional Neural Network counterpart in testing accuracy, algorithmic (training) stability, and convergence speed. Our findings highlight the robustness of the proposed model with sinusoidal positional encoding applied directly to the spectral input, addressing perturbations in training dataset shuffling and convolutional network weight initializations. Diverse synthetic datasets enhance model performance and generalization, as demonstrated by producing values consistent with evaluation ground truths. Applications of *TPCNet* to observed emission data reveal strong agreement between the predictions and Gaussian decomposition–based estimates (from emission and absorption surveys), emphasizing its potential in HI emission analysis. Looking ahead to the SKA era, *TPCNet's* capabilities will be essential for processing an unprecedented wealth of HI emission data to efficiently map the HI distribution in galaxies' interstellar medium. This, in turn, will allow us to probe the properties of the atomic medium across cosmic time and provide insights into galaxy evolution.

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Mapping HI and Dark Matter Distribution in Low and Intermediate Mass Galaxies through LADUMA

Dr Toky Herimandimby Randriamampandry

University of the Western Cape

Abstract

LADUMA, or Looking At the Distance Universe using MeerKAT Array, is one of MeerKAT large HI surveys aiming to resolve galaxies in HI up to redshift 1. This survey has already identified around 200 galaxies, primarily comprising low and intermediate mass systems, crucial for understanding galaxy formation and evolution.

Utilizing the widely-used 3D tilted ring model software, 3D BAROLO, we derived precise rotation curves, velocity dispersion curves, and HI distribution maps for these galaxies. By integrating the derived rotation velocities with optical images from the Dark Energy Legacy Survey, we explored the dark matter and baryonic contents of these galaxies.

This presentation will highlight our findings, including inferred dark matter profiles modeled with the Einasto profile, and provide insights into the kinematics and HI distribution of these low and intermediate mass systems, essential for advancing our understanding of galaxy formation and evolution.

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HI Scaling Relations in the SKA Era

A/Prof Martin Meyer

ICRAR/UWA

Abstract

The SKA and its pathfinders will transform our understanding of how HI is distributed in the Universe and the role it plays in galaxy evolution. A key observational goal in this context will be to improve our understanding of the high level scaling relations that link HI content to the other major galactic ingredients and characteristics, and the manner in which they have evolved with time. These HI scaling relations are a core constraint for any model of galaxy evolution, and with each improvement in our understanding of their form, scatter, and dependencies, comes a corresponding opportunity for insight into the diversity of physical processes that underpin them. I will review recent progress in the field, as well as advances made with the use of statistical analysis methodologies, such as HI stacking, for extending the regimes in which these relations can be studied.

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The simulation of the 21cm interferometer signals for HI gas in galaxies

Dr Jian Fu

Shanghai Astronomical Observatory, China PR

Abstract

In this talk, we will present our recent work on the simulation of the 21cm interferometer signals by radio arrays for HI gas in galaxies. We will first introduce our recent developed software OmniUV, a toolkit to simulate the observational signals for interferometer arrays, which can offer the simulations for visibility data and image reconstructions. We will use the HI gas outputs from Illustris-TNG and L-Galaxies semi-analytic model to simulate the 21cm signals of HI gas by radio arrays. We create the mock light cones to mimic the observers coordinates and convert the HI mass to 21cm flux. We adopt the configurations of SKA1-mid and MeerKAT into OmniUV and generate the visibility data for HI gas in nearby Universe, and we can also reconstruct the mock images based on the mock visibility data. Our work can help to test the observations strategies and target selections for HI sources by future interferometer arrays, like SKA, FASTA etc.

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A search for cold gas in the Magellanic system with ASKAP: Novel approach using Time-frequency analysis of hyper-spectral data

Dr Antoine Marchal

RSAA (ANU)

Abstract

I will present recent work exploring the use of time-frequency analysis (Fourier and Wavelet transforms) on hyper-spectral data of the 21 cm line acquired by the ASKAP, pointing the way to new approaches suitable for analyzing the massive data that will be delivered by the Square Kilometer Array (SKA). This advances a broader effort exploiting 21 cm emission line data alone to extract integrated properties of the multi-phase structure of HI gas. Specifically, I will focus on demonstrating how these tools can be used to search for cold gas in the Magellanic system as a whole, including the leading Arm and the Magellanic Stream. Ultimately, these tools will catalyze discoveries made with the SKA from multiple communities of astronomers working on understanding the structure and evolution of diffuse matter in the Milky Way and nearby galaxies.

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The Neutral Gas Reservoirs around Nearby Galaxies

Dr. Peter Kamphuis

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Abstract

It has been know for decades that in order to maintain the observed star formation rates, spiral galaxies require ongoing replenishment of their neutral gas reservoir. To date observational evidence of the required accretion remains elusive. In this talk I will present results from a systematic search for neutral hydrogen around the galaxies in the Hydrogen Accretion in LOcal GalaxieS (HALOGAS) survey (Heald et al. 2011, Kamphuis et al. 2022).

The HALOGAS observations are still some of the most sensitive HI observations around and probe the neutral gas reservoir around 22 nearby galaxies down to column densities of a few times 10^18 cm^-2, well below the densities predicted by the simulations where accretion should occur. We show that the total observed neutral hydrogen reservoir, i.e. including the gas in companions and satellites, does not suffice to sustain the star formation rates observed in these galaxies. Additionally, we show that extensive cloud complexes, as seen in NGC 891, M31 and the Milky Way, are not common place in nearby galaxies. We calculate that this lack of neutral gas is no longer merely a sensitivity issue.

These results mean that nearby galaxies can not be accreting enough gas to sustain the observed star formation rates in a neutral form. The cold mode accretion seen in the simulations must either relate to ionized hydrogen or is lacking entirely in nearby galaxies. To conclude we will compare our results with the latest results from SKA pathfinder HI surveys.

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1299

Identification and cleaning of contaminants for HI intensity mapping using machine learning techniques

Ms Mosima Masipa

University of the Western Cape

Abstract

HI intensity mapping is a recent observational technique that promises to open a new exquisite window into constraining cosmology. Observations at these radio frequencies (~ 1 GHz) are however contaminated by several signals that threaten a detection of the cosmological signal. In particular, Radio Frequency Interference (RFI) is one of the most serious contaminants faced by modern radio telescopes. This is especially true for the low signal to noise quantities targeted by cosmology. Looking for RFI in data is one of the most important and time consuming processes in current observations with radio telescopes. This project aims to apply machine learning methods to available single dish MeerKAT data to try to flag the RFI and compare with standard RFI flagging algorithms. Particular emphasis will be given to deep convolutional network architectures which have been previously proposed for MeerKAT. The same techniques will also be tested for other contaminants, such as the strong sky foregrounds.

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1305

Quantifying the Impact of Ram-Pressure and Tidal Interactions on Gas Stripping and Accretion in Galaxy Groups

Mr Xuchen Lin[1], Dr Jing Wang[2]

[1]Department of Astronomy, School of Physics, Peking University, China. [2]Kavli Institute for Astronomy and Astrophysics (KIAA), Peking University, China

Abstract

Most galaxies evolve in groups, but multiple mechanisms at work still need dissection. Utilizing new HI data from WALLABY and FAST, we study the effect of ram-pressure (RP) and tidal interactions in two distinct groups.

For satellites in the intermediate-mass group of NGC 4636, we develop two parameters to quantify these two effects on gas-stripping in HI-bearing galaxies: the strength *S* of these two external forces at the optical-disc edge, and the outside-in extents of HI-disc stripping by either effect or by them collectively. Widespread gas-stripping affects 80% of HI-detected non-merging galaxies. We identify the dominant mechanism for each galaxy, revealing stronger correlations between the corresponding *S* and galaxy properties within each sub-sample. Furthermore, we estimate the timescale of gas-stripping, which decreases with distance to the group centre, ranging from $\sim$1Gyr to $\lesssim$10Myr. We thus preliminarily break the degeneracy of these two on gas removal.

For the nearby M51 group of a merging pair, we jointly de-convolved VLA and FAST (FEASTS) data to analyse the kinematics from small to large scales. The strong tidal interaction produces large amount of diffuse HI, whose turbulent mixing with the CGM could bring about a cooling flow rate comparable to the SFR. RP is found to enhance the diffuse-to-dense gas conversion, and its braking effect may also induce inflow. These results imply that tidal-interaction–induced cooling to be an important channel of gas accretion.

Our studies quantify in a physically motivated way the details and processes of environmental-effects–driven galaxy evolution.

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The physical connection between angular momentum and cold gas is not that simple

Luca Cortese

ICRAR-UWA

Abstract

In our current theoretical framework, the growth of angular momentum of galaxies is tightly connected to their ability to accrete gas and use it for star formation. As such, for decades there has been the expectation that the amount of cold gas in discs is primarily set by a galaxy's angular momentum. However, observational confirmation of this has been missing due to the lack of large representative samples of galaxies for which information on cold gas content and angular momentum were available. In this talk, we will show how data from the extended GALEX Arecibo Survey (xGASS) have allowed us to quantify for the first time the physical connection between cold gas content and angular momentum across the whole galaxy population (from gas-rich to gas poor). Our findings highlight how angular momentum is not the only, and in some cases not even the primary, driver of HI content in nearby galaxies, contrary to what expected from analytical models of disc stability. By combining xGASS with cosmological hydro-dynamical simulations such as EAGLE and TNG we will unveil under which conditions and why the physical connection between HI and angular momentum is broken.

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1314

The first WALLABY public data release: enabling new science with a large sample of spatially resolved galaxies

Dr Tobias Westmeier

International Centre for Radio Astronomy Research, The University of Western Australia

Abstract

WALLABY is a large-scale extragalactic HI survey currently being carried out on the Australian SKA Pathfinder (ASKAP). Between 2019 and 2022 WALLABY carried out a pilot survey with the aim of verifying the observing and data reduction strategy and post-processing workflow. The pilot survey targeted 6 fields covering a total of 360 square degrees of sky. About 2400 galaxies detected in HI emission in those fields out to a redshift of ~0.08 have now been released to the public.

A crucial aspect of the WALLABY pilot survey is the fact that most of the galaxies are at least marginally resolved by the 30-arcsec beam, thus enabling new science based on the morphological analysis of a large statistical sample of resolved HI discs. I will briefly describe the observations and data processing and give an overview of the resulting galaxy sample and data products that have been made available to the community. I will then highlight some of the first scientific results from WALLABY that have been enabled by the combination of sample size and angular resolution, with a particular focus on the influence of the environment on the neutral gas component of galaxies.

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Uncovering Extraplanar Gas in UGCA250 with the Ultra-Deep MHONGOOSE Survey

Dr Sushma Kurapati[1], Prof D.J. Pisano[1], Prof Erwin de Blok[2]

[1]University of Cape Town. [2]ASTRON, the Netherlands Institute for Radio Astronomy

Abstract

It is becoming increasingly clear that gas accretion is necessary to sustain the observed levels of star formation rates in galaxies. A key area of focus lies in the disc-halo interface region, which offers insight into gas exchange processes between the disc and the circumgalactic medium. Using HI 21 cm observations from the ultra-deep MHONGOOSE survey, we explore extraplanar gas in the edge-on galaxy UGCA250. The combination of high column density sensitivity and high spatial resolution — ranging from 6.8×10^{19} cm^{-2} at 6'' resolution to 6.4×10^{17} cm^{-2} at 90'' resolution (at 3σ over 20 km/s) — over a large field of view, is ideal for studying the underlying physics governing extraplanar gas and the disc-halo connection. These data reveal that UGCA250 has nine companion galaxies and features a tail-like extension southwest up to ~34 kpc (in projection). Additionally, we identify a counter-rotating cloud with forbidden velocities, possibly indicative of a foreground galaxy. We construct a detailed tilted ring model for this edge-on galaxy to gain a deeper understanding of the vertical structure of its neutral hydrogen. The model that best matches the observed data cube features a thick disk with a scale height of ~3 kpc and an HI mass constituting about 25% of the total HI mass. Furthermore, we discuss various possible scenarios for the origin of the extraplanar and anomalous gas in UGCA250. This extraplanar gas is detected for the first time in UGCA250, and the HI halo/thick disc exhibits structures on various scales.

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Spatial Variation of Cold and Unstable Neutral Hydrogen Gas of the Milky Way in the Southern Sky

Mr Callum Lynn, Dr Antoine Marchal, Professor Naomi McClure-Griffiths

Australian National University

Abstract

Star formation occurs through the gravitational collapse of dense molecular clouds, however the processes leading to the production of these over-densities are still unclear. One key element seems to be related to the efficiency of thermal condensation of the neutral interstellar medium from warm to cold gas, leading to the formation of molecular cloud precursors. As part of the Galactic Australian Square Kilometre Array Pathfinder (GASKAP) neutral Hydrogen (HI) survey, we have observed more than 2000 background radio sources distributed homogeneously across a 300 square-degree region in the southern sky, making it the first unbiased survey with high source density ever observed. While hundreds of them show direct detections of Milky Way HI absorption against these background sources, ~2000 sight-lines are dominated by noise. However, these noise-dominated sight-lines still carry multiphase information on the interstellar medium of the solar neighbourhood. I will present a stacking analysis of this sample of spectra classified as non-detections revealing, for the first time, the properties of the unstable neutral medium and its phase transition to the cold neutral medium over a large region of the southern sky. Uniquely, I will show how the high source density of our survey allows us to probe the spatial variation of both the cold and unstable gas compressed along the wall of the Local Bubble, a region that is a primary laboratory for investigating the early phase of star formation.

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The HI asymmetries within the host galaxies of fast radio bursts

Dr Marcin Glowacki[1], Dr Karen Lee-Waddell[2,3]

[1]Curtin Institute of Radio Astronomy. [2]AusSRC. [3]CSIRO

Abstract

While analysis of localised fast radio burst (FRB) host galaxies typically focuses on the stellar component, neutral hydrogen (HI), traced through the 21-cm transition with radio telescopes, informs us on the gas content of galaxies. The HI distribution can reveal to us the history of the galaxy through asymmetry, such as merger events that may not be evident from the stellar information alone. This is an important consideration for understanding the environments of FRBs and their progenitors. We report on HI follow-up of several host galaxies of FRBs identified by the CRAFT survey team and other surveys, including the first commensal detection and localisation of FRB20211127I, and the detection of HI emission in the FRB host galaxy with ASKAP. While other examples have shown strong asymmetric HI spectra or disturbed HI distributions, MeerKAT follow-up of FRB20211127I revealed remarkably normal HI gas – unlike any previous detection of HI emission in an FRB host, complicating the previous picture supporting a 'fast channel model' for FRB progenitors. Separate MeerKAT observations also demonstrated how we can use HI to obtain the redshift of obscured FRB host galaxies where optical follow-up is difficult, such as those at low Galactic latitudes.

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The lifecycle of gas in Hickson compact groups as seen by MeerKAT

Dr Roger IANJAMASIMANANA, Dr Lourdes Verdes-Montenegro, Dr Amidou Sorgho, Mr Ixaka Labadie

Instituto de Astrofísica de Andalucía (IAA-CSIC)

Abstract

Hickson Compact Groups (HCGs) are systems of four to ten galaxies located close to each other, making them prime targets for studying the processes that quench gas and star formation. These groups exhibit similar conditions to those found in rich clusters but they are located in less dense environments. According to an evolutionary sequence proposed in the literature, HCGs undergo three main phases. In the first phase, the galaxies' kinematics are mostly unperturbed, with the bulk of their neutral hydrogen gas (HI) located within their disks. In the second phase, galaxy interactions disrupt the gas kinematics and morphology, displacing a significant portion of the gas out of the disk to form tidal tails and bridges. In the third phase, most or all of the gas exists as features not associated with the disks of the galaxies. In this talk, we present results from recent MeerKAT HI observations of six HCGs in phase 2 and phase 3 of their evolutionary sequence. The superb sensitivity of MeerKAT allowed us to detect many extended features not previously seen by the Very Large Array (VLA) for phase 2 groups. We use advanced 3D visualisations of these groups to aid in the separation of extended structures not associated with the disk of the member galaxies. For phase 3 groups, no diffuse Hi emission was found, though we detected high-brightness features not previously seen at the core of the group. We also detected many surrounding galaxies that opened up a new window to study environmental effects on the evolution of these galaxies.

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Conference summary and forward look on HI in and around galaxies in the SKA era

Prof. Thijs van der Hulst

Kapteyn Astronomical Institute, University of Groningen

Abstract

This presentation will be a combination of a summary of the highlights of IAU symposium 392 "Neutral hydrogen in and around galaxies in the SKA era" and personal reflections on the advances in HI research in the last fifty years. In addition I will address the promise and perspective of future HI research with the high quality data from the SKA precursors and eventually the completed SKA.

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1430

Exploring the disk thickness of HI galaxies in MHONGOOSE

Mr Notahiana Ranaivoharimina

University of Cape Town

Abstract

Understanding the thicknesses of disk galaxies is crucial to further determine galaxy properties such as the volumetric star formation law and the shape of dark matter halo. The neutral hydrogen (HI) component stands out due to its ubiquity in disk galaxies and its tight connection to star formation and feedback in galaxies. In this project, we examine the HI scale heights h of four edge-on MHONGOOSE galaxies at $z \sim 0$ and find the presence of both an HI thin and thick disk with typical values of h_thin = 0.7 - 1.4 kpc and h_thick = 1.4 - 3.6 kpc. We will also discuss how the HI scale heights relate to other properties of the galaxies, including the scale height in the IR and optical, and investigate the implications for star formation and feedback in these galaxies.

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Atomic Gas Over 8 Gyr of Cosmic History with the DSA-2000

Ryan Keenan[1], Fabian Walter[1], Leindert Boogaard[1], Marcel Neeleman[2]

[1]Max-Planck-Institut für Astronomie. [2]NRAO

Abstract

Atomic gas disks provide the source of cool gas that will eventually fuel star formation, and are also an interface between galaxies and accreting material from the intergalactic medium. The history of this atomic gas is critically linked to the building and evolution of galaxies. The DSA-2000 will survey HI over three-quarters of the sky beginning in 2028. The planned survey will provide an unprecedented combination of sensitivity and sky coverage. We expect to detect of HI emission from massive galaxies up to z=1 and will produce extensive target catalogs for high-resolution follow-up with the SKA. I will discuss our work preparing for the DSA-2000 HI survey. I will show our forecasted constraints on the HI mass function and the total HI mass density of the universe over 8 billion years of cosmic history. These results will reveal a key phase of the baryon cycle with exquisite detail and place tight constraints on models of galaxy evolution.

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Background HI Galaxies in the MHONGOOSE Survey

Ryan Keenan[1], Erwin de Blok[2], Fabian Walter[1]

[1]Max-Planck-Institut für Astronomie. [2]ASTRON

Abstract

The sensitivity and wide bandpass of MeerKAT mean that even targeted observations detect HI emission from large numbers of background galaxies. MHONGOOSE targeted 30 galaxies for deep (55 hour) MeerKAT observations. Wideband spectra recorded as part of the survey contain HI emission from galaxies at z<0.6 at a ~50 km/s velocity resolution. This provides a volume of ~2.4x10^8 Mpc^3 over which to search for serendipitous HI background galaxies. We will present the first results from our mining of this rich dataset. Significant numbers of background galaxies are present with only the first 10% of data for each field. We plan to use this data to measure the HI mass function and constrain the evolution of the cosmic HI mass density.

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Determining the properties of galaxies in MeerChoirs groups

JC Viljoen

North-West University. South African Astronomical Observatories

Abstract

MeerChoirs is an HI study of the Choirs groups (Sweet et al., 2013), a selection of 15 nearby groups catalogued in SINGG (Meurer et al., 2006). Galaxy groups hold a significant position in the cosmic hierarchy, bridging the gap between low-density field environments and high-density clusters, revealing how galactic interactions and rising density impact galaxies as they move from the blue cloud to the red sequence. The Choirs groups are late-type dominated, gas-rich, and believed to be in the early stages of assembly. Compared with the interaction-rich Hickson Compact groups, the Choirs groups are more representative of typical group environments, some displaying morphological similarities to the local group, with approximately half featuring pairs of large interacting spirals alongside numerous dwarf galaxies.

This study examines HIPASS-J1059-09, at D=122Mpc, with M_{HI}=10.42dex and M_{200}=1.09$M_{\odot}$, this group features a central pair of spiral galaxies with a tidal dwarf and several nearby spiral and dwarf galaxies. The MeerKAT observations improved the resolution and field of view of previous HI imaging, allowing for a detailed study of intragroup interactions and their effects on galaxy properties. Faint gas bridges were observed between the central spirals and HIPASS-J1059-09:S2, and interactions between HIPASS-J1059-09:S2 and HIPASS-J1059-09:S6 were also observed. The HI peak was observed outside the central spiral, suggesting complex gas dynamics, ongoing interactions, and gas stripping processes. These findings provide insights into the ongoing interactions and material exchanges within the group. Furthermore, previously unseen group members were revealed, thus expanding our understanding of the group's composition and dynamics.

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HI at unprecedented sensitivities: the remarkable HI contents of MHONGOOSE galaxy UGCA320 and its neighbours

Nikki Zabel[1], Sushma Kurapati[1], D.J. Pisano[1], Erwin De Blok[2,3,1], Julia Healy[2]

[1]UCT. [2]ASTRON. [3]University of Groningen

Abstract

One of the key questions in the field of galaxy evolution is "How do galaxies assemble and evolve?". The MeerKAT HI Observations of Nearby Galactic Objects - Observing Southern Emitters (MHONGOOSE) survey aims to address this question by imaging the diffuse gas at the outskirts of galaxies down to HI column densities as low as ~5x10^17 cm^-2 for the first time, looking for direct evidence of accretion, among other science goals. In this talk I will show results from one of the MHONGOOSE targets, UGCA320. UGCA320 is an edge-on dwarf galaxy (stellar mass ~10^9 Msol) with a remarkable HI disc. It contains extraplanar gas that can only be detected with these highly sensitive observations, as well as asymmetries and velocity structures that cannot be explained with simple models. UGCA320 is part of a small galaxy group, and has possibly interacted with one or more of its neighbours. These are also included in the MeerKAT FoV, and have resulted in some very interesting serendipitous HI detections that warrant detailed, individual studies of their own. In this talk I will present a detailed analysis of the HI content of UGCA320, and discuss possible interpretations in the context of the group environment. The surprising low column density features we detect with these ultra-deep observations showcase excellently what unprecendented detections of the neutral hydrogen in and around galaxies the SKA might bring, not only in groups of dwarf galaxies, but in a wide range of galaxy types and masses.

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First MeerKAT Observations of the Brightest M31-M33 Neutral Hydrogen Cloud in the Circumgalactic Medium of M31

Miss Kyra Kummer, Professor D.J. Pisano

University of Cape Town

Abstract

In 2004, Braun and Thilker discovered a bridge of faint, diffuse HI gas appearing to link the galaxies M31 and M33. Follow-up, higher resolution observations by Wolfe et al. (2013, 2016) with the Green Bank Telescope (GBT) revealed that the filament broke up into individual and discrete higher column density clouds in the region surveyed. The nature and origin of these clouds remains an open question. Previous observations lacked the spatial and spectral resolution to probe the internal structure of the clouds, limiting our understanding of these objects.

We present the first MeerKAT observations of the brightest HI cloud in the M31-M33 filament, at a resolution of 40" - a factor of 13x higher than the GBT. Our analysis unveils previously unseen details in the internal kinematic structure of the HI cloud. We measure the peak HI column density to be N_{HI}~10^{19} cm^{-2} - an order of magnitude greater than previously observed. We recover approximately two-thirds of the HI mass detected by the GBT.

We see signs of ram pressure stripping implying a CGM HI number density of n_{HI}~10^{-4}. The cloud may also have been tidally disrupted by M31. Both results suggest that this cloud is being destroyed as it falls through the CGM of M31.

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First MeerKAT Observations of the Brightest M31-M33 Neutral Hydrogen Cloud in the Circumgalactic Medium of M31

Miss Kyra Kummer, Professor D.J. Pisano

University of Cape Town

Abstract

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We present the first MeerKAT observations of the brightest HI cloud in the M31-M33 filament, at a resolution of 40" - a factor of 13x higher than the GBT. Our analysis unveils previously unseen details in the internal kinematic structure of the HI cloud. We measure the peak HI column density to be NHI~1019 cm-2 - an order of magnitude greater than previously observed. We recover approximately two-thirds of the HI mass detected by the GBT.
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Understanding the Evolutionary History of UGCA319 Through Analysis of HI Gas Distributions & Kinematics

Omri Scannell[1], Nikki Zabel[1], D.J. Pisano[1], Erwin De Blok[2,3,1]

[1]UCT. [2]ASTRON. [3]University of Groningen

Abstract

The dwarf irregular galaxy UGCA 319 (Mstar ~ 3^8 Msol) was serendipitously detected in HI as part of the MeerKAT HI Observations of Nearby Galactic Objects - Observing Southern Emitters (MHONGOOSE) survey. Being part of the same small galaxy group as one of MHONGOOSE's main targets (UGCA 320), and as such contained in MeerKAT's FoV, UGCA 319 was discovered to harbour a very unusual HI "disc". It appears to consist of several clouds, of which it is, at this stage, unclear whether they are accumulating or dissipating. My study of UGCA 319 aims to investigate the characteristics of this unusual dwarf galaxy, in order to understand the galaxy's HI gas dynamics and its evolutionary context within its galaxy group. Besides studying the neutral gas distribution and kinematics using tools such as moment maps and position-velocity diagrams, I perform Gaussian decomposition of the HI line where appropriate, and I exploit the "Visualization Laboratory" to analyse the 3D structure of the neutral gas in this galaxy in detail. Additionally, our analysis is complemented by deep VST optical imaging to provide further insights into the galaxy's morphology. Not only does UGCA 319 provide important insights in the formation and evolution of dwarf galaxies in groups, it is also a great example of the unexpected but important surprises the SKA will bring us.

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On-The-Fly interferometric imaging with the MeerKLASS survey

Dr. Suman Chatterjee

University of the Western Cape, Cape Town, South Africa.

Abstract

MeerKLASS, the MeerKAT Large Area Synoptic Survey, aims to survey large areas of the sky with MeerKAT in order to probe cosmology using the single dish HI intensity mapping technique, while producing continuum images with the interferometer. The target is to cover 10,000 deg2 on the UHF band with 25 uJy rms and 13'' resolution (a new survey in the L-band with the MeerKAT extension aiming at 5,000 deg2, 9 uJy rms and 5'' has also been proposed). The single dish survey requires a fast scanning mode at constant elevation in order to deal with systematics. This requires the use of the "On-The-Fly" (OTF) interferometric imaging technique to enable commensal observing for intensity mapping and interferometric imaging. In this work, we demonstrate that science-quality OTF interferometric continuum imaging with fast scanning speeds is possible with MeerKAT, using available MeerKLASS data. We develop a framework to transform MeerKLASS scan observations into OTF-format measurement sets and mitigate these issues. We use these measurement sets to produce OTF interferometric imaging snapshots and employ two different techniques to add multiple OTF snapshots. Till now we have processed OTF snapshots in L-band, that cover about 300 square degrees in the Southern sky and achieved an image sensitivity of ~140 uJy and we aim to reach about 30 uJy with the existing observations. In future, with many fold data acquisition by the MeerKLASS survey we expect to embark on the search for slow transient and deep imaging.

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How to observe your favourite HI source(s) with the SKA telescopes?

Dr Sarrvesh Seethapuram Sridhar, Dr Shari Breen, Dr Nichol Cunningham, Dr Sharmila Goedhart, Dr Jimi Green, Dr Danny Price

Square Kilometre Array Observatory

Abstract

The SKA Low and Mid telescopes are next-generation flagship radio astronomical facilities that will revolutionize radio astronomy for decades. With the SKA telescopes now officially in their construction phase, the first HI observations are almost in sight, but when is the HI community likely to see their first SKA data? What kinds of HI science will be possible and when?

In this talk, I will provide a detailed overview of the technical capabilities of the SKA telescopes and describe how the telescopes can be configured to achieve transformational HI science. I will also introduce several user-facing tools (like the sensitivity calculator and subarray simulation tool) that SKAO has recently released to the community. I will conclude with a timeline for the telescope construction and how the community can participate in the Science Verification process.

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Rotation Curves from Cosmological Simulation with Mock HI Cubes for Comparison with Observations

Mr Nhlakanipho Kunene[1], Prof Lerothodi Leeuw[1], Prof Maarten Baes[2], Mr Andrea Gebek[2]

[1]University of the Western Cape. [2]Ghent University

Abstract

HI rotation curves are one of the main tools to investigate the connection between baryonic and dark matter in galaxies. We present a pipeline designed to produce realistic observed HI data cubes for galaxies extracted from cosmological hydrodynamical simulations, while fully considering radiative transfer and other observational effects. More specifically, we examine synthetic rotation curves for a large sample of simulated disc galaxies selected from the TNG50 simulation, generated using the SKIRT radiative transfer code. We compare the rotation curves to those derived from HI observations from cutting-edge telescopes like MeerKAT, and critically investigate the effect of observational effects and rotation curve modelling tools. The project's outcomes are poised to significantly narrow the divide between simulated and observed data in cosmology, offering invaluable insights for studies comparing cosmological simulations with observational data through galaxy kinematics.

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Large-scale HI content of late-phase Hickson Compact Groups

Dr Amidou Sorgho, Dr Lourdes Verdes-Montenegro, Dr Ianjamasimanana Roger

CSIC-IAA

Abstract

In hierarchical assembling, galaxies are predicted to undergo pre-processing within groups before infalling into denser environments such as clusters. During this pre-processing phase, they are expected to lose an important fraction of their star formation reservoir, their HI gas. Due to their moderate size and compactness, Hickson Compact Groups (HCGs) form a unique laboratory for understanding the role of environments on HI and galaxy evolution. An evolutionary sequence with three main phases contextualises the systematic differences in HCGs' evolution. As compact groups evolve, HI is stripped from member galaxies into the intragroup medium, forming bridges and tails. In the late phase, most of the HI is found in a diffuse form, with a significant amount missing. However, until recently, no HI observations with sufficient sensitivity and resolution have allowed for a comprehensive understanding of the transition towards the late phases. Leveraging MeerKAT's enhanced capabilities, we have mapped the HI in and around six HCGs in the intermediate and late phases of the evolutionary sequence. In this talk, I will discuss the similarities and distinctions between the two phases regarding the large-scale HI content and distribution, and what these imply in the context of the rapid transition of HCGs from intermediate to late evolutionary phase.

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Turbulence properties and star formation in nearby spiral and dwarf galaxies

Ms Nancy Julianna TOVOLAHY

University of Antananarivo

Abstract

In this analysis, we trace the turbulence properties in nearby spiral and dwarf galaxies and compare them with their star formation distribution. We use Gaussian decomposition of the velocity profiles of neutral atomic hydrogen (HI) and statistical tools from the TurbuStat package to trace the turbulence properties of our sample galaxies. We infer their local star formation rate using ultraviolet and infrared radiation as tracers. Our sample galaxies include spiral and dwarf galaxies from The HI Nearby Galaxy Surveys (THINGS). We aim to understand the possible effects of turbulence on the local star formation rate.

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The Gas Depletion Timescale of Star-Forming Galaxies at Intermediate Redshift.

Ms Lara Featherstone

University of Cape Town (UCT). South African Astronomical Observatory (SAAO)

Abstract

Neutral Hydrogen (HI) gas reservoirs make up the bulk of the interstellar medium as well as the raw fuel out of which stars eventually form. The star formation rate (SFR) density has been observed to decline sharply over the past 10 Gyr (since z~2). Through stacking HI data from the uGMRT, Chowdhury et al. (2022) have recently measured the average HI masses and HI depletion timescales <t_HI> = <M_HI>/<SFR> of galaxies at redshifts 0.74 < z < 1.45. They credited the observed decline in the SFR density to a lack of cold gas accretion from the circum-galactic medium or mergers at z~1 that could replenish and sustain the HI reservoirs of star-forming main sequence (SFMS) galaxies.

The L-band dataset from the deep HI survey, LADUMA, on the MeerKAT radio telescope is ideal to probe the gas-depletion timescales of galaxies and study the cosmic SFR density at intermediate redshift (0 < z < 0.56). In this work, we use the first LADUMA L-band data release consisting of 127 hours of observations of the LADUMA field. For a sample selection of SFMS galaxies, we utilise the HI spectral stacking software (HISS - Healy et al 2019) to determine average HI depletion timescales at intermediate redshift.

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Multi-tracing the primordial Universe with future surveys

Miss Mponeng Kopana[1], Prof Roy Maartens[1,2,3], Dr Sheean Jolicoeur[4,1]

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Abstract

HI intensity mapping (21cm maps) trace the large-scale structure in the Universe, and contain a wealth of information about the origins and evolution of that structure, which in turn provide measurements and tests of the standard cosmological model. In particular, 21cm maps can provide accurate measurements of redshift space distortions generated by galaxy peculiar velocities. Since fluctuations seed the large-scale structure, any primordial non-Gaussianity of local type will leave an imprint on the tracer power spectrum on ultra-large scales. We employ and develop models of 21cm intensity maps and their power spectra, as expected from HIRAX and PUMA, in order to forecast the precision with which we can measure the non-Gaussianity parameter (f_NL). We include linear effects in redshift space, in addition to telescope beam and foreground effects. These are interferometer modes of 21cm intensity mapping will be investigated. Furthermore, we investigate the combination of 21cm intensity maps with contemporaneous galaxy surveys, such as those planned for the Euclid and MeggaMapper telescopes. Such synergies can suppress some of the systematics that affect each survey, as well as improving on the precision and accuracy of cosmological measurements made by the separate surveys.

Session

IAUS 389 Gravitational Wave Astrophysics

1712

Was the recent radio activity of PKS 2014-55 triggered by a merger?

Mr Leon Mtshweni[1], Dr Kshitij Thorat[1], Prof Roger Deane[2,1]

[1]University of Pretoria. [2]University of Witwatersrand

Abstract

Gas in the inner regions of a galaxy can be siphoned into a SMBH to transform it into an AGN. It is through these interactions and galactic mergers that starving blackholes are fed and kept active. We present new high spectral resolution MeerKAT observations of HI absorption in the restarted X-shaped radio galaxy PKS 2014-55. The multi-component spectrum reveals three features, all redshifted relative to the systemic velocity of the radio core, suggesting an inward motion of gas clouds towards the core. Notably, all three components exceed the galaxy's typical rotational velocity of approximately 100 km/s, suggesting potential infall into the supermassive black hole and subsequent AGN fueling. At present, there is no conclusive evidence linking the redshifted gas directly to fueling the AGN. For completeness, we consider alternative explanations: the least redshifted and strongest components may represent regularly rotating gas, as they remain relatively close to the galaxy's rotational velocity. In contrast, the broad component could be a foreground cloud of warm gas gravitationally bound by PKS 2014-55. We also detect HI emission from nearby dwarf galaxies. The recent reactivation of PKS 2014-55, coupled with the spatial proximity of these dwarf galaxies, suggests a possible merger as a triggering event. Our observations help put constraints on the neutral hydrogen dynamics correlated with a newly restarted jet activity. This finding underscores the significance of such interactions as potential drivers of AGN and highlights the need to further study gas associated with galaxies.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1717

A new HI perspective of star forming galaxies in the Local Universe

Dr Dane Kleiner

ASTRON

Abstract

I will present high resolution, ultra-deep H_I images of the nearby, newly discovered interacting NGC 4781 triplet, observed by MeerKAT as part of the MHONGOOSE survey. The triplet is situated at 11 Mpc, and consists of two late types and one dwarf irregular galaxy. The global properties and scaling relations are consistent with other late type, star forming galaxies of the same stellar mass. However, the diffuse (10^{17} - 10^{18} cm^{-2}) H_I component shows a remarkable new scenario of interacting galaxies. There is extensive (~ 50 kpc) extra-planar H_I gas associated with the two late type galaxies as well as an extended H_I tail complex that connects the two satellite galaxies. The H_I velocity field shows many diffuse components that are not associated with the rotating disk, and both late types contain large coherent arcs of H_I with a high (30 - 80 km s^{-1}) velocity dispersion, well outside the stellar disk. Two quick, successive flybys that tidally disturbed the diffuse H_I but left the H_I in the disk and stellar component untouched is likely responsible for the observed properties. We compute the timescale of the flybys and compare it to similar galaxies in the SIMBA simulations. We predict that the SKA will detect many systems like this, as extensive diffuse H_I complexes is likely very common for late-type, star-forming galaxies in close (e.g. < 100 kpc) proximity.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

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1730

The rapid removal of HI from dwarf galaxies

Dr Dane Kleiner

ASTRON

Abstract

I will present results of how quickly the smallest galaxies lose their H_I in the Fornax Cluster. As part of the MeerKAT Fornax Survey, we detect (and resolve in most cases) H_I in 17 dwarf galaxies that range between $M_{HI} \sim 10^6$ - 10^9 M_{sol}. Up until now, galaxies of this H_I mass have only been detected in the Local Group. The deep MeerKAT observations enable the exploration of low column density (10^{18} - 10^{19} cm^{-2}), resolved (~ a few to tens arcsec) H_I in dwarf galaxies at 20 Mpc. I will present the collection of evidence that results in late type star-forming dwarf galaxies losing their H_I in only a few hundred Myr once tidal and / or hydrodynamical forces in the cluster act on their interstellar medium. We also detect H_I in 3 early type dwarfs (out of 260), a rare class of objects with H_I, that are at a different stage of evolution compared to the late type dwarfs. I will discuss the different scenarios that lead to the early type dwarfs containing H_I. Due to the efficient removal of H_I from low-mass galaxies, the H_I Mass Function of the Fornax collapses below $M_{HI} = 10^7$ M_{sol}.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1732

POST-STARBURST GALAXIES IN THE COSMOS FIELD

Mr Martin Shanobe

University of Cape Town

Abstract

Post-starburst galaxies (PSBs) play a role in galaxy evolution as they bridge the gap between actively star forming galaxies and their quenched counterparts. Characterised by their lack of massive young stars and a substantial fraction of intermediate-mass A- and F-type stars, they offer a plausible transitional channel between the two phases. Moreover, PSBs are among the prime candidates for investigating why some gas-rich galaxies quench their star formation; they are thought to be descendants of starburst galaxies and some are known to possess substantial reservoirs of neutral hydrogen gas (HI). We present a catalogue of 39 spectroscopically selected PSBs, at $z<0.45$ within the Cosmic Evolution Survey (COSMOS) field. We measure their colours, star formation rates and morphologies finding indications suggestive of a transitional phase. We find, using empirical emission line diagnostic techniques, that some galaxies within our sample have LINER-like emission properties, which further supports our claim that they are in an intermediate evolutionary phase and hints at a potential quenching pathway. In addition, we leverage HI emission data and radio continuum data from the COSMOS HI Large Extragalactic Exploration Survey (CHILES) and the MeerKAT International Giga Hertz Tiered Extragalactic Exploration (MIGHTEE) survey to study the star formation history and star formation potential in these PSBs.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

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1740

Calculating the spectral index of the Galactic synchrotron emission using UHF MeerKAT data

Mr Sifiso Mahlalela

University of the Western Cape

Abstract

Our project focuses on measuring the defused Galactic synchrotron emission to probe the Galactic magnetic field and point source distribution across redshift and various angular scales. We are examining the 8 blocks of observational data acquired in 2022, where the Temperature-Temperature plot method is employed to do the analysis of the synchrotron emission by calculating the spectral index. Since this method requires two different frequencies to do the analysis, we use the Haslam map at 408 MHz with our frequency channels. This approach helps in validating the current pipeline as well as probing the Interstellar Medium (ISM). The correlation of coefficient with Haslam helps in identifying regions that are affected by the RFI. Despite a strong correlation coefficient, we see peculiar behaviour from the spectral index. Unlike the anticipated patterns, the spectral index changes drastically as the frequency increases particularly on regions characterised by steep slopes. This unexpected behaviours requires more investigation.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1802

Chemical diversity in distant damped Lyman-alpha absorbers

Tanita Ramburuth-Hurt

University of Geneva

Abstract

Damped Lyman-alpha absorbers (DLAs), defined as gas systems with hydrogen column densities greater than $10^{20.3}$ cm^{-2}, are important for understanding the distribution and evolution of neutral hydrogen gas, shedding light on the formation and chemical makeup of galaxies across cosmic epochs through their absorption of light from distant quasars. With high resolution spectroscopy it is possible to study chemical variations and kinematics between individual gas components within DLAs. Without information on the HI content for individual gas components, however, metallicity cannot be directly calculated in each component. MeerKAT and the SKA have the potential to resolve the caveat in the future. In the meantime, dust depletion can be used as a proxy for chemical enrichment. This talk will focus on a component-by-component analysis of 64 DLAs between $1.7 < z < 4.2$, highlighting the main results, which include chemical diversity within galaxies, evidence for alpha-element enhancement, and potential hints for gas inflows and outflows. These results are important for understanding the chemical evolution of galaxies and galactic gas cycles.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1804

Searching for AGN-associated HI 21-cm Absorption in the MIGHTEE survey

Ms Kathleen Charlton[1], Dr Jacinta Delhaize[1], Prof Matt Jarvis[2,3], Dr Ian Heywood[2,4,5]

[1]University of Cape Town. [2]University of Oxford. [3]University of the Western Cape. [4]Rhodes University. [5]South African Radio Astronomy Observatory

Abstract

Two important components of galaxies, which are thought to play important roles in their evolution, are the neutral hydrogen gas (HI) content and active galactic nuclei (AGN) actvity. Yet very little is known about the relationship and interplay between these components. The phenomenal sensitivity achieved with the precursor telescope MeerKAT now allows us to more directly examine the influence of AGN feedback on the gas content of galaxies. Thus, we present a study of the AGN-associated HI absorption detected in the MIGHTEE-HI survey over a redshift range of $0 < z < 0.6$. This is first done in a targeted search and then followed by a blind survey using both SoFiA-2 and Flash-Finder in order to compare and confirm results.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1829

HI Intensity mapping with MeerKAT: primary beam effects on foreground cleaning

Dr Siyambonga Matshawule

University of the Western Cape

Abstract

HI intensity mapping surveys will provide a great opportunity to study the evolution of neutral hydrogen across cosmic time and constrain cosmology in the post-reionization Universe. The MeerKAT Large Area Synoptic Survey (MeerKLASS) is the proposed HI IM survey to be conducted with the MeerKAT and future SKAO radio telescopes, mainly in single-dish mode. The successful application of this observational technique requires good accuracy in the separation of strong astrophysical foregrounds and the cosmological HI signal. Foreground cleaning methods are often applied under the assumption of a simplistic Gaussian primary beam.

In this talk, I will discuss how we simulate a single-dish HI intensity mapping wide-area survey with MeerKAT radio telescope characteristics to test the cleaning of foregrounds in the presence of a realistic primary beam model with a non-trivial frequency dependence. Using the same observation pipeline I discuss how we probe the effect of primary beam sidelobes in the recovery of the cosmological HI signal, particularly in the presence of strong point sources.

Session

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1856

DESIGN AND DEVELOPMENT OF A L-BAND FOUR-ELEMENT INTERFEROMETER FOR THE STUDY OF GALACTIC NEUTRAL HYDROGEN EMISSION

Mr Albert Kuntu Forson[1], Prof. Nalini Heeralall-Issur[1], Prof. Deshpande A. Avanish[2], Prof. Peter Wilkinson[3], Dr. Kumah Golap[4], Mr Paul Akumu[1]

[1]Department of Physics, University of Mauritius. [2]Raman Research Institute Bangalore, India , Inter-University Centre for Astronomy and Astrophysics, Pune 411007, India, Indian Institute of Technology, Kanpur 208016, India. [3]School of Physics and Astronomy, University of Manchester U.K. [4]National Radio Astronomy Observatory, USA

Abstract

Understanding the complexities of our galaxy's structure and dynamics is a challenge due to our position within its rotating disc of stars, gas, and dust. Optical wavelengths face hindrances from dust obscuration, while radio waves, especially the 21cm line emission of neutral hydrogen (HI), offer a potent investigative tool. HI, distributed across various spatial scales in the Milky Way, exhibits a power-law nature in spatial power spectra, ranging from 2.2 to 3.0. Previous studies have demonstrated that the spatial power spectrum can be directly sampled through interferometric measurements of HI on corresponding short baselines. This enables the determination of structures at various scales and the construction of Interstellar Medium (ISM) models.

Despite advantages shown in past interferometry studies, limitations emerged due to dish sizes, restricting exploration of shorter baselines. This paper presents the design and development of an L-band four-element interferometer at the Mauritius Radio Astronomy Observatory, featuring a baseline of 8 - 62m. This system facilitates the large-scale study of galactic neutral hydrogen, monitors the sky for radio transient sources, and serves as a crucial radio astronomy instrument for research, training, and outreach in Africa. Overcoming challenges, including cyclone-adapted mechanical stability, the converted satellite dish antennas proved durable under extreme weather conditions. Tests, including wide-band and narrow-band mode measurements, validated the system's performance, yielding encouraging results on the Galactic HI spectrum. The study, detailed by A. K. Forson et al. (2023), provides valuable insights into radio astronomical measurements and interferometry

Session

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1916

Gas filaments and nebulosity in the field around Stephan's Quintet

Dr Simon Kemp

Instituto de Astronomia y Meteorologia, Universidad de Guadalajara. Mexico

Abstract

Since the pioneering work of Arp and collaborators in the 1970s it has been known that the field between Stephan's Quintet and NGC 7331 contains much diffuse gas and filamentary structures. Little to no work on the nature of these structures was done is subsequent years although a new deep colour image was published by Duc et al . (2018) confirming the existence of the structures and showing them n fine detail. Here we carry out a detailed study of the structures using the data of Duc el al., and some deeper exposures of selected fields and look for detections in other wavebands. One filament is just a tidal feature (principally stars) associated with the interactions in Stephan's Quintet, but a couple of others which may or may not be to be tidal features, seem to be directed towards the Quintet and another to NGC7331,while a couple seem to be associated with extragalactic radio sources. Some seem to be Galactic in nature with possible HII regions or reflection nebulae (although the relatively high Galactic latitude makes this less likely), and also detected in WISE 12 microns and in UV. We compare with recent HI observations of the area obtained using FAST which suggests that there may be some lower-velocity gas in HI associated with two of these filaments and NGC 7331.

Session

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1918

Survival and synthetic observables of neutral atomic hydrogen in galactic wind simulations

Dr Wladimir Banda-Barragan

Yachay Tech University

Abstract

We discuss the evolution of radiative cloud systems embedded in starburst-driven galactic winds. In our 3D simulations of single-cloud and multi-cloud models embedded in supersonic winds, atomic clouds are able to radiate while they accelerate downstream. We show that individual clouds are rapidly eroded and destroyed by dynamical instabilities in such models, but multicloud gas streams are able to survive. We show that radiative cooling promotes the survival of dense gas and the development of rain-like filamentary outflows, akin to those seen in observations. We also find that hydrodynamic shielding in cold gas streams reduces drag forces and contributes to preserving dense atomic gas. Re-condensation and shielding then ensure that dense gas is replenished along the flow. Magnetic fields offer some extra stability to dense gas in models where they are included. Magnetic fields transverse to the wind alter the morphology of wind-swept clouds by making the flow around them more laminar, and we show that such changes of magnetic origin do have an effect on synthetic observables, particularly on ion spectral lines. Broader spectral lines of neutral atomic hydrogen are characteristic of clouds embedded in transverse magnetic fields. At the end of this talk, I compare the dynamical, morphological, and spectral properties of dense outflowing gas in our simulations to those of atomic (HI) gas components in the nuclear wind of our Galaxy.

Session

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1920

New science results from individual HI detections in the LADUMA field

Andrew Baker[1,2], Amir Kazemi-Moridani[1], John Wu[3], Sarah Blyth[4], Benne Holwerda[5]

[1]Rutgers, The State University of New Jersey. [2]University of the Western Cape. [3]Space Telescope Science Institute. [4]University of Cape Town. [5]University of Louisville

Abstract

The Looking At the Distant Universe with the MeerKAT Array (LADUMA) survey is probing HI in emission to redshift z = 1.44 within a single field that encompasses the Chandra Deep Field South. This presentation will introduce LADUMA, its first public data release, and two science analyses based on the 200+ galaxies that have been individually detected in the initial tranche of the survey's L-band observations. The first analysis features a novel forward-modeling approach to determining the HI mass function that fully accounts for systematic uncertainties in the process of measuring HI masses. The second analysis leverages machine learning techniques to identify a previously unreported low-mass, gas-rich galaxy group in the LADUMA field. Both analyses establish benchmarks that can be fruitfully extended to higher redshifts or wider areas in deeper survey datasets. The presentation will comment on prospects for such analyses with Square Kilometre Array (SKA) pathfinders and with the SKA itself.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1936

Peculiar velocities and cosmological constraints from HI Tully-Fisher surveys

Professor Matthew Colless[1], Ms Paula Boubel[1], Dr Khaled Said[2], Prof. Lister Staveley-Smith[3]

[1]Australian National University. [2]University of Queensland. [3]University of Western Australia

Abstract

The WALLABY HI survey on the Australian SKA Pathfinder is expected to measure Tully-Fisher distances and peculiar velocities for about 50,000 galaxies in the nearby universe. We describe a new Bayesian methodology for simultaneously fitting the parameters of the Tully-Fisher relation and a model of the velocity field reconstructed from a redshift survey density field. This approach deals effectively with selection effects and biases and yields significantly more precise distances and peculiar velocities for individual galaxies. We demonstrate the methodology on the HI Tully-Fisher subsample of the Cosmicflows-4 dataset and obtain an improved estimate of the growth rate of structure in the present-day Universe from a comparison of the predicted and observed velocity fields. We explore the quality of the ASKAP HI Tully-Fisher data from the first year of WALLABY survey observations and make forecasts for the ultimate constraints on the growth rate of structure from WALLABY.

Session

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1938

What's the connection between radio SED shape and HI absorption in ASKAP-FLASH pilot data?

Emily Kerrison[1,2], Prof Elaine Sadler[1,2], Dr Vanessa Moss[2,1]

[1]University of Sydney. [2]CSIRO Space & Astronomy

Abstract

The First Large Absorption Survey in HI (FLASH) is compiling the first complete sample of HI-absorbed sources in $0.4 < z < 1$ unbiased by selection effects. This will allow us to determine whether the high HI-detection rate seen to date in CSS and GPS sources (thought to be the compact, young precursors to massive radio galaxies) is influenced in some way by the complex selection effects in previous targeted HI searches. I present here a study of the broadband spectral properties of sources detected in ASKAP-FLASH pilot data, outlining our novel approach to spectral classification and discussing the spectral energy distributions of sources detected in HI absorption with FLASH. I discuss the implications for the spatial distribution of the neutral gas and jet-gas interactions, and compare findings from the FLASH pilot to a sample of HI-detected sources compiled from the literature. I end with future possibilities for statistical studies of broadband spectral shape and its connection with HI detections, with the knowledge that several new and forthcoming untargeted surveys of the SKA era offer us an unprecedented opportunity to explore the interaction between young radio sources and the ISM of their host galaxies.

Session

IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

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1942

The mystery of extremely HI rich galaxies

Dr Helga Denes, Victor Capa

Yachay Tech University

Abstract

The properties of most galaxies in the universe follow scaling relations related to the physics that govern galaxy evolution. For example, there are scaling relations between the stellar mass of late-type galaxies and their neutral hydrogen (HI) content. Based on these scaling relations we can also identify unusual galaxies, such as HI-deficient galaxies with relatively low HI content and HI-excess galaxies with relatively high HI mass compared to their stellar mass. The possible reasons for the later could be either recent gas accretion or an inefficient conversion of the HI to molecular gas. Since recent gas accretion is difficult to prove conclusively, we investigated gas conversion by analysing the molecular gas content of five extremely HI rich galaxies from the HIX galaxy sample. Carbon monoxide (CO) is a good tracer of the molecular gas content of galaxies, so we obtained CO observations of the sample galaxies with the Atacama Large Millimeter Array (ALMA). We obtained resolved CO maps from which we derived the mass and the distribution of the molecular gas in each of the galaxies. We analysed the kinematics of the molecular gas disks and compared it to the HI, stellar and star formation properties of the galaxies. While we find that our sample galaxies have relatively regularly rotating molecular gas disks, their molecular gas fraction is significantly lower than what is expected from scaling relations.

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1949

ASKAP-FLASH: Research highlights and progress updates from a large-area HI 21-cm absorption survey

Dr. Hyein Yoon[1,2], Prof. Elaine Sadler[2,3,4], Dr. Elizabeth Mahony[4], ASKAP-FLASH team .[5]

[1]Departmant of Physics and Astronomy, Seoul National University, South Korea. [2]Sydney Institute for Astronomy, The University of Sydney, Australia. [3]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), Australia. [4]ATNF, CSIRO Space and Astronomy, Australia. [5].

Abstract

We present the latest results from the First Large Absorption Survey in HI (FLASH), an untargeted survey searching for 21-cm line absorption within the redshift range of $0.4 < z < 1.0$ using the Australian Square Kilometre Array Pathfinder (ASKAP). Considering our understanding of the HI gas content of galaxies at intermediate redshifts still incomplete, 21-cm absorption provides a unique and unbiased probe of HI beyond the local Universe. The survey has successfully completed two phases of Pilot Surveys and commenced the first year of the Full Survey toward the wide-field southern sky with DEC < +15 degrees and $|b| > 8.5$ degrees. Throughout the Pilot Surveys, covering around 3000 square degrees of the sky, we detected ~30 candidates of associated and intervening absorbers, revealing a diverse range of line properties across all redshifts. These absorbers are linked either to nearby host galaxies or distant background radio sources, respectively. We will highlight some of the newly discovered spectra and present how we trace the origin of 21-cm line absorption. Additionally, we will discuss the scientific and technical insights from the Pilot Surveys and then provide an update on the progress of the ongoing Full Survey, which will continue for the next five years.

Session

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1957

Largest Galactic HI Absorption Survey to Date: Cold Atomic Gas in the Magellanic Cloud Foreground Using Australian SKA Pathfinder

Dr. Hiep Nguyen[1], Prof. Naomi McClure-Griffiths[1], Mr. James Dempsey[1,2], Prof. John Dickey[3], Dr. Min Young Lee[4], Mr. Callum Lynn[1], Dr. Claire Murray[5,6], Prof. Snežana Stanimirović[7], Prof. Susan Clark[8,9], Dr. Joanne Dawson[10,11], Dr. Helga Dénes[12], Prof. Steven Gibson[13], Dr. Katherine Jameson[14], Prof. Gilles Joncas[15], Prof. Denis Leahy[16], Dr. Yik Ki Ma[1], Dr. Antoine Marchal[1], Dr. Marc-Antoine Miville-Deschênes[17], Dr. Nickolas Pingel[7], Dr. Juan Soler[18], Dr. Jacco van Loon[19]

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Abstract

We present the largest Galactic HI absorption survey to date, utilizing the Australian SKA Pathfinder Telescope (ASKAP) at an unprecedented spatial resolution of 30". This survey targets 2765 continuum background sources toward the Magellanic Clouds, a significant increase compared to a total of 373 sources from previous Galactic absorption surveys. We aim to investigate the physical characteristics of cold (CNM) and warm (WNM) atomic gas in the Milky Way foreground, at high latitudes (−45°, −25°). We detected strong HI absorption toward 464 lines of sight, yielding an absorption detection rate of 16.8%. By performing Gaussian decompositions for ASKAP absorption–emission spectra, we directly determine HI optical depths, temperatures, and column densities for 580 CNM and 745 WNM Gaussian

components. Our analysis of CNM temperature and optical depth reveals an anti-correlation between these two parameters, indicating that CNM with lower opacity tends to have a higher temperature. Furthermore, we observe a distinctive piece-wise pattern in the correlation between HI column density (N_{HI}) and dust extinction (A_V), characterized by a turning point at $A_V = 0.35$ *mag* and $N_{HI} = 7.9\times10^{20}$ cm^{-2}. The plateau at $A_V > 0.35$ *mag* potentially signifies a threshold for the formation of diffuse molecular gas, with the support of the cumulative dust shielding effect. To address the challenge of limited radio sources for absorption measurements, future work will focus on applying Deep Learning techniques to ASKAP emission data to derive cold HI properties on large scales and compare them with absorption-based results.

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1960

DESIGN OF A FOUR-ELEMENT L-BAND INTERFEROMETER RECEIVER FOR RADIO ASTRONOMICAL IMAGING AND TIME DOMAIN STUDIES

Mr. Paul Akumu[1], Mr. Albert Forson[1], Prof. Nalini Heeralall-Issur[1], Prof. Avinash Deshpande[2], Dr. Kumar Golap[3], Prof. Peter Wilkinson[4]

[1]University of Mauritius. [2]Raman Research Institute. [3]National Radio Astronomy Observatory. [4]University of Manchester

Abstract

An array of four 2.4-meter parabolic dishes, with tracking capability, has recently been set up at the Mauritius Radio Telescope site. It has East-West baselines ranging from a length of 8 meters to a maximum length of 62 meters with a combined sensitivity of about 4 Jansky. This project aims to design and develop a receiver front and backend link, as well as a data processing pipeline, for this new array. The receiver will operate in wideband mode with a bandwidth of up to 100 MHz for potential transient detection and a narrow band mode of up to 2 MHz to observe galactic neutral hydrogen spectra. The front end will down-convert the target center frequency of 1420.4 MHz down to baseband frequencies that can be accommodated by the digitizer. The backend processing will be implemented on a custom FPGA-based digital board that facilitates fast implementation of DSP algorithms such as the Fast Fourier Transform and cross correlation of the six potential baselines. Once complete, the array will be used for radio astronomy research activities as well as a training tool for the University of Mauritius. The wide beamwidth of the relatively small dishes will help in the search for bright Southern radio transients such as FRBs and the observation and mapping of galactic neutral hydrogen emission.

Session

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1961

FAST HI and OH absorption survey towards radio AGNs

Dr Yogesh Chandola

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Abstract

Atomic neutral hydrogen along with molecular gas in and around active galactic nuclei (AGN) host galaxies acts as a fuel reservoir for both star formation and AGN activity. Hence, it is important to understand the kinematics and distribution of this gas in these systems to understand the fueling and feedback activity. In radio bands, the HI 21-cm absorption line provides a unique method to probe the atomic hydrogen gas. Also, the molecular gas can be traced using the OH 18-cm line. FAST with its wide band receiver allows observations of both spectral lines simultaneously. In this talk, I will present the results of our recent HI and OH absorption survey of 40 compact radio AGNs with the FAST where we report of 6 HI absorption detections from 13 sources with good data. Three absorbers are discoveries. In addition to this, we also have OH absorption non-detections towards the 23 RFI-free spectra. In this talk, I will discuss the effect of radio luminosities, mid-infrared WISE colours and UV luminosities on the HI absorption detection rates. Sources with higher radio luminosities can have lower detection rates due to high spin temperature while high UV luminosities can ionise the gas. I will further discuss the implications of these results for HI surveys with Square Kilometer Array (SKA) pathfinders such as FAST, uGMRT, ASKAP, MeerKAT and in future with SKA.

Session

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1976

Looking to the future of HI observations: from pathfinders to the SKA

Dr Kristine Spekkens

Queen's University in Canada

Abstract

The advent of innovative new radio telescopes and instruments around the world has enabled HI observations of galaxies that are broader, deeper and sharper than ever before. This talk will give an overview of the extragalactic HI landscape from the present day through to the SKA era, with a focus on large surveys with pathfinder facilities that are paving the way for transformational Key Science Projects with the SKA.

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IAUS 392 Neutral hydrogen in and around galaxies in the SKA era

1995

The host galaxies of HI absorption lines at intermediate redshift

Professor Elaine Sadler[1,2], Dr Hyein Yoon[3], Mr Simon Weng[1]

[1]University of Sydney, Australia. [2]CSIRO, Australia. [3]Seoul National University, Korea

Abstract

We have identified the host galaxies of over 30 of the HI 21-cm absorption lines so far detected by the ASKAP First Large Absorption Survey in HI (FLASH) at redshift $0.4 < z < 1.0$. Our sample comprises both gas-rich galaxies with associated radio-loud AGN and normal galaxies intervening along the line of sight to background radio sources. Radio searches in the HI 21-cm line are unaffected by dust extinction, and our sample represents one of the first genuine 'HI-selected' galaxy samples at intermediate redshift. We will outline the main properties of the galaxies in this HI-selected sample, compare them to the overall galaxy population in the same redshift range, and discuss the prospects for future studies with the SKA.

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2032

MAMMOTH-Subaru: Mapping LAEs and LABs Traced by IGM/AGN at Cosmic Noon

Dr. Yongming Liang

Institute for Cosmic Ray Research, University of Tokyo

Abstract

We have carried out narrowband imaging observations targeting eight fields (~12 deg^2) with NB387 and NB400 on Subaru/HSC for detecting Lyman-alpha at z=2.2 and 2.3 traced by groups of strong Lyman-alpha absorbers in IGM or groups of SDSS/eBOSS QSOs. The idea was initially motivated by the concept of Mapping the Most Massive Overdensity Through Hydrogen (MAMMOTH; Cai et al. 2016) and thus dubbed the MAMMOTH-Subaru project. As a result, we construct a catalog with >3,000 Lyman-alpha emitters (LAEs) and >100 Lyman-alpha blobs (LABs) situated in dense IGM regions at Cosmic Noon. This sample is unique for both the large number of galaxies in narrow redshift ranges and the wide survey areas with rich sightlines toward background SDSS quasars. This talk will elucidate how the MAMMOTH-Subaru survey allows us to have unique discussions on the variation of LAE-IGM HI correlation and the statistics of LAEs/LABs.

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The Local Group L-band Survey: The VLA's Legacy of HI in Our Nearest Neighbors

Dr. Eric Koch

Center for Astrophysics | Harvard & Smithsonian

Abstract

We present the Local Group L-band Survey (LGLBS; lglbs.org), a VLA legacy survey providing the best-possible high-resolution 21-cm HI and 1-2 GHz continuum images of 6 star-forming northern Local Group galaxies (D=0.5-1 Mpc): M31, M33, NGC6822, IC10, IC1613, and WLM. The high sensitivity and spatial resolution in these key ISM and star formation tracers coupled with a complete external view of our neighboring galaxies offers new insights into major questions: how much cold, dense atomic gas exists in galaxies? How does it relate to molecular gas and star formation? I will present the first LGLBS HI results towards answering these open questions, including the ubiquity of complex atomic ISM kinematics from molecular cloud (20 pc) to galactic scales (> kpc), and the new constraints this provides on turbulent driving in the ISM from stellar feedback versus galactic-scale processes. LGLBS demonstrates the incredible promise for the SKA and ngVLA to expand these studies across the complete nearby star-forming galaxy population, linking answers from these currently open questions to the broader population and evolution of galaxies.

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Multiwavelength Studies of the Star Formation History of Fornax Cluster Galaxies

Dr Dejene Zewdie

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Abstract

The Fornax cluster provides us with an interesting environment to study galaxy evolution. It is still actively assembling mass, with the infalling group, Fornax A, on the outskirts of the cluster and an overdense area around the brightest cluster galaxy in the centre. The study of the environment of this cluster of galaxies and the physical processes that describe the transition in color from blue galaxies to red galaxies is of particular importance in galaxy evolution. We target these galaxies to measure the age-sensitive Dn4000 and H-delta indices, as well as gas-rich, HI-detected galaxies with H-alpha equivalent width. This enables us to distinguish between galaxies governed by evolution and those whose star formation was interrupted during the last ~Gyr. I will discuss our ongoing efforts to characterize the environments of the Fornax cluster using stellar population indicators. Our aim is to constrain quenching time-scales and compare these indicators with the HI gas content of the galaxies, using multiwavelength observations from MeerKat, SALT, and MUSE. In this talk, I will present our ongoing analysis focused on studying the stellar populations of the galaxies, emphasizing the effects of the cluster environment and its connection to their gas content.

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2092

Scatter of the HI-Halo Mass relation of central galaxies and improving HI detections towards massive clusters

Manasvee Saraf

International Centre for Radio Astronomy Research. Commonwealth Scientific and Industrial Research Organisation

Abstract

Does a halo's mass influence the gas content in its central galaxy? Simulations reveal a nuanced pattern: the median atomic hydrogen (HI) mass of centrals increases with halo masses at low halo masses, peaks at a transition halo mass, and declines with the prominence of active galactic nuclei feedback in the halos. Conversely, observational studies find a weak, if not flat, relation between mean HI mass and halo mass, implying an insignificant impact of the halo's mass on its central's HI content. Moreover, the considerable scatter seen in simulations remains unconstrained in observational studies relying on spectral stacking methods.

Using the extended GALEX Arecibo SDSS Survey (xGASS), my study explores the scatter of the HI-halo mass relation of centrals. My findings reveal that the low halo mass end is dominated by star-forming centrals, displaying increasing HI content with halo mass, while quenched centrals are prevalent at the high halo mass end. Importantly, I establish a significant physical link between the scatter and the specific angular momentum of these galaxies. In this talk, I will elaborate on these results.

Currently, observations at the high halo mass end are dominated by HI non-detections. Galaxy clusters also prevail at this end, compromising spectral-line data due to the presence of bright or extended radio continuum sources. Considering this limitation, I will also present the outcomes of my efforts to optimize the Widefield ASKAP L-band Legacy All-sky Blind surveY (WALLABY) pipeline for detecting HI in a galaxy cluster hosting numerous continuum sources.

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2112

Unveiling the large-scale structure of the Universe with 21cm Intensity Mapping

Marta Spinelli

Observatoire de la Cote D'Azur

Abstract

The redshifted 21cm line of Neutral Hydrogen (HI), detected by radio telescopes can probe the large-scale structure of the post-reionization Universe via Intensity Mapping (IM) techniques. This makes HI one of the most promising observables to map the late-time evolution of the Universe, with the potential of transforming our understanding of dark matter and dark energy.

In this talk, I will discuss HI Intensity Mapping with the SKA Observatory precursor MeerKAT and the key challenge in this type of experiments: subtraction of the bright foregrounds, orders of magnitude stronger than the HI signal. Subtraction can be achieved with component separation techniques but the quality of foreground subtraction needs to be carefully check against simulations. I will then discuss the cross-correlation of the HI signal with galaxy survey data tracing the same underlying dark matter distribution. Cross-correlation allows a strong reduction of systematics down to the detection of the HI signal in current MeerKAT data. Finally, I will discuss the road map for the future and what we hope to achieve once the full SKAO will be operational.

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2117

Linking atomic and molecular gas stripping with quenching in satellite galaxies at different infall stages

Prof Barbara Catinella

ICRAR/University of Western Australia

Abstract

Because of its direct connection to star formation, molecular hydrogen is a particularly useful probe to understand how and when star formation ceases in satellite galaxies during their infall. However, until now, studies of the effect of environment on molecular gas have been sparse and have not even clarified whether or not H_2 is directly removed by environmental effects.

In this talk, I will present new results from the ALMA/VERTICO and MUSE/MAUVE surveys of the Virgo cluster, which are providing us with a unique view on stripping and quenching in satellites. Specifically, I will present direct evidence for systematic H_2 stripping in satellite galaxies, and discuss how stripping carves its way within the disk at sub-kpc scale. I will also show that, while most of the gas is stripped, nearly all satellites are able to retain gas in their inner disks that could keep forming stars for several Gyr. I will discuss how these new results can be used to reconcile tensions in the estimate of quenching timescales for satellite galaxies across mass and environment.

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The WALLABY view of the cold ISM structure in nearby galaxies

Prof Barbara Catinella

ICRAR/University of Western Australia

Abstract

Contrary to what routinely done at other wavelengths, wide-area HI surveys of the local Universe have been hampered by the limited resolving power of single-dish telescopes. Excitingly, the advent of SKA precursor telescopes will allow us to characterize not only the global gas content but also its distribution for hundreds of thousands of galaxies. In this talk, I will present the first results of the Widefield ASKAP L-band Legacy All-sky Blind surveY (WALLABY), the SDSS equivalent for HI studies of the local Universe. WALLABY is being carried out with the Australian SKA Pathfinder and is building up the largest census of atomic hydrogen in the local Universe, with a spatial resolution that is almost a factor of 10 better than the state-of-the-art, single-dish ALFALFA survey. While only at its beginning, WALLABY is opening up a new parameter space of discovery and in this talk I will focus on ongoing efforts in the area of HI scaling relations. Specifically, I will discuss the quantification of HI structural parameters and discuss how scaling relations involving HI sizes and surface densities reveal a diversity in HI surface density profiles. I will also show how these data can be used to learn the about the interplay between HI and star formation in the stellar disks of galaxies and will conclude with some remarks on the future outlook for these studies in the SKA era.

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2128

Neutral Hydrogen in Galaxies Across Cosmic Time

Ms Munir Hoosain[1,2], Associate Professor Sarah Blyth[1], Dr Rosalind Skelton[2]

[1]University of Cape Town. [2]South African Astronomical Observatory

Abstract

The Cosmic Neutral Hydrogen Density (Ω_{HI}) is a parameter which measures the quantity of neutral hydrogen gas in the universe across cosmic time. Because HI, through its transformation into molecular hydrogen, is the key ingredient for the eventual star formation in galaxies, understanding its evolution is crucial for understanding the turnover in the cosmic star formation density at redshift ~2. While Ω_{HI} is well established in the local universe through direct HI emission measurements and at very high redshifts through observations of damped Lyman-alpha systems, there are very few measurements at intermediate redshifts and those that exist have quite large uncertainties. Taking advantage of the sensitivity of MeerKAT, techniques such as spectral stacking, and the depth of the Looking At the Distant Universe (LADUMA) survey, I will present the evolution of Ω_{HI} for $z \leq 0.56$ within the LADUMA field using our first release of L-band data. These results will be compared to other recent measurements from HI surveys to obtain a clearer picture of neutral hydrogen in our universe. LADUMA will thus link the local and high redshift measurements, covering a crucial phase of the universe's history and galaxy evolution

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Updates from the Hydrogen Epoch of Reionization Array

Dr Piyanat Kittiwisit

University of the Western Cape

Abstract

The Hydrogen Epoch of Reionization Array (HERA) is an SKA precursor telescope located at the South Africa Square Kilometre Array site that has been specifically designed to measure the 21 cm power spectrum from Cosmic Dawn through the Epoch of Reionization. First results from the “Phase I” design of the instrument were recently published and placed the most stringent upper limits on the 21-cm power spectrum to date. These upper limits were improved in a follow-up analysis using a larger set of data from the same observing campaign, yielding interesting constraints on the X-ray heating of the intergalactic medium. An upgraded version of the experiment, featuring an improved signal chain and a new widefield feed with a wider bandwidth, is now collecting data. In this talk, we discuss the current status of the HERA experiment, review the results from the latest publication, and provide an outlook for future developments.

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The cold gas distribution and regulation in the nearby galaxies

Dr. Niankun Yu

National Astronomical Observatories, Chinese Academy of Sciences (NAOC)

Abstract

The cold gas in galaxies is an important medium of the baryon cycle, and the gas content and distribution play an important role in regulating star formation. We take advantage of the Arecibo and FAST data to derive the gas distribution and dynamics of neutral hydrogen in nearby galaxies. Additionally, by combining multi-band information, such as observations from telescopes like MaNGA and ALMA, we found that the molecular-to-atomic gas ratio is positively related to the oxygen abundance and stellar mass surface density. The results suggest that efficient atomic-to-molecular gas conversion happens in massive galaxies with high metallicity. Using the FAST mapping data, we reveal faint atomic gas distribution in a ring galaxy and disentangle its complex kinematical features.

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Probing the neutral hydrogen content of the local universe with intensity mapping.

Mr Mogamad-Junaid Townsend

University of the Western Cape

Abstract

The line intensity mapping (IM) technique is a novel probe which has, so far, been used to make significant progress in our understanding of the large-scale structure of the universe, especially in the post-reionisation era. With MeerKAT, the most powerful radio interferometer built to date, we have the potential to make statistical detections of the 21 cm emission signal from neutral hydrogen (HI) by using this technique. Understanding this signal will help provide insights into the nature of dark matter, one of the key topics currently being explored in cosmology. In this talk, we discuss the use of the MeerKAT International GHz-Tiered Extragalactic Explorations Survey (MIGHTEE) Early Science data with the intensity mapping technique to statistically measure the 21 cm signal in the low redshift, inner halo, or quasi-linear cosmological scale and beyond, regime. We compare this to actual detections of HI galaxies made with the same MIGHTEE survey data to test how robust the HI intensity mapping technique is at low redshifts where direct detections of the neutral hydrogen content in and around galaxies are practical with radio telescopes. This is useful as it allows us to test various cosmological models and simulations against the results from the data at these redshifts and scales. Furthermore, we look at interesting considerations and challenges that need to be taken into account when using intensity mapping and discuss how this could be useful for future analyses which make use of this technique.

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The LADUMA DR1 source catalogue: a behind-the-scenes look at source finding strategies

Dr Jacinta Delhaize[1], Dr Marcin Glowacki[2,3], Ms Leyya Stockenstroom[1], Dr Ed Elson[4], Prof Andrew Baker[5], A/Prof Sarah Blyth[1]

[1]University of Cape Town. [2]International Centre for Radio Astronomy Research. [3]Curtin University. [4]University of the Western Cape. [5]Rutgers University

Abstract

LADUMA is the deepest, narrow HI extragalactic survey well underway with South Africa's SKA precursor telescope MeerKAT. It uses both the MeerKAT L-band and UHF-band receivers, ultimately covering HI redshifts out to z~1.4 (and OH redshifts out to z~1.84!) With MeerKAT's excellent sensitivity, we eagerly anticipate the detection of 21cm emission via direct detection and/or stacking out to earlier cosmic epochs than ever before.

However, we have to walk before we can run. First, we have to establish and calibrate source detection methods at lower redshifts - which turns out to be trickier than it seems! On behalf of the LADUMA Source Finding Working Group, I will present a behind-the-scenes look at the construction of the LADUMA DR1 Source Catalogue, soon to be released publicly. I will report on our spectral line source finding results using several different manual, automated and semi-automated strategies. Comparisons, tips, successes and failures will all be presented, in the hope that it will assist the wider community in their HI source finding attempts using SKA precursors and pathfinders.

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The Distribution and Impact of Mid-Infrared Emission on Neutral Gas Disks in Nearby Galaxies

Mx. Debosmita Pathak, Dr. Adam Leroy, Dr. Todd Thompson, Dr. Laura Lopez

The Ohio State University

Abstract

I will present new JWST/MIRI measurements of the distribution of mid-infrared (mid-IR) emission and estimates of the magnitude and impact of infrared reprocessed radiation pressure in the neutral gas disks of 19 nearby star-forming galaxies from the PHANGS-JWST Cycle-1 Treasury survey. We show how the gas column density and strength of turbulence vary in the cold neutral medium (CNM), and the variation in radiation pressures in HII regions across galaxies. The JWST images reveal mid-IR emission with complex substructure that simultaneously traces the distribution of dust and gas, as well as heating from young stars at very high resolution (0.3”-0.85”, 10-100 pc) unprecedented beyond the Local Group. We have used these images to make the first measurement of the probability distribution functions (PDFs) of mid-IR intensity and CNM gas column density, and estimate the strength of turbulence in the CNM of galactic disks. The PDFs reveal two distinct components: a roughly log-normal PDF at lower intensities from the diffuse ISM and a high-intensity power-law component from VLT/MUSE-identified HII regions which is particularly prominent at 21 microns. The maps of dust emission give us direct access to dynamical feedback mechanisms from mid-IR radiation. Within the HII regions, we combine estimates of the optical extinction and mid-IR intensity to estimate directly for the first time the strength of total infrared reprocessed radiation pressure in more than 6,000 HII regions, and find that the reprocessed pressure term is of order 20% of the so-called direct radiation pressure from young stars.

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Diffuse Gas in and around Galaxies: our understanding of cosmic ecosystems

Dr Abhisek Mohapatra

University of Cape Town

Abstract

In the paradigm of modern galaxy formation and evolution studies, one of the essential missing pieces of the puzzle across the cosmic timescale is a detailed picture of the role of diffuse gas in and around galaxies. The diffuse atomic and molecular gas, serving as the fuel for star formation, spans a wide range of column densities, delineating the baryonic content of the galaxy, the circumgalactic medium (CGM), and the Intragroup medium (IGrM). To comprehend full gas recycling, it is imperative to construct a sample of galaxies that is both uniform and representative across a broad parameter space. This work delves into the H I emission project of the Looking at the Distant Universe with the MeerKAT Array (LADUMA), a large survey program utilizing the cutting-edge MeerKAT interferometry telescope. In this talk, I will showcase the remarkable properties of our unbiased sample of galaxies observed in H I emission. We have identified and cataloged several loose galaxy groups from this sample, providing us with a unique opportunity to investigate the detailed environmental effects. By closely examining these systems, we shed light on the intricate interplay between galaxies in a complex environment, exploring how such interactions impact the observed H I scaling relations. Furthermore, we quantify deficient/excess diffuse CGM and IGrM gas in group galaxies, shedding light on their interplay.

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Physical drivers of HI asymmetries in spatially resolved SIMBA galaxies.

Ms Nadine Hank[1], Professor Marc Verheijen[1], Associate Professor Sarah Blyth[2]

[1]Kapteyn Astronomical Institute - University of Groningen. [2]Department of Astronomy - University of Cape Town

Abstract

The physical processes and environmental conditions that drive galaxy evolution over cosmic time can result in distortions and asymmetries in a galaxy's stellar and/or gaseous components. The neutral hydrogen (HI) disks of galaxies are particularly sensitive to these processes as they are relatively fragile and diffuse, and typically extend beyond the stellar disks. However, the susceptibility of HI to being disturbed by external gravitational (e.g. galaxy mergers and tidal interactions) and hydrodynamical (e.g. ram-pressure stripping) forces, as well as internal secular processes (e.g. stellar and AGN feedback), has made it difficult to identify which process may be the primary driver of the observed asymmetries. Furthermore, HI asymmetries have been understudied in comparison to optical asymmetries due to the paucity of data.

The latest generation of untargeted HI surveys on the SKA pathfinder telescopes is changing this and will enable detailed studies exploring the HI in galaxies using much larger samples than previously available. In the lead-up to these new datasets, we utilise the SIMBA hydrodynamical simulations to investigate HI asymmetries in ~1000 spatially resolved, low redshift galaxies to understand and contextualise the disturbances in the HI reservoirs of galaxies. Using synthetic HI datacubes designed to match observations from the Apertif Medium-Deep Survey, we quantify various asymmetry parameters and investigate the dynamic histories of galaxies over ~2 Gyr to discern whether the observed asymmetries arise from mergers, tidal interactions, or other phenomena. We also investigate whether correlations between HI asymmetry and baryonic mass exist for galaxies with different dynamic histories.

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2235

Statistical approaches to selecting strong gravitationally lensed HI and OH sources in wide-field SKA surveys

Dr Charissa Button[1], Prof Roger Deane[2,1]

[1]University of Pretoria. [2]University of the Witwatersrand

Abstract

Neutral atomic hydrogen (HI), as a key transitory phase in the baryon cycle, has a crucial role in star formation. Strong gravitational lensing will be a powerful tool in providing direct detections of HI emission at intermediate to high redshifts, as well as lower HI masses, that would otherwise not be possible within practical observing times, while also enabling HI dynamical modelling due to the increased angular extent. A complementary approach to targeting individual highly-magnified lensed systems identified at other wavelengths is to use the magnification bias and the exponential drop-off of the HI mass function at the high end to select highly-magnified HI emission sources in deep, wide-area spectral line surveys that will be undertaken with the SKA1-Mid. Since hydroxyl (OH) megamasers will also be detected within these large surveys, the same method can be applied to search for lensed OH megamasers in the same data, particularly as the smaller solid angles of OH lend themselves to higher magnification factors. Using a semi-analytical formalism to describe the lensing probability and its effect on the observed HI mass function and OH luminosity function, we explore selection criteria based on the peak flux density threshold where these lensed sources will be preferentially selected. These results contribute to the scientific yield of the SKA1-Mid surveys by combining high sensitivity observations with the natural amplification of strong gravitational lensing to directly observe both H I and OH at cosmological epochs well beyond the peak of cosmic star formation and AGN activity.

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The cosmic web in the LADUMA field

Mr. Tilman Oelgeschläger[1], Assoc. Prof. Sarah Blyth[1], Dr. Rosalind Skelton[2]

[1]University of Cape Town. [2]South African Astronomical Observatory

Abstract

In this work we investigate the role that cosmic filaments play in the evolution of galaxies. Cosmic web filaments are an intermediate density environment containing around 45% of the baryonic matter in the Universe. Filaments have been observed to affect the cold gas reservoir of galaxies within them. Study of this effect is mostly limited to the local Universe due to the intrinsic faintness of the neutral hydrogen (HI) signal and the need for large samples of galaxies with spectroscopic redshift measurements to accurately identify the large-scale structure. I will present my work on recovering the large-scale structure in the cosmic volume being investigated by the Looking at the Distant Universe with the MeerKAT Array (LADUMA) survey, one of the large survey projects on the MeerKAT radio telescope in South Africa. The LADUMA survey aims to measure the HI gas content of galaxies up to redshifts of $z=1.4$. I will present a map of filaments in the LADUMA volume in the redshift range $0.2 < z < 0.4$, identified using the DisPerSE software package and a limited sample of spectroscopic redshift measurements obtained from LADUMA's ancillary data catalogue. I examine the relations between the properties of galaxies in the LADUMA volume and their distance to the nearest cosmic web filament. In particular, I will investigate the effect of the filament environment on the HI content of galaxies, which is measured through spectral line stacking of galaxies near and far from the identified large-scale structure.

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Investigating Star-Formation and Supernavae in Messier-82

Mr Sibongumusa Shungube

University of Pretoria

Abstract

Messier 82 (M82) stands out as a starburst galaxy, situated approximately 12 million light years away, exhibiting an extraordinary rate of star formation exceeding that of our own Milky Way. This vigorous star-forming activity is believed to be triggered by gravitational interactions with its neighboring galaxy, M81. One notable feature of M82 is its attention grabbing dense population of compact radio sources. Despite this attention, a comprehensive analysis of the galaxy's gas composition and distribution, particularly in terms of neutral hydrogen (HI) and molecular gas, has remained elusive. In this study, we leverage the observational capabilities offered by the e-MERLIN telescope, an array of seven radio telescopes in the UK, to delve deeper into the gas dynamics of M82. Our dataset, acquired in 2016 at 1.5 GHz, offers high and improved spectral resolution and sensitivity, allowing for detailed mapping of HI and hydroxyl (OH) lines. Previous studies performing such an analysis dates back to 1995 (Wills et al. 1999), which showed HI absorption against a number of radio sources in M82, confirming that many if not all of the radio sources reside in M82 and enabling the distribution of HI gas to be mapped. However, the limitations of previous observations have left gaps in our understanding, prompting the need for more comprehensive and high-resolution studies, and e-Merlin attempts to close this gap.

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A serendipitous MeerKAT discovery of an HI-rich galaxy group with megaparsec-scale filamentary-like structure

Mr Graham Lawrie

University of the Witwatersrand

Abstract

Environmental effects within cosmological overdensities like galaxy groups and clusters have been shown to impact galaxies and their gas reservoirs. This makes the study of a wide range of environments important in order to discern between different models of galaxy evolution. This work reports the serendipitous discovery and properties of a large overdensity of HI galaxies at z~0.04. The galaxies appear to lie in a filamentary-like structure of Mpc scale. Dark Energy Survey (DES) DR2, and Wide-field Infrared Survey Explorer (WISE) data are used to investigate the star formation rates, stellar masses, and stellar morphologies enabling individual galaxy analysis and comparison of this structure's properties with established scaling relations. The HI and sub-arcsec DES imaging reveal a large number of interacting galaxies in this collective group, including both galaxy-galaxy tidal interactions as well as a potential example of ram pressure stripping. Additionally, we find a compact group of 4 galaxies in the heart of the larger structure. To place this discovery and the environmental effects in context, we use a state-of-the-art cosmological hydrodynamical simulation, SIMBA, to construct light cones and investigate the prevalence of HI overdensities. This enables a prediction on how many more such structures might be discovered with MeerKAT to provide a rich sample to study galaxy transformation and enable a MeerKAT HI perspective on low-redshift large-scale structure.

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HI emission stacking and the search for high redshift gravitationally lensed HI emission in a Hubble Frontier Field

Mr Graham Lawrie

University of the Witwatersrand

Abstract

Constraining the evolution of HI with redshift is vital to discriminate between models of galaxy evolution. Currently, our direct observations of HI emission are limited to the low-redshift universe ($z \lesssim 0.3$) due to the intrinsic faintness of the forbidden hyperfine transition required for 21-cm emission. This work explores two ways to overcome this challenge: (1) stacking HI spectra of optically identified galaxies with known redshifts and (2) through leveraging the gravitational lensing that occurs when massive clusters magnify background HI emission. In the first instance, we stack HI emission from galaxies with spectroscopic redshifts beyond the Abell 370 ($z \sim 0.375$) cluster to constrain the HI properties of galaxies at up to $z \sim 1$. Moreover, Abell 370's high magnification allows us to search for direct detections of lensed HI within the 'Great Arc' at $z \sim 0.725$ and other lensed candidates within the MeerKAT UHF band observations. A high signal-to-noise detection will result in the highest redshift concrete direct HI emission detection. Any lensed detections, together with the stacked HI results, will provide unique constraints on the HI properties of galaxies in a previously unexplored parameter space.

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MeerChoirs: A view of the HI in Nearby Galaxy Groups

Dr Moses Mogotsi[1,2,3], Mr Sriram Sankar[4], Dr Amidou Sorgho[5]

[1]Southern African Large Telescope. [2]South African Astronomical Observatory. [3]University of Cape Town. [4]International Centre for Radio Astronomy Research. [5]Instituto de Astrofisica de Andalucia

Abstract

MeerChoirs is a MeerKAT HI survey of Choir groups (Sweet et al. 2013). These are 15 nearby (23 - 151 Mpc), gas rich (HI masses= 9.92 - 10.61 logMsol) and spiral dominated groups that cover a wide range of properties but are more representative of common group environments than Hickson Compact Groups (HCGs). The groups are in an earlier stage of assembly than most HCGs. Environment plays an important factor in the baryon cycle of galaxies and their evolution. And galaxy groups provide a view into intermediate environments between the field and galaxy clusters. A key aspect of the evolution of galaxies in dense environments is the amount of cold gas within and outside of galaxies, as highlighted by studies of HCGs. MeerChoirs provides an unprecedented combination of sensitivity, spatial resolution and field of view of the HI in the Choir groups. We find signatures of galaxy interactions, extraplanar gas, intra-group gas and outflows. In this talk I will present the results of kinematic analysis of the galaxies within the groups - showing how much gas is within the galaxies, how much gas is extraplanar and how much is in the intra-group medium. This will shed light on how the HI reservoirs of galaxies within groups are affected by different group environments, and how this affects their star formation and evolution.

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The HI properties of Green Pea galaxies

Archishman Khasnovis[1], Nissim Kanekar[1], Sangeeta Malhotra[2], James Rhoads[2]

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Abstract

Cosmic reionization is expected to have been caused by Lyman-continuum (LyC) radiation from dwarf starburst galaxies at z>6. However, it is not clear how the escape of LyC photons depends on local conditions in these galaxies, which are difficult to observe directly. Local analogs of the EoR galaxies, such as Green Pea galaxies (GPs), allow detailed studies to understand the mechanisms of LyC leakage. GPs are low-redshift dwarf starbursts, with properties similar to those of the EoR galaxies and which have been found to show significant LyC leakage. Studies of neutral gas in GPs are critical to understand their starburst activity and the LyC leakage: cold neutral gas is the fuel for star-formation, but can also absorb LyC photons, preventing them from escaping the galaxy. We have hence begun a project to measure the HI content and distribution in a large sample of low-z GPs. In this talk, I will present results from a new Green Bank Telescope (GBT) 21cm survey of 30 GPs at z<0.05. I will discuss the dependence of the 21cm detection rates, the HI masses, the HI-to-stellar mass ratios, and the HI depletion timescales on the ratio of [OIII]5007 to [OII]3727 line luminosities, a proxy for LyC leakage, and other optical properties. Finally, I will present results from Very Large Array 21cm mapping studies of GPs, which directly probe the HI spatial distribution in and around the GPs, and provide clues to causes of the starburst activity and leakage of LyC and Ly-α radiation.

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Searching for UDG and LSBs in the Hydra cluster with MeerKAT HI

Mr Nazir Makda[1,2], Assoc Prof Sarah Blyth[2], Dr Rosalind Skelton[1]

[1]South African Astronomical Observatory. [2]University of Cape Town

Abstract

Ultra diffuse galaxies (UDGs) are a low surface brightness population of galaxies exhibiting large sizes. Their recent unexpected abundance in clusters has brought into question our understanding of galaxy evolution and the effect of the harsh cluster environment. Using MeerKAT HI observations of the Hydra I cluster, a nearby Southern galaxy cluster with ongoing galaxy interactions and evolution, we explore the neutral hydrogen content in low stellar mass galaxies, specifically investigating UDGs. HI detections can provide redshift and therefore cluster membership information for optically low surface brightness galaxies (LSBs) for which optical spectroscopy is difficult to perform. Detailed observations of these low stellar mass galaxies in HI provide insight into the processes undergone by these galaxies in these harsh and dense environments. I will present these results as well as investigation of the dark matter fraction of these galaxies using the measured HI radial velocity, HI and stellar masses and baryonic Tully-Fisher relation. Further, we examine the properties of UDGs and LSBs in the Hydra I cluster and how the different tidal processes and mechanisms in the cluster environment affect the evolution of UDGs and LSBs within the clusters.

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A cloud-scale view of the star-formation process in nearby galaxies: prospects for HI surveys

Dr. Eva Schinnerer

MPIA

Abstract

There have been significant advances of our understanding of the neutral gas-star formation-stellar feedback matter cycle (a.k.a. star formation process) in nearby galaxies in recent years. Driven by a combination of molecular gas observations by ALMA, dust imaging from JWST, mapping of young stellar populations by HST and HII regions from optical spectroscopic imagers like MUSE at resolution of ~100pc or better are implying that the properties of molecular clouds depend on the kilo-parsec properties of the environment they live in, their lifetimes are dominated by the collapse time, star formation proceeds rapidly, and stellar feedback leads to their quick disruption. I will provide a summary of the observational evidence supporting this picture and discuss how future observations from SKA and ngVLA can help to refine our understanding by providing observations of the atomic phase at a resolution of cloud-scales, i.e. ~ 100pc.

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2367

New HI views of our own Galaxy and the Magellanic Clouds

Prof Snezana Stanimirovic

University of Wisconsin, Madison

Abstract

The neutral interstellar medium (ISM) is a vital player in the star formation process, based on its major contribution to the ISM's mass, and bears the brunt of the stellar feedback. In particular, the diffuse ISM is not only the key for building seeds for star formation – interstellar molecules – it also shields molecules from the harsh effects of stellar feedback and therefore determines the duration of their survival.

As numerical simulations of galaxy evolution continue to include more complex ISM physics, detailed understanding and inclusion of key sources of stellar feedback and the exact effects they have on the diffuse ISM are essential.

In this talk, I will review results from several recent neutral hydrogen (HI) surveys of the Milky Way and the Magellanic Clouds, specifically focusing on the neutral gas thermodynamics, early stages of molecule formation, and interstellar turbulence.

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The DSA-2000 radio camera — a new window to the HI universe

Fabian Walter[1], Ryan Keenan[1], Marcel Neeleman[2], Erwin de Blok[3], Gregg Hallinan[4], Vikram Ravi[4]

[1]Max Planck Insititute for Astronomy Heidelberg. [2]National Radio Astronomy Observatory. [3]ASTRON. [4]California Institute of Technology

Abstract

The DSA-2000 will be a radio survey telescope and multi-messenger discovery engine. The array will consist of 2000 × 5m dishes instantaneously covering the 0.7 - 2 GHz frequency range (thus including HI from z=0 to z=1), spanning an area of 19 km × 15 km in Nevada. In an initial five-year survey, the DSA-2000 will image ~30,000 deg2 repeatedly over sixteen epochs, producing an HI and full-Stokes continuum sky map with 3.3 arcsecond spatial resolution. The HI line will be mapped as part of this all-sky survey with three different velocity resolutions: Galactic HI will be covered at ~0.2 km/s spectral resolution, HI in galaxies out to 100 Mpc distance will be observed at ~2 km/s, and HI out to redshift z=1 will be covered with resolutions varying between 28-58 km/s (depending on redshift). Amongst other things (covered by the contribution by R. Keenan) these HI observations will enable the determination of accurate rotation curve to assess the puzzling diversity in rotation curve shapes in nearby galaxies (solid-body vs. flat curves). The spectral resolution for our Galaxy (and some Local Group galaxies) will enable the separation of the cold and warm interstellar medium. The DSA-2000 is enabled by two breakthrough technologies, i) a low-cost antenna with an ambient temperature receiver and ii) a new generation of digital back-end known as a radio camera, that will output HI data cubes in real time.

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2390

Neutral hydrogen intensity mapping with MeerKAT

Prof Mario Santos

University of the Western Cape

Abstract

Neutral hydrogen (HI) intensity mapping is a promising technique to map the three-dimensional distribution of neutral hydrogen in the low signal to noise regime. On large scales, it can be used to probe cosmology by tracing the underlying dark matter. On smaller scales, it allows for the study of the HI distribution on cluster scales up to high redshifts. I will discuss the recent results obtained with the MeerKAT telescope, using data from the MeerKLASS collaboration as well as the MIGHTEE project. These include the measurement of the cross-correlation power spectrum with galaxy surveys over wide areas of the sky, and the first direct detection of the auto power spectrum at scales of 1.0 Mpc and redshifts of 0.32 and 0.44, with high statistical significance. Such measurements can further impose strong constraints on the HI density of the Universe.

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2413

The protective environment of substructures within galaxy clusters: a case study with A2626

Dr Julia Healy[1,2,3], Prof Sarah Blyth[3], Prof Marc Verheijen[2]

[1]ASTRON. [2]Kapteyn Astronomical Institute, University of Groningen. [3]Astronomy Dept, University of Cape Town

Abstract

Galaxy clusters, which form some of the largest structures in the universe, are home to hundreds of galaxies. Such dense environments are known to be very effective at removing the neutral atomic hydrogen (HI) gas reservoirs that are raw fuel for star formation. The removal of this gas results in a quenching of star formation in cluster galaxies. However, since galaxy clusters grow by accreting both individual and groups of galaxies, the question arises: what role does the immediate environment around the cluster galaxies play in increasing or decreasing the rate at which galaxies are quenched as they move into the dense cluster environment? Located at a distance of 250Mpc, A2626 is a moderate sized cluster with known substructure. Using deep HI observations obtained using MeerKAT, we explore how the local environment as traced by the cluster substructure affects the rate at which gas is removed from the galaxies in the different local environments. We find that galaxies entering the cluster in groups which are traced by the substructure lose their gas slower than galaxies that enter the cluster environment individually. This suggests that the local/group environment protects galaxies against the cluster-dominant gas removal processes.

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Unlocking mysteries of the early Universe with improved upper limits using MWA

Dr Ridhima Nunhokee

Curtin University

Abstract

The primary challenge in 21 cm cosmology is the presence of bright astrophysical foregrounds, which can of magnitude greater than the 21 cm hydrogen line. To mitigate their impact, subtraction and avoidance techniques are commonly employed. However, both methods are sensitive to systematic present in the data, which can influence the accuracy of the 21 cm measurements. Therefore, it is crucial to identify and alleviate these systematics. In this work, we utilise observations from the Murchison Widefield Array. We have developed a framework that derives various statistical metrics from data products, facilitating the identification of misbehaving antennas, corrupted timestamps, and frequencies. This allows us to isolate observations dominated by systematics. Furthermore, these metrics serve as probes to form clusters of observations sharing similar features, aiming to optimise upper limits on the 21 cm power spectrum. We explore k-Nearest Neighbourhood and Density-based algorithms. Finally, we present the power spectrum results obtained from systematic mitigation using the Cosmological H1 Power Spectrum Estimator (CHIPS).

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2436

Serendipitous discovery of an HI rich galaxy group falling into the NGC 5044 group

Dr Julia Healy

ASTRON

Abstract

In the hierarchical formation scenario, large structures such as galaxy clusters grow by accreting groups of galaxies. Studies have shown that galaxies residing in these dense environments such as clusters and groups tend to be gas-poor and quiescent with the gas-rich star-forming galaxies generally located in the lower density environments. This phenomenon is known as the morphology-density relation, and understanding how and where the galaxies transition from gas-rich and star-forming to gas-poor and quiescent is one of the major open questions in galaxy evolution studies. There is some evidence to suggest that galaxies are processed in the group environment prior to being accreted into cluster environments. This makes our discovery of a gas-rich group which appears to be on an infall trajectory toward the NGC 5044 group (a poor cluster with a halo mass of ~10^13 Msun) even more intriguing. Thanks to the high resolution, high sensitivity HI observations of this group obtained from the MHONGOOSE survey, we are able to explore in great detail how the HI in these galaxies are affected by their environment.

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Comparing ISM and star formation in isolated and interacting dwarf galaxies

Andras Peter Joo, Enikő Pichler, L. Viktor Tóth

Eötvös Loránd University Budapest, Department of Astronomy

Abstract

We present a comparative study of an isolated nearby dwarf galaxy DDO43 and the highly interacting pairs M51 and NGC4490/85 to explore HI dynamics and environmental processes. Leveraging high-resolution observations, we resolved the ISM structure and traced the effects of interaction on the ISM and star formation. Our analysis of HI data offers insights into the global and local environmental processes affecting gas content, while infrared observations unveil potential dust-obscured star-forming regions. Our findings suggest that interacting dwarf galaxies can accrete sufficient gas from inflows to fuel massive star formation. Notably, we observed higher star formation rates in the interacting galaxies compared to field galaxies, alongside a sub-solar average metallicity in the smaller galaxies.

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The HI discs of galaxies as probes of the baryonic physics of galaxy evolution

Dr. Jindra Gensior

Department of Astrophysics, University of Zurich

Abstract

Understanding what shapes the cold gas component of galaxies, which both provides the fuel for star formation and is strongly affected by the subsequent stellar feedback, is a crucial step towards a better understanding of galaxy evolution.

I will present detailed analysis of the atomic hydrogen (HI) in a sample of 60 Milky Way-mass galaxies from cosmological simulations. This set of simulations comprises galaxies evolved self-consistently across cosmic time with different baryonic sub-grid physics: three different star formation models and two different stellar feedback prescriptions. Therefore, this sample is ideally suited to study the link between HI and galaxy properties in a statistical sample, as well as to assess the impact of different baryonic physics models on the HI content of galaxies and to make predictions for observables that will distinguish between different physics.

I will discuss the complex interplay between star formation, feedback and HI properties of the galaxies and I will show that while the HI properties (mass, extent, density profile, scale height, morphology) of the simulated galaxies are in broad agreement with current observational results, they vary significantly between the different baryonic physics models, and depending on the properties and evolution of the galaxies. The morphology of HI discs is particularly sensitive to the different physics models. Thus, comparing the predictions from these simulations with the wealth of HI observations expected from (the precursors of) the SKA will significantly advance our understanding of galaxy formation and evolution.

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HI Distribution of Dwarf Starburst Galaxy

Dr. Pei Zuo

National Astronomical Observatories, Chinese Academy of Sciences

Abstract

We present the HI gas distribution around dwarf starburst galaxy NGC 5253, which showing asymmetric feature with a few kpc extension toward north-east direction in the interferometric data. This extension is likely indicating the dynamical connection between NGC 5253 and its nearby galaxy M 83. To investigate the possible HI bridge between these two systems, we acquire the HI mapping data around NGC 5253 from GBT and have detected the possible HI gas clouds. These clouds could play an important role in triggering intensive star formation activity in the dwarf galaxy NGC 5253.

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Stacking neutral hydrogen and hydroxyl emission from Infrared-luminous galaxies in the MeerKAT LADUMA field

Miss Mika Naidoo[1], Dr Sphesihle Makhathini[1], Prof Andrew Baker[2], Prof Roger Deane[1]

[1]University of the Witwatersrand. [2]Rutgers, The State University of New Jersey

Abstract

The 'Looking At the Distant Universe with the MeerKAT Array' (LADUMA) survey aims to investigate neutral hydrogen (HI) and hydroxyl (OH) emission at high redshifts ($z < 1.45$ and $z < 1.87$, respectively), enhancing the study of galaxy evolution over two-thirds of the age of the universe. We use L-band observations of the LADUMA field to stack HI ($z < 0.58$) and OH ($z < 0.89$) at the positions of Infrared (IR)-selected galaxies exceeding the luminous infrared galaxy (LIRG) threshold, in which HI and OH are not individually detected. LIRGs and ULIRGs are important for understanding galaxy evolution, as they are often the result of gas-rich merging and interactions. Through our LADUMA HI stacks, we set upper limits on the HI mass of our sample and discuss possible implications on the balance of the cool interstellar medium (ISM) phases in these galaxies. Through our OH stacks, we place upper limits on the OH-luminosity to IR-luminosity ratio and constrain the prevalence of OH megamasers within the LADUMA field. Stacking proves to be a valuable technique for probing HI and OH, allowing us to further our understanding of their role within a broader galaxy evolution context.

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Studying the HI content of AGN and non-AGN with the MIGHTEE-HI survey via stacking technique.

MR TUMELO MANGENA

University of Cape Town. South African Radio Astronomical Observatory

Abstract

I study the influence of AGN feedback on the HI content of galaxies, and explore their potential for future star formation during the various stages of their life cycle. Using the stacking technique, we explore the differences in HI content of AGN and non-AGN (matched based on redshift, stellar mass, and SFR/colour). We perform a stacking analysis of >200 sources in each class, with their 21cm spectra extracted from spectral cubes from the MIGHTEE-HI survey. Our input sample consists of galaxies with and without signatures of AGN activity across the MIGHTEE Early Science COSMOS and XMM-LSS fields in the low redshift ($z < 0.084$) and higher redshift ($0.22 < z < 0.5$) ranges. We gather galaxies within these specific regimes and areas, utilizing spectroscopic redshifts and multiwavelength AGN classifications, both published and unpublished. Furthermore, we differentiate between high-excitation and low-excitation radio galaxies (HERGs/LERGs) and examine differences in the HI content of each. Our preliminary results show evidence of HI detection in the low redshift samples of both AGN and non-AGN. No detection is yet made at higher redshifts for either sample. We discuss possible reasons for this. For example, this could be due to a dominance of gas-poor elliptical (quiescent) galaxies in the non-AGN sample, and similarly gas-poor low excitation radio galaxies (LERGs) in the AGN sample.

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Dark matter distribution in Milky Way-analog galaxies; what can we expect for the upcoming SKA era?

M.Sc. Natanael de Oliveira[1], Pro. Dr. Karín Menéndez-Delmestre[1], Prof. Dr. Thiago Gonçalves[1], Dr. Nicolás Garavito-Camargo[2], Dr. Pedro Beaklini[3], Prof. Dr. Marco Grossi[1]

[1]Valongo Observatry, UFRJ. [2]Flatiron Institute. [3]National Radio Astronomy Observatory

Abstract

Our current understanding of how dark matter (DM) is distributed within the Milky Way (MW) halo, particularly in the solar neighborhood, is based on either careful studies of the local stellar orbits, model assumptions on the global shape of the MW halo, or from direct acceleration measurements. In this work, we present a study of external galaxies with the intent of gaining insights into the DM distribution in MW-analog galaxies. We draw parallels between our current knowledge, its limitations, and our expectations for the upcoming SKA era. For this, we carefully select a sample of galaxies similar to the MW. With a need for deep, highly-resolved HI, our resulting sample is comprised of 15 galaxies observed from two approved VLA and GMRT programs. To perform our baryonic analysis, we use deep Spitzer mid-IR images at 3.6 and 4.5µm from the S^4G survey. Based on the dynamical three-dimensional modeling software ^{3D}Barolo, we construct rotation curves (RCs) and directly derive the gaseous and stellar contributions from their mass surface density profiles. Through a careful decomposition of the RCs into their baryonic (stars, gas) and DM components, we isolate the DM contribution by using an MCMC-based approach. Based on the Sun's location and the MW's R_{25}, we define the corresponding location of the solar neighborhood in these systems. We put forward a window for the DM density (ρ_{dm}=0.21-0.46 GeV cm^{-3}) at these galactocentric distances in our sample, consistent with the values found for the MW's local DM density, based on more traditional approaches.

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HI line properties and relationship to star formation in nearby dwarf galaxy DDO 43

Enikő Pichler[1], Bruce G. Elmegreen[2], Deidre A. Hunter[3], Andras Peter Joo[1], L. Viktor Tóth[1]

[1]Eötvös Loránd University Budapest, Department of Astronomy. [2]Katonah, NY 10536. [3]Lowell Observatory, Flagstaff, USA, 86001

Abstract

We describe one of the smallest nearby galaxies, revisiting the LITTLE THINGS (Local Irregulars That Trace Luminosity Extremes, The HI Nearby Galaxy Survey) data. The high-quality HI 21cm VLA spectra provide a resolved view of DDO 43's gas content. We look for gas kinematics traced by HI, and our spectra analysis results reveal the characteristics of local and global neutral gas flows in DDO 43. We report the comparative analysis of the derived HI parameters with available multispectral data tracing gas dynamics, interstellar dust properties and star formation. As stellar winds and supernovae drive interstellar gas and cause turbulent flows, while turbulence affects star formation by compressing and disrupting gas clouds, this feedback process is still awaiting answers. Our highlighted aim is to look for massive star formation areas and provide additional details on the relationship between interstellar gas motions and star formation.

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Strong lensing of neutral hydrogen with MeerKAT

Prof Roger Deane

University of the Witwatersrand. University of Pretoria

Abstract

Our view of the cosmic evolution of neutral hydrogen and the hydroxyl molecule in galaxies is being transformed through deep surveys with SKA precursors/pathfinders. Strong gravitational lensing can enable a deeper tier to the ongoing and planned spectral line surveys without some of the associated calibration risks posed by several thousand-hour integrations, source confusion, image-plane cube combination, and enormous data volumes. In this talk, I will present how relatively modest programmes on MeerKAT targeting known, optical/infrared-identified strong lensing systems are delivering amongst the most distant views of HI and OH emission in galaxies over cosmic time, providing a highly complementary approach to high-redshift spectral-line surveys on MeerKAT, and other facilities. Indeed, strong lensing surveys have leveraged this utility for decades in virtually every part of the electromagnetic spectrum, including almost every major spectral line that traces the interstellar medium in galaxies. MeerKAT's exquisite sensitivity demonstrates that we are now able to exploit the power of lensing to explore the high-redshift HI and OH universe.

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Probing Early Universe using the uGMRT: a case study with ELAIS-N1 observations at Band2

Prof. Abhirup Datta, Ms Rashmi Sagar, Mr. Samit Pal

Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore

Abstract

The detection of the redshifted 21-cm signal of neutral hydrogen is a promising probe to study physical processes in the early universe, from the Cosmic Dawn (CD) to the Epoch of Reionization (EoR). This quest has been extremely hard at low radio frequencies due to severely bright foregrounds, ionospheric corruption, radio frequency interference (RFI), and instrumental systematics. Here, we will present some recent uGMRT observations of the ELAIS-N1 field within the band-2 (120–250 MHz). This corresponds to the redshift range of 4.7–10.8. A significant feat is achieved with substantial 32- hour observations and an operational bandwidth of approximately 100 MHz. The resultant image reached an RMS noise level of 236 Jy/beam, the deepest image so far in this band of uGMRT. We will present glimpses of the data analysis and the final constraints obtained on the cosmic HI signal from the Cosmic Dawn and EoR. We have developed an end-to-end pipeline to study how systematics affects the extraction of the redshifted HI 21cm signal from future SKA-1 Low observations. In this talk, we will show the results from some recently observed additional 60 hours of data in Band2 and the renewed constraints on the HI 21cm power spectrum.

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Environmental processes traced by HI

Dr Mpati Ramatsoku

Rhodes University

Abstract

One of the primary objectives of ongoing research on galaxy formation and evolution is to understand the mechanisms that lead to the cessation of star formation and the subsequent emergence of passively evolving populations. The role of the cosmic web, which comprises inhomogeneous environments in which galaxies reside, is crucial to these studies. The galaxy densities in these environments vary significantly, ranging from approximately $0.2\boldsymbol{\rho}$ in cosmic voids to as high as $1000\boldsymbol{\rho}$ in compact groups, with $\boldsymbol{\rho}$ representing the average field density. Studies have revealed that in dense environments, the percentage of late-type (star-forming) galaxies is the lowest, whereas the percentage of early-type (non-star-forming) galaxies is the highest, and vice versa. Several hydrodynamic processes, including ram pressure stripping, viscous stripping, thermal evaporation, starvation, and gravitational processes such as mergers, tidal interactions, and harassment, occur in these environments. These processes leave an imprint on the disks of the delicate and diffuse raw material for star formation in the form of neutral atomic gas (HI). Therefore, it is essential to have a HI perspective when examining the environmental effects on galaxy evolution. This presentation will focus on recent advances made on this topic using highly sensitive and resolved HI observations with MeerKAT to trace environmental processes in the nearby Virgo filament and a range of galaxy clusters and groups within redshifts of $z< 0.05$.

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Cold clouds in the outskirts of the Magellanic Clouds

Hongxing Chen[1], Snezana Stanimirovic[1], Nickolas Pingel[1], GASKAP collaboration[2]

[1]University of Wisconsin-Madison. [2]GASKAP collaboration

Abstract

Atomic hydrogen (HI) is the most abundant component of the interstellar medium and exists primarily in two phases: the cold neutral medium (CNM) and the warm neutral medium (WNM). These phases are key to understanding star formation and are heavily influenced by galaxy metallicity. The Small and Large Magellanic Clouds (SMC and LMC) provide ideal laboratories for studying CNM and WNM properties in low metallicity environments. Recently, the Galactic-ASKAP HI (GASKAP-HI) survey using the Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope has provided unprecedented sensitivity and resolution in observing HI in the Magellanic Clouds and has identified the largest sample of HI absorption-detected cold clouds. Using these observations, we study cold HI in the extreme diffuse regions around the SMC and the LMC. We find that 90% (55%) of the CNM structures in the SMC (LMC) have spin temperature <40 K and are colder than the CNM in the Milky Way. The CNM fraction for sources in the outskirts of the SMC is below 0.3, whereas certain sources in the diffuse region of the LMC display CNM fractions higher than 0.7. In addition, we find one cold cloud that has been stripped of its WNM envelope and entirely consists of the CNM in the LMC. Our results suggest a more complex interstellar environment in the LMC, likely influenced by bubble expansion and interactions with the surrounding medium, which promotes cold cloud formation.

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New constraints on HI cosmology and galaxy evolution at z<0.5 from the MeerKAT telescope

Dr. Francesco Sinigaglia

Université de Genève

Abstract

The neutral hydrogen (HI) is ubiquitous in the universe and it plays a key role in galaxy evolution as it constitutes the raw fuel of star formation. The HI has been so far detected in single galaxies almost only in the nearby Universe z<0.1-0.2, due to the limited sensitiviy of current radio telescopes. In this sense, the spectral line stacking technique has emerged in the last decades as a valuable technique to overcome such an issue.

In this talk I present recent findings obtained by applying spectral line stacking to MIGHTEE-HI data, acquired with the MeerKAT telescope, one of the major SKAO precursors.

First, I present the first detection of HI scaling relations of star-forming galaxies at a median redshift z~0.37 (and for the first time beyond the nearby universe) obtained by applying 21cm spectral line stacking to a sample of thousands of galaxies with known spectroscopic redshift (Sinigaglia et al. 2023c). Subsequently, I present the results of the investigation of the HI content of galaxies in different large-scale structure environments, conducted with the same methodology (Sinigaglia et al. 2024a).

Eventually, I will show preliminary results from an ongoing study exploiting the findings reported above to derive semi-empirical constraints on the HI mass function and on the HI density parameter at z~0.37 (Sinigaglia et al., in prep.).

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Galaxy dynamics from statistical HI samples in the SKA era

Dr Federico Lelli

INAF - Arcetri Astrophysical Observatory

Abstract

The HI line at 21 cm is arguably the best tool to study the distribution of luminous and dark matter (DM) in nearby galaxies because HI disks are dynamically cold and generally more extended than the stellar components of galaxies, allowing us to measure the gravitational potential out to large radii. In this context, the SPARC (Surface Photometry and Accurate Rotation Curves) project has played an important role, providing HI rotation curves and near-infrared surface photometry for 175 galaxies at z=0. I will review the main results from the SPARC project, such as the properties of DM halos and the dynamical scaling laws of disk galaxies, but I will also highlight current limitations, such as data heterogeneity and limited statistics, which prevent us from fully testing LCDM models and alternative scenarios. I will then introduce the SPARC-1k database, which consists of about 1000 galaxies with near-infrared photometry from WISE and HI data from public telescope archives (ATCA, GMRT, VLA, WSRT). For all these galaxies, SPARC-1k will provide homogeneously derived HI moment maps and near-infrared photometry, as well as ready-to-use advanced data products (surface density profiles, rotation curves, mass models, and so on). SPARC-1k will increases the size of its predecessor by a factor of about six; this is a necessary intermediate step to get ready to the additional order of magnitude increase in sample size expected from existing and ongoing HI surveys with SKA precursors (e.g., AWES with Apertif, MIGHTEE-HI with MeerKAT, WALLABY with ASKAP) and ultimately with SKA-MID.

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Deep HI survey of the COSMOS field with FAST

Dr Hengxing Pan

University of Oxford

Abstract

We present a deep HI survey in the L-band conducted by the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) across the COSMOS field. This survey is specifically designed to overlap with the MIGHTEE COSMOS field, aiming to combine the sensitivity capability of the FAST and high-resolution of the MeerKAT telescope. We observed the field for 11 hours covering ~2 square degree, demonstrating that the FAST data have reached a median 3σ column density of $\sim 2\times10^{17}cm^{-2}$ over a 5km/s velocity width, allowing for studies of the distribution of HI gas in various environments, such as in galaxies, the Circum-Galactic Medium CGM and Intergalactic Medium (IGM). We visually searched the spectral cube for HI sources, and found a total of 80 HI objects, of which ~70 percent have been cross-matched with the MIGHTEE-HI catalogue. With the cross-matched sources, we measure their HI masses in the last billion years, and find that the FAST-HI sources are more HI massive on average than their MIGHTEE-HI counterparts by a median of ~0.1 dex for isolated galaxies and galaxy pairs, which further indicates that ~19% of the total HI gas exists in the CGM and IGM when the complex galactic environments, such as galaxy groups, are not considered. We describe a few FAST-MeerKAT synergy projects, highlighting the full potential of utilizing both radio instruments in studying the distribution of the diffuse HI gas and their evolution.

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Comparing 2D and 3D kinematical parametrizations of nearby disc galaxies

Mr Maminiaina Rakotovao

University Ankatso of Antananarivo

Abstract

Obtaining accurate kinematic parameterizations of galaxies is crucial for gaining insights into their formation and evolution. Among these parameters, the rotation curve stands out as particularly important. In this study, we employ high-resolution VLA data from The HI Nearby Galaxy Survey (THINGS) to compare rotation curves obtained through 2D and 3D methods. For the 2D approach, we utilize 2DBAT (2D Bayesian Automated Tilted-Ring Fit), while for the 3D approach, we employ FAT (Fully Automated TiRiFiC (Tilted Ring Fit Code)). Our objective is to examine the limitations and overall performance of these two methods in various case studies, such as highly resolved versus marginally resolved observations, the effects of disk thickness, and the impacts of inclination. We present preliminary findings based on a few galaxies from the THINGS dataset and discuss future prospects. These software applications will play an indispensable role in analyzing data from forthcoming surveys, such as the Square Kilometre Array (SKA), thus enabling comprehensive kinematic analysis.

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Making the Deepest Images of the Circumgalactic Medium

Ms Tasmiyah Rawoot[1,2], Dr W.J.G. de Blok[3]

[1]SARAO. [2]ASTRON. [3]University of Cape Town

Abstract

Theory suggests that galaxies accrete their gas through two types of accretion: hot and cold. Hot accretion involves gas falling into the dark matter halo, being shock-heated to the virial temperature of the halo, and then slowly cooling onto the disk of the galaxy in a quasi-spherical manner. This mode of accretion is predicted to be dominant for higher mass galaxies in the present day. On the other hand, cold mode accretion involves gas remaining at relatively cooler temperatures as it enters the dark matter halo and falling directly onto the disk of a galaxy along filamentary structures. This process should be the dominant accretion process in the early universe and for low mass galaxies in lower density environments. While there is some observational evidence that cold mode accretion is occurring, we lack details of how this process works. To gain further insight into the mechanics of gas accretion, we require sensitive maps of the surroundings of galaxies, the circumgalactic medium (CGM). We will present HI data for at least 1 galaxy (NGC 7424) in the IMAGINE survey and make a comparison of the HI fluxes and linewidths of the galaxies detected in the same galaxy by the MHONGOOSE survey. We will show how to best combine the data from MeerKAT and the ATCA in order to produce the deepest images of a single galaxy to search for evidence of cold-mode accretion in the CGM.

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Galaxy dynamics revealed by a physically motivated model for the integrated H I line profiles

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Abstract

Dispite the high spatial resolution of SKA, a fraction of the galaxies will be marginally resolved or unresolved, especially those at the low mass end or at cosmological distances. But the complexity and diversity of the integrated H I line profile still plague the attempts to model it and further extract information of the atomic gas in galaxies. In this work, I will present the Parametrized Asymmetric Neutral hydrogen Disk Integrated Spectroscopic Characterization (PANDISC) model, based on physical arguments and parameters that can provide a universal fit for the diverse and often asymmetric H I line profile. The power of the model in characterizing H I line profile will be demonstrated in a variety of samples and applications. With the application on the full ALFALFA spectral data, I will present the ensemble distribution of dynamical dynamical information including velocity distribution, line asymmetry, broad wings. I will also discuss the connection between these dynamical features to other physical properties of galaxies, and the implication on our understanding of the physical processes that shapes the H I disk.

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The HI Chronicles: Connecting Galaxy Evolution with the Cosmic Web

Nick Luber

Columbia University

Abstract

Understanding the nature of galaxy evolution requires describing the impact of the universe's large-scale structure, the so-called cosmic web, on the cold gas reservoirs in and around galaxies. I will explore this connection using two complementary observational datasets and methods of analysis. Firstly, leveraging data from the COSMOS HI Large Extragalactic Survey (CHILES) and HI stacking techniques, I will discuss how the average cold gas content of galaxies evolves out to a redshift of 0.5 in different cosmic web environments and compare these findings against measurements from the Illustrious simulations. The differences found between simulations and observations will demonstrate how future observations could constrain the treatment of the baryon cycle, and the interaction between galaxies and the cosmic web. Secondly, I will present compelling evidence of cosmic web ram-pressure stripping affecting a dwarf galaxy in our local universe—an insight into a process that may be prevalent in the quenching of low-mass galaxies. This comprehensive exploration underscores the pivotal role of the cosmic web in shaping galaxy evolution, highlighting the essential need for varied techniques and observations to unravel its complexities.

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MeerKAT observations of two nearby late-type galaxies offer new insights into accretion and AGN feedback with neutral hydrogen.

Miss Karina Santana[1], Prof Roger Deane[1,2], Dr Filippo Maccagni[3]

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Abstract

The replenishment of cold gas into late-type galaxies is required to sustain their star formation rate densities over cosmic time, however, observational evidence of this 'cold accretion' remains ambiguous. MeerKAT observations of nearby galaxies provide unique insights on the neutral atomic hydrogen (HI) gas morphology and kinematics from circum-galactic to circum-nuclear scales of galaxies, contributing to our understanding on how gas flows in and out of galaxies are responsible for the fuelling of star formation and active galactic nuclei (AGN). I will present MeerKAT observations of two nearby galaxies (NGC6240 and NGC5643) where we detect HI clouds and filaments enabling us to trace the interaction history of the galaxies and the gas flows onto their disks.

MeerKAT observations of NGC5643 trace the dense HI correlated with the star formation in the spiral arms and several external low-column density features, including a tail with extreme kinematics likely indicating cold gas accretion from the environment. NGC6240 is an archetypal post-merger system showing on-going dual nuclear activity and starburst-driven gas outflows/inflows. MeerKAT HI observations provide a new perspective on the gas dynamics near the dual AGN and as well the larger-scale interaction history.

These studies can be considered prototypical examples of how MeerKAT observations add important information to the holistic understanding of gas flows in already well-studied galaxies, and the impact on star formation and nuclear activity. Comparisons such as this preview SKA observations at higher redshifts where the galaxy merger rate, AGN prevalence, and cosmic star formation rate density are significantly higher.

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Quenching and boosting star formation: comparing the atomic and ionized gas components in Virgo dwarf galaxies.

Dr. Marco Grossi

Observatório do Valongo/Universidade Federal do Rio de Janeiro

Abstract

We present integral field spectroscopic (IFS) observations of a sample of star-forming dwarf galaxies (SFDG) in the Virgo cluster obtained with PMAS/PPak and atomic hydrogen (HI) observations taken with the GMRT telescope. The dwarfs are located in different regions of the cluster and present different star formation properties. In some cases the star-forming emission traced by the Hα line is centrally concentrated indicating that the cluster environment is gradually quenching the galaxies outside-in; in other dwarfs the asymmetry of the location of the star-forming regions and the presence of tails in the HI component suggest that ram pressure stripping is temporarily triggering star formation in the interface region between the interstellar and the intracluster medium. Moreover, some dwarfs present an enhanced star formation activity, indicating that gas accretion or, most likely, a dwarf-dwarf merger scenario may have occurred, as suggested by the evidence of inverted metallicity gradients in two galaxies of the sample. We analyze HI and Hα emission morphologies and velocity fields, and the metallicity profiles to better understand the stage of interaction of the dwarfs with the cluster environment and to investigate the effects on the quenching and boosting of the star formation process in dwarf galaxies. Lastly, we compare the Virgo sample with SFDGs in the Fornax cluster for which archival IFS and HI observations are also available, to assess whether the differences between the two environments reflect on the properties of their dwarf members.

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Leveraging the synergies between next-generation surveys with the SKA and LSST

Miss Nomthendeleko Motha

University of the Western Cape

Abstract

The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) will be an unprecedented optical survey capable of revolutionising many fields of astronomy. The Square Kilometre Array (SKA) telescope will be similarly groundbreaking in the radio regime. We aim to develop techniques that combine the data from these two complementary instruments to maximise potential scientific gain.

The 21cm neutral hydrogen (HI) emission line is ubiquitous throughout the universe and extremely useful for obtaining precise redshift information using a radio telescope. However this line is intrinsically faint and difficult to observe for distant galaxies. In 2017, Harrison, Lochner and Brown developed a Bayesian technique to extract the redshift from a radio spectrum by fitting a standard model to the expected HI emission. We propose an extension of this work by introducing a new and realistic model of the HI line. Additionally, we incorporate photometric redshift estimates as expected from optical surveys such as the LSST, and expand the model using a Bayesian hierarchical modelling approach to include population information to further constrain redshift information.

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Automating Galaxy Parameter Determinations for Application of the BTFR

Dr. Aileen O'Donoghue[1], Ms. Catherine Ball[2], Dr. Martha Haynes[2], Dr. Joseph Ribaudo[3], Dr. Rebecca Koopmann[4], Mr. Tyler Karasinski[1], Mr. Arya Desai[5]

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Abstract

The Baryonic Tully-Fisher Relation (BTFR), constrains models of galaxy formation and evolution and can be used to estimate distances and peculiar velocities. Application requires a template from measured parameters of rotational velocity and baryonic mass. Published BTFR templates express slightly different values for the relation. The scatter arises from uncertainties in the observables and derived properties plus intrinsic scatter. A major source of scatter is uncertainties in distances.

Using the complete Arecibo Legacy Fast ALFA Survey (ALFALFA, Haynes et al. 2018) and the Arecibo Pisces-Perseus Supercluster Survey (APPSS O'Donoghue et al. 2019), we have investigated the derivation of BTFR templates applicable to the detected galaxies. The gas mass is assumed to be dominated by HI and stellar masses are derived from available photometry. Ball et al. 2023 developed a curve-of-growth method for automating replicable measurements of total flux, recessional velocity, and velocity width in HI spectra, and derived a template BTFR for the ALFALFA sample.

We also aim to derive a template for galaxies with minimum-error supernova distances. New HI line observations with the Green Bank Telescope will be combined with spectra already available for these to derive a BTFR template with minimal distance errors

This work has been supported by NSF grants AST-1637271, AST-1637339, AST-1714828, AST-2045369. and AST-2045574 and by grants from the Brinson Foundation to MPH and CJB.

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The HI view of dwarf galaxies in the Local Void: a pilot survey with WALLABY DR1

Rayssa Guimarães-Silva, Marco Grossi

Observatório do Valongo

Abstract

The ΛCDM model predicts that voids harbour a population of gas-rich dwarf galaxies with very low metallicities. According to this model, dwarf galaxies are the first step in the build-up of more massive galaxies. Their growth can stem from dark matter halo mergers or gas accretion from the cosmic web, although the dominant mechanism remains unclear. Some studies suggest that the chemical evolution of dwarf galaxies in voids is dominated by internal processes linked simultaneously to stellar mass growth and enrichment of these galaxies. Others, mostly based on the analysis of HI gas morphology, find evidence of gas accretion. Thus, investigating dwarf galaxies in voids offers the chance to investigate how galaxies evolve free from the influences of massive galaxies within a mass range representative of earlier stages in galaxy formation and evolution.

We aim to trace how these galaxies evolve in low-density environments by analysing the dynamics and morphology of their neutral gas content. From WALLABY DR1 – an ongoing survey at 21 cm of the Southern Hemisphere carried out with the ASKAP telescope –, we selected 22 low-mass galaxies in the Local Void. We present the analysis of the HI surface density, kinematics, and velocity dispersion of the sample.

We find evidence of perturbed HI morphology and velocity fields in at least 32% of our sample. In particular, we analyse the nearest collisional ring galaxy, ESO179-031, composed of three known interacting dwarf galaxies. Its 21 cm data analysis shows clear evidence of tidal interactions and regions of increased turbulent speeds.

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Arecibo Confirms Infrared ZoA Galaxies Selected From Spitzer Data

Dr. Mayra Lebron[1], Dr. Carmen Pantoja[1], Dr. Alberto Noriega-Crespo[2], Andrea Boria[1], Dr. Hector Arce[3]

[1]University of Puerto Rico - Río Piedras Campus. [2]Space Telescope Science Institute. [3]Yale University

Abstract

We report the discovery of 7 new HI galaxies in the zone of avoidance (ZoA). A sample of 25 extremely low Galactic latitude Infrared galaxies located in the Sagitta-Aquila region (Marleau et al. 2008) were observed with the Arecibo Telescope. The velocity of the 7 new Arecibo HI sources range from 5,700 km/s to 10,900 km/s ($0.019 > z > 0.037$) and none of them have optical counterparts. The HI redshifts for these objects suggest a network of voids for the large scale structure toward the Galactic plane. Comparison between spectroscopic and photometric redshifts are in agreement for all sources considering the uncertainties in both methods. All detected galaxies were visible in the Wide-field Infrared Survey Explorer (WISE) and Herschel Space Observatory bands. A SED spectra using WISE, Herschel 2MASS and Spitzer photometry was modeled and agrees with spirals as previously reported. All sources were searched for counterparts in the Cornish 5 GHz continuum survey but no continuum emission was found at the noise level of the images. Marleau et al. (2008) demonstrated the feasibility of discovering galaxies in the ZoA using mid to far infrared data and this survey shows that mid-infrared sources are very good targets for HI studies of the ZoA.

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New infrared galaxy candidates near the Ophiuchus supercluster

Dr. Mayra Lebron[1], Dr. Carmen Pantoja[1], Julian Ramos[1], Kashmille Camacho[1], Natalia De Jesus[1], Andrea Boria[1], Luis Flores[1], Janiel Echavarria[1], Dr. Alberto Noriega-Crespo[2], Dr. Héctor Arce[3]

[1]University of Puerto Rico - Río Piedras Campus. [2]Space Telescope Science Institute. [3]Yale University

Abstract

We study the extension of the Ophiuchus supercluster toward the dust-obscured Milky Way disk (ZoA) using the Spitzer GLIMPSE 3D archived data. A catalog of galaxy candidates from the northern galactic bulge was compiled. Three color images covering a 24 sq deg area were visually inspected for galaxy identification using selection criteria based on morphology at the 8 micron GLIMPSE 3D images, following Marleau et al. 2008 work. 119 galaxy candidates were selected for the final catalog. Each candidate was also searched for a counterpart in the ALLWISE catalog. The WISE colors of the sample were compared with color-color diagrams of galaxies in the ZoA with detected and non-detected HI. Most of the galaxies in our catalog share the WISE color-color space with the galaxies with detected HI. We require spectroscopic observation to determine the membership in the Ophiuchus supercluster of the galaxies in our sample. Ongoing HI surveys like Wallaby will be of great benefit to this project.

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The control of the radial cold HI mass fraction by magnetic field

Adriana Gazol

IRyA, UNAM

Abstract

The cold to total HI ratio in the Galactic plane seems to remain approximately constant for galactocentric radius, Rg, between ~10 and ~20 kpc, despite the differences in physical conditions. In order to explore the possible role of the mean magnetic field on the radial control of the cold HI gas fraction, we perform numerical simulations of turbulent cubic boxes with 250 and 100pc by side including cooling functions adapted to model HI gas at Rg equal to 8.5, 11, 15 and 18 kpc. We find that, for the values of Rg we consider, the combined effect of radial magnetic field variations and forcing scale is enough to maintain the CNM mass fraction approximately constant between 11 and 18 kpc. In this case, the ratio between thermal and magnetic pressure as well as the Alfvénic Mach number in the CNM remain also approximately constant with Rg.

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Environmental effects on HI in simulations

Rory Smith

Universidad Técnica Federico Santa María

Abstract

Numerical simulations have proven crucial tools for understanding environmental effects that influence the HI content of galaxies. They have provided a variety of new tools and diagnostics that can be applied to observations to greatly deepen our understanding of the processes at play. Furthermore, recent results from cosmological simulations make it increasingly clear that we cannot ignore the close connection between dense environments and their surrounding large scale structure. However, while hydrodynamical cosmological simulations have been shown to be highly successful at matching global gas scaling relations of central galaxies, it remains challenging to accurately match the properties of satellite galaxies. Thus, the complex physics at play on satellite galaxies may potentially provide valuable constraints on the subgrid physics employed in the next generation of simulations.

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Separating Point Source Contaminants at the Visibility Level

Mr Shreyam Parth Krishna[1], Dr. Emma Tolley[1], Dr. Michele Bianco[2], Prof. Jean-Paul Kneib[1]

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Abstract

Bright point source contaminants are an ever-present problem in astronomy. This problem is especially pronounced for radio interferometric telescopes. The calibration for these telescopes is never perfect, and consequently even the smallest errors in the calibration of bright sources can cause interferometric artefacts that obfuscate weaker sources within the same field of view. This effect can strongly limit the dynamic range of images created by the next generation of radio interferometric telescopes. Peeling, or subtraction of modelled visibilities belonging to the bright source in visibility space, is often employed to combat this problem. However, this does not always remove all interferometric artefacts associated with the bright contaminating source.

We present a visibility-based method, Bluebild Imaging Plus Plus (BIPP), for the removal of contaminating point sources. BIPP is an interferometric imager developed to reconstruct the sky intensity matrix directly on the celestial sphere. It uses functional principal component analysis (fPCA) based on the intensity of sources to separate input visibilities into eigen-visibilities. These eigen-visibilities are then reconstructed into eigenimages, which can be optimally combined into energy levels for source separation. Since the fPCA is done on the visibilities directly, all energy levels contain artefacts only from the sources present within each energy level. We use this method to separate a contaminating bright source at two different frequencies for simulated observations made from a realistic sky model. In doing so we demonstrate the potential for BIPP to be used as a method for bright source separation.

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Characterization of Energy Injection in HI

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Abstract

Although it is widely accepted that interstellar turbulence plays a crucial role in determining the properties and evolution of the neutral atomic (HI) gas, the origin and properties of such turbulence are far from being fully established. The purpose of the present work is to characterize the nature of supernovae (SN) driven turbulence in HI. We perform numerical MHD simulations of a kpc region of the galactic disc, with solar neighborhood properties and including physical processes such as self-gravity, a vertical external potential, heating and cooling, and SN explosions. We focus our analysis in the central 100 pc^3 cubic region, where we reach an effective resolution of 0.2 pc to better characterize the properties of the turbulence driven by SNs and to study the physical properties of the HI. From an evolutionary perspective, we will present the following turbulence characteristics: a) the spatial power spectrum of density; b) the velocity power spectrum; c) the ratio of solenoidal to compressive modes, and d) the probability distribution functions (PDFs) of the coexisting gas phases (cold, warm, and hot). Our analysis of the neutral gas's physical properties provides insights into its distribution, thermodynamics, and dynamics, contributing to a deeper understanding of its evolution.

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Using gas kinematics to measure resonant structures in disc galaxies: the interaction of M51 with NGC 5195

Joan Font[1], John Beckman[2,3], Claire Dobbs[4], Miguel Querejeta[5], Benoit Epinat[6,7]

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Abstract

Interstellar gas offers advantages when quantifying the structure of the resonances in disc galaxies. The gas is concentrated close to the disc mid-plane, making it easier to determine its in-plane velocity components, and it offers sharp emission lines for good velocity resolution. These properties are shared by atomic, molecular, and ionized gas; high spectral and angular resolution over wide fields can be performed, especially for the ionized and molecular phases. We have previously shown that using gas kinematics corotation radii can be found, not only corresponding to the main bars of barred galaxies, but also to nuclear bars, and for the spiral arms, which usually exhibit several corotations, corresponding to a concentric annular density wave pattern. We have also shown that a gas kinematic technique gives precise correspondence with the structure found using the Tremaine Weinberg method for stars, but can cover a larger fraction of galaxy discs. In this contribution we present our recent study of the resonant structure of M51, using kinematic mapping with the CO molecule from PAWS supplemented with our own velocity map in Halpha, which is complemented with the analysis of the morphology of M51. We demonstrate the role of its interacting satellite NGC 5195 in stimulating the formation of the spiral arms and kinks, and demonstrate that it has twice passed through the plane of M51, calculating the time interval between passages. Our results are strengthened by comparison with simulations of this interaction.

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Application of persistence homology in 21cm observation

Cheng Cheng

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Abstract

With the SKA observation, there will be plenty of 21cm singals from Epoch of Reionization(EoR), which encoded the full history of Reionization. But the 21cm signals are highly non-gaussian. So the traditional statistic methods most of which investigate the gaussian information, can not fully extract the information encoded in the 21cm signals. Our work investigates the topological evolution of the ionized bubbles with the method of persistence homology not only to distinguish different reionization scinario but also constrain the parameters of reionization in a high accuracy.

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Linking Gas-Giant Atmospheres with Planetary Formation Constrained by JWST Observations

Liton Majumdar

National Institute of Science Education and Research (NISER), Bhubaneswar, India

Abstract

The elemental ratios of carbon, nitrogen, and oxygen in the atmospheres of gas giants may provide insights into their formation locations within the protostellar disk. In this presentation, I will discuss our recent work, wherein we utilized gas-phase chemical abundances of C, N, and O from various locations in an in-house disk physiochemical model called PEGASIS. These values served as sources for the envelopes of multiple gas giants observed through JWST GTO/GO programs. We evolved their atmospheric compositions using a 1D photochemical kinetics model for planetary atmospheres, incorporating a state-of-the-art chemical network and addressing both vertical mixing and photochemistry. I will also showcase synthetic transmission spectra grids for these atmospheres, demonstrating that many spectral features vary based on the location and physical environment in the disk where the planetary envelope accreted. In conclusion, I will emphasize how JWST transit observations, when combined with grids of planetary spectra generated using a coupled disk (either forming or hosting planets) and planetary atmosphere model, can effectively constrain the formation of gas giants. This approach provides robust, statistically significant, non-degenerate solutions for the planetary formation of different gas giants.

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A machine learning insight into the exoplanet populations

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Abstract

The growing number of exoplanet discoveries and advances in machine learning techniques have opened new avenues for exploring and understanding the characteristics of worlds beyond our Solar system. In this study, we employ efficient machine learning approaches to analyze a data set comprising 762 confirmed exoplanets and eight Solar system planets, aiming to characterize their fundamental quantities. By applying different unsupervised clustering algorithms, we classify the data into two main classes: 'small' and 'giant' planets, with cut-off values at R_p=8.13$R_\oplus$ and M_p=52.48$M_\oplus$. This classification reveals an intriguing distinction: giant planets have lower densities, suggesting higher H-He mass fractions, while small planets are denser, composed mainly of heavier elements. We apply various regression models to uncover correlations between physical parameters and their predictive power for exoplanet radius. Our analysis highlights that planetary mass, orbital period, and stellar mass play crucial roles in predicting exoplanet radius. Among the models evaluated, the Support Vector Regression consistently outperforms others, demonstrating its promise for obtaining accurate planetary radius estimates. Furthermore, we derive parametric equations using the M5P and Markov Chain Monte Carlo methods. Notably, our study reveals a noteworthy result: small planets exhibit a positive linear mass-radius relation, aligning with previous findings. Conversely, for giant planets, we observe a strong correlation between planetary radius and the mass of their host stars, which might provide intriguing insights into the relationship between giant planet formation and stellar characteristics.

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The interactions between debris discs exoplanets: A multi-wavelength view towards Beta Pic

Dr James Miley

Universidad de Santiago de Chile. Millenium Nucleus on Young Exoplanets and their Moons

Abstract

Debris discs are the final stage of circumstellar disc evolution, after which only planetary systems remain. Planets present in these systems mould and sculpt the remnant gas and dust, the density distributions that result contains clues for observers as to the properties of the planets that exist there.

In my talk I will present a multi-wavelength analysis of the archetypal debris disc, Beta Pictoris, a nearby system that hosts two exoplanets and has been used as a testing ground for both debris disc theory and for our observational capabilities for decades. The capabilities of modern facilities such as ALMA and the VLT have accelerated the field of debris disc science in recent years, a wealth of observations now exist making Beta Pictoris one of the most well-studied planet forming systems.

I will show new ALMA Band 3 observations that trace larger 'pebbles' in the disc and detect the CO(1-0) transition including the famous gas clump. Along with archival ALMA data these results are analysed in the context of previous infrared and scattered light observations. With these results I discuss the influence that giant planets can exert on debris disc density distributions and the consequences these interactions can have on the last stages of planet formation and on the atmospheres of the planets themselves.

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JWST imaging and spectroscopy of giant Oort cloud comet C/2014 UN271 during its return to the planetary region

Dr. Bryce Bolin

NASA Goddard Space Flight Center

Abstract

The Oort cloud comet C/2014 UN271, hereafter UN271, is ~140 km in diameter, large enough that it could be an intact example of a planetesimal that formed in the protoplanetary disk before being ejected into the Oort cloud. UN271 is currently beyond 16 au from the Sun. Given its large heliocentric distance, the temperatures on and below its surface are too low for efficient sublimation of water ice. Its activity is likely driven by hypervolatiles such as CO or CO2 and not H2O. It is dynamically new on its first inbound trip to the Solar System's planetary region providing the rare opportunity to study the volatile content of one of the original planetesimals in a pristine state. We present JWST/NIRSpec prism IFU observations of UN271 with R~100 covering the spectral range where we can detect emission features from the vibrational bands of the gas-phase all the main volatiles found in comets (such as CO2, CO and C2H6). Moreover, this range also includes absorption bands of solid-phase water-ice grains. Our observations, taken on December 22, 2022, and June 29, 2023, when the comet was at 18.6 au and 17.5 au from the Sun on the comet's CO and CO2 production rates, the activity driving mechanism, the presence and nature of water-ice grains in its coma. We will discuss the implications for the formation of the Oort Cloud and the original planetesimals.

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Probing Lava World atmospheres: Using ground-based facilities complementary to JWST

Dr. Engin Keles

Freie University Berlin, Germany

Abstract

Transmission and emission spectroscopy of exoplanet atmospheres enables us to infer the characteristics of planets in foreign stellar systems. Terrestrial planets are of special interest as they increase our understanding of their origin and evolution preparing us to characterize a true Earth-analog planet in the future. Recent discoveries confirmed the presence of terrestrial planets in very short orbits (< 1 day), resulting in surface temperatures above the critical value of ~ 1800K, where the surface rocks start to melt and release silicates into the atmosphere. Such worlds are denoted as Lava worlds. In our era, such small planets become accessible with e.g. JWST allowing us to probe the planetary atmospheres. However, also ground-based facilities enable us to give insights on the atmospheres of lava world planets complementary to insights inferred with e.g. JWST observations. We present how high-resolution transit observations of Lava Worlds can give complementary insights into lava worlds with respect to space-based observations.

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Solar Hydrologic Cycle Determines Earth and Venus Atmospheres Mass and Composition

Mr. Xuguang Leng

freelance

Abstract

Earth and Venus atmosphere mass and composition today are accumulated results of the solar hydrologic cycle over billions of years with comet collisions infusing gassy material onto the planets and solar wind blowing away the lighter gasses leaving only carbon dioxide and nitrogen on Earth and Venus. The comets entering the inner solar system have higher evaporation rate than collision probability, resulting in far less mass infusion to inner planets than outer planets. The solar hydrologic cycle theory predicts comet mass infusion ratio between Venus and Earth to be 1:0.61-0.80, based on their orbit sizes, planet diameters, and other factors. Comparing carbon dioxide and nitrogen mass in Venus atmosphere with nitrogen mass in Earth atmosphere plus carbon and nitrogen deposits in the crust by chemical processes, the ratio is 1:0.45-0.54. The deficit of carbon and nitrogen on Earth could be caused by the production, then blown away, of methane and ammonia in early eons when hydrogen was the dominant gas in Earth's atmosphere. Oxygen can accumulate in Earth’s atmosphere after comet infusion intensity had declined and hydrogen gas had been blown away by the solar wind about 2.5 billion years ago, which marks the starting of habitable window for complex life. Venus lacks a habitable window due to its orbit being too close to the Sun to have liquid water and associated chemical processes. The physics of the solar hydrologic cycle is applicable to other stars and exoplanets.

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Migration of bodies in the Proxima Centauri and Trappist 1 planetary systems

Dr. Sergei Ipatov

Vernadsky Institute of Geochemistry and Analytical Chemistry of Russian Academy of Sciences, Moscow, Russia

Abstract

The motion of bodies-planetesimals was studied in the Proxima Centauri and TRAPPIST 1 exoplanetary systems. The size of the feeding zone of planet Proxima Centauri *c* is discussed in [1]. It was noted that after hundreds of Myrs, some planetesimals could still move in elliptical resonant orbits inside the feeding zone of this planet that had been mainly cleared from planetesimals. The probability of a collision of a planetesimal initially located in the feeding zone of planet *c* with inner planet *b* was obtained to be about $2 \cdot 10^{-4}$ and 10^{-3} at initial eccentricity of orbits of planetesimals equal to 0.02 or 0.15, respectively [2]. A lot of icy material and volatiles could be delivered from icy zone near planet *c* to inner planets *b* and *d*. The inclinations of orbits of 80% of the planetesimals that moved between 500 or 1200 AU from the star did not exceed 10° [3]. It was obtained that several planets in the TRAPPIST-1 system accumulated planetesimals initially located at the same distance. Outer layers of neighbouring planets can include similar material. For comparison, it was concluded in [4] that each terrestrial planet incorporated planetesimals from the feeding zones of all terrestrial planets. The studies were carried out under government-financed research project for the Vernadsky Institute. [1] Ipatov S.I. Solar System Research, 2023. 57. 236-248. [2] Ipatov S.I. Meteoritics and Planetary Science. 2023. 58. 752-774. [3] Ipatov S.I. Solar System Research. 2023. 57. 612-628. [4] Marov M.Ya, Ipatov S.I. Physics–Uspekhi. 2023. 66, 2-31.

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Migration of bodies ejected from the Earth and the Moon

Dr. Sergei Ipatov

Vernadsky Institute of Geochemistry and Analytical Chemistry of Russian Academy of Sciences, Moscow, Russia

Abstract

The motion of bodies ejected from the Earth or the Moon was studied. The ejection of bodies from six opposite points of the Earth's surface, as well as from the far point of the Moon, was considered for a number of values of velocities and angles of ejection of bodies. The dynamical lifetimes of bodies reached a few hundred of Myrs. Over the entire considered time interval, with ejection velocity v_{esc} equaled to 11.5, 12, and 14 km/s, the values of the probability of a collision of a body with the Earth were approximately 0.3, 0.2, and 0.15–0.2, respectively [1]. At $v_{esc} \leq 11.3$ km/s, most of the ejected bodies fell back to the Earth. At $v_{esc} \geq 11.5$ km/s, the probability of a body ejected from the Earth colliding with the Moon was about 15–35 times less than that with the Earth. The probability of a collision with the Earth for a body ejected from the Moon was about 0.3–0.32 at v_{esc}=2.5 km/s, 0.2–0.22 at v_{esc}=5 km/s, and 0.1–0.14 at $12 \leq v_{esc} \leq 16.4$ km/s if the Moon moved in its present orbit. The total number of bodies delivered to the Earth and Venus probably did not differ much. The probabilities of collisions of bodies with Mercury and Mars usually did not exceed 0.1 and 0.02, respectively. The studies were carried out under government-financed research project for the Vernadsky Institute. [1] Ipatov S.I. (2024) Solar System Research, 58, N 1, in press.

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Implementing an AstroLab Project in Africa

Dr. Youssef Moulane, Prof Abdelouahad El Fatimy

Mohammed VI Polytechnic University

Abstract

We propose the implementation of an AstroLab project in Africa, dedicated to Astronomy and Planetary Science Education. Our goal is to significantly contribute to the development of digital education in astronomy across the universities/schools in the African continent. The AstroLab project seeks to inspire and engage students from diverse cultural backgrounds by providing them with a unique opportunity to conduct astronomical research and education through remotely accessed telescopes. This initiative is particularly crucial in regions where the lack of astronomy infrastructure impedes students from hands-on experience in this field. Moreover, we aim to implement this program in three distinct languages (Arabic, French, and English) to ensure accessibility and inclusivity for the diverse communities across the continent.

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Exploring the collinear Lagrangian points of exoplanet systems with P-R drag and oblateness.

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In this paper we study the location and stability of the collinear Lagrangian points for the RTBP for the case in which one of the primary bodies is radiating and the other is oblate. We consider the effect of Poynting-Roberson drag and investigate how the location and stability of the Lagrangian points change with changes in the radiation parameter β and oblateness a. We apply our results to ten exoplanet systems -- CoRoT-2~b, TOI-1278~b, HAT-P-20~b, Kepler-75~b, WASP- 89~b, TIC 172900988~b, NGTS 9~b, LP 714 - 47~b, WASP- 162~b and XO- 3~b, data of which has been taken from NASA exoplanet archives, with the aim of finding locations in these exoplanet systems where one can detect asteroids, primodial material or seeds where planet formation can take place. We find that the location of the collinear Lagrangian points changes with variation in radiation pressure and oblateness. Further, for all the ten planetary systems, studied in this paper, the Lagrangian points are unstable and can be locations where we expect to find minor planets, asteroids or debris. The unstability of the the Lagrangian points can be a possible cause of relocation and migration of planetesimals. These could be possible objects of observations with the James Webb.

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Physical Processes in the Coma of 29P/Schwassmann Wachmann 1

Dr. Youssef Moulane[1], Prof. Dennis Bodewits[2], Dr. Steve Bromley[2]

[1]Mohammed VI Polytechnic University. [2]Auburn University

Abstract

Distant comets, like 29P, offer significant clues about the primordial conditions and processes in the solar system as they provide evolutionary links between different populations of small bodies. One of the longstanding puzzles in planetary science is the presence of CO+ in the inner coma of the comet/Centaur 29P at 6 AU from the Sun. Early studies indicated that photoionization alone cannot explain the phenomenon we observe. Recent evidence suggests a correlation between CO+ production and the solar wind flux, rather than the solar UV flux. Understanding CO+ in distant comets requires investigating both the ionization and excitation processes. Different physical processes (such as photoionization, fluorescence, and solar wind charge exchange) lead to distinctly different populations that are accessible by observations, including the morphology, brightness, and spectral line distribution of CO+.

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The importance of ground-based transmission spectra in characterising stellar activity for JWST

Dr. Dominique Petit dit de la Roche, Prof.Dr. Monika Lendl

University of Geneva

Abstract

The James Webb Space Telescope's unprecedented precision and wavelength coverage have already led to many new discoveries in the field of exoplanets. However, this increased precision means contamination of the data by the host star's stellar activity is also observed more clearly. This phenomenon is highly variable and can introduce false positives of molecular features, such as those of water, which is also found in sunspots. This makes optical transmission spectra more important than ever, as their coverage of bluer wavelengths can not only give a measure of the amount of activity going on, but also distinguish between different types of activity such as spots and faculae, which are degenerate in photometric monitoring. In this talk I will present an optical transmission spectrum of the hot Jupiter WASP-69 b taken with the FORS2 optical spectrograph on the VLT. I will identify the signatures of spots and faculae, which would not be distinguishable with JWST data alone, but are nonetheless needed to distinguish between molecule detections in the planet atmosphere and on the stellar surface.

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Exploring Correlations of High-Altitude Aerosol Formation in Planetary Systems with Similar Parameters

Dr. Chima McGruder

Harvard University

Abstract

High-altitude aerosols prevent our ability to probe exoplanet atmospheres, by muting or completely obscuring molecular and atomic features. The ability to isolating a few system parameters that have strong correlations to high-altitude aerosol formation would be invaluable for further atmospheric studies and lead to optimal usage of the next generation of facilities like JWST, ARIEL, and the ground-based ELTs. Unfortunately, there currently is no way to a priori determine which planets are likely to be unobscured. The most current comparative studies looking for correlations between the atmospheric properties of gas giants and parameters such as their masses, radii, stellar metallicities, etc., have yielded no clear trends likely because they are fitting too many parameters simultaneously to relatively small numbers of planets. We have identified a subset of seven planets that differ from other studies because they match in most parameters. In essence, these planets provide a control sample to search for correlations amongst the two primarily differing properties: stellar metallicity and high-energy irradiation.

Combing new Magellan/IMACS transmission spectra with published data, we find a tentative correlation with optical atomic features, a proxy for high-altitude aerosol levels, and host star metallicity. The correlation was found after homogeneously rederiving the stellar, planetary, and orbital parameters of every system in the sample, reducing parameter biases. Though the precision of some of the current transmission spectra are not high enough to strongly support the tentative trend, if true, this trend has the potential to be foundational in theoretical and observational exoplanet atmospheric studies.

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The Comet Interceptor mission

Prof Colin Snodgrass

The University of Edinburgh

Abstract

Comet Interceptor is an European Space Agency (ESA) mission in cooperation with the Japan Aerospace Exploration Agency (JAXA). It aims to characterise through a close flyby a long period comet, preferably dynamically new, or an interstellar object. The main spacecraft will be accompanied in its encounter with the target comet's nucleus by two small probes, one provided by Europe, and the other by Japan, providing multi-point measurements of the cometary coma during the flyby. The mission is planned for launch in 2029. It is unique in being designed and built before its target is known: in the era of next generation sky surveys (in particular the Vera C Rubin Observatory's Legacy Survey of Space and Time) it is expected that incoming long period comets will be discovered at relatively large distance, but still with too little time to plan and launch a mission following discovery. Instead Comet Interceptor will launch to the Sun-Earth L2 point, sharing a launch with the ESA Ariel space telescope, and wait in space for a suitable target to be found. We will describe the mission and the preparations that are being made for science with it, including work towards identification of a suitable target. JWST will play an important role in the latter, as it is uniquely capable of studying the activity of comets at very large distance, and therefore characterisation of potential mission targets.

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A Search for White Dwarf Planets by Detecting the Unipolar Star-Planet Interaction

Alex Wolszczan[1], Ryan Lynch[2], Anish Roshi[3]

[1]Penn State University. [2]Green Bank Observatory. [3]University of Central Florida

Abstract

Observations of metal pollution in white dwarfs (WDs, e.g. Wilson et al. 2019), occulting asteroid-size debris (Vanderburg et al. 2015; Farihi et al. 2022), and, finally, evidence for a gas giant in close orbit around one of them (Vanderburg et al. 2020) demonstrate that dynamically evolved remnants of the original planetary systems can survive, in an altered form, the entire stellar evolution off the main sequence (Villaver & Livio 2009). This makes it very important to continue searches for WD planets using plausible methods, to better understand these evolutionary constraints. Here, we describe the design and pilot observations for a radio search for WD planets, exploiting the unipolar dynamo mechanism, similar to that observed in the Jupiter-Io system (Zarka 2018). This kind of a WD planet search was first proposed by Willes & Wu (2004, 2005).

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Search for new members and age estimation of the young Emilkowalski asteroid family

Prof. Eduard Kuznetsov, Dr. Aleksander Perminov, Victoria Safronova, Maria Vasileva

Ural Federal University

Abstract

We have searched for new members of the young Emilkowalski asteroid family. The number of family members reached 20. For 16 asteroids, we determined their proper synthetic orbital elements using Orbit9 software. We investigated the dynamical evolution of the asteroid family over a 5 Myr with Orbit9 software. Initial orbital elements were chosen from AstDyS database for epoch MJD 60200. Equations of motion for asteroids, eight major planets and Pluto dwarf planet were integrated simultaneously. Perturbations from the Sun oblateness, relativistic effects, and the influence of the diurnal Yarkovsky effect were considered. To estimate the ages of the pairs, we used the method of simultaneous convergence of the nodes and perihelion orbits, i.e., simultaneous zeroing of the differences of the longitudes of the ascending nodes and perihelion arguments. We considered all possible pairs between asteroids of the family. In the case of the zero-drift rate of the semi-major axis due to the influence of the Yarkovsky effect, the ages of the pairs do not exceed 2 Myr. The pairs 2009UL13 - 2009VF107 and 2020UZ20 - 2021TU55 have maximum age estimates of 1.51 and 1.58 Myr, respectively. In pairs with asteroid (14627) Emilkowalski, a maximum age estimate of 1.12 Myr was obtained for asteroid (476673) 2008 TN44. The obtained estimates of the age of pairs allow us to limit the integration interval in the study of the probabilistic evolution of asteroid family orbits to the range of 2 Myr. The study was funded by the Russian Science Foundation grant No. 24-22-00143, https://rscf.ru/en/project/24-22-00143/

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Dynamic evolution of the compact planetary system K2-72

Prof Eduard Kuznetsov, Dr Aleksander Perminov

Ural Federal University

Abstract

We consider the dynamic evolution of the compact four-planetary system K2-72. Star K2-72 is an M-type dwarf. The system contains three Earth-like planets and one super-Earth. We searched for low-order resonances within the uncertainty of determining the periods of the planets. To determine the resonant combinations of the semi-major axes of the orbits, the ratio of the mean motions of neighboring planets was represented as a segment of a sequence of convergent fractions. We considered a few scenarios for the evolution of the K2-72 system over 100 Myr using the Posidonius software, which considers tidal interactions. We showed that the compact planetary system K2-72 likely evolves beyond low-order resonances. A significant change in the large semi-major axes of the orbits of the K2-72 b and K2-72 d planets leads to the moving of the adjacent planets b–d and d–c out of the 7/5 and 8/5 resonance regions, respectively. The adjacent planets K2-72 d and K2-72 c are located far from the 2/1 resonance, which excludes the possibility of forming chains of mean motion resonances and, hence, 3-planet mean motion resonances. If the orbital eccentricities do not exceed 0.03, the evolution of the compact planetary system K2-72 over 100 Myr remains stable even in the presence of tidal perturbations. The authors were supported by the Russian Ministry of Science and Higher Education via the State Assignment Project FEUZ-2020-0038.

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Broadband Linear Polarimetry of Exoplanet Upsilon Andromedae b: Constraints on theOrbital and Physical Parameters

Yasir Abdul Qadir[1], Andrei Berdyugin[1], Vadim Kravtsov[1], Vilppu Piirola[1], Takeshi Sakanoi[2], Masato Kagitani[2], Juri Poutanen[1]

[1]University of Turku, Finland. [2]Tohoku University, Sendai, Japan

Abstract

Recent advancements in astronomical polarimetry have improved our ability to detect and analyze hot Jupiters like exoplanets, revealing details about their orbital parameters, atmospheric composition, and reflective properties. Combining polarimetry with spectroscopy and photometry offers a holistic understanding of exoplanets, including non-transiting hot Jupiters like Ups And b.

Our polarimetric observations of the Ups And star system spanned nearly three years, capturing data across different orbital phases of Ups And b. Utilizing the T60 telescope with the DiPol-2 polarimeter ensured precise measurements. Employing the Lomb-Scargle periodogram method, we identified periodic signals in our data.

Our findings revealed a polarimetric signal precisely at half of Ups And b's known orbital period, as expected for exoplanetary polarimetric data. Applying the Rayleigh-Lambert scattering model, we derived constraints on the exoplanet's orbital parameters, including inclination angle and longitude of periastron. Integrating these results with spectroscopic studies allowed determination of Ups And b's planetary mass, mean density, and surface gravity.

Additionally, analysis of Transiting Exoplanet Survey Satellite (TESS) photometric data suggested the presence of star spots on Ups And, affecting the observed polarimetric signal. Quantifying the scattering atmosphere radius and planetary albedo of Ups And b proved to be elusive.

In summary, high-precision polarimetry offers valuable insights into exoplanets, aiding in understanding their orbital and atmospheric characteristics. This study demonstrates the potential of polarimetry in characterizing various exoplanets and underscores the importance of integrating observational techniques for comprehensive planetary analysis.

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Reconstructing the host star's extreme ultraviolet and Lyman-alpha emission that drive exoplanet mass loss and photochemistry

Prof. Jeffrey Linsky[1], Prof. Seth Redfield[2]

[1]JILA/University of Colorado at Boulder and NIST. [2]Department of Astronomy, Wesleyan University

Abstract

Hydrodynamic mass loss from exoplanet's atmospheres is driven by the extreme ultraviolet (EUV) radiation of its host star, and photochemistry of important molecules in the upper atmospheres of exoplanets is driven primarily by the hydrogen Lyman-alpha radiation of the host star. Major parts of both the EUV and Lyman-alpha radiation are absorbed by interstellar hydrogen in the line of sight to the star. In this talk we will describe various techniques for reconstructing the intrinsic radiation received by exoplanets and discuss the accuracy and applicability of these techniques for understanding the radiation of solar-like and M dwarf host stars.

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Observing Biosignatures from Exoplanets outside the Conservative Habitable Zone

Prof. Amri Wandel

The Hebrew University of Jerusalem

Abstract

Amri Wandel

In analogy to satellites of Jupiter and Saturn in our Solar System, subglacial liquid water may be expected in exoplanets orbiting their host star outside of the Conservative Habitable Zone (CHZ). Recently Wandel demonstrated that subglacial liquid water can exist on exoplanets in a circumstellar region significantly extended compared with the conservative HZ boundaries. Planets further away than the outer CHZ can maintain subglacial liquid water if they have geothermal heat sources or form subglacial lakes similar to the Martian polar lakes. Tidally locked planets orbiting closer inwards than the inner CHZ border could have subglacial liquid water on their night side provided the atmospheric heat transport is low enough. Pressurized water can reach the planetary surface through faults and cracks in the ice cover, creating plumes and enriching the atmosphere with organic molecules that may be present in subglacial oceans. We discuss the conditions needed to accumulate biogases in an abundance high enough to be detectable in a transmission spectrum by JWST.

References:

Wandel, A. 2023b, Astronomical Journal 166(6):222

NASA 2023 https://www.nasa.gov/universe/exoplanets/webb-discovers-methane-carbon-dioxide-in-atmosphere-of-k2-18-b/

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Prediction of additional exoplanets in multi-planetary systems

Mahdiyar Mousavi-Sadr[1], Dr. Ghassem Gozaliasl[2,3], Prof. Davood M. Jassur[1]

[1]University of Tabriz. [2]Aalto University. [3]University of Helsinki

Abstract

We present the results of a search for additional exoplanets in all multi-planetary systems discovered to date, employing a logarithmic spacing between planets in our Solar System known as the Titius-Bode (TB) relation. We use the Markov Chain Monte Carlo method and separately analyze 229 multi-planetary systems that house at least three or more confirmed planets. We find that the planets in ∼53% of these systems adhere to a logarithmic spacing relation remarkably better than the Solar System planets. Using the TB relation, we predict the presence of 426 additional exoplanets in 229 multi-planetary systems, of which 197 candidates are discovered by interpolation and 229 by extrapolation. Altogether, 47 predicted planets are located within the habitable zone of their host stars, and 5 of the 47 planets have a maximum mass limit of 0.1-2$M_{\oplus}$ and a maximum radius lower than 1.25$R_{\oplus}$. Our results and prediction of additional planets agree with previous studies' predictions; however, we improve the uncertainties in the orbital period measurement for the predicted planets significantly.

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VLT/JWST imaging survey of giant planets around nearby, young white dwarfs

Dr. Hans Zinnecker[1], Dr. Wolfgang Brandner[2], Prof. Matthias Schreiber[3]

[1]Universidad Autonoma de Chile. [2]Max Planck Institute for Astronomy, Heidelberg, Germany.
[3]Universidad Tecnica Federico Santa Maria, Valparaiso, Chile

Abstract

We will present the rationale and results of our on-going 1.6 micron imaging survey of 20 nearby, young white dwarfs (WDs) for orbiting Jupiter-mass giant planets, carried out with the 8m ESO-VLT using laser guide star adaptive optics. These WDs with masses >0.8 Mo were selected to be progenitors of Main Sequence stars with masses of 2.5-4.5 Mo and are the only way to test the existence and hence formation of giant planets around intermediate-mass stars, predicted to survive post-Main Sequence mass-loss. They were selected using the DR3 GAIA catalog to be within 40 pc and limited to a total age (MS lifetime plus cooling age) of about 1 Gyr. The youth and proximity of the targets will make sure that the giant planets are young and self-luminous and hence detectable in high spatial resolution VLT LGS observations. The observations are scheduled and the results should be known by the time of the IAU symposium. We still miss true solar-system Jupiter-like analogues with ages of order 5 Gyr and low temperatures, and our WD survey aimed at Jupiters with ages ~1 Gyr can bridge the gap.

We will also discuss our proposed JWST observations at 5micron of the seven single WDs in the nearby (45pc), young (~800 Myr) Hyades cluster where we previously carried out 1.6 micron HST observation, albeit with no positive detection, with an HST detection limit of 5-10 Jupiter-masses (Brandner et al. 2020). The JWST observations will be 10 times more sensitive, with a detection limit of 0.5 Jupiter-masses.

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A new era in solar system astronomy with JWST

Dr. Geronimo Villanueva

NASA Goddard Space Flight Center

Abstract

The exploration of our solar system is being radically changed since the beginning of operations of the James Webb Space Telescope (JWST) in mid 2022. JWST's extraordinary sensitivity and instrumentation allow for sensitive searches for the building blocks of life and to test for habitability, also enabling new discoveries on small bodies to giant planets across our solar system.

Importantly, the pioneering science provided by JWST on astrobiology and evolutionary processes will not only be restricted to solar system research, but these findings will have strong implications on comparative planetology and the search for life and habitability beyond our system and in extrasolar planets. As we learn more about the diversity of molecular signatures and their connection to active processes in our solar system, we will be able to better correlate these to the data collected on exoplanets with JWST and future observatories. This together with the development of new powerful missions to probe the outer confines of our solar system and beyond, JWST will play a significant role in guiding the instrumentation and capabilities needed to effectively explore these distant worlds.

In this talk, we will present several key findings by JWST in our Solar System, focusing on the Mars system, Europa, Enceladus, and on primordial bodies.

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"Empowering Communities: Project Panoptes and the Wisdom of 'Ananse and the Pot of Wisdom'"

Anne Chamberlain[1], Michael Carroll[2]

[1]STEM Inspire Hawaii/ Project PANOPTES. [2]STEM Inspire Hawaii

Abstract

This abstract delves into the distinctive paradigm of Project Panoptes, a groundbreaking citizen science initiative revolutionizing exoplanet research by empowering local communities. Drawing inspiration from the West African folktale, "Ananse and the Pot of Wisdom," it establishes profound parallels between Ananse's journey and the unique niche occupied by Project Panoptes in the scientific landscape.

In the folktale, Ananse's avarice scatters the pot's wisdom, imparting the crucial lesson of shared knowledge. Similarly, Project Panoptes differentiates itself by democratizing exoplanet research through accessible, community-controlled telescopes, challenging the conventional scientific hierarchy.

This abstract delves into how "Ananse and the Pot of Wisdom'' serves as a compelling metaphor, underscoring the imperative of community ownership in scientific pursuits. Project Panoptes, with its innovative approach, aligns seamlessly with the folktale's moral, prompting introspection on the centralization of knowledge within the scientific community.

Emphasizing the transformative impact of community engagement, Project Panoptes fosters inclusivity and community pride, amplifying the collective ownership of exoplanet research. By sharing responsibilities and benefits, it emerges as a catalyst for reshaping the scientific exploration landscape.

In conclusion, this abstract encourages reflection on the wisdom encapsulated in the folktale as a guiding principle for redefining scientific exploration. Through Project Panoptes, we explore collaborative, community-driven approaches to exoplanet research, underscoring the importance of shared knowledge and echoing the timeless wisdom of the West African narrative within a unique niche in the exoplanet research domain.

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The CUISINES Project: Exoplanet Model Intercomparisons in the JWST era

Dr Thomas Fauchez[1,2], Dr. Linda Sohl[3,4], Dr. Guillaume Chaverot[5], Dr. Duncan Christie[6], Dr. Russell Deitrick[7], Dr. Jacob Haqq-Misra[8], Dr. Sonny Harman[9], Dr. Nicolas Iro[10], Dr. Kostas Tsigaridis[3,4], Dr. Geronimo Villanueva[2], Dr. Amber Young[2]

[1]American University. [2]NASA GSFC. [3]Columbia University. [4]NASA GISS. [5]University of Grenoble. [6]MPIA. [7]University of Victoria. [8]BMSIS. [9]NASA Ames. [10]DLR

Abstract

The exoplanet community possesses an incredible variety of models to match the astronomical diversity of exoplanets. In the era of exoplanet atmosphere characterization with JWST, it is more important than ever that models can consistently and correctly predict the observability of exoplanets, the retrieval of their data, and the interpretation of planetary environments from that data. Unlike Earth Science, however, we have only a few data available to validate model predictions. Model intercomparisons should thus play a pivotal role in this context to increase the robustness in our data prediction and interpretation, to improve mode skill, and to highlight model features that would require additional developments.

The Climate Using Interactive Suites of Intercomparisons Nested for Exoplanet Studies (CUISINES) Working Group of NASA's Nexus for Exoplanet Systems Science (NExSS) supports a systematized approach to evaluating the performance of exoplanet models and provides a framework for conducting community-organized exoplanet Model Intercomparison Projects (exoMIPs). The CUISINES framework adapts Earth climate community practices specifically for the needs of the exoplanet researchers, encompassing a range of model types, planetary targets, and parameter space studies.

In this talk, we will present the CUISINES framework and the last results from the exoMIPs in the context of JWST data.

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Hunting Protoplanets. The planet formation seen by ground-based telescopes.

dr Antonio Garufi

INAF, Osservatorio Astrofisico di Arcetri

Abstract

Over the last decade, the direct imaging of forming planets and their surrounding environment has been a key-challenge of the planetary science. The comprehension of how, where, and when planets form is crucial to determine the conditions for extraterrestrial life and the exoplanetary architecture that we see. High-contrast imaging facilities from the ground has revolutionized our view of the planet formation paving the way to the JWST studies. The first few protoplanets have been discovered and several hundred planet-forming disks have been characterized in the last ten years thanks to 8-m telescopes such as Gemini, VLT, and Subaru. Nonetheless, some unsolved questions await for the full employment of JWST and the onset of the ELT to be answered. In this presentation, a review of our search for protoplanets and our studies on planet-forming disks from visible and near-IR facilities is given, along with some considerations on the main challenges that await the field of the planet formation over the next few years.

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MUGANA Solar System Teaching Device for Primary and Secondary schools

Inventor Boniphace Rutta

African Invention Company

Abstract

This is a unique tool because it is a set of three teaching devices which have mechanical and electrical parts designed to be used by pupils and students of Primary and Secondary schools in the subjects of Physics and Geography.

The system features multiple moving parts which enable planets and other celestial bodies to rotate, revolve and facilitate real movement through the solar system.

These three devices are:

1. Solar System Kit (Planetarium Model – AGT/03/04/02)

2. Solar System Teaching Device (Model – AGT/03/03/02)

3. Solar System Standard Earth Globe (Model – AGT/03/05/01)

The Purpose and Benefits of this product (Solution provided):

1. Provides users with an educational tool designed to teach users about topics dealing with the solar system, mechanics and electricity/electronics.

2. Features an orbital concept and central arm capable of being rotated around the center bulb, allowing users to simulate the effect of planets revolving around the Sun.

3. Utilizes geared motors, operating via AC and DC power, to rotate and revolve planets (Earth) around the center bulb and allow each planet to rotate on its own axis.

4. Teaches and demonstrates students various concepts in Geography and Physics subjects.

Generally, this device functions as a more comprehensive educational tool for various aspects of the solar system when compared to standard models and globes.

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The Earth 2.0 (ET) Space Mission

Professor Jian Ge

Shanghai Astronomical Observatory, Chinese Academy of Sciences

Abstract

The “Earth 2.0 (ET)” space mission in China is to address a few of fundamental questions in the exoplanet field: How frequently habitable Earth-like planets orbit solar type stars (Earth 2.0s)? How do terrestrial planets form and evolve? Where did floating planets come from? ET consists of six 28 cm diameter transit telescope systems with each field of view of 550 square degrees and one 35 cm diameter microlensing telescope with a field of view of 4 square degrees. The ET transit mode will monitor ~2M FGKM dwarfs in the original Kepler field and its neighboring fields continuously for four years while the microlensing mode monitors over 30M I< 20.5 stars in the Galactic bulge direction. ET will merge its photometry data with that from Kepler to increase the time baseline to 8 years. This enhances the transit signal-to-noise ratio, reduce false positives, and greatly increases the chance to discover Earth 2.0s. Simulations show that ET transit telescopes will be able to identify ~10-20 Earth 2.0s, over 4000 Earth-sized terrestrial planets and over 30,000 new planets. The ET microlensing telescope will be able to identify over 1000 microlensing planets. With simultaneous observations with the ground-based KMTNet telescopes, ET will be able to measure masses of over 300 microlensing planets, including ~40 free-floating Earth mass planets and determine the mass distribution functions of free-floating planets and cold planets. ET will be operated at the Earth-Sun L2 orbit with a designed lifetime longer than 4 years. The mission status will be reported.

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Titre: astronomy in the north of MoroccoAuteur: stitou Mohammed.science and technology club.Tangier, Morocco

Astronomy in the north of Morocco Mohammed Stitou

work at ministry of national education

Abstract

The aim of the Science Club is to organize workshops that improve the technical and IT competence and skills of students. These transcurricular activities are based on STEM topics, astronomics applications, and space research, which are not included in the school curricula. Through these activities, students are acquainted with the latest results of science and technology, which they can apply in practical workshops. The achievements of the Science Club (planetrium observation of sky, etc.) show that these activities can motivate students to participate more effectively at classroom activities in order to learn theoretical subjects and later choose a career in this field

In addition to the rapid development of technology, the renewal of education is becoming increasingly important. In order to achieve this one needs to use challenging methods that reveal the creativity and innovative ideas of students. The Science Club's Robotics class provides the students with the opportunity to apply theoretical knowledge through inquiry (IBL) and project-based methods (PBL) to create autonomous and controllable devices.

Therefore, at the start of the Science Club program (at the beginning of the school year), a preliminary assessment of the students background knowledge has to be made in order to explore their interests on what they would like to learn about the proposed subject

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Connecting disk lifetime variety to planet diversity

Prof Susanne Pfalzner[1], Furkan Dincer[1,2], Dr Frank Wagner[1]

[1]Forschungszentrum Jülich. [2]Aachen University

Abstract

The length of time that protoplanetary disks exist is important in understanding how planets are formed. While most disks last between 1-20 million years, some can last for more than 40 million years. The often-used average disk lifetime can hide the diversity of their lifetimes. Our research shows that most stars have at least 5 million years to form planets. However, the length of time a disk exists depends on the mass of the star it surrounds, with high-mass stars losing their disks earlier. In the past, studies often underestimated the disk lifetime due to a focus on high-mass stars in distant clusters. Our study provides a more detailed picture of the disk lifetime distributions for stars of all masses. These lifetimes vary greatly, and we demonstrate how this diversity affects the formation of planets and planetary systems.

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The Dawn of a New Era for Exoplanet Detection and Characterization with JWST

Knicole Colon

NASA Goddard Space Flight Center

Abstract

We are in an extraordinary era of exoplanet science. This is thanks in great part to the number of current and upcoming facilities that are designed to enable the discovery of exoplanet systems or provide detailed characterization of exoplanets and their host stars across a wide range of ultraviolet to infrared wavelengths. In particular, the NASA/ESA/CSA James Webb Space Telescope (JWST), which successfully launched in late 2021, is the premier space-based facility for near- and mid-infrared astronomy over 0.6-28.5 microns. The 6.5-meter space telescope is specifically equipped with four state-of-the-art instruments that include capabilities for imaging, spectroscopy, and coronagraphy. Thanks to these powerful capabilities, JWST is providing unprecedented sensitivity and enabling detailed studies of both transiting and directly-imaged exoplanets and their atmospheres. In this talk, I will discuss the latest status of JWST and will highlight exoplanet results obtained within its first years of science operations. The early results include the first ever direct detection of an exoplanet beyond 5 microns, the first definitive detection of carbon dioxide in the atmosphere of an exoplanet, the first detection of photochemically-produced sulfur dioxide in the atmosphere of an exoplanet, and the first measurement of the temperature of a rocky, Earth-size exoplanet. I will also look ahead to what exoplanet discoveries we might expect in the future with JWST. The results from JWST are already re-writing exoplanet textbooks, and we expect that will continue for years to come.

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Comprehensive homogeneous investigation of orbital ephemeris and transmission spectrum of a Ultra-hot Jupiter: WASP-19 b using archival data of ground-based and space-based telescopes

Ms. Anitha Raj Rajkumar[1,2], Dr. Jeremy Tregloan-Reed[1]

[1]Universidad de Atacama. [2]European Southern Observatory (ESO)

Abstract

Exoplanets with ultra-short periods (P < 1 day) might experience orbital decay due to the tidal dissipation effect with the host star. My current work allows verification of the orbital ephemeris of the WASP-19b with the availability of long-term high-precision photometric and spectroscopic data including 28 unpublished transits from the Danish and TESS telescope. The transit timings were fitted with linear, quadratic & cubic ephemeris. This place limits on the modified tidal quality factor (Q'_*) to be $10^{5.5} \pm 0.08$.

The same data allows for a detailed study of the atmospheric properties of WASP-19b, via transmission photometry and spectroscopy. WASP-19A is an active host star with its surface littered with starspots, which if not correctly modeled, systematics are introduced into the transit timing measurements and transit depth, which latter affects the exoplanetary transmission spectrum. Additionally the signal from stellar inhomogeneities can outweigh the signal from planetary spectral characteristics (Rackham. B V., et al. 2023, arXiv:2303.15418). Therefore, to perform a full and complete orbital ephemeris study of WASP-19b requires the modeling of detected starspots. Incidentally, failing to model both occulted and unocculted starspots can skew measurements in the planetary radius affecting the broadband transmission spectrum (Mancini. L., et al. 2013a, A & A, 551, A11). Using the transit-starspot model, GEMC-PRISM (Tregloan-Reed, J., et al. 2013, MNRAS, 428, 3671; Tregloan-Reed, J., et al. 2015, MNRAS, 450, 1760) we perform the most complete, detailed, homogeneous analysis of all available data to estimate Q'_* and study the atmospheric properties of WASP-19b with the help of ground- and space-based archival data.

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In-plane Instability Equilibrium Points of the Restricted Three-Body Problem with P-R Drag and Variable Masses

Dr Tajudeen Oluwafemi Amuda[1], Dr Leke Oni[2]

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Abstract

This research investigates instability of the in-plane equilibrium points (EPs) of the restricted three-body problem with Poynting-Robertson (P-R) drag force and variable masses. The motion of the primaries and their mass variation is governed by the Gylden-Mestschersky problem (GMP) and unified Mestschersky law (UML), respectively, under the conditions that both primaries are radiation emitters with P-R drag. The dynamical equations are derived and it is seen that a pair of triangular equilibrium points (TEPs) which are defined by the mass parameter, radiation pressure and P-R drag force. The stability of the in-plane EPs is investigated analytically and numerically for a dust grain particle and it is seen that all the EPs are unstable. The P-R drag is a strong perturbing force which changes stability to instability and motion around the EPs are unstable in the presence of the P-R drag. Additionally, we explore the zero velocity curves around the in-plane EPs and our results show that the radiation pressure and P-R drag increase the region where motion of the dust grain is dynamically allowed, around the TEPs, though this influence is very minimal. Also, it is seen that as the mass parameter increases, the energy constant also increases thus increasing the region where motion of the dust grain is permissible. The stability of the in-plane EPs of the non-autonomous system which differ from those of the autonomized system by a function of time, are unstable.

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Exoplanets in education: rise of the robotic telescopes

Dr Edward Gomez[1], Dr Robert Zellem[2], Dr Anastasia Kokori[3]

[1]Las Cumbres Observatory. [2]JPL. [3]UCL

Abstract

Las Cumbres Observatory's (LCO) flagship education programme, Global Sky Partners, provides access to their education network of 10 x 0.4m class robotic telescopes, for external groups to run supported educational projects. These groups run a wide range of projects but a significant number of them study exoplanets, mostly with high-school students. LCO is ideally suited to this, providing high-availability, high quality data for time-domain astronomy projects. During this talk I will showcase the different approaches taken by our partners, with an emphasis on educational practices. I will also highlight citizen science exoplanet Global Sky Partners which are astronomer-led, Exoplanet Watch and ExoClock. These projects provide exoplanet observing tools, observing campaigns, and data processing software for reporting community sourced Transit Timing Variation measurements.

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Title: Unveiling New Parent Bodies in Meteor Showers: A Robust Methodological Approach

Dr Meryem Guennoun[1,2], Dr Jérémie Vaubaillon[3], Dr Zouhair Benkhaldoun[1,2]

[1]Oukaïmeden observatory. [2]Laboratory of High Energy physics and Astrophysics. [3]Institut de mécanique celeste et calcul des éphémérides

Abstract

The ongoing addition of meteor showers to the International Astronomical Union (IAU) list prompts the need for reliable identification of new parent bodies, especially with the increasing availability of video meteor measurements. Current methods, employing a high-threshold single-linking Dsh-criterion, raise concerns about accuracy and the legitimacy of newly associated parent bodies.

Our study aims to statistically identify new parent bodies within the context of evolving meteor showers.

Utilizing the Moroccan meteor observation network as a foundation, we delve into an advanced methodology for linking observed meteors to their parent bodies. Simultaneously, a comprehensive search for new parent bodies was conducted within the SonotaCo and EDMOND databases. Various methods for associating asteroids with meteors were explored and compared, followed by a meticulous statistical test to discern potential random associations.

The main emphasis of this presentation is to elucidate the complexity of the network's advanced linking methodology, demonstrating its success in accurately pinpointing the origins of meteors. Developed through collaborative efforts, the Moroccan network serves as a trustworthy and inventive platform for unraveling celestial phenomena. A compelling example will be provided to highlight the network's capability to forecast potential impact zones on Earth, thereby making a substantial contribution to our comprehension of the dynamic interplay between meteoroids and our planet.

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Interstellar objects as seeds for planet formation

Prof Susanne Pfalzner

Forschungszentrum Jülich

Abstract

Interstellar space seems to swarm with free-floating objects like 1I/'Oumuamua and 2I/Borisov. Generated during planet formation, these interstellar objects (ISOs) were ejected from their original planetary systems and now drift through interstellar space. This galactic background density of planetesimals can be incorporated into collapsing molecular clouds and the resulting protoplanetary discs and function as seeds for the next generation of planets. Here, we expand on this concept, showing that the efficiency of this planet-seeding process depends on several environmental factors, namely, the time at which planet formation takes place in the Galaxy, the location within the Galaxy, and the size of the star-forming cluster. Massive stars seem to lose their disc mass faster than low-mass stars but are much more efficient in producing hot Jupiters. The exceptionally high number of ISOs captured during the formation of massive stars might explain this swift formation of giant planets in these short-lived discs. As the Galaxy's density of interstellar objects increased over time, we hypothesize that today, we see the highest formation rate of giant planets.

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Ices on pebbles in protoplanetary discs

Dr. Anastasiia Topchieva[1], Dr. Tamara Molyarova[1,2], Dr. Vitaly Akimkin[1], Dr. Lomara Maksimova[1], Dr. Eduard Vorobyov[2,1]

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Abstract

The formation of solid macroscopic grains (pebbles) in protoplanetary discs is the first step toward planet formation. We aim to study the distribution of pebbles and the chemical composition of their ice mantles in a young protoplanetary disc. We use the two-dimensional hydrodynamical code FEOSAD in the thin-disc approximation, which is designed to model the global evolution of a self-gravitating viscous protoplanetary disc taking into account dust coagulation and fragmentation, thermal balance, and phase transitions and transport of the main volatiles (H2O, CO2, CH4 and CO), which can reside in the gas, on small dust (<1 mum), on grown dust (>1 mum) and on pebbles. We model the dynamics of the protoplanetary disc from the cloud collapse to the 500 kyr moment. We determine the spatial distribution of pebbles and composition of their ice mantles and estimate the mass of volatiles on pebbles, grown dust and small dust. We show that pebbles form as early as 50 kyr after the disc formation and exist until the end of simulation (500 kyr), providing prerequisites for planet formation.

All pebbles formed in the model are covered by icy mantles. Using a model considering accretion and desorption of volatiles onto dust/pebbles, we find that the ice mantles on pebbles consist mainly of H2O and CO2, and are carbon-depleted compared to gas and ices on small and grown dust, which contain more CO and CH4. This suggests a possible dominance of oxygen in the composition of planets formed from pebbles under these conditions.

The study was funded by a grant from the Russian Science Foundation 22-72-10029

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Activity Analysis on 68P/Klemola and 78P/Gehrels 2 in 2018–2020 Perihelion Passage

Dr Jianchun Shi

Shanghai Astronomical Observatory, CAS

Abstract

We performed secular monitoring broadband photometric observations on Jupiter Family Comets (JFCs) 68P/ Klemola and 78P/Gehrels 2 from 2018 November to 2020 March with the Yaoan High Precision Telescope. Our main purpose is to study the dust activity, coma properties, and dynamical history of the two comets and analyze the activity evolution of 78P/Gehrels 2 in the recent past. We use aperture photometry to obtain the magnitude and the A(0)fρ values from the R band observations. The maximum A(0)fρ values we recorded for 68P/Klemola and 78P/Gehrels 2 are 339.7 ± 4.4 cm and 1028.1 ± 13.3 cm, respectively, showing that the activity of 68P/Klemola is of middle level while 78P/Gehrels 2 is one of the most active JFCs. The mean color of 78P/Gehrels 2 is (B − V) = 0.88 ± 0.02 and (V − R) = 0.27 ± 0.02. Dynamical history analysis suggests that 78P/Gehrels 2 could have actually resided in this region for a long time in the past 1 Myr, though it recently migrated into the inner solar system. The high activity of 78P/Gehrels 2 reported in the past three perihelion passages could be attributed to the perihelion distance decl. from 2.3 to 2.0 au before 1997 that boosted the water-ice sublimation rate and formed new active regions. The activity decl. over recent apparitions could be attributed to the reformation of the dust mantle.

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Advances in Coronagraphy for Future Space Missions: Interferometric Apodization through Homothety (IAH) and its Application in APLC Coronagraphs

Mr. Jamal Chafi[1], Prof. Youssef El Azhari[1,2], Prof Ossama Azagrouze[1,2], Prof Abdelhadi Jabiri[1], Prof Zouhair Benkhaldoun[1], Dr. Abdelkarim Boskri[1], Mr. Aziz Qazbour[1]

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Abstract

Confronted with the inherent challenges of direct exoplanet observation, particularly the extreme contrast between stars and exoplanets, our study introduces an innovative technique based on numerical simulations. We have developed and assessed a method that combines Lyot coronagraphy apodized with an interferometric apodization technique employing homothety in segmented apertures, specifically designed for the next generation of large telescopes. This simulation-based approach provides a unique perspective on optimizing high dynamic range imaging techniques in the realm of exoplanet observation.

Our simulations utilized a wavelength range centered around 500 nm with a 50% bandwidth to test the effectiveness of this apodized method. The results indicate a significant improvement in contrast, including at reduced angular separations, demonstrating the potential of this technique for detecting exoplanets in close proximity to their host stars. Furthermore, our work reveals an almost constant contrast across the studied wavelength range, highlighting the low chromaticity of our Homothetic Interferometric Apodization (IAH) approach, a significant advantage over traditional methods.

These outcomes, derived from advanced numerical simulations, mark a significant breakthrough in enhancing exoplanet imaging capabilities, enabling more effective and precise exoplanet detection, even under conditions of low angular separation. The success of our apodization method underscores the importance of numerical simulations in the design of high dynamic range space imaging techniques, paving the way for new explorations and a deeper understanding of exoplanetary systems.

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Observables of 3D atmospheric and surface effects in JWST observations

Dr Vincent Kofman[1,2], Dr Geronimo Villanueva[1], Dr Thomas Fauchez[1,2], Tanvi Deshmukh[1]

[1]NASA Goddard Space Flight Center. [2]American University

Abstract

The James Webb Space Telescope has pushed the study of exoplanet exploration into a new age. Both in the resolution and the sensitivity space the telescope is an order of magnitude more powerful. Spectroscopic observations now challenge our models of planet formation and evolution, driving the development of new theory and tools. One aspect that needs to be considered in more detail is the spatial of the object. Many atmospheric and surface properties are highly variable across the planet and their visibility dependent on the geometry of the observations. New spectroscopic modeling efforts have opened up the possibility of high-spatial resolution three-dimensional modeling of exoplanet atmospheres. Even though these 3D effects are not resolved, they do translate into the observed spectrum. In this talk, we will demonstrate how the detectability of molecular features is affected by 3D effects, such as varying abundances and heights of clouds and molecules, as well as changes in surface coverage and temperature. We will compare 1D and 3D simulations of the same objects and show how the 1D averages do not represent the full object correctly.

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CO_2 and CO heterogenous outgassing and their isotopic ratios in Centaur 29P/S-W1 with JWST

Sara Faggi[1,2], Geronimo Villanueva[1], Adam McKay[3], Olga Harrington-Pinto[4], Michael Kelley[5], Dominique Bockelee-Morvan[6], Maria Womack[7,8], Charles Schambeau[7], Lori Feaga[5], Michael DiSanti[1], James Bauer[5], Nicolas Biver[6], Kacper Wierzchos[9], Yanga Fernandez[7]

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Abstract

Centaurs are a dynamical class of objects with orbits between Jupiter and Neptune, hypothesized to be transitional objects migrating from the scattered disk region of the Kuiper Belt towards becoming Jupiter Family Comets (JFCs). This defines their critical role in separating heritage versus evolutionary signatures in comets, i.e., they have not yet suffered frequent and repeated thermal processing by the Sun, as is experienced by JFCs.

On 20th February 2023, we used NIRSpec IFU PRISM mode to observe active Centaur 29P. The spectrum covers 0.59 to 5.29 mm, allowing simultaneous sampling of the fundamental rovibrational bands of H_2O, CO_2, and CO, including their isotopologues. Strong molecular signatures of CO at 4.67 mm and CO_2 at 4.25 mm were detected. The extraordinary sensitivity of JWST provided the first identification of $^{13}C^{16}O_2$, $^{13}C^{16}O$, $^{12}C^{17}O$ and $^{12}C^{18}O$ isotopes in a Centaur. To identify and characterize the isotopic signatures, we used fluorescence models and databases available in the Planetary Spectrum Generator (PSG) [Villanueva et al., 2018]. We will present 2D maps of detected CO and CO_2 emissions, that suggest heterogeneous outgassing, and we will compare our measured carbon and oxygen isotopic ratios with their in-situ values in 67P, and with terrestrial abundances. These investigations enable exploration of primitive material from a dynamical class of small bodies that may have a formation history in the protoplanetary disk distinct from that of long-period comets, yet have not suffered the thermal processing experienced by JFCs.

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Validation and study of exoplanets with sizes between Earth and Neptune for insights into their formation and evolution mechanisms

PhD student Mourad Ghachoui[1,2], Michaël Gillon[1], Zouhair Benkhaldoun[2], Mathilde Timmermans[1], Dr. Khalid Barkaoui[1], Dr. Laetitia Delrez[1], Dr. Francisco J. Pozuelos[3]

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Abstract

Planets between the size of Earth and Neptune, although absent from our Solar System, have been found to occur frequently around other stars. These planets have shown some important features in their radius and density distributions that can be related to their formation and evolution mechanisms. In this oral presentation, I will present our contribution to enlarge the sample of these planets with the TRAPPIST telescopes via the validation of planet candidates first detected by the Transiting Exoplanets Survey Satellite (TESS). I will also present the most important planets we have validated, discuss their potential for follow-up, and how such studies could shed light on the principles underlying the formation and evolution of these worlds

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The JWST MANATEE program: Atmospheric compositions, clouds, chemistry, and processes of a diverse exoplanet sample

Thomas Greene[1], Thomas Beatty[2], Taylor Bell[3,1], Jonathan Fortney[4], Michael Line[5], Nishil Mehta[6], Sagnick Mukherjee[4], Matthew Murphy[7], Kazumasa Ohno[8], Vivien Parmentier[6], Emily Rauscher[9], Everett Schlawin[7], Luis Welbanks[5], Lindsey Wiser[5], Kenneth Arnold[2]

[1]NASA - Ames Research Center. [2]University of Wisconsin. [3]Bay Area Environmental Research Institute. [4]University of California at Santa Cruz. [5]Arizona State University. [6]Université Côte d'Azur. [7]University of Arizona. [8]National Astronomical Observatory of Japan. [9]University of Michigan

Abstract

The JWST MANATEE MIRI and NIRCam guaranteed time observing program has observed panchromatic near-to-mid-infrared transmission and emission spectra of nine transiting exoplanets ranging in mass from 1.4 – 360 Earth masses and equilibrium temperatures of 400 – 1200 K. The initial results include the discovery that the rocky planet TRAPPIST-1 b lacks a substantial atmosphere, the first detection of CH4 in the transmission and emission spectra of a transiting planet (WASP-80 b), detection of differences in the evening and morning limbs of WASP-107 b, and detection of H2O, CH4, CO, CO2, SO2, and NH3 molecules in a range of planets with mini-Neptune to Saturn masses. Using model grids and atmospheric retrievals, we have leveraged panchromatic 2.4 – 12+ micron JWST data and transit/eclipse geometries to constrain the atmospheric compositions, metallicities, C/O ratios, disequilibrium chemistry, atmospheric structures, internal temperatures, effective temperatures, photochemistry, albedos, and cloud/haze properties of these planets. In this talk, we will discuss how these properties are correlated with the different planets and offer insights into dominant atmospheric processes, frequent CH4 depletion, and potential formation pathways of these systems. This will focus on probing the natures of Neptunes/mini-Neptunes (GJ 436, GJ 1214 b, GJ 3470 b, HAT-P-26b) and giants (WASP-80 b, WASP-69 b, WASP-107 b) as thoroughly as possible by leveraging the program's strategic strengths of broad wavelength coverage, multiple geometries (transit/eclipse), and state-of-the-art modeling. We will also offer some lessons learned regarding coherently analyzing data from multiple observations acquired with different instrument modes at different times.

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Mineralogy of (99942) Apophis derived from VNIR spectra and a new model

Professor Yunzhao Wu[1,2], Mr. Pengyue Wang[2]

[1]Purple Mountain Observatory, Chinese Academy of Sciences. [2]State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology, Macau

Abstract

Apophis was a potentially hazardous asteroid (PHA) and it has attracted the attention of researchers. Quantitative mineral abundances based on reflectance spectroscopy are of great significance for studying the compositions and evolution of NEAs and are also beneficial for the implementation of defense strategies for NEAs. In this study we show a new model for quantitively predicting mineralogy of S-type asteroids which was developed in Wang et al. (2022). The mineralogy of Apophis was derived using this model and the VNIR spectra which are available from the MIT-Hawaii Near-Earth Object Spectroscopic Survey(MITHNEOS) (Binzel et al. 2009). We determined that the abundances of olivine and pyroxene of Apophis are 53.46 wt% and 35.62 wt%, and the ratio of olivine to olivine +pyroxene is 0.60. It indicates that the Apophis corresponding meteorite analog was identified as an LL chondrite.

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Photometric monitoring of galactic star clusters and its relevance to JWST

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

Despite the significant expansion of the capabilities of observational astrophysics represented by *JWST*, the importance of ground-based observations not only does not lose their relevance, but also becomes an indispensable aid to the space telescope. The need for synchronous ground-based observations of targets observed by *JWST* is obvious, as well as support for *JWST* observations using ground-based time domain astronomy and indication for *JWST* of new targets detected by ground-based telescopes. In this sense, long-term monitoring of a large number of star clusters and associations carried out under the international Uzbek-Indian research project is of particular interest. Dense photometric time series of 15 galactic open clusters were obtained over 3 years (2021-2023). In 2003, time series were also obtained for 7 clusters. The combined analysis, together with the available data obtained by *TESS*, made it possible to discover a significant number of new variable stars and study the few known variables in these clusters. The resulting extensive observational material of sufficiently high accuracy and cadence also makes it possible to search for transits of probable new exoplanets. We will present the resulting observational database and the current results of its analysis. Further careful processing and in-depth analysis of this material is currently ongoing together with our Indian partners.

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Exoplanet Habitability: A multidimensional Approach (Using AI to study and Predict Planet Habitability)

Miss Vasuda Trehan

University at Albany SUNY

Abstract

As space technology advances, the possibility of humans becoming an interplanetary species becomes more realistic. Companies like SpaceX and Blue Origin are working towards making space travel more accessible to people. With the help of space observatories like James Webb and Hubble telescope, we can now study multiple planets and gather data about them. Bayesian data analysis is used to predict the spectral features of extrasolar planets, which is a challenging task that involves forecasting spectral bin heights with multi-planetary parameters. Each bin is a function of all the parameters, and spline curves with defined knots are used to model spectral bin heights. This iterative process helps us better understand Bayesian techniques and aligns with the broader goal of characterizing extrasolar planets through innovative data analysis. Ultimately, this will help us to understand the habitability of Earth better.

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Pinning down the masses of ultra-short-period earth-sized planets with extreme-precision radial velocities as prospective targets for JWST

Rena Lee[1], Dr. Fei Dai[1], Andrew Howard[2], Dr. Howard Isaacson[3], Jonathan Gomez Barrientos[2], Michael Greklek-McCeon[2], the KPF Team -[2], the TESS Team -[4]

[1]Institute for Astronomy, University of Hawai'i at Mānoa. [2]California Institute of Technology (Caltech). [3]University of California, Berkeley. [4]Massachusetts Institute of Technology

Abstract

Earth-sized “ultra-short-period” planets (USPs) comprise a recently growing class of exoplanets. USPs provide the clearest look into terrestrial planet composition, as they are among the only Earth-sized planets with readily detectable radial velocity (RV) semi-amplitudes using the current state-of-the-art instrumentation. Moreover, USPs are so intensely irradiated that any H/He atmospheres should be photoevaporated, lifting the degeneracy caused by thick primordial atmospheres, allowing for direct constraint of rocky core compositions. Here we report the confirmation of TOI-6324 b, an Earth-sized (R = 1.05 R_Earth) USP orbiting a nearby (~20 pc) M dwarf on an orbit of only 6.7 hours, with some of the earliest results from the newly commissioned Keck Planet Finder (KPF). Our intensive radial velocity follow-up with KPF has pinned down the planetary mass to be 1.3 M_Earth to more than 5 sigma precision, the lowest among USPs. We assess the planet's iron-to-rock ratio given our radius and mass measurements and compare to the broader population of USPs and terrestrial planets (such as GJ 367 b), with updated masses from KPF or ESPRESSO radial velocity data. The emission spectroscopy metric (ESM) for several of these USPs is ~20 or higher. TOI-6324 b and other USPs will serve as ideal targets for phase curve studies, such as with JWST, to probe surface composition and tidal distortion effects.

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Sharjah Astronomical Observatory (SAO) Transit Photometry of Exoplanets I: TOI 3604.01.

Mr Ammar Abdulla

Sharjah Academy for Astronomy, Space Sciences and Technology, University of Sharjah

Abstract

This study delves into a comprehensive analysis of the exoplanet TOI 3604.01 b through transit photometry observations conducted at the Sharjah Astronomical Observatory (SAO). Leveraging cutting-edge instrumentation, particularly the 17” Corrected Dall-Kirkham Reflector (CDK) and the SBIG STX16803 CCD camera. The study aimed to reveal insights into the physical properties of TOI 3604.01 b. Central to our observation is the exceptional PlaneWave Dall-Kirkham telescope, renowned for its precision from its reflective components that ensure optimal performance. With a 17" (432 mm) aperture and a focal ratio of f/6.8, this telesope proved ideal for in-depth exoplanetary characterization. The observations were facilitated by the SBIG STX16803 CCD imaging system with a 16-megapixel KAF-16803 CCD that operates at 9 microns. The camera's superior cooling capabilities, down to -50 degrees C below ambient with air only, and optional accessories, such as the FW7-STX 7-Position Filter Wheel, contribute to high-quality data capture. In this observation, the Sharjah Astronomical Observatory (SAO) utilized the CDK telescope with an R photometric filter. The main findings include the mid-transit Julian Date (JDmid) of 2460230.22617±0.00077 and the mid-transit Heliocentric Julian Date (HJDmid) of 2460230.22904±0.00077 with heliocentric correction (helcor) =0.00287,, corresponding to a UTC time of 2023-10-12 17:25:41. The transit duration was 78.2±2.8 minutes, and the transit depth was 0.0229±±0.0021 magnitudes. The radius of TOI 3604.01 was estimated to be 1.410±0.066 times the radius of Jupiter (Rjup). A comprehensive analysis and discussion of results will be expounded in the full paper.

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Planetary Instabilities can Explain the Orbital Architectures of Kepler Multis

Dr Sourav Chatterjee, Mr. Tuhin Ghosh

Tata Institute of Fundamental Research

Abstract

Understanding the formation and assembly of the multi-transiting planetary systems discovered by Kepler and TESS is one of the most interesting areas of today's exoplanet research. We investigate whether the properties and property correlations can be explained as a result of past dynamical instabilities or specific input from formation theories is crucial. We simulate a large number of direct N-body models of compact multi-planet systems consisting of planets similar in structural properties to those observed in Kepler's multis. We provide no input or fine-tuning in the initial orbital properties based on specific planet-formation theories. We carefully take into account the observational biases and transit probabilities in order to directly compare our modeled ensembles with those observed. We find that our generic model multiplanet systems, through dynamical instabilities, without any input from formation theories, can naturally reproduce the orbital architectures of the observed multis including the distributions of Hill separations, planetary masses and radii, orbital periods, and the ratio of orbital periods between adjacent transiting planets. We find that key correlations, including (i) intra-system uniformity commonly known as 'peas in a pod,' (ii) anti-correlation between planetary multiplicity and orbital eccentricities, and (iii) lower eccentricity for larger planets, naturally emerge as a result of past dynamical instabilities even when no such correlations were initially present in the models. Our results suggest that the orbital properties and correlations observed in Kepler's multis may have been sculpted through past dynamical instabilities independent of the formation process.

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The Varied Outcomes of Sub-Neptune Collisions

Dr. Sourav Chatterjee, Mr. Tuhin Ghosh

Tata Institute of Fundamental Research

Abstract

Most of the observed exoplanets in multiplanet systems are smaller than Neptune and larger than Earth. It is widely believed that most of the mass in these planets are confined within a small likely rocky core. However, most of the volume comes from an envelope that contains ~10% of the total mass. The low average densities, high star to planet mass ratio, and compact orbits for these planets indicate that dynamical instabilities, a natural outcome in maximally packed compact multiplanet systems, would often lead to planet-planet collisions. Using N-body models for the kinematics of the collisions, 1D hydro models to construct internal structures involving core, mantle, and envelope, and smooth-particle hydrodynamics (SPH) to resolve collisions while the planets are in orbit to the host star, we create detailed sub-Neptune collisions models. We find that in about 75% of these collisions the planets do not merge. If the collision is sufficiently energetic catastrophic mass loss from the planets may ensue resulting in the disruption of one or both planets. In all cases, significant mass may be lost from the planets forming long tidal tails which may be observed. We find simple analytical boundaries for the different outcomes- hit-and-run, merger, and catastrophic collisions- that can be incorporated into N-body simulations which traditionally incorporate simplistic 'sticky-sphere' assumptions for planet-planet collisions. Our results suggest that, especially for sub-Neptunes, this assumption is very wrong. A comprehensive numerical exploration of sub-Neptune collisions is underway. I will present the latest results.

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Magnetism of Saturn in the origin of the rings and in their peculiarities recorded by the Cassini probe. The Tchernyi-Kapranov effect.

Dr. Vladimir Tchernyi

Moderrn Science Institute, SAIBR

Abstract

We show that Saturn's magnetism makes an important contribution to the origin of dense rings and provides an explanation and evaluation of features observed by the Cassini probe that have not yet been explained, such as the equilibrium separation of ice particles in dense rings. The action of Saturn's magnetic field, in addition to the action of the gravitational field, explains the transformation of a protoplanetary cloud into a disk of a stable system of dense rings in a three-dimensional well with a strong flatness of their structure, and allows obtain formulas for estimating particle separation.

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Comparison of the light curves from single planet P and S type systems orbiting binaries with possible candidates systems.

Mr Usman Isa[1], Mr Abdullateff Momodu[1], Prof Zouhair BenKhaldoun[2], Mr Kaeouach Aziz Ettahar[2]

[1]PACS e-Lab. [2]Universite Cadi Iyad

Abstract

This study compares the light curves from binary systems having 1 planet in either S-Type and P-Type orbit with that of possible candidates systems. Data from TESS, Kepler and other telescopes is analyzed with the EXOTIC program and contrasted with the light curves of eclipsing, spectroscopic and visible binary systems.

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A Comprehensive Review on Past, Present, and Future Prospect on Exoplanet Detection. by Abel T. Sisaye, Debre Berhan University, North Shawa, Ethiopia.

Mr. Abel T. Sisaye

Debre Berhan University

Abstract

This review paper provides a glimpse into the remarkable evolution of exoplanet science over the past three decades and offers insights into its promising future. The field progress in detection methods, ambitious missions, and sophisticated data analysis capabilities. As of today, the confirmed number of exoplanets stands at 5,587. These discoveries have been made possible through innovative methods such as astrometry, imaging, radial velocity, transit, and microlensing. The paper chronicles the extraordinary journey from the first exoplanet ever detected (PSR B1257+12 b in 1992) to the "super-Earth" exoplanet (TOI-715 b) discovered in 2024. This progress has been achieved through advancements in detection technologies and the remarkable milestones achieved by missions like Kepler, TESS, and the Hubble Space Telescope, which have unveiled numerous exoplanets as well as the transformative potential of upcoming missions like PLATO, & Ariel, along with promising ground-based technologies like large interferometers. Nowadays, the impressive accomplishments of quantum computing in specific tasks like optimization problems raise intriguing possibilities for future applications in exoplanet science. While still an active area of research, quantum computing has the potential to significantly boost our capabilities in this field. The market interest is significant, with projections reaching $125 billion by 2030. Researchers are exploring ways to leverage quantum computers for specific tasks or create hybrid systems with classical computers to tackle complex scientific problems with help of AI. This review paper presents a comparative overview of exoplanetary science, aiming to bridge the gap between our current knowledge and the limitless possibilities that lie tomorrow.

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JWST Observations of Ceres, Pallas, and Hygiea: Surviving Planetary Embryos from Our Solar System's Formation

Dr. Andrew Rivkin[1], Dr. Cristina Thomas[2], Dr. Ian Wong[3], Dr. Stefanie Milam[3]

[1]Johns Hopkins University Applied Physics Laboratory. [2]Northern Arizona University. [3]NASA Goddard Space Flight Center

Abstract

Our understanding of planetary formation and evolution is built from decades of astronomical, laboratory, and theoretical studies. Objects representing the planetesimal and planetary embryo stages are still found today among the small bodies of the Solar System, where they are uniquely accessible for observations and, for those in the main asteroid belt, spacecraft visits and/or sample return on decadal-scale timeframes. The instruments on JWST provide an unprecedented opportunity for high-quality measurements of small bodies at wavelengths inaccessible from the Earth's surface.

We will present JWST spectroscopic measurements in the visible and infrared for three planetary embryo-sized main-belt asteroids: (1) Ceres, (2) Pallas, and (10) Hygiea. These are the three largest low-albedo objects in the main belt, and all show evidence of hydrated minerals on their surface. However, while Pallas appears to have a composition consistent with CM chondrite meteorites, Ceres and Hygiea have been observed to have compositions that include ammoniated minerals, suggestive of input of outer solar-system materials during their formation. We will discuss how JWST measurements update and extend our understanding of these objects, and how we can use these measurements as way to calibrate our extensive ground-based datasets.

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Interferometric Apodization using Deformable Mirror in a Michelson Interferometer to Improve Exoplanet Detection

PhD student AZIZ QAZBOUR[1], PA Youssef El Azhari[2], PhD student Jamal Chafi[1], PES Zouhair Benkhaldoun[1], PA Ossama Azagrouze[2], Doctor Abdelkarim Boskri[1]

[1]Cadi Ayyad University. [2]CRMEF Marrakech- Safi

Abstract

To capture images of Earth-like planets orbiting distant stars, advanced instruments with exceptional contrast ratios are imperative. While coronagraphs play a crucial role, they often lack the capability to achieve the requisite contrast levels independently. Hence, supplementary apodization techniques are indispensable for augmenting their rejection capabilities. In this context, we introduce an innovative apodization method that harnesses interferometry, seamlessly integrating a deformable mirror into the Michelson interferometer setup. This sophisticated approach entails splitting the incident Point Spread Function (PSF) into two components, introducing an additional inhomgenious phase $\phi(x, y)$ to one of them via a deformable mirror, and subsequently recombining them to yield an apodized PSF. We illustrate, in particular, the influence of several parameters of the deformable mirror on the optimization of the additional phase profile.

Keywords : High angular resolution – Apodization – Deformable mirrors – Exoplanets – Michelson interferometer – Interferometry

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Advancing Apodization Techniques: Optimizing Interferometric Apodization by Homothety for Exoplanet Detection

PhD student AZIZ QAZBOUR[1], PA Youssef El Azhari[2], PhD student Jamal Chafi[1], PES Zouhair Benkhaldoun[1], PA Ossama Azagrouze[2], Doctor Abdelkarim Boskri[1]

[1]Cadi Ayyad University. [2]CRMEF Marrakech- Safi

Abstract

New apodization techniques are emerging rapidly to enhance the coronagraphs' rejection capabilities and refine the optics for directly detecting exoplanets. One such technique, Interferometric Apodization by Homothety (IAH), involves splitting the incident Point Spread Function (PSF) into two using a 50 : 50 beamsplitter. One of the resulting PSFs has its amplitude reduced by a factor γ and its transverse dimension expanded by a factor η. By combining these two PSFs, an apodized PSF is generated. In this study, we aim to determine the optimal values of γ and η for apodization in both rectangular and circular apertures. We implement this approach in the laboratory using a Mach- Zehnder Interferometer with Cube Beamsplitters, chosen for their advantages over Plate Beamsplitters, including easy integration at a 0° angle of incidence and equal optical path lengths for reflected and transmitted light. This technique shows significant promise, achieving a contrast of approximately 10−4 at small angular separations around 1.8 λ/D.

Keywords : High angular resolution – Apodization – Interferometric Apodization by Homothety "IAH" – Exoplanets – Interferometry – Mach-Zehnder interferometer

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Surface pressure impact on nitrogen-dominated USP super-Earths atmospheres

Postdoctoral researcher Chouqar Jamila[1,2], Postdoctoral researcher Jacob Lustig-Yaeger[3], Professor Zouhair Benkhaldoun[2], Researcher Andrew Szentgyorgyi[4], Professor Abdelhadi Jabiri[2], PhD student Abderahman Soubkiou[2]

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Abstract

In our study, we explore the atmospheric composition and emission signatures of nitrogen-rich Ultra-Short-Period (USP) super-Earths across a temperature spectrum from cool to hot, examining their states in both chemical equilibrium and disequilibrium under varying pressures from 0.1 to 10 bars. Our grids show how different surface pressures can significantly affect the temperature profiles, the atmospheric abundances, and consequently the emission spectra of these planets. We find that the divergences due to disequilibrium processes would be possible to observe in cooler planets by targeting HCN, C2H4, and CO, and in warmer planets by targeting CH4 with HCN, using the NIRSpec and MIRI LRS JWST instruments. These species are also found to be sensitive indicators of the existence of surfaces on nitrogen-dominated USP super-Earths, providing information regarding the thickness of these atmospheres.

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Increased Precision in Stellar Parameters of HD189733b and HD209458 Using *TESS* Light Curves

Jaeyi Song, Dr. Jason Eastman

Harvard-Smithsonian Center for Astrophysics

Abstract

HD189733b and HD209457 are both canonical exoplanets with deep transits, short periods and bright host stars, allowing us to determine a precise and accurate radius and temperature. We used EXOFASTv2 to run a series of stellar fits and were able to infer HD189733b's radius to 1.1% (0.7585: +0.0088, −0.0086 $R_{\odot}$) and its temperature to 1.2% (5141: +61, −60 K) - a factor of 2 improvement in precision over previous studies. Our stellar radius is 2.6 sigma discrepant from its CHARA-measured interferometric value (0.805: +0.016, −0.016 $R_{\odot}$) which, we argue, are due to systematic errors in the interferometric radius. HD189733's angular size is only 1.1 mas, and interferometric radius measurements have shown significant disagreements when the angular diameter is below 1.25 mas. Thus, this suggests that the widely accepted stellar parameters are significantly overestimated and less precise than our conclusions. For HD209458, we were able to measure the radius to 1.5% (1.169: +0.017, −0.018, $R_{\odot}$) and the temperature to 1.8% (6150: +120, −100 K) - a factor of 2.8 improvement in precision over alternative studies. While HD209458 does not have an available interferometric radius, we determined that our values have a higher level of precision than traditional methods that rely on spectroscopy and theoretical modeling. In this paper, we generalize our procedure so we can accurately and precisely determine the radii and temperatures of stars with high signal to noise transiting planets while carefully accounting for systematic errors.

Keywords: data analysis, planetary systems, planetary parameters, TESS, EXOFASTv2

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Physical Characterization of Intriguing Distant Comets with JWST

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Abstract

Comets are remnant planetesimals from the primordial protoplanetary disk, offering invaluable insights into the origins of our Solar System, planetary formation, and the emergence of life on Earth. However, a significant challenge remains in distinguishing whether the properties observed in comets are intrinsic or the result of evolutionary processes. Recent discoveries of distant comets, active beyond the 5 AU water sublimation zone and, in some cases, extending past Uranus, are pristine objects with minimal solar heating and thermal alteration. These remarkable comets present a unique opportunity to examine well-preserved planetesimals from the early Solar System, linking their observed properties to the primordial conditions of the protoplanetary disk around the young Sun. The unprecedented sensitivity of the JWST enables in-depth characterization of distant comets and has finally opened the window to study pristine water ice in comets, a key piece needed to understand the formation of the Solar System. In this talk, I will review recent JWST studies of comets and highlight the major findings. I will also discuss the implications of these studies for our understanding of Solar System science.

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Shedding Light on Exoplanetary Science: Moroccan Efforts in Popularizing Planetary Sciences and Exoplanets

Ms. Hanane Essamlali, Pr. Zouhair Benkhaldoun

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Abstract

Morocco is seeing an exciting upswing in interest in planetary sciences and the study of exoplanets, alongside an increase in public outreach to make these subjects more approachable. This talk highlights the country's energetic push to demystify exoplanetary science for people from all walks of life. Through a diverse array of conferences, discussions, and gatherings, Morocco is breaking down complexities and sparking enthusiasm for space exploration. These initiatives are all about simplifying the intricate ideas of space. This session will showcase standout events and measures that reflect Morocco's dedication to science outreach. From star festivals to interactive online sessions, a variety of platforms are being leveraged to get communities talking and thinking about exoplanets and planetary science. This movement is especially timely with the advent of the James Webb Space Telescope, which promises to revolutionize our understanding of exoplanets. Morocco's forward-thinking approach in science outreach not only aims to educate but also to encourage global cooperation and public participation. Sharing lessons and insights, this presentation aims to encourage more initiatives and investment in science communication within Morocco and further afield. By coming together, we can bridge the gap between our world and distant planets, unravel cosmic mysteries, and inspire future generations of scientists.

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JWST Observations of KBOs, Centaurs, and Trojan asteroids: A unique window into the dynamical history of the outer Solar System

Dr. Ian Wong[1,2], Prof. Michael Brown[3], Dr. Noemi Pinilla-Alonso[4], Dr. Javier Licandro[5], Dr. Silvia Protopapa[6]

[1]NASA GSFC. [2]American University. [3]Caltech. [4]Planetary Science Institute, UCF. [5]Instituto de Astrofísica de Canarias. [6]SwRI

Abstract

Jupiter Trojans occupy two swarms centered on the Lagrangian points within Jupiter's orbit. At the other end of the giant planet region, Kuiper belt objects (KBOs) reside in a vast disk beyond Neptune's orbit. Recent theories of solar system evolution posit that these minor body populations, now separated by enormous distances, initially formed within the same primordial transneptunian planetesimal disk. They were then scattered and emplaced into their present-day orbits during a period of dynamical instability that dramatically altered the orbital architecture of the Solar System. A comparative study of their surface properties serves as a powerful empirical test of our current understanding of solar system history. In the first two years of science operation, JWST observed a broad sampling of small bodies across the Solar System, enabling detailed spectroscopic explorations of these enigmatic objects. These observations have revealed an astounding diversity of chemical species, as well as tantalizing trends that provide tentative support to the hypothesis of a common origin for the Trojans and KBOs. Of critical importance have been observations of Centaurs – inward-scattered KBOs that serve as ideal proxies for investigating the types of surface evolution that likely occurred on Trojans during their inward migration from the outer Solar System. In this talk, I will provide an overview of the main findings from these studies, discuss the wider impact of the results on our understanding of solar system evolution, and explore future avenues of study that will leverage the synergy between JWST and large ground-based surveys.

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Observational and Chemical Modelling of Protoplanetary Disks after FU Ori outbursts

Lis Zwicky[1], Dr. Tamara Molyarova[2], Dr. Vitaly Akimkin[3], Dr. Dmitry Semenov[4], Dr. Ágnes Kóspál[5], Péter Ábrahám[5]

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Abstract

FU Ori stars (FUors) are undergoing powerful luminosity outbursts of ~100 $L_{\odot}$ in magnitude and of several decades in duration. Such outbursts inevitably affect physical and chemical structure of the surrounding protoplanetary disk. Using astrochemical and radiative transfer modelling, we study the lasting impact of the outburst on disks with and without an envelope and how it changes flux in chosen molecular lines. We formulate a number of criteria indicative of a recent outburst activity based on the molecular emission, analyze the chemistry behind the flux change and apply the criteria to available observations of quiescent protoplanetary disks. The latter revealed ten objects with possible outbursts in the past and four of them satisfy multiple proposed criteria.

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1701

Dynamical Chaos and Disappearing Dust in the TYC 8830 410 1 Planetary System

Dr. Carl Melis[1], Dr. Johan Olofsson[2], Dr. Leonardo Paredes[3], Prof. Maxwell Millar-Blanchaer[4], Dr. Ralf Launhardt[5], Dr. Christopher Mann[6], Dr. Alycia Weinberger[7], Dr. Jorge Lillo-Box[8], Dr. Grant Kennedy[9]

[1]University of California, San Diego. [2]ESO. [3]University of Arizona. [4]University of California, Santa Barbara. [5]Max Planck Institute for Astronomy. [6]Université de Montréal. [7]Carnegie Institution of Washington. [8]Centro de Astrobiología (CAB), CSIC-INTA,. [9]University of Warwick

Abstract

TYC 8830 410 1 is a very dusty, intermediate-age, main sequence, Sun-like star. Optical monitoring of the star over several years has identified a transiting body with a period near 167 days that blocks >50% of the host star's optical light in each transit event, but radial velocity monitoring limits any orbiting companion to planet masses. We present a suite of ground- and space-based observations that have been used to characterize the star and its orbiting bodies, resulting in several outstanding enigmas. Chief among them are what appears to be transit timing variations in the arrival of the deep transit events, a dust grain distribution skewed to sub-micron sizes, significant radial velocity jitter that is not due to stellar activity, and what appears to be actively disappearing dust over the 2023-2024 timeframe. We explore an interpretation where TYC 8830 410 1 experienced a dramatic planetary system instability that has driven two major planets to collide.

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Simulation of Thermal Surface Waves in a Protoplanetary Disk in a Two-Dimensional Approximation

Dr Lomara Maksimova, Dr Yaroslav Pavlyuchenkov, Dr Vitaly Akimkin

Institute of Astronomy RAS

Abstract

Theoretical models predict that the obscuration of stellar radiation by irregularities on the surface of a protoplanetary disk can cause self-generating waves traveling towards the star. However, this process is traditionally simulated using the 1+1D approach, the key approximations of which — vertical hydrostatic equilibrium of the disk and vertical diffusion of IR radiation — can distort the picture. This article presents a two-dimensional radiative hydrodynamic model of the evolution of an axially symmetric gas and dust disk. Within this model, but using simplified assumptions from 1+1D models, we have reproduced the spontaneous generation and propagation of thermal surface waves. The key conclusion of our work is that taking into account two-dimensional hydrodynamics and diffusion of IR radiation suppresses the spontaneous generation and development of thermal waves observed in the 1+1D approximation. The search for the possibility of the existence of surface thermal waves should be continued by studying the problem for various parameters of protoplanetary disks.

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Volatiles and C/O ratios as a result of dust drift in self-gravitating protoplanetary discs

Dr Tamara Molyarova[1,2], Dr Eduard Vorobyov[3], Dr Vitaly Akimkin[2]

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Abstract

The planet formation process starts with dust growth in protoplanetary discs and is accompanied by the evolution of chemical composition. Elemental abundances, particularly, the C/O ratio, are seen as a way to connect the composition of planetary atmospheres with their formation scenario and the disc chemical environment. We model the chemical composition of gas and ices to study the evolution of C/O ratio in the disc due to dust dynamics and growth, as well as phase transitions of the volatile species. We use the 2D hydrodynamic code FEOSAD to simulate the formation and evolution of a protoplanetary disc in the thin-disc limit up to 500 kyr. The model includes self-gravity, thermal balance, dust evolution and gas-dust diffusion, and treats dust as a dynamically different and evolving component interacting with the gas. It also describes freeze-out, sublimation and advection of four most abundant volatile species: H2O, CO2, CH4 and CO. We demonstrate the effect of dust drift on the accumulation of the molecules on their snowlines and the implications for the C/O ratio in two models of different mass. Dense dust rings form near the snowlines and they also significantly affect the C/O distribution. Dust radial drift leads to global enhancement of the inner disc with the volatiles. Variations of C/O ratio in the gas and in the ice are associated with the snowlines and disc substructures and can appear even when the chemical reactions are neglected.
The study was funded by a grant from the Russian Science Foundation 22-72-10029.

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A New Tool for High-Precision Radial Velocity Measurements

Prof. William Welsh

San Diego State University

Abstract

The cross correlation function (CCF) is the standard way to measure wavelengths shifts between spectra, and thus construct Doppler radial velocity curves. Given the need for ever more precise RVs to detect and characterize Earth-mass planets, any improvement of the CCF can be of significant value. I present a new functional form for measuring wavelength shifts that has several advantages over the classic CCF. The technique is based on the concept of a physical resonance and uses a Cauchy-Lorentz function to estimate when the two spectra are best-matched in wavelength. Tests show that it offers higher resolution than the standard CCF, and this is its main strength. It also provides uncertainties for the RV estimate, and it is very simple to compute. The method should work particularly well for constructing "CCF images" (CCF vs. time or CCF vs. orbital phase), where higher resolution is extremely important for detecting a faint signal against the background. While it is a general technique that can be used to measure the shift between any two time series, this new version of the correlation function shows considerable promise not just for precision RVs but for many cases in astrophysics where a time lag or shift needs to be determined (e.g. AGN reverberation mapping, time lags between multiple images caused by gravitational-lensing, image registration, etc.).

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Thermal model of rocky exoplanets: Estimation magnetic diffusion time scales

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Abstract

Sustenance of magnetic field structure of rocky extra-solar planet is very important for the survival of life. Most importantly, understanding of magnetic field structure is also important for probing thermal structure of planets as magnetic diffusion is a function of temperature structure of the planetary core. For different spectral types, about 53 exoplanets with masses in the range 0.1 to 10 Earth masses with their respective radius and density data are obtained from NASA website (https://exoplanetarchive.ipac.caltech.edu). In the exoplanetary cores, from the information of hydrostatic equilibrium and with the estimated surface radius, mass and density, central pressure at the core are estimated. With simple equation of state and with composition of Iron and Nickel for the masses > 1.0 Earth masses and, Iron and Sulphur for the masses < 1.0 Earth masses, core temperature are estimated. For the the Earth and Mercury, estimated core temperatures are almost similar to the temperatures as quoted in the literature. From the Wiedemann-Franz law and with the assumption of similar thermal conductivity as in the Earth's core, magnetic diffusivity of the planetary cores are estimated. For different exoplanets, magnetic diffusion time scales are estimated and are found to be ~ million yrs if the planets have acquired the ratio Bd /B0 >1 and are ~ billion yrs if the the same ratio Bd /B0 is << 1 during early history of solar/stellar formation. Here Bd is exoplanet's dipole magnetic field structure and B0 is asymptotically uniform magnetic field structure of interstellar origin.

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Apatite Formation in Shergottite NWA-7397: Implications for the Mapping of Martian Meteorites

Amber Bonsall-Pisano[1], Geoff Howarth[1], Chad Peel[1], Gelu Costin[2]

[1]University of Cape Town. [2]Rice University

Abstract

Martian meteorites are currently our only existing samples from Mars. They are divided into two primary types, the shergottites and the nakhlite-chassignite types. The shergottites are by far the most abundant of the martian meteorites. Poikilitic shergottites are mineralogically the most complex sub-group among shergottites comprising multiple generations of both olivine and pyroxene and characterized by the presence of coarse-grained (>1cm) compositionally zoned pyroxene containing abundant olivine and chromite. Here we use various chemical analyses to accurately map the mineralogy of shergottites to constrain its petrogenesis.

For this sample, what we focused on was the phosphates. Mainly on the calcium phosphates, apatite ($Ca_5[PO_4]_3[F,CL,OH]$) and merrillite ($Ca_9Na(Fe,Mg)(PO_4)_7$). These phosphates contain specific volatile species that contain incompatible trace elements (ITE), which formed in the mantle during planetary cooling and allow us to observe how the Martian mantle cooled during planetary differentiation. The phosphates within the sample tend to appear more elongated in appearance. Merrillite and apatite show similar chemical properties with apatite tending to have F and Cl in its composition and merrillite having neither of those. Apatite and merrillite also show variations in their CaO content. This sample in particular, shows the melt boundaries between apatite and merrillite, which will be key in uncovering the melt inclusion properties of the early martian mantle.

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1801

Exoplanets in the Classroom - Bilingual Astronomy Resources for Educators, by Educators

Dr Marie-Eve Naud[1,2], Julie Bolduc-Duval[3], Dr Heidi White[1,4,2], Dr Nathalie Nguyen-Quoc Ouellette[1,4,2], Dr Frédérique Baron[2,5,4,1]

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Abstract

Over the past few years, astrophysicists, science educators, and teachers across Canada have collaborated to create the wealth of educational resources presented in **Exoplanets in the Classroom**. Activities, slide decks, short videos, biographies of Canadian astronomers, an FAQ, a glossary, and more are all available online at www.exoplanetsintheclassroom.ca, at no cost, to explore exoplanets and the search for life in the Universe.

During this talk, I will present these bilingual (French and English) resources and how they were developed, in a process led by astrophysicists and science educators at the Trottier Institute for Research on Exoplanets (iREx) at the Université de Montréal, in close collaboration with other educational partners. More than a hundred Canadian teachers have been involved in various ways in the project from its inception in 2021. Using their feedback, we iteratively built the resources to make sure they were easy to adopt and adapt and had significant connections with the science school curriculum, as well as that of other disciplines (mathematics, language, arts and more). Through the resources, they now have a novel way to review mandatory topics and learn more about cutting-edge research topics *and* the diversity of scientists behind them.

The resources, tested and approved by students and teachers from a wide range of backgrounds, can be adapted to anyone who wants to share their passion for astronomy with youth and members of the general public through booths, interactive activities, presentations in classrooms, in libraries, during career days, and at a plethora of other venues.

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JWST and cross-correlations: A faster alternative for atmospheric studies

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Abstract

The application of cross-correlation techniques to JWST observations has opened an alternate pathway to study exoplanet atmospheres. We recently developed a cross-correlation technique that leaded to the detection of CO in JWST/NIRSpec transmission spectra at medium spectral resolution, including novel hints of detection of isotopologues, which could provide some advantages compared to traditional techniques. Here we present the concept of applying cross-correlation techniques to JWST data, explaining the advantages and potential applications of this technique in the context of JWST, which might be of interest not only for exoplanetary atmospheres but also for other fields involving JWST observations. Additionally, besides the initial CO detection in WASP-39b, we show out latest results on more molecules detected through cross-correlations on NIRSpec/G395H observations, including H_2O and CO_2.

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Characterising the magnetic field and space environment of known exoplanet hosts: the case of GJ 436 and HD 63433

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Abstract

The characterisation of stellar magnetism of planetary host stars has increased momentum, especially for transmission spectroscopy investigations of exoplanets. Indeed, the magnetic field regulates how irradiated planets are, and the presence of inhomogeneities on the stellar surface hinder the precise extraction of the planetary atmospheric absorption signal. We are conducting a spectropolarimetric campaign to unveil the magnetic field properties of known exoplanet hosting stars included in the current list of Ariel targets.
I will focus on two of them: GJ 436 and HD 63433. The former is an M dwarf orbited by a warm-Neptune experiencing substantial atmospheric loss, modelled as a comet-like trail of hydrogen atoms. The latter is a young, solar-like star hosting two sub-Neptunes and an Earth-sized planet that have likely experienced different atmospheric evolution paths, since only the outer sub-Neptune planet has retained its atmosphere. We reconstructed the large-scale magnetic field via Zeeman-Doppler imaging, and used it as boundary condition to simulate the stellar magnetised wind and environment at the planetary orbits. For GJ 436, the planet motion is sub-Alfvénic, meaning that star-planet magnetic connections can occur, powering the anomalous ultraviolet flare distribution observed in the system. We derived the power released by star-planet interactions to be 10^{22}-10^{23}erg/s, consistent with the upper limit of 10^{26} erg/s measured from ultraviolet lines. For HD63433, we identified 10% of the innermost planetary orbit as sub-Alfvénic, while the outer planets are outside the Alfvén surface, and a bow shock between the stellar wind and the planetary magnetosphere could form.

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Numerical geodynamic simulations of the thermal evolution within the outer ice shell of Ganymede.

Dr Katherine Elizabeth Villavicencio Valero

University of Chieti - Pescara

Abstract

Ganymede has caught the attention of scientist due to its potentially of harboring the favorable conditions for hosting life. The JUICE mission was recently launched to conduct experiments on Jupiter and its Galilean moons, with a particular emphasis on characterizing Ganymede's internal dynamics, surface processes, and atmospheric conditions. Here, we present geodynamic experiments of the physical parameters that provoke melting within the outer ice shell and are associated to surface processes such as cryovolcanism and impact cratering. We perform a sensitive analysis of the thermal evolution for compressible and incompressible fluids by varying the viscosity, thickness, and pressure of the melting temperature, applying the Boussinesq Approximation (BA), Anelastic Liquid Approximation (ALA), and the Isentropic Liquid Approximation (ICA). Additionally, it was conducted a hyperspectral analysis on the surface contaminants regions like impact craters and cryovolcanism that might be connected to internal processes, using the data taken by the JIRAM instrument on board of the JUNO mission. Results show molten material under a restricted geophysical states that could allow for emerging material from the subsurface ocean to the surface. These results will support the objectives of the RIME instrument on board of JUICE mission, because they highlight specific conditions that, in the future, might help to have a better understanding of the internal mechanisms that could transfer heat on surface and modify the geology and atmospheric processes, and could also predict how much energy transfer takes place at the limit between the subsurface ocean and the bottom of the ice shell.

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1868

TRAPPIST-North at the Oukaimeden Observatory: a success story in the field of planetary sciences.

Prof. Zouhair Benkhaldoun[1,2], Dr. Emmanuel Jehin[3], Dr. Michael Gillon[4]

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Abstract

TRAPPIST-North (Z53) located at the Oukaimeden Observatory in the High Atlas Mountains in Morocco is a joint venture between the Cadi Ayyad University of Marrakech and the University of Liège since 2015. It became a key player in planetary sciences to which it has significantly contributed with several discoveries and key studies in both fields of exoplanets and small bodies of the solar system. TRAPPIST-North is a 60 cm remotely operated telescope, equipped with a very sensitive CCD camera and 18 filters that enjoys 250 clear and dark nights per year under good seeing. We will present in this communication the main statistics regarding the operation and publications of TRAPPIST-North as well as the most important results to which the team has contributed. A standout accomplishment is its role in identifying the TRAPPIST-1 planetary system, a breakthrough that reshaped our understanding of planetary formation and habitability beyond our solar system. Additionally, TRAPPIST-North's ongoing observations of comets and asteroids have deepened our comprehension of the composition, evolution and physical characteristics of these pristine solar system objects. Through its commitment to scientific inquiry, technological development of the Oukaimeden Observatory and formation of master and PhD students for many years, TRAPPIST-North has advanced our understanding of the cosmos and inspired future generations of astronomers. As we delve deeper into space exploration, TRAPPIST-North serves as an example to the impact of curiosity, collaboration, and innovation in unraveling the universe's mysteries.

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Equipping SALT's High-Resolution Spectrograph for Precision Radial Velocity Science

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Abstract

The High Stability (HS) mode of the Southern African Large Telescope (SALT) High-Resolution Spectrograph (HRS) is being developed to support precision radial velocity (PRV) science capability. The project includes a bespoke optical laser frequency comb (LFC) for the red (555-890 nm) channel of the HRS, as well as a PRV data reduction pipeline for the HS mode. The modular LFC design makes provision for future additions, such as extension of the LFC coverage into bluer regions of the spectrum. The LFC will be used in conjunction with the existing simultaneous thorium-argon feed on the spectrograph's HS bench. We are aiming to complete the installation and commissioning of the LFC during 2024 and to have the system science-ready in 2025.

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Approach of the NGC1977 star cluster tothe TOI-2796 host starHawi Yohanis Wakjira1, 2, Seblu Humne Negu1, Daria A.Mosunova3, Mariya D. Sizova3, Ekaterina S. Postnikova3, Natalia V. Chupina3, Anna M. Fateeva3, Alexander M. Fateev3and Sergei V. Vereshchagin3^ 1 Space Science and Geospatial Institute (SSGI), Entoto Observatory and Research Center (EORC), Astronomy and Astrophysics Department, Addis Ababa, Ethiopia[2]Finfine Aerospace and Robotics International Institute (FARIS), Addis Ababa, Ethiopia[3]Institute of Astronomy of the Russian Academy of Sciences Moscow, 119017 Russia

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Abstract

We looked for a rapprochement in space between astar cluster and an extrasolar planetary system in past epochs. We found a host star TOI-2796 – a candidatefor such approach for the cluster NGC 1977. These parameters allowed us to estimate the gravitational effect on the loss of comets from the Oort cloud of the TOI-2796.

The galpy package is used to calculate the orbital parameters for the sample. The MWPotential14 isused, a gravitational potential composed of a power law, exponentially cut-off bulge, Miyamoto-Nagaipotential disc, and Navarro-Frenk-White dark matterhalo.

By extending the track of the movement of the cluster and stars in past epochs (5.5 Myr), the time of the maximum approach (30 pc) of the host star withplanetary system TOI-2796 with the NGC 1977 hasbeen found. As the result of our research, we derivedthat the host star's approach with the cluster mightentail effects related with the cluster's gravitationalpull on the nuclei of comets located in the outer border of the planetary system's Oort cloud. The impact of approach on Oort cloud comets has been estimated.

According to our calculations, the NGC 1977 cluster was the closest to the host star TOI-2796 at the distance ≈ 29.85 pc. The result of our work is that the we found approach of the host star to the

cluster entailed effects associated with the gravitational influence of the cluster on the nuclei of comets located in the outer parts of the Oort cloud of the TOI-2796 planetary system. The result of this influence, on the one hand, may be the appearance of comets, which in later eras could approach the star, on the other hand, some cometary nuclei could leave the planetary system and end up in interstellar space. This depends on whether the directions of the velocity vectors of the star and the cluster were co-directional or opposite.

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Imaging and Spectroscopy of Titan in the Near-IR from JWST and Keck

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Abstract

Titan, largest moon of Saturn, is a unique world in the solar system being the only moon to possess a dense atmosphere. Penetrating the dense, hazy atmosphere is impossible at visible wavelengths, but becomes possible in the near-infrared where different wavelengths probe to the middle and lower atmosphere and even the surface. Since 2022 the James Webb Space Telescope, in partnership with large ground-based telescopes such as Keck, have pulled back the curtain on Titan's atmospheric workings as never before. Using imaging at wavelengths from 1-5 microns these telescopes have revealed the comings and goings of large clouds, evolving in latitude and altitude. At the same time, spectroscopy at 1-28 microns has provide an unprecedented combination of sensitivity and resolution probing molecular emissions in the middle and upper atmosphere. These include bands of CO, CO_2, HCN, CH_4, C_2H_6 and their isotopes; and the first direct detection of the methane photolysis product CH_3, an important ingredient of larger molecules. In this talk the latest results of the ongoing JWST-Keck synergistic observation campaign will be discussed, along with plans to observe Titan through the upcoming equinox in 2025.

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1968

Water at the earliest stages of star and planet formation

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Abstract

Water, an essential molecule for sustaining life on Earth, plays a crucial role in the physical and chemical processes governing the formation of stars and planets, serving as a primary coolant in the environments surrounding emerging stars. The journey of water from the earliest stages of star and planet formation to its eventual incorporation to exoplanetary atmospheres and its potential oceans is still a matter of debate. Very recent works using ALMA and JWST data reveals that water can be found in the inner astronomical units in protoplanetary disks, in the terrestrial planet-forming zone.

Detecting water molecules from ground-based telescopes is challenging due to the water vapor content within Earth's atmosphere, severely limiting atmospheric transmissivity. Nevertheless, water is one of the few compounds capable of generating bright maser emission within star-forming regions. Their exceptional brightness, narrow spectral profiles, and their origin in highly compact regions offer a unique set of characteristics that render them invaluable tools for investigating circumstellar structure and dynamics at sub-arcsecond spatial scales.

In this work we present our efforts to search and characterize water maser emission at submillimeter frequencies using the Atacama Large Millimeter Array (ALMA) in a sample of young stellar objects.

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2024

Terrestrial planet and asteroid belt formation by Jupiter–Saturn chaotic excitation: A comprehensive dynamical model for the inner solar system

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[1]Kindai University (Japan). [2]National Astronomical Observatory of Japan. [3]Chiba Institute of Technology (Japan)

Abstract

The Jupiter–Saturn chaotic excitation (JSCE) scenario offers a plausible explanation for several properties of the inner solar system. Still, simultaneously replicating the four terrestrial planets' orbits/masses and the asteroid belt's main properties remain elusive.

Here, we investigated the simultaneous formation of the four terrestrial planets (Mercury, Venus, Earth, and Mars) and the asteroid belt in the context of the JSCE scenario. We found that our terrestrial systems satisfied several inner solar system constraints.

An analysis of 37 optimally formed terrestrial planet systems allowed us to constrain the planets' building blocks, accretion history, and other fundamental properties. First, the obtained terrestrial planets acquired orbits and masses very similar to those observed in our solar system. In addition, other key results include Moon-forming giant impacts occurring within ~60 Myr, terrestrial planets' bombardment of late impactors represented by disk objects formed within 2 au, and bulk water acquired during the first 10–20 Myr of Earth's formation. In particular, achieving Earth's estimated bulk water content required the disk to initially contain sufficient water mass in objects beyond ~1–1.5 au. This requirement implies that Mercury, Venus, and Mars acquired water similar to the amount on Earth during their formation.

Finally, our model asteroid belt explained the asteroid belt's orbital structure, small mass, and taxonomy (S-, C- and D/P-types). The current asteroids represent a mixture of local asteroids that survived the dynamical depletion of the primordial asteroid belt by JSCE and captured asteroids from trans-Jovian reservoirs during the giant-planet instability/migration.

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2026

Effect of Non-Lambertian Emission on Small Bodies' YORP Spin-Up/Down

Ryota Nakano, Dr. Masatoshi Hirabayashi

Georgia Institute of Technology

Abstract

Accurately modeling the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect, which alters the spin states of small bodies through thermally-induced forces and torques [e.g., 1], is crucial for comprehending their dynamical and structural evolution.

Here, we explore the effect of non-Lambertian emission (NLE) on YORP, relaxing the Lambertian assumption that has been employed in the conventional YORP models [e.g., 2, 3]. The conventional models assumed that the sunlight reflection and re-radiation only result in the diffuse force which aligns with the facet's normal direction, regardless of the Lambertian or non-Lambertian emission. However, this assumption is not valid when considering complex NLE which induce forces in the tangential direction [e.g., 4, 5]. We will modify the SRP model [6] to incorporate such tangential force and investigate how it changes the YORP effect on small bodies.

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Probing the gas that builds planets: results from the JWST MINDS disk program

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Leiden Observatory, Leiden University, the Netherlands. Max Planck Institute for Extraterrestrial Physics, Garching, Germany

Abstract

The goal of the 120 hr MIRI Mid INfrared Disk Survey (MINDS) GTO program (Th. Henning, I. Kamp co-PIs) is to use JWST to (1) investigate the chemical inventory of the terrestrial planet forming zone, (2) to follow the gas evolution into the disk dispersal stage, and to (3) study the structure of protoplanetary and debris disks in the thermal mid-IR. The program builds a bridge between the chemical inventory of planet-forming disks and the properties of exoplanets. In total, about 50 targets (Herbig Ae stars, T Tauri stars, brown dwarfs and young debris disks) have been observed using MRS spectroscopy aiming at high S/N spectra covering the complete MIRI wavelength range. At the conference, results for several T Tauri and Brown Dwarf disks will be presented. Some disks are very rich in water whereas other disks show primarily hydrocarbon features. In addition to the many lines from CO, H_2O, CO_2, C_2H_2 and/or HCN, also surprising new molecules are detected. Together they point to a rich chemistry that is linked to the physical structure and dust evolution (radial drift of icy pebbles, dust traps) of the inner few au of these disks where planet formation occurs.

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A link between the size and composition of comets?

Dr Cyrielle Opitom[1], Dr James E. Robinson[1], Dr Uri Malamud[2], Dr Hagai Perets[2], Prof Jürgen Blum[3]

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Abstract

Models of cometary nuclei formation predict that if they have a pebble-pile structure and hence a low thermal conductivity, internal temperature build-up from radiogenic heating will be enhanced, leading to differentiation of the nucleus. For comets of sufficient size this heating leads to a thermal gradient and internal transport of volatile species, either depleting the nucleus or leading to a shell-like distribution of volatiles. Models predict that the degree of differentiation depends primarily on nucleus sizes and that a correlation should exist between the abundance of volatile species in comets and the size of the nucleus.

To verify that hypothesis, we have conducted an extensive literature search to gather measurements of the size and composition of comets, combined in a unified database. We find a significant correlation between the abundance of CO relative to water and the size of cometary nuclei, for all dynamical types of comets. This correlation is replicated our theoretical model based on previously published thermophysical models, supporting the theory that the nuclei of comets are differentiated due to radiogenic heating.

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Spectroscopic and morphological study of small bodies of the Solar System, trajectory simulation and impact risk in Burkina Faso.

André Zoungrana, Dr. Sié Zacharie KAM

Environmental Physics and Chemistry LaboratoryUniversity Joseph KI-ZERBO

Abstract

Formed around 4.5 billion years ago, our solar system contains remnants that are responsible for intense impacts on the planets, as evidenced by the many craters on the surface of the telluric planets. The recent events at Tunguska and Chelyabinsk in Russia and Bilanga in Burkina Faso demonstrate the danger that these small solar system bodies pose to the Earth. The aim of this study is to analyse data from the FRIPON network on objects penetrating the Earth's atmosphere and to characterise the chemical, morphological and dynamic parameters of Near-Earth Object using Gaia data and occultations to gain a better understanding of the fragmentation processes of these objects and their impacts, and to make recommendations to minimise or even avoid damage in the event of an impact. We present the preliminary results obtained by analysing Gaia data and the FRIPON network.

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Atmospheric Thermal Emission effect on Chandrasekhar's diffuse reflection problem

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Instituto de Ciencias del Espacio

Abstract

The solutions of the diffuse reflection atmosphere problem are very useful in the astrophysical context. Chandrasekhar was the first to solve this problem analytically, by considering atmospheric scattering. These results have wide applications in the modeling of planetary atmospheres. However, they cannot be used to model an atmosphere with emission. We solved this problem by including the thermal emission effect along with scattering. Here, our aim is to provide a complete picture of the generalized atmosphere problem in the presence of scattering and thermal emission, and to give a physical account of the same. For that, we take an analytical approach using the invariance principle method to solve the diffuse reflection finite atmosphere problem in the presence of atmospheric thermal emission. We established general integral equations of the modified scattering function and transmission function and their derivatives with respect to τ for a thermally emitting atmosphere. We customize these equations for the case of isotropic scattering and introduce new functions $M(\mu)$, $V(\mu)$,$W(\mu)$, analogous to Chandrasekhar's $H(\mu)$, $X(\mu)$, and $Y(\mu)$ functions. We provide a physical account of our results and a relation between modified S and T function. Our final results are consistent with those of Chandrasekhar's at the low emission limit. From the consistency of our results, we conclude that the consideration of the thermal emission effect in the diffuse reflection finite atmosphere problem gives more general and accurate results than considering only scattering observable in JWST era.

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Sulfur chemistry in protostars: linking the ice and the gas phases

Dr. Elizabeth Artur de la Villarmois

European Southern Observatory

Abstract

Sulfur-bearing molecules may have played an important role in the origins of life on Earth, however, the sulfur chemistry is poorly understood in the process of low-mass star and planet formation. Moreover, sulfur is found to be depleted by orders of magnitude in the gas-phase (in comparison to ISM values), the main sulfur reservoir in ices is still uncertain, and they show different S-abundances than cometary samples. Therefore, the main S-carrier is still missing in both, the gas and the dust-phase.

In this work, I will present recent results from the Perseus ALMA Chemical Survey (PEACHES) focussing on simple sulfur-bearing species (CS, SO, 34SO, and SO2) toward 50 Class 0/I embedded sources. We compare the spatial distribution and column densities of S-bearing species with complex organic molecules (COMs), associating the S-emission to different physical processes in sources with different evolutionary stages. In addition, the comparison between different star-forming regions indicate that the S-depletion in the gas-phase could depend on the external UV radiation toward the molecular cloud, and Perseus appears to be one of the regions with the highest depletion of sulfur.

With these ALMA observations we are tracing the sulfur content of the gas-phase, and we will compare our results with recent studies from JWST towards embedded protostars, which trace the ice content and warmer inner-regions. The main goal is to link the sulfur chemistry at earlier stages with planetary atmosphere observations.

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JWST: A New Explorer for Giant Planet Systems

Professor Leigh Fletcher

University of Leicester

Abstract

The first two years of JWST scientific operations have produced a treasure trove of new discoveries for the four giant planets, whilst challenging the community to develop innovative software tools to deal with untested instruments on a brand-new facility. Spectacular NIRCAM images of all four giants have provided new views of their churning weather systems, hazes, and ionospheric emissions, and have enabled the tracking of Jupiter's atmospheric dynamics at previously unseen altitudes. But the key strength of JWST is the integral field unit spectrometers, NIRSpec (0.6-5.3 μm) and MIRI/MRS (4.9-28.5 μm). These provide spatially-resolved spectroscopy at high spectral resolution (R~1500-3700) across their fields of view. Uranus and Neptune fit perfectly within the fields-of-view, whereas complex mosaics are needed for Jupiter and Saturn. This presentation will showcase some of the key giant-planet results from the Guaranteed-Time programmes (GTO) and Early-Release (ERS) Jupiter programme during Cycle 1 & 2. These include maps of Jupiter's Great Red Spot and South Polar aurora; observations of Io, Ganymede and the jovian rings; maps of Saturn's northern summertime hemisphere and rings; observations of Saturn's rings and small moons; and global maps of Uranus and Neptune from the troposphere to the ionosphere. The latter represent one of the most significant new datasets for Ice Giant science since the era of Voyager-2, and it is hoped that these rich observations will be the start of a long-term programme monitoring the evolving appearance of the giant planets over the lifetime of JWST.

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Planetary Systems in Clusters: Free-floating planets, captured planets,binary planets, and outside-in influence on the inner planets

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[1]Cornell University. [2]T.D. Lee Institute, Shanghai. [3]Shanghai Jiao Tong University

Abstract

Newly formed planetary systems in star clusters can experience stellar flybys, which change the system's architechture. We discuss several topics (based on recent/ongoing works): (1) What is the characteristics of free-floating planets and captured produced by stellar flybys? (2) What is the probability and property of free-floating binary planets? (3) How stellar flybys may influence the inner planetary system through "outside-in cascade"?

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First detection of water vapor surrounding a main-belt comet

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Abstract

Main-belt comets are small bodies in the Solar System situated in the asteroid belt that consistently show comet-like behavior (such as dust comae or tails) when they are closest to the Sun, strongly suggesting the sublimation of ice. The presence of main-belt comets indicates that water ice exists in the asteroid belt, yet no gas emissions have been observed around these objects despite thorough observations using the world's most powerful telescopes. Observations from the James Webb Space Telescope reveal that the main-belt comet 238P/Read possesses a water vapor coma, but does not have a significant CO_2 gas coma. These discoveries confirm that comet Read's activity is propelled by the sublimation of water ice, suggesting that main-belt comets differ essentially from the broader cometary population. It remains uncertain whether comet Read underwent unique formation processes or an evolutionary history; however, it is improbable to be a recent interloper into the asteroid belt from the outer Solar System. Based on these findings, main-belt comets seem to offer a glimpse into a type of volatile material not yet seen in studies of classical comets or in meteoritic samples, highlighting their significance for exploring the volatile content of the early Solar System and its evolution.

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ExoPlanetVisualiser: A Tool for Astronomy Education in Developing Countries

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Abstract

This paper aims to discuss a new address web-based application (app) known as *ExoPlanetVisualiser* for visualizing and communicating Astronomy related concepts. The current methods of visualizing, collecting and analyzing space data require complex resources such as high processors and high storage. To bridge the knowledge gap and provide easy access to astronomy/space education, this work proposes the use of *ExoPlanetVisualiser* app. This app serves as an intuitive and easy-to-use platform, specifically designed to empower individuals in developing countries who are in elementary schools, high schools, and universities to learn more about astronomy/space science. The app offers a range of interactive visualizations which offer an engaging and immersive learning experience. Users have the opportunity to explore the aspect of planetary science and exoplanets through interactive charts, enabling them to grasp complex concepts in a simplified manner. The app is a platform where certain concepts in astronomy and planetary science can be introduced and easily remembered.

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Super-Earth Discovery: TOI-1680 b Revealed by TESS and Ground-based Observations

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Abstract

We present the discovery of TOI-1680, a super-Earth planet orbiting an inactive M4.5 dwarf star, first identified by the Transiting Exoplanet Survey Satellite (TESS) and subsequently validated through ground-based observations. TOI-1680 b boasts a radius of 1.466R⊕ and an equilibrium temperature of 404 ± 14 K. With its estimated mass, TOI-1680 b emerges as an intriguing candidate for atmospheric analysis using the James Webb Space Telescope (JWST).

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Discovery of Three Sub-Neptune Exoplanets Orbiting M Dwarfs with TESS

Abderahmane Soubkiou[1], Khalid Barkaoui[2], Tianjun Gan[3], Zouhair Benkhaldoun[1]

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Abstract

We present the discovery of three sub-Neptune exoplanets orbiting M dwarf stars: TOI-2136 b (period 7.85 days, radius 2.19 ± 0.17 R⊕, mass 6.4 ± 2.4 M⊕), TOI-2084 b (period 6.08 days, radius 2.47 ± 0.13 R⊕), and TOI-4184 b (period 4.9 days, radius 2.43 ± 0.21 R⊕). All discoveries utilized TESS data combined with ground-based follow-up observations for confirmation. The location of these planets near the "radius valley" suggests diverse planetary formations around low-mass stars and holds promise for future atmospheric characterization with instruments like JWST.

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Design, Assembly and Test of G-CLEF's Exposure Meter

Henrique Lupinari[1], Rafael Ribeiro[1], Sagi Ben-Ami[2], Claudia Mendes de Oliveira[1], Andrew Szentgyorgyi[3]

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Abstract

This project aims to formulate, design, build and test a versatile, high-efficiency, low-resolution spectrograph to function as the G-CLEF (GMT-Consortium Large Earth Finder) exposure meter. G-CLEF, the first-generation Giant Magellan Telescope's (GMT) instrument, is a state-of-the-art, high-resolution, echelle spectrograph for the GMT, expected to be completed for the telescope's first light. The exposure meter plays a vital role in adjusting barycentric corrections of Doppler radial velocity (RV) by accounting for Earth's chromatic atmospheric influences. Its significance becomes pronounced in Extreme Precision RV (EPRV) measurements, where the atmosphere's wavelength dependency contributes to errors at the scale of tens of centimeters per second, the same level of precision required for detecting Earth-analog planets orbiting stars similar to the Sun, aligning with one of the primary scientific objectives of G-CLEF. In the context of this project, the entire process, starting with performance simulations, going through design trade-offs, and concluding with prototype tests, is shown.

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WASP-193 b: A Puzzling Super-Neptune with Extremely Low Density

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Abstract

WASP-193 b, a recently discovered "super-Neptune," throws a curveball at our understanding of planetary formation. This gas giant, transiting its star every 6.25 days, holds the distinction of being one of the lightest planets ever found, with a density of only 0.059 g/cm³. This raises crucial questions about its internal makeup and how such a low-density world came to be. Despite its proximity to its star and the resulting high temperature (1254 K), WASP-193 b presents an irresistible opportunity for future atmospheric studies. Its large transit depth, remarkably low density, and bright host star make it an ideal candidate for the James Webb Space Telescope (JWST). A single transit observation with JWST could provide unprecedented insights into the atmospheric composition and planetary mass of this enigmatic world, potentially revealing the secrets of low-density exoplanet formation

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Bringing the night sky to the living room: Reflections on 3+ years live streaming astronomical events

Dr Claudia Mignone, Dr Federica Duras, Dr Giulia Mantovani, Federico Di Giacomo, Giacomini Livia, Dr Filippelli Gianluigi, Dr Sandro Bardelli, Emanuele Scalise

INAF - National Institute for Astrophysics

Abstract

This presentation shares results and behind the scenes of “Il cielo in salotto” (in English, “The sky in your living room”), a format for live streaming astronomical observations created by the Italian National Institute for Astrophysics (INAF). The project started in late 2020 in the midst of the Covid-19 pandemic to engage the general public and students with astronomy and space science remotely, when observatory visits were not possible. The format later evolved, in the “new normal” scenario, as a complementary activity to in-person events, featuring astronomical phenomena – such as planet alignments, eclipses, different Moon phases, comets, sunspots, exoplanet-hosting stars – observed live by the INAF network of telescopes all around the country. These events are enriched by live interviews with INAF researchers and supported by large-scale public engagement campaigns conducted together with space enthusiasts, amateur astronomy associations and other partners. Viewers can ask questions live to the experts and also select some of the targets to observe. In this talk, we shall present lessons learnt and best practices from three and a half years running the project, along with some of the technical, logistics, content and communication solutions adopted in the format of potential interest to colleagues organising similar events in other countries. We shall also discuss the results of a focus group conducted for three years in a row during the summer “SuperMoon” broadcasts, a regular event taking advantage of the popularity of this event in the news to cover also current topics in planetary science.

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Bridging the Cosmos: Exploring Exoplanet Detection in Astronomy Education and Outreach

Dr Zakaria Belhaj

NAEC-Morocco. NOC-Morocco

Abstract

As we delve into the captivating realm of astronomy education and outreach, our talk seeks to shed light on the significance of the transit photometry detection technique in identifying exoplanets.

We collaborated with over 500 high school students, delving into a series of images captured by the Spitzer Space Telescope of the star HD 189733. The processing of data from these images were performed using the SalsaJ software.

The exoplanet HD 189733b, orbiting the star HD 189733, was discovered on October 5, 2005, utilizing the transit method in France. Classified as a hot Jupiter within the Jovian planet class, it boasts a brief orbital period of 2.2 days and resides in the constellation of the Fox.

Our engagement extended to training sessions for nearly 75 teachers, a component of the GTTP program initiated by NAEC & NOC Morocco, supported by the HPS Foundation and TITRITLAND.

This initiative is presently in the generalization phase, aligning with the SABIR project launched by IAU-OAE Center Italy. This collaborative effort involves participation from five NAECs: Italy, Lebanon, Spain, Turkey, and Slovenia.

The Sabir project, rooted in co-design principles, aims to craft Inquiry-Based Learning (IBL) activities for both high school teachers and students. Four IBL activities will be translated into English, French, Spanish, Arabic, Slovenian, and Italian, subsequently published on astroEDU.

Moreover, we are actively involved in processing data obtained from our observatory in Oukaimden. This endeavor employs SalsaJ to guide high school students in the detection of exoplanets using images captured by Moroccan astronomers.

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Spectral Characterization of a Complete Equatorial Sample of 615 K Dwarfs

Dr Hodari-Sadiki Hubbard-James[1,2], Mr Sebastian Gaxiola[3,2], Dr Todd Henry[2], Mr D. Xavier Lesley[4], Dr Leonardo Paredes[5,2], Dr Azmain Nisak[6]

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Abstract

We present a spectroscopic study's findings on the stellar characteristics, activity levels, space motions, and ages of nearby K dwarfs. This study involves members of the RKSTAR (RECONS K Stars) Survey, encompassing approximately 5000 K dwarf primaries within 50 parsecs. Initially, we established a benchmark set of 35 K dwarfs, aged 20 Myr to 5 Gyr, using high-resolution (R=80000) spectra from the CHIRON echelle spectrometer on the SMARTS 1.5m telescope at CTIO. We focused on two spectral signs of activity and youth: the Hα absorption line (6562.8 Å) and the Li I resonance line (6707.8 Å), which demonstrated significant trends in our calibration set. Our analysis extended to 615 K dwarfs within 33 parsecs, observed with CHIRON, and compared with our benchmark set. Interestingly, about 8% of these stars exhibit features suggesting youth or activity. Galactic *UVW* motions confirmed that the majority belong to the thin (80%) and thick (20%) disk populations, except for the halo star HD 134439. We identified a group of metal-poor K dwarfs, making up 4% of the local stellar population, with [Fe/H] values below −0.5 dex. As a result of this work, we have identified 500 K dwarfs that are calm host stars worthy of detailed efforts to detect terrestrial planets. This study will serve as a key resource for assessing host star suitability for exoplanet habitability.

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Education and outreach in planetary science

M Maram KAIRE

ASES

Abstract

For several years, the statistics of the baccalaureate examination in Senegal have shown a strong downward trend in the number of students in scientific fields in favor of other disciplines. However, Senegal, and Africa in general, has a crucial need for scientists to be able to support innovation and creativity, sources of economic growth and development.

However, various popularization and training activities in planetary sciences, carried out in the field since 2006 by the Senegalese Association for the Promotion of Astronomy (ASPA), have demonstrated a real interest among young people in space sciences in general. but more specific for astronomy and planetary sciences. This observation has motivated the strengthening of efforts in the promotion of these disciplines in order to accelerate their introduction into the education system. These creative activities with a scientific vocation, ranging from conferences, workshops, training, observation of the sky with a telescope and radio and television interventions, have created an indescribable enthusiasm for each event. Populations have shown their interest in this science which makes it possible to harmonize positions on certain social issues. The academic community expresses its attachment to astronomy, which, although it is not taught in Senegal, offers career prospects to resources who have opted for scientific fields.

This awareness led to the establishment, in March 2023, of the Senegalese Space Studies Agency, which is, among other missions, responsible for strengthening awareness and introducing planetary sciences to populations.

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Using score-based diffusion models for correlated 1/f noise reduction in JWST spectral data

Ms Salma Salhi[1,2,3,4], Dr René Doyon[1,5], Dr Laurence Perreault-Levasseur[2,3,4,6,7,8], Dr Loic Albert[2,1]

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Abstract

Transit spectroscopy is very sensitive to various sources of noise, and this is especially true when using the Single Object Slitless Spectroscopy (SOSS) mode on the NIRISS instrument aboard the JWST. Current methods to deal with 1/f (correlated) noise leave residuals that are almost double that of the expected readout noise. Deep learning models could be a way to mitigate this problem, as they have already been shown to be very efficient at a wide variety of tasks in astrophysical data reduction, including denoising. We construct a score-based generative diffusion model to learn the structure of the noise in dark SOSS images, including bad pixels, hot pixels, cosmic rays, and 1/f noise to create a model. We will then use this noise model as the data likelihood to analyze mock trace observations in a Bayesian framework, allowing us to produce posterior samples of the pixel values of the underlying trace. We aim to apply this method to time series spectroscopic observations, which will allow for a more accurate retrieval of the underlying trace parameters, potentially reducing our error to the photon noise limit. This has the potential to substantially improve our signal-to-noise by up to a factor of two for some spectral regions and thus enable higher precision transit spectroscopy.

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Charting new waters: JWST and the sub-Neptune realm

Dr Rafael Luque

University of Chicago

Abstract

Water worlds have been proposed to explain the origin and composition of sub-Neptunes. The hypothesis has regained momentum thanks to new developments in planet formation models, individual planet discoveries, and demographic studies of precisely characterized samples. Alternatively, the more widely assumed scenario suggests that these planets are indeed gas dwarfs, i.e. Earth-like cores with primordial H/He envelopes accounting for a small percentage of their total mass. TOI-1685b, however, does not fit into this picture. The 16-hour orbit planet has a low bulk density inconsistent with being a bare rock despite having a high equilibrium temperature. If the planet had a primordial H-rich atmosphere, it would have been stripped long ago. However, its size and bulk density are naturally explained with a water-rich core.

In this talk, I will present the first JWST observations of this planet during a full orbit, recently obtained using NIRSPEC G395H as part of program GO 3263. In one fell swoop, the observations provide transmission and emission spectra to constrain molecular abundances and a broadband phase curve to break the degeneracy of metal-enriched atmospheres with high mean molecular weight ones in transit. The dataset has therefore a legacy component with valuable information to aid observers, theorists, and modelers in investigating the properties of a completely new type of planet with no analog in the solar system.

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Complejo Astronomico Los Coloraos: an outreach oasis in the Andalusian desert

Dr Rafael Luque

University of Chicago

Abstract

In this talk, I will present the past, present, and future of a newly developed observatory devoted to astronomy outreach in the south of Spain that I have built with the help of private associates. Located at the heart of Granada's UNESCO Global Geopark, *Complejo Astronomico Los Coloraos* is the culmination of more than a decade of work in the rural areas of Andalusia doing hundreds of publicly open, free astronomical observations, experiment shows, introduction courses in schools, and helping local businesses to use the night sky as a natural resource to attract low-impact, ecological, and socially-responsible tourism. Our non-profit, *Turismo Astronomico*, has helped dozens of small businesses in the south of Spain to obtain dark sky certificates, provided advice to local governments on outdoor lighting policies and site characterization, organized trips to northern Europe to observe and capture auroras, and developed astronomy-themed viewpoints along trekking paths of natural reserves. Now, the observatory is the operations center of all our activities, where music, nature, gastronomy, and art complement our regular astronomical observations. In less than a year of operations, we have already provided data to a study published in A&A Letters on a recent occultation of the asteroid (319) Leona and contribute regularly with observations of exoplanet transits to the Exoclock project in preparation for ESA's Ariel mission. These activities highlight the potential of our new facility to actively contribute to professional research while accomplishing its main function as a learning and inspirational center for all people.

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Perihelion Activity of (3200) Phaethon is Not Dusty: Evidence from STEREO/COR2Observations

Prof Man-To Hui

Macau University of Science and Technology

Abstract

We present an analysis of asteroid (3200) Phaethon using STEREO/COR2 observations from 2008 to 2022. Although undetected in individual images, Phaethon was visible in stacks combined from the same perihelion observations, yet only at small ($\lesssim$30°) but not large ($\gtrsim$150°) phase angles. The observations are in line with the contribution from a bare nucleus, thereby seriously contradicting the interpretation based on HI-1 observations that attributes the perihelion activity to the ejection of μm-sized dust. We obtained an upper limit to the effective cross section of μm-sized dust to be $\lesssim 10^5$ m^2, at least three orders of magnitude smaller than earlier estimates based on HI-1 data. On the contrary, the COR2 observations cannot rule out the existence of mm-sized or larger debris around Phaethon. However, the fact that no postperihelion debris tail has ever been detected for Phaethon suggests the unimportance of such dust in the perihelion activity. We thus conclude that the perihelion activity of Phaethon is highly unlikely relevant to the ejection of dust. Rather, we deduce that the activity is associated with gas emissions, possibly Fe I and/or Na D lines. To verify our conjecture and to fully understand the perihelion activity of Phaethon, more observations at small heliocentric distances are desired. We compile a list of observing windows ideal for the search of gas emissions of the asteroid from ground telescopes. The best opportunities will be during total solar eclipses. The work was supported by FDCT grant No. 0016/2022/A1.

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Detecting and characterising exoplanets with HARPS-N

Prof. Ken Rice

Institute for Astronomy, University of Edinburgh

Abstract

HARPS-N is a high-resolution spectrograph located on the Telescopio Nazionale Galileo (TNG) on La Palma, primarily used to measure precise stellar radial velocities in order to estimate exoplanet masses. This is key for both determining internal planetary compositions and for identifying targets for atmospheric characterisation follow-up observations. The key science goals of the HARPS-N GTO Consortium has been to follow-up targets first identified by space-based transit missions such as Kepler, K2, and now TESS, and also to survery nearby bright stars to identify small exoplanet candidates. To date, a significant fraction of the small exoplanets with precise masses have been characterised using HARPS-N.

In this presentation I will highlight some of the transiting systems characterised using HARPS-N and also some of the recent results from the Rocky Planet Search programme which is surverying nearby bright stars. I will also present some future prospects, in particular synergies with ESA's CHEOPS mission and also the prospects for atmospheric follow-up observations with JWST.

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Planetary science and Exo-Planets from James Webb to public outreach and education

Dr Soumaya Saad

National Research Institute of Astronomy & Geophysics (NRIAG)

Abstract

Webb, the largest space telescope ever, has traveled a million miles into space and is four times farther than the Moon to begin its work observing star formation and the planetary systems inside and outside the solar system. Webb is a colossal feat of engineering designed to answer some of the biggest questions about our universe.

Webb's pioneering mission is very stimulating and must be exploited and employed to serve societies in education and awareness of astronomy, its impact is greater in the advancement of peoples and the development of concepts towards other worlds.

As coordinators of the offices of the International Astronomical Union for Education and outreach, we aim for everyone to participate in this exciting mission, as we started to create a program to raise awareness of the scientific expectations and achievements of Webb, even before its launch, as we seek to spread the concept that Webb belongs to everyone.

Thanks to the work of wide networks of teachers and specialists, James Webb's discoveries can be used and disseminated in communities, which will greatly affect the growing enthusiasm for the mission through primary school classes, high school science clubs and discovery centers and community groups.

To maximize the potential of the Webb mission to act as a springboard for schoolchildren to participate in science, technology, engineering and mathematics (STEM), we will work with educators to develop programmers and resources for primary schools and secondary schools and this will offer a tremendous opportunity to inspire and involve young people.

In this contribution we aim to exchange the experience with the international community in the field of outreach and education of planetary science and the study of the origin of life after the Webb launch.

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The Habitable Worlds Observatory

Dr Mark Clampin

Astrophysics Director, NASA Science Mission Directorate

Abstract

The James Webb Space Telescope (JWST) has transited the study of exoplanets to an era where we can conduct detailed studies of the atmospheres of many transiting exoplanets discovered by ground-based surveys and the Kepler and TESS missions. In particular, TESS has provided a rich target list of exoplanets orbiting relatively bright stars suitable for detailed spectroscopic study with JWST. In light of progress in the field of exoplanets, the 2020 National Academies Astronomy and Astrophysics Decadal Survey (Astro2020) recommended as its highest priority an optical/UV telescope optimized to conduct a study of nearby stars for the presence of habitable exoplanets and then characterize their atmospheres. Astro2020 suggested a yield of ~25 habitable exoplanets from the survey for further study. The telescope will also conduct a program of transformative astrophysics with an emphasis on ultraviolet wavelengths. This mission is known as the Habitable Worlds Observatory, and in the presentation, I will discuss the key scientific objectives, and NASA's plans for developing and operating the mission, together with the programmatic principles NASA will employ to achieve mission success.

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X-ray Characteristics of Narrow Line Seyfert 1 (NLS1) Galaxies, NGC 4051 and ARK 564, from *NuSTAR* Data

Dr Bosco Ororu[1], Mr Juma Kamulali[1,2]

[1]Makerere University. [2]Kyambogo University

Abstract

Narrow line Seyfert 1 galaxies are among the most variable AGN. We performed broad band X-ray spectral and timing analysis of NLS1 galaxies, NGC 4051 and ARK 564, from *NuSTAR* observations. Public data was obtained and processed using *nupipeline* and *nuproducts* to generate spectral, light curve and response files. X-ray spectra were fitted with a reflection model plus Gaussian component, and corrected for line-of-sight galactic absorption. The intrinsic powerlaw continuum is of slope $\Gamma \geq 1.6$, which is slightly steeper than in typical Seyfert 1 galaxies. Strong emission lines ($E_W \geq 100$ eV) were detected at $\sim$ 6.4 keV. The X-ray spectra above 10 keV exhibit a Compton hump, produced by Compton backscattering of hard X-ray photons by reprocessing optically thick accretion disc. The deduced 3-79 keV luminosity differ by 2 orders of magnitude ($\sim 6.1\times10^{41}$ erg s^{-1} for NGC 4051 and $\sim 2.47\times10^{43}$ erg s^{-1} for ARK 564). High-amplitude X-ray variability was analysed by means of cross power spectral density (CPSD), since simultaneous observations were made by *NuSTAR*. The average CPSD for each NLS1 galaxy was generated. The spectra were fitted quite well in the frequency range $\sim 10^{-3}$ to $\sim$ 0.2 Hz, using four broad Lorentzian models with ARK 564 revealing more variability power estimates (total rms = 63.6%) than NGC 4051 (total rms = 37.3%). The coherence of variablity ($Q < 2$) shows no evidence of QPOs, possibly owing to the short period *NuSTAR* observations.

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Discovery of milli-arcsecond scale jets of Double-lobed Radio-loud AGNs in spiral galaxies.

1st year PhD student Min-gyu Ryu[1], Prof. Jae-young Kim[1,2]

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Abstract

Historically, double-lobed radio-loud active galactic nuclei (DRAGN) with large kpc-scale jets have been found exclusively in giant elliptical or lenticular galaxies. However, approximately 30 DRAGNs have recently been discovered in spiral galaxies. Understanding their physical origin is not straightforward because of the large differences in the surroundings of supermassive black holes in spiral and giant elliptical galaxies. Therefore, high-resolution VLBI observations of the nuclei of spiral DRAGN objects can provide a lot of new insights about the accretion and outflow in the central engine region. We searched archival Very Long Baseline Array (VLBA) observations at C- and X-bands for those objects, finding previously known and also new VLBI detections of some spiral DRAGN objects. We analyzed VLBA-detected spiral DRAGNs to distinguish the difference from typical AGNs and obtained several interesting results. Our targets were also cross-verified using overlapping optical and radio images from SDSS, HST, FIRST, and LoFAR. These targets exhibit lower VLBI core brightness temperatures (~10^9K) compared to the average values of radio AGN (10^11-10^12K). Two of our four new objects show extended bipolar-shaped jets on milli-arcsecond scales. Using various methods, we estimate the jet intrinsic speeds of ~0.06-0.54c, which is only mildly relativistic. Despite their unique characteristics, spiral DRAGNs are still well aligned with other radio AGNs in the fundamental plane of jetted black hole activities (Merloni et al., 2003). In this talk, we will present the results of our analysis of spiral DRAGN objects and provide new insights into the mechanisms of AGN activation.

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Investigating magnetic launching of black hole jets with the Event Horizon Telescope

Dr. Georgios Filippos Paraschos[1], et al.[2]

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[2]Event Horizon Telescope Collaboration

Abstract

AGN-launched jets are a crucial element in the study of super-massive black holes (SMBH) and their closest surroundings. The formation of such jets, whether they are launched by magnetic field lines anchored to the accretion disk (Blandford & Payne 1982) or directly connected to the black hole's (BH) ergosphere (Blandford & Znajek 1977), is the subject of ongoing, extensive research.

3C84, the compact radio source in the central galaxy NGC1275 of the Perseus super-cluster, is a prime laboratory for testing such jet launching scenarios, as well as studying the innermost, sub-parsec AGN structure and jet origin. Very-long-baseline interferometry (VLBI) offers a unique view into the physical processes in action, in the immediate vicinity of BHs, unparalleled by other observational techniques. With VLBI at short (millimetre) wavelengths particular high angular resolutions are obtained.

Utilising such mm-VLBI observations of 3C84 with the Event Horizon Telescope, we study the magnetic field strength and associated accretion flow around its central SMBH. This is possible, as mm-VLBI measurements are capable of peering through the dusty torus surrounding the central engine of 3C84, which is known to block the line of sight to the sub-parsec counter-jet via free-free absorption. We furthermore study the magnetic field's signature in the core region, as manifested in polarised light. As part of this analysis we compare our observations to relativistic magneto-hydrodynamic simulations. In this talk I will present our most recent results and offer a comprehensive summary of BH jet launching in AGN.

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Interpreting the long-term variability of the changing-look AGN Mrk 1018

Simone Veronese

ASTRON. Kapteyn Astronomical Institute

Abstract

I present a thorough study of the Changing-Look Active Galactic Nucleus (CL-AGN) Mrk 1018. I analysed X-ray spectra and broad-band photometry, and performed optical-to-X-ray spectral energy distribution (SED) fitting to comprehend the observed changing-look behaviour from 2005 to 2019. By describing the X-ray spectra with a two-Comptonization model, I validate the changes in X-ray spectral shape and the optical-to-X-ray photometric dimming reported in the literature, and I also reveal a consistent hot comptonizing medium but a cooling warm component. This cooling, linked to the weakening of the magnetic fields in the accretion disk, explains the broad-band spectro-photometric variability and possibly the disappearing of the broad optical lines. I propose that the weakening is caused by the formation of a jet, in turn originated from the change of state of the inner accretion flow. Our optical-to-X-ray SED fitting supports this conclusion, as the normalised accretion rate is super-critical ($\mu=$0.06>0.02) in the bright state and sub-critical ($\mu=$0.01<0.02) in the faint state. Instabilities arising at the interface of the state-transition are able to reduce the viscous timescale to the observed ~10 years of Mrk 1018 variability. I explored a possible triggering mechanism for this state transition, involving gaseous clouds pushed onto the AGN sub-pc regions by a recent merging event or by cold chaotic accretion. This scenario, if validated by future simulations, could enhance our understanding of CL-AGN and raises questions about an accretion rate of ~0.02, coupled with minor disturbances in the accretion disk, being the primary factor in the changing-look phenomenon.

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Thermal and Non-thermal Processes and Structure Formation in Galaxy Center

Miss Farideh Mazoochi, Dr. Fatemeh Tabatabaei

IPM

Abstract

The most inner kpc regions of galaxies is central in galaxy formation and evolution studies. The central molecular zone (CMZ) of the Milky Way offers a unique laboratory to study the formation and evolution of structures surrounding its super massive black hole. We study the role of the thermal and nonthermal processes in the energy balance and structure formation in CMZ by taking advantage of the MeerKAT 1.3 GHz radio continuum observations, the ATCA H67 radio recombination line from the Survey of Water and Ammonia in the Galactic Center (SWAG), and the JCMT/NRO CO(1-0) data. For the first time, we present purely synchrotron emitting structures using the thermal radio template technique and estimate the equipartition magnetic field strength. The magnetic field is tightly correlated with molecular gas while it is uncorrelated with SFR in the CMZ. However, in the inner most region, i.e., the central nuclear disk (CND), the magnetic field strength and SFR are found correlated. This indicates that a small-scale dynamo mechanism is occurred due to a very recent star formation activity in CND. Investigating the thermal and nonthermal pressures as well as the mass-to-magnetic flux ratio, it is inferred that the molecular clouds are mostly stable and sub-critical. Hence, magnetic field must play an important role in stabilizing clouds against gravitational collapse or diffusion. Moreover, we find a sharp decline (increase) in the radial distribution of the neutral (ionized) gas toward the center at 1-1.5~pc likely due to the SMBH feedback.

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The nature of compact radio-loud AGN: a systematic look at the LOFAR AGN population.

Mr Jones Chilufya[1], Prof Martin Hardcastle[1], Dr Jonathon Pierce[1], Dr Judith Croston[2], Dr Beatriz Mingo[2], Dr Xuechen Zheng[3,4], Dr Ranieri Baldi[5], Prof Huub Rottgering[3]

[1]University of Hertfordshire. [2]The Open University. [3]Leiden University. [4]Shanghai Astronomical Observatory. [5]INAF - Instituto di Radioastronomia

Abstract

This study explores 55 nearby (z<0.1) high-excitation radio galaxies (HERGs) selected from the LOw-Frequency ARray (LOFAR) Two-metre Sky Survey (LoTSS) first data release (DR1). These objects are unresolved at 6-arcsec resolution at 150-MHz. Building on prior works examining LoTSS sources, it sheds light on low-frequency radio-source properties. High-frequency 6-GHz Very Large Array (VLA) observations reveal most objects remain compact (<1 kpc) at 0.3 arcsec resolution, with some displaying sub-kpc (1-3 kpc) extended radio emission with varied radio morphologies: one-jet, two-jet, and double-lobed structures. The radio spectra range from steep to flat/inverted and span the range seen for other compact radio sources such as compact symmetric objects (CSOs), compact steep-spectrum sources (CSSs), and gigahertz-peaked spectrum sources (GPSs). The spectral turnover observed for some sources at 150-MHz suggest self-absorption, which we investigate using synchrotron self-absorption (SSA) and free-free absorption (FFA) models. The position of these objects on the power/linear size (P-D) diagram hints at a continuum between Seyferts and radio-quiet quasars in AGN unified models, with similarities to so-called 'FR0' sources in spectral index distribution, radio-powers, and radio morphologies.

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Hunting with *HST* and *JWST* for Lower-Luminosity AGNs at Higher Redshifts

Dr. Norman Grogin

Space Telescope Science Institute

Abstract

The unique combination of high spatial resolution, imaging sensitivity, stability, and longevity afforded by *HST*, and more recently *by JWST*, enables galaxy-core variability searches to discover candidate low-luminosity active galactic nuclei (LLAGNs) with efficiency that rivals or exceeds the deepest X-ray and radio searches, particularly at higher redshifts ($z > 2$). Furthermore, the exquisite spectroscopic sensitivity of *JWST,* well into the infrared, has already revealed an unexpected prevalence of extreme-redshift LLAGNs via serendipitous discovery of broad rest-frame-optical emission lines among galaxies in early *JWST* surveys.

The fullest census of the AGN population at higher redshifts is crucial to answering key questions such as:

- Growth of supermassive black holes (SMBHs), from their early seed population(s)
- Contribution of AGNs to Re-Ionization
- Contribution of AGNs to galaxy quenching of star formation
- Connection to observed low-redshift SMBH/host-galaxy correlations

This poster will summarize the author's investigations into higher-redshift LLAGN discovery using *HST* and *JWST* surveys including GOODS, CANDELS, TREASUREHUNT, and CEERS.

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The role of AGN in regulating galaxy evolution in massive z~3-4 galaxies

Mx Monserrat Martinez[1], Dr Karl Glazebrook[1], Dr Themiya Nanayakkara[1], Dr Colin Jacobs[1], Dr Ivo Labbe[1], Glenn Kacprzak[1], Dr Casey Papovich[2]

[1]Swinburne University of Technology. [2]Texas A&M University

Abstract

An excess of massive quiescent galaxies (MQGs) have been found in the early universe (z~3-4). MQGs at this epoch suggest their stellar content was already in place in the first 1.5 Gyr of the Universe. These findings indicate that MQGs must have experienced a rapid quenching event. Although observational evidence is scarce, AGNs are the most suitable candidate for quenching these galaxies. In this talk, we present a sample of massive galaxies (10 <log($M\bigstar/M\odot$)< 11) at 3 < z < 4 from JWST NIRSpec and the ZFOURGE survey with K–band spectra of the Keck/MOSFIRE, VLT/KMOS. We find that a large fraction have strong [OIII]5007 and Hβ emission lines with large line widths (σ 100 – 450 km/s). These results show a significantly high AGN fraction in massive galaxies, ranging from 60–70%, pointing to the period between 3 < z < 4 being a time of heightened activity for the development of supermassive black holes in the massive end of the galaxy population and provide evidence for their role in the emergence of the first massive quenched galaxies at this epoch.

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Separating Star Formation, Active Galactic Nuclei, and Shocks in Galaxies

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[1]Center for Astrophysics | Harvard & Smithsonian. [2]Australian National University

Abstract

The cosmic evolution of galaxies and supermassive black holes (SMBHs) is believed to be correlated through interlinked physical processes. However, two aspects of the galaxy-BH correlation remain unclear: the fueling of Active Galactic Nuclei (AGNs) and the physical process of AGN feedback. Previous attempts to answer these questions using single-aperture spectra of galaxies have fallen short, as they only consider the dominant excitation source in the spectrum and cannot rule out the involvement of other excitation sources such as supermassive black holes, star formation, and shock excitations. Here, we present a solution for the mixing mechanisms in galaxy spectra analysis by building a new theoretical three-dimensional (3D) diagram to simultaneously separate star formation, AGN, and shocks in galaxies with integral field spectroscopy (IFU) data. This new 3D diagram incorporates the most up-to-date and self-consistent theoretical models for HII regions, AGN narrow-line regions, and the time-dependent shocks and precursor models. The inclusion of theoretical models in the new 3D diagram independently constrains the parameter space for each mechanism and provides information on the gas metallicity, ionization states, and shock velocity along with the separation. By applying this new 3D diagram, researchers can obtain detailed maps of the mechanism distribution, gas metallicity, and ionization states for individual galaxies. This will enable more comprehensive studies on AGN feedback and star formation across cosmic time.

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Exploring the radio-loudness of SDSS quasars with spectral stacking

Marina Arnaudova, Daniel Smith, Martin Hardcastle

University of Hertfordshire

Abstract

Quasars (or QSOs) are the most luminous manifestations of AGN. About 5-10% of these optically-selected sources emit strongly in the radio band, while the remaining 90% only weakly. This division into radio-loud (RL) and radio-quiet (RQ) raises the question of whether these objects are distinct populations or different evolutionary stages of a single one. To provide an answer, we combined 144 MHz radio observations from LoTSS DR2 with spectroscopic data from SDSS DR14Q to create the largest sample of uniformly-selected, spectroscopically-confirmed RL and RQ quasars at $0.6<z<3.4$ across 5634 deg^2. To investigate their properties, we developed a new spectral stacking algorithm and used it to create high-resolution composite spectra for each radio class, matched in redshift and absolute *i*-band magnitude. We found that RL quasars have a redder continuum and enhanced [OII] emission compared to their RQ counterparts. These results persist when additionally matching in black hole mass, suggesting that this parameter is not the defining factor in making a QSO radio-loud. In addition, these features do not gradually vary as a function of radio-loudness but are maintained even when probing deeper into the RQ population, indicating that a clear-cut division in radio-loudness is not apparent. We further show that RL QSOs exhibit a significant excess of star-formation relative to RQ quasars up to at least z=1.9. Given our findings, we explore potential explanations and discuss how advancements in future instrumentation and survey methodologies could deepen our understanding of the subject.

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Analysis of Atmospheric Precursors Associated with Earthquake (Seismic Activities) during Solar Cycle 24

Mr IsrealLeke Elijah, Dr Hammed Adeniyi Lawal, Mr Mukhtar Itopa Muhammed

Airforce Institute of Technology, Kaduna State Nigeria

Abstract

The study uses data from OmniWeb and ScienceBase U.S. Geological Survey to investigate possible links between solar activity-induced geomagnetic storms and seismic events using Python programming. The findings indicate a strong correlation between increased geomagnetic storm activity and subsequent earthquakes, with a strong probability. Interestingly, the correlation dynamics differ when it comes to the depth of earthquakes, with geomagnetic storms emerging more subtly ahead of deep seismic events. This research points to a complex relationship between Earth's geophysical reactions and space weather occurrences. The findings close the gap between solar activity and terrestrial seismic occurrences, highlighting the importance of trustworthy databases and encouraging additional research into the astrophysical mechanisms underlying the observed connections.

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Accretion flows and photon rings in nearby Universe

Venkatessh Ramakrishnan

Finnish Centre for Astronomy with ESO

Abstract

Following the transformational science enabled by the Event Horizon Telescope, we now focus on expanding the parameter space in terms of mass, spin and the role of magnetic field in extreme gravitational environment. It is thus imperative that imaging the silhouette of several black holes, beyond SgrA* and M87*, will provide vital constraints that will also probe the nature of (non-) General Relativity on a cosmological scale. I will present from an ongoing study with the EHT to image the photon rings and accretion flows of more AGNs in the nearby Universe. The structure of accretion flows will be driven fundamentally by their efficiency which will impact the opacity of the photon ring at the resolution set by the EHT. I will also show how the next generation EHT observations both from ground and space can be fundamental in this endeavour.

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EMU/GAMA: A Technique for Detecting Active Galactic Nuclei in Low Mass Systems.

Mr. Jahang Prathap

Macquarie University. The Australian Research Council Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO3D).

Abstract

We propose a new method for identifying active galactic nuclei (AGN) in low mass ($M_* \leq 10^{10} M_\odot$) galaxies. This method relies on spectral energy distribution (SED) fitting to identify galaxies whose radio flux density has an excess over that expected from star formation alone. Combining data in the Galaxy and Mass Assembly (GAMA) G23 region from GAMA, Evolutionary Map of the Universe (EMU) early science observations, and Wide-field Infrared Survey Explorer (WISE), we compare this technique with a selection of different AGN diagnostics to explore the similarities and differences in AGN classification. We find that diagnostics based on optical and near-infrared criteria (the standard BPT diagram, the WISE colour criterion, and the mass-excitation, or MEx diagram) tend to favour detection of AGN in high mass, high luminosity systems, while the "PROSPECT" SED fitting tool can identify AGN efficiently in low mass systems. We investigate an explanation for this result in the context of proportionally lower mass black holes in lower mass galaxies compared to higher mass galaxies and differing proportions of emission from AGN and star formation dominating the light at optical and infrared wavelengths as a function of galaxy stellar mass. We conclude that SED-derived AGN classification is an efficient approach to identify low mass hosts with low radio luminosity AGN.

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Exploring the Absence of Correlation Between Water Megamasers and AGNs: Unveiling a Puzzling Relationship

Dr Ahlam Farhan

Boğaziçi University

Abstract

Since their initial detection nearly five decades ago (Santos & Lépine, 1979), the phenomenon of microwave amplification by stimulated emission of radiation (maser), known as water megamaser (H2OMM), has captivated astronomers. Observed at a frequency of ≈ 22 GHz in approximately 200 galaxies out of over 6000 surveyed, water megamasers serve as invaluable tools for gauging distances to their host galaxies and computing the masses of their central supermassive black holes (SMBHs). Despite their significance, the detection rate of these megamasers remains remarkably low (<3%), further complicated by the incompletely elucidated physical conditions underlying their genesis. Researchers have thus redirected their efforts towards identifying patterns in the occurrences of water megamasers, aiming to shed light on which galaxies are most predisposed to harbor these enigmatic emissions. This study explores the correlation between water megamaser luminosity and the mass of central SMBHs across sub-samples of megamasers and kilomasers, uncovering unexpected insights and challenging previous assumptions. Additionally, an exploration of the anticipated correlation between 6.4 keV FeKa emissions and 22 GHz masers reveals an intriguing anti-correlation, prompting further investigation into the underlying mechanisms governing these phenomena. Future research endeavors, particularly utilizing Very Long Baseline Interferometry (VLBI), hold promise for clarifying the classification of maser galaxies and unraveling the intricate relationships between these emissions.

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Fermi Large Area Telescope Detection of Gamma-Rays from NGC 6251 Radio Lobe

Dr. Jin Zhang

Beijing Institute of Technology

Abstract

We report on the detection of extended gamma-ray emission from lobes in the radio galaxy NGC 6251 using observation data of Fermi Large Area Telescope (Fermi-LAT). The maximum likelihood analysis results show that a radio morphology template provides a better fit than a point-like source description for the observational data at a confidence level of 8.1σ, and the contribution of lobes accounts for more than 50% of the total gamma-ray flux. Furthermore, the gamma-ray energy spectra show a significant disparity in shape between the core and lobe regions, with a curved log-parabola shape observed in core region and a power-law form observed in lobes. Neither the core region nor the northwest lobe displays the significant flux variations in the long-term gamma-ray light curves. The broadband spectral energy distributions of both core region and northwest lobe can be will explained with a single-zone leptonic model. The gamma-rays of core region are due to the synchrotron-self-Compton process while the gamma-rays from northwest lobe are interpreted as inverse Compton emission of the cosmic microwave background.

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Using Ghana's 32-metre radio telescope for AGN research

Dr Emmanuel Proven-Adzri[1], Prof Nia Imara[2], Dr Theophilus Ansah-Narh[1], Dr. Naomi Asabre-Frimpong[1], Dr Benedicta Woode[1]

[1]Ghana Space Science and Technology Institute. [2]University of California, Santa Cruz

Abstract

The Ghana Radio Astronomy Observatory (GRAO) operates the newly refurbished 32-metre radio telescope. Ghana's 32-meter dish is positioned near the equator, giving it some prime advantage in observing sources in the South and in the North. It has a C-band receiver that can be used to detect specific spectral lines associated with molecular or atomic gas in the vicinity of AGNs. One key molecular line observed with the Instrument is methanol masers (CH3OH). Observations of methanol masers have revealed information about the physical conditions and kinematics of the gas surrounding AGNs. AGN and methanol maser sources observed will be presented. We intend to leverage this conference to position GRAO to actively participate in AGN science exploring observational strategies for AGN, and multi-wavelength surveys probing the physical conditions of black holes. Since AGNs exhibit powerful jets of relativistic particles emitting synchrotron radiation at radio frequencies, observations with the 32-metre radio telescope, can help trace and characterize these jets and their interactions with the surrounding environment. GRAO is open to collaborations in this regard.

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Chemical abundances of type-2 AGN in different environments.

Ms. Mehbuba Ahmed[1], Dr. Mirjana Povic[1,2,3]

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Abstract

The chemical abundance of active galaxies, which host AGN at their centres, remains poorly studied, mostly due to the difficulty of removing the effect of AGN in metallicity measurements. Particularly, the chemical abundance of active galaxies in different environments, including clusters/groups of galaxies, is still unknown. In this work, we use a novel HII-CHI-mistry code adapted to measure the chemical abundance of type-2 AGN. We measure the oxygen abundance, the nitrogen abundance, and ionisation parameter for ~ 12000 type-2 AGN from SDSS. We analyse the metallicity properties of type-2 AGNs in relation to other properties of AGN host galaxies and in terms of the environment. Additionally, for galaxies in groups/clusters, we study the metallicity properties in relation to the properties of galaxies in groups/clusters. We do not observe a clear/strong MZR, although we do observe that in groups/clusters the 12+log(O/H) abundance is higher with higher stellar mass galaxies. We observed 12+log(O/H) abundance decrease with increasing SFR. We do not find a fundamental plane of type-2 AGN, suggesting more complex scenarios in the behaviour of stellar mass, SFR, and metallicity when AGN are present compared to pure SFG. We find that type-2 AGN hosts, both early- and late-type, have on average higher 12+log(O/H) abundances in groups/clusters compared to field galaxies. Our results indicate neither simple group/cluster membership nor cosmic-centric distance seem to drive this effect. This work provided the largest catalogue of chemical abundances of type-2 AGN to date.

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Chandra-to-MeerKAT: Searching and characterising obscured AGN at 0.6<z<3

Dr Luigi Barchiesi[1,2,3], Dr Lucia Marchetti[1,2], Prof Mattia Vaccari[2,3], Prof Cristian Vignali[4,5], Prof Francesca Pozzi[4,5]

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Abstract

A fundamental phase of most AGN-galaxy co-evolution models is the obscured accretion phase, where a significant fraction of the SMBH mass is assembled in gas-rich conditions. Despite its importance, this phase is one of the least studied, mostly due to the challenges in selecting and identifying such obscured sources, as the high quantity of gas and dust absorbs most of the emission at optical and X-ray regimes. Therefore, we need to exploit a multi-wavelength approach to scry beyond the dust. UV narrow lines (such as [Ne V] and C IV) can be powerful tools to select obscured AGN, as those lines originate in the NLR and, as such, do not suffer from the obscuration of the AGN torus.
I will present the properties of the first UV-line selected sample of obscured AGN at 0.6<z<3.1 with a complete coverage from the X-rays to the Radio band, exploiting multi-wavelength spectro-photometric data ranging from Chandra to MeerKAT and VLA observations. This extraordinary multi-wavelength coverage of the COSMOS field allows us to create a coherent picture of the AGN and host-galaxy properties. I will show how we are able to properly characterise a large number of very obscured and CT-AGN that would not be recognised as such via single-band selection techniques. We will also investigate the AGN and SF interplay via the comparison with mass- and redshift-matched samples of non-active galaxies.

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Core-shift in parabolic accelerating jets – magnetic field assessment at gravitational radius

Dr Elena Nokhrina[1,2], Dr Alexander Pushkarev[3,1]

[1]Lebedev Physical Institute RAS. [2]Moscow Institute of Physics and Technology. [3]Crimean Astrophysical Observatory

Abstract

The core-shift method provides a powerful method to estimate the physical parameters in relativistic jets from active galactic nuclei. The classical approach assumes a conical geometry of jets and a constant plasma speed. However, recent VLBI observations have shown that neither may hold close to the central engine, where the plasma in the jet is effectively accelerating and the jet geometry is quasi-parabolic. We modify the classical core-shift method to account for these jet properties. The important constituent of this modification is a new relation between the magnetic field and plasma energy densities. Using this, we show that the core-shift index may assume values in the range 0.8−1.2 or 0.53−0.8 depending on the jet geometry and viewing angle, and index values within these intervals are indeed observed. We obtain expressions to estimate the jet magnetic field and the total magnetic flux in a jet. We show that the obtained magnetic field value can be recalculated down to the gravitational radius scale. For M87 this value is in good agreement with the results by Event Horizon Telescope (EHT Collaboration 2021). For NGC 315 the break is observed both in a jet apparent geometry and in a core-shift dependence on frequency (Ricci et al. 2022). Using both branches of the measured core-shift, corresponding to two different power-law dependences on frequency, we obtain the magnetic field amplitude that matches perfectly at the break. We discuss the possible applications of fitted broken core-shifts to estimating the physical parameters of jets in AGNs.

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Cultural Astronomy in Africa

Dr Jarita Holbrook

University of Edinburgh/Smithsonian Astrophysical Observatory

Abstract

Cultural Astronomy is interdisciplinary utilizing astronomy, understandings of particular cultures and their sky related arts, beliefs and practices. Horizon astronomy, the tropics, the equator and circumpolar stars are all important for understanding the specifics Indigenous Astronomy. Examples of Indigenous Knowledge / Indigenous Astronomy will be shown from across Africa. The relationship between Africans and the sky is ongoing, including the encounter of telescope astronomy. South Africa's investment in astronomy and astrophysics is commendable and the observing facilities are world class. The Square Kilometre Array radio telescope was the impetus for my study based in the Karoo focused on both Indigenous astronomy and how the SKA is being received by the local community. Clips from my film SKA≥Karoo Radio Telescope will be used to illustrate points about community expectations and economic benefit.

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ON THE EXTENDED UNIFICATION SCHEME OF NARROW LINE SEYFERT 1 GALAXIES AND BLAZARS

Mr Julius Matthew, Prof Finbarr Odo

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Abstract

Narrow Line Seyfert 1{NLS1} galaxies, defined by narrow emission lines and small black hole masses, reveal intriguing commonalities with blazars, renowned for their intense and beamed relativistic jet emissions. This paper reviews the evolving unification scheme of NLS1s and blazars. Unification models for AGNs have long been proposed in which orientation f AGN emitting axis to the line of sight causes the apparent differences between various subclasses of the AGN. Recent multi-wavelength observations have surprisingly indicated the presence of relativistic jets in NLS1 galaxies, and this has been a prompt to the proposed extended unification model. Nevertheless, questions persist about transitional objects and potential orientation-independent differences. Understanding the unity between NLS1 galaxies and blazars not only reshapes our perception of these cosmic entities but also deepens our understanding of the fundamental mechanisms underlying the cosmos.

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GAS FLOWS IN THE CENTRAL REGION OF NGC 4593 WITH MUSE

Mrs. DORCUS Mulumba[1], Prof. JOHAN KNAPEN[2,3]

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Abstract

Understanding how gas flows into galactic centers, fuels the AGN and in turn is expelled back through feedback processes is of great importance to appreciate the role AGN play in the growth and evolution of galaxies. We use MUSE-AO optical spectra of the inner 7''. 5 × 7''. 5 of the nearby Seyfert 1 galaxy NGC 4593 to understand how gas flows in and out of its nuclear region. We determine the stellar velocity and velocity dispersion and fit single-component Gaussians to various emission lines like [O iii] λ5007, [N ii]λ6583, Hα and Hβ to determine the main ionization mechanism. We also fit two-component Gaussians to [O iii]λ5007 to determine the kinematics of the ionized gas emission and characterize the outflow. The high resolution MUSE data capture structures of the circumnuclear region including the innermost spiral feeding the nucleus. From the stellar kinematic maps, we confirm the presence of a rotating disc and in the broad-component maps, the high velocity dispersion values of 250 -300km/s show that the gas is highly perturbed. The emission line flux ratio maps
show that the innermost 2'' (376 pc) are highly ionized by the AGN, while the emission line kinematic maps show the approaching side of a presumably bi-conic outflow. We estimate the mass-outflow rates and kinetic powers. The broad components of [O iii]λ5007 show blue-shifted velocities which spatially coincides with a region of high velocity dispersion hence confirming the presence of on outflowing gas.

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A first look at MIGHTEE quasars

Dr Sarah White

South African Astronomical Observatory (SAAO)

Abstract

Radio observations allow us to identify a wide range of active galactic nuclei (AGN), which play a significant role in the evolution of galaxies. However, studies of AGN detected in the radio tend to focus on those with powerful relativistic-jets, which are described as being 'radio loud'. I will present analyses of radio emission from quasars in the MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) fields, the majority of which are 'radio quiet'. Being at low radio-luminosities, it has been assumed that their emission is dominated by star formation, but previous multiwavelength analyses (White et al., 2015, 2017) led to controversial evidence that black-hole accretion makes a significant contribution towards the total radio emission from this type of AGN. Due to the greater level of sensitivity that MeerKAT provides, we are able to detect a larger fraction of star-formation-related radio emission (White et al., in collaboration review), with further analysis being required (White et al., in prep.). This includes careful consideration of the empirical scaling relations that are used to infer the fraction of AGN-related emission, as well as the impact of the quasar-selection criteria on the conclusions that are drawn. Such analyses have important implications for determining the accretion and star-formation histories of the Universe, and for creating robust samples of radio-quiet AGN. This then allows us to better-investigate the accretion and feedback processes taking place within this poorly-studied subset of the AGN population.

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The impact of AGN feedback in cosmological galaxy formation simulations

Dylan Nelson

Heidelberg University

Abstract

Feedback from supermassive black holes is an essential ingredient in all modern cosmological hydrodynamical simulations of galaxy formation. The energy released from these AGN reshapes the physical properties of galaxies, their gaseous halos, and the intergalactic medium itself. The impact of AGN feedback on observables, from the galaxy population to the large-scale cosmic web, can finally be captured in large-volume cosmological simulations of structure and galaxy formation. I will discuss some of the more interesting, and unexpected, findings from these simulations.

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Investigating black-hole fuelling and star-formation for radio-AGN and SFG in the COSMOS field

Ms Thando Mothogoane[1], Dr Sthabile Kolwa[1], Prof Soebur Razzaque[1], Dr Kshitij Thorat[2]

[1]University of Johannesburg. [2]University of Pretoria

Abstract

Understanding the complex relationship between nuclear activity, star formation, and galaxy growth is crucial for disentangling the mechanisms driving galaxy evolution. My project investigates how nuclear activity regulates star formation and galaxy growth. Utilising MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) Early Science data from the COSMOS field, we select radio sources down to a limiting radio flux density of 2 microJy. Combining these detections with multiwavelength photometric data in the optical and infrared allow us to constrain the physical properties of star-forming galaxies (SFGs) and radio active galactic nuclei (AGN) host galaxies within a redshift range of $0 \lesssim z \lesssim 5$. We obtain the physical properties by using spectral energy distribution fitting techniques. We check for the feasibility of the physical properties by comparing them to those derived from independent measures. We then explore relations between black hole accretion rate, star-formation rate, and stellar mass in both SFGs and the host galaxies of radio AGN. Determining how these properties relate to one another is crucial in building a narrative of how AGN activity regulates star-formation within galaxies and understanding the underlying physical mechanisms driving star formation and quenching across cosmic time.

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The social network of quasars

Dr. Roberto De Propris

Botswana International University of Science and Technology

Abstract

We use a sample of astrometrically selected quasars within the footprint of the GAMA survey to explore their environmental dependencies. We find that (a) quasars reside in similar environments as a comparison sample of galaxies within the same volume and matched in stellar mass and redshift; they generally prefer intermediate density environments; (b) their neighbouring galaxies seem to normal star forming objects by preference, with no evidence for star formation enhancement or suppression by the quasar environment; (c) the majority of quasars are hosted in star forming galaxies lying on the star formation main sequence; star formation in quasar hosts as nevertheless increased within the last 100 Myr, suggesting that the progenitors resided close to the green valley. However, quasar hosts have always been star-forming galaxies. Only 1/5 of quasars show evidence of quenching; (d) about 60% of quasars reside within Sa-Sc galaxies with a preference towards earlier types; quasars are found to be more frequent among Sa-Sb galaxies than among E/S0 galaxies or Sc and later galaxies when compared to a matched sample.

We conclude that at least in the local ($z < 0.3$) universe sampled by the GAMA survey, mergers are not the principle mechanism that induces AGN activity. Our observations favour secular processes such as te formation of bars, spiral arms and episodic increases in star formation due to internal shocks.

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Tales of (once upon a time) active galaxies

Dr. Dharam Lal

National Centre for Radio Astrophysics TIFR

Abstract

We will present high-resolution, high-sensitivity upgraded GMRT observations of several cluster fields. We will report a discovery of a remnant radio galaxy in Abell 2065 at z = 0.0726 and would present early results of four relic radio sources in clusters. In addition to presenting results for these sources using the upgraded GMRT, we would also present our understanding using MeerKAT (and Very Large Array) telescope(s). Together these facilities provide unprecedented micro-Jy sensitivity, in the range 250-1712 MHz at the angular resolution of ~4-7 arcsec. These images reveal remarkable variety of fine morphological structures in the form of spectacular diffuse structures, e.g, arcs, filaments, wisps, plumes, loops, etc. We will present our early results, including modeled ages, equipartition parameters of these once active sources and will discuss their possible progenitors. Although the number of known remnant and relic radio sources are beginning to increase, we emphasize the need for better data to understand the physics and nature of these poorly understood radio sources.

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A lack of LAEs within 5Mpc of a luminous quasar in an overdensity at z=6.9: potential evidence of quasar negative feedback at protocluster scales?

Dr Trystan Lambert

Universidad Diego Portales

Abstract

High-redshift quasars are thought to live in the densest regions of space which should be made evident by an overdensity of galaxies around them. However, campaigns to identify these overdensities through the search of Lyman Break Galaxies and Lyman alpha emitters have had mixed results. These may be explained by either the small field of view of some of the experiments, the broad redshift ranges targeted by LBG searches, and by the inherent large uncertainty of quasar redshifts estimated from UV emission lines. Here we present a three square degree search (~1000 pMpc) for LAEs around the z=6.9 quasar VIKJ2348-3054 using the Dark Energy CAMera (DECam), finding 38 LAEs. The systemic redshift of VIK J2348-3054 is known from ALMA [CII] observations and place the Ly-alpha emission line of companions within the NB964 narrowband of DECam. This is the largest field of view LAE search around a z>6 quasar conducted to date. We find that this field is ~10 times more overdense when compared to the Chandra Deep-Field South, observed previously with the same instrumental setup as well as several combined blank fields. This is strong evidence that VIKJ2348-3054 resides in an overdensity of LAEs. Surprisingly, we find a lack of LAEs within 5 physical Mpc of the quasar and take this to most likely be evidence of the quasar suppressing star formation in its immediate vicinity. This result highlights the importance of performing overdensity searches over large areas to properly assess the density of those regions of the Universe.

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Determining the hard X-ray spectrum of a luminous high redshift, Swift-BAT AGN

Miss Gloria Raharimbolamena[1], Dr Andrew Young[1], Dr Jiachen Jiang[2], Dr Daniel Kynoch[3]

[1]University of Bristol. [2]University of Cambridge. [3]University of Southampton

Abstract

Blazars are a rarer subset of radio-loud AGN in which one of the jets points directly towards Earth. A key emission process in blazars is inverse-Compton scattering at high energies. We consider the possibility that high redshift FSRQ-type blazars have luminous inverse-Compton peaks in or near the hard X-ray band and are, therefore, ideal targets for NuSTAR. SWIFT J0909.0+0358 is a high redshift AGN and one of the most luminous sources in the 157-month Swift-BAT catalog. The source is not classified as a beamed AGN in the catalog. However, according to its high luminosity at high redshift and the double-humped shape characteristic of its spectral energy distribution, the target is an FSRQ-type blazar, which is believed to have powerful jets. Using the first-ever NuSTAR observation of the object, we constrain its inverse-Compton peak for the first time. Determining the high energy cut-off of the inverse-Compton component in such a high-redshift blazar allows us to determine the jet properties, namely the total jet power and the bulk Lorentz factor, thereby testing unification models of blazar jets. We can then compare the jet power to the disc power in this high redshift galaxy.

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Searching for signatures of Pseudo-Dirac neutrinos in IceCube data from Astrophysical sources

Dr. Khushboo Dixit[1], Dr. Luis Salvador Miranda[2], Prof. Soebur Razzaque[1]

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Abstract

Neutrinos can be Majorana fermions while effectively behaving as Dirac fermions, i.e., they can be pseudo-Dirac particles. This leads to the prediction of active-sterile neutrino oscillation driven by a tiny mass-squared difference which is different from the neutrino oscillation scenario of only three active neutrinos over astrophysical distances. Hence, in this context, we aim to analyze the public data from IceCube neutrino observatory. Our goal is to search for signs of pseudo-Dirac signatures in high-energy neutrinos that come from astrophysical sources, namely NGC 1068, TXS 0506+056, PKS 1424+240, and GB6 1542+6129. Neutrino flux from these sources is reduced in the pseudo-Dirac scenario due to the conversion of active-to-sterile neutrinos. To achieve our goal, we have fitted IceCube data using astrophysical flux models for these sources in both scenarios of the standard flavor oscillations and the active-sterile oscillations. This enables us to constrain the active-sterile mass-square difference and the true source flux. Furthermore, we predict the ratios of astrophysical neutrinos of different flavors from these sources in the pseudo-Dirac scenario. These predictions can be verified in future neutrino detectors such as KM3NeT and IceCube Gen-2, which can eventually shed light on processes of high-energy neutrino emission from astrophysical sources.

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IMPRINTS OF SPIN ON THE SOLUTION AND EMISSION SPECTRUM OFACCRETION FLOWS AROUND BLACK HOLES

Dr. Shilpa Sarkar[1], Dr. Indranil Chattopadhyay[2]

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Abstract

We investigate accretion flows around rotating black holes (BHs) and obtain self-consistent transonic solutions in full general relativistic prescription. The flow is assumed to be viscous and radiative. Viscosity helps in the removal of angular momentum outwards, allowing matter to get accreted inwards. In addition, viscous heat dissipated makes the matter hotter. On the other hand, radiation mechanisms like bremsstrahlung, synchrotron, and their inverse-Comptonisations cools down the matter. Thus, the solution depends highly on the interplay between heating and cooling processes. In our work we investigate the entire energy–angular momentum parameter space and obtain both shocked and shock-free accretion solutions. Because of the spin in Kerr black holes, the event horizon is dragged to a region <2GM/c2 , increasing the efficiency of accretion process. Ample of works showed a rotating BH to yield high temperature solutions compared to a Schwarzschild BH. This suggests higher emission. Interestingly we have found a distinct annihilation line present only in extremely rotating BHs arising from regions very close to the central object. We have investigated further the other effects of spin on the spectrum obtained from accretion flows around BHs. We find efficiencies reaching >30%.

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Simulations of linear polarization of precessing AGN jets at parsec scales

Roman Todorov[1], Dr. Evgeniya Kravchenko[1,2], Dr. Ilya Pashchenko[2], Dr. Alexander Pushkarev[3,2]

[1]MIPT. [2]ASC Lebedev. [3]CrAO

Abstract

The latest results of the most detailed analysis of multi-epoch polarization-sensitive observations of AGN jets at parsecs scales by VLBI reveal several characteristic patterns of linear polarization distribution and its variability (Pushkarev et al., 2023; Zobnina et al., 2023). Some of the observed profiles can be reproduced by a simple model of a jet threaded by a helical magnetic field. However, none of the models presented to date can explain the observed polarization profiles with an increase in its degree towards the edges of the jet, and accompanied by a 'fountain' type electric vector pattern and its high temporal variability along the jet spine. Based on simulations of the VLBI observations of relativistic jets, we show here that the observed transverse linear polarization profiles, atypical for the simple magnetic field models can be naturally produced assuming the finite resolution of VLBI arrays and precession of a jet on ten-years scales, observational indications of which are found in an increasing number of AGN. In our simulations, we qualitatively reproduce the distribution of the electric vector and its variability, though the polarization images are characterized by a bright spine due to weak smearing, which is poorly consistent with observations. More effective depolarization can be obtained in models with the suppressed emission of the jet spine. In this talk I will present the results of our simulations, the first half of which is available at https://arxiv.org/abs/2402.07500.

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Unraveling the Drivers of Radio Outflows in Radio-Quiet AGNs: Insights from Magnetic Field Topology

Ms. Salmoli Ghosh[1], Dr. Preeti Kharb[1], Dr. Jack Gallimore[2]

[1]National Centre for Radio Astrophysics - TIFR, Pune. [2]Bucknell University

Abstract

Seyfert and Low Ionization Nuclear Emission Line Regions (LINERs) represent radio-quiet (RQ) active galactic nuclei (AGN) commonly observed in spiral galaxies, characterised by prominent emission lines in their optical and ultraviolet spectra. Recent sensitive radio surveys of Seyfert and LINER galaxies have unveiled kiloparsec-scale radio outflows (KSRs) in them (e.g., Gallimore et al. 2006). The origin of the KSRs in RQ AGN is highly debated with the primary suggestions being AGN-driven jets or winds, or starburst superwinds. One of the clearest ways to find an answer about the origin of the KSRs is to carry out a multi-scale investigation, spanning from parsec to sub-kpc to kpc scales with the help of telescopes like EVN, eMERLIN, VLA, and uGMRT. But usually, it gets difficult to study these radio-faint objects close to their jet launching site as about 80% of the flux goes missing at milliarcsec-scales from arcsec-scales. Hence, we seek an alternate way. Our approach involves probing distinctive structures of organised magnetic fields surrounding the black-hole-accretion-disk system persisting till the kpc-scales, via radio polarimetry. In this talk, we will present our results from such a multi-pronged study of 25 Seyferts and LINERs belonging to the CfA+12micron sample. Our study interestingly reveals bent jets and lobes within short-length scales with the magnetic fields exactly tracing them. Signatures of shocks are revealed through sites of magnetic field compression in some sources. Additionally, we observe [OIII], Hα, HI gas entrainment, and evacuation, indicative of both positive and negative feedback in RQ AGN.

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Dual AGNs: Detecting bright AGN pairs onto the path to binary black holes and black hole mergers

Vida Saeedzadeh[1], Dr Suvodip Mukherjee[2], Prof Arif Babul[1], Dr Michael Tremmel[3], Prof Thomas Quinn[4], Prof Lucio Mayer[5]

[1]University of Victoria. [2]Tata Institute of Fundamental Research. [3]University College Cork. [4]University of Washington. [5]University of Zürich

Abstract

Using the Romulus cosmological simulation, our study investigates the co-evolution of active galactic nuclei (AGN) and their host galaxies, focusing on observable dual AGN systems and identifying potential hosts of nano-Hertz, Pulsar Timing Array (PTA)-accessible gravitational wave (GW) signals. We examine the dynamics of SMBH mergers, exploring the characteristics and evolution of their host galaxies during periods of active accretion and the SMBH-SMBH merger process. Leveraging the novel sub-grid prescription for the SMBH model in the Romulus simulations—which follow the orbital dynamics of SMBHs—we compare the properties and occurrence rates of dual AGNs against those of single AGNs. This investigation includes examining the conditions that give rise to dual AGNs and comparing the properties of their host galaxies with those hosting single AGNs. Moreover, by focusing on merging SMBHs that emit low-frequency gravitational waves, we connect the study of galaxy evolution with the growing field of gravitational wave astronomy. Our findings show that the binary SMBHs detectable by PTAs predominantly reside in massive, low-redshift, early-type, galaxies that reside at the centers of galaxy groups.

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CosmoDRAGoN: simulated AGN jets in cosmological environments

A/Prof Stas Shabala

University of Tasmania

Abstract

Sensitive, high-resolution radio continuum observations are uncovering details of the complex interaction between kpc-scale AGN jets and their environments. I will present theoretical results from the Cosmological Double Radio Active Galactic Nuclei (CosmoDRAGoN) project: a large suite of simulated AGN jets in cosmological environments designed to inform interpretation of radio continuum observations.

CosmoDRAGoN uses a combination of numerical and analytical techniques. The jet dynamics are described by 3D relativistic hydrodynamic simulations, while synchrotron emissivity is calculated in post-processing using an analytical model which fully accounts for the relevant loss processes. CosmoDRAGoN environments are drawn from cosmological smooth particle hydrodynamics (SPH) simulations, which are then used as inputs for our grid-based hydrodynamic simulations of jets propagation. The initially conical jets are injected with a range of jet powers, speeds (both relativistic and non-relativistic), and opening angles; simulations then follow their collimation and propagation on scales of tens to hundreds of kiloparsecs, and spatially resolved synthetic radio spectra are calculated in post-processing.

Covering a broad range in jet and environment parameter space, our simulations successfully reproduce both FRI and FRII radio galaxy morphologies, and make predictions for spatially resolved evolution (including full radio SEDs) for both active and remnant lobes. I will discuss the relationship between observed and intrinsic jet and environment properties, feedback provided by the jets on the surrounding gas, and implications for interpreting observations from large radio surveys.

The CosmoDRAGoN simulation data, including synthetic radio images, are being made available to the community via a web app.

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Fundamental parameters of Weak emission Line Quasars using a fitting method

Laetitia Gibaud, Dr Hab. Marek Nikolajuk

Faculty of Physics, University of Bialystok

Abstract

Weak emission Line Quasars (WLQ) are a particular category of quasars, the most luminous subclass of Active Galactic Nuclei (AGN). WLQ exhibit extremely weak, sometimes undetected emission lines. Since their discovery, WLQ are still a matter of debate, in particular the mass of the supermassive black hole they host and their environment.

We study the broadband spectral energy distribution of a sample of several dozen of WLQ at redshifts ranging from 0,19 to 3,50. We explore a fitting method to determine properly the fundamental parameters such as the black hole masses, the accretion rates and other parameters of accretion flows (e.g. column densities). These parameters are crucial to understand the observed features.

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Development of a full angle- and polarization-dependent synchrotron and synchrotron self-Compton blazar emission model

Mr Motseothata Tisang

North-West University

Abstract

Blazars, characterized by jetted active galactic nuclei with relativistic jets directed at us, exhibit distinct features such as polarization in different wavebands and a bimodal spectral energy distribution (SED). These features are influenced by several parameters, including the viewing angle and the orientation of the magnetic field relative to the jet axis.

We present the development of a full angle- and polarization-dependent synchrotron and synchrotron self-Compton (SSC) blazar emission model with relativistic electrons in a perfectly ordered magnetic field. Utilizing our developed code, we simulate different viewing angles and magnetic field orientations relative to the jet axis, and explore the impacts on the SED and linear polarization degree of a typical blazar. We demonstrate that, as expected, the synchrotron emission depends more strongly on the viewing angle and the magnetic field orientation compared to the SSC emission. Particularly, when the viewing direction closely aligns with the magnetic field direction, the synchrotron emission is suppressed, while the SSC flux remains almost unaffected, although the SSC polarization also depends strongly on the magnetic field orientation.

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Incidence and energetics of AGN outflows in X-ray selected samples.

Miss Blessing Musiimenta

University of Bologna. INAF

Abstract

In the context of an evolutionary model, the outflow phase of an active galactic nucleus (AGN) occurs at the peak of its activity, once the central supermassive black hole (SMBH) is massive enough to generate sufficient power to counterbalance the potential well of the host galaxy. This outflow feedback phase plays a vital role in galaxy evolution. I will present results from my two recent studies. In the first study, we develop an approach to select powerful AGNs in the feedback phase using optical/IR colours, and optical and X-ray spectral properties from the eROSITA Final Equatorial-Depth Survey (eFEDS). We trace and characterise outflows using SDSS spectroscopy, and explore the link between AGN luminosity and outflow properties. We find that the X-ray selection (eROSITA) is a powerful tool to select AGN in the feedback phase and this X-ray active phase is the best tracer of fast winds. In the second study, we perform a spatially resolved analysis of a red, X-ray obscured and X-ray luminous quasar ("the Goldfish galaxy") at a redshift of z=0.6. Our analysis reveals that the quasar resides in a complex interacting system, possibly merging with three other galaxies, and driving extended outflows of about 9.6 solar masses per year. The outflows in this quasar are AGN-driven rather than star formation driven and they are less significant from the energetic point of view.

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Homogeneous fine classification of Active Galaxies based on the SDSS medium resolution spectra

Dr. Areg Mickaelian, Dr. Hayk Abrahamyan, Mr. Gor Mikayelyan, Mr. Gurgen Paronyan

Byurakan Astrophysical Observatory (BAO), Armenia

Abstract

The Sloan Digital Sky Survey (SDSS) provides a large number of medium-resolution spectra (spectral resolution is from 1850 to 2200) over the spectral range from 3600A to 10400A, and is a relevant homogeneous database for classification of galaxies. It contains spectra for 4,151,126 objects, most of which are galaxies and QSOs. Most of the important spectral lines (Balmer lines, OIII, OII, OI, NII, SII, etc.) for most of active galaxies are in this range. We have used SDSS spectra for the classification for activity types of a number of samples, from X-ray to radio, including the Markarian (Mrk) galaxies, X-ray selected AGN, ULIRGs/HLIRGs, Blazars from BZCAT, a sample of radio variable objects from NVSS/FIRST cross-correlations, etc. We aimed at obtaining homogeneous classifications of all these objects by means of the SDSS spectra. In addition, SDSS spectra provide many spectral features and details that were not available before, when using the old spectra. Three diagnostic diagrams and eye examination have been used and the combined activity types have been derived. A fine classification scheme was developed, where QSOs have subtypes like Seyferts (S1.0/Q1.0, S1.2/Q1.2, etc.), Narrow Line QSOs are introduced (NLQ), subclasses for Narrow Line Seyfert 1s and NLQs are used (NLS1.0/NLQ1.0, NLS1.2/NLQ1.2, etc.) and Composite spectrum objects have their subtypes. This classification scheme much better describes all fine details in the optical spectra and allows further study of active galaxies by subtypes for better understanding the Unified model and the physical properties of AGN and Starbursts.

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Spatially Resolving Active Galactic Nuclei at Low and High Redshift with the VLTI and GRAVITY

Dr. Eckhard Sturm

Max Planck Institute for Extraterrestrail Physics

Abstract

With VLTI/GRAVITY and near-infrared interferometry we can directly spatially resolve the broad-line region (BLR) to probe its structure and kinematics and to derive supermassive black hole (SMBH) masses via dynamical modelling. With the recent ongoing update from GRAVITY to GRAVITY+ these studies are now also possible at high redshifts.
I will summarize the current status of our ongoing programme on AGN with GRAVITY/+ at low and high z. We have spatially resolved the BLR for seven nearby AGN, supporting the rotating disk model (with evidence for outflows in some cases), directly measuring the masses of their SMBHs, and testing the BLR radius-luminosity (R-L) scaling relation. Our GRAVITY R-L relation implies that at higher luminosities the BLR size is smaller than that predicted by the standard R-L relation, similar to what studies have shown for highly accreting sources. I will present the first high-redshift observations of quasars with GRAVITY+ and highlight the first BLR detection and SMBH measurement. In the context of galaxy evolution, the SMBH is significantly under-massive relative to the host galaxy mass when compared to similar luminosity high-z quasars as well as the local M(BH) – M(stellar) relation for early type galaxies. This suggests the host galaxy built up before the SMBH but the SMBH is currently going through a rapid growth phase.
I will end my talk with an outlook towards a GRAVITY+ high-z programme aimed at probing galaxy-SMBH coevolution with the highest precision, observing hundreds of AGNs, especially for galaxies at the cosmic noon.

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Investigating AGN activity in Brightest Cluster Galaxies at intermediate redshifts

Dr Narges Hatamkhani

South African Astronomical Observatory

Abstract

We present the results of a multi-wavelength study of approximately 150 Brightest Cluster Galaxies (BCGs) to trace the evolution of Active Galactic Nuclei (AGN) feedback (both radio and quasar mode) and star formation properties of the central galaxies in clusters over a 3.4 Gyr time period ($0.3 < z < 0.8$). The clusters are detected with the Atacama Cosmology Telescope using the redshift-independent Sunyaev-Zel'dovich effect, which provides both mass estimates for the clusters and a clean and simple to model selection function. Our targets are selected from within the Dark Energy Survey footprint which ensures the availability of excellent quality deep *griz*-band imaging. The optical spectra of ~80% of the BCGs have been obtained with the Southern African Large Telescope and ~60% of the BCGs have radio emissions detected by the MeerKAT and the Australian Square Kilometre Array Pathfinder (ASKAP) telescopes. Using the combination of these excellent multiwavelength datasets, we will obtain new insights into the physical processes taking place in galaxies at the centres of clusters beyond $z > 0.3$.

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Close triple passage of galaxies as a cause of radioactivity

Dr. Ruben Andreasyan, Dr. Hayk Abrahamyan, Gurgen Paronyan, Gor Mickayelyan, Dr. Areg Mickaelian

BYURAKAN ASTROPHYSICAL OBSERVATORY

Abstract

The dynamics of a group of galaxies was studied, a member of which is the radio galaxy FRI type 3C31. It turns out that the galaxy NGC 383, which is the parent galaxy of 3C31, was close to two other galaxies in the group (NGC 380 and NGC 386) approximately 100 million years ago, which then began to move away from NGC 383 in opposite directions. Around the same time, 100 million years ago, radioactivity resumed in NGC 383, identified with the radio galaxy 3C31. Moreover, the directions of the radio jets exactly coincide with the directions of the receding galaxies. This suggests that a close triple passage of galaxies may be responsible for the appearance of new radioactivity in 3C31.

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Exploration of the X-ray – Radio relationship (or lack thereof?) of AGN

Dr Clara Pennock

The University of Edinburgh

Abstract

AGN activity is often revealed by strong X-ray and radio emission, even when the AGN is obscured at other wavelengths. Some AGN have been observed to be radio bright but X-ray faint, others X-ray bright but radio faint, as well as bright or faint/unobserved in both X-ray and radio. What determines whether the AGN will be X-ray or radio bright? Is it due to one mechanism that determines both, or two mechanisms in isolation, or even some mixture of the two?

We will present new measurements of luminosity functions simultaneously across both X-ray and radio wavelengths to provide a novel quantification of the incidence and energetic output from the AGN population in this multi-dimensional parameter space. We use x-ray and radio data from fields (Bootes, COSMOS, etc.) that have been well observed, with large catalogues of multiwavelength photometry and spectroscopy, to compare sources that that are X-ray and/or radio observed. We find that while X-ray and radio luminosities have a tendency to increase with redshift, we do not find any pattern between X-ray and radio luminosity at any given redshift. We also plot radio and X-ray luminosity functions for the radio and X-ray samples as a whole and compare them to the subset that is both X-ray and radio observed and find that their is a broad range of X-ray luminosity for a given radio luminosity range, and vice versa. This implies that the instantaneous X-ray power, often a tracer of accretion, is not correlated with the radio power.

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Training a machine learning algorithm to identify/classify extragalactic sources in stellar dense fields

Dr Clara Pennock

The University of Edinburgh

Abstract

There is an abundance of multi-wavelength photometric data from X-ray to radio that continues to be produced. One method to sort through these large datasets is machine learning, which is known to be able to effectively classify, sort and cluster astronomical sources by finding trends and patterns within multi-wavelength imaging data.

I will present new work using a probabilistic random forest algorithm to classify the ~130 million sources in the direction of the Small and Large Magellanic Clouds (SMC and LMC), an area of sky that comes with the additional challenge of increased stellar confusion when searching for the extragalactic. We used multi-wavelength data from Gaia, existing optical surveys, newly acquired near-IR data from VISTA, and IR data from Spitzer and WISE. The algorithm was trained on spectroscopically observed AGN, galaxies and 8 stellar classes which yielded accuracies of 0.90±0.01 and 0.87±0.01 for the SMC-trained and LMC-trained classifiers, respectively. The distributions of classes across the Clouds are as expected, with Magellanic sources concentrating in the centres of the Clouds, and extragalactic sources are more evenly distributed. When compared to Quaia, a Gaia low-resolution spectroscopy quasar catalogue, ~86% of Quaia sources in the Magellanic Cloud field were classified as AGN. The majority of X-ray and radio sources (wavelengths not used) are, as expected, classed as AGN. This work shows that machine learning techniques hold great potential to separate sources in large scale surveys, even in areas of high stellar density, such as looking through the Magellanic Clouds and the Milky Way.

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Diversity and equity in science

Prof. Debra Meyer

Sol Plaatje University

Abstract

Three decades of democracy and associated anti-apartheid legislation in South Africa does not translate to success in diversity, equity and inclusion (DEI) in academia in general or the sciences in particular. Most national universities have policies that govern aspects of DEI but these can be circumvented and side-lined. Universities mostly monitor progress at faculty level allowing departmental underachievement to disappear in the summation and making it possible for research groups to operate under the policy monitoring radar. Historically disadvantaged groups have access to study and work opportunities, but this seldom goes along with consideration of the conditions necessary for their success. The stress of being part of a group assumed to be less than or not good enough means being constantly alert to subtle and overt prejudice which can harm psychological well- being, increase the chance of burnout, and deplete the drive needed to complete research projects successfully. The same systemic bias, reinforced by institutional and historical structures and value systems seen internationally is experienced nationally as well. Given the benefits of diversity in scientific endeavour including that it keeps scientific stagnation at bay, it's hard to understand why it's not more actively protected.

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Deep-learning classifications of galaxy morphologies in large JWST surveys.

Mr Jason Shingirai Makechemu, Dr Brooke Simmons

Lancaster University

Abstract

Investigations of AGN host galaxies including their merger history and morphology have been conducted up to z ~ 2. However, new JWST surveys, such as COSMOS-Web and CEERS, permit investigation of the properties of AGN host galaxy populations in rest-frame optical between 0.5 < z < 4; this spans the entire cosmic noon period where both SMBH growth and galaxy star formation rates peak. We use the deep-learning classifier 'Zoobot' to determine galaxy morphologies in the aforementioned surveys. This is conducted via a transfer learning method that inherits prior training of Zoobot on ground-based imagery. Predictions of the JWST morphologies are then applied to the large multi-wavelength imaging set of COSMOS-Web, after being fine-tuned using Galaxy Zoo volunteer classifications of CEERS images. We further refine the AGN host galaxy classifications by training Zoobot to ignore the central AGN; we then assess the effectiveness of this method before comparing the evolution of host galaxy morphologies with that of inactive galaxies during this era of galaxy assembly. During this talk, a sample of identified AGN host galaxies will be presented, as well as a control sample of inactive galaxies that have been matched on properties such as stellar mass and redshift. Initial results on the differences between morphologies of AGN hosts, and their inactive counterparts will be shown.

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DISENTANGLING STAR FORMATION AND AGN ACTIVITY USING MULTIWAVELENGTH DATA

Dr. Harris Yao Fortune Marc

University of Felix Houphouet Boigny, Cote d'Ivoire

Abstract

We used a multiwavelength approach to study star-forming (SF) and active galactic nuclei (AGN)-dominated galaxies.
Unlike precedent works focused on individual wavelength regimes, we combined optical and infrared data, which we reprocessed using customised software in
order to enhance the data quality. This led to a better differentiation of the two main categories of galaxies that are indispensable to understanding galaxy
evolution (Yao et al. 2020). We incorporated early science continuum data from MeerKAT into our analysis (Yao et al. 2022).

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A population-based approach to understanding radio AGN feedback with LOFAR-VLBI

Dr Jonny Pierce

The University of Hertfordshire

Abstract

Early results from the LOFAR Two-Metre Sky Survey (LoTSS) revealed that radio AGN are prevalent in local massive galaxies, with all above a stellar mass of $10^{11} M_{\odot}$ being switched on at radio wavelengths. Inference-based jet modelling for LoTSS radio AGN then showed that the integrated power output of the population is sufficient to counterbalance X-ray radiative cooling losses in local groups and clusters, as required by current models of galaxy evolution. While these results exhibit the feedback potential of the population as a whole, the majority of LoTSS radio AGN are unresolved at the 6" resolution limit of the survey, meaning that the dominant scales on which the feedback occurs remained uncertain. In this talk, I will describe how we have combined LoTSS and LOFAR long-baseline imaging of the Lockman Hole field at resolutions of 6", 1" and 0.3" to measure the sizes of 1287 radio AGN and improve our understanding of the size distribution of the population. While many sources have projected physical sizes of 100 kpc - 1 Mpc, we see that the sample is dominated by galaxy-scale objects, with over half being < 30 kpc in size. We thus find that the uniform lifetime distribution capable of explaining the sizes of large radio sources cannot describe the size distribution of radio AGN across the population, with strong weighting towards shorter lifetimes being needed. I will also show how refined SED-based separation between AGN and star-forming galaxies allows the jet kinetic luminosity function to be investigated out to z ~ 2.5.

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Multiwavelength AGN classification in the age of big data

Dr Beatriz Mingo

The Open University

Abstract

Despite the success of the unified model in the past 30 years, AGN might still be the most over-classified objects in astronomy, with over 50 labels being commonly used to describe the phenomenon of gas accretion by a supermassive black hole. While we may be accused of over-enthusiasm when it comes to putting sources in boxes, not all AGN fall under the unification umbrella, and classifications can be useful to understand the complex physics involved in the AGN-galaxy co-evolution - as long as we use them sensibly. With ever-larger volumes of data being produced by new surveys, and the necessity to rely on automation, how should we approach future AGN classifications in a way that is physically meaningful and consistent across different wavelengths and instruments?

I will discuss some recent approaches to AGN classification which are attempting to tackle these questions, along with their advantages and shortfalls. I will also highlight some recent results illustrating the new areas of parameter space opened by new surveys, and how they might influence future classification efforts.

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The Host Galaxies of Luminous Quasars

Dr. Roberto Assef

Universidad Diego Portales

Abstract

Luminous quasars are likely a key ingredient in the evolution of massive galaxies, either by producing accretion-disk powered outflows or radio jets that heat and/or blow out the gas from the ISM/CGM necessary to continue star-formation. Understanding the feedback mechanisms that operate requires detailed knowledge of the supermassive black holes (SMBHs) properties and their host galaxies, particularly in regards to the state of the ISM/CGM during intense SMBH accretion phases. While host galaxies of luminous quasars have been traditionally difficult to study at UV and optical wavelengths due to the brightness of the accretion disk in type 1 objects outshining the stellar emission, observatories like ALMA in the sub-millimeter and JWST in the near- and mid-infrared are allowing us to look with unprecedented detail into these questions. Furthermore, during the last decade, families of very luminous type 2 quasars have been identified. In these objects the host galaxy is much easier to characterize although the SMBH properties are more difficult to gauge. In this talk I will present a quick review of the state of host galaxies in luminous quasars, focusing particularly on the most luminous ones known where these effects are likely maximized.

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Study of the star formation activity of the RedMaPPer galaxy cluster using radio continuum data

Mr Ny Ando Jurice Ralitera, Pr. Solohery Randriamampandry

A&A, Department of Physics, Faculty of Sciences, University of Antananarivo, B.P. 906, Antananarivo 101, Madagascar

Abstract

Utilizing extensive samples from the red-sequence Matched-filter Probabilistic Percolation (redMaPPer) catalogs, we explored star formation activities in clusters spanning a redshift range of $0.06 \leq z \leq 0.55$. These sources, located within the Jansky Very Large Array (JVLA) and Herschel footprints in the Stripe 82 region, offer insights into the average characteristics of member galaxies across varying redshifts and masses. Our stacking analysis revealed the average rest frame radio luminosity ($L_{1.4\,GHz}$) and star formation rate ($SFR_{1.4GHz}$) of these galaxies, based on JVLA Stripe 82 observations at 1.4GHz. This method allowed us to detect individual galaxies with low star formation rates at significant levels. Our research delves into the evolution of the star formation rate per unit cluster mass, its correlation with cluster mass, and the average cluster star formation rate per unit cluster mass against cluster mass and richness. Our findings indicate that the average properties of galaxies in the redMaPPer catalogs align with existing literature. Furthermore, we highlight the potential of deep radio surveys as powerful tools for studying cosmic star formation history, noting that comparable surveys have been conducted using the Spitzer Space Telescope and Herschel.

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Deciphering the Morphological Origin of Inversion-Symmetric Extra-galactic Bent Jets

Gourab Giri

University of Pretoria

Abstract

In a limited fraction of extra-galactic jets, a unique phenomenon unfolds as they deviate from their anticipated straight line trajectory, giving rise to inversion-symmetric sources with X-, S-, Z- and W-shape morphologies. The origins of these peculiar geometries remain intensely debated, especially with recent high-resolution observations challenging prior predictions. The complexity deepens as similar morphologies are discovered in galactic micro-quasars as well. Radio properties, including intensity, spectral, and polarisation features, present confounding aspects awaiting resolution. The present study focuses on numerical modelling to unravel the topological origins of these sources, examining the influence of the ambient medium and intricate processes within the central AGN. Emphasising micro-physical processes, the investigation explores the impact of particle cooling and re-acceleration on spectral and polarisation maps, elucidating the perplexing properties of anomalous spectral behaviour in such winged sources. Through an exploration of the effects of bent jets on the large-scale ambient medium (in galaxy clusters), distinct properties have been identified, offering entirely new insights into the origins of these morphologies. This presentation therefore outlines novel scientific inquiries, providing a comprehensive future direction for understanding these bent jetted sources.

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Radio jets expanding in gas-rich ISM: using cold gas to trace their impact

Prof Raffaella Morganti

ASTRON. Kapteyn Institute Groningen

Abstract

Radio jets are a spectacular manifestation of the nuclear activity in galaxies. The energy they release can strongly affect the ISM/IGM. However, the interaction is complex, and the coupling jet-ISM can depend on the jet power and can change as the jet expands. In this talk I will summarise the results we have obtained by using cold (molecular and HI) gas as tracer of the impact of the radio jet from its young phase. I will report on some of the recent results obtained with the high resolution (tens to hundreds pc) observations from ALMA, NOEMA and VLBI. The high spatial resolution is ideal for tracing the details of the interaction, allowing us to follow the impact of the jet expanding on the ISM. We find that newly born and young (< 10^6 yr) radio jets can drive massive outflows of cold, molecular gas. The outflows are, however, limited to the sub-kpc regions and likely short lived. On larger scales (a few kpc), the molecular gas appears to avoid the radio lobes and, instead, wraps around them. We suggest an evolutionary sequence where the effect of the radio plasma changes as the jet expands, from direct interaction to more gentle pushing of the gas aside, and likely limiting its cooling. Interestingly, the physical conditions of the molecular gas (traced by multiple CO transitions) are affected by this interaction. The implications of this scenario will be discussed.

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The Multi-Phase Outflows of Compact Obscured Nuclei (CONs)

Dr Clare Wethers

Chalmers University of Technology

Abstract

A significant fraction (20-40%) of (ultra-) luminous infrared galaxies (U)LIRG in the local Universe have been shown to host compact (r < 100 pc) obscured nuclei (CONs) with extreme nuclear column densities ($N_{H2} > 10^{24}$ cm^2). All known CONs host outflows, and thus likely play a critical role in nuclear feedback and galaxy evolution. Despite this, the exact nature of CONs and what drives their outflows remains unknown, with both AGN accretion and starburst activity suggested as possible power sources.

Zw049.057 is a known LIRG CON (z = 0.01299, $L_{FIR} = 1.9 \times 10^{11}$ L$\odot$). Recent wide-field optical IFU observations from MUSE reveal a clumpy ionized gas outflow on >1 kpc scales. On smaller scales of ~100pc, ALMA band 6 observations reveal a spectacular collimated molecular outflow along the minor axis and previous observations from the VLA show a faint radio jet, yet the symmetry angle of these various outflows are misaligned. It therefore remains unclear whether they are part of the same multi-phase structure, or whether they represent different flares of nuclear activity. Here, I will present a multi-wavelength view of Zw049.057 and discuss the potential connection between these different features. I will explore the potential driving mechanism(s) behind the observed outflows and discuss the impact this has on our understanding of CONs in the context of AGN-galaxy coevolution.

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Violent feedback-driven winds from high redshift Radio loud AGNs revealed by JWST

Dr. Namrata Roy

Johns Hopkins University

Abstract

AGN feedback via radio jets, despite the relatively short jet lifetime (10 Myr), can significantly impact the host galaxy. Hydrodynamical jet simulations tell us that radio jets can generate shocks and drive large-scale gas outflows through an expanding cocoon. Mapping the resolved energetics and the kinematics of the gas outflows will determine the amount of AGN feedback deposited by the radio jets. High-redshift radio galaxies (HzRGs) within the first billion years of the universe are particularly interesting to study since they host the most violent outflows and the luminous radio jets. In this talk, I will show how JWST, along with HST, ALMA, MUSE, etc, is starting to make groundbreaking progress in feedback studies by pushing *spatially resolved* observations toward high redshift. I will present JWST NIRSpec IFU data of two fascinating HzRGs at $z > 4$. They show conical ionized emission, clumpy gas morphology, and extraordinary outflow kinematics coincident with radio lobes. I will show that the spatially resolved mass outflow rates, ionization properties, and kinetic energy can provide a great deal of information on the effect of feedback on the host galaxy. Although we define “quasar-mode” and “radio mode” as separate stages of AGN feedback, I will show that radio galaxies can often perceive both modes simultaneously, especially at high redshifts. I will compare our observations to high-resolution hydrodynamical jet simulations. Our work is just beginning to scrape the surface of AGN feedback and detailed jet-ISM interplay at high-z. More such examples are needed.

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Variability and spectral study of seyfert 1 galaxies using long term X-rays observations

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Abstract

The observed iron lines in active galactic nuclei (AGN) offer a powerful tool to study the surroundings of black holes. We will present analysis of recent long-term X-ray observations from XMM-Newton and NuSTAR to study reverberation time delays between the direct continuum and the reflected component, and present detailed spectral analysis to study the environment of the supermassive black holes.

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Exploring Radio Galaxy Origin of Ultra-High Energy Cosmic Rays

Professor Dongsu Ryu[1], Professor Hyesung Kang[2], Dr. Jeongbhin Seo[3]

[1]UNIST (Ulsan National Institute of Science and Technology), South Korea. [2]Pusan National University, South Korea. [3]Los Alamos National Laboratory, USA

Abstract

We study the scenario that relativistic jets from radio galaxies are the primary source of the ultra-high energy cosmic rays (UHECRs) observed on Earth. Employing a model energy spectrum derived from numerical simulations of FR I and II jets, characterized by a double power law and an extended exponential cutoff, we assess the energy spectrum and mass composition of UHECRs coming from both nearby radio galaxies and those distributed across the universe. Assuming that the jet of Virgo A is more relativistic than those of Centaurus A and Fornax A, we predict that UHECRs seen in the northern hemisphere would have a higher flux and a lighter composition than those seen in the southern hemisphere at the highest end of the UHECR energy spectrum. Our results may provide insights for the explanation of discrepancies in energy spectrum and mass composition between Telescope Array and Pierre Auger Observatory observations.

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Linking AGN accretion states with properties of host galaxies

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Abstract

Supermassive black holes in galactic nuclei share a symbiotic relation with their host galaxies and play a key role in galaxy evolution. This has been demonstrated by many correlations that exist between the black hole mass and the properties of the host galaxy. Two mechanisms govern this interaction, the feeding of the black hole through the accretion of the gas and the feedback from the intense radiation and kinematic outflows from the accreting black hole. For a global study of the relation between the accretion processes and star formation in the host galaxies, we employ a large multi-wavelength sample of active galactic nuclei (AGN) to look for possible correlations. We focus on different accretion states, analogous to stellar mass black holes, for which various phenomena take place. The relativistic jets are launched in the hard state, while intense ionizing radiation and winds are released from the accretion disk in the soft state. In this talk, I will show how the AGN states can be defined and compared to X-ray binaries, and whether there is observational evidence for the link between the star formation processes and accretion states in a large AGN sample.

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Uncovering the Faintest Peaked Spectrum Radio Sources

Mr Fabio Luchsinger

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Abstract

Peaked spectrum (PS) radio sources have been studied for decades, but are largely unknown at low luminosity. With the new generation of telescopes producing deep, wide-field radio surveys, we aim to increase the number of known low-luminosity PS sources manyfold. The physical processes underlying their peaked spectra and the relative scarcity makes them interesting. They are thought to be young radio galaxies, where the jets from their AGN only recently began to launch. It is thought that the precursors of Fanaroff-Riley Type I are amongst the low-luminosity population, but very few known examples exist. Our work focuses on fields with a deep and broadband coverage across the electromagnetic spectrum, such as the XMM-LSS and ELAIS-N1 field. Within theses fields, we carried out radio spectral analyses using MIGHTEE continuum data and other radio catalogues. We further fit models to deduce the physical processes causing their spectral shape.

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The Role of Active Galactic Nuclei in Galaxy Evolution: How do jets propagate through the turbulent Interstellar Medium?

Olga Borodina[1], Yueying Ni[1], Jake Bennett[1], Rainer Weinberger[2], Lars Hernquist[1]

[1]Center for Astrophysics | Harvard & Smithsonian. [2]Leibniz Institute for Astrophysics Potsdam

Abstract

Observations and cosmological simulations tell us that disky, star-forming galaxies transform into elliptical, quenched galaxies. This transition can be driven, at least in part, by gas leaving the galaxy due to the energy injection from black holes in the galactic central region, known as active galactic nuclei, or AGN. Recently discovered FR0 sources, that host unresolved radio-loud sources and appear to be very common among a variety of galaxy types, could suggest that stalled jets play a crucial role in galaxy quenching.

Using the Arepo code we model the interstellar medium (ISM) in the central kiloparsec of a galaxy, with active turbulence driving and constant jet energy injection. With our simulations we find three main scenarios — jets passing almost unhindered through the ISM, jets being completely stalled near the injection scale, or the interesting intermediate stage when jets become highly disturbed and redirected by ISM structure. We show how the ISM's ram pressure and complex structure have a great impact on how the jet propagates.

This work sheds light on the open question of how energy from AGN couples to the gas in its host galaxy and in future our results can be utilised in building the next generation of cosmological simulations through making improvements on existing, often heuristic models of AGN.

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Exploring the resolve μJy extragalactic radio source population at high resolution with wide-field VLBI surveys and paving the way for SKA.

Dr. Ann Njeri

Newcastle University

Abstract

Current galaxy formation theory states that the energy released by AGN dramatically influences the evolution of their host galaxies. However, many questions remain around how this process works in the Universe, relating to both obtaining a complete census of AGN and to understanding how the energy is transferred from AGN into the host.

Deep wide-field radio surveys trace a large range of spatial and brightness temperature sensitivity scales, which play a key role in deriving a complete census of AGN. A combination of sensitivity and high angular resolution imaging over a range of spatial scales (arcsec-mas) is therefore required to successfully characterize the relative contribution of radio emission associated with AGN from star-formation. To isolate AGN contribution from star formation, we hypothesise that there exists a brightness temperature cut-off point separating pure AGN from star formation. The very long baseline interferometry (VLBI) is sensitive to high temperature brightness sources (AGN) only and is therefore one of the most crucial tools for disentangling these two processes. I will present the first multi-resolution (a few parsecs to kilo-parsecs scales) view of the transition between compact AGN and diffuse star formation through deep wide-field radio imaging from 5-1000 milliarcseconds (using EVN, e-MERLIN, VLBA, VLA of two extragalactic deep fields). I will show how the different spatial scales reveal a range of different structures. I will also discuss how these results can inform future SKA observations, in relation to survey biases, de-coupling AGN and star-formation and addressing key technical challenges for processing the data.

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Orbital motions of cD galaxies shaping radio structures: the case of 3C 338

Msc Abraao S. R. Antas[1], PhD Anderson Caproni[1], PhD Rubens G. E. Machado[2], PhD Tatiana F. Laganá[1], Msc Gilvan S. Souza[1]

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Abstract

Radio jets often exhibit structures with well-defined morphologies at kiloparsec scales, usually classified as Fanaroff-Riley I (low power sources formed by a bright central structure that ends in plumes) or II (high power sources with jets terminating in lobes and/or hotspots brighter than their active nucleus). However, some radio galaxies present much more complex radio structures than those described above. In this work, we study the relationship between orbital motions of radio sources and their observed morphology at radio wavelengths. Our analysis focuses on the cD galaxy NGC 6166, located in the central region of the galaxy cluster Abell 2199 and associated with the radio galaxy 3C 338. Lobe, jets, and a more detached southern structure (similar to a jet and labelled as ridge) are seen at arcsecond-scale images of 3C 338. Observational constraints provided in the literature are used to study the feasibility of NGC 6166 is moving around the center of Abell 2199 from the point of view of three-dimensional hydrodynamic simulations. Pseudo synchrotron images are generated from the simulations and compared with interferometric radio images, considering the system's orientation in relation to the line of sight. Our results show that the hypothesis of a non-static NGC 6166 in relation to the Abell 2199, together with a time-varying jet power during the last few tens of millions of years can be used to reproduce the overall radio morphology of 3C 338 inferred by interferometric observations.

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Spectral Ages of Remnant Radio Galaxies with MIGHTEE and SuperMIGHTEE Radio Surveys in the XMM-LSS Field

Sushant Dutta[1], Veeresh Singh[2], Ishwara-Chandra C. H.[3], Yogesh Wadadekar[3], Abhijit Kayal[2]

[1]IDIA, University of Cape Town. [2]Physical Research Laboratory, Ahmedabad. [3]NCRA-TIFR, Pune

Abstract

Radio galaxies, a subclass of active galaxies, exhibit bipolar collimated outflowing jets that form lobes via interaction with the intergalactic medium. The cessation of active galactic nuclei (AGN) activity in radio galaxies leads them into the remnant phase. Remnant radio galaxies are believed to be rare objects as they can be observed over a relatively short period of time before the radio lobes with no supply of fresh plasma completely fade away due to radiative and dynamical energy losses. In our recent work, we identified and characterized remnants using one of the deepest multi-frequency radio observations performed at 150 MHz, 325 MHz and 1.4 GHz using LOFAR, GMRT and JVLA, in the XMM-LSS field. In our study, we exploited faint (10 mJy at 150 MHz) and high redshift ($z \sim 1.0$) regimes and unveiled the largest remnant sample to date. Also, for the first time, we demonstrated the existence of a substantial population of small-size (<200 kpc) remnants. Furthermore, the timescales of the remnant phase and AGN duty cycle are vital to understanding the evolution of radio galaxies. The new radio observations at band-3 and band-4 from uGMRT carried out under the SuperMIGHTEE project, and *L*-band from MeerKAT (carried out under the MIGHTEE project) allow us to build densely sample spectral energy distributions (SEDs) which in turn yields better constraints on the spectral age estimates. In this talk, I will also emphasize the need for deep large-area multi-frequency radio surveys to understand the diversity and evolution of remnants.

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The unifying model of Jetted AGNs: the contribution of relativistic and orientation Effects

DR EVARISTUS IYIDA

University of Nigeria, Nsukka

Abstract

The unified model of jetted active galactic nuclei (AGNs) based on intrinsic properties presumes that the blazar subtypes of BL Lacertae objects (BLs) and flat-spectrum radio quasars (FSRQs) are aligned equivalents of Fanaroff–Riley type I (FR I) and Fanaroff–Riley type II (FR II) radio galaxies from where their parent sources are obtained. Using compiled radio, X-ray and γ-ray data of 397 blazars and 110 radio galaxies detected by the *Fermi* Large Area Telescope (*Fermi*/LAT- 4LAC), We computed the γ-ray core-dominance parameter (R_γ) and γ-ray emission components (beamed and unbeamed) to study the consequences of relativistic beaming and orientation effects on γ-ray properties of radio galaxies, BLs and FSRQs. Analysis of data shows that the distributions of R_X and R_γ, on average, are consistent with the prediction of the unified scheme in which FSRQs and BLs are strongly beamed and are inclined at smaller angles than radio galaxies. Through statistical tests with chance probability, $p < 0.05$, we find that the distributions of R_X and R_γ for radio galaxies and the blazar subtypes are not significantly different. There is a regular positive trend ($r > +0.60$) in the variation of radio core-dominance parameter – X-ray luminosity (R_r - L_x) data from radio galaxies to FSRQs through BLs, which suggests that radio galaxies could be relativistically less beamed population of jetted AGNs. The results are consistent with the unified model for radio galaxies and the conventional blazar subtypes.

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Observations of active galactic nuclei at the highest energies with the HAWC gamma-ray observatory

Dr Alberto Carramiñana[1], M.Sc. Fernando Ureña Mena[1], Dr Daniel Rosa González[1], Dr Anna Lia Longinotti[2]

[1]Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE). [2]Instituto de Astronomía, Universidad Nacional Autónoma de México (IAUNAM)

Abstract

The High Altitude Water Cherenkov (HAWC) observatory has monitored two-thirds of the sky for nine years in the light of TeV gamma rays. In 2021 we presented a survey of 138 active galactic nuclei previously detected by Fermi-LAT above 10 GeV in the nearby universe ($z<0.3$). The acquisition of xx% more data and improvements in our analysis techniques are allowing us to peer deeper into the extragalactic sky, beyond the high significance detections and follow-up of Markarian 421 and Markarian 501. In this work we present statistical evidence of long-term TeV emission from seven other BL Lac objects and two radio galaxies, in particular M87.

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The extremes of variability among AGN

Dr. S. Komossa[1], Dr. D. Grupe[2]

[1]Max-Planck-Institut fuer Radioastronomie, Bonn, Germany. [2]Department of Physics, Geology, and Engineering Technology, Northern Kentucky University, USA

Abstract

Results are presented from our ongoing monitoring campaigns (in the optical, UV, X-rays and radio) on some of the most highly variable AGN known, and the identification of new AGN in extreme flux or spectral states, including some of the highest-amplitude outbursts observed to date, deep low-states, unexpected long-term trends, and systems which exhibit extreme Seyfert-type transitions ("changing-look AGN"). Long-term lightcurves, densely covered for multiple years, and follow-up spectroscopy in different spectral bands including, for instance with XMM-Newton and SALT, are used to shed light on the underlying variability mechanisms including accretion disk and broad-line region physics. Remarkable differences are seen, for instance, in the optical spectral response to extreme outbursts, implying very different intrinsic variability mechanisms.

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Project MOMO: Testing binary SMBH models of the blazar OJ 287

Dr. S. Komossa[1], Dr. D. Grupe[2], Dr. A. Kraus[1], Dr. W. Kollatschny[3], Dr. M.A. Gurwell[4], Dr. Z. Haiman[5,6], Dr. L.C. Gallo[7], Dr. A.G. Gonzalez[7], Dr. F.K. Liu[8,9], Dr. R. Blandford[10], Dr. A. Tchekhovskoy[11]

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Abstract

OJ 287 is one of the best-known candidates for a compact binary SMBH system. It is also a nearby, bright, highly variable blazar.
In order to test predictions of different binary SMBH models, which differ for instance in the mass of the primary SMBH, and, independently, to understand disk-jet physics of vthis nearby blazar, we have set up the project MOMO (Multi-wavelength observations and modelling of OJ 287). In the course of MOMO, we carry out the densest and longest multi-frequency photometric and spectroscopic monitoring observations so far done of OJ 287 involving >13 frequencies from the radio to the high-energy regime, covering OJ 287 in all its extreme flux and spectral states, and involving space- and ground-based missions (including Swift, XMM-Newton, NuSTAR, Fermi, the Effelsberg telescope, SMA, the Xinglong telescope, HET, and other observatories).

A wealth of predictions have become testable recently, when one binary model predicted a sequence of bright outbursts, and other characteristic properties, none of which were observed. These results have profound implications for the binary nature of OJ 287, ruling out binary models which required a huge primary SMBH mass exceeding 10^10 M_sun, and favoring alternative models which used a more modest mass of 10^8 M_sun. These conclusions are independently confirmed by applying several independent methods of SMBH mass measurements. Further, the lightcurves and SEDs of OJ 287 reveal several exceptional deep flux fades and X-ray spectral states, and we also discuss their nature along with most recent constraints on binary SMBH models.

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The intriguing multi-wavelength properties of the radio-loud NLS1 galaxy and radio-calibrator 3C 286: disk or jet variability, and how much absorption ?

Dr. St. Komossa[1], Dr. S. Yao[2], Dr. A. Kraus[1]

[1]Max-Planck Institut fuer Radioastronomie, Bonn, Germany. [2]NAOC, Beijing, PR China

Abstract

3C 286, a well-known radio-calibrator source, was found to show remarkable multi-wavelength properties. Its rich and complex optical emission-line spectrum revealed its narrow-line Seyfert 1 (NLS1) nature. Given its strong radio emission, this makes 3C 286 one of the radio-loudest NLS1 galaxies known. 3C 286 is also one of very few known compact steep-spectrum (CSS) sources detected in the gamma-ray regime.

Observations in the X-ray regime, rarely carried out so far, revealed evidence for variability, raising the question if driven by the accretion disk or jet. 3C 286 is also well known for its damped Lyman alpha system from an intervening absorber at z = 0.692, triggering a search for the corresponding X-ray absorption along the line-of-sight.

Here, we present multiple new follow-up observations in the radio, X-ray, optical and UV band and discuss implications for the nature of the variability. Further, for the first time, spectroscopic data are deep enough to address the puzzle of the `missing' X-ray absorption along the line of sight. New radio observations combined with simultaneous higher-frequency optical-to-X-ray data are used to study the SED and the physical mechanisms that dominate its emission across the electromagnetic spectrum.

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Long-term X-ray temporal and spectral study of a Seyfert galaxy Mrk 6

Narendranath Layek[1,2], Prantik Nandi[1], Sachindra Naik[1], Neeraj Kumari[1], Arghajit Jana[3], Birendra Chhotaray[1,2]

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Abstract

We present a long-term X-ray study of a nearby Active Galactic Nucleus Mrk 6, utilizing observations from XMM–Newton, Suzaku, Swift, and NuSTAR observatories, spanning 22 years from 2001 to 2022. From timing analysis, we estimated variance, normalized variance, and fractional rms amplitude in different energy bands. The temporal study shows fractional rms amplitude (F_{VAR}) below 10 per cent for the shorter time-scale (∼60 ks) and above 20 per cent for the longer time-scale (∼weeks). A complex correlation is observed between the soft (0.5–3.0 keV) and hard (3.0–10.0 keV) X-ray bands of different epochs of observations. This result prompts a detailed investigation through spectral analysis, employing various phenomenological and physical models on the X-ray spectra. Our analysis reveals a heterogeneous structure of the obscuring material surrounding Mrk 6. A partially ionized absorber exhibits a rapid change in location and extends up to the narrow-line regions or torus. In contrast, another component, located far from the central engine, remained relatively stable. During the observation period, the source luminosity in the 3.0–10.0 keV range varies between (3–15) × 10^{42} erg s^{-1}

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AGN feedback on neutral gas.

Dr. Aditya J.N.H.S.[1], FLASH team[2]

[1]The University of Sydney. [2]The University of Sydney & CSIRO

Abstract

While optical and millimetre studies provide evidence of AGN jet-driven warm, ionised and molecular outflows, studies of HI 21-cm absorption against the radio AGN can inform us about the movement and distribution of cold neutral gas in AGN surroundings. Neutral gas is a reservoir of fuel for star formation. VLBI spectroscopic observations can trace the gas and its kinematics in the pc-scale AGN vicinities. I will present multiple detections of neutral gas outflows in the intermediate-to-high redshift (z~0.7-3.5) AGN systems, which include cases of highest HI mass-outflow rate, and, HI 21-cm absorption strength, that were detected with ASKAP, GMRT and MeerKAT. Compare their velocities with low-z systems, and with optical and millimetre gas outflows. Then I will discuss the effects of radiative AGN feedback on neutral gas, prevalent in high-z AGN-HI 21-cm absorption systems, and a possible connection between HI outflows and [O II] luminosities. Further, I will present cases of two local systems; one with recent eMERLIN HI 21-cm results, probing few X 100 pc-scale vicinities of a merger hosting an AGN, where HI inflow is likely fuelling the AGN core for a second episode of jet activity. And, another system being probed by VLBA+GBT(HSA) HI 21-cm observations, where the jet expansion is likely constrained by dense ambient gas; ineffective mechanical feedback and jet frustration scenarios. I will present the gas densities, compare results with existing simulations, and analyse their jet-gas interactions.

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Radio galaxies in cosmological simulations

Dr Nicole Thomas

International Centre for Radio Astronomy Research (ICRAR). University of Western Australia

Abstract

Radio galaxies are a population of active galactic nuclei (AGN) identified by the presence of relativistic jets observed at radio wavelengths. These radio galaxies play a key role in quenching and maintaining the quenched status of massive galaxies. While it is clear that these sources play an integral role in the evolution of galaxies, the physical processes describing the growth and feedback mechanisms of the central supermassive black holes are still poorly defined.
SKA precursors, such as MeerKAT, are already providing new insights into the faint population of radio galaxies, challenging our understanding of their nature, prevalence, and impact across cosmic time.
It is therefore vital that that we have the means to interpret these observations in the context of the larger galaxy population and specifically, the ongoing black hole accretion and feedback processes on a cosmological scale.

In this talk I will discuss the current status of AGN growth and feedback in cosmological simulations and how we can combine these with semi-analytical models (SAMs) to improve predictions of the global host galaxy and black hole properties of radio galaxies over cosmic time. I will briefly test these predictions with the MIGHTEE survey, a radio continuum survey on the MeerKAT array, as a vital step in constraining, and therefore understanding, the physical mechanisms describing black hole growth and feedback.

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Dual Role of Accretion Disk Winds as X-ray Obscurers and UV Line Absorbers in AGNs

Prof. Keigo Fukumura[1], Dr. Missagh Mehdipour[2], Prof. Ehud Behar[3], Dr. Chris Shrader[4], Dr. Mauro Dadina[5], Dr. Demosthenes Kazanas[6], Dr. Stefano Marchesi[7,8,5], Prof. Francesco Tombesi[9,6,10,11]

[1]James Madison University. [2]Space Telescope Science Institute, USA. [3]Technion, Israel. [4]NASA/GSFC/CUA. [5]INAF, Italy. [6]NASA/GSFC. [7]Universita degli Studi di Bologna. [8]Clemson University. [9]University of Rome "Tor Vergata". [10]UMD, USA. [11]INAF Astronomical Observatory of Rome

Abstract

The physics of AGN outflows is among the outstanding questions in high-energy astrophysics. In this presentation, we propose that a Compton-thick layer of a large-scale accretion disk wind can obscure continuum X-rays and also lead to broad UV absorption such as in the blue wing of CIV; the former originates from the inner part of the wind while the latter from the outer part of the wind as a dual role. Motivated by a number of observational evidence showing strong AGN obscuration phenomena in radio-quiet Seyfert 1 AGNs (e.g. NGC 5548 and NGC 3783), we demonstrate, by utilizing a physically-motivated wind model coupled to post-process radiative transfer calculations, that an extended disk wind of stratified structure (e.g. morphology, velocity and density) could naturally cause a sufficient obscuration qualitatively consistent with UV/X-ray observations. Predicted X-ray hardness ratio and UV/X-ray correlation are presented as a consequence of variable spatial size of the wind in this scenario.

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A Fourier-Transformation Model for the Production of X-ray Time Lags from AGN Accretion Discs

Thunyapong Mahapol, Doctor Peter Becker

George Mason University

Abstract

The complex and rapidly varying X-ray emission from active galactic nuclei (AGNs) may provide insights to the thermal and dynamical structure of the central black hole accretion disc. To analyse the observed variability, X-ray time lags which are the temporal delays between Fourier transforms of light curves in hard and soft X-ray energy channels can be used. These time lags may be either hard lags or soft lags, depending on whether the variability in the hard energy channel follows that in the soft channel or vice versa. The source for the observed X-ray time lags from AGNs has been a subject of debate. In this study, we investigate the scenario where the X-ray time lags are generated by thermal and bulk Comptonisation, as well as spatial reverberation of iron L-line and K-line seed photons, which are produced via fluorescence due to local instability. We model the inner region of the accretion flow as a hot, geometrically thick ADAF disc, with the outer radius equal to the shock formation radius located just outside the centrifugal barrier. Using a Fourier-transformed, vertically-averaged transport equation in cylindrical coordinates, we analyse the time-dependent radiative transfer in the inner ADAF region and simulate the X-ray time lag data. We then compare the simulated time lags to the observed time lags for model fitting. Our new model successfully reproduces the complex X-ray variability data for the Seyfert 1 galaxies 1H 0707-495 and Ark 564.

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Parsec-scale jet direction variations in active galaxies

Ivan Kostrichkin[1], Dr Alexander Plavin[2]

[1]Moscow Institute of Physics and Technology. [2]Black Hole Initiative

Abstract

We present the results of analyzing the variations of the apparent jet direction of 2311 quasars at frequencies from 2 to 43 GHz observed from 1994 to 2023. To perform this analysis, we developed an automated algorithm to measure the direction from VLBI images. We find that the apparent jet rotation is likely caused by the precession or wobbling of the nozzle at its beginning. Other scenarios, such as the non-radial motion of individual jet components, are less likely. In the approximation of the apparent jet rotation rate staying constant over time, we determine that the typical rates are faster at higher frequencies, ranging from 0.22 deg/yr at 2 GHz to 1 deg/yr at 43 GHz. If this variability is periodic, we can infer that characteristic periods are on the order of 100-1000 years. We evaluate potential scenarios for jet nozzle direction changes, from binary system to plasma instabilities, and constrain their physical parameters to be consistent with the measured direction variations.

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Exascale AGN Science in the Desert: Building on the Big Data Precursors

Dr Jordan Collier

Curtin Institute of Radio Astronomy (CIRA). Inter-University Institute for Data Intensive Astronomy (IDIA). Western Sydney University

Abstract

The Square Kilometre Array (SKA) is a global multi-billion dollar project set up to build and operate the world's largest telescope, primarily located within the desert regions of the Murchison, Western Australia, and the Northern Karoo, South Africa. To fully exploit the scientific output of the immense amount of data flowing from the telescopes, the SKA Observatory (SKAO) is working with science communities across the world through SKA Regional Centres (SRCs), which are nationally lead hubs containing infrastructure for supporting the science and computing required by this international community.

In this presentation, I will cover the AGN science projects facilitated by the SRCs and their prototypes in Australia and South Africa, namely the Australian SRC (AusSRC), and the Inter-University Institute for Data-Intensive Astronomy (IDIA), including my own research interests investigating young and distant AGN, and our use of the ilifu facility, operated by IDIA, and the Pawsey Supercomputing Centre, to analyse these data.

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1301

GeV–TeV emission from Compton-induced cascades in blazar-type AGN jets

Mr Mfuphi Ntshatsha[1], Prof Soebur Razzaque[1], Prof Markus Boettcher[2]

[1]University of Johannesburg. [2]North-West University

Abstract

Active Galactic Nuclei (AGNs) are some of the most luminous astrophysical objects throughout the entire electromagnetic spectrum. Blazars, a subclass of AGNs, are especially luminous in the high-energy (HE, 100 > MeV) to very high-energy (VHE, > 100 GeV) gamma-ray band. Their emissions can vary on timescales as short as days. According to the unified scheme for radio-loud galaxies, blazar jets are aligned close to our line of sight. In these jets, particles are accelerated to relativistic speeds, leading to the Doppler enhancement of their emissions to high energies. Furthermore, the scheme identifies radio galaxies as the misaligned parent class of the blazar population. By this assumption, they can be expected to be intrinsic HE to VHE emitters. Indeed, late-generation Atmospheric Cherenkov Detectors have been detecting a growing number of radio galaxies emitting in the gamma rays. Previous works have shown that given mild magnetic fields and external low-frequency radiation fields in AGN environments, Inverse-Compton-induced gamma-ray cascades can produce these emissions. We refine this work by including the more realistic Shakura-Sunyaev accretion disk model expected to be found in AGN-type systems. We study the radiative signatures resulting from such cascades as an explanation for HE–VHE emissions from radio galaxies. We then use them to evaluate their contribution to the broadband spectral energy distributions of some radio galaxies and blazars.

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1309

Investigating the Origin of the X-ray to Gamma-ray Emission In Cen A with INTEGRAL

James Rodi[1], Elisabeth Jourdain[2,3], Manuela Molina[4], J. P. Roques[2,3]

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Abstract

The nearby radio galaxy Centaurus A (Cen A) provides opportunities to study emission mechanisms across the electromagnetic spectrum. However, the physical process(es) underlying the emission from X-rays to soft gamma-rays has long been debated (thermal Comptonization from a corona vs synchrotron self-Comptonization (SSC) from a jet). Recent analysis of radio to X-ray polarimetry measurements find the polarimetry SED is consistent with an SSC model of 1-3% polarization. This implies a spectral cutoff above ~ 1 MeV. We present spectral results from 3 keV to 1 TeV to constrain the spectral cutoff in Cen A to test the SSC model.

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Multi-wavelength and VLBI study of a neutrino blazar 0735+178

undergraduate Yu-Sik Kim[1], Professor Jae-Young Kim[1,2]

[1]Kyungpook National University, Korea. [2]Max Plank Institute for Radio Astronomy, Germany

Abstract

Neutrinos, being neutral particles, allow for tracking their spatial origins well regardless of interstellar magnetic fields. This characteristic makes neutrino blazars an ideal target for studying the origins and physics of high-energy cosmic particles. IceCube detected a significant high-energy neutrino event in 2021 Dec 08, and then the blazar PKS 0735+178 rose as a new major neutrino candidate. PKS 0735+178 reached its peak flux at the time of the arrival of the neutrinos, suggesting a correlation between neutrino emission and electromagnetic radiation. However, the source's current flux level in 2022 is rising again. By using data from various observations, including radio (VLBA), gamma-ray (Fermi-LAT), X-ray (Swift X-ray), and optical (g, V) (ASAS-SN), we aim to explore the connection between neutrino generation and electromagnetic radiation across various wavelengths and find a physical model that explains the observed neutrino flare. For this, we especially analyze the VLBA monitoring observations in detail and explore the kinematics of VLBI components. Notable, we find the ejection of a new VLBI component at the time of sharp rise of neutrino and electromagnetic flux. In this talk, we present preliminary results from our study.

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1351

A high precision mass measurement of the central black hole in the massive elliptical galaxy NGC 2513 with ALMA molecular gas dynamics

Shelley-Anne Harrisberg[1], Dr. Sabine Thater[1], Dr. Dieu D. Nguyen[2], Assoc. Prof. Dr. Alvaro Hacar[1]

[1]Department of Astrophysics, University of Vienna. [2]Centre de Recherche Astrophysique de Lyon (CRAL), Université de Lyon

Abstract

Supermassive black holes (SMBH) are believed to co-evolve with their host galaxies. Evidence for this co-evolution is found in the form of several correlations between the SMBH mass and various properties of the host galaxy, the tightest of which is the bulge stellar velocity dispersion. In order to better understand these correlations, a large and robust dataset of SMBH measurements is required, particularly in the low- and high-mass regime where measurements are still relatively few.

In this talk, I present the results of a mass measurement of the putative SMBH in the massive elliptical galaxy NGC 2513. The measurement is obtained via the method of cold molecular gas dynamics, using high resolution ALMA (Atacama Large Millimetre/sub-millimetre Array) observations.

I introduce the method, its advantages and limitations. I then present how I derive the luminous mass using near-infrared images from the Hubble Space Telescope, taking detailed dust masking into account. This is a necessary step, as an accurate knowledge of the luminous mass of the galaxy is crucial towards obtaining a precise SMBH mass measurement. I then present how I combine different CO(2-1) ALMA observations to obtain the highest possible resolution at a sufficient sensitivity. By forward modelling the resulting ALMA datacube with the KinMS (KINematic Molecular Simulation) routines developed by Davis et al. (2013), a best-fit model to the data is attained. Finally, I discuss my SMBH mass measurement with respect to different SMBH evolution scenarios and future requirements needed to significantly advance the field.

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The extremes of NLS1 variability in the era of the space mission SVOM

Dr. Dawei Xu[1,2], Dr. S. Komossa[3]

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Abstract

The extremes of variability provide us with important new insights into accretion physics of AGN and their environment. Here, we address the largely unexplored class of changing-look (CL) narrow-line Seyfert 1 (NLS1) galaxies. Our focus lies on their detection through the space mission SVOM (Space Variable Objects Monitor). We spotlight NGC 1566, a standout CL AGN known for its great proximity and exceptional outbursts. By examing its NLS1 characteristics, NGC 1566 serves as a local prototype for similar systems yet to be discovered, especially through SVOM. Furthermore, we investigate the broader implications and utility of CL phenomena within NLS1 galaxies, underscoring how a more extensive identification of such systems will significantly propel our understanding of the physics surrounding the rapid growth of supermassive black holes.

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1380

Search for AGN in the early Universe with JWST

Dr Jan Scholtz

Cambridge

Abstract

With the first year of JWST data, AGN have been in the forefront of galaxy evolution, as an explanation of AGN early quescient galaxies, stochastic star formation and their contribution to the re-ionisation of the Universe. In this talk, I give an overview of identification of AGN at high redshift with rest-frame UV and optical data, its challenges and a need for new photoionisation modelling. Finally, I will discuss the properties of AGN host galaxies, their co-evolution with galaxies and our current constraints on seeding of the supermassive black holes with AGN observations up to z=11.

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The Nature and Impact of Radio-quiet AGN on their Host Galaxies

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[2]Indian Institute of Astrophysics

Abstract

Active galactic nuclei (AGN) are the energetic and luminous centres of massive galaxies that are powered by mass accretion onto supermassive black holes. AGN are expected to influence galaxy evolution through their outflows, which are especially prominent at radio frequencies, as well as through ionising radiation from their accretion disks. This process is known as "AGN feedback" and is essential to explain a wide variety of astrophysical phenomena including the tight correlation observed between the black hole mass and the galactic bulge mass. The vast majority of AGN are however "radio-quiet" and have radio outflows that barely extend beyond their own host galaxies. I will present multi-scale and multi-band data on eclectic samples of radio-quiet AGN and demonstrate that in spite of their radio compactness, radio-quiet AGN can influence the gas and star-formation in their host galaxies through jets and thereby act as agents for radio-mode AGN feedback. I will present data showing that jet formation and propagation, especially in radio-quiet AGN, is likely to be a complex process and therefore warrants regular Very Long Baseline Interferometry (VLBI) monitoring to be fully understood. In particular, I will discuss how two-epoch VLBI observations of some LINER galaxies are revealing superluminal jet motion in them, suggesting that relativistic jets can also be present in radio-quiet AGN, similar to those in the more powerful radio-loud AGN. I will discuss the implications of these findings on the larger question of the radio-quiet/radio-loud AGN divide.

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The Complex Star Formation History of the Halo of NGC5128 (Cen A)

Mr. Mahdi Abdollahi[1], Ms. Sima Taefi Aghdam[1], Dr. Atefeh Javadi[1], Mr. Seyedazim Hashemi[2,3], Dr. JACCO TH. VAN LOON[4], Dr. Habib Khosroshahi[1], Ms. Roya Hamedani Golshan[5], Dr. Elham Saremi[1,6,7], Dr. Maryam Saberi[8]

[1]School of Astronomy, Institute for Research in Fundamental Sciences (IPM). [2]Department of Physics and Astronomy, University of California Riverside. [3]Department of Physics, Sharif University of Technology. [4]Lennard-Jones Laboratories, Keele University. [5]I. Physikalisches Institut, Universität zu Köln. [6]Instituto de Astrofisica de Canarias, C/ Via Làctea s/n. [7]Departamento de Astrofisica, Universidad de La Laguna. [8]Rosseland Centre for Solar Physics, University of Oslo

Abstract

NGC5128 (CenA) is the nearest giant elliptical galaxy and one of the brightest extragalactic radio sources in the sky, boasting a prominent dust lane and jets emanating from its nuclear supermassive black hole. In this paper, for the first time in a galaxy outside the Local Group, we construct the star formation history (SFH) of two small fields in the halo of NGC5128: a northeastern field (Field 1) at a projected distance of ∼ **18.8** kpc from the center, and a southern field (Field 2) ∼ **9.9** kpc from the center. Our method is based on identifying long-period variable (LPV) stars that trace their sibling stellar population and historical star formation due to their high luminosity and strong variability; we identified 395 LPVs in Field 1 and 671 LPVs in Field 2. Even though the two fields are ∼ **28** kpcs apart on opposite sides from the center, they show similar SFHs. In Field 1, star formation rates (SFRs) increased significantly around t ∼ **800** Myr and t ∼ **3.8** Gyr; and in Field 2, SFRs peaked around t ∼ **800** Myr, t ∼ **3.8** Gyr, and t ∼ **6.3** Gyr, where t is lookback time. The increase in SFR ∼ **800** Myr ago agrees with previous suggestions that the galaxy experienced a merger around that time. The SFH reconstructed from LPVs supports a scenario in which multiple episodes of nuclear activity lead to episodic jet-induced star formation.

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The nature of changing-look AGNs: a journey through multi-epoch spectroscopy and multi-wavelength studies

Dr. Dawei Xu[1,2], Dr. Jing Wang[3]

[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China. [2]University of Chinese Academy of Sciences, Beijing, China. [3]Guangxi University, Nanning, China

Abstract

"Changing-look" active galactic nuclei (CL-AGNs), as AGNs with a temporary appearance or disappearance of their broad emission lines, show a spectral transition within a timescale of years to decades. The nature of this rare phenomenon remains an open question. Our research has delved into the multi-epoch spectroscopy and multi-wavelength studies of CL-AGNs. Here, we highlight (1) the spectroscopic identifications of new CL-AGNs; (2) Swift/XRT follow-up observations that reveal the association of the CL phenomenon in two recently identified repeat CL-AGNs is with either X-ray luminosity or X-ray spectral slope; and (3) the investigation of the coevolution between SMBHs and their hosts by examining the newly identified CL-AGNs in a sample of local "partially obscured" AGNs.

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1483

Quasar environments

Mrs. Maria Stone

University of Turku. Finnish Centre for Astronomy Research with ESO (FINCA)

Abstract

In this talk, I present research done throughout my PhD on investigating quasar environments using observations in the optical and near-infrared regimes.

Galaxies are termed as the visible 'building blocks' of the Universe. However, they do not exist in isolation. There is an exchange in energy and matter between the galaxy and its environment. Certain galaxies have active supermassive black holes in their centers, and are called 'active galactic nuclei' (AGN). Active galaxies have high luminosities from non-stellar emission, sometimes outshining the host galaxy starlight. The emission spans the full electromagnetic spectrum. The size of the emitting region is very small compared to the scale of the host galaxy. There are many unanswered questions about AGN, including the mechanisms responsible for triggering and maintaining this activity. AGN are broadly divided into two groups: Type I quasars which show broad and narrow emission lines in the optical, and Type II quasars which only exhibit the narrow emission lines. In my research, I use observations of the environments to understand AGN and their role in the evolution of galaxies. During my PhD studies, I focused on studying in particular the environments of nearby Type I quasars and compare them to inactive galaxies, using survey data (GAMA, SDSS) and new observations. In several papers included in my dissertation, it has been shown that major mergers do not seem to be the dominant mechanism for triggering the less distant quasars, and our data is more consistent with alternative scenarios: secular evolution and minor mergers.

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1501

Active galactic nuclei (AGN) in the green valley

Dr Antoine Mahoro[1], Prof Pović Mirjana Pović[2,3,4], Prof Petri Väisänen[1,5], Prof Pheneas Nkundabakura[6], Dr Kurt van der Heyden[7]

[1]South African Astronomical Observatory (SAAO). [2]Space Science and Geospatial Institute (SSGI), Entoto Observatory and Research Centre (EORC). [3]InstitutodeAstrofisicadeAndalucía(IAA-CSIC). [4]MbararaUniversityofScienceandTechnology(MUST). [5]Finnish Centre for Astronomy with ESO. [6]University of Rwanda. [7]University of Cape Town

Abstract

We present a study of properties of active and non-active galaxies in the so- called green valley, suggested to be a parameter space where galaxies undergoing morphological transformation may be found. We studied the connections of the far-infrared active and non-active galaxies at 0.2<= z <= 1.2 using public data from the COSMOS field, one of the largest and deepest galaxy surveys, and our own data from the 11m-SALT. In particular, we studied their star formation rate, morphological properties and stellar populations, as well as the [OIII]λ5007 Å emission line profile in order to characterise gas flows in the galaxies.

Overall, we found that far-infrared AGN green valley galaxies in our sample have enhanced star formation rate in comparison to non-AGN green valley galaxies, suggesting that if there is any influence of the AGN on the star formation properties of their host galaxies, it would be positive AGN feedback, rather than negative feedback that has been suggested in most previous X-ray and optical studies.

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1510

MeerKAT and uGMRT search for restarted radio AGN in the XMM-LSS field

Tombo Fitahiana Rarivoarinoro[1,2,3], Dr Zara Randriamanakoto[3], Prof Russ Taylor[2,1], Dr Dharam Lal[4]

[1]University of Cape Town. [2]Inter-University Institute for Data Intensive Astronomy. [3]South African Astronomical Observatory. [4]National Centre for Radio Astrophysics

Abstract

AGN are known to undergo multiple cycles of nuclear activity but the mechanisms behind these are still under debate. However, such details are crucial information for understanding galaxy evolution and the mechanisms driving jet triggering. By using 250 to 1400 MHz observations of the XMM-LSS field from the superMIGHTEE/uGMRT (σ = 4 µJy/beam) and the MIGHTEE/MeerKAT (σ = 1.5 µJy/beam) surveys, we select a parent sample of 300 sources. From visual inspection, we classify eleven potential restarted radio galaxies. Most of them are characterized by the so-called Double-Double Radio Galaxy (DDRG) morphology, where the source displays a double pair of lobes which have been proven to be an imprint of radio AGN intermittency. However, in some cases, we found sources that have the DDRG structure in only one side which might be due to nonuniform density across the source environment or it might be a tantalizing hint of different timing in the restarting activity in both sides of the galaxy. By using other classification criteria, including high core prominence and steep core, we expect to discover other restarted radio AGN. Afterwards, we will investigate how the host environment influences the radio AGN duty cycle. Furthermore, superMIGHTEE observations will offer sensitive polarization information in addition to MIGHTEE-pol. We will therefore trace the polarization properties of our classified restarted radio AGN. This will allow the exploration of magnetic field roles in radio AGN duty cycle which might complement the picture of radio AGN that we have so far.

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1520

An overdensity of Lyman Break Galaxies around Hot Dust Obscured Galaxies

Dr. Dejene Zewdie

Instituto de Estudios Astrofísicos, Facultad de Ingeniería y Ciencias, Universidad Diego Portales, Av. Ejército Libertador 441, Santiago, Chile. Centre for Space Research, North-West University, Potchefstroom 2520, South Africa

Abstract

Studying the environments of high-redshift galaxies is crucial for understanding the physics of the early Universe and providing insights into how galaxies evolve across cosmic time. The Lyman break selection approach is one of the well-used techniques for studying the environment of high-redshift galaxies. A population of hyper-luminous obscured quasars known as Hot Dust - Obscured Galaxies (Hot DOGs) were identified by the Wide-field Infrared Survey Explorer satellite telescope (WISE). We are studying the environment of the most luminous 3 Hot DOGs. We found an overdensity of LBGs around each Hot DOG. Our results strongly suggest that Hot DOGs are an excellent tracer of protoclusters. In this talk, I will discuss our interesting results about the environment of Hot DOGs, which are somewhat higher than what is typically found for radio galaxies and luminous quasars at a similar redshift.

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The South Pole Telescope AGN Monitoring Campaign: First Release of SPTpol Bright AGN Lightcurves

Dr. John Hood

University of Chicago

Abstract

The South Pole Telescope (SPT) collaboration has started a campaign to monitor active galactic nuclei (AGN) that will grow to include more than 1,000 sources. Here, we show SPT AGN light curves and data for 100+ sources that are being made publicly available for the first time. We show data from the SPTpol instrument, which was designed for observations of the CMB at angular scales of 1 arcminute and larger and ran from 2012 to 2016. These observations come from the 500-square-degree SPTpol survey field, which was covered several times a day using detectors that were sensitive to radiation in bands with centers at 90 and 150 GHz. We discuss the data processing pipeline, the matched filter process, and the source selection parameters. We also show light curves for selected sources and variability statistics for the full sample. All of the data products we show here will be available for download through the SPT Treasury Record of AGN With Historical Activity and Time Series, or STRAWHATS, catalog. This is the first step in a larger release that will include polarized AGN light curves from SPTpol data and three-band polarized light curves from the ongoing SPT-3G survey. This project will serve as a basis for monitoring AGN with current and future CMB experiments like Simons Observatory and CMB-S4, as well as multi-wavelength studies with facilities like VRO-LSST and Strobe-X.

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1548

Identifying interesting AGN in DINGO continuum images

Mr Muphulusi Nekhavhambe

Dr Jacinta Delhaize University of Cape Town. Dr Robin Cook University of Western Australia

Abstract

To obtain a complete picture of galaxy evolution and active galactic nuclei (AGN), we need to observe them at different wavelengths. At radio wavelengths, radio continuum observations provide an insight into some of the most energetic phenomena that occur within galaxies, namely star formation and feedback from supermassive black holes. The Deep Investigations of Neutral Gas Origins (DINGO) survey, recently conducted on the Australian Square Kilometre Array Pathfinder (ASKAP), was primarily designed as an HI spectral line survey, however it simultaneously provides sensitive continuum observations. We present a first look at DINGO continuum maps within the Galaxy and Mass Assembly (GAMA) fields G23, G15, and G09. We have performed initial source finding using both PyBDSF and PROFOUND. By comparing these, we have developed a technique to automatically identify AGN with interesting, extended features such as wide-angle tails and precessing jets.

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The co-evolution of the earliest supermassive black holes and their host circumgalactic media

Dr Jake Bennett

CfA | Harvard & Smithsonian

Abstract

Current and future use of instruments like ALMA, JWST and the SKA will allow a detailed investigation of the surroundings of high-redshift massive galaxies, allowing us to probe the processes driving the evolution of them and their gaseous haloes. Of particular interest is the potentially competing roles of cosmological inflow and feedback from supermassive black holes (SMBHs).

The largest SMBH discovered at z > 6 to date has an inferred mass in excess of 10^10 solar masses, raising questions about both how they reach such a size, and the impact these monster BHs have on their surroundings at early times. The role they could play in heating the gas around early quasars, cutting off inflows and interrupting star formation, is so far largely unconstrained. Additionally, as the masses inferred from observations have a significant associated uncertainty, it is important to explore how the use of probes of the CGM could also be used to further constrain early BH growth in protoclusters.

We use cosmological simulations to study such systems, looking at how the accretion of material onto the protocluster leads to black hole growth, and in turn how the host is impacted by feedback from that growth. We further discuss predictions for observations, across a range of wavelengths, of such an object.

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Variability analysis of a subsample of Southern Calibrators Observed by MeerKAT

Ms Elizabeth Kamau

Rhodes University

Abstract

Calibration is a crucial process that ensures that radio interferometers like MeerKAT and the upcoming Square Kilometre Array provide accurate scientific products. Calibrators are objects in the sky whose characteristics are utilized to calibrate radio arrays. Ideal calibrators should be bright, compact, and most importantly, be a non-variable radio source. We investigate the intrinsic variability of a MeerKAT calibrator subsample, building on previous studies of potential southern calibrators observed by KAT7 as MeerKAT provides a higher resolution and sensitivity. We perform data reduction on raw data, imaging, and light curve extraction for observed calibrators. We also conduct a statistical analysis to analyze flux variability quantitatively. At length, this assessment of the intrinsic variability of calibrators is crucial for understanding their behavior, phenomena that cause extrinsic variability and ultimately improving radio array calibration.

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Multi-wavelength properties of Herschel blazars

Mr Mekuanint Hailemariam, Prof Lerothodi Leeuw

University of Western Cape

Abstract

The universe undergoes several processes that lead to the production of gamma rays. Among the processes are supernova explosions, energetic electrons interacting with magnetic fields, and cosmic rays interacting with interstellar gas. The detection of electromagnetic radiation and high- energy particles from galactic and extragalactic sources is crucial to studying the properties of the sources and how high-energy particles accelerate and propagate in the interstellar medium. Nowadays, the availability of high-accuracy data from various telescopes (i.e., from radio to gamma-ray observing facilities) makes it convenient to study a wide range of astronomical phenomena in our universe, ranging from studying radiation from compact sources, like the case of active galactic nuclei (AGNs), to probing the large-scale structure of the universe. In this project, we are investigating the multi-wavelength properties of gamma-ray blazars in the Herschel field. I cross-matched the Herschel catalog with the ROMA-BZCAT catalog, which has gamma-ray blazars, in order to identify blazars in the Herschel catalog. We also look into the Fermi sources in Herschel's footprint.

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Temporal and spectral study of the BL-Lacertae during 2021 flare

Dr Rukaiya Khatoon, Prof. Markus Boettcher

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Abstract

BL Lacertae, the prototype of the BL Lacertae (BL Lac) class of blazars, underwent a massive outburst across multiple wavebands during the months of July and August 2021. Specifically, the Fermi Gamma-ray Space Telescope's Large Area Telescope (Fermi-LAT) recorded bright γ-ray emission on July 30, 2021, detecting an 0.1 – 500 GeV γ-ray flux of approximately 0.9 × 10−5 photons cm−2 s−1. Simultaneously, the Swift-XRT/UVOT monitored the source across X-ray, optical, and UV wavelengths during the γ-ray flare. Remarkably high levels of brightness were detected. We investigated the source's variability by examining its fractional variability amplitude. This analysis revealed a pattern of variability with the highest variability occurring in gamma-rays, succeeded by X-rays, then optical, UV, and radio emissions. To elucidate the observed major activity episodes in July and August 2021, we employed a time-dependent leptonic model that incorporates diffusive shock acceleration and radiation transfer. By employing this model, we were able to reproduce the broadband spectral energy distributions and the corresponding light curves. This approach provided valuable insights into the acceleration of particles during these significant periods of heightened activity.

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Arrival Direction Studies of Ultra-High-Energy Cosmic Rays Detected by the Pierre Auger Observatory

Dr. Bruno Lago

CEFET/RJ - UnED Petrópolis

Abstract

The origin of ultra-high-energy cosmic rays remains an enigmatic phenomenon, and studies about their arrival direction play an important role in the attempt to solve this issue. The Pierre Auger Observatory, located in Argentina, stands as the world's largest cosmic ray observatory exhibiting an effective area spanning 3,000 km² and an accumulated exposure of 135,000 km² yr sr over 19 years of operation. These studies are performed using the events reconstructed with the surface detector of the Observatory over the entire field of view which covers about 85% of the sky. To analyze large angular scales in the distribution of arrival directions, we employ a combined Fourier analysis in right ascension and azimuth above the full trigger efficiency. The “east–west” method is used for energies at which the efficiency is small. For studies on small and intermediate angular scales, our approach involves blind searches for overdensities, investigations around the Centaurus region, and likelihood analyses using astrophysical catalogs. At large scales, we observe a first-harmonic modulation in right ascension above 8 EeV with a significance of 6.9σ. This suggests an extragalactic origin above this energy. Above ~ 40 EeV the intermediate-angular-scale analyses reveal an excess near Cen A with a significance of 4.0σ, while catalog-based searches yield a 3.8σ signal from nearby starburst galaxies. These results provide crucial insights into the origins and distribution of ultra-high-energy cosmic rays, advancing our understanding of cosmic ray astrophysics and underscoring the unique capabilities of the Pierre Auger Observatory in unraveling cosmic mysteries.

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X-ray properties of high-redshift Radio Loud and Radio Quiet Quasars observed by Chandra

Ms Fatma Shaban

Cairo University

Abstract

We performed a study of high redshift ($z > 2$) quasars, looking for the main differences between Radio Loud Quasars (RLQ) and Radio Quiet Quasars (RQQ) in the X-ray band. Our sample of 472 RQQ and 81 RLQ was selected by cross-matching the SDSS DR7 quasars catalog with the Chandra Source Catalog. We computed the X-ray luminosity for the two samples and confirmed the X-ray luminosity excess of RLQ over RQQ. We fit the X-ray spectra assuming the absorbed power law model and obtained the photon index (Γ) values for all the sources in the sample. We excluded quasars with a low number of counts (<10) and large uncertainty on the best-fit photon index ($\Gamma_{err} > 1$), and obtained the mean values of $\Gamma_{RLQ} = 1.70_{-0.33}^{+0.36}$ and $\Gamma_{RQQ} = 2.19_{-0.44}^{+0.46}$ for the RLQ and RQQ samples, respectively, showing that the RLQ have flatter (harder) X-ray spectra than RQQ. The Kuiper-two test confirms this result with the significant difference between the RLQ and RQQ photon index distributions ($D_k = 0.37$ and P-value $=10^{-6}$). We also evaluated the hardness ratio distributions and confirmed that the spectra of RLQ are flatter than the spectra of the RQQ. The RLQ's hard-to-soft ratio distribution is skewed towards the hard X-ray band, while the RQQ is towards the soft X-ray band. The hard-to-medium and medium-to-soft ratios show no difference.

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Investigating the radio properties and star formation activity of galaxy population at higher z.

MSc Student Miora Mbolatiana Randrianasy[1], Pr. Solohery Randriamampandry[2,3]

[1]Astrophysics and Astronomy - Faculty of Sciences - University of Antananarivo. [2]Head Astrophysics and Astronomy - Faculty of Sciences - University of Antananarivo. [3]Postdoctoral Research Fellows SAAO

Abstract

Galaxies are captivating celestial objects, with intricate dynamics that astronomers explore. This reveals the fundamental processes behind their formation and evolution, providing profound understanding of our vast universe.

In this study, we investigate the radio properties and star formation activities of galaxies using archival data from the COSMOS surveys, encompassing a broad spectrum of observations, from optical to radio frequencies, coupled with associated redshift information. Our research incorporates 3GHz data, covering an extensive region of approximately 1.8 square degrees within the COSMOS field. Additionally, we analyze the data using photometric redshift, cataloging an impressive 10,830 sources detected at or above the 5σ significance level, effectively spanning a generous 2-square-degree area of the COSMOS field. To enhance our analysis, we also plan to integrate publicly available radio data obtained from SKA MeerKAT/MIGHTEE continuum observations conducted within the COSMOS field.

In this poster, we outline the primary objectives of our research project and provide an overview of the data sources we are working on. We present our initial findings and provide a glimpse into our future work.

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Where do high-z quasars live?

Dr. Tommaso Zana

Sapienza, University of Rome

Abstract

According to theoretical models, including numerical simulations and clustering studies, the most massive supermassive black holes at high redshift are expected to reside at the centers of the most massive dark matter halos. This is also a fundamental requirement to explain the steady and efficient gas inflow necessary for the fast growth of such compact objects.
A denser environment would result in a region with a more numerous population of satellite galaxies around the quasar.
However, observational data has not yet provided clear evidence of this scenario, since there are both observations reporting numerous companion galaxies orbiting around a quasar, as well as numerous quasars with no apparent satellite. This discrepancy has been triggering active debates throughout the community.
A possible satellite misdetection may be due to the quenching effect of quasar feedback on its companion galaxies.
Although this process has been frequently blamed to explain why some observations cannot detect enough quasar satellites, I will demonstrate, through the use of cosmological hydro-simulations, that quasar feedback is generally positive on companions, enhancing their star formation activity.
I will then focus on the intrinsic geometrical bias introduced by the ALMA telescope and, in general, by any limited-field of view instrument. I will show a rigorous statistical framework to interpret a recent observational survey of high redshift satellites and conclude that observations do not disagree with each other, thus confirming the high-density scenario.

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1646

Comparison of AGN luminosity distances and cosmological parameters derived using the X-ray/UV and BLR radius-luminosity relations

Dr. Michal Zajaček[1], Prof. Bozena Czerny[2], Dr. Narayan Khadka[3], Prof. Bharat Ratra[4]

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Abstract

Active galactic nuclei (AGN) are promising alternative probes in cosmology due to the fact that they are localized both in the local Universe as well as at higher redshifts, when first galaxies were just forming. In this regard, they partially bridge local measurements performed using calibrated type Ia supernovae and distant measurements provided by the cosmic microwave background. They could thus help solve current tensions in cosmology, such as the Hubble tension. Up to now, two relations have been employed to standardize AGN: X-ray/UV luminosity relation and the broad-line region radius-luminosity relation. In Khadka et al. (2023), we tested both relations using the sample of 58 reverberation-mapped, X-ray detected AGN. While the radius-luminosity relation yields cosmological constraints consistent with the standard flat LambdaCDM model, the X-ray/UV luminosity relation prefers the matter parameter significantly larger than given by standard cosmological probes. In addition, the distribution of the differences of the two luminosity distances has a peak that is positively shifted with respect to zero and the distribution is clearly asymmetric. In Zajacek et al. (2024) we found that the differential extinction of X-ray and UV photons always contributes to the difference in the luminosity distances inferred using the two standardization methods. For the studied sample, we quantify the amount of extinction to be ~0.03-0.28 mag in terms of the X-ray/UV colour index. This amount of extinction is rather mild and consistent with the majority of type I AGN, where it can be attributed to dust in nuclear regions.

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1650

X-Ray Catalog of Radio Galaxies Identified through the MeerKAT Galaxy Cluster Legacy Survey

Dr Satish Sonkamble, Prof. Ilani Loubser

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Abstract

We compiled an X-ray catalog of radio galaxies identified through the MeerKAT Galaxy Cluster Legacy Survey (MGCLS) by cross-referencing data from the Dark Energy Camera Legacy Survey (DECaLS), eROSITA X-ray survey, Mid-IR WISE survey, and LoTSS 144 MHz radio survey. Numerous radio galaxies were detected in the soft X-ray range (0.5–2 keV). Our investigation uncovered key statistical characteristics of these sources and examined their mass and accretion properties. We specifically targeted obscured AGN populations using radio and Mid-IR emissions, which remained largely unaffected by obscuration. Luminosity relationships between X-ray and Mid-IR, as well as X-ray and 1.4 GHz radio emissions, were also investigated. We also investigated the connection between the AGN jet and the disk for these sources.

Session

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1658

A New Way to Measure Time Delays for Reverberation Mapping

Prof. William Welsh

San Diego State University

Abstract

The time lag between AGN continuum and broad emission-line light curves gives us an estimate of the light-travel time across the Broad Line Region (BLR), and thus the physical size of the BLR. If velocity-resolved emission line light curves are used, we can then also infer the geometry and flow of the BLR gas, and thus estimate the mass of the supermassive black hole. The cross correlation function (CCF) is the standard way to estimate the time-delay lags. In this work, I present a new functional form for measuring the lag that offers several advantages over the venerable CCF. This technique is based on the concept of a physical resonance to estimate the lag - it is not an improved numerical method to compute the standard CCF nor a way to handle data gaps. Tests show that it offers higher resolution than the standard CCF, and this is its main strength. It can also provide uncertainties in the lag estimate, and it is very simple to compute. While it is a general technique that can be used to measure the shift between any two time series, the method works well for the reverberation mapping case where the AGN light curves typically contain significant red-noise. The higher resolution yields smaller and more statistically robust uncertainties and sharper velocity-delay maps.

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1675

The LOFAR Two-Metre Sky Survey: Unveiling the nature of the faint source populations and identifying underlying AGN with Prospector

Mr Soumyadeep Das

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Abstract

Spectral energy distribution (SED) fitting has been extensively used to determine the nature of the faint radio source population. Recent efforts have combined fits from multiple SED-fitting codes to account for the host galaxy and any active nucleus that may be present. We show that it is possible to produce similar-quality classifications using a single energy-balance SED fitting code, Prospector, to model up to 26 bands of UV - far-infrared aperture-matched photometry for over 31000 sources in the ELAIS-N1 field from the LOFAR Two-Metre Sky Survey (LoTSS) Deep fields first data release. One of a new generation of SED-fitting codes, Prospector accounts for potential contributions from radiative active galactic nuclei (AGN) when estimating galaxy properties, including star formation rates (SFRs) derived using non-parametric star formation histories. Combining this information with radio luminosities, we classify 92 per cent of the radio sources as a star-forming galaxy, high/low-excitation radio galaxy, or radio-quiet AGN and study the population demographics as a function of 150 MHz flux density, luminosity, SFR, stellar mass, redshift and apparent r-band magnitude. Finally, we investigate the SFR--150 MHz luminosity relation for a sample of 133000 3.6 micron-selected z<1 sources, finding that the stellar mass dependence is significantly weaker than previously reported, and may disappear altogether at moderate to high SFR regimes. This study makes it significantly easier to classify forthcoming radio source samples from LoTSS and elsewhere, and have important implications for upcoming radio frequency studies of star-forming galaxies.

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1681

Merger-AGN connection in galaxy close pairs

Miss Josephine Chishala[1], Prof Roberto Depropris[1], Dr Mirjana Povic[2]

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Abstract

Most (if not all) galaxies host a supermassive black hole (SMBH) in their center. When these SMBHs accrete cold gas, and the viscous drag on the accretion disks produces a highly luminous source we identify as an active galactic nuclei (AGN). AGNs are some of the most luminous sources of electromagnetic radiation in the universe. It is commonly assumed that AGNs are triggered by violet relaxations such as the ones that occur in mergers and interactions which induce feedback that suppresses star formation. Therefore, suggesting a connection between Mergers, AGN activity, and star formation. However, this is not observational well supported. Despite decades of years being dedicated to establishing a connection between the three, the theoretical and observational results remain inconsistent, leaving an open question on the topic, and indicating the need for additional studies to be carried out. In this work, we aim to go a step further in understanding the connection between galaxy mergers, AGN activity, and star formation. This will be achieved using a mass-selected sample of low redshift($z < 0.1$) galaxies in dynamically close pairs. We will test for increased star formation and AGN activity via their NUV -r colors and x-ray luminosity as a function of pair separation in projected distance and velocity. We compare the properties of the widely separated objects to those of galaxies at smaller separations and therefore more likely to be interacting.

Session

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1707

Multi-phase and multi-wavelength: the feeding and feedback AGN cycle revealed by sensitive observations of the ISM

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Abstract

MAGNHIFFIC (MeerKAT AGN HI feeding and feedback investigation close-by) is an on-going survey of 16 nearby (<40 Mpc) active galactic nuclei (AGN) which leverages the combined power of sensitive and high resolution MeerKAT, ALMA and MUSE observations to study how the multi-phase gas sustains the AGN feeding and feedback loop. MeerKAT's wide field of view and sensitivity to low-column density neutral atomic hydrogen (HI) allows us to simultaneously probe the small scales near the super-black hole (SMBH), the larger scales of the galactic disks and the environments of nearby AGN. ALMA and MUSE observations probe at parsec resolution the kinematics and physical conditions of the molecular and ionised gas fuelling the SMBH and/or flowing out of the circum-nuclear regions and galaxy because of feedback from the AGN radiative wind and jets.

I will show recent results from four radio-jetted sources which together cover the full range of nuclear activities, i.e. newly started activity, jets piercing through the gaseous medium of the host galaxy and sources with giant radio lobes. The multi-wavelength observations allowed us to infer which mechanisms fuel and sustain the nuclear activity, distinguishing, for example, between ‘external’ phenomena (mergers and interactions) and ‘internal’ phenomena (cold chaotic accretion, secular events). Furthermore, we identified how the multi-phase gas fuelling the nuclear activity is also affected by the energetic feedback of the expanding radio jets, and how these two mechanisms can co-exist self sustaining the nuclear activity.

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1719

Was the recent AGN activity of PKS 2014-55 triggered by a merger?

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Abstract

PKS 2014-55 is a unique radio galaxy; it classifies as a giant, X-shaped and more importantly shows three separate epochs of AGN jet activity revealed by deep observations with the South African MeerKAT radio telescope. What gives rise to this recurrent activity is not yet fully established. Here we present new high spectral resolution MeerKAT observations of HI absorption near the core of PKS 2014-55, which may give clues to the recurrent AGN activity. The multi-component spectrum reveals three features, all redshifted relative to the systemic velocity of the radio core, suggesting an inward motion of gas clouds towards the core. Notably, all three components exceed the galaxy's typical rotational velocity of approximately 100 km/s, suggesting potential infall into the supermassive black hole and subsequent AGN fueling. At present, there is no conclusive evidence linking the redshifted gas directly to fueling the AGN. For completeness, we consider alternative explanations: the least redshifted and strongest components may represent regularly rotating gas, as they remain relatively close to the galaxy's rotational velocity. In contrast, the broad component could be a foreground cloud of warm gas gravitationally bound by PKS 2014-55. We also detect HI emission from nearby dwarf galaxies. The recent reactivation of PKS 2014-55, coupled with the spatial proximity of these dwarf galaxies, suggests a possible merger as a triggering event. Our observations help put constraints on the neutral hydrogen dynamics correlated with restarted jet activity. This finding underscores the significance of such interactions as potential drivers of AGN activity.

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1721

Unveiling the Optical Variability of Blazar OJ 287: Insights from Kottamia Astronomical Observatory

Mr Eslam Elhosseiny

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Abstract

Blazars, driven by supermassive black holes at the hearts of active galaxies, exhibit remarkable variability across the electromagnetic spectrum. Among these, OJ 287 stands out for its intriguing behavior. In this study, we conduct a thorough analysis of OJ 287's optical variability, utilizing raw data from the Kottamia Astronomical Observatory's (KAO) 1.88m telescope.

From December 28, 2021, to January 29, 2024, we monitored OJ 287 over 123 nights , with five nights of continuous observation detecting minimal variability. Leveraging high-temporal-resolution data, we probe mechanisms driving its variability across various time scales, from intra-night fluctuations to long-term trends.

Statistical analyses and comparisons with theoretical models yield insights into the underlying processes governing blazar variability. Our findings underscore the significance of multi-band observations in unraveling the complexities of blazar behavior, providing crucial constraints for theoretical models. This study advances our comprehension of OJ 287's enigmatic nature, paving the path for further exploration into this captivating cosmic phenomenon.

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1745

Numerical simulations of an intriguing head-tail radio galaxy in the outskirts of Abell 754

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Abstract

Low-frequency radio images have been used to map several clusters of galaxies. One of this clusters is Abell 754 (A754), formed from an ongoing collision between two smaller substructures. Besides a diffuse halo-like emission and radio relics, observations at frequencies below some GHz revealed the presence of a fainter radio source towards the eastern border of A754. Its complex morphology resembles that seen in head-tail galaxies, where the jet and counter-jet are bent back close each other, in the opposite direction from the brighter core-like feature (coincident with its optical host galaxy) seen in the radio maps. In this work, we explore the scenario where those bends are produced by ram-pressure forces due to the relative motion of the host galaxy through the intracluster medium. Viable orbits of this active galaxy are integrated numerically considering observational constraints from multiwavelength observations of A754 and the own target galaxy. Three-dimensional magnetohydrodynamic simulations are used to evolve a pair of jets emanating from the galaxy's core, which moves through the A754's environment according to the orbits derived previously. Our numerical results suggest the feasibility of the ram-pressure scenario in the case of this galaxy.

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1767

Investigating the X-ray jet emission mechanism of two radio-loud quasars at z ~ 3

Jaya Maithil[1], Daniel Schwartz[1], Aneta Siemiginowska[1], Preeti Kharb[2], Chi C. Cheung[3], Doug Gobeille[4], Herman Marshall[5], Giulia Migliori[6], John Wardle[7], Diana Worrall[8], Bradford Snios[1]

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Abstract

One of the outstanding questions in extragalactic astrophysics is unraveling the interplay between actively accreting supermassive black holes and their host galaxies. A pivotal aspect of this inquiry involves studying energetic jetted outflows, which transport energy from the galactic center to spatial scales spanning from milliparsecs to megaparsecs. While jets are primarily observed at radio wavelengths in nearby quasars, several factors favor X-ray jets at high redshifts. The X-ray emission in relativistic jets is attributed to the inverse Compton scattering of the cosmic microwave background (IC/CMB), which is enhanced by the $(1+z)^4$ increase in CMB energy density at high redshifts. Conversely, the radio surface brightness undergoes a cosmological dimming of the same factor. Additionally, the electrons responsible for X-ray production via IC/CMB have longer lifetimes compared to electrons emitting GHz synchrotron radiation. The detection of X-ray jets in high-redshift quasars is limited, making the findings of each detection crucial for understanding the trends in jet populations across cosmic time. This study focuses on two z~3 radio-loud quasars that present kiloparsec-scale extended X-ray emission but lack an extended underlying radio jet. Their VLBI observations confirm relativistic jet speeds. I will present the follow-up deeper Chandra X-ray and high-resolution, high-sensitivity Very Large Array 6 GHz radio observations of these quasars. Using the IC/CMB model, I will present the constraints we found on relativistic beaming parameters and magnetic fields, providing insights into the enthalpy flux of these high-redshift quasar jets.

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1805

Investigating the nuclear activity in the least dense regions of the nearby Universe

Dr Ignacio del Moral-Castro

Pontificia Universidad Católica de Chile

Abstract

Unveiling the mechanisms that trigger active galactic nuclei (AGN) is a crucial problem for our understanding of the galaxy formation and evolution. Interactions/mergers are associated with powerful AGN, less luminous AGN would be driven by secular processes. Despite recent optical studies trying to identify triggering mechanisms in the local Universe, the main drivers for AGN triggering in isolated galaxies still remain unclear.

Large-scale galaxy distribution reveals a foam-like structure, characterized by filaments, sheet-like walls, dense clusters, and under-dense regions called voids (~70% of the Universe's volume), which are not devoid of galaxies despite their names. Void galaxies are negligibly affected by interactions/mergers, so their evolution is mostly due to internal evolution. They might have gone through a different dark halo mass assembly than galaxies in denser environments, suggesting an influence of the large-scale environment on the black hole growth. However, the number of studies characterising AGN in voids is scarce.

Are the properties of the host galaxies in different environments different? What does this tell us about the co-evolution of AGN and their host galaxies? We will try to shed light on these fundamental topics presenting the current state of our southern-northern hemisphere project using data from the on-going CAVITY survey (Domínguez-Gómez, J., Nature, 2023, Pérez et al. submitted), the first statistical study of galaxies in voids. We will characterise the abundance of AGN in voids, their position within these regions and their properties studying the possible influence of void environment and differences with other environments.

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1810

Investigation of Inverse Compton Emission and Cooling Processes in Relativistic Particle Acceleration at Shear Boundary Layers within Relativistic Jets

Dr. Tej Chand[1,2], Prof. Markus Boettcher[2]

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Abstract

Relativistic jets within active galactic nuclei (AGN) and gamma-ray bursts (GRBs) are structured with a fast inner spine surrounded by a slower outer sheath, forming shear boundary layers (SBLs). We present findings from particle-in-cell (PiC) simulations investigating magnetic field generation from initially unmagnetized plasma and particle acceleration within these SBLs. Specifically, we examine the impact of inverse Compton cooling on relativistic particles, incorporating self-consistent calculations of the resulting radiation spectrum. Our results demonstrate significant Compton cooling influenced by the energy characteristics of the external radiation field. Additionally, we observe strong anisotropy in the emitted radiation, particularly along the jet direction. This study sheds light on the dynamics of relativistic jets and offers potential insights into the Doppler Factor Crisis.

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1812

The Spectral Ages of GRGs with MeerKAT

Ms Kathleen Charlton[1], Dr Jacinta Delhaize[1], Dr Kshitij Thorat[2]

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Abstract

Giant radio galaxies are the largest and potentially oldest AGN systems in the universe. Thus they are an ideal laboratory to probe the latest stages of galaxy evolution as well as the surrounding inter-galactic medium. Spectral aging is one technique that can be utilized to determine the distirbution of ages thoughout a source and thus how it has evolved over time. In this study we present a spatially-resolved spectral age analysis of three giant radio galaxies (GRGs) in the COSMOS field. One of these GRGs is reported as such here for the first time with a projected linear size of 1.29 Mpc at z=0.1035. We examine the spectral age distributions of the three GRGs using new MeerKAT Open Time UHF-band (544-1088 MHz) observations, as well as L-band (900-1670 MHz) data from the MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) survey. Two different models of spectral ageing, the Jaffe-Perola and Tribble models, are applied. The results are compared to dynamical ages of GRGs modelled in a standard cluster density environment. Our results are consistent with the theory that the dominant factor in a radio galaxy's size is age, rather than environment or power of the galactic nucleus.

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1815

The incidence of AGN in galaxies with different stellar population ages: probing SMBH fueling mechanisms throughout the galaxy lifecycle

Dr. Qingling Ni

MPE

Abstract

Among galaxies where the global cold gas supply is not sufficient, it has been argued that stellar mass loss may provide an important, additional source of fuel for accretion onto the black hole (BH). Utilizing spectroscopic samples of galaxies from SDSS at z=0−0.35 and the LEGA-C survey at z=0.6−1 that have X-ray coverage from XMM-Newton or Chandra, we test this stellar mass loss fueling scenario by investigating how AGN activity and BH growth vary with the break strength at 4000 Å, Dn4000 (which is closely related to the age of stellar populations), as younger galaxies are considered to have higher stellar mass loss rates. We found that when controlling for host-galaxy properties, the fraction of log LX/M⋆ > 32 (which roughly corresponds to Eddington ratios ≳1%) AGN and sample-averaged black hole accretion rate (BHAR) decrease with Dn4000 among Dn4000 ≲ 1.9 galaxies, suggesting a higher level of AGN activity among younger galaxies, which supports the stellar mass loss fueling scenario. For the oldest and most massive galaxies at z=0−0.35, this decreasing trend is not present anymore. We found that, among these most massive galaxies at low redshift, the fraction of low specific-accretion-rate (31 < log LX/M⋆ < 32) AGN increases with Dn4000, which may be associated with additional fueling from hot halo gas and/or enhanced accretion capability.

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1821

N-body simulations of a clumpy torus in AGNs with dissipation, wind and accretion

Prof. Elena Bannikova[1,2,3], Dr. Peter Berczik[4], Dr. Volodymyr Akhmetov[5,2], Mr. Sergey Skolota[2], Dr. Marina Ishchenko[4], Prof. Massimo Capaccioli[1]

[1]INAF - Astronomical Observatory of Capodimonte, Italy. [2]V.N.Karazin Kharkiv National University, Ukraine. [3]Institute of Radio Astronomy, National Academy of Sciences of Ukraine. [4]Main Astronomical Observatory, National Academy of Sciences of Ukraine. [5]INAF - Astronomical Observatory of Torino, Italy

Abstract

The central regions of active galactic nuclei (AGNs) exhibit a complex dynamics due to a variety of physical mechanisms. An important role is played by the mutual influence of the radiation pressure, which generates winds/outflows, and dissipation effects, which are responsible for the accretion of matter from the torus to the disk. The main goal of our work is to study the mutual influence of the dissipation effects between the clouds in the torus and the wind from the accretion disk. We have performed a set of N-body simulations of the clumpy torus with dissipation effects between clouds which are orbiting around a supermassive black hole (SMBH). The wind is simulated as the radiation pressure from the accretion disk with a dependence on the polar angle. To account for the accretion on the SMBH, we choose a sphere with a radius equal to that of the accretion disk. The clouds passing through this radius are assumed to feed the accretion disk, thus finally increasing the SMBH mass. The result of our simulations shows that the dissipation effects maintain the geometrical thickness of the torus during the whole simulation time. There is a self-regulation of the system, which is provided by the equilibrium between wind and accretion. The dissipation leads to the matter accretion from the clumpy torus with the formation of a ring-like structure between the accretion disk and the torus. This may account for the recent discovery of the ring-like structure in the central region of NGC 1068.

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1840

Resolving extreme star formation and black hole activity in a high redshift quasar

Ms Jayde Bhana

University of Pretoria

Abstract

Understanding feedback processes occurring in quasars and the nature of their faint radio emission is needed to reconcile known theories of galaxy formation and AGN evolution. It is unclear whether the faint radio emission from optically bright quasars is associated with weak jets, star-formation or another process close to the black hole. To shed light on this area, for which there have been several recent statistical studies, I will present new detailed observations of an extremely luminous high redshift (z=3.911) quasar that aims to resolve underlying emission mechanisms at radio wavelengths. The extreme radio luminosity of the gravitationally lensed quasar APM08279+5255 results in a star-formation rate density exceeding the Eddington-limited star-formation rate by a significant fraction. Using very long baseline interferometry (VLBI), we dissect the relationship between star-formation and accretion processes driving quasar activity. First, we present high angular resolution observations (50-100 mas) with the VLA at 22 GHz and e-MERLIN at 1.5 and 5 GHz. With these data, we find evidence for a flat-spectrum radio component associated with the optically bright quasar and evidence for offset steep spectrum emission. Next, using the European VLBI Network (EVN) at 1.7 GHz, we detect a compact radio core with a brightness temperature consistent with AGN activity. However, considerable radio emission is resolved-out on VLBI-scales, suggesting an extended component likely associated with star-formation exists. Our results demonstrate that high angular resolution imaging of both continuum and spectral emission are necessary to interpret weak radio emission found for the large fraction for quasars (>65%).

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1876

A high(er) fraction of Active Galactic Nuclei identified in massive galaxies

Dr. Stephanie Juneau

NOIRLab

Abstract

Supermassive black holes reside at the centers of galaxies and likely play an important role in galaxy evolution via active galactic nuclei (AGN) feedback. However, our understanding of the role of AGN in galaxy evolution is hampered by our incomplete census of AGN. To improve our ability to identify AGN, we investigated the efficacy of traditional optical and infrared AGN diagnostic diagrams using an unprecedented sample of 5.8 million galaxies with optical spectra from the ongoing Dark Energy Spectroscopic Instrument (DESI) survey, which is more than 10 times larger than SDSS in the same redshift range. Combining optical emission line measurements with the deepest available WISE infrared photometry, we have jointly analyzed a variety of different AGN diagnostics, and present new recommendations to more sensitively select AGN. One of our most significant findings is that we infer a higher AGN duty cycle in massive star-forming galaxies relative to previous efforts. This implies an even tighter AGN-host galaxy connection than inferred before. Overall, this work has important ramifications for both AGN classification and the co-evolution of AGN and their host galaxies. Lastly, I will highlight how the DESI spectroscopic survey can further enable a slew of discoveries for follow-up with JWST but also with ALMA, MeerKAT and eventually Rubin thanks to its footprint overlapping with part of the southern hemisphere sky.

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Probing the persistency of ring-like structure in M87 using 86GHz global VLBI observations

Deokhyeong Lee[1], Jae-Young Kim[1,2]

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Abstract

M87 is well-known as an ideal source for studying jet launching and accretion flow because of its proximity, large central SMBH, and large spatial resolution. Since the EHT 2017 and 2018 observations at 230 GHz revealed a persistent black hole shadow in the center of M87, new lower-resolution but higher-sensitivity GMVA+ALMA 2018 observation at 86 GHz also discovered a ring-like structure.

Typically, ring-like structures imprint characteristic signatures in the visibility domain, which can be modeled by geometric models instead of direct imaging.

The GMVA 2020 observation, a new GMVA observation with an upgraded sensitivity, presents the signatures. Motivated by it, we reanalyzed all previously published GMVA observations of M87 to look for the signatures of a ring-like structure in the VLBI core region. We find that these signatures were evident not only in the GMVA+ALMA 2018 observation but also in the archival and 2020 GMVA observations. We then fitted symmetric, geometric ring models to the GMVA observations. This enabled us to explore the persistency and variability of the ring-like structure at 86 GHz.

The analysis suggests that the 86 GHz ring structure is a consistent feature across many epochs, and the 2018 result is not chance coincidence. Furthermore, the 86 GHz ring-like structure is persistently larger than the 230 GHz EHT ring structure. We find indications of time variations in the size of the ring, suggesting that the 86 GHz ring-like structure more likely represents an accretion flow. We will discuss details of these findings in this talk.

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1934

Hunting down young radio AGN with bayesian SED fitting

Emily Kerrison[1,2], Dr Vanessa Moss[2,1], Prof Elaine Sadler[1,2]

[1]University of Sydney. [2]CSIRO Space & Astronomy

Abstract

Identifying the very youngest radio AGN, in which the jets have yet to break out through the ISM of their host, is key to understanding their formation and duty cycle. We know these radio sources exhibit a peak in their spectral energy distribution (SED), but this peak can be a challenge to detect owing to the number of flux density measurements required. I present here RadioSED, a Bayesian modelling framework tailored to classifying broadband radio SEDs by making use of large-area, publicly available radio surveys of the southern sky completed over the last two decades. Moving beyond a simple two-point spectral index, I show how the data provided from recent large-area surveys allow us to examine spectral shape as a function of frequency, which is key to identifying these youngest, most compact radio AGN. I discuss our application of RadioSED to the Stripe 82 field to construct a new, uniform sample of these young radio AGN, for the first time capturing peaks from megahertz through to tens of gigahertz. Not only do we recover all 11 previously published young radio AGN, but we increase this sample by over an order of magnitude, bringing their total to well over 100 in just 300deg^2 of sky. These first science results demonstrate a new radio SEDfitting framework that is robust, reliable and scalable, making it an exciting tool for radio and multiwavelength astronomers alike as upcoming instruments see first light and new all-sky surveys begin across the electromagnetic spectrum.

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MeerKAT observations of fast outflows of cold gas at intermediate redshifts

Dr Elizabeth Mahony[1], Dr Marcin Glowacki[2], Team FLASH[1]

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Abstract

It is well established that AGN feedback plays a crucial role in the evolution of galaxies. One such signature of feedback are fast outflows of cold gas, traced by broad wings observed in HI 21-cm absorption lines in powerful radio galaxies. The sensitivity of MeerKAT, combined with the wide frequency coverage on a radio-quiet site, means it is uniquely suited for searching for these outflows at intermediate redshifts where feedback processes play a critical role in quenching star-formation and transforming galaxies. In this talk I will highlight the complementarity of ASKAP and MeerKAT in searching for these outflows and present results from HI observations of a sample of powerful radio galaxies, exploring how jets interact with the ISM of AGN host galaxies at a critical point in the lifecycle of radio galaxies.

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The Connection Between AGNs and Galaxies at z > 3.5 Revealed by JWST

Dr. Luis Ho

Peking University

Abstract

The intricate mechanism of black hole coevolution within their host galaxies remain enigmatic, particularly in the context of feedback processes. These processes can be investigated by studying the historical ratio of black hole mass to host stellar mass. While black hole mass at high redshifts can be determined through spectroscopic methods, detecting starlight from the host galaxies, particularly in quasars, poses a significant challenge, even with the capabilities of the James Webb Space Telescope (JWST). In this study, we apply a novel multi-band and imaging decomposition tool, GALFITS, to a sample of 42 high-redshift (z > 3.5) spectroscopically confirmed type 1 active galactic nuclei (AGNs), including 15 of the brightest quasars at z >~ 6. Our method utilizes both the spectral energy distribution and the morphological characteristics of AGNs and galaxies, enabling consistent modeling across all JWST NIRCam broad-band images. We achieve a high and robust host detection rate of ~90% across the entire sample, demonstrated with extensive mock simulation tests. Our results indicate that the black hole to stellar mass ratio remains relatively constant for z > 3.5, consistent with local correlations. Additionally, we explore the relationship between black hole mass accretion rate and star formation rate in these type 1 AGNs.

Session

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1972

Finding and Characterizing AGN in the Epoch of Reionization with JWST NIRSpec Spectroscopy

Dr. Sofía Rojas-Ruiz[1], Prof. Tommaso Treu[1], Dr. Guido Roberts-Borsani[2]

[1]University of California - Los Angeles. [2]University of Geneva

Abstract

I will present work using JWST NIRSpec spectra to constrain the abundance of active galactic nuclei (AGN) during the epoch of reionization at redshift $z > 5.5$, or within the first billion years of the universe. Recent studies employing JWST NIRCam imaging have suggested an excess of AGN harboring supermassive black holes (SMBHs) of 10^{6-8} solar masses at such high redshifts. Latest theoretical models of black hole formation predict different number densities of SMBHs depending on light or heavy initial mass seeds. To differentiate between both theoretical pathways, I looked for AGN in public NIRSpec data from JWST Treasury Programs including CEERS, COSMOS-Web, GLASS, JADES, and UNCOVER. All spectra are reduced using the same methodology in order to mitigate biases. The rich spectral information in the rest-UV allows for AGN identification, characterization, and calculation of black hole mass using the H-β emission line. Available multi-wavelength observations in radio and X-ray are used to help classify the sources. I will show insights on the AGN rest-UV luminosity functions at $z > 5$ in increasing one-step redshift bins to measure the abundances and link these results to black hole seeding theories. Finally, using the same redshift bins, I calculate the escaping ionizing fraction of AGN and compare it to that of galaxies during reionization. These findings offer an opportunity to disentangle the origin of SMBHs and are an important precedent to large surveys such as Euclid, and the upcoming Vera Rubin Legacy Survey of Space and Time, and the Roman Space Telescope.

Session

IAUS 394 All-inclusive AGN

1982

AGN can dominate host-galaxy-scale cold dust emission

Jed McKinney[1], Christopher Hayward[2], Lee Rosenthal[3], Juan Rafael Martínez-Galarza[4], Alexandra Pope[5], Anna Sajina[6], Howard Smith[4]

[1]UT Austin. [2]Flatiron Institute. [3]Caltech. [4]Harvard-Smithsonian CfA. [5]UMass, Amherst. [6]Tufts University

Abstract

The conventional wisdom is that long-wavelength (>100 micron) emission from cold (T ~ 20-40 K) dust is heated exclusively by emission from young, massive stars; consequently, the far-IR (FIR) emission at long wavelengths can be used as a 'pure' tracer of star formation even when the bolometric luminosity of the AGN is much greater than that of the host galaxy's stellar population. Recently, a number of groups have revisited this topic by performing radiative transfer on hydrodynamical simulations of AGN-hosting galaxies. I will present simulation results that demonstrate that contrary to the conventional wisdom, obscured AGN can drive cold dust emission on kpc scales, sometimes dominating the dust heating. Consequently, the FIR luminosity may overestimate the star formation rate of the most dust-obscured AGN-hosting galaxies, and high-redshift IR-luminous galaxies may harbor more obscured AGN than we think.

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2023

Decomposing X-ray Variability in Seyfert I AGN with Principal Component Analysis

Dr. Ashkbiz Danehkar

Eureka Scientific, Oakland, CA, USA

Abstract

X-ray surveys of some active galactic nuclei (AGN) in the local universe show stochastic short-term variability at small amplitudes, in addition to long-term state transitions analogous to those seen in X-ray binaries. The origin of such transition X-ray variability is not fully understood, but some of them were ascribed to transient obscuration events caused by eclipsing outflow and others to X-ray coronal flares. In this work, we consider X-ray variability in a group of Seyfert I AGN, including NGC 3783, NGC 3227, Mrk 335, and NGC 4051, whose central regions are less obscured by the AGN torus. We use principal component analysis (PCA) to reduce the dimensionality of the multi-epoch X-ray time-segmented data. This gives us the PCA components that mainly cause the X-ray fluctuations. Our analysis indicates the change in the power-law emitting source, via either obscuration or flaring, is mainly responsible for transition variability. Higher-order PCA components include small variations in ionizing absorbers, which may be caused by time delays between different stratification layers in absorbing outflows, in addition to a tiny contribution (<1%) from relativistically broadened reflection emission likely from light-bending fluctuations near the event horizon, which is consistent with the fact that the supermassive black hole spin remains stable over the course of multi-epoch observations. We see that PCA decomposition could help us make X-ray variability in AGN less complicated, leading to simpler data that could be used for more accurate spectral analysis with machine learning algorithms.

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2069

The relationship between SMBHs and their host galaxies at intermediate redshift in the variability-selected AGN sample

Atsushi Hoshi

Tohoku University

Abstract

Unveiling the relationship between SMBHs and their host galaxies at intermediate redshift is essential in understanding the formation of the BH-bulge relation from high-z ($z \geq 4$) to the local universe. Using the variability-selected AGN sample ($z \leq 4.5$) constructed from the Subaru HSC-SSP Ultra-deep survey in the COSMOS field, we obtained the wide range of the BH mass ($M_{BH} = 10^{5.5-10}\ M_{sun}$) based on the single-epoch method and the stellar mass ($M_{star}=10^{10-12}\ M_{sun}$) by using the SED fitting. We found that the redshift evolution of the BH-stellar mass ratio (M_{BH}/M_{star}) depends on the M_{BH} which is caused by their no significant correlation of M_{BH} and M_{star}. Variable AGNs with massive SMBHs ($M_{BH}>10^{9}\ M_{sun}$) at $1.5<z<3$ show considerably higher BH-stellar mass ratios (> ~1%) than the BH-bulge ratios (M_{BH}/M_{bulge}) observed in the local universe for the same BH range. This implies that there is a typical growth path of massive SMBHs which is faster than the formation of the bulge component as final products seen in the present day. For the low-mass SMBHs ($M_{BH}<10^{8}\ M_{sun}$) at $0.5<z<3$, on the other hand, variable AGNs show the smaller BH-stellar mass ratios (< 0.1%) compared to the AGNs at $z>4$, which is consistent with ratios in the local universe when considering the disk contribution. We interpret that host galaxies harboring less massive SMBHs at the intermediate redshift have already acquired sufficient stellar mass, although high-z galaxies are still in the early stage of galaxy formation relative to those at the intermediate/local universe.

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2081

Australia Telescope Compact Array radio monitoring of gamma-ray emitting AGN

Philip Edwards

CSIRO

Abstract

This talk will describe a long-running, multi-frequency, flux density monitoring program using the Australia Telescope Compact Array (ATCA) that is an active component of multi-wavelength programs identifying and characterising southern high-energy astrophysical sources. The majority of bright gamma-ray AGN are also bright, and variable, radio sources, and studies of the correlations between variability can help determine the origin, and hence physical mechanism, for the gamma-ray production. ATCA monitoring is undertaken in the 4cm, 15mm and 7mm radio bands to study the time- and spectral-evolution of AGN. Radio observations provide a range of time resolutions from rapid flares to slower change over months to years. In the mm bands the emission is typically optically-thin and displays higher and more rapid variability which, taken together with gamma-ray variability, is particularly valuable in identifying the physics of the gamma-ray emission. The core of the program is a set of ∼180 AGN, primarily Fermi-detected gamma-ray sources, with about thirty TeV gamma-ray sources, with 10 candidate neutrino associations rounding out the current source list. Examples comparing and contrasting radio variability with gamma-ray variability will be presented. The data are made publicly available shortly after the observations.

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2121

Limitations on the emitting particles spatial distribution and heating mechanism in relativistic jets

Ms. Valeriya Frolova[1], Dr. Elena Nokhrina[2,1], Dr. Ilya Pashchenko[2,1]

[1]Moscow Institute of Physics and Technology. [2]Lebedev Physical Institute

Abstract

Recent VLBI observations have revealed the AGNs with double- and triple-peaked transverse intensity profiles, particularly, M87 (Hada 2017, Walker et al. 2018) and 3C 273 (Bruni et al. 2021). There can be several reasons for such intensity profiles: (i) boosting and de-boosting of the emission from different parts of the jet; (ii) a spatial distribution of non-thermal electrons, which can be produced due to developing instabilities (e.g., McKinney 2006, Chatterjee 2019, Hardee & Eilek 2011, Nikonov et al. 2023), shear acceleration (Ostrowski 1990, 1998), Ohmic heating or equipartition (Lyutikov et al. 2005); (iii) a non-uniform structure of the jet; (iv) opacity effects (e.g., Zakamska et al. 2008). Many of these mechanisms may act simultaneously (e.g. Gabuzda et al. 2021). In presented work, we calculate radiative transfer for synchrotron emission with self-absorption from magnetohydrodynamic semi-analytical models by Lyubarsky 2009 and Beskin et al. 2017 to explore the effect of stratified jet structure on the total intensity profiles. We show that double-peaked profiles appear either in the models with high maximal Lorentz factors or in optically thick conditions, and triple-peaked profiles in radio galaxies provide constraints on the fraction of the emitting particles in a jet, favouring the localization of non-thermal electrons at the jet edges and Ohmic heating.

Session

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2166

AO imaging of the nuclei of Sy 2 galaxies: indications of an unexpected highoccurence of nuclear stellar rings

MSc Nina Mackensen, Prof. Dr. Jochen Heidt

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Abstract

We present and discuss adaptive optics aided Ks-band images of the cores of 18 nearby Sy 2 galaxies taken with the Large Binocular Telescope. Using GALFIT a 2-dimensional radial-symmetric light distribution consisting of up to three Sersic profiles was subtracted to reveal the underlying innermost structure. As expected (and known) from earlier studies the cores reveal a wide range of structure which can be used to pinpoint down the dominant mechanisms feeding the active nucleus such as central bars, spiral arms etc. To our surprise more than 50% of our targets show a faint nuclear stellar ring with semi-major axes ranging from 0.3-4 kpc. This number is significantly higher than what has been found in earlier studies (mostly from HST), where only about 10% of all sources showed evidence of a nuclear ring. This could be due to the fact that only a fairly simple 1-dimensional analysis was carried out in the latter case. To validate/falsify our results, we performed extensive tests using mock galaxies.

The rings were modeled with GALFIT using Fourier and bending modes as wellas truncation functions. We compare their physical properties to the ones found for nuclear stellar rings in non-active galaxies and interpret their properties in the context of feeding/feedback mechanisms

Session

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2167

The role of AGN in galaxy evolution through the multidimensional and multiwavelength studies of green valley

Dr. Mirjana Povic[1], Dr. Antoine Mahoro[2], Ms Beatrice Nyirasengiyumva[3], Dr. Dejene Zewdie[4], Mr. Daudi Mazengo[5], Ms. Delphine Nishimwe[6], Dr. Pheneas Nkundabakura[6], Dr. Petri Vaisanen[2], Dr. Kurt Van Der Heyden[7], Dr. Tom Mutabazi[3], Dr. Cosmos Dumba[3], Dr. Paola Popesso[8], Dr. Jefta Mvukaye Sunzu[5], Dr. Roberto Assef[9], Dr. Manuel Aravena[9]

[1]Space Science and Geospatial Institute. [2]SAAO, South Africa. [3]MUST, Uganda. [4]NWU, South Africa. [5]University of Dodoma, Tanzania. [6]University of Rwanda, Rwanda. [7]UCT, South Africa. [8]ESO, Germany. [9]UDP, Chile

Abstract

The green valley galaxies, located between the red sequence and the blue cloud, have showd to be important for understanding the quenching of star formation, the morphological transformation of galaxies from late- to early-types, and the evolution of galaxies across cosmic time. Most of the AGN detected in X-rays have been found in the green valley, suggesting that AGN may be responsible for quenching star formation in galaxies. Many studies that analysed large optically selected samples of active galaxies suggested the same. However, this picture seems to become more complex when using other multi-wavelength data, such as in FIR, where active galaxies in the green valley have recently been found to have higher star formation rates, within the same stellar mass range, compared to inactive ones, suggesting signs of positive AGN feedback. This talk will summarise the research carried out in the framework of the intra-African collaboration between 5 countries and external collaborations to better understand the role of AGN in the quenching of star formation in the green valley at both low and high redshifts, using multi-wavelength data, SED fittings, integral field spectroscopy, detailed analyses of the green valley selection criteria, and including the role of AGN in the quenching of star formation when considering the inside-out assembly galaxy candidates. This research collaboration trained several Master's and PhD students in 5 African countries whose work will be acknowledged.

Session

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2170

AO spectroscopy of the AGN-starburst galaxy NGC 6764

Prof. Dr. Jochen Heidt[1], MSc Nina Mackensen[1], Dr. Dave Thompson[2]

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Abstract

NGC 6764 is a low-redshift barred spiral galaxy which has inconsistently been classified as a Wolf-Rayet, a LINER or a Seyfert 2 galaxy based on seeing-limited long-slit spectroscopy. As part of an adaptive optics aided imaging survey of Seyfert 2 galaxies in the Ks-band, we found three distinct cores in the center of NGC 6764 separated by 0.06", 0.16" and 0.17" corresponding to a projected separation of just 10, 27.6 and 28.6 pc, respectively.
To understand the nature of these three sources, and to unambiguously determine their physical nature, we carried out adaptive optics aided medium-resolution (R ~ 3500) spectroscopy of them using the Large Binocular Telescope. In case these cores constitute indeed of an AGN and one or two strong star-forming regions separated by just a few 10s of parsec, NGC 6764 offers a unique opportunity to study such a close co-existence as well as feedback mechanisms. The very first results of these observations will be presented and discussed.

Session

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2171

SWEEPs: The Synoptic Wide-field e-MERLIN EVN Commensal Program

Célestin Herbé-George[1,2], Prof. John McKean[1,2], Dr. Jack Radcliffe[2,3], Prof. Raffaella Morganti[4,1]

[1]Kapteyn Astronomical Institute. [2]University of Pretoria. [3]Jodrell Bank Centre for Astrophysics, University of Manchester. [4]ASTRON

Abstract

The high angular resolution and sensitivity of VLBI offers a unique tool to identify and study AGN and star-formation activity over cosmic time. VLBI observations are crucial for identifying young radio sources and unveiling older restarted sources. With the recent addition of e-MERLIN within the EVN, radio imaging over a large range of angular scales is now possible and allows detailed studies of the role of black hole feedback and jet-induced star formation in galaxies. To answer these questions and to find rare radio sources, all-sky VLBI surveys are needed. Despite recent technical advances, such as multiple phase centre correlation and multi-source self-calibration, only a limited part of the sky has been observed within a few well-studied fields. To enter the realm of large statistical studies of AGN at high resolution, a significantly larger area of sky must be observed with VLBI.
SWEEPs (Synoptic Wide-field e-MERLIN EVN Program) is a commensal survey mode for the e-MERLIN + EVN, where single-target PI-led observations are re-correlated at the position of all LOFAR sources within 12 arcmin. This program has the potential to observe up to ~9000 radio sources per year, yielding an expected 1900 VLBI detections without any additional observing time. Here, we present the initial multi-scale results and methods from the pilot program, revealing the extended emission of our objects. Additionally, the imaging techniques that are required to reconcile the long and short baselines of eMERLIN + EVN will be presented, important techniques that will be needed for future the SKA-VLBI mode.

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2284

Dr Alfredo Carpineti From Pride in STEM & IFLScience

Dr Alfredo Carpineti

Pride in STEM/IFLScience

Abstract

Dr Carpineti talks about his experience in EDI and his work to promote diverse voices in astronomy

Session

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2301

SALT spectroscopic follow-up of the G4Jy Sample

Miss Precious Sejake

University of Pretoria

Abstract

The emission from active galactic nuclei (AGN) is thought to be driven by the accretion of material onto a supermassive black hole at the centre and, in some cases, may produce relativistic radio jets. These powerful radio jets are thought to impact their host galaxy by suppressing or promoting star formation. Additionally, the mechanism behind jet production is still not fully understood and how the properties of AGN evolve with redshift. This is because detailed studies are limited to 173 `radio-loud' active galaxies in the revised Third Cambridge Catalogue of Radio Sources (3CRR), primarily in the Northern Hemisphere. To investigate how the properties of such sources vary as a function of redshift and/or environment, a larger sample known as the GLEAM 4Jy (G4Jy) was constructed. This sample comprises 1,863 of the brightest radio sources distributed across the southern sky (Declination < 30) and, as such, is over ten times larger than the 3CRR. However, the currently available redshift survey covering the southern sky, 6dFGS, is shallow, so the majority of the G4Jy sources do not have redshift information in the literature. 586 G4Jy sources with mid-infrared counterparts have been observed with SALT (South African Large Telescope - a multi-semester campaign, PI: White). In this talk, I will present the details of the redshift measurements for G4Jy sources at Declination between -40 and -10 deg and the properties of sources at Declination -25 and -10 deg, and Right Ascension 125 and 250 deg.

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The search for supermassive black hole binaries in wide-field VLBI data

Mrs Sophia van der Dussen-Reinecke

University of Pretoria

Abstract

Many, if not all, galaxies are believed to host a supermassive black hole (SMBH) which is thought to form an integral ingredient in the evolution of the host galaxies through feedback mechanisms. In this scenario, the host and SMBH is expected to grow symbiotically and one of the favoured scenarios comes from major mergers of galaxies where the SMBHs are expected to merge. To this date, very little is known about these elusive systems. The great time scales of their lives as well as their mysterious nature calls on many studies to be able to intricately observe their properties as well as to gain insight into their formation and the overall role they play in their host galaxy's evolution.

In this scenario, we expect that there would be a plethora of evidence for binary SMBHs (B-SMBHs), however, confirming their existence, especially at parsec scales is often difficult. One possible method comes from Very Long Baseline Interferometry, whose milliarcsecond resolving power, allows us to resolve the B-SMBHs at parsec scales. In this presentation, I shall talk about a potential B-SMBH found in a wide-field VLBI survey of the GOODS-N data. Using ancillary Hubble Space Telescope spectra, we find that this object, has a high chance of being a B-SMBH, thus providing a proof-of-concept for this method of B-SMBH detections. Finally, I shall introduce our initial findings and estimates from a new survey of B-SMBHs using a new commensal wide-field VLBI survey which covers many degrees of the sky.

Session

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2326

Testing the presence of fast winds in the X-ray spectra of 3c 120

Dr. Mauro Dadina

INAF-OAS

Abstract

The presence of ultra-fast outflows (UFOs) in AGN as been measured in the X-ray spectra of many AGN via blueshifted absorption Fe features at E>7 keV. The launching mechanism of these winds, however, is not clear and both radiation-driven and MHD-driven mechanisms have been proposed. Among the sources for which signatures of fast winds have been recorded in X-rays, some are radio-loud. For none of these sources, however, the UFOs signatures have been persistently measured in the entire available sets of X-ray observations. This is indeed an almost "typical" feature of UFOs, since we know that only in the X-ray spectra of few objects UFOs are almost always measured (see for example the case of the radio-quiet QSO PDS 456). Here we present preliminary results obtained by using physically motivated models of radiation-driven winds (DW model) on the XMM-Newton + NuSTAR data of the radio-galaxy 3c120, a source for which the detction of UFOs were previously reported. The basic idea is to test if the DW model, that predict also the emission features due to the outflowing wind, may be used to infer the presence/properties of the outflow also when it is not measured via the absorption features.

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2327

The (relatively) unexplored regime of AGN in dwarf galaxies: AGN frequency and the role of environment in black-hole triggering

Mr Brian Ongeri Momanyi Bichang'a

University of Hertfordshire

Abstract

Given their dominance of the galaxy number density, dwarf galaxies are central to our understanding of the observable Universe. While the incidence of AGN and their impact on galaxy evolution has been studied in massive galaxies, less is known about the role of AGN in the evolution of dwarfs. We search for AGN in the nearby ($z < 0.3$) dwarf population, using SED-fitting (via Prospector) applied to deep UV to mid-infrared (MIR) photometry of $\sim$500 dwarf galaxies. Around a third of our dwarfs show signs of AGN activity. We caution, however, that selecting objects with MIR detections, which are likely to contain hot dust, may skew the sample towards AGN in the first place and lead to an overestimate of the AGN fraction. Compared to their non-AGN counterparts, dwarfs that host AGN do not show any differences in their distances to nodes, filaments and nearby massive galaxies. This suggests that AGN triggering in the dwarf regime is not correlated with either the immediate environment (traced by nearby massive galaxies) or the large-scale environment in which the AGN resides. Finally, dwarf AGN hosts exhibit similar levels of star formation activity as their non-AGN counterparts, suggesting that the presence of AGN does not lead to the prompt quenching of star formation in dwarf galaxies.

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2334

MOJAVE XXII: The Spatial and Temporal Evolution of Faraday Rotation in AGN jets

Dr Jack Livingston

Max-Planck-Institut für Radioastronomie

Abstract

Active Galactic Nuclei (AGN) generate extreme luminosities, and their central engines have strong magnetic fields and high electron densities which play a major role in the formation of relativistic jets. The Faraday Rotation (FR) MOJAVE project presents resolved polarimetric images of 25 AGN derived from 15/24/43 GHz observations using the Very Long Baseline Array (VLBA). These span across 23 epochs between August 2019 to June 2021, giving us a unique view into both the spatial and temporal evolution of the magneto-ionic media of AGN. We derive FR, intrinsic electric vector position angle (EVPA), spectral index, and depolarisation maps. For “quasar” jets, we see longitudinal magnetic fields, whereas for “BL Lac objects” we see transverse jet magnetic fields. We find that AGN cores have large FR values that are highly spatially and temporally variable, with rest-frame RM values in excess of 100000 rad/m/m. At variable times core regions also show evidence for non-lambda2 dependent FR, which is suggestive of FR internal to the emission of the source. By combining depolarisation and FR information, we find further evidence of internal FR and find a collection of sources that show a transition between internal and external FR between the core and jet regions, which change over time, allowing us to unravel the nature of their magneto-ionic environments.

Session

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2340

Painting the invisible Cosmic structures with radio galaxies

Miss Katlego Mogamisi[1], Dr Kshitij Thorat[1], Dr Etienne Bonnassieux[2]

[1]University of Pretoria. [2]University of Würzburg

Abstract

Radio galaxies, key players in the process of cosmic structure formation, also serve as its probes, influencing and being influenced in turn by interactions with their ambient medium, and through this complex interplay shapes the Universe as we know it. Components of the Cosmic Web, such as the filamentary structure which is formed of agglomerations of galaxies of various sizes and very diffuse gas, are difficult to characterise with direct observations. Observations of radio galaxies will allow us to infer the presence of such "invisible" structures. Similar studies have been conducted before, where the authors studied the relationship between the radio galaxies and their environment, e.g. Subrahmanyan et al. (2008), Bruggen et al. (2021), and Brienza et al. (2023).

With the help of the South African MeerKAT radio telescope we aim to identify tracers of ambient medium seen in the morphology of the radio galaxies interacting with them. We use the MeerKAT Galaxy Cluster Large Survey (MGCLS) dataset, which is a treasure-trove of radio galaxy images in dense environments. In this talk I'll illustrate with key examples how radio galaxies are a unique and powerful tool for investigating cosmic structures. With MeerKAT's unprecedented sensitivity to the diffuse emission associated with radio galaxies, the MGCLS dataset provides a unique and powerful tool for our investigation.

Session

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2360

Tracing the origin of radio emission in AGN and SFGs via spectral shape

Dr. Sthabile Kolwa[1,2], Prof. Russ Taylor[3,2], Mr Lennart Heino[3], Dr Srikrishna Sekhar[4], Prof Mattia Vaccari[5], Dr Emmanual Ocran[6]

[1]The University of Johannesburg. [2]The Inter-University Institute for Data-intensive Astronomy. [3]The University of Cape Town. [4]The National Radio Astronomy Observatory. [5]The University of the Western Cape. [6]Korea Astronomy and Space Science Institute

Abstract

Constraints on spectral index and spectral shape for radio source populations are crucial in properly *k*-correcting radio luminosities. Hence, radio spectral indices are invaluable in the calibration of radio luminosity functions which provide us with essential information about how star-forming galaxies (SFGs) and host galaxies of radio-active galactic nuclei (AGN) are distributed through space. We make use of upgraded Giant Metrewave Radio Telescope (uGMRT) band-3 and band-4 and MeerKAT L-band radio continuum detections which form superMIGHTEE dataset. With these data and optical/near-infrared detections, we detect radio-AGN and SFGs up to 2 microJy allowing us to probe and thus study the faintest of these sources in XMM-LSS. We observationally constrain relations between spectral shape and galaxy properties such as flux density, stellar mass, rest-frame frequency, and optical colour index. Doing so, we find that over 70% of our source population have steepened spectral shapes indicative of synchrotron ageing from optically thin magnetised plasma around AGN. We also find no significant evolution in spectral index. This leads us to conclude that adopting a canonical spectral index of alpha=-0.7 is generally sufficient for *k*-correcting radio luminosities derived at radio continuum observing frequencies within a range of 100 MHz to 2 GHz.

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2362

High-resolution insights into black hole accretion dynamics and jet phenomena

León Salas[1], Gibwa Musoke[2], Koushik Chatterjee[3], Sera Markoff[1], Oliver Porth[1], Matthew Liska[4], Bart Ripperda[2]

[1]Anton Pannekoek Institute for Astronomy, University of Amsterdam. [2]Canadian Institute for Theoretical Astrophysics, University of Toronto. [3]Institute for Research in Electronics and Applied Physics, University of Maryland. [4]Center for Relativistic Astrophysics, Georgia Tech

Abstract

High-resolution Event Horizon Telescope (EHT) observations provide a new and exciting avenue to test models of black hole accretion. Current EHT results imply that both M87* and SgrA* favor Magnetically Arrested Disks (MAD) models, in which a strong and dynamically important magnetic field in the disk can interrupt the accretion flow, cause episodic flux eruptions, and launch powerful jets. Recent work shows that MADs feature complicated dynamics such as Rayleigh-Taylor instabilities, plasmoid-unstable current sheets, and surface waves in jets. Such instabilities could provide a route for particle acceleration, potentially explaining the mechanism that power the flares observed in M87* and SgrA*.

General Relativistic Magnetohydrodynamic (GRMHD) simulations are a powerful tool for modelling the black hole accretion process. The MAD regime can be difficult to simulate, and it remains unclear which numerical resolutions adequately capture the evolution. We perform a convergence study of GRMHD MAD simulations, exceeding the status quo by an order of magnitude in resolution. We find that low resolutions inadequately capture plasma mixing between low-density blobs and the accretion disk, despite converged time-averaged disk quantities. Additionally, waves along the jet sheath induce mixing. At higher resolutions, we observe the sheath to be thinner, resulting in increased temperature, reduced magnetization, and greater variability. Those differences could change the radiative emission of high-resolution simulations. Using higher resolutions to study the immediate environment of black holes and jet base phenomena will allow us to make connections between horizon scales and the larger-scale jets in Active Galactic Nuclei.

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2399

Cataloguing Compact Sources for Star Formation Rate studies in MERGHERS Pilot Fields

Brenda Homera[1], Kenda Knowles[2], James Chibueze[3]

[1]North-West University. [2]SARAO/Rhodes University. [3]University of South Africa

Abstract

Understanding the star formation activity within galaxy clusters is crucial to discern the evolutionary processes of these cosmic structures, and radio data can provide dust-unbiased radio luminosities for star formation studies. I will present my work on studying radio-derived star formation rates (SFRs) in a sample of galaxy clusters from the MeerKAT Exploration of Relics Giant Halos and Extragalactic Radio Sources (MERGHERS) survey's pilot sample. The newly calibrated and processed continuum images at 1.28 GHz have improved sensitivity over the initial processing, and our radio source catalogues are 80% complete above 0.1 mJy (95% complete above 0.3 mJy), with 99% purity. When combined with photometric redshift information from the 9th data release of the Dark Energy Camera Legacy Survey, we have been able to probe cluster member SFRs out beyond $2R_{200}$ using sub-90 minute radio observations with MeerKAT.

Session

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2418

Studying population changes in sub-arcsecond scale active galactic nuclei at low radio frequencies

Dr Rajan Chhetri, Prof Ron Ekers, Dr John Morgan

CSIRO Space & Astronomy

Abstract

Active Galactic Nuclei at radio frequencies span a wide range in angular sizes. Understanding the low frequency population at sub-arcsecond scale is important to understand the evolution of radio galaxies. However, identifying them in large numbers has been difficult at frequencies below 1 GHz. With the new generation of radio telescopes operating at low frequencies, overcoming this challenge will allow us to better understand the evolution of radio galaxies.

We have developed the technique of widefield interplanetary scintillation (IPS) with the Murchison Widefield Array (MWA). IPS is the radio analogue of the twinkling of stars at night, but induced by the solar wind. This technique very efficiently identifies sub-arcsecond scale compact objects in large numbers (~300 objects are identified with compact structure from ~900 sq. deg. sky with only 10 minutes of observation). We are currently extending this technique to use the wide field of view of the ASKAP radio telescope, identifying ~150 sub-arcsecond scale objects with just 2.5 minutes of observation at 888 MHz.

With these identifications we found that the compact source population at low frequencies is quite different from its gigahertz counterpart. The blazar population, which is dominant at gigahertz frequencies, gives way to peaked spectrum sources as the dominant population at low frequencies.

The IPS technique increases the capability of both the ASKAP and SKA-low to probe objects at over an order of magnitude larger range of angular scales, and will provide a high density of calibrators necessary for the multi-facet calibration required for the SKA.

Session

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Degendering Physics in India: Why So Slow?

Professor Prajval Shastri

Raman Research Institute

Abstract

It has been over a quarter of a century since attention was drawn to the evidence that the over-representation of men in the Indian physics enterprise is due to societal patriarchy leaching into academia which then results in gender-based discrimination within. Consequent acknowledgement of this phenomenon by the government, that was also accompanied by significant funding resulted in a couple of laudable interventions. Progress has been slow, however, likely because several mitigative interventions sought to address only the symptoms and were themselves moulded by patriarchy. The Gender in Physics Working Group of the Indian Physics Association was launched with the vision of stepping away from the all-too-common “fixing-the-women” approach by drawing attention to the root causes of gender inequity. One of the outcomes was the Hyderabad Charter for Gender Equity in Physics, that seeks to address these systemic problems. Its recommendations are vindicated by several examples from the astrophysics enterprise globally. Some of these lessons will be described.

Session

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Astro Sequoia: a blueprint to decolonize research and mentoring in galaxy evolution

Professor Jorge Moreno

Department of Physics and Astronomy, Pomona College

Abstract

In this talk I will share a blueprint to create research directions and spaces that are more inclusive and challenge existing systems of domination. During the first part of the talk I will discuss how violent language has permeated the field of galaxy evolution, and I will share lessons from Kichwa culture that can help us mitigate this. The second part will be devoted to this blueprint. Rather than adhering to traditional ways, we can create anti-hierarchical collectives where the most marginalized voices are prioritized. To achieve this, this blueprint implements the following key pillars: (1) justice education, (2) community town halls, (3) accountability systems, and (4) art. I will discuss effective ways to implement this blueprint across communities, wherein trust and mutual solidarity can be built.

Session

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2445

Resolving X-ray activity in AGN at large redshift

Dr. Daniel Schwartz[1], Alysa Rogers[2], Dr. Cristiana Spingola[3], Dr. Giulia Migliori[3], Dr. Anna Barnacka[1,4]

[1]Smithsonian Astrophysical Observatory. [2]University of Wisconsin, Madison. [3]INAF – Institute for Radioastronomy, Bologn. [4]Jagiellonian University Observatory

Abstract

We are using gravitational lensing to significantly increase spatial resolution, revealing X-ray activity generated by supermassive black holes in the centers of distant galaxies. In this work we combine astrometric data from Gaia with imaging from the Chandra X-ray Observatory of the quadruply-lensed quasar HE 0435–1223 to measure the offset between the source plane positions of the optical and of the X-ray emission. We measure the X-ray source position for HE 0435-1223 within a 1σ quasi-elliptical region of 0.5 x 1 milli-arcsecond (mas), less than 10 pc at the redshift of 1.689. To an equivalent of 3.4 σ the X-ray emissions are offset by a projected 3 mas from the source plane position deduced from the Gaia data. While such an difference, if real, could possibly result from a pc-scale X-ray jet, or even a binary or offset AGN system, we pursue interpretation as a mass outflow such as is seen on scales up to kpc in nearby type II AGN.

Session

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Radio-neutrino studies of blazars: inspiring progress and exciting opportunities

Prof. Yuri Kovalev[1], Dr. Alexander Plavin[2], Prof. Sergey Troitsky[3], Dr. Yuri A. Kovalev[4]

[1]Max Planck Institute for Radio Astronomy. [2]Harvard university. [3]Institute of Nuclear Research, Moscow. [4]Lebedev Physical Institute, Moscow

Abstract

We present results from a joint analysis of VLBI observations of blazars and neutrino data from IceCube supplemented by ANTARES and Baikal-GVD. We have found a 4σ-significant observational evidence that high energy neutrinos are generated in radio-bright blazars and arrive preferentially during their flares. VLBI effectively selects active galaxies with jets whose electromagnetic and neutrino emission is relativistically boosted towards us. We summarize ongoing efforts and new opportunities for multi-messenger studies to explore the nature of blazars' nuclei as powerful proton accelerators.

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Global linear polarization parameters of AGNs with NOEMA

Dr. Sergio Dzib

Max-Planck-Institut fuer Radioastronomy

Abstract

NOEMA (and its predecessor, the PdBI array) use AGNs as phase and amplitude calibrators. Observations lasting above six hours, usually cover a wide range of paralactic angles that global linear polarization parameters (polarization fraction and angle) can be obtained to these calibrators by means of the Earth rotation polarimetry (ERP) technique. This is possible because the strength (>0.3 Jy) and the point-like structure (for NOEMA observations) of these AGNs. I will present ERP results obtained to 240 AGNs observed since 2009. The results may help to select adequate polarization calibrators (e.g., to future full stokes polarization observation with NOEMA) and to study emission processes in AGNs.

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Exploring mass measurements of supermassive black holes in AGNs using GAMA photometry and spectroscopy

Dr. Sarah Casura[1], Prof. Dragana Ilić[2]

[1]Universität Hamburg. [2]University of Belgrade

Abstract

In the era of massive photometric surveys, we explore several approaches to estimate the masses of supermassive black holes (SMBHs) in active galactic nuclei (AGN) from optical ground-based imaging, in each case comparing to the independent SMBH mass measurement obtained from spectroscopic data. We select a sample of 28 type 1 AGN hosted by nearby galaxies from the Galaxy And Mass Assembly (GAMA) survey. We perform multi-component spectral decomposition, extract the AGN component and calculate the SMBH mass from the broad Hα emission line width and flux. The photometric g and i band data is decomposed into AGN+spheroid(+disc)(+bar) components with careful surface brightness fitting. From these, the SMBH mass is estimated using its relation with the spheroid Sérsic index or effective radius (both used for the first time on ground-based optical imaging of AGN); and several variants of the more widely used scaling relations based on bulge or galaxy stellar mass.
We find no correlation between the Hα-derived SMBH masses and those based on the spheroid Sérsic index or effective radius, despite these being the most direct methods involving only one scaling relation. The bulge or galaxy stellar mass based methods all yield significant correlations, although with considerable scatter and, in two cases, systematic offsets. We provide possible explanations for this and discuss the requirements, advantages and drawbacks of each method. These considerations will be useful to optimise stategies for upcoming high quality ground-based and space-borne sky surveys to estimate SMBH masses in large numbers of AGNs.

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Is the mystery of the missing red giants related to the existence and effect of the central galactic jet?

Dr. Petr Kurfürst, Dr. Michal Zajaček

Masaryk University

Abstract

The cause of missing red giants near the center of our galaxy has long been investigated. In the last few decades, many publications and explanatory theories have been proposed for this phenomenon. Relatively recently, an analytical theory has been proposed within our team that predicts a long-term ablation of the surface layers of red giants during repeated passages through the relativistic galactic jet. We currently perform multidimensional numerical modeling of this phenomenon. Using advanced multidimensional hydrodynamic codes, we calculate the ablation rate of the red giant's surface layers as it passes through differently parameterized jets, at different distances from the galactic center. Consequently, we also consider the hydrodynamic behavior of the stars after leaving such a jet, in particular the thermally conditioned mass loss. The latter can be induced both by the exposure of deeper subsurface layers of the star and by thermodynamic interaction with hot interstellar material near the galactic center. These changes, especially considering the large number of stars in the dense Nuclear Stellar Cluster that may undergo similar evolution, can contribute to significant visible changes in the observable characteristics of the region. We also discuss the effect of this process on galactic nuclei in general, and especially on an AGN jet density structure and morphology, which is the process that can cause its observable variability.

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Uncovering the high-energy emission of jetted AGN at cosmic dawn

Andrea Gokus[1], Markus Boettcher[2], Manel Errando[1], Ivan Agudo[3], Petra Benke[4], Florian Eppel[5], Leonid I. Gurvits[6], Jonas Hessdoerfer[5], Jeffrey A. Hodgson[7], Svetlana Jorstad[8], Matthias Kadler[5], Yuri Y. Kovalev[4], Michael Kreter[2], Mikhail Lisakov[9,4], Fe McBride[10], Roopesh Ojha[11], Jorge Otero Santos[3], Eduardo Ros[4], Florian Roesch[5], Joern Wilms[12]

[1]Washington University in Saint Louis. [2]North-West University, South Africa. [3]Instituto de Astrofisica de Andalucia-CSIC. [4]Max-Planck Institute for Radioastronomy. [5]University of Wuerzburg. [6]Joint Institute for VLBI ERIC. [7]Korea Astronomy and Space Science Insitute. [8]Boston University. [9]Astro Space Center of Lebedev Physical Institute. [10]Bowdoin College. [11]NASA Headquarters. [12]Dr. Karl Remeis Observatory Bamberg

Abstract

Some active galactic nuclei (AGN) are able to launch powerful jets, which, when pointed towards the Earth, are called blazars. The matter of relativistic jets launched by AGN is transparent to high-energy gamma-ray radiation, hence allowing us to study its relation to the accretion and jet launching processes. High-redshift blazars (z>3) detected at gamma-ray energies therefore enable us to probe their jets down to the black hole due to the (1+z) frequency transformation and study the accretion processes and black hole growth in the early Universe. However, the detection of gamma-ray emission from these distant sources is difficult, and only about a dozen have been detected by the Large Area Telescope (LAT) onboard the Fermi satellite.

Due to their very variable nature, we can utilize blazar flares as unique opportunities to detect and characterize the gamma-ray emission from high-z blazars and to gather contemporaneous multiwavelength observations, which are necessary to interpret their spectral energy distribution and physical parameters. In particular, the combination of gamma-ray and VLBI observations is a unique tool to study the location and physical mechanisms of the high-energy emission in blazar jets. For this reason, we designed a program to find flares in high-z blazars in real time, which is suitable to trigger observations across the electromagnetic spectrum, by using public Fermi-LAT data.

Our presentation will showcase how we successfully caught two high-redshift blazars during luminous flares and use our obtained comprehensive, multi-wavelength data sets to enhance our knowledge about jetted AGN at cosmic dawn.

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MeerKAT view of serendipitously discovered giant sources from the MGCLS.

Dr Nceba Mhlahlo[1], Dr Nadeem Oozeer[2], Dr Kabelo Kesebonye[1]

[1]Wits University. [2]South African Radio Astronomy Observatory

Abstract

We report the detection of a sample of new giant radio galaxies (GRGs)
observed using the MeerKAT radio telescope. We also present a serendipitous discovery of a sample of largely giant radio sources that were noticed in the MeerKAT Galaxy Cluster Legacy Survey (MGCLS). The sources have projected sizes ranging from $\sim$ 0.72 Mpc to $\sim$ 1.43 Mpc, in the redshift range of ~0.06 −0.35.

We aim to dissect 7 of the new GRGs and address various physical and environmental parameters.

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Goal-Oriented Stacking: Selection of AGN Host Galaxies below the Radio Detection Threshold.

Mr Jacques Smulders[1], Prof Roger Deane[2]

[1]University of the Witwatersrand. [2]University of the Witwatersrand / University of Pretoria

Abstract

Active Galactic Nuclei (AGN) are known to have a significant impact on the evolution of massive galaxies. Measuring this impact requires multiwavelength observations of AGN activity, from radio through X-rays and gamma-rays, where possible. However, a large population of AGN are radio-quiet and their properties at long wavelengths are not well understood as they often fall below the radio detection threshold. Previous studies have addressed this challenge by employing stacking to study these faint radio-quiet sources, using observed or derived properties in making heuristic sub-sample selections in order to make statistical detections and inferences. What has not been explored is designing algorithms to select the sample itself, based on goal-orientated stacking objectives, such as maximising or minimising the aggregate result from stacking. A goal-oriented stacking approach has been used to select a physically correlated sub-population of radio-quiet AGN in the COSMOS field by optimising the central signal-to-noise in the stacked radio maps of the VLA and MeerKAT at ~1-3 GHz. We make comparisons with galaxies selected from hydrodynamical simulations, such as SIMBA, and construct a synthetic radio map by modelling the AGN and star-formation induced radio emission of simulated galaxies. We aim to further understand the statistical aggregate properties of radio-quiet AGN host galaxies up to redshift ~4, enabling statistical detections of what will only be possible with future deep surveys with the SKA for individual sources.

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Broadband modeling of the M87 nucleus

Andrzej Niedzwiecki[1], Michal Szanecki[1], Agnieszka Janiuk[2]

[1]University of Lodz, Poland. [2]Center for Theoretical Physics, Warsaw, Poland

Abstract

We consider the broadband multiwavelength properties of M87*. In the spectral model based on the GR MHD simulation (with the HARM_COOL code), the observed SED between the millimeter and optical/UV range is reproduced by synchrotron emission of thermal electrons for the accretion rate ~0.001 M_{sun}/year and the black-hole spin parameter a~0.9, while the inverse Compton emission of the same electrons slightly overproduces the observed X-ray flux. Our results thus disfavor a significant non-thermal component in the electron distribution. The parameters of the emission region in our fitted model are in agreement with the polarimetric EHT observations. We also consider the production of GeV/TeV radiation by the proton synchrotron and the photopion emission.

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Radiation from falling particles to powerful AGNs with supermassive black holes in SdS geometry

Dr. Tolu Biressa

Jimma University, Department of Physics, Ethiopia

Abstract

Radiation from radially in falling particles into Schwarzschild Black Holes has much studied. There is a great deal of seminal works in various frameworks including: Einstein's linearized and non-linearized field equations (in the classical field theory framework), quantum field theory, Quantum optics, and in other approaches. However, there are limited studies under the more general SdS spacetime geometry, where the Schwarzschild is a special case. So, in this paper we derive radiation of particles falling to supermassive black holes like in powerful AGNs in the SdS geometry. Then, examine the effect of Λ on the spectrum of the radiation.

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The Secular Growth and Co-Evolution of Supermassive Black Holes and Galaxies

Dr Brooke Simmons[1], Mx Izzy Garland[1], Mr Matthew Thorne[1,2], Mr Jason Shingirai Makechemu[1], Dr Rebecca Smethurst[3], Prof Chris Lintott[3]

[1]Lancaster University. [2]Kavli Institute for the Physics and Mathematics of the Universe. [3]University of Oxford

Abstract

Active galactic nuclei are fuelled by multiple channels bringing material from galactic and extragalactic scales to the central black hole. Additionally, simulations and observations have shown in recent years that "secular" (i.e., non-merger) processes dominate the growth of black holes over cosmic time. Cosmological simulations also predict that some (but *not* all) properties of supermassive black holes should be different in systems with secular versus merger-driven accretion histories. Observationally, merger-free black hole growth is relatively understudied, partly because isolating merger-free galaxies is particularly challenging in the presence of luminous AGN. Past results have often seemed contradictory (e.g., whether/how black holes co-evolve with merger-free host galaxies) or have lacked statistical power (e.g., to clearly determine whether galactic-scale disc instabilities fuel AGN). This talk presents new results that (a) the seeming contradictions of merger-free co-evolution studies can be completely explained by drawing from a unified population using different selection biases; (b) merger-free galaxies hosting luminous (quasar-like) AGN have the same Eddington ratio distributions as quasars hosted in merger-driven systems, but are slightly less luminous and have slightly lower-mass black holes; and (c) disc galaxies with stronger galactic-scale bars are significantly more likely to host AGN than those with weaker bars, and both are more likely to host AGN than unbarred disc galaxies. There is also evidence that merger-free AGN have higher spins than those with merger-dominated histories, but more observations are needed. The talk will also discuss future prospects for discovery on this topic with surveys using JWST, Euclid, and Rubin/4MOST.

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2707

The Quasar 3C 47: Extreme population B jetted source with double-peaked profile.

Dr. Paola Marziani[1], Dr. Ascencion Orozco[2], Dr. Mirjana Povic[3], Dr. Jaime Perena[2], Alice Deconto[2], Mr. Shimeles Mengistue[3]

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Abstract

The presence of an accretion disk (AD) in active galactic nuclei (AGN) has limited and indirect observational support. To evaluate the extent to which the AD is a source of the broad Balmer lines, near-UV and the UV lines in radio-loud (RL) quasars, we focused on an extremely jetted RL quasar, 3C 47 at z = 0.425, that shows a double-peaked profile. The work presents its new optical spectra from the CAHA 3.5m telescope to address the question of whether the AD can account for the observed double-peaked profile. For this purpose, a relativistic Keplerian accretion disk model, a Bayesian approach, and a multicomponent non-linear fitting were utilized. In addition the profile of the prototypical high ionization lines is also modeled by the contribution of the AD, with additional components due to outflows and emissions from the innermost part of the narrow line regions. The model successfully explained the observed double-peaked profiles of Hβ, Hα and MgiiλλΔ2800. The profile of the high ionization lines is also modeled by the contribution of the AD, along with fairly symmetric additional components (a failed wind scenario) and emissions from the innermost part of the narrow line regions (NLRs). The agreement between the observed profile and the model is remarkable. The findings support the notion that the double-peaked profiles originate from the rotating AD. The main alternative, a double BLR associated with a binary black hole is found to be less appealing than the disk model for the quasar 3C 47.

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Polarization analysis of the 2nd brightest radio galaxy MRC 0600-399 in Abell 3376 Galaxy Cluster

Prof James Chibueze[1], Dr Haruka Sakemi[2]

[1]University of South Africa. [2]Kagoshima University

Abstract

MRC 0600-399 is a head-tail radio galaxy in a merging galaxy cluster Abell 3376. The jets are bent drastically in the direction opposite to the one predicted by the ram pressure induced by the cluster merger. We conducted the high-sensitivity MeerKAT observation and the three-dimensional magneto-hydrodynamic (MHD) simulations and concluded that the jets interact with the ordered magnetic field in the cluster (Chibueze, Sakemi, Ohmura et al. 2021). However, we require an additional scenario to explain the northern jet, which propagates a longer distance than the southern one, about 50 kpc. We carried out polarization analysis for the jets, such as the RM-synthesis. We found that the polarized intensity got higher between the northern jet's middle (N2) and terminal (N3) regions. In addition, the Faraday depth values of N3 are higher than those of other jet parts. Based on these results, we consider the scenario to explain how to form N3, the reconnection between the magnetic fields of the jet and the intra-cluster, and the transportation of the cosmic-ray electrons which are reaccelerated at the reconnection point. In this talk, we report these results and discuss the scenario.

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Connection of AGN and starbursts in a sample of LIRGs

Prof Petri Väisänen

Finnish Centre for Astronomy with ESO. South African Astronomical Observatory

Abstract

I present results based on VLT and SALT observations of a sample of Luminous IR Galaxies (LIRGs). In this talk, in particular, I concentrate on the aspect of what the data reveal of the growth and evolution of the starburst and AGN phenomena in the sources. Is there an on-going interplay and how is their evolution intertwined, what exactly triggers (and extinguishes) what, and what the role of gas flows is. I will present examples of e.g. cases where various components of an on-going galaxy interaction are revealed to be in distinctly different evolutionary phases, with evidence of both on-going and extinguished star-formation, of budding AGN activity, and strong gas flows. Also, distinct differences in these gas outflow properties, as a function of star-formation and/or component age, provide interesting constraints on the development of superwinds driven by both current star-formation and AGN activity, and thus evolution of galaxies.

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Redshift Measurement of Gamma-Ray Blazars for the Cherenkov Telescope Array

Dr Eli Kasai[1], Dr Nuria Alvarez-Crespo[2], Prof. Michael Backes[1,3], Dr Ulisses Barres de Almeida[4], Dr Josefa Becerra González[5,6], Dr Catherine Boisson[7], Prof. Garret Cotter[8], Dr Vandad Fallah Ramazani[9], Dr Paolo Goldoni[10], Dr Olivier Hervet[11], Dr Elina Lindfors[12], Prof. Walter Max-Moerbeck[13], Dr Devika Mukhi-Nilo[14], Dr Santiago Pita[15], Dr Bhoomika Rajput[13], Dr Megan Splettstoesser[11], Prof. Brian Van Soelen[16], Prof. David A. Williams[11]

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Abstract

Blazars, which comprise BL Lacs and FSRQs, are the brightest persistent sources in the High Energy (HE) and Very High Energy (VHE) gamma-ray sky. Because their UV/optical radiation is often dominated by non-thermal, and, in the case of BL Lac objects, featureless continuum radiation, the determination of their redshift is extremely difficult. Only about 50% of gamma-ray blazars have a firm measurement of their redshift. The modelling of the blazars' VHE emission and of its interaction with the extragalactic background light thus suffers from strongly reduced precision. Furthermore, the effects on blazars' radiation of proposed beyond-Standard Model physics phenomena such as Lorentz Invariance Violation and Axion-like Particles cannot be reliably investigated. During CTA operations, several hundreds of new blazars will be detected, most of them without redshift. In order to mitigate this condition, we devised an optical observing campaign. Likely targets were selected through Monte Carlo simulations of CTA observations using the Fermi 3FHL catalog as a starting point. Our campaign, started in 2019, has been recognized as necessary support for the AGN Key Science Project of CTA. It involves deep observations using, among others, 10-m class telescopes such as Keck, SALT and the VLT. Three papers have been published and one is about to be submitted. We present here the status of our campaign and its future developments.

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Deep wide-field VLBI surveys and its promising future

Mr Theophilus Matsepane

University of Pretoria

Abstract

For over two decades, VLBI has been used to survey milliarcseconds sky, primarily the active galactic nuclei (AGN). Studying galaxies with activities such as star formation (SF) and AGN will enable us to understand the formation and evolution of galaxies. Most of the AGN population is found at high redshift, often too faint and hard to detect with a typical radio telescope. Probing such a population requires using an array with a very long baseline, i.e. VLBI, which can resolve these galaxies at high redshifts and allow us to study them in finer detail. However, traditional VLBI is inherently limited to a narrow field of view. In this talk, I will discuss the challenges VLBI faces with observing the entire field of view “wide-field” VLBI and how we can overcome them. The survey covered in this talk was conducted using the EVN and e-MERLIN (EVN+e-MERLIN) array. I will touch on the challenges of calibrating EVN+e-MERLIN array data, present the newly VLBI-detected sources and touch on the promising future of EVN+e-MERLIN array.

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Millimeter AGN lightcurves from the Atacama Cosmology Telescope and multiwavelength cross-correlation

Erika Hornecker, Prof. Adam Hincks

University of Toronto

Abstract

The Atacama Cosmology Telescope (ACT) was a ground-based CMB experiment in the Atacama desert in Chile that observed the millimeter sky between 2008 and 2022 at frequencies ranging from 90 GHz to 220 GHz with three detector arrays. Starting in 2016, ACT mapped ~40% of the sky (18,000 square degrees) at ~arcminute angular resolution, covering most areas of the scanning region with a sub-week cadence. The combination of the angular resolution, large footprint, and high cadence of the experiment made the instrument an excellent tool for millimeter transient science. Indeed, over the history of the survey over 20,000 sources have been detected at more than 5σ, and the single-visit, 3σ sensitivity to point sources was ~50 mJy at 100 GHz. We are working on an initial catalogue of ACT lightcurves containing the ~200 brightest active galactic nuclei (AGN) in its data, sampled over several years.

In this talk we will briefly describe the ACT lightcurve dataset and present some of the AGN studies being conducted with these lightcurves, including the use of these lightcurves for multiwavelength cross-correlation with optical and gamma-ray lightcurves.

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Evidences for intermediate-mass black holes in analogues of high-redshift star forming galaxies

Dr Thiago Goncalves

Valongo Observatory. Federal University of Rio de Janeiro

Abstract

How do supermassive black holes grow during the peak of galaxy formation in the universe? Although the answer may lie in high-z galaxies, observing this process taking place represents a major observational challenge. In this talk, I present preliminary evidence that a sample of low-redshift star-forming galaxies with properties that classify them as local analogues to high-z objects may host intermediate-mass black holes (log M_sun ~ 5-6), with important implications to their use as laboratories for the growth of supermassive black holes in galaxies. This sample was originally selected NOT to include evident AGN activity as diagnosed by a BPT diagram; nevertheless, a subset of these objects present unresolved emission in their centers even with ALMA or HST, down to 100 pc sizes, with subsequent studies showing modest to no signs of or nuclear activity, either from deep X-ray studies or from VLBI observations. Molecular gas is also heavily concentrated, with high surface densities as indicated by high resolution ALMA data. Another key piece of evidence comes from the ratio between the restframe MIR continuum flux and the the X-ray emission: there is a clear excess in X-ray luminosity suggesting further (albeit inconclusive) clues to the existence of nuclear activity in these galaxies. Future NIR observations of high-excitation lines should be able to determine once and for all whether there is a harder ionizing source in these galaxies beyond the UV flux from massive stars.

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A multi-wavelength view of AGN feedback impact on the central kiloparsecs of galaxies

Anelise Audibert[1,2], Cristina Ramos Almeida[1,2], Giovanna Speranza[1,2], Patricia Bessiere[1,2], Jose Acosta Pulido[1,2], Pedro Henrique Cezar[1,2], Donaji Esparza Arredondo[1,2]

[1]Instituto de Astrofísica de Canarias. [2]Universidad de La Laguna

Abstract

Active galactic nuclei (AGN) winds and jets are potential drivers of multi-phase outflows and can significantly modify the interstellar medium (ISM) properties of their host galaxies. The Quasar Feedback (QSOFEED) project aims to investigate the impact of multi-phase quasar-driven outflows and jets on the nuclear regions of quasar host galaxies. These regions have dynamic timescales similar to the AGN activity lifetime and offer a way to assess the influence of the current AGN episode on the galaxy. Through a comprehensive analysis that combines high-resolution observations from cutting-edge facilities (e.g. ALMA, JWST, Keck, GTC, and Gemini) with contemporaneous galaxy properties and hydrodynamical simulations, the QSOFEED project provides insights into the efficiency and coupling of AGN outflows with host galaxies. I will present our latest results on how feedback from outflows influences star formation and the ISM in a sample of radio-quiet quasars, investigated through an analysis of multi-phase gas kinematics and resolved stellar population synthesis. I will also discuss preliminary results from our JWST program to study the impact of multi-phase outflows on recent star formation, as traced by polycyclic aromatic hydrocarbon molecules. We find evidence that AGN feedback is not depleting gas reservoirs or suppressing global star formation, but the observations reveal that the radio jets/winds strongly disturb the morphology, kinematics, and distribution of young stellar population (ages < 100 Myr) within the central kiloparsecs of galaxies. These results highlight the importance of the jet-ISM interaction in the AGN feedback, even in the context of radio-quiet galaxies.

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The interplay of AGN and environment in quenching of star formation for MaNGA GV galaxies

Mr. Daudi Thadei Mazengo[1,2], Prof Mirjana Povic[3,4,5], Prof. Paola Popesso[2], Prof. Petri Vaisannen[6], Prof. Jefta Sunzu[7]

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Abstract

The fraction of red galaxies increases with time as galaxies transit from blue, in the blue cloud(BC) to red, in red sequence(RS) via green valley(GV) in color-magnitude diagram. The intermediate colors of GV galaxies(GVG) predict recent quenching of star formation, where quenching timescale to reach quiescence is ∼100 Myr for GV-ET-galaxies and ~2.5 Gyr for GV-LT-galaxies.Primarily, AGN feedback is considered for quenching of star formation in massive galaxies, and correlation of central black hole mass with galactic bulge mass. While for environment; ram-pressure stripping(rps), starvation, tidal phenomena are proposed. Cosmological hydrodynamical simulations from EAGLE indicate that satellite galaxies (stellar mass<10^10 M_sun) in the RS are quenched by rps in the outskirts of more massive haloes, while RS galaxies(stellar mass>10^10 M_sun) are quenched by feedback from central SMBH. We identify GVG in the MaNGA survey to study their properties as a function of their nuclear activity depicted through nuclear X-ray, radio emission or optical-IR colors, and environment. Particularly relating galaxy sSFR and metallicity radial profiles with the galaxy probability of hosting an AGN. The local galaxy environment is defined based on optically selected group catalogs based on SDSS spectroscopic data. We stack GVG in eRASS1 data to study hot gas amount around galaxies, estimate gas X-ray luminosity, density and temperature to estimate impact of rps and starvation. The analysis based on this unprecedented dataset will shed light on timescale and origin of quenching to transit from BC to RS through the GV.

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Exploring AGN Feedback: [FeII] Ionization in a Redshift z = 0.4 Red Quasar Revealed by the JWST Q3D Program

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Abstract

Red quasars with powerful galactic outflows offer unique insights into the critical "blowout" phase of galactic evolution, where black hole feedback purges gas and influences star formation (SF) in galaxies. However, intense quasar photoionization complicates this picture, obscuring feedback processes such as outflow-induced shocks and SF. The evidence for such feedback has also predominantly been indirect. Near-infrared [FeII] emission serves as a diagnostic tool for fast shocks driven by quasars or SF. We thus explore the kinematics and [FeII] ionization in the red quasar F2M1106 at z = 0.435, leveraging the cutting-edge JWST NIRSpec IFU to gather direct and spatially resolved evidence of shock signatures extending beyond the quasar's illumination cone. Additionally, F2M1106 serves as a test case for assessing the efficacy of the Q3Dfit package, designed to streamline PSF decomposition and spectral mapping of JWST IFU. Our analysis reveals [FeII] kinematics consistent with the previously observed extended and ionized [OIII] outflow, indicating [FeII] ions are primarily photoionized by quasar-originating X-rays, which penetrate deeply into the atomic gas through the outflow. An emission line ratio analysis using MAPPINGS III shock models further identifies evidence of shock ionization in the southwest, where the outflow runs into the ambient medium. Additionally, using line ratio maps, we characterize the interstellar medium to have high electron densities, n_e ~10^4 electrons per cubic centimeter and find no significant dust extinction in these regions, A_v ~0.8. Our study thus offers direct evidence of outflow-induced feedback and reveals its pivotal role in shaping galactic evolution.

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JWST reveals the multi-phase outflow of the Seyfert galaxy MCG-05-23-16

Dra Donaji Esparza

IAC

Abstract

Understanding the process that drives the connection between AGN and their host galaxy is studied differently. The feedback effect is one of these fronts due to its measurable impact on the host galaxy. However, feedback is complex and involves several processes, such as outflows driven by central parts of AGNs. Understanding the behaviour of these outflows is essential because they are a crucial piece to reproducing the observed scaling relations in the current cosmological models.

Recent works show that AGN with the same luminosity can have a broad range of outflow rates. These results imply that we still have a long way to go to understand how the outflows are launched and driven through the ISM of the host galaxy. Our JWST Cycle 1 proposal titled: "Closing in on the launching sites of AGN outflows" (P.I. Shimizu) has the objective of studying and highlighting the physical processes that determine the prominence of the observed outflow through a sample of AGN with similar distances and luminosities but with outflow rates differing by two orders of magnitude. In this talk, I will focus on the case of MCG-05-23-16, an early-type galaxy classified as Sy1.9, which has the lowest outflow rate of our sample and remains poorly understood in most of the wavelengths. I will share the results of ionized, warm, and cold molecular gas kinematics analysis, leveraging the JWST, VLA, and ALMA data. Finally, I will discuss the implications of our results in the AGN-host coevolution scenario.

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MeerKAT observations of NGC 6240 offer insights from both radio continuum and spectral-line perspectives, highlighting synergies.

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Abstract

AGN feedback is a key driver of the evolution of massive galaxies over cosmic time and the nearby post-merger system, NGC 6240, serves as an important snapshot thereof. NGC 6240 hosts a sub-kpc dual AGN and meets the far-infrared luminosity to be classified as an UltraLuminous InfraRed Galaxy (ULIRG), a rare occurrence in the nearby universe. In this talk I present discoveries of complex, multi-epoch, Mpc-scale radio emission centred on the dual AGN. MeerKAT observations enable high-fidelity spectral age comparisons, unveiling the timescales of nuclear activity. The same observations provide a new perspective on the neutral gas (HI) in and around the NGC 6240, enabling us to determine its dynamical timescales and to investigate the interaction history of this system. High-fidelity imaging and accurate spectral ageing from these newly-discovered, multi-epoch radio lobes and HI surrounding the dual AGN add important information to the holistic understanding of this post-merger system and to connect the merger, starburst, and jet-triggering timescales. Comparisons such as this preview SKA observations which will enable such studies over much larger statistical samples of sources and at higher redshifts where the galaxy merger rate, AGN prevalence, and cosmic star formation rate density are significantly higher.

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Inclusion, Diversity, Equity and Accessibility in Action

Dr. Kartik Sheth

NASA HQ

Abstract

Amongst the many initiatives we undertook at NASA, I co-chaired the Anti-Racism Action Group at NASA HQ in the Science Mission Directorate. Using design Thinking principles, we worked to establish eight short term action items, over 200 long term actions and fundamentally began changing the culture to align with NASA's core value of Inclusion. I will describe the lessons learned in this endeavor and discuss what worked and what didn't work to move the needle. I also piloted adding Inclusion Plans to our research proposals, starting with NASA's Astrophysics Theory program and then expanding it to other research areas in astronomy. This idea was picked up by the Department of Energy who introduced their own version of this for their Office of Science. I will describe the lessons learned from these pilots and how that is changing our field. Finally I will discuss ideas for new initiatives to help increase equity and inclusion in many areas of science from a government perspective and share what I have learned from serving at the White House in the Executive Office of the President.

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Environments of Quenched Low-Mass Galaxies with AGN

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Abstract

With the discovery that actively accreting supermassive black holes – active galactic nuclei (AGNs) – can inhabit low-mass galaxies, it becomes possible to study how an AGN influences a low-mass galaxy's gas content and star formation. However, it is difficult to disentangle whether a galaxy is shutting down – quenching – its star formation because there is an AGN or due to environmental effects such as interactions between galaxies. We use the Sloan Digital Sky Survey IV Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey to select samples of low-mass galaxies that have AGNs based on their optical emission line ratios. To further our understanding of the effect of AGNs and the environment on the star formation in low-mass galaxies, we study the group richness and star formation rate of our AGN and non-AGN samples. We find that low-mass galaxies with AGNs are more likely to be found in isolation or in low-mass groups than the non-AGN sample, and this trend is even more pronounced in the quiescent galaxies hosting AGNs. This suggests that the environment did not play a large role in quenching the star formation in these galaxies.

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Prospects of Detecting a Jet in Sagittarius A* with VLBI

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Abstract

Does the supermassive black hole at the center of our galaxy, Sagittarius A* (Sgr A*), have a jet? Results from Event Horizon Telescope (EHT) data favor accretion flow models in which one is present, however, it has not been conclusively detected. Using simulated data based on the 2017 EHT best-best models of Sgr A*, we explore the possibility of detecting this jet with existing and next-generation VLBI arrays at 86, 115, 230, and 345 GHz. The competing astrophysical effects of jet power, jet variability, and interstellar scattering due to ionized plasma between Earth and the Galactic Center add complexity to the prospects for jet recovery in images of Sgr A*. In addition, the VLBI arrays we consider have different configurations and instrument sensitivities that significantly influence their ability to image the jet. While current VLBI arrays are unable to capture the jet, next-generation arrays at 86 and 115 GHz such as the ngVLA and the next-generation EHT are able to image the jet. The prospects towards detecting a jet in Sgr A* are bright and motivate the continued development of these next-generation radio observatories.

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Multiwavelength Analysis of the Interactions Between Radio Galaxy Jets and the Intracluster Medium

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Abstract

Galaxy clusters, the largest gravitationally bound structures in the universe, often host radio galaxies with jets that are powered by active galactic nuclei (AGN). These clusters evolve through highly energetic mergers and accretion, leading to the creation of shocks and cold fronts in the intracluster medium (ICM) and the amplification of intracluster magnetic fields. Changes in the morphology, flux, and spectral features of radio jets have been shown to coincide with X-ray discontinuities corresponding to cold fronts or shocks. This suggests that these changes are caused by jet-ICM interactions. The aim of this study is to search for evidence of such interactions. We use observations from the MeerKAT radio telescope to investigate the complex morphology of a sample of radio galaxies within galaxy clusters, including some with large-scale bends. Through radio spectral index analysis, we locate regions along the jets where interaction with the ICM potentially occurs. To support this, we use XMM-Newton observations for X-ray imaging and spectral analyses of the cluster environments of these radio galaxies. This provides insight into the density and temperature distributions of the ICM, which allows us to identify shocks and cold fronts. This research advances our understanding of complex jet-ICM and the evolution of radio galaxies.

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Dust and Cold Gas Properties of Starburst HyLIRG-Quasars at z ∼ 2.5

Mr Feng-Yuan Liu

University of Edinburgh

Abstract

Some high-z active galactic nuclei (AGNs) are found to reside in extreme star-forming galaxies, such as hyper-luminous infrared galaxies (HyLIRGs), with AGN-removed L_{IR} of $> 10^{13}\,L_{\odot}$. In this paper, we report NOEMA observations of six apparent starburst HyLIRGs associated with optical quasars at $z \sim 2-3$ in the Stripe 82 field, to study their dust and molecular CO properties. Five out of the six candidates are detected with CO(4-3) or CO(5-4) emission, and four in 2mm dust continuum. Based on the linewidth-$L'_{CO(1-0)}$ diagnostics, we find that four galaxies are likely unlensed or weakly lensed sources. The molecular gas mass is in the range of $\mu M_{H2} \sim 0.8 - 9.7 \times 10^{10}\,M_{\odot}$ (with $\alpha = 0.8\,M_{\odot}\,(K\,km\,s^{-1}\,pc^{2})^{-1}$ and μ is the unknown possible gravitational magnification factor). We fit their SEDs, after including the observed 2mm fluxes and upper limits, and estimate their apparent (uncorrected for possible lensing effect) star formation rates (μSFRs) to be $\sim 400 - 2500\,M_{\odot}\,yr^{-1}$ with depletion time of $\sim 20 - 110$ Myr. We notice interesting offsets, of $\sim 10 - 40$ kpc spatially or $\sim 1000 - 2000\,km\,s^{-1}$ spectroscopically, between the optical quasar and the mm continuum or CO emissions. The observed velocity shift is likely related to the blueshifted broad-emission-line region of quasars, though mergers or recoiling black holes are also possible causes, which can explain the spatial offset and the high intrinsic SFRs in the HyLIRG-quasar systems.

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3012

Recent findings about the L_X-L_{UV} relation in quasars and the physics behind it

Dr. Matilde Signorini

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Abstract

Given the persistence of X-ray emission in AGN over time, there must be a physical mechanism that transfers energy from the accretion disc to the X-ray corona. Although this process remains poorly understood, one observational result offers insight: the non-linear relation between X-ray and UV emissions, typically expressed as $\log(L_X)=\gamma \log(L_{UV})+ \beta$. This relation and its parameter values serve as both a foundation and a test for models aiming to describe the interaction between the accretion disc and the corona. In this talk, I will discuss the most recent advances in understanding the properties of said relation. By conducting a detailed spectroscopic analysis, we have been able to determine which physical quantities serve best as proxies for the UV and X-ray luminosities, shedding light on the physical mechanisms at play. I will also present evidence that the characteristics of the L_X-L_{UV} relation remain constant across all redshifts and that, when high-quality data are available, the observed dispersion lowers significantly. Furthermore, I will show that when we consider the observational contributions (like variability and inclination) to this already small dispersion, they can fully account for it. This means that, intrinsically, the physical mechanism behind the relation must be very tight, across different luminosities and cosmic epochs. Finally, I will comment on possible physical models for the L_X-L_{UV} relation, and I will mention how the relation can be implemented not only to understand AGN physics but also to measure cosmological distances and trace the expansion of the Universe.

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WIYN ODI imaging of low-z quasar host tidal features

Dr. Susan Ridgway[1], Dr. Mark Lacy[2], Dr. Dan Li[1], Dr. Wilson Liu[1], Dr. Jayadev Rajagopal[1]

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Abstract

Current theories of galaxy formation typically invoke phases of powerful quasar activity and energetic feedback in the evolutionary history of every massive galaxy, with a phase of quasar activity triggered by major mergers. Nonetheless, HST imaging found that while bright, optically-selected quasars may have hosts with a range of morphologies, most low-z hosts appeared to be undisturbed early-type galaxies. Deeper HST imaging showed low-level tidal relicts in many of these seemingly passive ellipticals (Canalizo & Stockton 2001). HST imaging of AGN samples at higher redshift and luminosity show minimal evidence for enhanced incidence of merger remnant morphologies in the AGN hosts over mass-matched samples of inactive galaxies (e.g. Villforth et al. 2018). Using the shallow but wide-field PanStarrs and DESI legacy imaging surveys allows systematic study of the host properties of a large sample of VLASS/Gaia-selected low-z quasars spanning a range in radio luminosity from radio-quiet to radio-loud. Here we present some preliminary results of a small program to use the WIYN wide-field imager ODI to obtain deep multicolor images (including u-band) of a few of these low-z quasar targets, in which the shallow survey images gave some indications of the existence of tidal tails or other extended merger-remnant emission. By determining ultraviolet—optical colors in these extended features, we can place some limits on stellar content and stellar age, and hope eventually to assess how predominant recent gravitational interactions are in low-z quasar samples that are not as bright or as unobscured as the typical sample studied by HST.

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Using ALMA as a Thermometer for Host Galaxy Growth of Quasar

Dr. Takafumi Tsukui[1,2], Dr. Emily Wisnioski[1,2], Prof. Mark Krumholz[1,2], Dr. Andrew Battisti[1,2]

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Abstract

Complementary to the recent JWST efforts to detect quasar host galaxies, ALMA observation provides the best window for characterising host galaxy growth in terms of star formation rate (SFR) and available gas reservoir. However, the potential AGN contribution to ALMA dust continuum images is usually ignored and poorly understood, leading to significant uncertainty for the SFR estimate. To address the question, we conducted spatially resolved modelling for multi-band dust continuum emissions (Band7/9) for high redshift bright quasar (z=4.4). The analysis, for the first time, shows a significant pixel-by-pixel temperature variation in the high redshift quasar with an unambiguous peak in the centre, which coincides with the optical quasar position and dust continuum peak. Spatially resolved data allow us to self-consistently constrain dust opacity without additional free parameters by linking the dust mass and the physical area subtended by the beam. The dust opacity derived from the spatially resolved analysis disagrees significantly with that derived from unresolved data. The SED analysis combined with the spatial decomposition (point-source AGN and extended host galaxy) reveals that the AGN contribution significantly alters the derived total SFR, revising the total SFR of the source to 1700 Msun/yr from 5000 Msun/yr in the literature. SFR density and gas mass density after the successful decomposition show a similar linear relation to other high-z submillimeter galaxies. Panchromatic AGN and host decomposed SED analysis by both JWST and ALMA is a promising path forward to determine mass build up under the influence of the active quasar.

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How Do AGNs Affect Stellar Populations in Low-Mass Galaxies?

Catherine Witherspoon[1], Eric Wilcots[2]

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Abstract

Actively accreting supermassive black holes – also known as active galactic nuclei (AGNs) – can enhance or shut down – quench – star formation in massive galaxies. It is less certain, however, how the presence of an AGN can affect the stellar populations and star formation histories in low-mass galaxies. Using resolved optical spectroscopy from the Sloan Digital Sky Survey IV Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey, we select 42 low-mass galaxies with emission line ratios suggestive of AGN activity. We study the star formation histories of these galaxies in order to understand how AGNs might influence or drive the star formation quenching process. We find that the AGN sample has older stellar populations than the non-AGN sample as well as star formation histories that indicate less recent bursty star formation. Additionally, the AGN sample has mass-weighted stellar ages that are 10 times lower within one effective radius of the galaxy centers than in the outer regions of the galaxies. Given that previous studies of low-mass galaxies hosting AGNs found that they tend to be gas-poor, it is possible that we are catching these galaxies as they are quenching their star formation.

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3040

Modeling AGN SED in Cosmological Simulations

Tong Su

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Abstract

The study of the spectral energy distribution (SED) of active galactic nuclei (AGN) plays a crucial role in several aspects, including the physics of black hole (BH) accretion, AGN feedback, AGN luminosity functions (LF), and in understanding the AGN-galaxy co-evolution. In this work, we study the accretion model for a wide range of the Eddington-normalized accretion rate. We calculate the structure and the corresponding SED of the accretion flow by specifying BH mass and accretion rate. For accretion rate below a critical value, the accretion flow is described as the Advection-Dominated Accretion Flow (ADAF). Above this value, the accretion flow takes the form of a disk-corona system built up via magnetic reconnection; in this regime, a multi-color blackbody component naturally emerges as reaches unity. Combining with the semi-analytical model of galaxy formation L-galaxies, we derive the SEDs of AGNs in the simulated galaxy catalog. By integrating over specific wavelength ranges, we obtain the bolometric, soft X-ray, hard X-ray, and optical/UV LF theoretically. By comparing with observations, we found good agreements among AGN properties between our predictions and observational data at redshift $z<1$. However, our model's predictions deviate from observational data for $z>1$. We argue that such deviation may arise from the inherent BH growth history in the semi-analytical models.

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Multiwavelength Investigations of Obscured Quasars across Local and Distant Universe

Dr. Pallavi Patil[1], Dr Andreea Petric[2], Karolina Garcia[3], Prof Mark Whittle[4], Yuanze Luo[1], Dr. Dario Fadda[2], Dr. Mark Lacy[5]

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Abstract

The merger-driven evolutionary scenario predicts the presence of a critical transitional phase during which the recently (re)ignited Supermassive Black Hole (SMBH) is fueling at its peak and is actively injecting kinetic energy into the host's Interstellar Medium (ISM). This SMBH growth occurs behind thick columns of dust while the host galaxy is still experiencing substantial starburst activity. Although there is mounting observational evidence of AGN-driven impact on the ISM, we still do not understand how the AGN can regulate the galaxy growth by driving outflows and quenching the SF. In this talk, I present a comparison of MIR spectroscopic observations of nearby galaxies with the prediction of crucial ISM tracers such as [CII], CO, and H2 estimated using a modelization tool. We present the archival SOFIA FIFI-LS and Herschel PACS observations of a heterogeneous sample. It allows us to look across a wide range of parameters, e.g., AGN fraction, obscuration, warm gas temperature, dust properties, and merger state. We compare the ISM and dust characteristics of the local sample with a distant population of heavily obscured quasars (z~1-3) selected by cross-matching WISE-NVSS surveys. Pilot ALMA investigations of cosmic noon quasars show the dust and cold molecular gas distribution in this unique sample that is likely to be in the post-merger state. Finally, I discuss the implications of such comparison studies that would be beneficial for understanding the impact of AGN on their host galaxy in the context of galaxy evolution.

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Probing parsec scales in AGN with radio and optical astrometry

Dr Sasha Plavin[1], Dr Yuri Kovalev[2], Dr Eileen Meyer[3], Dr Leonid Petrov[4], Lizbeth Tan[3]

[1]Black Hole Initiative. [2]MPIfR. [3]UMBC. [4]NASA

Abstract

The launch of the Gaia mission has enabled millisecond-scale optical position measurements, and multiwavelength astrometry when combined with VLBI in radio. We have demonstrated that radio-optical discrepancies in AGN positions are caused by astrophysical properties of their disk-jet system. The extended jet emission affects radio and optical measurements in different ways, and these differences can be used to study the disk-jet interplay at parsec scales. Recently, we have performed dedicated follow-up observations of AGN selected by their radio-optical offsets with the Hubble Space Telescope and with VLBI arrays. They have confirmed our early conclusions. In this talk, I will demonstrate how Gaia let us find AGN with extended optical jet emission that requires efficient plasma re-acceleration mechanisms. I will discuss how the VLBI-Gaia synergy helps us interpret radio images correctly, and how it opens new ways to study optical flares in AGN.

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A panchromatic view of the circumgalactic medium surrounding a brightest cluster galaxy at z=0.4

Prof Allison Man, Lucas Kuhn, Laya Ghodsi

The University of British Columbia

Abstract

Star formation within galaxies is regulated by the circumgalactic medium (CGM) through gas inflows and outflows. I will present an analysis of the comprehensive view towards the multiphase (warm and cold molecular + ionized) gas and dust analysis of a BCG at z=0.4. The target harbours one of the largest known H2 reservoirs, elevated star formation, and a strong radio AGN. We obtained new JWST/MIRI MRS observations that detect warm H2 lines, indicating that the molecular CGM is warmer than the interstellar medium within the BCG. I will present preliminary results a joint analysis of the warm and cold molecular gas in the CGM and BCG, using ALMA and single-dish observations of CO and [CI] emission lines. Archival HST and VLT/MUSE observations enable us to tie the gas and dust conditions to the resolved stellar populations. I will discuss the implications of this work on the possible link between the enhanced star formation in this BCG and its CGM, as well as the role of AGN feedback in regulating star formation. This case study serves as a pathfinder for using JWST to complement existing multi-wavelength observations of the gas, dust and stars of massive galaxies and their CGM using JWST.

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z~5 Quasar Search via Deep Learning and Bayesian Information Criterion from The Hyper Suprime-Cam SSP Survey PDR3 Data

Yunyi Choi, professor Myungshin Im

Seoul National University

Abstract

Using data from the Hyper Supreme-Cam Subaru Strategic Survey Program data (HSC-SSP PDR3), we applied deep learning to select quasar candidates near z ∼ 5. Faint quasars at high redshift are essential indicators of the amount of ultraviolet photons that ionize the intergalactic medium (IGM) of the early universe. In a previous study (Shin et al. 2022a), a flag called 'pixelflags crcenter' was used to exclude objects with cosmic rays detected within 3 pixels of the center of that object when selecting quasar candidates. This significantly reduced the effective survey area (nearly by a factor of two) and the number of quasars discovered. Therefore, this study excludes the flag in the catalog query conditions to select as many quasar candidates as possible. Using the Deep/UltraDeep(D/UD) data, we selected candidates based on deep learning and Bayesian Inference Criterion methods. This approach allowed us to select quasar candidates compared to traditional color selection methods with low contamination rate (20.7% → 3.4%).

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AGN vs. (S0 Type) Host Galaxy Relation at All Scales

Dr. Lyuba Slavcheva-Mihova, Dr. Boyko Mihov

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Abstract

Seyfert nuclei host predominantly early-type disk galaxies. On the other hand, the central regions of active and inactive S0 galaxies, contrary to later types, differ in their dust amount, gaseous kinematics, etc. We have selected S0 galaxies from a Seyfert sample previously studied by us with the aim to explore the active nucleus vs. host galaxy relation at all scales.

We perform 2D structural decomposition and discuss the output parameters. In particular, the bulge Sérsic index, together with other criteria, is informative for the incidence of pseudo-bulges and the possible nuclear activity feeding by secular evolution rather than interaction-driven inflow. Model residuals and unsharp masking are helpful in unveiling features, as tails, arcs, ripples, bridges. We analyse them using simulations in terms of the galaxy interaction status. As a result, parameters like companions' mass ratio, tidal features' age, time after first passage, and star formation (SF) history are acquired. Using UV-to-FIR data, we build the Spectral Energy Distributions (SEDs) and fit them with the *AGNfitter* code accounting for the emission of the accretion disk, torus, host galaxy stellar population, and cold dust. As a result, AGN and SF parameters are acquired. Going inwards, emission and dust features are explored by means of structure and colour maps of high-resolution data. After the AGN subtraction, SEDs are constructed and then fitted with the stellar population model. This results in SF history assessment in the circum-nuclear region. We discuss the relation between the host galaxy properties and the AGN parameters at various scales.

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Tying Extremely Powerful AGN Feedback to Beads-on-a-String Star Formation in a Merger-Rich Galaxy Cluster

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Abstract

With two central galaxies engaged in a major merger and a remarkable chain of 19 young stellar superclusters wound around them in projection, the galaxy cluster SDSS J1531+3414 (z=0.335) offers an excellent laboratory to study the interplay between mergers, AGN feedback, and star formation. New Chandra X-ray imaging has revealed rapidly cooling intracluster gas, with two “wings" forming a concave density discontinuity in the cluster’s central 100 kpc. Low-frequency LOFAR observations uncover diffuse radio emission strikingly aligned with the "wings,'' suggesting that they are actually the opening to a colossal X-ray supercavity. The steep radio emission is likely an ancient relic of one of the most energetic AGN outbursts observed to date, with 4pV > 10^61 erg. North of the supercavity, GMOS and ALMA detect a ~100 billion solar mass reservoir of warm ionized and cold molecular gas surrounding the young stars but redshifted up to + 800 km/s with respect to the southern central galaxy. We propose that the multiphase gas originated from low-entropy gas entrained by the X-ray supercavity, and suggest that tidal interactions stimulated the beads on a string" star formation morphology. Our work not only illuminates how large-scale AGN feedback and galactic dynamics regulate localized star formation processes in SDSS J1531+3414, but also offers a potential window into the feedback processes that shaped the earliest galaxy clusters, which are characterized by similarly dynamic environments.

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Tracers of galactic outflows for different feedback models in NIHAO

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Abstract

The formation and evolution of galaxies is a complex and multiscale problem, where gas flows play an important role. Cosmological simulations have illustrated that feedback mechanisms from stellar winds, radiation fields, supernovae and active galactic nuclei (AGNs) can effectively drive galactic winds. However, the details of the driving mechanisms behind gas in- and outflows are still unclear. We use the state-of-the-art cosmological hydrodynamical simulation of Milky Way like galaxies (NIHAO) to study the effect of different feedback processes on gas in- and outflows at different gas temperatures to investigate the underlying mechanisms driving gas flows for edge-on galaxies. We compare simulation runs with and without AGN feedback, with different star formation thresholds and with local photoionization. Metals seem promising to trace the difference between different feedback models. To validate and extend our findings, we study the edge-on spiral galaxies from the GECKOS (Generalising Edge-on galaxies and their Chemical bimodalities, Kinematics, and Outflows out to Solar environments) survey, a large MUSE program recently granted. Furthermore, we build a virtual telescope to create mock-MUSE observations of our simulated galaxies. This enables us to compare and treat the simulations and observations in the same way. Our aim is to understand better the different feedback mechanisms, which drive gas outflows, from a simulation perspective and to perform realistic comparison to observational data.

Session

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Activity of the Mauritanian Astronomy Association

Activity of the Mauritanian Astronomy Association Ely cheikh Ould Mohamed Navee

Mauritanian association for astronomy

Abstract

The Mauritanian Association for Astronomy was established on 07/17/2019. This society aims to contribute to the development of astronomy in Mauritania through courses in schools, institutes, high schools and the university. The Association aims to establish an astronomical observatory to encourage scientific research in the field of astronomy in Mauritania by installing a huge number of Cameras and linking them to the astronomical observatory to monitor the sky day and night 24 hours a day.

One of the Association's objectives is to encourage scientific activities in general and encourage activities related to astronomy in particular.

And linking cooperation and exchange halls with other associations and organizations working in the field of astronomy.

It aims to organize events: conferences, discussions, study trips, and introductory courses in science in general and astronomy in particular.

The Mauritanian Astronomy Association aspires to integrate astronomy curricula into educational institutions.

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Hands-on Astronomy: How to integrates STEAM Educational Elements into Astronomy Outreach and Public Education

Exodus Chun-Long Sit

NOC Hong Kong

Abstract

Astronomy education plays a pivotal role in both formal school settings and public science communication. This presentation focuses on an interdisciplinary project STEM+A@Astronomy, which aims to develop low-cost STEAM activities. By integrating science, technology, engineering, arts, and mathematics, this project aims to cultivate learners' curiosity and hands-on skills in public outreach, science communication, and astronomy education. The interactive activities encompass space science, astronomical observation, dark sky protection, and planetary science in a versatile framework to make astronomy learning more accessible, affordable, and engaging, enabling a wider audience to explore the wonders of the universe under one sky.

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A Drop of Rain Falls on the Gobi Desert- Cooperation between Mongolia and Japan to promote astronomy -

Dr. Hidehiko Agata

National Astronomical Observatory of Japan

Abstract

This talk will discuss a certain "butterfly effect" in the dissemination of astronomy. NAOJ's "You are Galileo!" project has supported astronomy education in Mongolia.

"You are Galileo!" is an astronomy education project started in 2008 that has brought telescopes to schoolteachers and children in developing countries through inexpensive telescope-assembling workshops and astronomical observation events. It is one of the legacies of the IYA2009 project. http://kimigali.jp/index-e.html

It has been held most frequently in Mongolia, where a total of seven Mongolian domestic expeditions have been co-hosted by NAOJ and the National University of Mongolia. Totally 440 telescope kits were distributed. In 2009, our NAOJ team first visited Mongolia with Professor Tsolmon Lenchin of the National University of Mongolia. Her son will launch Mongolia's first astrotourism travel company in 2020. When he was a student in Mongolia, "You are Galileo!" project, he came up with the idea for this startup while helping with the project. Also working for this first Mongolian astrotourism company is a boy (about 13 years old at the time) whom we met in July 2014 in Bayan-Ulgii, deep in the Altai Mountains in the extreme northwest of Mongolia. He was born and raised as a herder deep in the Altai Mountains, nearly 3,000 meters above sea level, and he was a star-loving boy who enthusiastically supported the observing sessions. We would like to examine these changes in Mongolia over the past decade.

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Activities conducted in Greece, in the frame of the institution of OAO/NOCs

Dr Margarita Metaxa

Arsakeio High School. Greek co-NOC. National Observatory of Athens, associate for education

Abstract

Greece entered the scheme of NOCs for the first time in 2019, for the IAU100 celebrations. Since then, we have conducted under the guidelines and support of OAO/IAU lot of related projects. The various outreach activities that have been held within this frame, were effective having remarkable penetration to the Greek society. In my presentation I will discuss a. all the projects that has been accomplished for the period 2019-2024, under different NOCs (I was part of the scheme of NOC all those years) and their legacy b. the way that the various projects enhanced the collaboration between amateur and professional astronomers, reinforced specific citizen science projects, and as well international collaborations.

Finally I will discuss how contemporary technical innovation (AI etc), could be implemented to OAO/IAU projects in order to reinforce communication in the new digital environment and needs, hoping to contributed as well to the scientific literacy of the citizens. The discussion will be based on my experience with 2 already implemented projects:

1. “Life in extreme conditions, searching for a second Earth”, a poster enhanced with AR.
2. “A picture is worth a thousand words”, an activity for Light Pollution matching art with AI.

To conclude the involvement of Greece in outreach activities through the institution of NOCs OAO/IAU, reinforced the ecosystem of astronomy in Greece and improved it a lot.

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Harnessing Infographics for Astronomy Education in Resource-Limited Regions: The Case of Iraq

Dr Ali Al-Edhari

Al-Muthanna University

Abstract

This study investigates the impact of infographics on astronomy education within the resource-constrained context of Muthanna Governorate, Iraq. Aimed at enhancing the understanding of astronomical concepts, the research evaluated the effectiveness of infographics in making education more accessible and engaging, particularly in areas with limited educational resources. Our analysis encompassed a diverse demographic, with 200 participants varying in age, gender, and educational background. The study employed both printed and digital infographics, disseminated through social media and public distributions, to measure the effectiveness, preference, and impact on educational engagement. Key findings reveal that infographics significantly increase comprehension of astronomical concepts, with an average effectiveness perceived at 84.95%. Digital formats were preferred, with an 80.5% average preference rate, indicating a shift towards technology-enhanced learning. Gender-based preferences were notable, with 90% of female participants favoring infographics compared to 70% of male participants. Engagement and motivation levels were substantially higher among those who learned through infographics, with increased follow-up attendance and active participation. The study also identified and addressed barriers to infographic implementation, such as resource limitations, technical challenges, and resistance to change. Strategies to overcome these hurdles include leveraging open-source tools, developing low-tech infographics, and initiating educator training programs. Conclusively, our research supports the integration of infographics into educational curricula, particularly in astronomy and other resource-limited settings, to foster interactive learning experiences and democratize access to scientific knowledge.

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The Travelling Telescope

Mr Chu Owen, Mrs Susan Murabana Owen

The Travelling Telescope

Abstract

Access to hands-on science in Africa is limited. The Travelling Telescope strives to provide stargazing sessions and planetarium shows for a range of schools across Kenya, and we use our astro-tourism work to remain sustainable. We have also built the first fixed planetarium in Kenya, the dome of which is a low cost alternative to traditional planetaria construction, specifically relevant to equatorial regions of our planet.

We provide stargazing sessions in schools and for the public. Using 3 different telescopes we are able to have large crowds gathered under Kenya's equatorial skies. We use 2 large reflectors on tracking mounts (an 8" and a 12") primarily for the planets and the Moon, and a Unistellar telescope which can provide stunning views of various nebula, galaxies & supernova remnants using its image enhancement technology. This telescope also joins with others around the globe and helps contribute to scientific enquiry, including filming the recent DART mission.

In addition, we travel with a mobile planetarium (using an 8 meter or a 5 meter dome) and provide presenter-lead shows along with fulldome planetarium documentaries. We have also built a unique dome using bamboo - a low cost approach to providing a fixed planetarium in an underserved region.

We also try to highlight the importance of bringing "A" from art into STEM to produce STEAM. Our night time events are by nature conducted in the dark, where sound becomes a crucial sense, and so we use music and voice to enhance our night time events.

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Astronomy education using technical innovation: two case study

Dr Margarita Metaxa[1], e-learning specialist Maria Tsoura[2]

[1]Arsakeio, national Observatory of Athens. [2]Department of Pedagogy and Primary Education National and Kapodistrian University of Athens

Abstract

Astronomy is a fascinating science that leads to understanding the history and nature of science in general, while is connected to environmental issues. These unique characteristics turn Astronomy to a pop-science, attracting many young people in science and technology. Many scientific, educational societies and government agencies have produced materials and educational resources in astronomy for either formal or informal education. Innovation especially the integration of artificial intelligence (AI) in education has the potential to transform the way students learn and teachers educate in a most effective way. It can lead to deeper knowledge, as students interact in blended semiotic learning systems, with real and virtual world activities, to build scientific literacy and literacy for science. I will present and discuss two activities we have created using technology:

1. "Life in extreme conditions, searching for a second Earth", a poster enhanced with AR.
2. "A picture is worth a thousand words", an activity for Light Pollution matching art with AI.

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Outreach Astronomy in Egypt: Tools and Resources

Prof. Dr Somaya Saad

National Research Institute of Astronomy and Geophysics, NRIAG

Abstract

Science in general represents a basic part of our culture and human conscience, since it is one of the sustainable development goals and pillars of societal progress.

Astronomy is the most fascinating science, attracting people of all ages and arousing their curiosity. The astronomy for outreach and awareness are considered as one of the most important goals of the International Astronomical Union where the Office of Astronomy Outreach OAO plays a leading role in the field of astronomy communication. The National coordinators of Astronomy outreach (NOCs in Egypt) participating in achieving the goals of astronomy outreach and awareness with the general public through conferences, seminars, training , Astronomical Observation Camps, workshops and many other creative activities.

Here we will share with you the most important activities of astronomy outreach, and the tools, resources and the multiple elements that contributed to the success of this role in the Egyptian society.

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SpaceJam 2023: Improving Visibility and Reputation of GSSTI During the World Space Week

Dr Naomi Asabre Frimpong

Ghana Space Science and Technology Institute (GSSTI), Ghana. African Astronomical Society (AfAS)

Abstract

SpaceJam 2023 represents an initiative undertaken by the Ghana Space Science and Technology Institute (GSSTI) to bolster its visibility on both a local and global scale within the context of space science and technology. This initiative integrated science, technology, interactive games, and music to render space science and astronomy more accessible to a diverse audience. It facilitated a wide array of hands-on experiences, attracting substantial participant engagement and media coverage, notwithstanding the logistical challenges encountered. These obstacles, together with the strategies implemented to address them, provide valuable lessons for the enhancement of future events. The significant amount of media coverage that SpaceJam has received is acknowledged for its vital role in expanding the initiative's influence and scope.This presentation will delve into the planning, implementation, challenges faced, and successes realized during SpaceJam 2023. It will also outline prospective strategic improvements for upcoming iterations, reaffirming GSSTI's commitment to promoting scientific inquiry, innovation, and broad-based involvement in the exploration of space science and technology.

Session

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Professional – Amateur Research Collaborations (PARC)

Prof. Aniket Sule[1,2], Dr. Timothy Spuck[3]

[1]Homi Bhabha Centre for Science Education (HBCSE-TIFR), Mumbai, India. [2]IAU OAE Center India.
[3]National Science Foundation, USA

Abstract

In this talk, we present a brief review of the activities of the IAU EC working group on Pro-Am relations. This includes statistical insights from our global survey on amateur astronomers, professional amateur research collaborations (PARC) portal and initial workshops conducted to kick-start such collaborations. We discuss differing needs of different sections of global amateur astronomy community and varying type of support necessary to foster meaningful collaborations. Although it is true that most amateur astronomers in developed countries tend to have their own high end observing equipment and access to clean and relatively dark skies, most astronomy enthusiasts in developing countries are based in dense urban centres and often lack equipment necessary for quality observations. They are, however, well adapt in other skills which can be brought to use to make PARC more inclusive.

Session

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Bridging the Gap: Strengthening Collaboration Between Professional and Amateur Astronomers for Enhanced Public Outreach

Ms Caterina Boccato[1], Mr Cesare Pagano[2], Mr Andrea Alimenti[2], Ms Livia Giacomini[2], Ms Clementina Sasso[1]

[1]Istituto Nazionale di Astrofisica - INAF. [2]Unione Astrofili Italiani - UAI

Abstract

In Italy collaboration between professional and amateur astronomers (Pro-Am) is a consolidated habit in research, with established practices and structured ways of collecting and sharing scientific data. On the other hand, in the field of public outreach, there are many Pro-Am collaborations but they are often local, based on personal relationships, and focused on a specific activity. At our current knowledge there are not widespread methodologies of structured collaboration in this area.

Istituto Nazionale di Astrofisica (the Italian public national institute for professional astronomers) and Unione Astrofili Italiani (the Italian national association of amateur astronomers) formed a joint team to focus on this topic.
The first initiative was to take a first snapshot of the current state of collaborations in our Country, through an informal survey among both INAF astronomers and the Italian amateur community.

The main purpose of this survey is to build a concrete data foundation on which the team is developing a memorandum of understanding (MoU) between INAF and UAI for a truly effective and concrete collaboration.

The outcome is very interesting, in terms of both quantitative and qualitative aspects. Most importantly, the survey provides relevant data points on what is working, what is not working and what should be done to make these collaborations even more effective. The team is planning future projects, framed by the MoU, as follow-up based on these findings.

Session

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Mobile Planetarium in Remote Areas – The Mobile Planetarium in Namibia

Marieke Baan, Joanna Holt, Joris Hanse

Netherlands Research School for Astronomy (NOVA)

Abstract

In addition to bringing together professional astronomers, the IAU advocates the use of astronomy as a means of uniting and engaging people across the world. Our shared night sky is the perfect starting point, particularly in remote areas where the stars are not swamped by city lights. With these ideas in mind, NOVA began to discuss sharing its experience and expertise with a Mobile Planetarium in the Netherlands with other countries, in particular Namibia. A week's pilot visit in 2019 was a resounding success, reaching more than 1600 learners and their teachers in remote regions of the country. Shortly after, plans were made for a permanent AMT Mobile Planetarium project - a collaboration between the Africa Millimeter Telescope, Radboud University, the University of Namibia, and NOVA. Funds were granted through the OAO NOCs Funding Scheme 2020 to support the development of two products: 1) Namibia-specific planetarium content and 2) further materials to support the planetarium project. After a delay due to Covid19, NOVA carried out the first training of planetarium students in Namibia in May 2022 during which the new planetarium content was tested. The training visit highlighted the need for a new basic astronomy course for Namibian students wanting to work with the planetarium. The astronomy course was finalized in early 2024 and will be tested in the next NOVA training in Namibia in March 2024.

The OAO project was granted to Eli Kasai (NOC-Namibia), Tsolmon Renchin (NOC-Mongolia) and Marieke Baan (NOC-Netherlands).

Session

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The Decadal Odyssey: A Glimpse into NOC-Ethiopia within the Journey of IAU-OAO

Kirubel Menberu Alemu[1,2,3], Alemiye Mamo Yacob[2,4]

[1]Ethiopian Space Science Society (ESSS). [2]Space Science and Geospatial Institute (SSGI). [3]Office for Astronomy Outreach (OAO). [4]East African Regional Office of Astronomy for Development (EA-ROAD)

Abstract

The astronomy outreach community in Ethiopia has been actively engaging the public in astronomy through various initiatives. Collaborating with the Ethiopian Space Science Society (ESSS) and the Space Science and Geospatial Institute (SSGI), NOC-Ethiopia has played a pivotal role in these efforts. This presentation delves into NOC-Ethiopia's decade-long journey and its significant contributions to astronomy outreach.

Over the past decade, NOC-Ethiopia, in collaboration with ESSS and SSGI, has organized numerous activities to promote astronomy education and awareness. These include public lectures, school outreach programs, and telescope observation sessions across Ethiopia. These initiatives have successfully reached a wide audience, including students, teachers, and the general public, fostering a greater interest in astronomy and space science.

NOC-Ethiopia has actively participated in several Office for Astronomy Outreach (OAO) projects, such as NameExoworlds, which had a nationwide impact, and the regional Dark Sky and Astro-tourism Outreach project involving five East African NOCs and funded by OAO. Additionally, it has been involved in 100 Hours of Astronomy, resulting in winning the SSVI Telescope—a crucial instrument for further outreach activities. Besides OAO-led projects, NOC-Ethiopia has collaborated with the wider International Astronomical Union (IAU) community in Ethiopia, contributing to OAE and OAD-led and funded activities

This presentation will highlight key activities and achievements of NOC-Ethiopia over the past decade, demonstrating its impact on astronomy education and outreach in Ethiopia. It will also address future plans and challenges faced by NOC-Ethiopia as it continues its mission to promote astronomy and space science in the country.

Session

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Challenges of outreach programs for inclusive astronomy in Morocco

Professor Abdelmajid BENHIDA

FST Marrakech

Abstract

In this work, I will present our experience in Morocco. Indeed, we have set ourselves the goal of promoting inclusive astronomy and orienting girls to STEM fields. Indeed, we collaborate with associations in and around Marrakech that promote education for rural girls, especially those from disadvantaged backgrounds.

We ensure sustainability by extending these workshops to other girls' schools throughout the year. We have led many activities such as:

- Visits: Meet school-age girls directly in their homes, awaken their curiosity and share knowledge about astronomy and STEM.

- Training: Creation of astronomy clubs within their Provide specialized training to improve their outreach capabilities.

- Visits to Educational Homes for School-Aged Girls.

Session

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Ivorian Astronomy Association: Promoting astronomy outreach in Côte d'Ivoire

Dr Kassamba Abdel Aziz DIABY[1], Dr Harris Yao Fortune Marc[1], Dr N'Guessan Kouassi[1], Dr Pancrace Aka[1], Dr David Baratoux[1,2]

[1]University Félix Houphouët-Boigny. [2]Institut de Recherche et de Développement (IRD)

Abstract

The Ivorian Astronomy Association was created to promote astronomy in particular and space sciences in general. It is the brainchild of a group of students and researchers in geomagnetism, aeronomy and astrophysics. The idea of creating such an association came from the observation that there was an ever-increasing drop in the number of students taking science as major. As a result, there is a shortage of teachers in disciplines such as mathematics and physics in the country. The aim of the association is to inspire students to take up scientific studies and also to educate the public about astronomy. Since its creation, approximately 10,000 high school students across the country have been positively impacted by the various activities. Astronomy clubs have been set up in a number of schools, and practical training courses are organised on a regular basis. Feedback from the teachers and pupils we have visited has been very positive. This means that the Ivoirian Astronomy Association plays a key role in raising awareness of the importance of astronomy.

Session

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Reflecting on my journey as part of the NOCs network

Dr Zara Randriamanakoto[1,2], Mr Deralaza Rafieferantsoa[2]

[1]South African Astronomical Observatory. [2]Malagasy Astronomical Society

Abstract

Making astronomy accessible to all has its own challenges, especially for communities in developing countries such as Madagascar. With support from local volunteers and various key stakeholders, the National Outreach Coordinator of the IAU Office for Astronomy Outreach (NOC OAO) has been implementing a number of projects and initiatives to promote astronomy to the public since its appointment in 2017. This covers a wide range of activities such as school visits, stargazing parties, the use of social media for community digital outreach, and running annual national Astro Quiz "Le Rendez-Vous des Astrophiles". In particular, the NOC OAO recently completed a successful project named "Orion Astro Lab", thanks to the financial support of the NOCs funding scheme. The project goal is to build a strong network of astronomy club leaders who will work together to promote science including astronomy to the local community. This is necessary given the increased interest of astronomy in the country. This talk will report the milestones, challenges and lessons learned from the implementation of astronomy outreach initiatives led by the NOC OAO in Madagascar.

Session

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3D Printing and Astronomy for Students with Visual Impairments: The STEM Career Exploration Lab

Dr. Thomas Madura[1], Dr. Carol Christian[2], Dr. Tiffany Wild[3], Dr. David Hurd[4], Lindsay Bartolone[5], Noreen Grice[6], Dr. Hilarie Davis[7], Dr. Joy Harris[8], Kenneth Silberman[9], Skye O'Beollain[3], Ellen Hoke[10]

[1]San Jose State University. [2]Space Telescope Science Institute. [3]Ohio State University. [4]Pennsylvania Western University. [5]Self. [6]You Can Do Astronomy LLC. [7]Technology for Learning Consortium, Inc.. [8]Council of Schools and Services for the Blind. [9]NASA Goddard Space Flight Center. [10]Ellen Hoke Corp

Abstract

3D printing holds promise for students with blindness/visual impairments (B/VI) in addressing astronomy content, concept development, and providing access to information normally displayed visually. To bolster astronomy and STEM opportunities for students with B/VI, we developed the Career Exploration Lab (CEL), which employs tactile astronomy instruction via 3D printing and specially designed 3D-printed astronomy models. The centerpiece of our project is the 3D printer build, wherein students with B/VI assemble and use a desktop 3D printer. To date we have held ~20 week-long CEL summer camps in 12 states around the United States, serving a total of ~120 students with B/VI. We worked with Teachers of the Visually Impaired and STEM teachers via annual Educator Partner Institutes (EPIs) to develop our astronomy lessons and 3D models. 34 educators from 11 states have participated and assisted with our CEL summer camps. We gathered pre- and post-intervention data via surveys, astronomy assessments, and interviews, resulting in what is likely the largest research study to date on astronomy and 3D printing instruction for students with B/VI. We present our CEL approach, a sample of our lessons and 3D models, insights learned, and best practices. Once fully tested and refined, we will make our 3D models and lessons freely available. We find 3D printing is useful in showcasing scientific data for understanding and appreciation of astronomy. This work is supported by an Innovative Technology Experiences for Students and Teachers (ITEST) grant from the National Science Foundation (Award 1949458).

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Sharing a fragment from the start of our world: international exhibits of grains collected from asteroid Ryugu by the Hayabusa2 mission

Dr Elizabeth Tasker, Dr Masaki Fujimoto, Dr Kate Kitagawa, Dr Tomohiro Usui

Japan Aerospace Exploration Agency (JAXA)

Abstract

On December 6, 2020, the Japan-led Hayabusa2 spacecraft returned a tightly sealed container to Earth holding grains collected from asteroid Ryugu. These grains are now being studied by scientists around the world to uncover clues about how the planets formed, and how habitability began on Earth. But to avoid contamination from the Earth's current life-heavy environment, such studies must be conducted in controlled cleanrooms, where very few people will ever set foot. With 60% of the sample stored for the next generation of scientific investigation, having the current work so restricted in visibility risks severely reducing the ultimate impact of the mission. So how can the amazement and importance of returning a sample from space be shared beyond the laboratory?

To tackle this issue, the Hayabusa2 curation team assigned a few of the asteroid grains for outreach, removing these from the scientific study and making them available for public display. In addition to displays around Japan, the team have collaborated with two major European museum, the Science Museum in London and Cité de l'espace in Toulouse, to exhibit the grains internationally. The team worked closely with the museums to design exhibits that would showcase the importance of the grains, and make the tiny particles as visible as possible to museum visitors. This presentation will look at the importance of outreach for the mission, the design of the exhibits and the woes of transporting asteroid grains around the globe!

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Astronomy communication and influencing via Instagram

Ana Rita Costa Silva

Instituto de Astrofísica e Ciências do Espaço

Abstract

Social media have an ubiquitous presence in the daily lives of younger generations, turning them into the ideal platforms to **communicate science to teens and young adults**. Instagram and TikTok are the preferred mobile apps of young people, which is leading many academic and scientific institutions, as well as science communicators, to be present in this virtual world.
For the past couple of years, I have been managing and producing content for an **Instagram account where I communicate about Astronomy and being an Astronomer**. The account's username is @astrophd.rita, and there I share the "backstage" of astronomy research and my experience as a PhD candidate in this field. The main goal is to influence a new generation to be interested in Astronomy, Astrophysics, and Space Sciences. The foundation of this account is to be as **honest and true to reality as possible**, presenting both the pros and cons of these fields and careers. This fosters the **humanization of science**, allowing social media users to recognise and associate a face to this science, and find someone with whom they can interact without having to leave their house, contributing to **tearing down access barriers**.
In this talk, I will describe my experience as a science communicator on Instagram, review the current scene of Astronomy/Space Science communication on Instagram, and share with the audience the strong potential of social media mobile apps to reach younger people, who might be the astronomers of the future, if exposed to more "science influencers".

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Top-Down approach to astronomy outreach at the national level in Thailand

Matipon Tangmatitham

National Astronomical Research Institute of Thailand. International Training Center in Astronomy under the auspices of UNESCO

Abstract

Astronomy outreach and communication is traditionally done via a bottoms-up approach: with many independent groups of people contributing to the efforts. However, in many developing countries there is not enough science infrastructures for any independent group alone can gain enough traction. As a result, there was virtually zero astronomy outreach activities in Thailand. When the National Astronomical Research Institute of Thailand (NARIT) was founded two decades ago, we recognize that the missing astronomy outreach is detrimental to the scientific literacy and appreciation from the public. For the past twenty years, NARIT has been undertaking one of the most ambitious astronomy outreach programs ever attempted: to have one single outreach team that will transform the entire outreach landscape into a healthy and sustainable environment. Via multitudes of our efforts including social media articles, star parties, investing in planetariums and museum infrastructures, public nights, astronomy camps, training workshops, etc. we have successfully and completely transform the landscape of astronomy outreach in Thailand. Starting from zero twenty years ago, we now enjoy interacting with close to a million participants annually in all our outreach efforts combined. More importantly, citizens of Thailand now enjoy a thriving ecosystem never seen before in astronomy and science outreach where many science bloggers, astrotourisms, astronomy camps, etc. can now make a career communicating astronomy with the public.

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Stars Shine for Everyone: Fostering Inclusivity and Unity in Astronomy Outreach.

President & Co-Founder Suhel Ahmeti

Kosovar Astronomical Society / Prishtina Observatory & Planetarium. National Coordinator of Astronomers Without Borders. National Outreach Coordinator of IAU/OAO for Kosovo. National Astronomy Education Coordinator of IAU/OAE for Kosovo

Abstract

As a passionate advocate for astronomy outreach, education, and diversity, I am privileged to share my efforts at the IAU General Assembly in Cape Town, South Africa. In recent years, I have been committed to fostering a global appreciation of astronomy while eliminating barriers to accessibility in Kosovo, a region historically burdened by ethnic divisions and tensions.

I've worked to make astronomy inclusive for marginalized groups in Kosovo, such as those with disabilities, economically disadvantaged individuals, and people living in remote areas. I've hosted outreach sessions, and multi-ethnic astronomy camps, distributed solar glasses and telescopes through the "Stars Shine for Everyone" program, and reopened the Prishtina Observatory with UN support that was abandoned for more than 40 years which is now serving as a multi-ethnic science hub for children and youth coming from diverse communities. These efforts aim to share the marvels of the universe with those who might not have access to astronomy resources due to the various challenges they face.

By bringing people together to build trust under the vastness of the night sky, I've shown how astronomy can break down barriers, inspire a new generation of scientists, and create positive change both within Kosovo and internationally.

In my presentation at the GA2024, I seek to inspire others by sharing valuable knowledge, in seeking donations and experiences gained in Kosovo. I aim to encourage the embrace of diversity, dissolve barriers, and foster a welcoming environment where individuals can connect and explore the captivating mysteries of the universe.

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A summary report on Spanish OAO NOC activities for 2021-2024

Prof. Ana Ulla-Miguel[1,2], Dr. David Galadí-Enríquez[3], Dr. Amelia Ortiz-Gil[4]

[1]Applied Physics Department, Universidade de Vigo, Campus Lagoas-Marcosende, s/n, E-36310 Vigo, Spain.. [2]Instituto de Física e Ciencias Aeroespaciais. Universidade de Vigo – Campus de As Lagoas, 32004 Ourense, Spain. [3]Department of Physics, University of Cordova, Spain. [4]Observatorio Astronómico - Universidad de Valencia Edifici Instituts d'Investigació. c/ Catedrático José Beltrán,2 E- 46980 Paterna (Valencia), Spain

Abstract

From August 2021 to August 2024, the Spanish OAO/NOC team has been composed by a NOC (Ana), a vice-NOC (David) and a former NOC as advisor (Amelia). After August 2024 this will change, with our current vice-NOC becoming NOC and new names from the Spanish astronomy community –not yet designed, occupying the vice-NOC and advisor posts. In this communication we intend to highlight some of the relevant activities developed in the triennium, with Pro-Am collaborations, Dark and Quiet Skies initiatives or NOC funding projects such as Amanar and SKAO, as examples. Particular attention can also be given to the Spanish NameExoWorlds22 results obtained and to the Solar Eclipse 26-27-28 project already in preparation. The experience gained is expected to aid our NOC team to foster and to expand even further ongoing and future collaborations, reaching out to as many stakeholders as possible.

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1468

GALAXY CRUISE: A Citizen Science Project Increasing Number of Users

Kumiko Usuda-Sato[1], Masayuki Tanaka[1], Michitaro Koike[1], Seiichiro Naito[1], Makoto Ando[1], Kei Ito[2], Hitoshi Yamaoka[1], Tomofumi Umemoto[1]

[1]National Astronomical Observatory of Japan. [2]The University of Tokyo

Abstract

GALAXY CRUISE (https://galaxycruise.mtk.nao.ac.jp) is the first citizen science project of the National Astronomical Observatory of Japan using big data taken by the Subaru Telescope, an 8.2-meter optical-infrared telescope near the summit of Maunakea, Hawai'i. With a PC or tablet, Citizen Astronomers classify and identify interacting galaxies. We completed Season 1 in April 2022 and published the first scientific paper in September 2023 (M. Tanaka et al. 2023, PASJ, 75, 986). We also released the Season 1 galaxy catalog for researchers.

GALAXY CRUISE enables the general public to access and explore the world's highest-quality vast cosmic images. The results of the users' questionnaire conducted in July 2021 show that Subaru's beautiful images highly motivate Citizen Astronomers to continue classifying galaxies. Detailed training sessions for galaxy classifications and voyage-themed websites fascinate researchers and educators to introduce GALAXY CRUISE in their outreach activities inside and outside Japan. In this sense, our project meets IAU Strategic Plan Goal 4, "The IAU engages the public in astronomy through access to astronomical information and communication of the science of astronomy."

We are now "cruising" in Season 2 with fainter galaxies. In Season 2, we try to spend our effort on 2-way interactions with the general public. In addition to monthly NEWS articles, we provide live streaming by GALAXY CRUISE scientists in Japanese and English to share tips on galaxy classification and our scientific goals and updates.

In our talk, we will report on the main scientific results and how uses grow in various countries.

Session

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1492

Imortance of networking in Outreach and Astronomy through the eyes of an India's prime Observatory.

Ms Janvi Agarwal

Aryabhatta Research Institute of Observational Sciences(ARIES), Nainital

Abstract

At our institution, we deeply value the power of teamwork and collaboration in driving our astronomy outreach efforts. Proudly home to India's largest optical telescope, the 3.6m DOT, we share observing time with Belgium, showcasing a model of international collaboration. Additionally, our institution boasts the world's first liquid mirror telescope for Astronomy, the 4m ILMT, which supports an Open Data Policy intended for citizen science projects driven by data science. In my presentation, I aim to spotlight our unique facilities and emphasize the collaborative ethos that propels our Astronomy and outreach. We engage diverse audiences in daily outreach activities of national/international significance. Our outreach aims in actively participating in exhibitions and cultivate partnerships with different institutional organizations.

Operating from a remote location, our telescopes are vital sources of reliable data for advanced scientific endeavors. Furthermore, I will highlight the Aditya L1 support cell, a joint initiative by ISRO and ARIES, serving as a training center for a community of enthusiasts involved in collaborative satellite data analysis for the Solar Physics community. I would like to present how we can enhance the networking with the rural community and rural areas with almost no resources.

I will discuss strategies for expanding our astronomy outreach facilities and inspiring seasoned stargazers and budding scientists to join us in the pursuit of discovery and exploration. Apart from all these, I would also like to give a glimpse of the challenges one can face in the outreach with such a unique setting and infrastructure.

Session

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1544

RAPAS, PRO-AM NETWORK FOR SCIENTIFIC ALERTS, 2024 STATUS

M. Thierry Midavaine[1], Dr William Thuillot[2], Prof. Michel Dennefeld[3]

[1]Societe Astronomique de France. [2]IMCCE, Observatoire de Paris. [3]IAP/Paris, CNRS and Sorbonne University

Abstract

RAPAS is a french ProAm project networking Amateurs with Professionals, for the detection and follow-up of astronomical transients. Funded under the Paris Observatory Incentive Pro-Am Action (AIP) since 2022, it aims at standardising observationnal practices. We designed a set of broad-band filters (to increase sensitivity with small telescopes) along the Gaia G, Bp and Rp bandpasses and already equiped 25 telescopes, with another set to come-up this year. We have also launched the design of two low-dispersion spectrograph prototypes, to characterise the Alerts, which will be finalised this year for a wider distribution. At the same time, we are testing and calibrating the photometric observations of the various participants. This program, once stabilised, will be further extended to international collaborations.

Session

EC WG Pro-Am Relations in Astronomy

1554

EmpoweringHer: Unlocking the Potential of Girls in Rural South Africa

Miss Onesimo Mtintsilana

University of Witwatersrand. South African Institute of Physics

Abstract

Gender disparities in STEM fields persist globally, with cultural stereotypes and societal expectations often discouraging young women from pursuing careers in science. In South Africa, these challenges are compounded by a lack of support structures and opportunities for female students, particularly in rural areas. The EmpowerHer project, initiated by Algorythm Tech and Sivenkosi Uphawu, seeks to address these issues by promoting the participation of girls in physics through targeted outreach efforts.

This abstract outlines the project's objectives, strategies, and outcomes. By reaching out to rural schools in the Eastern Cape Province, EmpowerHer aims to introduce girls in grades 1-11 to the importance of physics and science through practical exercises and experiments. Recognizing the importance of 21st-century skills in preparing learners for the future, the project incorporates coding into its activities, emphasising its relevance in both technology literacy and data analysis—a crucial aspect of physics.

Through this presentation, we will highlight the progress and impact of the EmpowerHer project, including increasing awareness of physics careers, promoting enrolment in the South African Institute of Physics, and educating participants about WiPISA (Women in Physics in South Africa). Furthermore, we will discuss the challenges faced and lessons learned, along with future directions for sustaining and expanding the project's reach.

EmpowerHer represents a significant step towards challenging stereotypes, empowering girls, and fostering a more inclusive and diverse scientific community in South Africa.

Session

Office for Astronomy Outreach institutional meeting

1642

The Power of Hybrid Events

Dr. Rosa Doran

NUCLIO. The Centre for Earth and Space Research of the University of Coimbra (CITEUC)

Abstract

Since 2019, a series of hybrid events have emerged around the world. In this talk, I would like to discuss the importance and power of these events. Some statistics on the number of participants, in particular from developing countries, are very encouraging and clearly indicate the need for these events. However, there is now what is called the Zoom overload. There are many online activities, and participants are somehow overwhelmed with the offers and unsure how to cope with the multiple opportunities. In this presentation, we would like to share some numbers of hybrid conferences and training opportunities and present a few suggestions of innovative ways to reach out and make sure that communities around the globe are reached and feel represented by our initiatives.

Session

Office for Astronomy Outreach institutional meeting

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On the Path of the Golden Ring Project: An Initiative from IAU - OAO NOCs of Colombia, Honduras, Nicaragua, Costa Rica, Panamá and Brasil

Dr. Camilo Delgado-Correal[1,2,3], Andrés Torres Cañas[4,5,6], Javier Mejuto[7,8], Emilio Zuniga Hernández[9,10], Edwin Santiago Leandro[11,12,13], Carlos Fernández Valdés[14,15,16], Eduardo Monfardini Penteado[17,18], Josina Oliveira do Nascimento[19]

[1]Francisco José de Caldas District University of Bogotá. [2]Geographic Institute Agustín Codazzi - IGAC. [3]ViceNOC IAU - OAO Colombia. [4]Astronomical Observatory - Metropolitan Technological Institute - Medellin, Colombia. [5]Colombian Astronomy Network - RAC. [6]NOC IAU - OAO Colombia. [7]Archaeoastronomy and Cultural astronomy Department, Space Sciences Faculty, Universidad Nacional Autónoma de Honduras. [8]NOC IAU - OAO - HONDURAS. [9]ASAFILE - Asociación de Astrónomos Aficionados de León, Nicaragua. [10]NOC IAU - OAO - NICARAGUA. [11]Centro de Investigaciones Espaciales (CINESPA). [12]Universidad de Costa Rica (UCR). [13]NOC IAU - OAO - COSTA RICA. [14]Universidad Latina de Panama. [15]Asociación Panameña de Aficionados a la Astronomía - APAA. [16]NOC IAU - OAO - PANAMÁ. [17]IAU Office of Astronomy for Education (OAE). [18]NOC IAU - OAO - BRASIL. [19]ViceNOC IAU - OAO - BRASIL

Abstract

The **Path of the Golden Ring** was an initiative of the Office for Astronomy Outreach of the International Astronomical Union in Colombia (IAU - OAO Colombia) joined with the National Outreach Coordinators - NOCs of Nicaragua, Costa Rica, Panama, Honduras, and Brazil. For this project, the NOCs of the mentioned countries aimed to promote a campaign for the appropriation and dissemination of science related to the Annular Solar Eclipse visible in much of the Americas ocurred on October 14, 2023, including the countries that were part of this project. This was a great opportunity to involve people from different backgrounds and interests in astronomy. The funds provided by OAO - IAU were invested in the design, editing, and production of seven (7) high-definition and subtitled videos to explain the eclipse from each participating country in the project. Likewise, a book about the eclipse was edited and published with an ISBN number, available to anyone who wishes to consult it, completely free of charge. Additionally, two micro-courses were conducted, the first on generalities of the eclipse and the second on how to photograph and build suitable filters to record the eclipse. As part of the project and with the aim of conducting activities with a differential focus, we teamed up with NASA to distribute 30 tactile booklets to teach blind or visually impaired individuals how they could perceive the eclipse, its trajectory, and the hours of occurrence. In overall terms, the actions of this project directly impacted about 10000 people.

Session

Office for Astronomy Outreach institutional meeting

1718

Empowering School Girls and Children in STEAM Education: The Case of C-Link Outreach Program in Ethiopia

Ms Frehiwot Garomssa, Mr Alemiye Mamo

Space Science and Geospatial Institute

Abstract

In the pursuit of nurturing the next generation of scientists and fostering innovation, directing attention towards children and girls is imperative.The Women, Children, and Youth Affairs (WCYF) department, within the Space Science and Geospatial Institute (SSGI), collaborates on impactful initiatives, such as the SSGI KAAI (Knock, Attract, Act, Innovate) outreach project, in partnership with the East Africa Regional Office of Astronomy for Development (EA-ROAD).

The C-Link project, a collaboration involving IAU European ROAD, EA-ROAD, WCYF of SSGI, and Miskaye Hizunane Medehane Alem Monastery School in Ethiopia, focuses on children aged 6 to 9 from diverse countries. Aligned with Carolina Ödman's vision of global accessibility to the Universe, the initiative aims to transcend borders and foster interconnectedness.

To ensure equal opportunities and inclusivity, the WCYF team addresses the educational needs of students in remote areas, developing a STEAM education program for schoolgirls and children in Ethiopia. Actively promoting global experience-sharing activities through the C-Link project under the SSGI KAAI framework, the WCYF team scales the initiative to remote Ethiopian schools.

Efforts within the C-Link project aim to reach communities, providing necessary tools for full participation in global experience-sharing activities. In conclusion, this abstract shares insights the potential impact of the C-Link outreach program in empowering schoolgirls and children in Ethiopia. The collaboration between SSGI and EA-ROAD strives to establish a scalable model for advancing STEAM education, contributing to a more inclusive and sustainable educational landscape in Ethiopia.

Session

Office for Astronomy Outreach institutional meeting

1839

From virtual present to real future: planetarium show and virtual reality as a tool to describe the future of high-energy astronomy.

Federico Di Giacomo[1], Laura Daricello[2], Anna Wolter[3], Sandro Bardelli[1], Antonio De Blasi[1], Laura Paganini[3], Valentina La Parola[4], Antonino La Barbera[4], Laura Leonardi[2], INDACO group .[5]

[1]INAF -Osservatorio di Astrofisica e Scienza dello Spazio. [2]INAF - Oservatorio Astronomico di Palermo. [3]INAF - Osservatorio Astronomico di Brera. [4]INAF - Istituto di Astrofisica Spaziale e Fisica Cosmica. [5]INAF - Istituto Nazionale di Astrofisica

Abstract

Over the next few years, between Chile and the Canary Islands, the Cherenkov Telescope Array Observatory (CTAO) will install more than 60 telescopes, of three different sizes, which will form the largest ground-based gamma-ray observatory. To date, this large international observatory is still under construction, but thanks to the most advanced virtual technologies, it will be possible to delve into the details of the future of CTAO, in which Italy is involved.

Within the framework of the PNRR CTA+ project (PNRR M4C2 IR0000012 CTA+), funded by the European Union and led by the National Institute of Astrophysics (INAF), a public engagement project has been funded for the use of virtual reality, 3D videos, interactive infographics, etc., to describe the scientific and technological goals of CTAO. Among the various multimedia products, currently being developed by a professional company in the field of new technology, there is the creation of a virtual reality exhibit and a planetarium show. The virtual experience, in particular, is conceived as a real tour in which users will have to overcome a series of challenges in order to explore in detail high energy astronomy.

The main objective of this project is to use the new technologies, such as virtual reality, immersive videos, gaming strategies for educative purposes etc., in order to exploit the "wow effect" to capture the interest of the public and describe the science and technology of CTAO, the future of the largest ground-based gamma ray observatory, and the italian contribution in this project.

Session

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1852

LOOK UP! Learning from the past, looking at the future

Federico Di Giacomo[1], Antonella Gasperini[2], Mauro Gargano[3], Valeria Zanini[4], Mariachiara Falco[5]

[1]INAF - Osservatorio di Astrofisica e Scienza dello Spazio. [2]INAF - Osservatorio Astrofisico di Arcetri. [3]INAF - Osservatorio Astronomico di Capodimonte. [4]INAF - Osservatorio Astronomico di Padova. [5].

Abstract

The new technologies are changing every aspect of our social and work lives. In the same way, digital tools are becoming increasingly important to preserve, disseminate and valorize cultural heritage. Following this approach and using new technology we developed Look Up!, an articulate project to study and promote the historical astronomical atlases preserved in the Italian Astronomical Observatories, the most ancient scientific institutions in Italy.

Look Up! is an effective virtual tool designed to allow digital visitors to explore and understand how our knowledge of the cosmos, Moon, and planets has evolved and changed. Using virtual reality, 3D models, videos, audio, etc., visitors can explore the scientific and cultural contents of the stellar and cartographic atlases. Users interact with them to have information about the instruments used to observe and measure the stars, the cosmology of the time and the cultural environment in which the atlases were created.

Using the contents conveyed within the exhibition and in partnership with Save the Children-Italia, we have realized a series of educational workshops for children living in Italian urban areas of greater social fragility. So, the workshops aim to reach that segment of the school population that suffers from greater social fragility, promoting and supporting the individual's self-determination and self-expression, regardless of personal condition, gender, social status, or culture of belonging. In doing so, we use the cultural heritage of Italian astrophysics as a tool for growth and an opportunity to develop new skills and passions.

Session

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1965

When the Universe knocks on the Atmosphere's door - The Very High Energy sky goes to Theater

Dr. Anna Wolter[1], Dr Laura Paganini[1], Dr Adamantia Paizis[2], Dr Martina Cardillo[3], Dr Valentina La Parola[4], Dr Antonino La Barbera[4], On behalf of gruppo INDACO[5]

[1]INAF - Osservatorio Astronomico di Brera. [2]INAF - IASF Milano. [3]INAF - IAPS Roma. [4]INAF - IASF Palermo. [5]INAF

Abstract

We brought on stage the Very High Energy science, the most recent window on the extreme phenomena of the Universe. It was a fascinating challenge for us, with an intriguing blue twist. To "see" the highest energies we resort to a unique instrument: Earth's atmosphere. It acts as a detector, in which the passage of high energy photons from cosmic sources produces, through the Cherenkov effect, a faint blue glow that can be captured by optical telescopes with very rapid electronics. As INDACO (INAF for Dissemination of ASTRI and CTAO), we organize the outreach program for two projects, ASTRI, INAF-led, and the international CTAO, the largest ground-based gamma-ray observatory. Thanks to the PNRR CTA+ project, funded by the European Union and led by INAF, we were able to take the Cherenkov effect to the theater.

We worked with Pacta . dei Teatri, a theatrical company seated in Milano, promoter of the theatrical Festival "ScienzaInScena" (science-on-stage). We introduced our science and aims, and starting from our material and suggestions they produced a play. *Echi di luce - e l'Universo bussò alle porte dell'aria* premiered in Milano this past January with several successful replicas. Blending script, music, lights, sounds, and dance, a few key points were conveyed: the atmosphere, so precious for life, becomes an instrument; TeV emission unveils the accelerated Universe, jets, winds and the like; Italy has a pivotal role in this research.

I'll discuss our collaboration with the theatrical company, the achieved objectives, and ways to improve for future events.

Session

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2013

Dark Sky as a Tool in Community Building, Promoting Culture and Protecting Heritage: From a Global Community Engagement Framework

Mr Saeed Jafari

World Space Week Association. Department of Linguistics, University of Kurdistan. Space Generation Advisory Council

Abstract

Astronomy, and dark sky in particular, can be used for the benefit of society and to achieve the United Nations Sustainable Development Goals. As light pollution continues to threaten our natural environments and cultural landscapes and impacts satellite constellations as well, the importance of preserving our dark skies has gained significant recognition. This presentation will look at the Global Community Engagement Framework for Dark Sky initiatives, emphasising the collaborative efforts required to achieve tangible outcomes. The talk will highlight how Dark Sky initiatives and efforts have revitalised communities, preserved cultural heritage, and stimulated economic growth through the use of case studies and best practices from around the world. These examples include IDA efforts, IAU Dark Sky for All activities, IAU CPS actions, Heritage of the Sky Project contests and more. Furthermore, we will explore the multidimensional benefits of dark skies, including improved quality of life, enhanced opportunities for stargazing and local economies and tourism, and the preservation of ecosystems in line of inclusion, diversity, and equity. Towards this framework, I discuss our monitoring and evaluation approach by these three key themes: suggest the role of community engagement in fostering a sense of ownership and pride in preserving dark skies, community-led initiatives to celebrate cultural festivals and events connected to the night sky, and addressing the challenges and opportunities for incorporating dark sky preservation into heritage conservation practices.

Session

Office for Astronomy Outreach institutional meeting

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The Future of Meetings in astronomy: reflections on lessons learned from TFOM

Dr Vanessa Moss[1,2,3], Dr Aidan Hotan[1], Emily Kerrison[2,1], Dr Rika Kobayashi[4], Dr Mike Peel[5], Dr Glen Rees[6], Dr Elizabeth Tasker[7], Dr Ron Ekers[1]

[1]CSIRO. [2]University of Sydney. [3]University of Queensland. [4]Australian National University. [5]Imperial College London. [6]The Future of Meetings. [7]ISAS JAXA

Abstract

Over a hundred years have passed since the first IAU General Assembly, with many innovations in technology taking place over this time. With emerging technologies such as widespread internet, powerful portable computing, readily-available automation and affordable mixed reality, the possibilities for innovating the ways in which we meet to be more accessible, inclusive and sustainable are vast. We have only begun to scratch the surface of the future of interaction.

"The Future of Meetings" (TFOM) community of practice has been active since 2020 to experiment with these emerging technologies, seeking innovation both in the design of our interactions (online, hybrid and in-person) and in the ways of employing technology to do so more effectively. We will present an overview of our highlight activities over the last several years, with a particular emphasis on the innovations in astronomy communication that we have explored and demonstrated during this period.

We are now at a turning point in astronomy. As individuals and collective organisations, we have the power to choose a path forward that enables more distributed global voices than ever before to be part of our future astronomy collaborations while minimising the cost to our planet. A key goal of TFOM is to share our experiences and expertise in the hope that, with the relative ease of adoption of contemporary innovative technologies, others are empowered to choose the same path of "beyond being there" that we have.

Session

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2127

A research-based outreach project to promote gender equality in STEM

Dr Clementina Sasso[1], Dr Silvia Galano[2]

[1]INAF - Astronomical Observatory of Capodimonte. [2]Department of Physics "E. Pancini", University of Naples Federico II, Italy

Abstract

Worldwide in Science, Technology, Engineering and Mathematics (STEM) areas of studying and working, women are strongly underrepresented, this is true also in Astronomy field even if Astronomy results to be one of the most fascinating and attracting matter also for girls. Contrarily women are the majority in health and cure related areas. This phenomenon of horizontal segregation affects all nations' scientific, technological, and economic growth, because almost half of the population - women - result active in society under their possibilities and cut off from decisions that affect their future. One of the main causes of this horizontal segregation are gender stereotypes. These can be defined as a common set of values shared by individuals in a society, determining what is suitable or not for individuals according to their gender. These stereotypes influence, explicitly and implicitly, students' choices about their future school and work careers. For example, they may lead girls to disregard STEM-related paths of study because these are perceived as more suitable for males. In the same way boys may be discouraged from choosing to study literature or humanistic paths of study because considered as more suitable for girls. In this way gender stereotypes limit students' future perspective.

Drawing on results in research in Science Education, in particular studies focused on gender stereotype in STEM, we developed teaching/learning and outreach activities to support teachers worldwide to address gender stereotypes in their classrooms thus supporting students in recognizing and deconstructing STEM related gender stereotypes.

Session

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Collaborative Partnerships Enhancing Mobile Planetarium Outreach: The case of the African Millimetre Telescope Mobile Planetarium Project

Miss Victoria Nakafingo

Stellenbosch University. University of Namibia

Abstract

The African Millimetre Telescope mobile planetarium project is a collaboration between the University of Namibia and Radboud University, as well as various internal and external bodies to bring astronomy education directly to communities across Namibia. The project was honoured with the prestigious Annie Maunder Prize for their outreach and public engagement at the beginning of this year (2024), which demonstrates the project's innovative approach. Through partnerships and collaborations, the project has been able to attract students that operate the planetarium, acquire resources and overcome challenges such as logistical barriers, geographical remoteness and cost. To date, they have reached over 12500 people of which are mostly learners from both urban and rural communities. This abstract highlights the role and the importance of collaborative partnerships in promoting science programs and creating innovative solutions to science education.

Session

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2183

A glimmer of hope through the Spacebus Morocco initiative

Dr Meriem Elyajouri

SpaceBus Morocco. NOC Morocco. Institut d'Astrophysique Spatiale (IAS), Université Paris Saclay, CNRS

Abstract

Following the devastating earthquake that struck Marrakech and its surrounding regions in Morocco, the urgent need for a collaborative and innovative response became apparent. In response to this crisis, we relaunched the Spacebus Morocco project, an outreach program aimed at bringing science directly to the people affected by the disaster. This initiative, established in collaboration with the NOC and NAEC Morocco, alongside Cadi Ayyad University, the Oukaimeden Observatory, and the Atlas Dark Sky Foundation, was designed to "Bring Science to the Doorstep of the Residents."

Dedicated to the earthquake-impacted regions, this iteration of the Spacebus Morocco was characterized by its proven track record in scientific outreach. Our objective was to offer the local communities opportunities for scientific discovery, learning, and amazement that resonated with African values and culture.

The 4th Annual Conference of the African Astronomical Society (AfAS), held in Marrakech from April 15 to 20, 2024, served as an exceptional platform to enhance the impact of the Spacebus Morocco initiative. The conference convened experts from Africa and beyond, facilitating an unmatched integration of expertise into our outreach efforts.

Our ultimate aim was to reignite curiosity, emphasize astronomy as a tool for education and development, and contribute to the reconstruction efforts in the earthquake-stricken areas. This presentation reflects on the success of the Spacebus Morocco project, underscoring its role as a catalyst for recovery and a testament to the resilience of the human spirit in the face of adversity.

Session

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The Cosmic Savannah podcast: Showcasing Afro-centric astronomy to the international public

Dr Jacinta Delhaize[1], Dr Daniel Cunnama[2], Dr Tshiamiso Makwela[3,4,1], Mr Francois Campher[1]

[1]University of Cape Town. [2]South African Astronomical Observatory. [3]IAU Office of Astronomy for Education. [4]Max-Planck-Institut für Astronomie

Abstract

We will present The Cosmic Savannah - a podcast launched in 2019, which serves as a unique platform to spotlight Afro-centric astronomy to the African and international general public. Our podcast features insights from astronomers across the African continent and covers diverse topics such as astronomy research, telescopes, instruments, ethno-astronomy, citizen science, and outreach projects. This podcast stands out as the only astronomy platform in Africa run by professional astronomers. With 5 seasons, 90 episodes, and 111 guests to date, our inclusive approach has resulted in 52 (47%) female guests and 52 (47%) black or people of colour guests, with 78% based in Africa, spanning various research areas and seniorities. We are accessible globally, with our content freely available on all podcasting platforms, via our website (www.cosmicsavannah.com) including transcriptions, and via YouTube with multilingual subtitles, ensuring widespread and inclusive reach. In 2021, The Cosmic Savannah was a finalist for the South African National Science Communication Award, which highlighted its significance in the science communication landscape. Additionally, we are dedicated to ensuring sustainability and knowledge transfer within the astronomy communication space. As such, we have developed and delivered several workshops to train over 100 South African scientists in science communication and podcasting, and an astronomy podcasting bootcamp for postgraduate students who produced and published their own mini-episodes of The Cosmic Savannah. At IAU GA, we will share the lessons we learned over the past 5 years of running The Cosmic Savannah and provide advice and encouragement for others considering a similar endeavour.

Session

Office for Astronomy Outreach institutional meeting

2188

Communicating Exoplanet Exploration Through NASA Eyes

Dr Anjali TRipathi

NASA Jet Propulsion Laboratory

Abstract

Today, the number of known exoplanets exceeds 5000, with the knowledge that there are hundreds of billions more in the Milky Way galaxy, alone. Yet, most public discussions of planets focus on less than ten. In this talk, we will share the narratives and tools we are using to communicate the expanding story of exoplanet exploration - past, present, and future. Starting from a review of historical discoveries within the Solar System, we will shift to examples of how we are addressing the challenge of engaging audiences to think about the future of exoplanet exploration, including with telescopes like the Habitable Worlds Observatory. We will highlight efforts to raise community awareness of the stars that may be targeted in the search for the nearest Earth-like planets, and we will showcase our publicly available NASA Eyes on Exoplanets website, featuring new developments to visualize these stars. Integrated into this interactive tool are inclusive and accessible text descriptions, to invite a broad range of users. NASA Eyes on Exoplanets received more than 1 million visits in 2023, and we will discuss the range and impact of this work. We will share companion materials, both physical and digital, to enable a range of astronomers and educators to join us in engaging more communities in the thrill of exploring planets beyond our own.

Session

Office for Astronomy Outreach institutional meeting

2213

Once in a Blue Moon

Ms Tebogo Habedi

ArcelorMittal Science Centre/ SAASTEC

Abstract

For scientists, the invisible world is just as familiar as the visible one, but it is a totally new encounter for our general public. South Africa makes a profound contribution to astronomical research, yet this wealth of astronomy is not known to our larger population due to prevailing constraints. Science Centres and other science engagement practitioners are therefore faced with the responsibility to bridge the gap between science and society and facilitate learning at the grassroot level of scientific understanding.

The 32nd IAU GA 2024, first of its kind on African soil, opens great opportunities for ambassadors who are passionate about astronomy and keen to educate and deliver astronomy programmes to interact, collaborate, share and learn from global researchers and experts in this field so that they can be empowered to successfully facilitate astronomical science engagement programmes to the larger (especially rural) communities.

This presentation briefly explores the initiatives of ArcelorMittal Foundation (ArcelorMittal Science Centre) in our quest to expose, introduce and educate our community to not only appreciate the beauty of the night skies, but to also realise the power that astronomical research brings to improve our daily lives, in collaboration with other stakeholders who share the same vision.

Session

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2299

Cosmic Resilience: Building Mental Health Awareness through Astronomy

Mr Dominic Vertue

Office of Astronomy for Development (OAD)

Abstract

In this initiative, we explore the potential of astronomy to serve as a therapeutic tool in enhancing mental health awareness and fostering resilience. By drawing parallels between the vastness of the universe and the inner strength of individuals, we aim to develop outreach materials that inspire reflection on one's place in the cosmos, promoting a sense of belonging and perspective that can be beneficial in coping with psychological stress. Through workshops and interactive sessions that integrate astronomical concepts with mindfulness and resilience training, we examine the link between the awe-inspiring nature of celestial phenomena and psychological well-being. Our approach is grounded in the theory that experiencing awe and wonder can lead to a broadened sense of self and an improved capacity to find meaning in life, which are crucial components of mental resilience.

Session

Office for Astronomy Outreach institutional meeting

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Radio Cosmos: A french-language podcast for the general public

Emma Tolley

EPFL

Abstract

I present updates on our SKAO/IAU funded outreach project for a french-language podcast called "Radio Cosmos", including planning, content development, initial recordings, and lessons learned about podcast production.

Session

Office for Astronomy Outreach institutional meeting

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Astronomy Awareness at University of Limpopo Science Centre

Mr. Sandile Rikhotso, Ms Refilwe Ramohlale, Mrs Annelize Potgieter

University of Limpopo

Abstract

The University of Limpopo Science Centre has in the past 15 years been involved in Astronomy outreach and awareness activities. These activities include the International Year of Astronomy, competitions, talks, stargazing and workshops for various publics. This presentation will highlight all these activities with the objective of sharing the experience, the impact, best practices, challenges as well as the role of partnership on the success of the activities. As a science centre located in a rural area called Mankweng in Limpopo province, the surrounding communities lack more knowledge on science related topics that have an impact on their daily lives. Therefore, more exposure and awareness activities such as Astronomy communication is needed. Working with rural communities provides an impactful experience to the science centre as well as the communities at large. Astronomy in African culture plays an important role in terms of best practices in explaining the series of events that occur in life as part of nature. Language barrier becomes one of the challenges in most community members in understanding scientific terms related to Astronomy, hence a good science communicator plays a huge role as a medium in communicating astronomy terms in a simple manner. This allows communities to have more knowledge, better understanding and how to use astronomy education to better their lives.

Session

Office for Astronomy Outreach institutional meeting

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Playing Solar System - positive interactions with science for children in minority communities

Dr Veronica Allen

University of Groningen

Abstract

For the past several years, I have devoted my efforts to refining an interactive educational program centered on the solar system, tailored specifically for children. With invaluable input from artists, philosophers, parents, and educators, this initiative has evolved into what is now recognized as the Solar System Dance. Enjoyed by hundreds of children as young as 4 years old, this engaging activity combines movement, play, and structured learning to impart foundational knowledge about our planetary neighborhood while fostering an appreciation for the joy of scientific exploration.

Recognizing the importance of equitable access to educational opportunities, particularly in rural and underserved communities, I actively seek to extend the reach of this program to instill curiosity and cultivate interest in science where it may be lacking. In my presentation, I will share my experiences to illustrate the impact of this initiative and offer insights into its implementation, with the hope of inspiring others to integrate similar initiatives into their own communities and contribute to the broader dissemination of scientific knowledge.

Session

Office for Astronomy Outreach institutional meeting

2472

Second star to the right: the INAF cultural project connecting art, tourism, heritage and astronomy in historical cities.

dr Alessandra Zanazzi[1], Dr Francesca Aloisio[2], Dr Valeria Cappelli[3], Dr. Laura Daricello[4], Dr. Salvo Guglielmino[5], Dr. Laura Leonardi[4]

[1]INAF Osservatorio Astrofisico di Arcetri. [2]INAF Sede Centrale. [3]Studio Bleu. [4]INAF Osservatorio Astronomico di Palermo. [5]INAF Osservatorio Astrofisico di Catania

Abstract

We present an innovative public outreach project by INAF (Italian National Institute for Astrophysics) and Studio Bleu, searching a new format for a valuable cultural experience, communicating science and involving different audiences in discovering the connection between astronomy, art and society. Science and Astronomy in fact were considered a most relevant part of the cultural heritage of many historical Italian cities, they were connected to spirituality and marked daily life. Walking downtown it is easy to find clocks, meridian lines, zodiacs, painted skies and constellations, ancient geographical maps, places connected to scientists such as Galileo Galilei. Masterpieces of art that contain "astronomical secrets" unveil the importance that the observations of the sky and its movements always had for mankind. "Seconda stella a destra" (Second star to the right) is the first editorial series of Astro-touristic guidebooks of the cities (Rome, Florence, Padua, Palermo, Catania) that invite citizens to search for science into monuments and historical places.

With this talk, we want to analyze the main characteristics and outputs of the project: the guidebooks but also walking tours with astronomers, family activities, students' visits, public events, augmented reality enhancements. Moreover, we want to point out the impact the project has both at a local level – e.g. by creating new important cultural synergies among institutions, museums, cultural and scientific stakeholders in the cities – and at a professional level by sharing and consolidating a process of co-creation between scientists and communication experts.

Session

Office for Astronomy Outreach institutional meeting

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2475

Hiker´s Guide through the Galaxy

Dr. Sarah Casura

Universität Hamburg

Abstract

Hiker's Guide through the Galaxy is an outreach format combining hiking or cycling through nature with science communication. The initiative was organised by "Wissenschaft im Dialog" (German organisation for science communication) as part of the "Wissenschaftsjahr 2023 - Unser Universum" (year of science 2023 - our Universe), and was also promoted and supported by Astronomers for Planet Earth.

A total of 17 tours guided by scientists were offered across Germany between June and October 2023, ranging from Planet Trails to hikes around historically important astronomical sites and modern Observatories. The tours are documented and remain accessible online (on komoot.com) so that people can follow them and benefit from the astronomical information for many years.

Together with a colleague, I led a guided hiking tour to Hamburg Observatory. Starting in the nearby village of Börnsen, we followed the "Natur- und Geschichtspfad Bergedorf-Börnsen" (nature and history path from Bergedorf to Börnsen) to the Observatory in Bergedorf, where we finished with a visit to a number of our historical telescopes. At different stops along the way, we highlighted historical landmarks and natural specialities of the region; as well as talking about our own scientific projects and more general topics in astronomy.

In support of the mission of Astronomers for Planet Earth (of which I am a member), we put a special emphasis on communicating the uniqueness of planet Earth in space, the wonder of the nature we were hiking through and the necessity to stop the climate crisis in order to preserve our own habitat.

Session

Office for Astronomy Outreach institutional meeting

2479

Astronomía en Español desde Alemania (Astronomy in Spanish from Germany)

Dr. Sac Nicté Medina

Max Planck Institute for Radio Astronomy

Abstract

Scientific information **in our own language allows us a better comprehension** and appropriation of knowledge, more active social participation and to vocational inspiration. However, an important aspect in our modern era is **human mobilization**, therefore living in other countries with other **languages leaves several groups of people with a gap in their understanding** about scientific knowledge. As a Spanish speaker who resides in Germany, I noticed that all the Astronomy outreach offers in Germany are carried out in German and very few in English, however there are no offers in other languages such as Spanish despite the large population that lives in Germany and the large number of students of the Spanish language. Therefore, **I decided to create a social project call *Astronomía en Español desde Alemania*** (Astronomy in Spanish from Germany) to connect the Spanish speaker in the German city of Bonn with Astronomy in their own language. This project offers public events in the Public Observatory about Astronomical topics to **connect society with scientific activity and promote integration into German Astronomy** by highlighting the participation of nearby research institutions, give information of institutes, museums or exhibitions related to Astronomy that can be visited in Germany. This **unique project shows interesting results**, not only Spanish speaker were interested, also German speaker that learn Spanish and seek for activities to connect with Spanish speakers are very interested. Spanish teachers invite their student and bilingual families are interested that their children are able to improve their Spanish with Astronomy.

Session

Office for Astronomy Outreach institutional meeting

2513

Crisscrossing Africa for Astronomy Outreach and Building Partnerships

Prof Jamal Mimouni

Depart. of Physics,University of Constantine1, Algeria. Centre de Recherche en Information Scientifique et Technique - CERIST, Constantine

Abstract

In this presentation, we highlight an initiative by the African Astronomical Society (AfAS) over the last two years, focusing on countries within Africa that exhibit limited engagement in astronomy at both academic and popular levels. Notably, around 80% of the continent's 54 nations display scant to nonexistent astronomical activities, with nearly half entirely devoid of it. In light of this, AfAS has embarked on a mission to integrate these nations into the global astronomy community, especially in preparation for the forthcoming AG-2024 event, giving rise to five targeted campaigns with a particular emphasis on the Sahel region. Locally referred to as "Astronomy Weeks," they aimed at setting significant milestones to foster the growth of academic astronomy in collaboration with local partners. Activities included visits to numerous universities, Ecoles Normales Supérieures, high schools, and other educational institutions, alongside dialogues with government entities, especially Ministries of Education, to advocate for astronomy's inclusion in educational curricula. These efforts have yielded some degree of success that we will be presenting. Each campaign was tailored to meet the specific needs of the countries involved, with a focus on some of the continent's least economically developed nations, including French-speaking countries like Niger, Chad, Mali, Guinea, and the Democratic Republic of the Congo (DRC), which typically rank lower in scientific academic performance. The success of these campaigns has been significantly enhanced through close collaboration with local NOCs and National Astronomy Education Coordinators (NAECs), ensuring the sustainability and effectiveness of our efforts to advance astronomy throughout Africa.

Session

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2555

Astronomy Outreach in Nepal

Mr. Suresh Bhattarai[1,2,3,4], Ms. Manisha Dwa[1,2,3,4]

[1]Nepal Astronomical Society. [2]IAU Office for Astronomy Outreach. [3]IAU Office of Astronomy for Education. [4]OAE Node Nepal

Abstract

Astronomy Outreach in Nepal received a momentum after the formation of Nepal Astronomical Society (NASO) in 2007. During the first couple of years, it spent time to understand the best form of organizational structure and stability. It was only in August 2014 when it received a legal status in Nepal. This legal status opened doors for the collaboration with the government institutions officially. As a part of its, NASO has played active role in formulation of the National Science, Technology and Innovation Policy 2019, Celebration of the National Science Day since 2017, etc.

This paper will share the development of astronomy outreach community in Nepal. It will discuss the role of NASO in hosting and supporting different national, regional and international events related to astronomy and physics as well as youths. It will also share how joining IAU NOC network helped us to amplify our activities in Nepal. It will share the impact of NOC funding scheme to implement the first Telescope Making Workshop and distribute the telescopes to the participating teachers' school for astronomy outreach in their area. It will also discuss the impact of this funding scheme to create regional harmony making astronomy accessible to more people in the countries of participating NOCs.

Session

Office for Astronomy Outreach institutional meeting

2556

Astronomers for Planet Earth: Astronomy as a tool to convey awareness for planetary boundaries

Dr. Leonard Burtscher[1,2], Dr. Tobias Beuchert[3], Dr. Annika Kreikenbohm[4], Dr. Katharina Leiter[5]

[1]Leiden Observatory. [2]Astronomers for Planet Earth. [3]Max-Planck-Society. [4]Universität Würzburg. [5]Planetarium Nürnberg

Abstract

News reports about extreme weather events are omnipresent, rallies and demonstrations for climate action cannot be overheard. Yet, even progressive thinking humans deny the severity and urgency of the climate crisis. The problem is simply too monstrous to grasp and many prefer not to think about a possibly distopic future. On the other hand, public support for climate action is high, even among voters of conservative parties. To overcome this status of cognitive dissonance, we have developed a novel format that uses astronomical story telling, combined with organ music and spectacular settings in churches. In our show "registers of the universe", that we have performed three times in Germany over the past two years, we tell the story of our universe, from the beginnings to planet Earth, and use this background to subtly highlight the significance of planet Earth for humankind. Our show is meant to empower people to take action and give them hope through joint climate action. Reactions so far have been overwhelmingly positive, both in our feedback survey as well as in the local press. We intend to expand the format to more locations, and possibly more languages and will be keen to discuss it with other outreach professionals at this IAU GA.

Session

Office for Astronomy Outreach institutional meeting

2612

Successes and Challenges of Communicating Astronomy with the Public in Zambia

Mr. Prospery Simpemba, Dr. Saul Paul Phiri, Dr. Joseph Simfukwe, Mr. Jackson Siantuba

Copperbelt University, Department of Physics, P. O. Box 21692, Kitwe, Zambia

Abstract

Astronomy outreach in Zambia started way back in the years. We saw an increase of activities and open publicity, first during the 2001 solar eclipse which attracted heavy publicity and astro-tourism. This was then followed by the International Year of Heliophysics in 2003 and later by the International Year of Astronomy (IYA2009) in 2009. These events sparked a lot of interest in astronomy and physics in general. The national outreach activities followed the legacy of the IYA2009. Since then, many event have been organised during Yuri's Night, World Space Week and National Science Weeks. In this presentation, we highlight the successes scored over the years and pinpoint on teething challenges in communication astronomy in Zambia.

Session

Office for Astronomy Outreach institutional meeting

2614

Building Peace and Cultural Exchange through Astronomy Outreach: Lessons from Libya's First Space Camp and the Celestial Sands AstroCamp.

Mr Amjid Khurwat[1,2,3], Dr Meriem El Yajouri[4,5]

[1]Roaya for Astronomy Foundation. [2]NOC Libya. [3]Annir Initiative. [4]NOC Morocco. [5]Institut d'Astrophysique Spatiale (IAS), CNRS, Paris Saclay University

Abstract

The first Space Camp in Libya, organized by the Roaya for Astronomy Foundation, and the collaborative initiative known as the Celestial Sands AstroCamp represent pioneering efforts in leveraging astronomy outreach for promoting peace and cultural exchange. Held in May 2023 in the historically significant city of Cyrene, the Space Camp ignited curiosity of twenty young minds. Activities ranged from talks on climate change to discussions on the philosophy of science, to a talk by NOC Morocco, highlighting the cultural significance of lunar cycles in Islamic tradition.

Building upon the success of Palestine's AstroCamp and Libya's Space Camp, the Celestial Sands AstroCamp is a joint project by the NOCs of Morocco, Palestine, and Libya, aiming to extend the impact of astronomy outreach across North Africa. By bringing together diverse communities under the pristine dark skies of Morocco and Libya, the initiative promotes unity and understanding while celebrating the rich cultural heritage of the region.

This presentation intends to shed light on the experiences and lessons gained from organizing and participating in these groundbreaking events. It will explore the impact of these efforts in Libya and the broader North African region, emphasizing the significance of astronomy outreach and nurturing a passion for space exploration among young people. By showcasing the transformative power of astronomy outreach in fostering peace and cultural exchange, this presentation aims to inspire and motivate the audience to actively engage in similar initiatives and appreciate astronomy communication on both local and global levels.

Session

Office for Astronomy Outreach institutional meeting

2618

Shining Bright: NOC Brazil's Journey Through Astronomy Public Engagement

Eduardo Penteado[1], Arianna Cortesi[2], Felipe Carrelli[3], Gleici Kelly de Lima[4], Josina Nascimento[5], Mariana Féo[6], Willdson do Nascimento[7]

[1]IAU Office of Astronomy for Education. [2]Federal University of Rio de Janeiro. [3]Freelancer. [4]São Paulo State University. [5]National Observatory. [6]Student. [7]Federal University of Sergipe

Abstract

Since its establishment in 2018, NOC Brazil has been actively involved in numerous astronomy outreach initiatives, both in alignment with OAO framework projects and independently initiated endeavors. Initially, our focus lay in establishing a robust support network, crafting a website, and cultivating a vibrant social media presence to amplify our outreach efforts. Subsequently, we delved into collaborative global endeavors within the OAO framework, notably contributing to projects like Telescopes For All, NameExoWorlds, and organizing impactful live sessions as part of Women and Girls in Astronomy. Furthermore, we forged partnerships with fellow NOCs, leveraging opportunities under the NOCs Funding Scheme to materialize projects like The Art of Astronomy—a virtual exhibition designed to showcase public artwork inspired by astronomical themes. Additionally, we actively engaged in research endeavors, notably exploring the resilience of our astronomy outreach community during the pandemic. With Brazil boasting a wealth of astronomy communicators, spanning professionals, amateurs, and enthusiasts nationwide, our vision for NOC Brazil is clear: to serve as a central hub, providing easy access to information on ongoing initiatives and opportunities within the astronomy outreach landscape while committed to expanding our collaborations with fellow NOCs globally, amplifying public engagement through a diverse array of activities, and contributing to the body of knowledge through rigorous research endeavors within the field of astronomy outreach. In this talk, we reflect on NOC Brazil's achievements, exploring such multifaceted efforts which are integral to our mission of democratizing access to astronomy, ensuring its relevance and accessibility to all.

Session

Office for Astronomy Outreach institutional meeting

2651

Looking Up: The Growth of Astronomy Community and Media in Indonesia

Avivah Yamani

langitselatan. Planetary Science Institue

Abstract

Indonesia, the archipelago country spanning the equator with 18,110 islands and islets. The country presents a unique landscape with a beautiful night sky that sparks the interest of the public in astronomy. While the country boasts dark sky sites in many areas, light pollution in major cities poses a challenge. However, this hasn't decreased public interest in astronomy, evidenced by the flourishing astronomy community and its evolving relationship with social media.

These various social media platforms indeed empower astronomy enthusiasts to create a group and connect to each other. Social media connects astronomy communities and media to a wider audience to share information and knowledge as well as organize events and ignite public interest and awareness. Social media acts as a catalyst by spreading astronomy knowledge beyond geographical constraints and ending up bringing astronomy groups from online platforms to real life communities in many cities in Indonesia.

In Indonesia, astronomy communities play important roles in nurturing public interest in astronomy through various outreach programs including Star Party, Workshops, Storytelling, by offline gathering or online broadcast. The communities are not alone as the media also contributes to increasing public attention to astronomy. The major media outlets are increasingly incorporating astronomical news and events, while dedicated astronomy online platforms provide in-depth astronomy content catering to both enthusiasts and the general public.

This paper will discuss about the development of astronomy communities and media in the past decades, the impacts to societies, and the future development.

Session

Office for Astronomy Outreach institutional meeting

2674

A New Podcast for Sharing Astronomy Programs Worldwide Used for Social Impact

Mike Simmons

Astronomy for Equity. Blue Marble Space Institute of Science

Abstract

Groups worldwide, from volunteer astronomy clubs to IAU agencies, use astronomy to improve the lives of individuals, communities, and society in general. Most are small, independent efforts known to few outside their small networks. As a result, innovative resources and methodologies they create are not shared with the broader astronomy community. Likewise, they may not benefit from the innovations developed elsewhere, often by others who would be natural collaborators. Their limited reach also impacts the potential for identifying sponsors and other supporters.

The value of using astronomy for social impact is substantial but largely unknown. But the many shining examples of social impact programs in the worldwide astronomy community present a dazzling and diverse array of practical social benefits unmatched by any other science.

Astronomy for Equity's podcast features the ways in which astronomy is being used to improve lives, communities, and society. The podcast shares programs of using astronomy for social impact, from well-known bloggers to otherwise anonymous groups in developing countries and isolated communities. The goal is to build a larger audience for impactful astronomy together, both for the benefit of the existing worldwide astronomy outreach community and to increase awareness of the value of astronomy and space science as inspiration for entering STEM careers, introducing STEM in schools, and providing access to science for rural communities, the disabled, and communities traditionally excluded from STEM fields. This presentation will share the many diverse and innovative programs that are featured with examples and an analysis of reach and impact.

Session

Office for Astronomy Outreach institutional meeting

2697

Space Mails: Bridging Educational Gaps Through Astronomy Newsletters in Pakistan

Ms Yumna Majeed

Exploration - Cosmos to Classroom

Abstract

The COVID-19 pandemic has disrupted education, resulting in increased drop-out rates for students without internet access and challenges for those who do. Exploration, a space-education organisation, launched the Space Mails initiative in Pakistan to address this issue. The aim was to promote astronomy education and engage students and schools in astronomical activities during lockdown. Space Mails involved sending letters to students that answered space-related questions and provided educational resources, including creative lesson sheets, astronomy activities, and other materials. Students enthusiastically received the mail and gifts that sparked their interest in learning something new.

To expand the project's reach to underserved communities with limited internet access, the Space Mails team plans to develop a printed series of newsletters filled with informative news, fun facts, and creative games related to astronomy. Each newsletter will feature a space-themed poster on one side and content on the other. This approach will establish a sustainable project model where schools and families can pay a small registration fee to receive monthly newsletters, enabling low-income schools and underserved communities to access them for free.

.Space Mails is an innovative approach that encourages learning and engagement in astronomical activities at schools and at home, particularly for children who want to explore non-digital activities post-pandemic and have limited or no access to the internet. Overall, Space Mails is an innovative solution that can help address the education disruption caused by the pandemic, promote interest in astronomy, and enable greater access to educational resources in underserved communities.

Session

Office for Astronomy Outreach institutional meeting

2709

ASTRO ACCEL: Using a network of networks (NoNs) to increase research capacity and effectiveness within astronomy education, engagement, communication, and culture

Dr. Anica Miller-Rushing[1], Amanda Barrera[1], Kelly Blumenthal[2], Nicolas Bonne[3], Yasmin Catricheo[1], Bret Ferenchak[4], Saeed Salimpour[5], Gretchen Stahlman[6], Tim Spuck[1,7], Tiffany Stone Wolbrecht[1]

[1]Associated Universities Inc.. [2]International Astronomical Union Office for Astronomy Outreach (OAO). [3]University of Portsmouth. [4]Logos Evaluation. [5]International Astronomical Union Office of Astronomy for Education (OAE). [6]Florida State University. [7]National Science Foundation

Abstract

The field of astronomy has witnessed a paradigm shift in recent years with the emergence of networks of networks (NoNs) as a powerful tool to offer a holistic perspective on complex systems, enabling astronomers to leverage and understand the interconnectedness and hierarchical structures present within the field. ASTRO ACCEL is a new initiative working to build an international network of networks (NoN) to accelerate research and research to practice in astronomy education, engagement (outreach), communications and culture. The 3-year project initially engaged 13 networks across 6 continents of our globe to explore and develop tools and techniques and build the human infrastructure necessary for a vibrant and sustainable NoN. We now seek to engage additional research and practitioner network partner institutions and individuals, including for our newly established Early Career Researcher (ECR) Network. This presentation will provide an overview of the project's current status, short and long-term plans, and how you can get involved. ASTRO ACCEL is funded by the U.S. National Science Foundation's Office of International Science & Engineering.

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2781

Ethiopian Amateur Astronomy Community at the Ethiopian Space Science Society: Achievements, Challenges, and Future Prospects

Kirubel Menberu Alemu

Ethiopian Space Science Society (ESSS). Space Science and Geospatial Institute (SSGI). Office for Astronomy Outreach (OAO)

Abstract

The Ethiopian Space Science Society (ESSS) serves as a hub for astronomy enthusiasts, nurturing a vibrant community dedicated to science communication. One of the key initiatives of ESSS is the development of an amateur astronomy community with access to telescopes and maintenance capabilities. This presentation showcases the achievements, challenges, and prospects of the Ethiopian Amateur Astronomy Community at ESSS.

ESSS has significantly contributed to promoting astronomy awareness and education across Ethiopia. Through outreach programs like public lectures, school visits, and stargazing events, the community has engaged a diverse audience, igniting a passion for astronomy among students, teachers, and the public. The community's interest in stargazing has also expanded to include astrophotography and live streaming of astronomical events.

Despite successes, the community faces challenges such as limited resources and infrastructure, hampering outreach efforts. Purchasing telescopes in Ethiopia is challenging due to the lack of vendors and cumbersome customs procedures. ESSS has resorted to DIY maintenance for telescopes and accessories due to these challenges. However, the growing interest in astro-tourism could lead to policy changes to improve access.

Looking ahead, the Ethiopian Amateur Astronomy Community at ESSS aims to overcome these challenges and expand its impact by including telescope training, technical support for telescope owners, and furthermore enhancing collaboration with international partners, and advocating for increased support for amateur astronomy in Ethiopia.

This presentation provides a comprehensive overview of the Ethiopian Amateur Astronomy Community's journey at ESSS, highlighting achievements, challenges, and future aspirations in advancing astronomy education and outreach in Ethiopia.

Session

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2782

Astro Expeditions Chile: astronomy off the beaten path

María Fernanda Durán

Associated Universities Inc. (AUI) / National Radio Astronomical Observatory (NRAO). National Outreach Committee (NOC) Chile

Abstract

For decades, Chile has hosted some of the world's most important telescopes, catalyzing the development of astronomy research and outreach. The connection between the development of astronomical science and the pristine skies abundant in the northern part of the country permeates the collective imagination. However, this association has inadvertently led people from other regions to perceive astronomy as inaccessible. In recent years, the Chilean National Outreach Coordination team (NOC) has collaborated with various institutions to dispel misconceptions and promote countrywide interest in astronomy.

To achieve this, we have developed a collaborative approach to organization and logistics of expeditions to remote corners that maximizes their impact while fostering bonds between communities, scientists, and communicators. The pilot program of this approach was implemented in 2022 in the southernmost part of the country, the Chilean Patagonia in the Región de Magallanes. Four teams toured different locations, offering talks, workshops, and star parties, culminating the week in the regional capital. The second expedition took place in 2023 in the Región de Los Lagos, with five teams bringing astronomy to various locations, including some accessible only by ferry or boat.

In this presentation, we will outline the method and share lessons learned, demonstrate the impact of these events, and hopefully inspire others to replicate this initiative in their own countries.

Session

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2798

Tips for Effectively tracking and evaluating outreach efforts — the case study of ORION project in Madagascar

Mr Deralaza Rafieferantsoa[1], Dr Zara Randriamanakoto[2,3]

[1]Vice-NOC Madagascar. [2]South African Astronomical Observatory. [3]NOC Madagascar

Abstract

Scheduled between April - December 2022, ORION Astro Lab is an initiative designed to orientate aspiring Astronomy Club Leaders in Madagascar and Senegal. The ORION project is unique in a way that no previous formal training for Astro Club Leaders had been run in most regions of Africa and it was also an opportunity for all the stakeholders involved in the project to share best practices and expertise in astronomy outreach. For Madagascar, in particular, ORION was deemed successful based on key performance indicators (e.g. targets reached, number of newly formed Astro Clubs) that we had set at the beginning of the project implementation. This talk reports best practices of monitoring and evaluation we adopted throughout the implementation of the completed project funded by the IAU Office for Astronomy Outreach.

Session

Office for Astronomy Outreach institutional meeting

2869

Making astronomy outreach careers visible

Dr Claudia Mignone

INAF - National Institute for Astrophysics

Abstract

This poster reflects on two separate but related projects: the first one is "Universe World", a bi-monthly interview series with astronomy / science communicators, researchers and educators from around the world, to explore career paths that led people to their current positions as well as professional trends, local and global challenges, and best practices. Launched in 2021, the column has featured almost 20 profiles at the time of writing. It is published on EduINAF, the outreach & education online magazine of the Italian National Institute for Astrophysics, both in English and Italian language. The second project is "Astronomy outreach jobs" (astronomyoutreachjobs.wordpress.com), a blog launched in February 2024 to collect open vacancies in the field of astronomy and space science outreach. The platform has a double purpose: primarily, to provide greater visibility in one single place to jobs that are regularly advertised around the world under the broad umbrella of public outreach and communication of astronomy. Besides, the blog also aims to create an archive displaying the wide variety of professional roles available in this field. During its first month, the platform received over 1000 visits and collected 32 job ads (however, most of them in Europe and North America so far) including a few proposed by members of the community. This experiment, run on a best-effort basis, wishes to spark a discussion on whether our community could actually benefit from such a platform and where it would be best hosted.

Session

Office for Astronomy Outreach institutional meeting

2872

Pixel and Cosmo Hunters: game-based activities research at INAF

Alessandra Zanazzi[1,2], Giannandrea Inchingolo[1,2], Rachele Toniolo[3,4,2], Silvia Casu[5,2], Sara Ricciardi[6,2], Stefania Varano[4,2], Valentina La Parola[7,2], Giovanni Contino[7,2]

[1]INAF Osservatorio Astrofisico di Arcetri. [2]Game Science Research Center. [3]Università di Bologna Dipartimento di Fisica e Astronomia. [4]INAF IRA Bologna. [5]INAF Ossevatorio Astronomico di Cagliari. [6]INAF OAS Bologna. [7]INAF IASF Palermo

Abstract

In recent years INAF have been researching new approaches for Astronomy and STEM communication and education, in particular based on games. In fact, we are part of the Game Science Research Center, an inter-university research group aimed at promoting game based methodologies for Public Engagement.

We will discuss two original games: a board game, Pixel, targeted to kids and young adults (14+), and a card game, Cosmo Hunters, targeted to children and kids (10+).

PIXEL theme and mechanics recreate the environment of astrophysics research where players have to make decisions autonomously and collaboratively; manage the observation time and choose whether to observe small details at high resolution or the entire body at low resolution; results are shared with the community and publications help obtain more winning points at the end.

In Cosmo Hunters the players collect observation-cards at different wavelengths using the appropriate telescope-cards. The game works with easy mechanics, delivering the concepts that astrophysicists observe radio, IR, visible, UV and Gamma light with different telescopes and that multifrequency observations are needed and bring different information.

Both games were developed through an innovative co-creation process, involving different professionals: scientists, communication experts, illustrators, game developers… Both games have been iteratively tested at several public events (major Science Festivals and game Fairs, European Researchers' night events, etc.) to ensure a fun professional-grade gaming experience and they have been extensively evaluated during game-based learning activities with high schools (Pixel) and middle school (Cosmo Hunters) students.

We will present the results of these evaluations.

Session

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2917

The Ghana Planetarium: Exploring the Universe and Enhancing STEM education through Astronomy

Ms Sarah Abotsi-Masters[1,2,3], Mr Solomon Appekey[4,2,5,6]

[1]OAE. [2]Ghana PLanetarium. [3]EduSpots. [4]Xavier Space SOlutions. [5]University of Leeds. [6]CanSat Ghana

Abstract

For over a decade, the Ghana Planetarium has stood as a testament to the vision of a Ghanaian/British couple, serving as a beacon for hands-on STEM education and a hub for astronomy enthusiasts. As the country's first and only planetarium, it has ignited the imaginations of thousands of students, from kindergarten to tertiary levels, through captivating planetarium shows that bring the cosmos within reach.

Beyond traditional education, the planetarium has hosted engaging weekend events for the public, offering a diverse range of activities such as art and crafts, model building, interactive games, and talks by esteemed guest speakers. Visitors have also enjoyed telescope and solarscope viewings, alongside a multitude of hands-on experiments.

The planetarium's impact extends beyond Ghana, attracting university lecturers, astronomy professors, and even NASA engineers, who generously volunteered their time to deliver inspirational talks. In addition, the planetarium team has been involved in establishing astronomy clubs in schools, facilitating meetings of the Astronomical Society of Ghana, and organizing enriching teachers' workshops. In response to the COVID-19 pandemic, the planetarium swiftly adapted, offering online sessions for both children and adults, ensuring continued access to astronomical education.

Through its multifaceted approach, the Ghana Planetarium has provided a one-of-a-kind experience unparalleled elsewhere in the country, enriching the lives of thousands and bridging the gap between scientific concepts and everyday experiences. Its contribution to STEM education and the advancement of astronomy in Ghana is undeniable, cementing its status as a vital educational institution

Session

Office for Astronomy Outreach institutional meeting

2927

Synergy Between IAU-Initiated and Authentic Activities: a Recipe for a Robust Success in Astronomy Outreach

Dr. Lyuba Slavcheva-Mihova

Institute of Astronomy and NAO - Bulgarian Academy of Sciences

Abstract

Jan. 12th, 2019, Sofia. The largest *100 Hours of Astronomy* event with a total of 1,700 people involved. This is one of the 120 activities within all *IAU100* projects, in which Bulgaria participated with enthusiasm!

August night in 1970 on a mountain meadow. Thirty students monitor meteor showers at the first Astro Camp. 53 years later the site welcomes 70 young observers for the 53rd time... 2023 seems richest in astronomical outreach activities ever, for instance:

- *Astronomy Day in Schools*, *Masterclasses at CERN*, *European Researchers' Night*, *Women in Astronomy* events, *Modern Space Research* Forums;
- Festivals, Open Days & anniversary celebrations (e.g. Zwicky's birth with his daughters as guests) at planetaria;
- National Young Astronomers' Conferences and Astro Camps;
- Olympiads in Astronomy;
- *Planetarium in the Kindergarten*, children's space camps;
- Contests - national (e.g. *Cosmic Eggs*) and international (e.g. *Milky Way Photographer*).

Based on my experience as a NOC for 6 years already, I can *prescribe* a recipe for a robust success in Astronomy outreach:

Rx: Participate actively in the IAU-initiated projects. The instantaneous celebration of the achievements of astronomy gives the feeling of integrity and power to cope with global problems (e.g. light pollution).

Rx: Preserve the authentic traditional activities, they connect us to our ancestors and keep the diversity.

Rx: Assign an active role to the audience through contests, camps, quizzes, etc. to make astronomy inspiring to them.

Blue neon lights. *Neptune stage* passes into *Martian stage. Live chat with NASA astronauts.* These are not sci-fi movie scenes but *Hello Space| Bulgaria Calling 3.0*, June 29th, 2023 - the event that fits best the above criteria. Up to now.

Session

Office for Astronomy Outreach institutional meeting

2983

NOCs Funding Scheme - effectively bridging national and cultural barriers

Samir Dhurde

Inter-University Centre for Astronomy and Astrophysics

Abstract

abstract TBD

Session

Office for Astronomy Outreach institutional meeting

3018

On the road: the treasures hidden inside the dome of an itinerant planetarium in Brazil

Ms. Mariana Gomes[1,2], Mr. Mateus Nunes[3,2], Ms. Bruna Dias[2]

[1]FIOCRUZ (RJ). [2]Brazilian Olympics of Astronomy and Astronautics. [3]UERJ

Abstract

Across the doors of the dome, a whole new world is presented for everyone, inviting each one not only to contemplate the night sky, planets, and a myriad of constellations but also to ponder the diversity of worldviews and our position and role in the Universe. On the centenary celebration of the modern planetariums, we acknowledge their potential to bring the wonders of the Universe to everyone and communicate Astronomy to the public. Simultaneously, this milestone invites us to reflect on the inaccessibility of the spaces dedicated to promoting Astronomy to most of the population. Amid this reality, itinerant planetariums emerged and dared to do the inverse process: to meet society in its daily life. However, this process involves comprehending that every place where a planetarium arrives, we embrace different realities, social backgrounds, and perceptions of the world and Universe. In this work, we aim to share the experiences and good practices acquired during the past ten years of itinerancy of the planetarium from the Brazilian Olympics of Astronomy and Astronautics. Through free planetarium sessions and hands-on rocket-making workshops nationwide, we expect to explore not just the local sky, ethnoastronomy, and astronomical concepts, but also discuss how to promote justice, equity, diversity, and inclusion inside the dome. By considering each planetarium session a unique opportunity to communicate Astronomy, we discover a brilliant treasure inside the darkness of the dome: the personal experiences and memories individuals bring to astronomy sessions create infinite universes under the same sky.

Session

Office for Astronomy Outreach institutional meeting

3042

Astro-Tainos/Cultural Astronomy in the Antilles

Manuel Grullon[1], Dr. Rulx Narcisse[2], Dr. Mayra Lebron[3,4]

[1]NOC - Dominican Republic. [2]NOC - Haiti. [3]NOC - Puerto Rico. [4]University of Puerto Rico - Río Piedras Campus

Abstract

Astro-Tainos/Cultural Astronomy in the Antilles is a regional collaborative outreach project developed by the IAU National Outreach Coordinators of the Dominican Republic, Haiti and Puerto Rico and funded by the OAO NOC Funding Scheme. This project focuses on the incorporation of the knowledge of the ancient cultures of the Caribbean about the sky into the astronomical outreach activities in the region. Up to now the mythological stories and ancient knowledge about the heavens that are told in the Caribbean are limited to a few cultures mostly from Europe. The presence of the Caribbean stories into the astronomical discourse is missing. The core idea of *Cultural Astronomy in the Antilles* project is to collect Tainos stories linked to their astronomical knowledge and mythology and create astronomical outreach material to be include on outreach activities in the Caribbean territories where the pre-Columbian Taino people lived, allowing current inhabitants to better understand our common origins. In this work we present the experience, outcomes, benefits and challenges during the development and implementation of Astro-Tainos/Cultural Astronomy in the Antilles project in Haiti, Dominican Republic and Puerto Rico.

Session

Office for Astronomy Outreach institutional meeting

3074

Highlights of Astronomy Outreach Efforts in Africa

Ms Duduzile Kubheka

African Astronomical Society (AfAS). South African Astronomical Observatory (SAAO). BRICS Astronomy. Stellenbosch University

Abstract

The presentation delves into the extensive array of initiatives spearheaded by the African Astronomical Society (AfAS) and the IAU-GA 2024 Outreach and Education Committee over the year, underscoring the pivotal role of networking, prioritising people, and fostering accessible and inclusive outreach endeavours. Throughout the year, numerous interactions with stakeholders have been facilitated to ensure the broad dissemination of projects across diverse regions of Africa.

Key highlights include the Ambassadors Program, which employs the innovative cascade outreach model to extend the reach of astronomy initiatives. Additionally, the Science Communications Ambassadors Program aims to cultivate a cadre of communicators adept at disseminating scientific concepts to diverse audiences. The #AfricaLookUp campaign endeavours to merge astronomy with art, weaving narratives that reflect varied perspectives on the night sky. Moreover, dialogue sessions have been conducted with science engagement professionals to foster collaboration and knowledge exchange.

These initiatives represent a concerted effort to engage communities across Africa in the realm of astronomy, leveraging innovative approaches and partnerships. By emphasising inclusivity and engagement, these projects aim to inspire curiosity, foster scientific literacy, and facilitate dialogue among diverse audiences. Through ongoing collaborations and dialogue with stakeholders, AfAS and the IAU-GA 2024 Outreach and Education Committee strive to ensure that astronomy remains accessible and relevant to people from all walks of life across the African continent.

Session

Office for Astronomy Outreach institutional meeting

3087

Re:Birth of Vietnamese Astronomical Society – Lessons and visions from an old yet new organisation

Tan Vu Nguyen[1], Phuong Loan Huynh[1,2,3], Tuan Duy Dang[1,2,3]

[1]Vietnamese Astronomical Society. [2]Ho Chi Minh City Astronomical Association. [3]Ho Chi Minh City Amateur Astronomy Club (HAAC)

Abstract

In the end of 2023, the Vietnamese Astronomical Society (VAS) held its long-awaited general meeting and elected a new chairperson. This happened after ten years of near total inactivity and dysfunction. Besides, a non-professional-or-amateur astronomer was elected to the board for the first time. In addition, both professionals and non-professionals are warmly welcome to become members and friends of VAS.

The long overdue changes in leadership and composition of the national organisation of astronomers in Vietnam are significant, meaningful, and naturally well received. The new leadership is determined to renew the society both inside and outside the country. One step at a time, VAS has been reaching out to reconnect as well as to reconcile with amateur clubs nationwide. Internationally, the Society rushes to resume Vietnamese national membership status and restart international collaborations within the IAU framework.

Among the new board members of VAS, there is now a representation of amateur astronomy. This is also deemed as an official recognition for the tireless efforts of Vietnamese amateur astronomers in engaging the public with astronomy. To keep this momentum, astronomy communication is now part of VAS agenda, built on work of the NOCs and the IAU global outreach activities.

This presentation will tell the tale of the rebirth of VAS with the emphasis on the role of amateur astronomers in Vietnam and their work in reviving this Society. What is next? It remains to be seen but hard lessons of the past ten years are reviewed critically to prevent future repetition.

Session

Office for Astronomy Outreach institutional meeting

3106

Bridging the Gap: Fostering Professional-Amateur Collaboration in Astronomy through Citizen Science Initiatives: A Case Study of the Apadilangit Citizen Science Project

Mr Muhammad Hafez bin Ahmat Murtza

IAU Inclusive Outreach (Inspiring Stars) SubWG. Apadilangit ; Universe Awareness Malaysia

Abstract

The Apadilangit Citizen Science Project stands as a beacon for promoting astronomy in Malaysia through collaborative efforts between professionals and amateurs. With a core mission of bridging the gap between these two groups, Apadilangit harnesses the enthusiasm of citizen scientists who aspire to contribute meaningfully to astronomical research. More than merely spectators, these citizens actively engage in data collection and analysis, fostering a sense of ownership and participation in scientific discovery.

The project's foundation lies in the creation of a robust platform tailored to Malaysia's citizen scientists while drawing inspiration from successful global citizen science initiatives. Boasting over 1000 dedicated citizen scientist, Apadilangit represents a significant grassroots movement driving astronomical research forward. Apadilangit Citizen science project https://apadilangit.com/citizenscience/

In a groundbreaking partnership, Apadilangit collaborates closely with University Malaya to develop the country's inaugural citizen science project for astronomy. With a specific focus on radio astronomy and solar observations, the project aims to demystify complex astronomical concepts while encouraging public involvement in scientific endeavors.

As the project gains momentum, its initial focus centers on promoting radio astronomy, providing participants with valuable insights into this fascinating field. Through Apadilangit, the boundaries between amateur stargazers and seasoned astronomers blur, creating a dynamic ecosystem where curiosity and collaboration fuel scientific progress.

Session

EC WG Pro-Am Relations in Astronomy

3124

Utilizing the Science of Science Communication to Engage Vulnerable Audiences in Astronomy: Insights from the Soha Astronomy Volunteer Network

Fatemeh Bonyadi

Ph.D candidate in Science Communication

Abstract

In the Soha Astronomy Volunteer Network, we employ two science communication frameworks: 1) the classic Audience Pyramid in science communication, and 2) the Engagement Model for public involvement in science.

Audience Pyramid: Our science communication employs a four-tier Audience Pyramid. The base represents the lay public, followed by the interested public, the involved public, and finally, scientists.

Engagement Model: Over time, the Participation model has proven most effective in engaging individuals in science. We utilize this model to elevate individuals within the Audience Pyramid.

We encourage non-specialist public participation in hosting astronomy night events for vulnrble communities. Collaboration with individuals from various backgrounds, such as artists, athletes, and celebrities, enhances the engagement of vulnrable communities in these events. Our approach targets communities with special needs, fostering a sense of community and inclusion.

Our experience has shown that involving the lay public in a scientific event that incorporates play and emotional engagement can significantly enhance community involvement and raise participants' awareness. Furthermore, it can serve as a tool to elevate them within the Audience Pyramid, turning them into interested audiences.

We collaborate with psychologists to tailor events to the specific needs of the target audience. Finally, we invite participants (both lay public who assist in event organization and target audience) to share three significant insights about the event. These insights may include newfound knowledge about astronomy or specific needs identified within the target community, which can be addressed and adjusted. Feedback from participants indicates that both groups become interested in astronomy.

Session

Office for Astronomy Outreach institutional meeting

Final category: Office for Young Astronomers institutional meeting

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Career Development Challenges for Young Astronomers in some African countries: The case of Ethiopia

Dr. Yikdem Mengesha Gebrehiwot[1], Dr. Solomon Belay Tesema[2], Dr. Gebregiorgis Abraha Fikade[1]

[1]Mekelle University. [2]Space Science and Geospatial Institute (SSGI)

Abstract

Ethiopia is one of the ancient countries in Africa with diversified culture. Astronomy was part of the culture of ancient Ethiopians and it needs a structured effort of the young astronomers to trace back its history. After establishment of ESSS in 2004, astronomy becomes familiarized in the urban elementary and high schools. The outreach programs of the society play a great role for the involvement of students in different astronomical activities and the number of young astronomers increased in the country. Although, such improvements are observed in the country, there are certain obstacles of astronomers in their career. There is no undergraduate program for astronomy in Ethiopia and students are restricted to only two elective courses in the physics program. Some interested graduates may join MSc and then PhD in Astronomy in SSGI and few public universities, although the research fund is not significant. Families are also negatively influenced kids not to join Astronomy, for two reasons. Astronomy is taken as conjuring activities by parents. The socioeconomic factor is another reason; most of the students come from the lower class and need their children to join professions with high revenue. In Ethiopia there are no local postdoc and postgraduate diploma opportunities and the future of the astronomers depends on international scholarships grants. African Astronomers need to aware curriculum developers and policy makers on the challenges of Astronomy. The study will focus on career development challenges of African countries, in particular the case of Ethiopia and will recommend possible solution.

Session

Office for Young Astronomers institutional meeting

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Career Development Challenges for Young Astronomers in some African countries: The case of Ethiopia

Dr Yikdem Mengesha Gebrehiwot[1], Dr Solomon Belay Tessema[2], Dr Gebregiorgis Abraha Fikade[1]

[1]Mekelle University. [2]Space science and geospatial institution

Abstract

Ethiopia is one of the ancient countries in Africa with diversified culture. Astronomy was part of the culture of ancient Ethiopians and it needs a structured effort of the young astronomers to trace back its history. After establishment of ESSS in 2004, astronomy becomes familiarized in the urban elementary and high schools. The outreach programs of the society play a great role for the involvement of students in different astronomical activities and the number of young astronomers increased in the country. Although, such improvements are observed in the country, there are certain obstacles of astronomers in their career. There is no undergraduate program for astronomy in Ethiopia and students are restricted to only two elective courses in the physics program. Some interested graduates may join MSc and then PhD in Astronomy in SSGI and few public universities, although the research fund is not significant. Families are also negatively influenced kids not to join Astronomy, from two reasons. Astronomy is taken as conjuring activities by parents. The socioeconomic factor is another reason; most of the students come from the lower class and need their children to join professions with high revenue. In Ethiopia there are no local postdoc and postgraduate diploma opportunities and the future of the astronomers depends on international scholarships grants. African Astronomers need to aware curriculum developers and policy makers on the challenges of Astronomy. The study will focus on career development challenges of African countries, in particular the case of Ethiopia and will recommend possible solution.

Session

Office for Young Astronomers institutional meeting

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The International Schools for Young Astronomers: historical overview

Prof. Itziar Aretxaga[1], Prof. David Mota[2]

[1]Instituto Nacional de Astrofísica, Óptica y Electrónica. [2]Univ. of Oslo

Abstract

The International School for Young Astronomers (ISYA) is a program started in 1967 by the IAU in order to aid the development of astronomy graduate students around the world, targeting specifically astronomically underdeveloped countries and isolated groups. Within its 57 years of existence, it has organized 44 schools in 27 countries. Schools usually have ~30-50 students aided by a team of 10-15 lecturers for a 3-week long intensive and broad-scope program. Over time, ISYAs have hosted nearly 1500 students and 400 lectures.

The ISYA program is evaluated in the context of the experienced gathered in the field. We highlight the impact of the program on developing countries throughout its history, the typical trajectories of attended alumni which develop professional astronomy careers and the overall impact of the program perceived by alumni at different stages of their career.

Session

Office for Young Astronomers institutional meeting

1286

Stellar Futures: Empowering Emerging Astronomers in Central America and the Caribbean (Alpha-Cen)

Dr Paola Oliva Altamirano

Alpha-Cen. Our Community/SmartyGrants

Abstract

In 2016, a small group of astronomers united to foster the growth of astronomy in Central America and the Caribbean, particularly concentrating on nurturing the emerging generation of astronomers in their early careers. Over the course of four years, this initiative evolved into Alpha-Cen, an association with 105 active members.

Alpha-Cen has achieved success through conferences, astronomy schools, a mentorship program, and diverse outreach projects. Additionally, it has facilitated connections for thesis supervisions and external research internships. This presentation aims to share our journey, highlighting the steps taken to ensure transparency, good governance, and collaborative engagement among our growing membership.

Session

Office for Young Astronomers institutional meeting

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ISYA in Relation to Other Astronomy Themed Schools: An Appraisal of Impact on Career and Professional Development

Dr.Ki Kingsley Okpala

University of Nigeria

Abstract

Over the years, participation in the International School for Young Astronomers (ISYA) has opened a world of opportunities in Astronomy and Astrophysics to many of the participants of the school and has always been described as a reference point in the career paths of its alumni. In this talk, a review of notable take-away from the 1999 ISYA is presented. Experiences from similar schools -Vatican Observatory Summer School (VOSS) and the Heliophysics Summer School (HSS) is also shared. Personal reflections of their impact on Career and Professional Development are presented. In addition, the possibility of further enhancement in the impact and sustainability of the ISYA is discussed.

Session

Office for Young Astronomers institutional meeting

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The IYA Journey – A story of Success

Mr. Prospery Simpemba

Copperbelt University, Department of Physics

Abstract

The International School for Young Astronomers has been a solid foundation for many alumni. This presentation showcases the inspiring Journey of Prospery Simpemba (featured alumni) after attending the 2012 IYA in Cape Town that marked the change of career from solar energy materials to astrophysics. The impact of the 2012 school is today seen through the many achievements (projects, schools, workshops, curriculum development and collaborations) that have been scored and how so many non-IYA alumni have benefited from these efforts. The talk will inspire young and upcoming astronomers to stretch to their full potential such that the sky will never be the astronomical limit. Today, we learn how the influence and mentorship of the facilitators of these schools can bring positive change and shape the career path of a once armature astronomer.

Session

Office for Young Astronomers institutional meeting

2999

Pan-Africa School for Emerging Astronomers - A Decadal Journey

Prof James Chibueze[1], Dr Linda Strubbe[2], Dr Bonaventure Okere[3], Dr Jielai Zhang[4]

[1]University of South Africa. [2]University of British Columbia. [3]Centre for Basic Space Science, University of Nigeria, Nsukka. [4]University of Sydney

Abstract

The Pan-Africa School for Emerging Astronomers evolved from the West African International Summer School for Young Astronomers which started a decade ago. The main purpose of the school is to contribute to the production of a critical mass of astronomers in the continent, by exposing young university students and school teachers to astronomy concepts through inquiry-based teaching methods and hands-on astronomy research methodologies. The successes recorded by the school over its 10-year existence are evident in its vibrant alumni. PASEA 2024 will be hosted by Monastir Science Palace, Tunisia and this will leave us with just one more region (East Africa) to go in covering all 4 regions of the continent. This talk will highlight the successes of PASEA, its current funding mechanism and outline the sustainability plans for the next decade.

Session

Office for Young Astronomers institutional meeting

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Empowering Future Astronomers: The Impact of OYA in Pakistan and Beyond

Hira Fatima

National Center in Big Data and Cloud Computing, NED-UET. Institute of Space Science and Technology, University of Karachi Pakistan

Abstract

International schools play a pivotal role in shaping the careers of early astronomers, providing them with advanced knowledge, practical skills, and global networking opportunities that are often unavailable in their home countries. These schools foster collaboration, inspire innovative thinking, and equip participants with the tools needed to excel in their fields. The true impact of these programs is best seen in how alumni benefit personally and professionally, and in how they contribute to the development of their home countries. In my talk, I will share my transformative journey from attending the International School for Young Astronomers (ISYA) in 2019 to becoming a driving force for change in Pakistan. Inspired by this experience, I dedicated myself to enhancing astronomy education and became the IAU OAE National Astronomy Education Coordinator for Pakistan. Invited by OYA to the IAU General Assembly in 2022, I explored various IAU offices and opportunities, leading me to spearhead numerous projects in Pakistan. These initiatives, backed by national and international organizations like IAU OAE, IAU OAD, IAU OAO, RAS, and LCO, focus on astronomy and STEM education, research, outreach, and astro-tourism. My efforts extended beyond borders when I was selected as a member of the education and outreach team for the Radio Galaxy Zoo citizen science project and an associate member of ASTRO ACCEL. Join me to discover how OYA empowered and inspired me to transform the astronomy education and research landscape in Pakistan and beyond.

Session

Office for Young Astronomers institutional meeting

Final category: Office of Astronomy for Development institutional meeting

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Astro-Tourism development in Mongolia

Educator and Researcher Chinzorig Bayarkhuu

"Extremum Educational Center LLC"

Abstract

ORAL

Abstract

Astro Ecology activity in Mongolia

Chinzorig Bayarkhuu[1], *Tsolmon Renchin*[2], Wenwen ZUO [3], Thijs Kouwenhoven [4]

[1] *Extremum Education Center LLC, Ulaanbaatar, Mongolia*

[2] *Space Science laboratory, Physics Department, National University of Mongolia, Ulaanbaatar*

[3] *EA-ROAD*

[4] *EA-ROAD*

Email: shunhlai9@gmail.com

The purpose of our activity " Astro Ecology" is to explore potential positive impacts of Astro-tourism and tree planting for Environment Protection in the Gobi Desert, and for wellbeing. This yead we will organize " Astro Ecology" tour on 4-10 September in Gobi desert of Mongolia. The tour contributes to the global battle against desertification. The percentage of forest is decreasing annually, causing environmental issues for our society and region. Recently, a nationwide movement has been launched, "to plant 1 billion trees by 2030," as a part of Mongolia's commitment to the United Nations Sustainable Development Goals, as well as a way to address the problems of desertification, deforestation, and food insecurity. To plant trees in a semi-desert area is one of the main activities for the Astro Ecology activity. Therefore, we have decided to organize this exciting Astro-Ecology activity with researchers, international scientists, local

people and tourists on the Gobi forest plantation, and engage in reforestation annually in Mongolia (September).

The tour includes invited lecture presentations with inspiration of the night sky. Participants will explore the impacts of understanding the vastness of the universe, and our participation and role as co-creators in it, on human nature. This talk aims to distribute astro ecology activity among astronomers in the world.

Session

Office of Astronomy for Development institutional meeting

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Status of Astronomy Development in West Africa: A Report from WA-ROAD

Dr Bonaventure Okere[1,2], Dr Emeka Onyeuwaoma[1]

[1]Centre for Basic Space Science and Astronomy, Nsukka. [2]West African Regional Office of Astronomy for Development

Abstract

There is no denying the fact that Astronomy is important to the development of African countries. In West Africa, the development of Astronomy started in the late 1950s. Efforts to make countries in the Region counted among countries with frontline Astronomy research instruments have been slow due to various reasons. In this presentation, we shall review the factors responsible for the slow growth and the current status of Astronomy development in West Africa.

Session

Office of Astronomy for Development institutional meeting

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ASTRONOMY SITUATION IN SYRIA

Dr Mohamad alassiry

Syrian Astronomical Association. Arab Union for Space and Astronomy

Abstract

When talking about Exceptional cases in the development astronomy We must talk about Syria and know what happened there in order to benefit from the experiment which Syria has passed and actually astronomy my country has influenced by the Syrian's crisis.To appreciate science situation generally in Syria.we must start from the entire of the crisis which deprived Syrians from the simplest life requirements.Then we decided that our life must continue and we must take notice of our thinking and our way of understanding because these are the main reasons of the crisis in Syria and from this point we set off.We tried many times to change curriculums in Syria and we succeeded.We pay attention to children where ever they were through our activities. And now our activities could create smile among Syrians despite of all the suffering.We could accommodate and achieve many improvements.We use media for our science programs and we connect with the international astronomy union and gave the name of Tadmor to a planet and the els .By hope, science and hard work we reach the point that we set off from and built our observatory by our own selves.This is our letter to your distinctive conference.By science and education countries progress, and science mustn't stop at all and we must always start and be attention to the mind and awareness, because the perfect science is the best way to build perfect country and advanced future.This is our experiment in Syria is in front of you

Session

Office of Astronomy for Development institutional meeting

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The NOVA SKIES Programme - A training on entrepreneurial competences for young astronomers

Dr. Giovanna Pugliese

API-University of Amsterdam

Abstract

The NOVA-SKIES (Skilled, Innovative and Entrepreneurial Scientists) programme is the implementation in the Netherlands of the original SKIES project, funded by the EU (through the Horizon 2020 programme), and created to address a specific call of IAU.

The pilot SKIES project ran from March 2021 till August 2022, and aimed to provide training on innovation, entrepreneurship and open science for PhD candidates and early-career researchers in the field of astronomy science in Germany, Poland, Portugal, South Africa and The Netherlands.

The Implemented NOVA-SKIES programme started in July 2023 and will run till the end of 2028, supported by NOVA funding. The programme provides training on innovation, entrepreneurship, and development of soft and hard skills for PhDs and PDs, and creates career opportunities for PhD candidates and early-career researchers in the field of astronomy in the Netherlands. The programme aims to support the recognition of the competences of young astronomers, and allows them to become self-aware of their skills and of the constructive way in which they can transfer them in any career they decide to pursue. Once outside academia, thanks to the strong awareness of their values, our PhDs and post-docs become active STEM ambassadors in the society, and this represents an important goal of the astronomical field as a whole.

In this talk, I will provide an overview of the programme and share the ongoing efforts we are making to continue and expand the original international collaboration.

Session

Office of Astronomy for Development institutional meeting

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VO Tools and Data Analysis for Copperbelt University, Zambia: VO-OAD Special Grant: Execution, Methodology, Lessons learned

Dr Priya Shah, Prof Syed Najamul Hasan

Maulana Azad National Urdu University, Hyderabad, India

Abstract

With the help of funds from the IAU-OAD and VO, we were awarded a project based on Virtual Observatory for Masters students in Africa. We spent three weeks in October-November 2023 with the postgraduate students and faculty at Copperbelt University, Zambia conducting three workshops for students and faculty. This nvolved use of Virtual Observatory tools like TopCat and Aladin, as well as python coding with Jupiter notebooks that we provide. This projectwas useful not only for students of Astronomy and Astrophysics, but also to teach students coding in python and skills that are useful for Data Analysis. In this talk, I shall discuss details of the project: Execution, Methodology, Lessons learned

Session

Office of Astronomy for Development institutional meeting

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VO Tools and Data Analysis Manual for undergraduate and postgraduates students

Prof Syed Najamul Hasan, Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

A laboratory manula has been prepared for undergraduate and postgraduates students based on VO Tools and Data Analysis of Astronomy Archival Data. The experiments were demonstrated in a three week program at Coppperbelt University, Zambia funded by the IAO-OAD. We shall describe the experiments and their implementation at a global level in Universities.

Session

Office of Astronomy for Development institutional meeting

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First approach to a Astrotourism experience certification in Andean countries

Dr Beatriz García[1], PhD Faiber Rosas[2,3], PhD Giovanni Pinzón[4], PhD Nicolás Vázquez[5]

[1]CONICET, UTN-FRM. [2]Departamento de Física - Universidad de Nariño, Colombia. [3]Observatorio Astronómico y Cultural Silatupue, Colombia. [4]Universidad Nacional de Colombia, Observatorio Astronómico,. [5]Escuela Politécnica Nacional, Ecuador

Abstract

Astrotourism is a growing cultural activity that requires planning to be successful and produce the desired impact on citizens. In general, there are no concrete or formal links between entrepreneurs in this topic and professional astronomers who could provide advice and even certify the quality of the initiatives. In Latin America, various public and private ventures have emerged in recent years, in part due to government support for obtaining certifications for astrotourism destinations, by recognized international entities.

Currently, the Ministries of Tourism of various countries such as Colombia, Ecuador, Chile, Peru and Argentina are looking for a way to put an international seal on the best local astronomical destinations. For this reason astrotourism requires planning.

The relationship and cooperation between academia, non-formal education and tourism could also be beneficial to ensure originality of the offers, even in the same territory.

This contribution presents a first approach to those activities and topics that are relevant to astronomy in general, that can be addressed by professional or amateur astronomers (in the latter case who are in contact with professionals) and that would allow certification, according to certain indicators, the proposed tourist experience

Session

Office of Astronomy for Development institutional meeting

Poster upload

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400

Illuminating the Night Sky ; Harnessing Astronomy for Socio-Economic Development in the Niger Delta Region of Nigeria

Engr. Timi Ekubo

Astronomers Without Borders. Nigeria

Abstract

- This study investigates the role astronomy plays in the Niger Delta region of Nigeria, focusing on its potential applications and contributions in diverse aspects of societal development and scientific advancement. The Niger Delta region is known for its rich cultura heritage and diverse ecosysystems, this presents a fantastic context for exploring the intersections of astronomy with local traditions, environmental conservation, education, and economic development. Looking at both qualitative and quantitative research methods, the study examines the historical significance of astronomy in the region, including indigenous knowledge systems related to celestial observations and cosmology. This also explores contemporary efforts to promote astronomy education and research, outlining initiatives aimed at engaging communities,fostering scientific literacy, and addressing socio-economic challenges. Furthermore, the study investigates development goals, such as environmental monitoring, renewable energy, and the promotion of STEM (Science, Technology, Engineering and Mathematics) education. with a deep understanding of the cultural, scientific, and socio-economic dimensions of astromy and its relevance to local communities in the niger Delta and beyond.

Session

Office of Astronomy for Development institutional meeting

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Enhancing Development through Astronomy: Insights from AWB Nigeria's OAD Funded Projects

Ms Olayinka Fagbemiro[1,2], Ms Effionmwan Etim[1,2], Mr Timi Ekubo[1,2], Mr Onuche Ogu[1,2], Mr Bashir Yusuf[1,2]

[1]Nigerian Space Agency. [2]Astronomers Without Borders (AWB) Nigeria

Abstract

As the founder and national coordinator of Astronomers Without Borders (AWB) Nigeria, I have had the privilege of spearheading multiple initiatives aimed at harnessing astronomy for developmental goals, supported by the IAU Office of Astronomy for Development (OAD). From 2018 to 2021, AWB Nigeria has implemented various projects under the OAD's funding umbrella, including Girls Astronomy Outreaches, Astronomy camps for internally displaced (IDP) children, and support activities during the COVID-19 pandemic. These projects, targeted at high school girls and children affected by insurgency in northern Nigeria, were designed to inspire, educate, and provide solace through the vast and hopeful perspective that astronomy offers.

Reflecting on the impact of these initiatives, we observed significant outcomes in terms of increased interest in STEM fields among participants, enhanced community awareness of astronomy's educational value, and the provision of emotional and intellectual support to displaced children in crisis periods. Evaluating the impact of these projects involves both quantitative and qualitative measures, including participant feedback, follow-up studies on educational trajectories, and community engagement levels.

Looking ahead, the evolving landscape of OAD funding and project implementation calls for adaptive strategies that ensure sustainability, broader reach, and deeper impact. This includes leveraging the network of regional offices for localized support and developing scalable project models. Our experiences underscore the critical role of astronomy in fostering resilience, education, and hope amidst challenging circumstances, aligning with the IAU's vision of astronomy for development.

Session

Office of Astronomy for Development institutional meeting

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Andean Network of Astrotourism Entrepreneurs

Dr Nicolás Vásquez[1], Dr. Giovanni Pinzóm[2], Dr Faiber Rosas-Portilla[3], Nicolás Noriega[1]

[1]Escuela Politécnica Nacional. [2]Universidad Nacional de Colombia. [3]Observatorio Astronómico y Cultural Silatupue

Abstract

The Andean network of astrotourism entrepreneurs exemplify the profound intersection between astronomy and cultural enrichment across diverse global communities. The human fascination with celestial phenomena not only inspires awe but also paves the way for socioeconomic advancement, particularly among rural sectors. Astrotourism, as a conduit for experiential engagement, holds immense potential for the Andean region to pioneer specialized tourism experiences.

The IV Workshop on Astronomy in the Andes served as a pivotal forum where indigenous communities and forward-thinking tourism entrepreneurs converged, seeking guidance from astronomers on leveraging astrotourism. This collaborative exchange, uniting entrepreneurs, scholars, astronomers, and indigenous communities, underscored the imperative to establish a dedicated network aimed at innovating the tourism landscape. This initiative entails crafting immersive itineraries for celestial experiences and infusing traditional crafts with stellar motifs, thereby enhancing their cultural significance.

Illustrating the scope of astro-tourism activities, several promising ventures were presented, showcasing how traditional products can be imbued with celestial narratives, thereby elevating their cultural resonance and enriching their stewards. Through this collaborative effort, the Andean network of astro-tourism entrepreneurs endeavors to not only foster economic growth but also preserve and celebrate the rich cultural tapestry.

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Office of Astronomy for Development institutional meeting

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IAU–International Visegrad Fund Mobility Awards

Dr. Pedro Russo

Leiden Observatory, Leiden University, the Netherlands. IAU EROAD, Europe

Abstract

The IAU–International Visegrad Fund Mobility Awards is a unique mobility scheme for Bachelor (BSc) and Master (MSc) astronomy students, building cross-border cooperation across four Visegrad Group countries: the Czech Republic, Hungary, Poland and the Slovak Republic. The IAU–International Visegrad Fund Mobility Awards builds research capacity in institutions and raises the regional and global recognition of the astronomy community. Students will be given the opportunity to further develop their research skills and strengthen their career opportunities in astronomy and STEM-related fields. Two cohorts of 12 students (a total of 24 students, 6 per country) will undertake a three-month summer research programme at a partner institution during 2023 and 2024. During this talk we will provide an overview of the mobility programme as well potential lessons learnt for similar projects.

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Developing Space Science in Ghana through Experimental Satellites

Mr Solomon Appekey

CanSat Ghana. University of Leeds. Xavier Space Solutions

Abstract

With no formal curriculum (at basic school level) in astronomy or space science in Ghana, there is no direct knowledge and sustainable approach to teaching and learning astronomy and space science. This affects how science is taught with several implications on the teaching and learning outcomes in schools.

Our experimental satellite (Cansat) approach uses an actual space mission to introduce and deliver astronomy & space science. This Cansat project simulates a real, large, satellite (including all the subsystems), but with limited complexity. The Cansat project teaches students how to build experimental satellites (alongside skills: mathematics, coding, electronics, etc.) with real life applications such as remote sensing, weather monitoring etc.

We began our first Cansat project (2021) which involved more than 200 students from 10 public and private tertiary schools. In this project, targeted and reached 400+ students from selected high schools in 3 regions in Ghana. Another aspect of this project is the involvement of local electronics companies in the design of the first microcontroller boards for Cansats.

Our Cansat project has shown to be a sustainable way of introducing and teaching astronomy, space science and basic science. Additionally, it has aslo proven to be an active way of involving the youth in the space sector especially with a focus on the application of space technologies to solving Ghana's basic problems.

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Research on access, use and effective exploration of astronomical data

Dr. Johanna Casado[1], Dr. Beatriz García[2]

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Abstract

Space science data analysis historically relies heavily on visual methods, although most data originates from invisible parts of the electromagnetic spectrum. This restricts studying the unknown based on screen resolution limitations and excludes those with visual impairments. To address challenges facing persons with disabilities in research, education and careers, this investigation aims to create novel data access approaches prioritizing accessibility and inclusive design principles. It has been demonstrated that multimodal perception (the use of more than one sense) can be a valuable complement to visual exploration and understanding of complex scientific data, particularly in the case of astrophysical data, which are composed of a combination of different oscillatory modes resulting in a complex array of final data. This proposal focuses on the human ability to adapt to data and interact with sound to analyze data sets and develop an application aimed at leveling the playing field for accessing information in the fields of astronomy and astrophysics for individuals with disabilities. Furthermore, it advocates for the study of scientific and technological capabilities for the development of tools with an innovative, user-centered approach, addressing specific social problems, utilizing open-source programming languages, and designing infrastructure to enhance inclusion.

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Lusophone Constellation: looking for a common agenda.

Joana Latas[1,2], Rosa Doran[1], Valente Cuambe[3], Vinicius Oliveira[1,4]

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Abstract

The Portuguese language is a shared identity that connects and joins people in this network. It brings an added value to PLOAD actions as a Portuguese-speaking project, which is witnessing a strong growth. According to the World Population Perspectives (2022) report, by the end of the 21st century, the number of Portuguese speakers will nearly double its current 260 million speakers, a growth driven mainly by the African countries. Moreover, the socio, cultural and economic diversity of countries and regions that come together in the PLOAD network comprises different challenges in terms of the development of their scientific, technological and educational systems.

Consolidating the PLOAD's agenda was the main goal of the Lusophone Constellation project, funded by OAD, which strengthened our identity. After selecting three celebrations related with PLOAD's mission, we ran a joint programme with a global and online component and another local and face-to-face one. High-impact local initiatives were central to support societal needs, on which astronomy can contribute. In this communication we will focus the PLOAD coordinators' perceptions related with the impact of this hybrid program. Particularly, we will emphasize, on one hand, how the global activities strengthen the sharing of practices between different PLOAD countries and regions, while, on the other hand, the role of local activities to promote the establishment of local partnerships in the different nodes. In the same way, we will also emphasize the COSPAR and PLOAD partnership as a new trend in PLOAD action.

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"The Impact of the Arab Regional Office of Astronomy for Development (AW-ROAD) and its Associated Arabic Language Expertise Centre (AW-LOAD) on Astronomy Advancement in Jordan and the Arab World"

Dr. Awni kasawneh[1,2,3,4], Diala Taneenah[4,3]

[1]Coordinator of the Arab Regional Office of Astronomy for Development (AW-ROAD). [2]University of Sharjah, P.O Box: 27272, Sharjah, United Arab Emirates. [3]Arab Union for Astronomy &Space Sciences, P.O. Box: 782 -11941, Amman Jordan. [4]Al al-Bayt University, Mafraq, 25113 Jordan

Abstract

Abstract: A review on the activities and achievements of the Arab Regional Office of Astronomy for Development (AW-ROAD) and its Associated Arabic Language Expertise Centre (AW-LOAD) on Astronomy Advancement in Jordan and the Arab World" is given on the occasion of the 9th anniversary of the official foundation of AW-ROAD. AW-ROAD membership, AW-ROAD electronic newsletters AW-ROAD News), AW-ROAD webpage, Annual Meetings, Annual Prize for Young Astronomers and other awards, international relations, participation in international organizations, AW-ROAD International Summer Schools, regional and local schools, AW-LOAD science camps, other events, other matters related to astronomical education, astronomical heritage, amateur astronomy, astronomy outreach and AW-ROAD further contribution particularly in Space Activities, Laws and Regulations in Jordan & the Arab World are described and discussed.

Keywords: Arab world office of astronomy for development, Arab union for astronomy &space sciences, Arab astronomical societies, electronic newsletter, annual meeting, summer schools, science camps, astronomical school lectures, annual prize, astronomical heritage, astronomical education, outreach, astronomy and Space Sciences, Asia-Pacific Space Cooperation Organization.

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OAD-Supported Projects in East Africa: Impact Assessment, Lessons, and Future Directions

Mr. Alemiye Mamo Yacob

Space Science and Geospatial Institute (SSGI). East Africa Regional Office of Astronomy for Development (EA-ROAD)

Abstract

Over the past decade, the Office of Astronomy for Development (OAD) has supported approximately 25 projects in the East African region. These projects, strategically aligned to employ astronomy as a tool for addressing societal challenges and promoting sustainable development, demonstrate a diverse range of activities. This article presents an evaluation of their impact, lessons learned, and future recommendations.

The evaluation highlights various projects that promote science education, community engagement, and socio-economic development. These projects not only fostered scientific curiosity but also addressed societal challenges such as gender inequality, educational barriers, and health crises like COVID-19. Findings underscore the societal benefits of funding astronomy projects, including enhanced educational outcomes, increased interest in STEM fields, and economic development through astro-tourism.

Lessons learned emphasize the effectiveness of hands-on education, community collaboration, and the need for sustainability. Recommendations for the future include prioritizing inclusivity, community engagement, and integrating astronomy into educational curricula. This integration should also involve online collaboration and astro-tourism for resilience and economic growth.

In conclusion, the article suggests that sustained support for astronomy initiatives in East Africa and globally can contribute to holistic community development and scientific advancement.

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IAU South West and Central Asian ROAD: Recent Activities

Dr. Areg Mickaelian, Mrs. Sona Farmanyan, Ms. Gayane Baleyan, Mr. Gor Mikayelyan

Byurakan Astrophysical Observatory (BAO), Armenia

Abstract

The IAU South West and Central Asian Regional Office of Astronomy for Development (SWCA ROAD) was founded in 2015 in frame of the IAU Strategic Plan and Office of Astronomy for Development (OAD) regional network. The Byurakan Astrophysical Observatory (BAO, Armenia) is hosting the office. From the beginning, Armenia, Georgia and Iran agreed for this regional collaboration and Kazakhstan, Tajikistan and Turkey joined in 2017 as well. SWCA ROAD is active in all three main directions: 1) professional astronomy (including inter- and multi- disciplinary sciences, education at university level, etc.), 2) astronomy education (at children, schools and public level) and 3) public outreach (including communication, scientific (astro) tourism, etc.). Among the recent activities one could mention the Regional Astronomical Workshops (the next one, 4th, to be held in Sep 2024), Regional Astronomical Summer Schools (RASS, the last one was held in Sep 2023 and was combined with the 1st Inter-Regional Astronomical Summer School, IRASS, organized jointly with Arab World Regional Office), organization of the joint Armenian-Georgian Colloquium in 2023 (15th in this series), recent Scientific (Astro) Tourism developments (Astro Tourism webpage for the whole region), collaboration with E-ROAD (Erasmus+ projects) and Arab World ROAD (collaboration agreement between 2 ROADs, etc.). Regular face-to-face meetings have been organized with the OAD, IAU GAs and OAD sessions there, European Annual Meetings, MEARIMs, etc. Further plans include involvement of new regional countries, development of the regional VO network both for scientific and educational purposes, and development of Astronomy-related inter- and multi- disciplinary sciences.

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The formation of the Astronomy Club In Nepal

Mr jayanta Acharya

Takshashila Astronomy Club

Abstract

In recent years, the field of astronomy has witnessed an increasing interest worldwide. Nepal, with its rich cultural heritage and stunning natural landscapes, is primed to embrace this fascination with the cosmos. Astronomy Club will actively engage in outreach activities, such as public stargazing events, astronomy-themed exhibitions, and school visits, to raise awareness about the importance of astronomy and its relevance to society. Astronomy Club in Nepal represents a significant step towards democratizing access to astronomy and fostering a culture of scientific inquiry and exploration in the country. Through its inclusive and participatory approach, the club aims to empower individuals to engage with the universe in meaningful and enriching ways. The Paper explain about the official process to establish astronomy Club in Nepal and what are the challenges and we we could establish and function it.

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Physics for Development, Education, and Outreach Programs by the South African Institute (SAIP): An Overview and Opportunities for Collaboration.

Dr Brian Masara

South African Institute of Physics (SAIP)

Abstract

The SAIP provides a platform for physicists and astronomers to network, collaborate, support one another, communicate their subject, influence science and technology policies, promote the study and applications of physics and astronomy, monitor the quality standards of training, and foster the development of physics and astronomy. This talk highlights SAIP's education, outreach and developmental initiatives and explores areas of cooperation to support the Sustainable Development Goals (SDGs). SAIP initiatives are implemented through the hub-and-spoke model, enabling broad-based participation and collaboration.

SAIP outreach programmes include the Physics in our Everyday Life series, participation in the National Science Week, South African Physics Olympiad (SAPhO), Women in Physics, etc. The shortage of qualified and competent physics teachers and poor maths and science education remains a significant challenge in South Africa. To address this challenge, the SAIP runs the Physical Science Teacher Development. Given the shortage of physics laboratory facilities in most schools, training on virtual physics experiments was introduced in 2022. These programmes benefit over 2 million people per annum.

SAIP would like to engage the physics and astronomy community in a new programme, "Physics in My Village", which aims to promote impactful physics research and capacity building while concurrently providing solutions that improve basic service delivery in water, food, energy, and climate change. The program aims to impart science skills for the future of work, empower women and youth, involve society in citizen science and establish a lifelong love of science and technology through Early Childhood Development (ECD) science capacity building.

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Cultural Astronomy and Astrotourism : A flag program for sustainable development of rural communities in the Andean Region of America

Dr. Faiber Rosas-Portilla[1,2], Dr. Nicolás Vázquez[3], Dr. Giovanni Pinzón[4], Dra. Beatriz García[5], Lam Wu[6,7]

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Abstract

Since the beginning of the first human civilizations, astronomy has played a fundamental role in the development of people. In the Andean region of America, many indigenous cultures have combined their ancestral knowledge around astronomy with their daily lives, establishing customs that are still preserved to this day. However, modern society has slowly lost admiration, respect and connection with the night sky due to a growing technological wave that increasingly pollutes our dark skies.

The places in the world where the sky is most usable for astrotourism precisely belong to rural communities, both civil and indigenous. Currently, there is a growing general desire among many local entrepreneurs within the communities of our andean region to recover and encourage the emotions that the night sky and astronomy are capable of creating in human beings. Therefore, the development of new economic alternatives that involve astrotourism will depend on bilateral support, organization and planning between entrepreneurs and professionals in astronomy.

In this contribution we present the current goals of the Andean Regional Office of Astronomy for Develpment that are based on three fundamental pillars: the creation of a new network of entrepreneurs in astrotourism, the certification of the quality of astrotourism activities proposed by entrepreneurs and the strengthening of educational and inclusive activities around astrotourism as well as in formal and non-formal education institutions. The advances of this coordination will be presented in the V Andean Workshop of Astronomy host by Universidad de Nariño and Observatorio Astronómico y Cultural Silatupue in Pasto, Colombia.

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Smartphone astrophotography for the development of astrotourism in the Andean Region of America

Lam Wu[1,2], Doctor Faiber Rosas-Portilla[3,4]

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Abstract

In the era of social media and the evolution of technology available to everyone, capturing everyday experiences and moments with photographs has become a natural purpose for new generations. With the advancement of modern photography from increasingly sophisticated and easy-to-use devices, the practice of astrophotography using only a smartphone is a growing reality that is efficiently combined with astrotourism and can be applied to different ages. The smartphone astrophotography allows us to create a pleasant and memorable experience around astronomical knowledge through the simple action of taking a photograph with a device within our reach, however, it requires astrotourism entrepreneurs to be trained to teach the public the proper technique for performing astrophotography. The methods and results of this initiative are discussed here and future plans and international applicability of the initiative for the Andean Region of America are also mentioned.

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Astronomy for Mental Health activities in Spain: supporting elderly people, refugees and children

Dr. Sandra Benitez Herrera

European Space Agency

Abstract

Research shows that astronomy-related activities have a positive impact on mental well-being. Enhancement in quality of life, positive emotions and relaxation were some of the outcomes found in those studies. These restorative effects of Astronomy might specially benefit groups affected by severe challenges, such as refugees, elders, children struggling with sickness...

Within the framework of the OAD Astronomy for Mental Health flagship, a pilot project was established in 2022-2023 together with the *Guillermo and Alicia* Foundation - a Spanish non-profit organization for the care of elderly people. After the Covid-19 pandemic, the elderly community was identified as one of the most vulnerable due to the stress related to isolation, fear of contracting the virus and uncertainty of the future.

The activities consisted of inspiring talks about Astronomy and tailored visits to the ESA European Space Astronomy Center. More than 20 volunteers from Astronomy research centers all over Spain participated in these. Evaluation questionaries were applied finding a high rate of satisfaction. Participants reported feeling active, an increase in their personal growth and improved self-esteem.

After this success, we will expand the activities to include other publics. We are currently collaborating with the Nirakara Mindfulness Association, run by a group of professionals in the areas of psychology and neuroscience, with whom a pilot star-gazing activity was organized in fall 2023. Moreover, a collaboration with *Juegaterapia*, a program working with children living at the oncology units of the main hospitals in Madrid, will start this year to support struggling children and their families.

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The impact of hands-on and eyes on the sky activities after 15 years NASE

Dr. Rosa M. Ros[1], Dr. Beatriz García[2], Eng. Ricardo Moreno[3], Dr. Ederlinda Viñuales[4]

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Abstract

In general, current projects in STEAM are developed in a specific framework that addresses planning, design of activities, development of materials, its distribution and use, testing and general review and the impact of the programs.

Over 15 years, the NASE applied this methodology in its courses, which allowed it to be implemented in 73 countries (40% of the world), and in this way involve 46 IAU members and more than 1,000 volunteers who cooperate with the updating of the workshops, the translation of their resources (currently available in 26 languages) and the training of trainers.

In this presentation, we analyze the impact of this approach to a “hands-on” methodology without neglecting the theoretical aspects of the discipline without losing rigor in the concepts, which has become one of the quintessential of inter, multi and transdisciplinary activities of the times we live in, in the STEAM context.

The statistical results will also be presented, showing the traction curves, the number of courses per country and continent, the creation of Local Working Groups and an estimation of teachers and students who propagate astronomical topics in the world and who, at least once in their school life, have used, experimented, applied the “NASE format” (using observations,

models and practical activities) in their classes, science clubs, science fairs and even in their homes.

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Empowering Astronomy for Development: Challenges and Lessons Learned from Our North American Journey

Sr. STEM Education Specialist Yasmín Catricheo[1], NA-ROAD / WGAP Coordinator Karla Garcia[2], AURA Corporate Communications Coordinator Shari Lifson[3], Staff Associate for Facilities Planning and Management Tim Spuck[4], VP of Science Engagement at Adler Planetarium Laura Trouille[5]

[1]Associated Universities Inc. (AUI). [2]North American Regional Office of Astronomy for Development (NA-ROAD). [3]Association of Universities for Research in Astronomy (AURA). [4]U. S. National Science Foundation. [5]Adler Planetarium / Zooniverse

Abstract

This presentation offers a narrative of the inaugural years of our North American Regional Office of Astronomy for Development, aligned with the IAU Office of Astronomy for Development and the United Nations Sustainable Development Goals. We will share challenges and lessons learned in three main areas: fundraising, awareness building, and project development. We will highlight the transformative power of relatively modest financial investments, pulling examples from our Women and Girls in Astronomy Program and our work with a fundraising consultant. We will also touch on the multifaceted challenges and opportunities in building awareness across a diverse region comprising numerous countries, cultures, and communities. Finally, we will share lessons learned while spearheading projects (Women and Girls in Astronomy, Accessible Astronomy Software for All, and Zooniverse) and in establishing connections with key partners in astronomy for development across our region (through the structure of our multi-institutional Governing Council, our Advisory Board, and beyond). Our journey reflects a navigation of opportunities and obstacles. We hope to contribute to the collective knowledge of the IAU and OAD Regional Offices and help foster astronomy's potential as a catalyst for positive change.

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Impact of Astronomy Clubs in stimulating interest in STEM education in secondary students in a rural setting

Dr Chika Onuchukwu

Chukwuemeka Odumegwu Ojukwu University, Anambra State

Abstract

This study was carried out in Nnewi South Local Government Area of Anambra State. Five public/government/private secondary schools in Amichi Nnewi South LGA were used, 200 Senior Secondary school students, 200 junior secondary school students and 50 science teachers randomly selected from schools. The study examined the effects of introducing Astronomy Club in secondary school in stimulating teaching and learning of STEM. The instrument used for data collection was the questionnaire. Statistical mean score and standard deviation were used to analyze the answer to the research question. The result showed that the introduction or existence of Astronomy Club in secondary school will have positive effects in stimulating the teaching and learning of physics and STEM education. Furthermore, OAD sponsored a project which established an Astronomy Clubs in 4 out of the 5 schools, on the average, we observed about 15%-20% increase in STEM subjects enrollment among the senior secondary school students

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Addressing education, societal, industrial, development, public outreach via Radio astronomy in Greece: The added value of the Hellenic Radio Telescope THERMOpYlae

Assistant Professor Nectaria Gizani[1], Assistant Professor Giorgos Veldes[2]

[1]Hellenic Open University, School of Applied Arts and Sustainable Design. [2]University of Thessaly, Physics Department

Abstract

We report on the benefits of radio astronomy for development using the Hellenic Radio Telescope THERMOpYlae. The Radio telescope is the result of the conversion of a telecommunication antenna, which gives an added value to the development of the country (benefits in science, industry, astrotourism, education, outreach) and of the science of radio astronomy globally.

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To the sun and (almost) back again: astronomers' conference travel footprint in 2019

Andrea Gokus[1], Knud Jahnke[2], Paul M. Woods[3], Vanessa A. Moss[4,5], Volker Ossenkopf-Okada[6], Elena Sacchi[7], Adam R. H. Stevens[8], Leonard Burtscher[9], Cenk Kayhan[10], Hannah Dalgleish[11], Victoria Grinberg[12], Travis A. Rector[13], Jan Rybizki[14], Jacob White[3]

[1]Washington University in Saint Louis. [2]Max Planck Institute for Astronomy. [3]Independent Researcher. [4]CSIRO. [5]Sydney Institute for Astronomy. [6]University of Cologne. [7]Leibniz Institute for Astrophysics Potsdam. [8]International Centre for Radio Astronomy Research. [9]Leiden Observatory. [10]Erciyes University. [11]University of Southampton. [12]European Space Research and Technology Centre. [13]University of Alaska Anchorage. [14]Weimar Institute of Applied Construction Research

Abstract

In 2019, astronomers travelled a total distance of more than 1.5 Astronomical Units to attend in-person meetings all over the globe, resulting in an average of 1.0 ± 0.6 tons of CO_2-equivalent emissions per participant per meeting. While meetings including personal contact and direct networking opportunities are perceived as more effective in fostering collaboration, they are significantly less sustainable and inclusive compared to virtual formats, which, with the right tools and setup, can be as successful. We will present our assessment of the greenhouse gas (GHG) emissions related to all Astronomy meetings in 2019, and discuss how we can use our results to establish a better path forward to make Astronomy more inclusive and sustainable for future meetings.

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Improving Air Quality Monitoring through Research and Trainings on IoT-Based Air Sensors

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[1]Alioune Diop University. [2]Research Centre for Nuclear Science and Technology, P.O. Box 4110 Yaoundé, Cameroon. [3]Independant Researcher, Austria

Abstract

Atmospheric pollution is a global threat with an increasing health, environmental, social, and economic costs. Poor air quality is becoming an emerging issue in African cities. This situation is driven by urbanization and industrialization, but governments have been too slow to react. Instruments based on low-cost sensors and Internet of Things are increasingly considered as solution to evaluate the concentration of different pollutants in place of standard monitors. They have several advantages: easy to design, cheap and can be easily deployed. Here we present the IoT4AQ project, funded by the International Astronomical Union (IAU). Its main objective is to carry out research and organize training sessions for researchers and students on the design and implementation of low-cost sensors for air quality monitoring. Participants are trained in IoT techniques showing how to build low-cost sensors-based instruments and deploy them. The project started on February 2023, and will last for two years. A couple of hands-on trainings and online seminars will be organized each year. Specific objectives are: (1) organize hands-on trainings and seminars on IoT and air quality monitoring, (2) train researchers, teachers, and students on various aspects of air quality monitoring and (3) improve Physics education in Africa through low-cost sensors and IoT. Expected outcome are as follows: (1) train participants on IoT and air quality monitoring; (2) improve the experimental skills of participants; and (3) increase awareness of the threat that represents atmospheric pollution. So far, we designed three monitoring systems, organized one online training and one hands-on training.

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BARCo: Bringing Astronomy to Rural Communities of Colombia

Dr. Sofía Rojas-Ruiz[1], MSc. Natalia Oliveros-Gomez[2], Juan Pablo Carvajal[3], Felipe Ortiz-Ferreira[4], Dr. Nataly Ospina[5], MSc. Ángela Pérez[6,7], MSc. Laura Ramírez-Galeano[8], MSc. Juan Pablo Uchima-Tamayo[9]

[1]University of California - Los Angeles. [2]Johns Hopkins University. [3]Pontificia Universidad Católica de Chile. [4]Industrial University of Santander - Colombia. [5]University Autonoma Madrid. [6]Planetarium of Medellin - Colombia. [7]OAE - National Astronomy Education Coordinator Colombia. [8]University of Geneva. [9]Universidad de La Serena - Chile

Abstract

The Education Program from the Network of Colombian Astronomy Students (RECA in Spanish) is addressing the absence of astronomy education in Colombian rural schools. Despite the growing interest in science among students in these areas, infrastructural limitations such as lack of internet access hinder traditional educational efforts. To bridge this gap, we are developing the project "BARCo: Bringing Astronomy to Rural Communities of Colombia" with support from the Office of Astronomy for Development. We aim to deliver astronomy education directly to rural schools, reaching approximately 5,000 children from all regions of Colombia across 100 institutions. Recognizing the challenges of internet access, BARCo adopts a multifaceted approach. Each school receives a box containing materials for astronomy activities, games, and a USB drive with instructional materials and interviews with Colombian astronomers. These resources are supplemented by online access to materials through the RECA website and YouTube channel, ensuring the scalability and longevity of the project. To ensure engagement and monitor progress, teachers are encouraged to share photos and videos of activities, fostering accountability and feedback. Furthermore, BARCo encourages cultural exchange from all the diverse communities in Colombia by incorporating a final activity where schools create "Voyager Golden Records" showcasing their customs and astronomical knowledge. By fostering collaboration among diverse communities, the project aims to promote social cohesion and peace in the country. Overall, BARCo represents a pioneering effort to democratize access to STEAM education, leveraging technology and community engagement to empower rural schools and foster scientific literacy and social harmony in Colombia.

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On Indo-Uzbek Collaboration in Observational Astronomy

Prof. Alisher S. Hojaev

Ulugh Beg Astronomical Institute

Abstract

We present information about large-scale multifaceted Indo-Uzbek collaboration, covering all areas of *OAD* activity. The astronomies of Uzbekistan and India have traditional historical connections: for example, during the construction of the *Jantar Mantar* observatories in India, the experience of the *Ulugbek Observatory* in Samarkand was widely used. Active cooperation resumed in 2021 with a three-annual scientific project to study variable stars supported by the governments of India and Uzbekistan. Initially, *ARIES*, India and *UBAI*, Uzbekistan were involved. In the project's research part, a large number of variable stars were discovered and studied both in clusters and outside them, based on our observations and the use of *TESS* data, some results of which have already been published in peer-reviewed journals and proceedings of international conferences. In terms of education, long-term internships were carried out for young Uzbek astronomers at *ARIES*, where they gained experience in observations with 3.6-meter active telescope - a prototype of 4-meter adaptive telescope to be installed in Uzbekistan. In terms of project's outreach activities, we gave lectures at a number of institutes and universities in India on the ancient roots of Uzbek astronomy and on popularization of astronomy. In terms of further development of collaboration, India has expressed a desire to join the *IIA*, *TIFR*, *CRIST* University, etc., which intend to create a novel *polarimeter* for Uzbekistan. We hope our experience will be useful for astronomers in other countries. We are open to expanding cooperation, which upon completion of 70-meter radio-telescope in Uzbekistan, may become a multi-frequency.

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Impact Report of the IAU Office of Astronomy for Development's Funded Projects in 2022-2023

Rena Lee

Institute for Astronomy, University of Hawai'i at Mānoa

Abstract

The IAU OAD funds projects to advance educational and economical development across the globe, leveraging astronomy and its infrastructures to do so. While pursing similar goals, each of the projects vary widely in scope, depending on their geographical locations, community resources, volunteers & project leaders, and more. In this presentation, we share how we systematically evaluated the impact and efficacy of the OAD funded projects from 2022, establishing an evaluation procedure for future cycles of funded projects (2023 and beyond). We outline the evaluation criteria for assessing project impact, contributions to UN Sustainability goals, and budgetary efficiency. Projects were independently scored based on their commitment to their proposed budget allocations, societal reach, sustainability, and other individually outlined project goals, as well as their ability to adapt to unforeseen obstacles in completing their goals. We present the impact report for 14 projects, and assess strategies for amending OAD support and organization structures to optimize project impact, while easing some overhead burden on individual project leaders.

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Science and Astronomy in Southern Botswana

Prof Fulvio Franchi[1,2], Mr Bill Tomlinson[3], Mrs Patricia Tomlinson[3], Dr Moletlanyi Tshipa[4], Dr Ceren Ulusoy[2,5]

[1]Università di Bari - Aldo Moro. [2]Botswana International University of Science and Technology. [3]Diamonds in the Sky. [4]University of Botswana. [5]Girne American University

Abstract

Basic education inequality between remote area dwellers and others has long been a problem in Botswana. Distances are great and conditions make equal distribution of resources uneven, a condition exacerbated by the pandemic. Teachers in rural areas live in tents and are often deprived of minimal tools for teaching. Lack of transport and resources erodes the motivation of both pupils and teachers precluding the access to decent education. There is need for a change in paradigm in the science education in rural areas, introducing ad hoc solutions to empower teachers and inspire young people.

The project SASB (Science and Astronomy in Souther Botswana), funded by the IAU-OAD, organized a week-long event in Southern Botswana to promote science education for teachers and pupils from rural schools. In the first phase of the project, 13 teachers (mostly young women) from rural schools were provided with training in planetary science, geology and astronomy for practical use with their students. SASB provide science experiment kits, including a small telescope and a paper microscope.

The second phase of the project took place at Machana primary school. Students were taught how to run simple experiments using a paper microscope and attended a star gazing event that triggered their imagination and love for science.

At the end of the project a simple questionnaire teachers filled a questionnaire in order to collect their feedback and improve the quality of the activities. This project has been already replicated with the support of the Government of Botswana.

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1323

Pioneering Astronomy in Remote Communities of Central America – The El Rincon Pilot Project

Dr Paola Oliva Altamirano

Alpha-Cen: Astrophysics in Central America and the Caribbean. Our Community/SmartyGrants

Abstract

El Rincon is a small community in Honduras with around 400 residents who live and work in coffee fields. Children are expected to work from an early age, and access to education and entertainment is limited. Oved, born and raised in El Rincon, possesses a strong drive to uplift the skills of his community. For the past six years, he has been working to connect this community with scientists, artists, and educators through the internet.

Alpha-Cen is an association created to foster the development of astronomy in Central America and the Caribbean. They have partnered with Oved to build a 12-month program that will bring science education to the community. This project, funded by the Office of Astronomy for Development (OAD), has now kicked off, and we would like to share our process of getting to know the community, designing a program, and applying for funding with you.

Session

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1343

Impact of science outreach interventions towards high school learners

Miss Ndanganeni Mahani

South African Institute of Physics -SAIP

Abstract

The purpose of this study was to investigate the impact of science outreach interventions towards high school learners. Quantitative, descriptive research was conducted through a comprehensive review of existing literature and data analysis, and several key findings emerged. Firstly, exposure to STEM at an early age is critical for fostering interest and engagement among diverse student populations. Secondly, mentorship and peer support are essential for building confidence and sense of belonging among underrepresented groups in STEM fields. Science learning and teaching has gained prominence in modern economic due to their importance in the development and management of modern technology that modern economy relies on (UNESCO, 2017). The use of outreach interventions becomes as important just as the learning and teaching as it aims to promote the teaching and learning techniques for effectiveness.

Session

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1370

Use of Astronomy as a tool to improve gender balance in Tertiary Institutions

Dr. Edward Jurua

Mbarara University of Science and Technology

Abstract

The number of women in the science disciplines is still low in Uganda. In the case of Mbarara University of Science and Technology, the percentage of bachelor's degrees going to ladies in physics and mathematics is about 7%, while for chemistry and biology it is close to 15%. This is a very small percentage which needs to be increased. There is evidence that culture has a large influence on the participation of women in Sciences. In order to change this perspective about pursuing science careers, we organised a number of activities, which included visits to selected secondary schools, Universities and other institutions to investigate the climate for girls/women, to catalogue the problems that they face, and to suggest improvements that could be made. We present our findings in this paper.

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SEAROAD update: Astronomical activities and development in the southeast Asia region

Matipon Tangmatitham

National Astronomical Research Institute of Thailand (NARIT). International Training Center in Astronomy under the auspices of UNESCO (ITCA)

Abstract

As the operator of the largest optical and radio telescope and the only astronomy research institute in the region, along with being the host to SEAROAD, the National Astronomical Research Institute of Thailand (NARIT) is tasked with promoting astronomical activities for development in the southeast Asia region. Having also been designated as the International Training Center in Astronomy under the auspices of UNESCO (ITCA), Thailand hosted many international conferences and workshops aimed at training and capacity building of in astronomy for many career astronomers and students in the region. Many workshops are also held overseas for regions such as Laos, Timor-Leste, Philippines, etc. International collaborations are also forged between members of the regions, with many more coming in the years to come.

Session

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Empowering Global Communities Through Data Skills Development: The Hack4dev Initiative

Eslam Hussein[1,2], Sally Macfarlane[1], Kevin Govender[3], Charles Takalana[4], Duduzile Kubheka[5], Nikhita Madhanpall[6,2]

[1]Inter University Institute for Data Intensive Astronomy. [2]Development In Africa with Radio Astronomy. [3]IAU Office of Astronomy for Development. [4]African Astronomical Society (AfAS). [5]South African Astronomical Observatory. [6]Wits University

Abstract

Hackathons, recognised as the Office of Astronomy for Development's (OAD) third flagship, have been pivotal between 2018 and 2022. In collaboration with OAD, the Inter-university Institute for Data Intensive Astronomy (IDIA), and supported by Development in Africa with Radio Astronomy (DARA) Big Data, we led hackathon programs to equip the next generation with vital data science skills. These programs, specifically aligned with the needs of the Square Kilometre Array (SKA), and the broader astronomy community, have contributed to addressing the challenges posed by the era of big data.

As the initiative progressed, what began as a series of outreach events transformed into a more substantial developmental effort, garnering increased support from the academic community. Under the banner of "Hack4dev", the project has expanded, welcoming additional partners like BRICS Astronomy and the African Astronomical Society (AfAS)

Drawing from our extensive experience and feedback, along with a comprehensive review of relevant literature, we have developed a vision to enhance the impact of our efforts. "Hack4dev" is poised to introduce an innovative framework aimed at broadening developmental impacts and providing deeper insights into societal dynamics through big data. By leveraging our network of partners, we plan to launch micro-program events, such as hackathons, on a global scale. These initiatives will empower the public and Hack4Dev alumni to select, organise, and participate in their own events, further supported by training, resources, and funding from Hack4Dev. This approach is designed to foster sustainable innovation and empower communities worldwide.

Session

Office of Astronomy for Development institutional meeting

1529

Astronomy for a Better World: Reflections on the OAD

Prof. Debra Elmegreen

Vassar College

Abstract

Using astronomy as a tool for development is one of the primary goals of the IAU Strategic Plan for 2020-2030. Some of the specific actions in the plan are for the IAU Office of Astronomy for Development (OAD) to contribute significantly to UN Sustainable Development Goals, develop global key projects, establish more regional offices, and use astronomical technology to help position young people for career opportunities throughout society. Here the IAU President reflects on significant milestones over the past triennium and looks to future priorities and opportunities.

Session

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On the Prisoner's Reformation Programme in Nigeria through Astro-prison Projects

Dr. Chukwujekwu Ofodum, Dr. Bonaventure Okere, Dr. Dominic Onyeuwaoma, Mr. Timothy Egbuim

Centre for Basic Space Science, Nsukka Nigeria.

Abstract

We present the result of the evaluation of an astro-based prisoner's reformation programmes that were executed in Nigeria over the past three years. Astro-prison which received major sponsorship from the IAU-Office of Astronomy for Development (OAD) is an innovative project strategically aimed at educating, inspiring and preparing inmates at correctional centres (prisons) for a better life after incarceration. Over the past two series of programme across five correctional centres in South-east region of Nigeria, Astro-prison project has successfully impacted on inmates various astronomy and basic science related skills aimed at boosting their human capacity thereby engendering peaceful coexistence between these inmates and the larger society post-incarceration. Explicitly, Astro-prison has had direct contact with over five hundred inmates thereby boosting their human capacity by impacting numerous strategic skills inherent in: astro-tourism, snail farming, bee-keeping and fish farming on them. Again, the programme which also leveraged on astro-based motivational expositions like: Pale-blue-dot, light pollution and dark-sky conservation for strategic value re-orientation would engender responsible lifestyle by inmates post-incarceration. With the impacts recorded through astro-prison, Zero Hunger, Good Health/Well Being as well as Peace, Justice and Strong Institutions which are the bedrock of the United Nation's Sustainable Development Goals (SDGs): 2, 3 and 16 have been realized. Consequent upon these successes, there is need for Astro-prison to be scaled-up and strategically adopted as a national tool for intensive value re-orientation and character reformation for correctional centre's inmates across Nigeria.

Session

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1678

Astronomy and the Reduction of Anxiety: Digestible Astrophysics and Immersive Experiences

Dr. Ashley Cooper-Leonhart

Carlos Albizu University, Miami Campus. Psychological Wellness Center

Abstract

Anxiety disorders are the most common form of mental illness in the world, with approximately 301 million people suffering from this condition (World Health Organization (WHO), 2023). Mental health practitioners are constantly looking for new ways to treat clients presenting with anxiety, as sometimes traditional or more well-known modalities fall short and are difficult to utilize when the client is not in the therapy office. The purpose of this research is to determine if exposure to immersive experiences such as stargazing, combined with a digestible astrophysics' factsheet, will aid in the reduction of the symptoms and severity of anxiety. The methods of this study include the use of the Hamilton Anxiety Rating Scale (HAM-A), to determine levels of anxiety which will be assessed in participants pre and post exposure to stargazing and introduction to an astrophysics factsheet. The ratings from the scale will undergo a Pearson's Correlational Analysis to determine if the exposure model impacts the scores of participant's levels of anxiety. If so, the incorporation of this model would be recommended into settings such as clinical practices as part of 'homework,' for clients to utilize independently after therapeutic sessions. However, the overarching goal is to make this model accessible to all, even those who do not have direct access to therapy, to assist in their mental well-being.

Session

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OruMbya@PLOAD: diverse voices from the Global South

Prof Alan Alves-Brito[1], Prof Ariana Cortesi[2], The PLOAD Team[3]

[1]Federal University of Rio Grande do Sul. [2]Federal University of Rio de Janeiro. [3]PLOAD/IAU/OAD

Abstract

One of the great challenges of scientific dissemination and popularization in Global South countries is to broaden their horizons, giving visibility, voice and listening to populations that have historically been excluded from the processes of scientific protagonism and also from accessing cultural equipment and devices for dissemination and popularization of scientific knowledge in the region. Among these populations, Black, maroons (quilombolas), indigenous and other traditional communities stand out. We will highlight, in this work, the theoretical (interculturality), methodological (meeting of knowledge) and epistemological (decolonization of astronomy) contributions of the OruMbya scientific dissemination and popularization project, which has been receiving funds from the International Astronomical Union Office of Astronomy for Development (IAU/OAD). With Astronomy in Cultures as the main focus of the project, our main goal is to celebrate Astronomy as the fuel of life, in which the stories of the stars are preserved in the resilience of people from four different continents (America, Africa, Asia and Europe) shared through scientific and cultural activities aimed at the dissemination of knowledge, the promotion of social inclusion and sustainable development in the context of the IAU/OAD/PLOAD (Portuguese Language Office of Astronomy for Development). We have organized, on an intercontinental scale, several virtual and face-to-face activities that seek to work, through the meeting of knowledge (african, afro-Brazilian, indigenous and european-asian matrices) and reaffirmation of black and indigenous identities in Brazil in view of the decolonization of narratives on heaven-earth relations in different cultural contexts.

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Astronomy Levels the Playing Field: Analysis of Cosmic Cup in Jhansi, India.

Mr Kushagra Shrivastava[1,2,3], Mr Charles Lee[3]

[1]National University of Singapore. [2]Royal Astronomical Society. [3]Cosmic Cup

Abstract

Astronomy is usually absent from the limelight (at best hidden behind the broader umbrella of physics) when it comes to pre-university education. The issue is exacerbated in Indian Tier Y and Z cities, where standard curriculum education is prioritised. Furthermore, the limited extracurricular opportunities are mostly available for privately-funded English-medium schools, and not for publicly-funded Hindi-medium schools. To expose pre-university students to Astronomy in Jhansi, a Tier Y city, we organised Cosmic Cup in April 2023 – an astronomy competition for Grade 9 to 12 students from all educational institutions. The competition involved an open-universe test for qualifiers, a team round for the semi-finals, and a quiz round for the finals. Cosmic Cup saw 800+ registrations from 50+ schools, was funded by Jhansi Smart City, and was featured on major media outlets like the Times of India. While the overwhelmingly positive response indicated a strong enthusiasm for astronomy, Cosmic Cup was mainly commended for being highly inclusive. We tried to provide equal treatment and opportunities for both English and Hindi-medium students, and hence the latter did not feel inferior to the former (which is usually the case). Astronomy bridging the disparity between the two mediums was an unexpected outcome, but it motivated us to transform Cosmic Cup into a (currently unregistered) non-profit organisation, and our mission changed. Now, we not only aim to expose students to astronomy and create a community of passionate individuals, but also decrease the education inequity in Jhansi and beyond to level the playing field.

Session

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1898

Dark Skies: Reconnecting People with the Night

Dr Christopher Barnes[1], Dr Holli-Anne Passmore[2]

[1]University of Derby. [2]Concordia University of Edmonton

Abstract

The global environmental crisis is one of the biggest challenges of our time and - while there is a growing body of research that demonstrates a link between the human-nature relationship, pro-conservation behaviour and mental wellbeing - more needs to be done to mitigate the impact of human activities on biodiversity and natural systems. Indeed, far less is understood about the importance natural darkness plays in our lives and the psychological benefit there may be from establishing a strong connection to the natural environment at night. This presentation reports on the development and validation of two new psychometric scales; The Night Sky Connectedness Index (NSCI) and the Dark Sky Protection Scale (DSPS), and how they relate to a broad range of psychological factors. Moreover, our findings indicate that, not only are the measures robust, but they also illustrate that, (i) a greater connection to the night sky is significantly and positively related to a person's mental health and happiness, (ii) those who live in more light-polluted areas are less connected to the night sky, (iii) those with an interest in the night sky - such as astronomy - feel more connected to it independent of the frequency they engage with it, and (iv) that night sky connectedness is the strongest predictor of dark sky conservation behaviour. These new measures may provide a way to assess stargazing interventions that encourage people to appreciate the beauty and wonder of the night sky, promote mental health, and restore the human-night sky relationship.

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1984

Unifying Tatacoa's Resources for Community Benefit

Dr. Giovanni Pinzon, Ms. Libia Martinez, Msc. Jonhatan Bernal, Mr. Sebastian Lozano, Mr. Andres Molina, Ms. Cristina Quiazua, Ms. Daniela Botero, Ms. Aurora Sanchez, Dr. Santiago Vargas-Domínguez

Universidad Nacional de Colombia

Abstract

The Tatacoa region in Colombia is rich in natural, heritage, and cultural assets. Our project aims to integrate these resources with basic sciences, benefiting the local community and supporting the recovery of the public observatory (OATA) through an improvement of the current tourist offer. We've established the first astrotourism laboratory, connecting local fauna, flora, astronomy, and paleontology in close collaboration with Science clubs from the "Gabriel-Plazas" local school and local authorities. We have transformed a nearby house into an information hub, offering paid tourist packages including a solar system to scale and a set of box light posters explaining the history of the universe. A committee comprising entrepreneurs, the parent school association, local authorities, and CAM will ensure the survival of science clubs. This holistic approach fosters community engagement, scientific exploration, and sustainable income generation.

Session

Office of Astronomy for Development institutional meeting

2001

Under Iran Sky Programme: How to Share and Protect Indigenous Astronomical Knowledge and Indigenous Languages

Mr Saeed Jafari[1,2,3], Mr Hossein Khalili[4,5], Ms Shirin Zandian[4,6]

[1]World Space Week Association. [2]Space Generation Advisory Council. [3]Department of Linguistics, University of Kurdistan. [4]Under Iran Sky Programme. [5]Heritage of the Sky Project. [6]Andromeda Astronomy Outreach Project

Abstract

Indigenous peoples today, are arguably among the most disadvantaged and vulnerable groups of people in the world. Current data indicates that at least 40% of the 7,000 languages used worldwide are at some level of endangerment. While reliable figures are hard to come by, linguists agree that Iranian native and indigenous languages are particularly vulnerable because many of them are not taught at school or used in the public sphere.

To raise awareness of the sharing and translation of indigenous astronomical knowledge and cultural exchanges through a shared sky, the OAD/OAO-funded Under Iran Sky programme has launched an open online astronomy education school to develop a sense of universal citizenship that helps educate students and young people from indigenous communities and minority groups. The programme developed different strategies to reach diverse communities throughout the country, like producing Persian astroEDU, distributing Universe in Box for children, and accessing online resources and activity kits, to bring astronomy closer to broader audiences.

In this talk, I will present and review practical public engagement projects in which individuals and organisations use cultural astronomy, astronomy education and communication to recognise indigenous knowledge and respect indigenous learning systems. Our outcome showed that where Indigenous knowledge is not homogeneous, we can learn from certain common ways. In conclusion, we'll look at several Indigenous techniques, particularly the notion of Connection and Empathy, and discuss how a gateway to the public's and Indigenous people's involvement can emphasise the importance of being empathetic through a shared intangible cultural heritage.

Session

Office of Astronomy for Development institutional meeting

2097

SciGirls - Empowering girls and female teachers through astronomy inconflict-affected rural areas

Dr. Mirjana Povic

Space Science and Geospatial Institute, Ethiopia

Abstract

The world faces a huge gender gap in science. In Ethiopia, only about 13% of all scientists are women, and this fraction is even lower when considering the fundamental sciences. Girls avoid choosing STEM mainly due to a lack of support and/or information. This becomes even more evident when going to remote areas, where 80% of the Ethiopian population lives. The SciGirls project aims to improve the gender gap in science in the long-term by empowering rural female secondary school students and their female science teachers through astronomy and its multidisciplinarity. In 2022 we organised a carefully designed capacity-building workshop for 30 participants across Ethiopia, with the aim of training future STEM advocates in rural and remote areas. The girls and teachers carried out different activities in their communities during 2023. This year we are planning additional activities focusing on 4 regions that have been severely affected by conflicts over the past 3 years. SciGirls is one of the 2022 and 2024 projects funded by OAD. During this talk, we will share valuable experiences we have gained through interaction with girls and female teachers who work and live in very harsh conditions, where they rarely have any external support to fulfill their dreams. The SciGirls approach has so far yielded very positive results and the project can serve as a model also in other countries.

Session

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2101

The connection of “how we science” with UN Sustainable Development Goals

Dr Vanessa Moss[1,2,3], Dr Aidan Hotan[1], Emily Kerrison[2,1], Dr Rika Kobayashi[4], Dr Mike Peel[5], Dr Glen Rees[6], Dr Elizabeth Tasker[7], Dr Ron Ekers[1]

[1]CSIRO. [2]University of Sydney. [3]University of Queensland. [4]Australian National University. [5]Imperial College London. [6]The Future of Meetings. [7]ISAS JAXA

Abstract

As we look to the future, it is clear that incorporating the UN Sustainable Development Goals in all aspects of our activities is critical to move forwards in a way that does the least harm. We have found there are key ways in which adjusting how we conduct scientific practices, such as meetings and collaboration, can have a huge impact on progressing a number of UN SDGs (e.g. 3, 4, 5, 8, 9, 10, 11, 12, 13). Further, realising these improvements to the ways we work is something that cuts across a range of disciplines, requiring interdisciplinary collaboration and coordination.

“The Future of Meetings” (TFOM) community of practice has been active since 2020, seeking innovation both in the design of our interactions (online, hybrid and in-person) and in the ways of employing technology to do so more effectively. We will present an overview of the strong connection between the UN SDGs and the importance of reconsidering how we meet and collaborate for improved accessibility, inclusivity and sustainability.

We are at a turning point in astronomy in that, as individuals and collective organisations, we have the power to choose a path forward that enables more distributed global voices to be part of our future astronomy collaborations than ever before while minimising the cost to our planet. A key goal of TFOM is to share our experiences and expertise in the hope that others are empowered to choose the same path of “beyond being there” that we have.

Session

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Advancing Disaster Resilience in Ethiopia: Harnessing Astronomy and Interdisciplinary Collaboration for Sustainable DevelopmentBella Roman

Mrs Bella Bayu

self

Abstract

Advancing Disaster Resilience in Ethiopia: Harnessing Astronomy and Interdisciplinary Collaboration for Sustainable Development

Bella Roman

Ethiopia grapples with an array of natural and human-made disasters, prominently recurring droughts and floods that disproportionately impact impoverished and vulnerable communities. As Ethiopia strides forward in space science and geospatial applications, the potential role of astronomy and space science gains recognition in mitigating these hazards, saving lives, and addressing climate change impacts.

Astronomy provides indispensable tools for comprehensive hazard and risk assessments, enabling timely responses, delivering relief efforts, and assessing disaster impacts. By integrating disaster risk management (DRM) principles with innovative astronomy technologies, we can augment the precision of early warnings, identify vulnerable areas, and offer evidence-based insights for policymaking. Applying astronomy plays a pivotal role in promptly delivering early warning data, empowering communities, including women and vulnerable populations, to prepare and mitigate risks. Leveraging these technologies proactively addresses economic and social losses, ultimately contributing to creating a more resilient, gender-equal, and inclusive Ethiopian society.

These abstract aims to showcase ongoing work on a disaster risk management project, "Building Resilience in Ethiopia," illustrating how interdisciplinary synergy is crucial for addressing global challenges and advancing United Nations SDGs. Additionally, it emphasizes the integration of a gender lens and collaboration with NGOs, significantly enhancing the effectiveness and inclusivity of these interdisciplinary efforts. This holistic approach fosters impactful strides towards achieving the UN SDGs.

Session

Office of Astronomy for Development institutional meeting

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Elimisha Msichana Elimisha Jamii na Astronomia *(Swahili for "Educate a girl, educate the entire community with Astronomy").*

Dr Ann Njeri

Newcastle University

Abstract

Due to several socio-economic issues (early marriages, teenage pregnancies and poverty), school dropout rates are high among schoolgirls in rural areas of Kenya and Uganda. Addressing this issue of gender disparity in education is s critically important for the social and economic growth within these regions. With this in mind, I founded Elimisha Msichana Elimisha Jamii na Astronomia (EMEJA), Swahili for 'educate a girl, educate the entire community with astronomy'. EMEJA, supported mainly by funding from the International Astronomical Union-Office of Astronomy for Development (IAU-OAD), is a project addressing some of the above socio-economic issues in rural Kenya and Uganda via Astronomy outreach programmes, mentorship, targeted STEM workshops and scholarships opportunities, guided and supported by long-term student tracking and monitoring.

I will show how, using Astronomy themed-activities and events, we are: 1) ensuring 100% primary-secondary school transition for girls in rural regions by supporting them throughout high school; 2) engaging the local communities in positively tackling the above socio-economic issues; 3) increasing the number of girls selecting Physics and STEM subjects in high school and beyond; 4) creating resources for the often underfunded/underdeveloped local secondary schools, and lastly; 5) creating computer literacy (almost non-existence in these regions) as a lasting legacy for this project. The project has reached over 7,000 schoolgirls (and their parents) in 30 public schools, equipped science and computer laboratories for the participating schools. I will also share how similar programmes can be replicated across Africa, to address gender disparity in education and achieve SDGs 4 and 5.

Session

Office of Astronomy for Development institutional meeting

2231

Flagship 1: Astronomy for Socioeconomic Development

Samyukta Manikumar, Joyful Mdhluli

IAU Office of Astronomy for Development

Abstract

Astronomy has immense potential to improve people's lives, and specifically the socioeconomic status of people living in rural areas. In line with the objectives of the International Astronomical Union's Office of Astronomy for Development (IAU-OAD) to harness the power of astronomy to drive sustainable development across the globe, this talk will present the OAD's astrotourism initiatives and flagship project that fosters interdisciplinary collaboration between astronomy and tourism. By giving importance to local cultural astronomy and heritage, and lowering barriers to entry into astrotourism, the approach strives towards local socioeconomic development in rural areas.

The OAD has funded several projects that use astronomy and tourism to improve the livelihoods of rural communities. In addition to this, the flagship project is building resources to be disseminated to individuals and businesses in remote/rural areas, helping them to build their own astro-tourism products and promoting astro-tourism as a sustainable livelihood option. By introducing the concept of night sky tourism, the resources will help rural inhabitants capitalise on dark rural skies, offering authentic experiences rooted in local culture and nature.

This talk will describe the OAD's flagship project on this subject, and related resources

that aim to support and expand night sky tourism globally.

Session

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A report on project “ACEN”, an IAU-OAD support initiative: A lens to the society

Ms. Manisha Dwa, Mr. Suresh Bhattarai

Nepal Astronomical Society

Abstract

In 2022, we were awarded a funding from IAU-OAD to implement a project named ‘Astronomy for Community Development” in Nepal. As an implementation of the project, we reached out to 6 schools in 4 different provinces in the country and implemented them in 6 schools which were selected on the basis of factors as gender, socio-economic, marginality, privilege. As a part of the project, astronomy clubs were formed in each school with an executive committee of 10-15 members who later conducted outreach activities with their resources in 5 schools in their surroundings.

This paper will talk about the implementation of the project ACEN and its impact among the students and the community. Besides, it will share the success story and how the ownership among the mentors thus created worked with the responsibilities they bore with the data generated out of their work. Also, it will discuss about the hindering factors that challenged the club thus formed and what can be done to make it more fruitful and functioning. Furthermore, the report will also share about the reach in each province and the post ACEN support NASO mentors are providing to these clubs and their members to commemorate different space and astronomy related events in Nepal.

As an outcome of the ACEN project as a whole, the paper will briefly discuss about how the local government is showing interest on integrating astronomy in their area.

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Office of Astronomy for Development institutional meeting

2277

Best Practices in Fundraising and Income Generation

Genevieve Marshall

IAU Office of Astronomy for Development

Abstract

A core component to achieving the Sustainable Development Goals (SDGs) is leveraging funding for programmes delivering impact on the SDG targets. Astronomy traditionally has a successful track record in securing institutional funding for research but broader income generation is an area which holds opportunity for astronomy related organisations to secure funding. This session will explore key strategies to help you define and target alternative audiences to help organisations achieve financial sustainability.

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Office of Astronomy for Development institutional meeting

2296

SheMatters: STEM-based community engagement to empower Malagasy girls and under-aged mothers from disadvantaged communities

Ms Miora Rakototafika[1], Mrs Zara Randriamanakoto[2], Ms Bénite Tantely[1]

[1]University of Antananarivo. [2]SAAO

Abstract

SheMatters is a STEM-based community engagement initiative aimed at empowering girls from disadvantaged communities, particularly those residing at Akany Avoko Ambohidratrimo, a foster home for disadvantaged youth in the outskirts of the capital city in Madagascar. This project seeks to inspire and provide hope to vulnerable girls through astronomy outreach, practical skills transfer, and career orientation. By leveraging the expertise of Malagasy women scientists as role models and through the collaboration with the IAU Office for Astronomy Outreach - NOC Madagascar, SheMatters aims to instil confidence, ignite interest in STEM fields, and equip the girls with essential life skills, providing them with the tools and motivation to pursue their dreams and build a brighter future. The core ideas of SheMatters revolve around conducting regular sessions and stargazing events to engage the girls in hands-on activities, storytelling, and networking opportunities. The timeline includes monthly visits led by a dedicated team of graduate student volunteers, with the first session coinciding with the International Day of Women and Girls in Science in February 2024. Through this project, we aim to demonstrate how astronomy can be used as a powerful tool to support the United Nations Sustainable Development Goals (SDGs) such as quality education, reduced inequalities, and partnership for the goals.

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2304

The Universe Within: Using Astronomy to Explore Inner Spaces and Mental Health

Mr Dominic Vertue[1], Dr Joyful Mdhluli[2], Mrs Mampho Ledimo[2]

[1]Office of Astronomy for Development (OAD). [2]OAD

Abstract

This project seeks to investigate how the themes of exploration and discovery in astronomy can mirror the journey of understanding and nurturing one's mental health. We will delve into how the metaphorical journey through the universe can serve as a powerful tool for introspection and self-discovery, enabling individuals to confront and navigate their inner worlds. By leveraging the narrative of cosmic exploration, we aim to create educational materials and experiences that encourage individuals to explore their own minds, fostering a greater awareness of mental health and the importance of psychological care. Our approach is based on the premise that engagement with the vastness and mystery of the cosmos can inspire a deepened sense of personal insight and emotional growth, contributing to overall mental wellness.

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SSGI's Vital Contribution to OAD Mission: Advancing Astronomy in the East African Region and Beyond

BETELHEM NIGUSE MULUGETA

Space Science and Geospatial Institute (SSGI)

Abstract

Over the past decade, astronomy and space science have experienced significant development in the East African region. The establishment of space science agencies and institutes, the formulation of space policies and strategies, and the governments' investments in infrastructure and human development have all played crucial roles in this success. The Space Science and Geospatial Institute (SSGI) in Ethiopia has been a key player, taking on a leadership role in the development of astronomy not only within Ethiopia but also in the broader East African context. SSGI has invested heavily in both infrastructure and human capital development in the field of space science and astronomy.

SSGI represents Ethiopia as the national member of the International Astronomical Union (IAU) and actively participates in various IAU initiative programs. The institute has organized numerous IAU symposiums and even hosted the East Africa Regional Office for Astronomy for Development (ROAD), one of the 11th IAU offices dedicated to astronomy development, fully funding the project. SSGI possesses two one-meter diameter telescopes, a 5-meter diameter planetarium, and engages in various research and outreach activities in astronomy.

In this talk, we will highlight the main activities that SSGI has accomplished in the past decades in Ethiopia and at the regional level. We will discuss its contribution to achieving the OAD mission and advancing astronomy in East Africa and beyond.

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Hanle Dark Sky Reserve in India: socio-economic development using science tourism.

Dr. Niruj Mohan Ramanujam[1], Mr. Dorje Angchuk[1], Mr. Stanzin Norlha[2], Mr. Nawang Dorji[3], Mr. Sonam Jorphail[1], Mr. Tsewang Gyalson[1], Dr. Annapurni Subramaniam[1], Mr. Tsewang Stanzin[4], Mr. Anmol Tikoo[5]

[1]Indian Institute of Astrophysics. [2]Bhabha Atomic Research Centre. [3]Tata Institute of Fundamental Research. [4](Formerly at Indian Institute of Astrophysics). [5]Independent Researcher

Abstract

Hanle Dark Sky Reserve (HDSR), situated in a wildlife sanctuary in Himalayan Ladakh, is India's first official dark sky region, over a region of about 1000 sq km centred around the Indian Astronomical Observatory. HDSR is inhabited by communities which were nomadic only a generation ago. The main source of employment apart from grazing is manual labour and the tourism industry in the capital.

HDSR, a science-driven sustainable development program, offers an alternative path. Local villagers, with varying education levels, have been trained as astro-tourism guides using telescopes funded by the government. This, along with increasing number of homstays, is a source of livelihood during the tourist season.

HDSR is also a nucleus for the development of STEM education and astronomy throughout Ladakh. We are offering a course in astro-tourism with University of Ladakh, to train future guides from across the country. We are reviving astronomy labs in schools across Ladakh too. The administration has funded 8 telescopes to promote astro tourism elsewhere as well.

I will focus on how HDSR contributes to socio-economic development through science among the semi-nomadic communities, as well as promotes STEM education in Ladakh, and is a training hub for astro-tourism elsewhere in India as well. I will discuss how these align with the UN SDGs too. I will also describe how HDSR is being used to unearth and preserve traditional astronomy knowledge among the nomadic communities, which would otherwise be lost in the coming decade.

Session

Office of Astronomy for Development institutional meeting

2498

Astronomers for Planet Earth

Dr Beatriz Mingo[1], Dr Andrea Gokus[2], Ms Sarah Wagner[3], Dr Leonard Burtscher[4,5], Dr Mandeep Gill[6,7]

[1]The Open University (UK). [2]Washington University in St Louis (USA). [3]Universitat Wurzburg (DE). [4]Leiden University (NL). [5]Astronomers for Planet Earth (DE). [6]University of Minnesota (USA). [7]Fermi National Laboratory (USA)

Abstract

Founded in 2019, Astronomers for Planet Earth (A4E) is a volunteer, global network of nearly 2000 astronomers, with a common goal: addressing the climate crisis from an astronomical perspective. As astronomers, from amateurs, to students, to professionals, we have a unique perspective on our planet and the fragility of the ecosystems that sustain us all, and we have the ability to convey these concepts effectively and engage large audiences. Professional astronomy relies on the stability of these ecosystems, while also carrying a large carbon footprint, which we must urgently measure and reduce.

Environmental sustainability, accessibility, inclusiveness, and social justice are inextricably linked. This is reflected both in our diverse membership and in the many facets of our work, which ranges from public engagement and the development of teaching materials to liaising with professional astronomers, and publishing reports and tools to quantitatively address the environmental impact of our field. We also work with large international consortia and government bodies to promote policy changes which will make our field more sustainable. In this talk, I will describe our principles and structure, highlighting how they align with the goals of the IAU's Office for Astronomy Development. I will also showcase some of our work and recent milestones, and show ways in which more astronomers and institutions can join in to help us preserve our planet and our field for future generations.

Session

Office of Astronomy for Development institutional meeting

2514

Overview of OAD activities

Dr Joyful Mdhluli

Office of Astronomy for Development

Abstract

The Office of Astronomy for Development (OAD) by the International Astronomical Union is dedicated to harnessing the potential of astronomy for advancing sustainable development on a global scale. Recognising astronomy's multidisciplinary nature and its profound connections to culture and heritage, the OAD views it as a versatile tool capable of addressing various societal challenges.

The OAD channels its efforts into several key areas for positive impact: Enhancing Educational Outcomes, Skill Development, Socioeconomic Growth, and Mental Health and Well-being. The primary objective is to cultivate partnerships and collaborations with diverse entities, including organisations, governments, and communities, ensuring that the benefits of astronomy are inclusive and accessible to all.

During this presentation, we will provide an overview of the OAD's activities since its establishment. Up to date, the OAD has supported over 200 projects spanning across more than 100 countries globally, establishing 11 regional and language offices. Additionally, the OAD conducted a comprehensive analysis of lessons learned and trends observed, leading to the identification of global "flagship" projects. These projects receive heightened attention and are directly coordinated by the OAD to maximise their impact.

Session

Office of Astronomy for Development institutional meeting

2529

TENTH ANNIVERSARY OF SAROAD

Mr Jackson Siantuba, Mr Prospery Simpemba, Dr Saul Paul Phiri

Copperbelt University

Abstract

The Southern African Regional Office of Astronomy for Development (SAROAD) was established on 14th August 2014 when a memorandum of understanding was signed between the International Astronomical Union (IAU) and the Copperbelt University (CBU). The regional office covers sixteen member countries namely: Angola, Botswana, the Democratic Republic of Congo, Ghana, Kenya, Kingdom of Eswatini (Swaziland), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Zambia, and Zimbabwe. Since its inception, SARAOD has been pivotal in fostering regional coordination of astronomy activities and providing linkage for local and international collaboration. In this presentation, we discuss the achievements of the office over the past decade and its plans aligned to the 2020-2030 IAU Strategic Plan. Highlights of regional projects, mostly funded through the OAD's annual call for proposals will be showcased. Some of the activities carried out during this period included AstroLab workshops, the Teacher Training Program (TTP), the Network for Astronomy school education workshop, Go-Lab workshops and the Pan-African School for Emerging Astronomers summer school. These activities have helped to develop the human resources of astronomers and related personnel in the region. We will further discuss the collaborations established to have a united front as we use astronomy as a tool of social and economic development.

Keywords: regional coordination, regional projects, workshops, collaboration.

Session

Office of Astronomy for Development institutional meeting

2657

EXPLOITATION OF RADIO INTERFEROMETERS FOR CAPACITY BUILDING - TOWARDS THE LOFAR GLOBAL CITIZENSHIP RADIO ARRAY -"GLORAY"

Prof. George Miley[1], Prof. Leah Morabito[2,3], Prof. Neal Jackson[4], Rudolf Le Poole[1]

[1]Leiden Observatory, Leiden University, The Netherlands. [2](2) Centre for Extragalactic Astronomy, Department of Physics, Durham University, Durham, UK. [3](3) Institute for Computational Cosmology, Department of Physics, University of Durham, Durham, UK. [4]University of Manchester, Jodrell Bank Centre for Astrophysics, Oxford Road, Manchester, UK

Abstract

We shall show how the unique infrastructure of a radio astronomical interferometer array can be exploited for stimulating development. The International LOFAR Telescope is the world's largest high-resolution radio telescope operating at low frequencies (<300 MHz). It is a trans-European facility, with a network of mutually dependent antenna stations that stretch over ~ 2000 km. We suggest adding stations and extending it to North Africa, the Middle East and West Asia. The new "GLORAY" facility would have >50 times better resolution than SKA1-LOW, and the ultimate combination of sensitivity and resolution for low-frequency astronomy. A revolutionary aspect of GLORAY would be to exploit the intercontinental infrastructure of mutually dependent antenna stations as local hubs for innovation and education. These could be used individually for research by local scientists and for projects that needs comparative measurements over 3 continents. GLORAY could create unique new opportunities for applied research, in e.g. ionospheric physics, solar weather, lightning, AI, precision agriculture, meteorology and seismology. GLORAY would build on the inspirational South African vision of MEERKAT and SKA-MID as engines for advancing the UN SDGs and could be a tool for science diplomacy. Particularly important would be SDG4 (Education), SDG5(Gender Equality), SDG9(Infrastructure and Innovation), SDG10(Reduced inequalities), SDG13(Climate) and SDG16(Peace). Stimulating Global Citizenship would be a prominent goal from the outset. The educational aspects would be implemented in collaboration with the OAD and UNESCO. With its innovation hubs, GLORAY could exploit global, regional, and local funding opportunities beyond those of pure science.

Session

Office of Astronomy for Development institutional meeting

2718

Astro-Phy Quench - Unlocking potential through STEM exposure for undeserved and underrepresented community

Ms Mirwat Shamshad, Mr Uzair Yusuf

School of Astronomy and Physics

Abstract

"Astro-Phy Quench", an **OAD** funded project, worked on inclusion and diversity by engaging underserved students from **conflict-affected** and **remote parts** of Pakistan. The project sought to foster a sense of science identity through informal physics and astronomy-related blended learning interactions. The project involved 1) Introductory course on **Astronomy using online telescope** 2) Introductory course on P**article Physics with ATLAS Model**, 3) International collaborations with large research infrastructures like **Canadian Light Source (CLS)** 4) Guest talks and celestial observations.

Around **five hundred students** from conflict affected / remote regions of Pakistan were part of **Astronomy project** using online telescope. Apart from introductory guiding sessions on astronomy, they were provided with free subscription to online telescope network.

Similarly **62 female students** from a community of remote region participated in introductory course on **particle physics**. They built 3D models of ATLAS Detector (LHC, CERN) learning engineering connections.

Virtual visit to **Canadian Light Source (CLS)** and **Beam Light Source Student Experience (LiSSE)** was conducted for **73 students** of remote mountainous region. CLS is one of the largest science projects in Canada. During the virtual tour, students learnt how CLS works, and examples how researchers have used this facility to conduct research in the fields of health, agriculture, environment, and advanced materials. Students also experienced soil research activity, while connecting to classroom curriculum.

Astrophy Quench Project also trained **three undergrad girl students** as **STEM ambassadors**. Guiding sessions were conducted with them on different agendas. They were given STEM experience, encouraged to write blogs, develop their communication and collaboration skills.

Session

Office of Astronomy for Development institutional meeting

2772

First steps towards the creation of the first Astronomical Society in Mozambique

Mr. Francisco Fenias Macucule[1,2], Mrs. Yara Simango[2,3]

[1]University of Namibia. [2]Associacao Mocambicana de Astronomia (AMAS). [3]University of Leeds

Abstract

Since 2017 when the DARA (Development in Africa with Radio Astronomy) basic training started in Mozambique we have taken a huge step in the development of astronomy in Mozambique. However the community of astronomers in the country is still very small, there are only 13 astronomers in Mozambique. Therefore we created the Mozambican Astronomical Society, translated from the Portuguese Associação Moçambicana de Astronomia (AMAS). AMAS is a non-governmental organisation dedicated to bridging the gap between scientific knowledge and public understanding of astronomy in Mozambique.

We are bringing to the presentation the first steps towards creating AMAS, and the impacts of our activities so far. Recognising the limited access to astronomy education and resources, AMAS implements diverse outreach activities targeted at various communities.

Through stargazing events, interactive workshops, culturally relevant storytelling sessions, and collaborations with schools and institutions, AMAS fosters astronomical curiosity and knowledge.

This presentation aims to highlight our efforts to take astronomy to Mozambique, as well as current challenges and potential future challenges, and inspire participants with valuable insights into establishing and implementing effective astronomy outreach initiatives, particularly in underserved regions. By igniting the spark of curiosity about the cosmos, AMAS demonstrates the transformative power of astronomy in fostering scientific literacy and community engagement.

Session

Office of Astronomy for Development institutional meeting

2776

Tracking the Zambia DARA cohorts

Dr Steven Mudenda

Department of Physics, University of Zambia

Abstract

The Development for Africa in Radio Astronomy (DARA) project has been instrumental in fostering the growth of radio astronomy and high-tech skills across Africa during its six-year implementation. This initiative has trained at least ten Zambian graduates annually, equipping them with essential expertise in radio astronomy and related fields. This paper explores the trajectory of these graduates post-training, examining their current endeavors and the impact of their education on both the individual and broader societal levels.

Through comprehensive surveys and interviews, we have gathered insights into the diverse career paths pursued by DARA graduates. Our findings reveal a portion of alumni actively engaged in cutting-edge research, academia, and industry roles, both within and beyond the realm of radio astronomy. Furthermore, many graduates have become catalysts for change within their communities, leveraging their expertise to address pressing societal challenges and inspire future generations.

Reflecting on the impact of the DARA project, we identify key successes, including the expansion of Africa's scientific workforce, the advancement of research capabilities, and the promotion of international collaboration. However, challenges such as resource constraints and sustainability issues persist. To build upon the achievements of DARA, we propose several strategies for future enhancement.

Session

Office of Astronomy for Development institutional meeting

2792

Astronomy Videos for Kids in Pakistan

Roshaan Bukhari[1], Dr Salman Hameed[1,2], Abdullah Kawish[1], Marria Khan[1]

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Abstract

Kainaat Kids is an IAU-OAD supported project that connects Pakistani (and broader South Asian) kids to the universe, through high-quality videos in Urdu language on *YouTube*. Our primary audience is young kids aged between 10 to 16 years. The project began in 2021, partly in response to the pandemic. Our team was scattered in 4 different countries including the US, England, Turkey and Pakistan, and 3 different cities within Pakistan (Karachi, Lahore and Islamabad). Our workflow adapted to a pan-continental presence, where meeting with team members from different timezones became a routine.

The first season of Kainaat Kids includes 10 episodes that follow astronomy in Pakistani curriculum. Each episode is about 10 minutes in length, and includes live hosts as well animations. The content of Kainaat Kids is grounded in cultural and regional relevance. The analogies used, characters developed and examples quoted are all locally derived. For example, while describing seasonal changes on Earth, summer is related with locally grown mangoes. The animations have a distinct South Asian flavor, and all the hosts are fluent in Urdu. These videos have been adopted by several schools as supplementary material.

In this presentation, we want to highlight the challenges and rewards that go into making such a culturally relevant astronomy show for kids, and the process that it requires to work collaboratively across cities and countries. We will present snippets from our second season of *Kainaat Kids* as well.

Session

Office of Astronomy for Development institutional meeting

2893

A holistic approach to societal impact: the African Millimetre Telescope in Namibia

Ms. Emilia Iiyambo[1], Mrs Amanda Schut[2], Mr Zandré Duvenhage[2], Prof Michael Backes[1,3], Prof Marc Klein Wolt[2], Ms Maaike Pierik[2], Dr Joanna Holt[2], Mr Hans-Werner Matthaei[2], Mr Lott Frans[1], Mr Hiiko Katjaita[1], Mrs Sigrid Shilunga[1], Ms Queen Delight Namene[1], Mr Francisco Macucule[1], Ms Simasiku Namene[1], Ms Victoria Nakafingo[4], Dr Eli Kasai[1], Prof Heino Falcke[2], Prof Sera Markoff[5], Prof Rob Fender[6], Dr Elina Lindfors[7], Prof James Chibueze[8], Ms Hélène Honsbein[9,1]

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Abstract

The Africa Millimetre Telescope (AMT) will be a new millimetre wavelength radio telescope in Namibia. It is designed to add to the Event Horizon Telescope network to create colour movies of black holes, as well as provide data for single dish science cases. Though not yet operational, the multi-million Euro project already has an impact on Namibian society.

The AMT project is built on three pillars: science, design and construction, and societal impact. One of the goals the AMT sets itself is to have a holistic approach in making an impact on Namibian society. The outcome of these three pillars should be interwoven and function on the principles of partnership, equality and the will to contribute to a positive future for all.

The challenging question is how to ensure that any astronomical instrumentation project has a meaningful and sustainable impact on the society in which it is placed. Who determines which impact is needed, and how to go about achieving those goals? Which challenges arise in an international collaboration with partners from different continents? And how can a project build on existing capacity within these three pillars? Ultimately the AMT aims to be an African facility, run by African partnerships and used by African scientists. This contribution will explore how an international, and inter-cultural astronomy project can approach societal impact in a meaningful and sustainable way, as well as invite dialogue on the topic.

Session

Office of Astronomy for Development institutional meeting

2934

Development in Africa with Radio Astronomy (DARA) Research at the University of Mauritius

Assoc Prof (Dr) Nalini Heeralall-Issur

University of Mauritius

Abstract

The University of Mauritius (UoM) has been involved in the teaching of Astronomy and Astrophysics and in Radioastronomy research, related to the Mauritius Radio Telescope (MRT), since the 1990s. However, with no scholarships in place for many years, we suffered from a brain drain with most of our best students doing well in research elsewhere.

Since 2019, thanks to a Development in Africa with Radio Astronomy (DARA) collaboration between UoM and the University of Leeds of the UK, UoM has been hosting six DARA funded research students. Four were from other African SKA partner countries (Ghana, Kenya, Mozambique and Madagascar). This partially reversed the brain drain while allowing us to bring our share to the DARA endeavor of promoting development in Africa through radio astronomy.

We present here highlights of the DARA students research in various fields (Earth radio leakage from mobile towers in the context of SETI, Fast imaging of FRBs with MeerKAT data, Investigating possible nature of FRBs, the setting up of an array of small parabolic antennas for HI observations and radio transient detections and ML analysis of satellite data for ship detection in our EEZ).

We also discuss the various challenges faced to ensure the effective progress of the students in our small island in the COVID era, with extended lockdowns and when external guidance were strictly limited to online exchanges.

Session

Office of Astronomy for Development institutional meeting

2964

Closer to the sky: co-creating astronomical knowledge in the favela complex of Cantagalo Pavão Pavãozinho (PPG) in Rio de Janeiro

Arianna Cortesi[1], Maria Clara Heringer Lourenço[1], Claudia Mignone[2], Claudio Alberto Barbosa Araujo[3], Gabriela Rufino[1], Alan Alves Brito[4]

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Abstract

Closer to the sky is an IAU/OAD funded project which aims at co-producing scientific knowledge in collaboration between astronomers and artists/educators living in the favela of Cantagalo-Pavão-Pavãozinho (Rio de janeiro, Brazil). It is the result of the collaboration between researchers and students from the Valongo Observatory (UFRJ), artists, educators, and community residents. In particular, we work in close collaboration with the social project 'Ninho das Águias', where classes and night sky observations are held. Using astronomy to increase children's interest in science and promote english learning, this work happens on a local libraby from the Ninho das Águias, using a decolonial approach, fostering curiosity and challenging colonial assumptions, combining several key components, such as: researching education and science communication in vulnerable contexts, developing new literacies for this children; outreach activities and creation of artistic materials inspired by astronomy.
The project adopts active methodologies, following Paulo Freire and Marcelo Arouca ideas, aiming to promote a dialogic approach, empowerment, autonomy and critical thinking about the oppressive realities faced by many. The project also draws inspiration from the Montessori method by designing activities involving physics and astronomy experiments promoting children's independence. Moreover, decolonised literature resources are used to construct the studying material of the classes.

The success of the project has led to collaborations with other initiatives, such as AstroTribe in India, and represents a valuable example of co-creating knowledge in a multidisciplinary way.

Session

Office of Astronomy for Development institutional meeting

3050

Astrostays : Creating sustainable livelihoods through Community Led Astro-tourism

Sonal Asgotraa

Astrostays

Abstract

Astrostays is a community-led Astro-tourism initiative that merges Astronomy and community development interventions for creating sustainable socio-economic opportunities for indigenous communities in rural areas. With the community at the center, the model goes beyond traditional astronomy-based offerings – bringing economic benefits of tourism directly into villages - transforming rural homestays into Astronomy Hubs and holistically empowering local communities. Trained on basics of astronomy and know-how of operating telescopes, the local homestay owners (mostly women) conduct night sky gazing sessions for the tourists, creating a new channel of revenue generation, that has eventually led to increase in stimulus to local economy, reducing youth migration and preservation of age-old Himalayan heritage.

Session

Office of Astronomy for Development institutional meeting

3084

Looking outward to above and beyond: The decade-long impact of OAD projects in Vietnam

Tan Vu Nguyen[1], Thanh Dat Hoang[2,1], Huu Thinh Nguyen[3,1]

[1]Vietnamese Astronomical Society. [2]Max Planck Institute for Radio Astronomy. [3]University of Illinois Urbana-Champaign

Abstract

Four projects funded by the IAU OAD in just three years were the unexpected results but welcomed with enthusiasm in Vietnam. That happened in the early days of the OAD funding scheme and left a great impact on the state and the development of astronomy in this young and populous country in South-East Asia. This presentation tells the after story of these OAD funded projects in Vietnam and how meaningful they have been to field of astronomy in the country.

Among the four above-mentioned funded projects, one aimed at universities and research, while the other three focused on the general public. The timing back then was perfect as it was the prime time for amateur astronomy in Vietnam, when amateur astronomy clubs nationwide were blooming, with Ho Chi Minh City Amateur Astronomy Club (HAAC) in the leading position. HAAC was also the main force behind two projects for the public, which supported amateur astronomical societies in Vietnam; and then it went on to represent Vietnamese amateur astronomers domestically and internationally (under the brand of VietAstro).

Meanwhile, the astronomy project for universities sowed the vital seeds of the country's future research in astronomy. Indeed, it laid the foundation for younger generations of Vietnamese professional astronomers, which many of them have returned to the motherland and so far have been carrying out research at Vietnam National Space Center (VNSC) in Hanoi. As a spill over, amateur and professional astronomers have joined hands to revive Vietnamese Astronomical Society (VAS) with great hope ahead.

Session

Office of Astronomy for Development institutional meeting

3093

Assessing the Impact of OAD Funded Projects

Ms Thobekile Sandra Ngwane

University of Cape Town. South African Astronomical Observatory

Abstract

This work summarises the findings of an internship done at the International Astronomical Union's Office of Astronomy for Development (OAD), which began in December 2023 and focused on evaluating the impact of projects funded by OAD implemented in diverse regions over the past decade.

The assessment used questionnaires to capture the experiences and perspectives of project leaders and student participants directly involved in OAD-funded projects. This explored how their participation impacted their lives and career options

Furthermore, this work will delve into personal insights gained and experiences during the internship at the OAD, providing a holistic view of the practical outcomes of astronomy-based initiatives and their long-term effects on communities.

Session

Office of Astronomy for Development institutional meeting

3128

Utilizing the Science of Science Communication to Engage Vulnerable Audiences in Astronomy: Insights from the Soha Astronomy Volunteer Network

Fatemeh Bonyadi

Allameh Tabtab'i univaesity/ UNESCO chair on science communication

Abstract

In the Soha Astronomy Volunteer Network, we employ two science communication frameworks: 1) the classic Audience Pyramid in science communication, and 2) the Engagement Model for public involvement in science.

Audience Pyramid: Our science communication employs a four-tier Audience Pyramid. The base represents the lay public, followed by the interested public, the involved public, and finally, scientists.

Engagement Model: Over time, the Participation model has proven most effective in engaging individuals in science. We utilize this model to elevate individuals within the Audience Pyramid.

We encourage non-specialist public participation in hosting astronomy night events for vulnrble communities. Collaboration with individuals from various backgrounds, such as artists, athletes, and celebrities, enhances the engagement of vulnrable communities in these events. Our approach targets communities with special needs, fostering a sense of community and inclusion.

Our experience has shown that involving the lay public in a scientific event that incorporates play and emotional engagement can enhance community involvement and raise their awareness and serve as a tool to elevate them within the Audience Pyramid, turning them into interested audiences.

We collaborate with psychologists to tailor events to the specific needs of the target audience. Finally, we invite participants (both lay public who assist in event organization and target audience) to share three significant insights about the event. These insights may include newfound knowledge about astronomy or specific needs identified within the target community, which can be addressed and adjusted. Feedbacks from the participants indicates that both groups become interested in astronomy.

Session

Office of Astronomy for Development institutional meeting

3130

Dark-sky tourism to benefit indigenous communities in Namibia

Dr Sisco Auala[1], Prof. Michael Backes[2,3]

[1]Namibia University of Science and Technology. [2]University of Namibia. [3]North-West University

Abstract

There is already evidence supporting the use of indigenous knowledge systems for socio-economic development in Namibia. However, the valuable resource of indigenous knowledge of astronomy is often no longer shared and is at risk of being lost altogether. The inclusion of indigenous starlore within tourism experiences in Namibia may come to help. Dark sky tourism (DST) – where visitors can experience a pristine night sky unaffected by light pollution – is a niche tourism activity that can provide new opportunities for rural communities in Namibia, supporting sustainable development goals via economic development, job creation, and mitigating poverty.

Session

Office of Astronomy for Development institutional meeting

3132

Lessons Learned from the fully-virtual A4E Symposium 2022

Sarah Wagner

Univeristy of Würzburg, Germany

Abstract

I present the organization and planning that stood behind the first symposium by Astronomers for Planet Earth (A4E) which took place in December 2022. Due to less greenhouse gas emissions and global availability, we decided to conduct the one-week symposium fully virtual exploring, for instance, asynchronous presentations and the tool Gather.town. Besides a discussion on these tools in my talk I want to present a summary of the feedback we obtained from participants and what we (as in the astronomical community) can learn from this for future conferences and events.

Session

Office of Astronomy for Development institutional meeting

3183

Science as a global public good

Dr Vanessa McBride

International Science Council

Abstract

The vision of the International Science Council (ISC) is of science as a global public good. This means that scientific advancement should contribute to the common welfare of humanity, improving the quality of life for people while promoting responsible stewardship of our planet. In this presentation we discuss some of the ISC's initiatives in this area, while also highlighting the key contributions of fundamental sciences, such as astronomy, in the science for development space.

Session

Office of Astronomy for Development institutional meeting

3184

The significance of the OAD in the global science landscape

Dr Khotso Mokhele

Office of Astronomy Development

Abstract

The principle of using astronomy and other sciences in order to stimulate the development of society was in place within the South African science landscape long before the OAD was hosted there, with projects like the Southern African Large Telescope (SALT) and the Karoo Array Telescope (MeerKAT), a precursor to the Square Kilometre Array (SKA). South Africa has thus always been a natural home for the OAD and continues to be a driving force in the global science-for-development conversation. This talk will reflect on what it means for the OAD to exist, and what has made this initiative stand out among other sciences. It will also reflect on the future, given all the incredible developments in astronomy, and the OAD's potential to make an even more significant contribution to global development moving forward.

Session

Office of Astronomy for Development institutional meeting

Final category: Office of Astronomy for Education institutional meeting

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ASTRONOMY- CLOSER TO THE CLASSROOM IN ROMANIA

MS ELISABETA ANA NAGHI[1,2,3], MRS FELICIA-ELENA CĂLMUC[4,5]

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Abstract

Every school should represent an innovation centre, a place where the educational process should be built and implemented based on an interdisciplinary approach, while students are being inspired to create their own future.

The international astronomy educational programmes OAE and OAO of the International Astronomy Union(IAU), together with astronomy and space science programmes undergone at European and national level, have inspired a large group of Romanian teachers to organize and implement such activities with their students, as well as to take part in conferences, workshops and seminars based on astronomy issues.

Specific activities

More than 1500 students were involved in IAU-OAO and OAE astronomy programmes in more than 100 Romanian schools(Women and Girls in Astronomy, Dark Skies, 100 Astronomy Hours, ADIS, World Space Week, EAAE- Drawing contest, research projects- Catch a Star, etc.). We also need to mention the training programmes for the Romanian students currently participating to the International Astronomy Olympiads, as well as the creation of an Educational Astronomy Centre dedicated to students who can benefit of the mentorship of more experienced peers who once took part in astronomy competitions at international level.

More than 200 teachers took part to conferences and seminars, as well as training courses based on topics such as astrobiology, astrophysics and astronomy, organized together with OAE, NASE, ESA-ESERO, etc.

A group of teachers created an astronomy curriculum for primary level approved by the Romanian Ministry of Education in 2022 and an astronomy curriculum for the secondary level is being currently developed.

Session

Office of Astronomy for Education institutional meeting

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Three years of Astronomy writing in Chekhumukhi: A newsletter by JVV, Telangana, India

Dr Priya Shah

Maulana Azad National Urdu University, Hyderabad, India

Abstract

In India, the school curriculum does not have a substantial component of Astronomy and hence it is important to identify various instances that can be used to connect students to astronomy. I have been writing a newsletter every month for school students since the past three years (April 2021) (https://jvvtelangana.in/chekumuki/, https://wordpress.com/page/clearskies2019.wordpress.com/295) in which I highlight important events in Astronomy news, some articles on concepts, meteor showers and important astronomical events like eclipses, etc. Articles also include some hands-on activities that students can do on their own, yearly quiz comptetiions and activities. This material written in lucid form is a very useful supplement to classroom activities that can be used by teachers as well as students. Also, since this year, we supplent material with videos. As a RAEC, IAU-OAE and on behalf of JVV (People's Science Forum) we distribute these in schools in Telanagna, India.

Session

Office of Astronomy for Education institutional meeting

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Office of Astronomy for Education Node - France

Pr Emmanuel Remy[1,2], Dr Gilles Remy[3]

[1]LDAR. [2]CY Cergy Paris Université. [3]LERMA / CY Cergy Paris Université

Abstract

In 2021, the Office of Astronomy for Education Node - France was created in CY Cergy Paris University (OAENF-CY, http://oaenf.cyu.fr). This node is one among many others that are coordinated by the IAU Office of Astronomy (hosted in the Haus der Astronomie in Heidelberg, http://astro4edu.org)

The purpose of the OAENF-CY is substantial, long-term support of the objective of the IAU OAE. In particular, the OAENF-CY is specializing in coordinating actions to translate resources from French to English and English to French ; evaluating and providing high-quality astronomy teaching resources based on up-to-date didactics research ; Professional teacher training ; promoting the network of francophone countries.

Our main effort is to bring together the french-speaking community involved in astronomy through different actions. Our first activity was to initiate a directory of francophone actors in the field of astronomy for education. Some portraits of actors have been made. A listing of the main structures in France is underway, with a collaboration with the French National Coordinators. Two international conferences have been organised, online for the first one (https://astroedu-fr.sciencesconf.org/) and in Tunis for the second one (https://astroedu-fr-2023.sciencesconf.org/). Both conference helped to gather the francophone community.

A local event is organised every year in the premises of CY Cergy Paris University, to communicate astronomy with schools in the surrounding and students or teachers of our university. During those events, the Mobile Planetarium of Cergy (https://cylerma.cyu.fr/planetarium) and our Human Orrery (handsonuniverse.org/france/planetaire) are used to communicate.

Session

Office of Astronomy for Education institutional meeting

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Exploring the universe: The Role of Al-Khawarizmi Astronomy Center as an Educational Hub in Malacca, Malaysia.

Dr Kassim Bahali

Universiti Kebangsaan Malaysia (National University of Malaysia). Malacca Sharia Astronomy Society

Abstract

The Al-Khawarizmi Astronomy Centre comprises an Observatory, a planetarium, a robotics observatory, a training center, and accommodation, serving as a pivotal hub for astronomical education. Recognizing the significance of astronomy knowledge in today's society, the Malacca state government established this center with a mission to foster awareness about astronomy's importance, bolster astronomy initiatives in schools, and cultivate widespread astronomical literacy. Equipped with a range of educational facilities, including observatories, a planetarium, a training center, and accommodation, the center primarily focuses on educational endeavors such as short courses, seminars, workshops, exhibitions, quizzes, planetarium shows, and observational activities. Additionally, it conducts research on phenomena like the visibility of the crescent moon and solar activity. These multifaceted activities are accessible to both students and the general public, playing a pivotal role in nurturing an appreciation for the universe and the significance of astronomy. Through its efforts, the center significantly contributes to the advancement and enrichment of astronomy education in Malaysia.

Session

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Astronomy- closer to the classroom in Romania

Ms Elisabeta Naghi[1,2,3], Ms Felicia Elena Călmuc[4]

[1]member of the Romanian National Astronomy Committee. [2]national coordinator for astronomy education in Romania- NAEC. [3]inspector for mathematics and astronomy , Education Ministry. [4]Palatul Copiilor Craiova, Romania

Abstract

Every school should represent an innovation centre, a place where the educational process should be built and implemented based on an interdisciplinary approach, while students are being inspired to create their own future.

The international astronomy educational programmes OAE and OAO of the International Astronomy Union(IAU), together with astronomy and space science programmes undergone at European and national level, have inspired a large group of Romanian teachers to organize and implement such activities with their students, as well as to take part in conferences, workshops and seminars based on astronomy issues.

Specific activities

More than 1500 students were involved in IAU-OAO and OAE astronomy programmes in more than 100 Romanian schools(*Women and Girls in Astronomy, Dark Skies, 100 Astronomy Hours, ADIS, World Space Week, EAAE*- Drawing contest, research projects- *Catch a Star*, etc.). We also need to mention the training programmes for the Romanian students currently participating to the International Astronomy Olympiads, as well as the creation of an Educational Astronomy Centre dedicated to students who can benefit of the mentorship of more experienced peers who once took part in astronomy competitions at international level.

More than 200 teachers took part to conferences and seminars, as well as training courses based on topics such as astrobiology, astrophysics and astronomy, organized together with OAE, NASE, ESA-ESERO, etc.

A group of teachers created an astronomy curriculum for primary level approved by the Romanian Ministry of Education in 2022 and an astronomy curriculum for the secondary leve lis being currently developed.

Session

Office of Astronomy for Education institutional meeting

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Astronomy and Curriculum: An international perspective

Dr Saeed Salimpour

Deakin University (Research for Educational Impact). IAU - Office of Astronomy for Education

Abstract

Teaching and learning in schools is for the most part governed and informed by the curriculum. Over the years, various efforts have endeavoured to enhance the curriculum particularly in the context of science education. The aim has been to engage a diverse range of learners, and make teaching and learning reflective of the contemporary practices of science. This includes creating links between various disciplines, and providing students the opportunity to engage with “authentic” science. Astronomy is seen as having enormous potential to provide a rich context for creating such interdisciplinary links, and affording students the opportunity to experience and engage with authentic practices.

This presentation highlights preliminary results from the analysis of astronomy in the curriculum of 71 countries around the world, and in doing so sets the context for exploring how astronomy can be effectively leveraged in the curriculum.

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Adopting Astronomy-style Data Visualization for Physics Education in Uganda

Dr. Elizabeth Naluminsa, Dr. Nelson Ndugu, Prof. Florence D'ujanga, Dr. Daniel Mukiibi, Dr. Bosco Oruru

Makerere University

Abstract

Low motivation in formative academic stages leads to low levels of scientific career engagement after graduation, which further feeds into low scientific innovation at national level. One way to boost motivation levels in students is the use of captivating teaching aids and practical exposure to abstract scientific concepts. We present here a new project at our institution titled; "Immersive Technology for Physics". This project was inspired by the IDIA visualisation project (iDaVIE). In our project, we shall be rendering simple simulated datasets from physics into 3D graphics to be used by teachers for conveying abstract concepts. It shall cover the basic core concepts in the physics curriculum (high school or undergraduate). We plan to leverage already existing astronomical software such as "Partiview/ DigitalUniverse" to render the datasets. In our presentation we shall share the planned methodology, updates so far, outcomes and anticipated impact of the project.

Session

Office of Astronomy for Education institutional meeting

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Achievements of The OAE –Egypt Center during 2022 and 2023

Prof. Abd El Fady Morcos

National Research Institute for Astronomy and Geophysics. Acadmy of Scientific Research and Technology

Abstract

The OAE-Egypt Center has achieved significant milestones on five key axes. The first axis concerned by developing the science curriculum for the pre-Univeristy stage, in form of two stages curricula due to ages (12y-15y) and (16y-18y) , and will be provided to decision-makers. At the same time training courses for the teachers were done to empower teachers to deliver astronomy lessons in effective way. Arabic booklets and books were published and sold at its cost. The OAE-Egypt Center fosters a vibrant regional network, collaborating with NAEC teams in Arabic-speaking countries (thanks to SHAW organizers to give chance for Arabic speakers in a private session). Translating educational materials into Arabic language break the language barriers and make understanding easier. Additionally and models were designed to simplify the explanation of modern astronomical concepts. The Center's achievements not only benefit Egypt but also inspire and empower the entire Arabic-speaking world to reach for the stars. It is also illuminated the path for countless young learners, igniting their passion for astronomy and nurturing future generations of scientists and space enthusiasts.

Session

Office of Astronomy for Education institutional meeting

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Unveiling the Universe for Future Generations: Integrating Astronomy and Cosmology in Egyptian School Curricula

Prof. Abd El Fady Morcos

National Research Institute of Astronomy and Geophysics

Abstract

Egypt has a rich history in astronomy, but its schools need better teaching of astronomy and cosmology. We looked at how these subjects are taught in Egyptian schools and found limited content, teachers feeling unsure, and students with different levels of knowledge and interest. Aiming to improve the situation, it is suggested to create specific astronomy and cosmology lessons that match national standards and cover important topics. On the other hand training teachers on how to teach astronomy and cosmology, using local resources effectively will make learning fun with activities, digital tools, and connections to everyday life and Egyptian culture. Collaboration between teachers, scientists, and space agencies to build a strong learning environment and boost national pride in space exploration must be encourage. Finally, by teaching astronomy and cosmology better, we can help students to understand science better, think critically and inspire them to become scientists and engineers. Also it will give Egyptian student a chance to explore the universe and be a part of its discovery journey.

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Enhancing Astronomy Education in Nigeria: A Report on National Efforts and Achievements

Ms Olayinka Fagbemiro

Nigerian Space Agency. Astronomers Without Borders (AWB) Nigeria

Abstract

Over the past two years, Nigeria has made significant strides in advancing astronomy education under the auspices of Astronomers Without Borders (AWB) and the dedicated efforts of the National Astronomy Education Coordinator (NAEC). This report outlines the key initiatives, challenges, and successes encountered in our journey to elevate astronomical literacy and enthusiasm among Nigerian students and educators. Our comprehensive approach has involved the development and distribution of educational resources, organization of workshops and training sessions for teachers, and the hosting of public outreach events to spark interest in astronomy across diverse communities. One of the flagship programs has been the "Stars in Schools" project, which directly engaged students in under-resourced schools through interactive sessions and practical observations, thereby democratizing access to astronomical knowledge. Despite facing logistical and infrastructural challenges, the resilience and passion of our team have led to notable achievements, including the establishment of amateur astronomy clubs and the participation of Nigerian students in global astronomy competitions. This report not only highlights the progress made in Nigeria but also serves as a testament to the potential for impactful astronomy education initiatives in regions with limited resources. We look forward to sharing insights, and lessons learned, and fostering international collaborations at the IAU General Assembly in Cape Town, in August 2024.

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Transforming Education through Astronomy: My Journey as IAU OAE National Astronomy Education Coordinator in Pakistan

Ms. Hira Fatima

National Center in Big Data and Cloud Computing, NED-UET, Karachi, Pakistan. Institute of Space Science and Technology, University of Karachi, Karachi, Pakistan

Abstract

In this presentation, I will delve into my journey as the IAU OAE National Astronomy Education Coordinator in Pakistan and explore how this role has empowered me to advance astronomy education initiatives in my country. I will discuss how I leveraged this position to establish a network of passionate teachers and educators committed to enhancing astronomy education. Additionally, I will highlight collaborations with planetariums, science centers, and other national and international organizations that have contributed to our collective efforts. Furthermore, I will showcase impactful initiatives, including numerous astronomy teacher training workshops, supported by the IAU Office of Astronomy for Education. These endeavors have led to significant improvements in astronomy education across Pakistan. I will also address the challenges encountered, lessons learned, milestones achieved, and our ongoing journey towards further transformative initiatives in education through astronomy.

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“A SPACE EXPLORATION EXPERIENCE IN ARSAKEIO SCHOOL”THE VALUE OF STEM APPROACH IN ASTRONOMY EDUCATION

Dr Margarita Metaxa

Arsakeio/national Observatory of Athens

Abstract

In my presentation I will present and discuss the model and outstanding outputs of space education (STEM based) we have implemented to 150 students in ARSAKEIO, the oldest educational organization in Greece, for the first time for 2023-2024. We selected and used material from NASA;s excellent ARTEMIS educational program, translating it and adapting it to the greek curriculum. Space education is important any more for students since a. we are leaving in a new era where our youngsters, “generation Z”, is growing with completely different attitude and perceptions from our own b. our students are already citizens of the Space Age! Therefore, astronomy education ecosystem must endorse new standards, proposing valuable solutions. Space education gives these opportunities (it's the definition of STEM education) since through it students can be informed and engaged to related issues, in a most challenging and effective way. This helps them to a. be "literated" in science/astronomy, according to the guidelines IAU has adopted for the coming decade, and b. act as responsible future citizens, having the chance to be informed and follow STEM careers. Finally I will discuss future networks through IAU, for space education.

Session

Office of Astronomy for Education institutional meeting

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Getting Astronomy (Back) into the Curriculum – An Australian Case Study

Mr Robert Hollow[1], Dr Saeed Salimpour[2,3]

[1]CSIRO, Space and Astronomy. [2]Deakin University. [3]IAU Office of Astronomy Education

Abstract

Australia has a national Australian Curriculum for core subjects including Science, but it is implemented at a State level. In late 2022 the New South Wales Educational Standards Authority (NESA), responsible for curriculum and examination standards for K-12 education in the most populous state, released a draft new syllabus for the integrated Science course in Years 7-10 of high school. Despite astronomical concepts being included in the Australian Curriculum for these levels they were absent in the draft NSW syllabus. We outline how the Australian professional astronomical community in conjunction with the IAU Office of Astronomy Education was mobilised to respond to this omission and the results in the final syllabus version released in late 2023. This case study provides some useful learnings that can be applied elsewhere.

Session

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Advancing Astronomical Literacy via Student Writing Contests

Dr. William Waller

Endicott College. The Galactic Inquirer (http://galacticinquirer.net). IAU/OAE/US-NAEC (http://naec-us.org)

Abstract

Scientific literacy encompasses the ability to read scientific literature and to effectively communicate scientific knowledge and reasoning via writing, speaking, and other means. This skill comprises a key goal of K-12 education, as borne out by educational standards worldwide (cf. *The Next Generation Science Standards* followed by U.S. schools). Advancing astronomical literacy provides a compelling gateway to advancing scientific literacy overall, as the subject of Astronomy is both interdisciplinary and very popular. In this presentation, I propose the development of an astronomical writing contest for students attending secondary schools. Such a contest would engage students in creative writing projects suitable to their grade levels. In my own science classes, I have obtained impressive results with the student writing that I assigned and mentored (cf. https://sites.google.com/site/sciencegazette/ap-physics?authuser=0, http://galacticinquirer.net/). For the proposed competition, writing genres could include research reports, essays, book reviews, speculative fiction, dramatic scripts, poems, and musical lyrics for optimal inclusion. Potential partners could include national astronomical societies, observatory consortia, library organizations, telescope manufacturers, textbook publishers, and other supporters of astronomical inquiry. These prospects will be discussed within the context of the IAU and its international purview.

Session

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Let’s learn with astroEDU!

Livia Giacomini[1,2,3], Silvia Casu[1,2], Edward Gomez[4,3], Giulio Mazzolo[3], Gwen Sanderson[5,3]

[1]INAF, National Institute for Astrophysics. [2]OAE Center Italy. [3]astroEDU. [4]Las Cumbres Observatory. [5]OAE

Abstract

Few fields have captured humanity's imagination with such intensity as astronomy. Hence, it comes as no surprise that astronomy has inspired numerous educational activities and that several authors have worked to make them available to teachers and outreach professionals worldwide. However, concerns may arise regarding the scientific accuracy, educational efficacy, and unrestricted accessibility and usability of these activities. Addressing such issues is the main goal of astroEDU (https://astroedu.iau.org), a project operating under the auspices of the IAU's Office of Astronomy for Education OAE. AstroEDU is an online portal where educators can submit their educational activities on astronomy, Earth, and space science for others to use in their classes or outreach events. AstroEDU ensures the high quality of the activities submitted by carrying out a rigorous peer-review process, from both educational and scientific standpoints, akin to publications in the scientific literature. To be more inclusive and make activities accessible and reusable by the largest community possible, astroEDU includes not only an international edition in English, but also a local edition in Italian and a new one in Spanish. Each edition is managed by a dedicated editorial board, and editions in other languages will be launched in the coming years. AstroEDU is also exploring how emerging technologies such as Artificial Intelligence can enhance the user experience with A.A.A, an AstroEDU A.I. Assistant. With this talk we want to encourage the broad community to join our mission by using and submitting activities and helping with the diffusion of astroEDU.

Session

Office of Astronomy for Education institutional meeting

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Astronomy in Chad

Mamadou Mahamat Djabbi

Thies University of senegal

Abstract

Astronomy in Chad has seen significant growth thanks to awareness campaigns carried out in high schools and universities. Workshops on astronomy have been organized in collaboration with primary school teachers to promote this discipline among young people. These efforts aim to spark interest in astronomy and enhance teachers' skills in effectively imparting this knowledge.

Session

Office of Astronomy for Education institutional meeting

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OAE-Egypt: The role of the remote access and networking in enhancing the astronomy education

Prof. Somaya Saad

National Research Institute of Astronomy and Geophysics, NRIAG

Abstract

Recently, after the Corona pandemic, remote access and networking have played a significant role in astronomy education and it has been greatly affected.

The wide participation as well as the exchange of data and experiences has become possible. The networks have provided the possibility of cooperation by organizing many seminars, workshops and training in an interactive manner.

We will review here how the remote access and the astronomy networks have enhanced the work of the OAE- Egypt in developing the mechanisms of astronomy education among students and teachers, not only in Egypt but also at the level of Arabic-speaking countries.

Session

Office of Astronomy for Education institutional meeting

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Introductory Astronomy lecture series on Stars: Experiences and Lessons

Dr. Sarita Vig[1], Dr. Rajeevan P. P.[1,2]

[1]Indian Institute of Space science and Technology (IIST), Thiruvananthapuram, Kerala, India.
[2]Breakthrough Science Society, India

Abstract

Astronomy is fascinating for most people but they are unable to learn it or take formal courses due to various limitations. However, they're keen to take it up if an opportunity is provided. To address this, an online set of interactive lecture series was given during Sept-Nov 2021 for a total 16 hrs duration. This was part of activities taken up as NAEC-India, IAU-OAE. The lecture series titled 'Introduction to Stars' invited applications from the public in general with higher secondary level pre-requisites in Maths and Physics. The lecture series dealt with understanding the apparent motion of stars and Sun in the sky, as well as providing information about stars. The response was overwhelming and being online, we had participants from across India. About eight tests were also conducted as part of the series, and those who passed were given certificates. This presentation will focus on the methodology and logistics, statistics, feedback and significance of hosting such interactive lecture series.

Session

Office of Astronomy for Education institutional meeting

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Astronomy Activities for Promoting Scientific Evaluation in Secondary Education

Dr. Janelle Bailey[1], Dr. Doug Lombardi[2]

[1]Temple University. [2]University of Maryland

Abstract

Critique and evaluation of scientific explanations is often a complex cognitive task. Consequently, students may find engaging in these scientific practices challenging. However, instructional scaffolding can facilitate the teaching and learning of critique and evaluation. Over a decade of research has revealed that one such scaffold--the Model-Evidence Link (MEL) diagram, designed to help students critically evaluate alternative explanations--increases their ability to understand complex scientific concepts. The preconstructed MEL (pcMEL) provides two models and four lines of evidence. A second form, the build-a-MEL (baMEL), allows greater student agency in selecting from provided choices (three models and eight lines of evidence) to make and use a new MEL diagram. Astronomy topics for these tools include the Moon's formation (pcMEL) and the Origins of the Universe (pcMEL, baMEL). Each activity requires students to read background material about the lines of evidence, make judgments about the connections between those lines of evidence and each competing explanatory model, and then determine which model is more plausible. The Moon formation pcMEL asks students, working in collaborative groups, to compare and evaluate the giant impact versus co-formation models. The Origins baMEL has groups evaluating two out of three possible models: the Big Bang, steady-state, and explosion models. These activities, among others in Earth science topics, are being developed as part of US NSF-funded projects (#2201012, 2201015), with all materials freely available to instructors. The activities are appropriate for secondary students as well as preservice secondary teachers and early undergraduate students.

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Astronomy education projects in Reunion Island: an overview of past, recent and upcoming activities

Matthieu Renaud[1,2], Sylvie Perrigault[3], Sébastien Boyer[4], Ludovic K-bidi[5], Lise-Marie Dandin[5], Emeric Le Floc'h[6], Samuel Challéat[7]

[1]LUPM, CNRS/IN2P3, Université de Montpellier, France. [2]OSU-Réunion, Saint-Denis, La Réunion. [3]A.A.R. organisation, Les Makes Observatory, Saint-Louis, La Réunion. [4]Académie de La Réunion, Les Makes Observatory, Saint-Louis, La Réunion. [5]Académie de La Réunion, Tévelave, La Réunion. [6]CEA/Département d'Astrophysique, Paris, France. [7]GEODE, CNRS/INEE, Toulouse, France

Abstract

For over thirty years, Les Makes Astronomical Observatory in Reunion island, a French overseas department about 700 km East of Madagascar and part of the Mascarenes Archipelago, has been dedicated to outreach activities, school-designed pedagogical and remote research programs in general astronomy. After summarizing its historical achievements, we will present the recent projects developed for teachers, primary and secondary schools, and at the University level, with a particular emphasis on participative sciences. We will discuss the OAE-supported Teacher Training Program (TTP22) and the associated pedagogical projects which have been carried out in relation with the preservation of the night sky, considered as a natural environment with an important cultural dimension, that needs to be preserved from the ever-growing light pollution. We will then discuss on how these starry-sky-based programs have the potential to increase the awareness among the participants regarding the light pollution issue and could open up to further interdisciplinary projects on the nocturnal environment. Future developments, especially within the recently-founded laboratory of citizen sciences LASCAR (**LA**boratoire de **S**ciences **C**itoyennes pour l'**A**cadémie et la **R**égion Réunion), through the setting of research programs dedicated to secondary schools in order to exploit the on-site instruments data, will also be presented.

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Office of Astronomy for Education institutional meeting

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Capturing the Magic: An Evaluation Framework and Toolkit for Assessing the Impact of Astronomy Education Practices

Dr Sophie Bartlett

IAU Office of Astronomy for Education. Cardiff University

Abstract

It is well known that inspiring and impactful astronomy education initiatives are taking place in schools across the world, but much of this knowledge remains largely anecdotal or based on limited feedback data from audiences. To further the field of astronomy education research outside of university level, we must work towards systematically evaluating educational practices to better understand what works to achieve outcomes, where challenges lie, and where efforts should focus.

This talk will introduce the audience to the Office of Astronomy for Education's recently launched Evaluation Framework and Toolkit. The open-access resource is designed to aid astronomy education practitioners in systematically evaluating their programmes to yield transferable, evidence-based practices. Employing a realist approach, the framework delves in to what works, for whom, and under what circumstances. This is a crucial feature that allows practitioners to account for the intricate nuances and complexities presented across different educational settings; the influence of cultural and practical components that vary not only across countries, but across local geographies and diverse school settings.

The resource guides users through evaluating their programmes from start to finish, through setting objectives; creating a logic model; deciding what type of data to collect, when to collect it, and from whom; ethical considerations; and choosing appropriate data collection tools.

During this presentation, the audience will be guided through the toolkit and introduced to the suite of data collection tools that they can adopt to systematically capture the engagement with and impact of the of their education programme.

Session

Office of Astronomy for Education institutional meeting

1502

OAE Center India: Baseline survey for the status of Astronomy education

Dr. Moupiya Maji[1], Prof. Surhud More[1], Prof. Aniket Sule[2]

[1]Inter-University Center of Astronomy and Astrophysics (IUCAA). [2]Homi Bhaba Centre for Science Education (HBCSE)

Abstract

The Office of Astronomy for Education (OAE), Center India was established in February 2022 at IUCAA in collaboration with HBCSE-TIFR, with three key objectives: professionalize astronomy education, provide access to quality resources, and promote astronomy in curricula in the Indian context. The Center has conducted and funded various teacher training programs within India and developed resources for facilitating and evaluating such workshops. The Center also generates quality astronomy resources, e.g. translations of the IAU astronomy glossary into Indian languages, converting them into graphical cards, translation of books related to Indian astronomy contributions, and generating a positional astronomy booklet aimed at school children. The Center has also created a textbook analysis tool to evaluate the different astronomy-related material in various textbooks within the country.

A significant focus of the Center is the promotion of astronomy in curricula, demonstrated through astronomy education research projects, like the Baseline Survey and Textbook Analysis projects. In the Baseline Survey for the status of astronomy education in India, we investigated student perceptions about various facets of astronomy education, e.g. astronomy content in the syllabus, interest in astronomy, and connections with their cultural knowledge. This survey was conducted nationwide in 10 languages with over 2000 students across different environments. We will present the analysis of data collected as part of this survey. The results reveal that although students are interested in astronomy, even basic astronomical concepts remain poorly understood. This data will inform the development of an improved astronomy curriculum and effective teacher training programs.

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Office of Astronomy for Education institutional meeting

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The IAU Office of Astronomy for Education – (brief) history and current state

Dr Markus Pössel

IAU Office of Astronomy for Education. Haus der Astronomie. Max Planck Institute for Astronomy

Abstract

Founded in late 2019, the IAU Office of Astronomy for Education (OAE) is the newest office of the IAU. Its mission, derived from the IAU's strategic plan 2020–2030, is to use astronomy to support primary and secondary school education world-wide. To this end, the OAE helps teachers to bring astronomy into their classrooms, and astronomers to support teachers and educators. Specifically, the OAE supports professionalisation in astronomy education, curates and produces helpful resources, and maintains an international network of volunteers to help coordinate astronomy education efforts. The talk gives an overview of the work that has been done so far at the OAE as well as future plans, and it discusses ways that astronomers can themselves actively support the OAE's work.

Session

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The 7 pillars for community building

Dr. Rosa Doran

NUCLIO. The Centre for Earth and Space Research of the University of Coimbra (CITEUC). COSPAR

Abstract

The sustainability of educational efforts is secretly hiding in the hands of empowered educators. There are hundreds of projects being funded every year to support the improvement of astronomy education. Many of these projects come with a component of professional development and a very small fraction foresee the creation or integration of a community of practice. The secret to the sustainability of projects is not providing access to free materials and resources available on the internet. It requires a strong component of professional development, support for their implementation and the existence of a community of practice. It also requires strong engagement strategies, recognition of the efforts and involvement of the whole school community. This presentation discusses the importance of the 7 pillars for community building: Engagement, training, support, recognition, community building, communication and evaluation.

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Office of Astronomy for Education institutional meeting

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Empowering Primary Science Educators: Insights from a Hands-On Astronomy Workshop in Ghana

Ms Sarah Abotsi-Masters[1,2,3], Mrs Naomi Asabre Frimpong[4,5]

[1]OAE. [2]Ghana Planetarium. [3]EduSpots. [4]Ghana Space Science and Technology Institute. [5]African Astronomical Society

Abstract

The Ghana NAEC team in collaboration with the Ghana Space Science and Technology Institute (GSSTI) organized a 2 day teacher training workshop for Primary science teachers, having been selected by the OAE as one of the recipients of the first batch of TTP grants. Science teachers from schools within a 10-mile radius of the Ghana Radio Astronomy Observatory (GRAO) were selected with the aim of fostering closer ties between the Observatory and the local community, while building capacity in teaching astronomy.

Topics for the workshop were selected from the Ghana Education Service Science curriculum. Each session utilized a PowerPoint presentation to introduce the main concepts, complemented by short videos, as well as astronomy software such as Stellarium and Celestia, and crucially all sessions featured engaging hands-on activities.

The response from the teachers was overwhelmingly positive, with their feedback stating the workshop was very useful, successful, insightful and an eye-opener. Prior to the training, teachers reported confidence levels in teaching astronomy topics ranging from 40% to 60%, and this rose significantly to 80% - 90% after the workshop. Teachers identified the videos and practical activities as the “most useful” parts of the workshop.

We believe that the training had a significant impact on the participating teachers, both in terms of improving their astronomy knowledge and by stimulating curiosity about our universe, a curiosity which we hope will be passed on to their students. The insights gained and challenges encountered during the workshop will be instrumental to future training initiatives.

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Office of Astronomy for Education institutional meeting

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Astronomical education enhances the future of humanity!-- Introduction of OAE Center China and its affiliated organization, Beijing Planetarium

Jian Li

the Beijing Planetarium, OAE Center China

Abstract

The Beijing Planetarium was officially opened to the public in 1957, and the OAE Center China was established in 2022 as an extension of it. In recent years, the Beijing Planetarium and OAE Center China have been actively involved in promoting astronomical education. Here are four key aspects of their work:

1.Development of Astronomy Courses for Primary and Secondary Schools: The course development project team collaborated with experts from the Physics Department of Tsinghua University to create astronomical teaching materials, including PPTs, teacher lecture materials, procurement of experimental equipment, and training for teachers for 15 courses.

2.Conducting Teacher Training: Annual teacher training sessions are held, attracting educators from various provinces and cities in China. The astronomy teacher training has been a reputable brand in China.

3.Astronomy Olympiads:The China National Astronomy Olympiad (CNAO), initiated in 2003 and hosted by the Beijing Planetarium, is one of the 28 national competitions for primary and secondary school students officially recognized by the Ministry of Education. Every year, the winning students of CNAO are sent to participate in IAO (International Astronomical Olympiad), IOAA (International Olympiad on Astronomy and Astrophysics), and other international Astronomy Olympiads. Beijing Planetarium and OAE Center China also hosted the International Astronomical Olympiads.

4.Astronomical Science Popularization through Live Streaming: Since 2019, the Beijing Planetarium has been organizing live broadcasts, featuring public science lectures and live explanations of astronomical phenomena. In 2023, it organized more than 40 live broadcasts.

These initiatives have transformed the Beijing Planetarium and OAE Center China into a boundaryless educational platform for children.

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Exploring the Efficacy of Hybrid Learning in Astronomy Education

Mr Muhammad Rayan Khan[1,2,3,4], Miss Hira Fatima[1,5,3]

[1]National Astronomy Education Coordinator team for Pakistan. [2]Cosmic Tribe SMC Pvt Ltd. [3]Institute Of Space Science And Technology (ISST), University Of Karachi. [4]Associate of IAU Inter-Commission C1-C2-C3-C4 WG Astronomy in Culture (WGAC). [5]National Center Of Big Data Analytics And Cloud Computing, NED-UET

Abstract

This study delves into the efficacy of hybrid learning in astronomy education, with a dual focus on enhancing engagement and deepening comprehension among students while emphasizing impact and accessibility. Employing a multifaceted approach that integrates qualitative analysis and quantitative evaluation, we aim to illuminate how hybrid learning impacts student engagement, comprehension, and preparedness for celestial exploration.

Drawing from empirical data and pedagogical insights, our investigation seeks to unravel the intricate dynamics that underpin the effectiveness of hybrid learning in astronomy education. Moreover, perspectives gleaned from a comprehensive survey of astronomy educators offer valuable insights into the implementation and effectiveness of hybrid learning methodologies, with particular attention to their impact and accessibility.

By enriching pedagogical discourse and equipping educators with innovative tools, our findings contribute to advancing astronomy education in a manner that emphasizes impact and accessibility. We aspire to inspire a new wave of cosmic enthusiasts, ensuring that the wonders of the universe are accessible to all who seek to explore them.

Session

Office of Astronomy for Education institutional meeting

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Astronomy Education and Outreach in Ethiopia, A Catalyst for Scientific Community Building

Alemiye mamo Yacob

Space Science and Geospatial Institute (SSGI)

Abstract

This talk provides a comprehensive examination of the current landscape of astronomy education and outreach in Ethiopia, emphasizing its role as a catalyst for scientific engagement and community development. Recognizing astronomy as a gateway to science, Ethiopia is strategically incorporating it into its educational framework to promote science literacy. The study investigates initiatives and programs implemented in schools and universities, shedding light on their effectiveness in fostering scientific interest among students. Additionally, the paper explores outreach initiatives and community engagement programs designed to bring astronomy closer to the wider populace, particularly underserved groups. Despite notable progress, challenges such as limited resources and cultural factors persist. The paper underscores the transformative impact of astronomy in building a scientific community, shaping Ethiopia's future scientific landscape, and contributing to global scientific endeavors. It concludes by identifying opportunities for growth, including international collaboration, technology integration, and leveraging local resources. Overall, this talk contributes to the ongoing discourse on astronomy education and outreach in Ethiopia, offering insights into its challenges, impact, and potential for fostering a vibrant scientific community.

Session

Office of Astronomy for Education institutional meeting

2406

Astronomy Education in Brazil

Prof Alan Alves-Brito

Federal University of Rio Grande do Sul

Abstract

Despite advances in recent years, astronomy education faces major curricular and epistemological challenges, capable of addressing the structural issues that cross the country in the 21st century, especially when taking into account the potential that astronomy develops as one of the most exciting fundamental basic sciences. I will present, in this talk, a critical overview of the research on Astronomy Education in Brazil, presenting its current challenges and possibilities. I will present some of our national initiatives at primary and secondary schools, which have allowed us to rethink the initial and continuum formation of primary and secondary teachers, as well as the creation of an anti-racist and anticolonial education project in astronomy, which have helped us to problematize socioscientific, methodological, epistemological and curricular issues in basic and higher education in astronomy.

Session

Office of Astronomy for Education institutional meeting

2641

OAE Teacher Training Programme - Astro-STEM Workshop and Mentorship for high school teachers in Kenya.

Dr. Ann Njeri[1], Ms. Susan Murabana[2], Ms. Tabitha Alango[3,4]

[1]Newcastle University. [2]Travelling Telescope. [3]Maasai Mara University. [4]Elimisha Msichana Elimisha Jamii na Astronomia

Abstract

Astronomy education in Kenyan secondary schools is currently limited, despite its relevance to science subjects including physics and geography.
Elimisha Msichana Elimisha Jamii na Astronomia (EMEJA) is committed to addressing this gap and fostering appreciation for Astronomy through Astronomy outreach and Astro-STEM workshops and mentorship programmes aimed for high school students in rural regions of Kenya. To complement these Astro-STEM workshops and mentorship for students, we delivered a similar workshop aimed for the teachers in the participating schools in Kitale, Kenya. The objective of the Astro-STEM workshop and mentorship for teachers was to help enhance the teachers understanding of Astronomy and its relevance in everyday life, with a focus on integrating simple Astronomy hands-on practicals in classroom teaching. We trained the teachers on how to use softwares such as Stellarium in the classroom and how to model the solar system using readily available materials such as clay and toothpicks for effective delivery of topics such as the solar system. We also discussed some of the strategies that can be used to overall, enhance the delivery and performance of STEM subjects in high schools. Here, we will share the workshop design, implementation, success and why such workshops are important in complementing Astronomy education and outreach.

Session

Office of Astronomy for Education institutional meeting

2653

Initiatives for Astronomy education in Low-income schools in Pune – India

Dr. Raka Dabhade

Fergusson College, (Autonomous) Pune, India

Abstract

The department of physics, Fergusson College, Pune offers Astronomy and Astrophysics as one of the subjects. In this regard, apart from Astronomy popularization among the general public through Astro Club we have also taken up the issue of popularizing the subject in low-income government schools where by the teacher student ratio is extremely high and science and math's teachers are also not available in many of these schools.

Students from the physics department both undergraduate as well as postgraduate students visit these schools as part of their continuous internal assessment. Various topics in basic astronomy are prepared by the students and with the permission of the school principal lessons are conducted at primary and secondary schools. The classes are conducted in local language with some mixed English words. The school teachers also enjoy these lessons and simultaneously get insights into Astronomy education.

The students then submit a copy of their presentations together with other teaching aids, with geotagged photographs of the sessions conducted and a completion letter form the school principal. The students are then graded accordingly by our physics department staff.

Due to this exercise apart from educating the children in these low-income schools, the teachers there are also exposed to the subject and our students to feel socially responsible and enhance their teaching skills. In this work we present these activities carried out in various low-income schools in and around Pune city in the state of Maharashtra, India.

Session

Office of Astronomy for Education institutional meeting

2876

ACEAP - The Chile Expedition for Astronomy Educators and Outreach Professionals

Tiffany Stone Wolbrecht[1], Yasmin Catricheo[1], Tim Spuck[2]

[1]Associated Universities, Inc.. [2]U.S. National Science Foundation

Abstract

Since 2015, the Astronomy in Chile Educator Ambassador Program (ACEAP) has been bringing amateur astronome, K-16 formal and informal educators, planetarium and science center professionals and astronomy communicators and influencers to the U.S.-funded observatories in Chile. While at these facilities, ACEAP Ambassadors get special access and training related to the facilities and instruments, the science, data products, and communicating STEM concepts. Throughout the Chile expedition and when they return home, Ambassadors share their experience and observatory resources with schools, community groups, and the general public. This innovative professional development experience is open to ten astronomy education and outreach professionals here in the U.S. and abroad annually, and has often been described by many participants as, “the best professional development experience of my life!” Five positions are funded by an NSF grant and the remainder are funded by participants or their institution. Visit https://astroambassadors.com/ for more information or to submit your application. ACEAP is a collaboration between Associated Universities Inc. (AUI) and Association of Universities for Research in Astronomy (AURA), and the observatories they manage in Chile, including CTIO and Gemini which are now part of the new NSF’s NOIRLab, and the National Radio Astronomy Observatory and ALMA, and is supported by the National Science Foundation.

Session

Office of Astronomy for Education institutional meeting

3114

Where astronomy and exploration meet - celebrating celestial navigation!

Dr Nicola Loaring, Dr Steve Bell, Miss Toni Wilmot

His Majesty's Nautical Almanac Office (HMNAO), UKHO.

Abstract

This abstract introduces an innovative series of workshops designed for primary and secondary school students, aiming to intertwine history, science and maths in the study of celestial navigation. They focus on scaffolded inquiry based learning activities incorporating fun practical activities and demonstrations. Linked to and expanding upon the UK national curriculum, the activities can be adapted for use both within the classroom and for STEM club activities worldwide.

1. The history of celestial navigation:

Students delve into the history of celestial navigation from ancient civilizations to modern-day innovations, uncovering examples from diverse cultures around the world. Through engaging activities and storytelling, students are introduced to the significance of celestial navigation in shaping human exploration.

2. The changing sky:

In this astronomy-focused workshop, students explore the motion of stars, the moon, and the sun in the sky. Bridging primary and secondary science, students will observe changes for themself as well as learn about the underlying reasons for moon phases, eclipses, solstices, equinoxes and orbits via interactive demonstrations, hands-on experiments and simulations.

3. The tools of celestial navigation:

This workshop introduces students to both historical and modern tools used in maritime and space based celestial navigation. By integrating elements of history, design & technology, science and mathematics, students are immersed in constructing and using their own sextants.

Session

Office of Astronomy for Education institutional meeting

3169

Bridging Cultures through STEAM: The MIRTO /STEAM-Med Initiative for Primary Education in the Mediterranean

Alessandra Zanazzi[1,2], Dr Sara Riccardi[1,2], Dr Stefano Sandrelli[1,2], Claudia Mignone[1,2], Livia Giacomini[1,2], Stefania Varano[1,2], Silvia Casu[1,2], Gloria Tirabassi[1,2]

[1]INAF, National Institute for Astrophysics, Italy. [2]OAE Centre Italy

Abstract

Since establishing the I-OAE office, our team has championed a co-design approach involving National Astronomy Education Coordinators (NAEC) and educators. This choice is grounded in the belief that grassroots processes are essential for developing activities both meaningful and beneficial to diverse communities. This strategy also aims to foster new connections across countries and among individuals. Our pilot project, MIRTO/STEAM-Med, represents a practical embodiment of this philosophy. It involved the co-design of educational resources around the common theme of light, which were implemented first remotely, facilitating peer pairing and mentoring among NAEC of 12 countries and later during a one-week, in-person workshop on the island of Lampedusa, a highly symbolic location at the heart of the Mediterranean sea. Finally, all resources have been published in a multilingual booklet and on the open online platform AstroEdu. As such, this project is strategically positioned at the nexus of our focal interests: primary education for children up to 12 years and the Mediterranean region.

Our contribution will focus on the MIRTO/STEAM-Med project's commitment to inclusivity, collaboration, and innovation in educational practices, providing insights into the potential and challenges of co-designed educational initiatives. We will also discuss our ongoing collaborative efforts in Astronomy Education in the OAE framework: FRESCO and Sabir. Both projects involve online meetings and a week of in-person activities. Both are co-design projects: Sabir to produce IBL activities for high school students; FRESCO playful and Game-based-learning resources for children (up to 12 years) within a worldwide community.

Session

Office of Astronomy for Education institutional meeting

3170

Fostering Collaborative Environment in Astronomy Education for science teachers in Asia

Manisha Dwa[1,2], Suresh Bhattarai[1,2]

[1]OAE Node Nepal, Kathmandu, Nepal. [2]Nepal Astronomical Society, Kathmandu, Nepal

Abstract

OAE Nepal Node (N-OAE), established in July 2021, mainly focuses on citizen-science projects in low-tech environments, teacher training programs and training for astronomy Olympiads whilst working to build the OAE's network of collaborations particularly in the SAARC region and, more generally, with countries facing similar challenges around the globe.

The first three years of the N-OAE was spent mainly re-building the network, re-connecting with peers in the region and implementing some of the activities of Nepal Astronomical Society that have high impact at the regional level. It will mainly discuss the N-OAE's works with people in the SAARC countries: Afghanistan, Bangladesh, Bhutan, India, Nepal and Pakistan. The paper discussed how N-OAE supported OAE HQ within its capacity for its several activities. Also, it will discuss the collaborative efforts with OAE Center India for proposing the Regional SHAW-IAU Workshop on Astronomy for Education in Nepal. Similarly, it will discuss its relation with OAE Center China and Yunnan Observatory for the capacity building of astronomy educators through its International School for Regional Young Astronomers (ISRYA) held in December 2023. It will also discuss the collaborative efforts with IAUS375 organizing committee and NAEC Nepal to introduce about N-OAE and conduct teacher training programs in 2022 and 2024 in Nepal.

Finally, it will discuss the challenges, opportunities and impacts of the cross-cultural, cross-border approach of N-OAE while working from Nepal.

Session

Office of Astronomy for Education institutional meeting