Patrika

July 1993 No. 28 Newsletter of the Indian Academy of Sciences

59th Annual Meeting

At the invitation of the Indian Institute of Petroleum, Dehra Dun the 59th Annual Meeting of the Academy will be held at Dehra Dun, from 5 to 8 November 1993.

The scientific programme will consist of two symposia, two evening lectures and lecture presentations by new Fellows and Associates.

All Fellows and Associates attending the Annual Meeting will be paid first class railway fare from their place of residence to Dehra Dun and back, in case they are unable to obtain travel support from other sources. Arrangements for the stay of Fellows, Associates and other delegates will be taken care of by the organizers.

During the period of the Annual Meeting, the Editorial Boards of the Academy journals and the Sectional Committees will also meet at Dehra Dun.

Mid-Year Meeting

The fourth mid-year meeting now a regular feature of the activities of the Academy, will be held on Friday, 23 July and Saturday, 24 July at the Indian Institute of Science, Bangalore.

There will be 16 lectures by new Fellows and Associates and an Evening lecture by Prof. U R Anantha Murthy, Sahitya Akademi, New Delhi on "The search for identity in an Indian writer: A personal view".

The lectures by Fellows and Associates are:

R. Ramaswamy, JNU, New Delhi
"Experimental quantum chaos"

G.R. Desiraju, University of Hyderabad, Hyderabad
"C–H...O hydrogen bonds and molecular recognition"

A.K. Raychaudhuri, IISc., Bangalore
"Certain recurring themes of metal-insulator transition as seen at low temperatures"

A.K. Kshirsagar, IUCAA, Pune
"Gravity without metric"

S.P. Bhattacharyya, IACS, Calcutta
"On the analysis of reaction paths – A local versus a global approach"

A.V. Krishna Murty, IISc., Bangalore
"Theoretical modelling of structural components"

A.K. Lala, IIT, Bombay
"From membranes to molecular devices"

K.N. Ganesh, NCL, Pune
"Chemically modified nucleic acids: Synthesis and applications"

S.K. Saidapur, Karnatak University, Dharwad
"Evolution of diverse reproductive patterns among the Indian amphibians"

K. Dharmalingam, MKU, Madurai
"The fragile genome"

K.V.S. Rao, International Centre for Genetic Engineering & Biotechnology, New Delhi
"Development of new vaccines: Problems and perspectives"

R. Bhatia, ISI, New Delhi
"Perturbation of matrix spectra"

U.C. Mohanty, National Centre for Medium Range Weather Forecasting, New Delhi
"Role of physical processes on the simulation and prediction of Asian summer monsoons"

R.K. Shyamasundar, Tata Institute of Fundamental Research, Bombay
"Challenges in the design of real-time reactive systems

A. Nangia, University of Hyderabad, Hyderabad
"Synthesis of iridoid lactones"

R.K. Saxena, Jawaharlal Nehru University, New Delhi
"Cytokines in cellular communications"

Molecular Electronic Structure and Dynamics

A National Symposium on "Recent Trends in Molecular Electronic Structure and Dynamics Calculations" was held from February 5 to 7, 1993 in the Department of Chemistry, Indian Institute of Technology, Kharagpur, under the sponsorship of the Academy, with partial financial support from the Indian National Science Academy, New Delhi. Thirty scientists including a few research scholars took part in the Meeting. Twentyseven papers covering various frontier areas in theoretical chemistry were presented. This Meeting was to have been originally held from December 11 to 13, 1992, but was postponed to February 1993 due to political disturbances in the country. Due to the smaller number of participants than that expected earlier, the topic-wise programme as planned could not be followed.

The technical sessions started with the inaugural lecture by D. Mukherjee (IACS, Calcutta), dedicated to late Prof. S. Basu, former Palit Professor, Calcutta University and former Director, IACS, Calcutta. D. Mukherjee spoke on averaged quantum dynamics in the strong coupling regime within a coupled cluster framework.

A. Saran (TIFR, Bombay) reported on quantum mechanical PCILO calculations on the conformation of three selective dopamine D2-receptors, namely, remoxipride, eticlopride and NCQ 115.

D. Majumdar (IACS, Calcutta) spoke on a theoretical study of conformational and electronic properties of several novel heterocyclic cardiotonics. R.P. Semwal (SGRR College, Dehradun) presented a method based on molecular connectivity to predict b–p, m–p, density and r.i. of normal hydrocarbons. Parallelisation of the SCF method for closed shell molecules and the parallelisation of molecular electrostatic potential program on a highly parallel transputer based system, PARAM, was described by A.C. Limaye (University of Poona). The effect of basis sets and population analysis schemes on the calculation of group electro-negativity was next described by S. Nath (IIT, Kharagpur).

An intermediate Hamiltonian approach in tackling size-extensive dressing in molecular many-body theory was reported by D. Mukhopadhyay (IACS, Calcutta). P.K. Nandi (IIT, Kharagpur) spoke on *ab initio* calculations on the electronic structure, stability and bonding of dialkali and dihydrogen halide cations. A.K. Mishra (Matscience, Madras), elaborated the effect of chemisorption of electronic transitions at an electrochemical interface. Biplab Bhattacharya (IISc, Bangalore) described the results of the calculations of electron-transfer rates at the interfaces as a function of parameters related to the electronic structure of the reactant, adsorbate, the condensed phase substrate and the solvent. Two approaches to the wave packet dynamics on coupled electronic surfaces were presented by M. Durgaprasad (Central University, Hyderabad).

S. Pal (NCL, Pune) reported on a coupled cluster response approach for the study of molecular properties. Various strategies based on theoretical studies, for tailoring electrically conducting polymers were described by A.K. Bakshi (Panjab University, Chandigarh). M. Banerjee (Burdwan University) discussed the applicability of AM1 and MNDO methods in the calculation of molecular polarisability and hyperpolarisability. The status of the notion of lifetime in the first order processes was critically examined in his talk by K. Bhattacharya (Burdwan University).

A.K. Mukherjee (Raj College, Burdwan) described a graph–theoretical procedure based on the vertex alternation scheme for the determination of eigenvalues of Huckel matrices. The use of cellular automata in solid state and dynamical calculations was discussed by N. Sukumar (Theorie Intel, Madras) with reference to Su-Schrieffer-Heeger Hamiltonian. S.K. Ghosh (BARC, Bombay) described a density functional formalism for Coulomb liquids. P.K. Chattaraj (IIT, Kharagpur) reported on *ab initio* calculations on a large number of binary complexes resulting from acid-base interactions in order to elaborate the HSAB principle.

Ab initio calculations were reported by S. Singh (IIT, Madras) to understand the nature of ion–molecule interactions on the basis of stabilisation energy, force constant and harmonic frequency.

A serious disagreement between theory and experiment was pointed out by A.B. Sannigrahi (IIT, Kharagpur) in the electronic spectrum of SiH^+. A.K. Bhattacharjee (Bose Institute, Calcutta) reported on theoretical estimates of the rotational barrier around the C–C bond adjacent to the CN group in methyl and ethyl amines. B.L. Tembe (IIT, Bombay) dealt with

molecular dynamics simulation on systems relevant to charge transfer processes. A general feature of the topograph of molecular electrostatic potential was presented by R.N. Shirsat (University of Poona).

G. Sanyal (IACS, Calcutta), presented a systematic non-perturbative cluster cumulant method of deriving thermal averages of quantum many-body systems and illustrated its application to strongly coupled anharmonic oscillators. N. Sathyamurthy (IIT, Kanpur) reported on the results of a three-dimensional time-dependent quantum mechanical study of the reactions $He + H_2^+$ $He H^+ + H$ for zero angular momentum collisions in hyperspherical coordinates. Applications of electric field mapping to molecular recognition and reactivity were described by P.C. Mishra (Banaras Hindu University).

The last technical session was followed by an informal half-an-hour discussion on the future trend of theoretical chemistry in India. Based on the feedbacks received from the participants it was suggested that younger scientists and research scholars should be more actively associated with this type of Meeting than their well established colleagues. The date and venue of the next Academy Discussion Meeting on the same topic were tentatively fixed.

Special Publication

Hepatitis B Virus and the Public Health, Selected papers of Baruch S. Blumberg– Introduction by W. Thomas, London, 1992, pp. 505, Rs.175/US $30.

Professor Blumberg visited India during 1986 as Raman Visiting Professor. The Council of the Academy considered it appropriate to publish a volume of his selected papers in view of the continuing public health interest in the Hepatitis B Virus and the present volume was published in 1992.

Blumberg received the Nobel Prize in Medicine in 1976 for the discovery of the hepatitis B virus (HBV) and for studies of the variation in host response to the virus. He with his colleague Irving Millman also invented the first vaccine for hepatitis B, a vaccine that was unique in concept in that it was derived from viral proteins circulating in the peripheral blood of humans chronically infected with the virus.

The present volume consists of 3 parts. The first on hepatitis B virus consists of 46 papers with subsections on hepatitis B virous sub-types, sex ratio, insects and cancer, published during 1965–1988. The second on epidemiology and polymorphisms consists of 12 papers. The last, consists of 8 miscellaneous papers.

Prof. Blumberg's Gandhi Memorial Lecture on "Solving and Creating Problems: Hepatitis B Virus and the Public Health" delivered at the Raman Research Institute, Bangalore on 30 January 1986 is reproduced in full in the beginning of the volume followed by an introduction to the selected papers by Blumberg himself. At the end is a complete list of 413 papers published by Blumberg and his colleagues from 1951–1990.

Special Issue of Journal

Proceedings in Earth and Planetary Sciences, Vol. 102, No.1 March 1993, pages 1–281, "Climate and Global Warming".

Climatic changes have now attracted worldwide attention. By mid-October 1992 the UN Framework Convention on Climate Change had been signed by over 150 countries. The World Meteorological Organization has for many years organized the World Climate Programme, with its many sub-programmes such as the World Climate Research Programme and the Programme on Climate Variability. The UN Conference on Climate and Development held in Rio de Janeiro in June 1992 set up guidelines to prevent further degradation of the environment (Agenda 21). This special issue is devoted to climate in view of the worldwide interest in climate and climate change.

The articles are divided into five sections. Beginning with two overviews by acknowledged experts in the field, on the "Increased greenhouse effect" by A Wiin-Nielsen and on "Climate and global change in relation to sustainable development: The challenge to science" by G O P Obasi; the next section deals with predictability and interannual variability and consists of 6 articles covering different aspects ranging from rainfall anomalies, the predictability of a coupled ocean– atmosphere model to a climate attractor. The next section is on forcing mechanisms, fluctuations in relative sea level and a model for simulating the circulation in the Bay of Bengal. Regional studies are described in the next section from East Africa to Malaysia. The last section deals with atmospheric chemistry

and the impact of data collected by INSAT.

The Editor is to be congratulated on preparing and publishing this special issue and it is hoped that it would encourage younger scientists.

Obituaries

Dilip Kumar Banerjee was born on 16 January 1912. He took his D.Sc. degree in 1941 from the Calcutta University, after which for the next 6 years he worked as Sir P.C. Ray Post-Doctoral Fellow and as Honorary Lecturer in the Post-Graduate Department, Calcutta University. In 1946 he joined the College of Engineering and Technology, Jadavpur, as Professor of Organic Chemistry and worked there till 1954, during which period he was Watumull Foundation Fellow and Post-Doctorate Fellow of the University of Wisconsin from 1947–49. He joined as the Head of the Department of Organic Chemistry, Indian Institute of Science in 1954, a position he held with distinction till 1971. The next academic year, 1971–72 he was the Director of the Institute. He continued his association with the Department as Honorary Professor till 1975.

His subject for research were the synthesis of steroids, terpenoids etc; reaction mechanism, spectroscopy and X-ray crystallography. It is easy to recognize at least three influences which shaped the direction and content of his research work:

(1) An approach to synthesis and structure prevalent at the Science College of the Calcutta University during the thirties and forties, on the synthesis of polycyclic compounds, degradation products – of bile acids of other steroids and terpenoids. (2) His collaboration with W.S. Johnson at Wisconsin culminating in a significant paper on the synthesis of the mammalian female sex hormone esterone and its isomers in 1952. (3) His appointment to the Chair of Organic Chemistry – a position which did not have any formal teaching duties, but an access to abundant pool of talented students and post-doctoral workers, and last but not the least, the services of a preparation section where intermediates involving more than eight steps could be prepared and supplied to the students.

For a person trained only in the classical methods of organic chemistry, he made every effort to use in his research work, most of the physical tools for the determination of structure as these tools became available. He believed, however, in teaching and learning from laboratory experience. In the field of his interest he was an extremely careful and thorough experimental investigator. In his writing and talking to small groups his gift of expression and rare feeling for the idiom were evident. In giving credit to his collaborators and students he invariably displayed a sense of fair-play and often generosity.

He was a deeply religious person. Sometimes his friends and colleagues could be embarrassed by his enthusiasm for lost causes. He was elected a Fellow of the Academy in 1957.

After a protracted illness he passed away at Bangalore on June 10, 1993.

Podila Brahmayya Sastry was born on 24 May 1913, in a doctor's family at Kakinada, Andhra Pradesh. He graduated from Andhra Medical College and obtained his MBBS degree in 1939. He joined the Department of Physiology and started teaching and research and obtained his M.Sc. in Physiology, from the Andhra University in 1952. He was deputed under the Colombo Plan to work under Prof. F.C. MacIntosh, FRS., studied the acetylcholine transmission in brain and nerves and obtained his Ph.D. degree in Physiology from McGill University, Montreal, Canada, in 1956.

He held the post of Professor of Physiology from 1951 to 1968 and acted as Vice-Principal and Principal from 1964–68. Even after his retirement he continued research till 1985 as Emeritus Medical Scientist, ICMR, as medical retired teacher-scientist of UGC and Emeritus Scientist, Andhra Pradesh.

His outstanding original research interests were in (1) Vitamin C metabolism in health and disease, (2) acetylcholine transmission in brain, ganglia, nerves and neuromuscular systems, studies on experimental focal cortical seizures in cats, choline and acetylcholine fluxes in the brain of rats, (3) acetylcholine activity in human placentas in health and disease, and (4) experimental and clinical studies on the bioaccelerator effects of "Filatov's biogenic stimulators" in placental extract.

He was elected a Fellow of the National Academy of Medical Sciences in 1970 and the Indian Association of Biomedical Sciences in 1989. He was elected a Fellow of the Academy in 1978.

He passed away on 28 May 1993. In his death, we have lost a dedicated teacher, distinguished research worker and humanitarian.

Daulat Singh Kothari was born on July 6, 1906. After his early schooling in, what is now Rajasthan, he went to Allahabad to do his M.Sc. in physics. His life-long association with Prof. M.N. Saha, who was then at Allahabad, began at that time. He went to England for his higher studies and obtained his Ph.D. from the Cambridge University. He worked with Fowler, Rutherford and Kapitza. In his scientific work he applied the ideas of quantum statistical mechanics to the study of stellar objects. He calculated the effect of pressure ionization in stellar systems and came to the conclusion that objects more massive than the planet Jupiter will be unstable against collapse due to pressure ionization. This work attracted considerable attention at that time.

Soon after his return to India he joined the University of Delhi as a Reader and Head of the Department of Physics in 1934. Delhi University had a very small department of physics at that time with no post-graduate courses. M.Sc. course started in 1942. He was soon successful in making the physics department of Delhi University into a leading one not only in India but also internationally. Quantum mechanics and field theory were taught to students in M.Sc. classes for the first time in India, in the forties and fifties.

Around 1948 he joined as defence science adviser to the Government of India while continuing his teaching in the university. He was responsible for the emergence of several defence science laboratories and for creating experts in this area and inspiring them to do work of high quality. He applied some of the ideas, which he had used earlier, like pressure ionization, to defence science areas like the theory of explosives. The Government of India had invited Prof. P.M.S. Blackett from UK to advise them on operational research. With the help of Prof. Blackett, whom he knew from his Cambridge days, he introduced the study of operation research in defence science as well as in academic departments.

In 1961 he was appointed Chairman of the University Grants Commission. He held this job for more than 10 years. During this period he was Chairman of the Education Commission constituted to prepare a report on the whole field of education. The report of the body, generally known as the Kothari Commission report presented in 1966, formed the basis of the national educational policy adopted by the government. The scheme of 10 + 2 +3 for education in force now was one of the recommendations made and another which was implemented, was that of science subjects being made compulsory for all students up to the 10th class. He was also chairman of the commission on scientific and technical terminology during 1961–64. He took active interest in school science education and textbook writing, which was then being taken up by the newly started National Council for Educational Research and Training.

He was Chancellor of Jawaharlal Nehru University, New Delhi. His simplicity, sincerity, nobility, coupled with his sharp intellect, which enabled him to penetrate to the core of a problem, made politicians, bureaucrats and scientists seek his advice till his last day.

The revolution of quantum mechanics left a lasting impression on him. He loved to teach quantum mechanics and in his lectures and conversations brought in the ideas of duality and uncertainty to illustrate scientific and other phenomena. He took pleasure in deriving many difficult results in a simple way using Heizenberg's uncertainty principle. He used to remark on the similarity in the underlying principles of quantum mechanics and the ideas of Indian philosophy especially the ideas in the Upanishads, Bhagawadtgita and Syadvad of jain philosophy. He will be always remembered as a natural and highly gifted teacher. He strongly believed in the necessity for a "teacher to be always a student and keep learning". Till the end, he would surprise people by his awareness of modern developments in science. Even as chairman of UGC he would devote at least one hour every day to reading the latest journals in physics.

He was awarded the Padma Bhushan in 1962 and Padma Vibhushan in 1973. He was elected general president of Indian Science Congress in 1964. He was President of the Indian National Science Academy in 1973 and was elected foreign member of USSR Academy of Sciences in 1973. He was elected a Fellow of the Academy in 1975. He was a Fellow of the Third World Academy and received the UNESCO award for distinguished contributions to the objectives of UNESCO.

In the last decade he became increasingly interested in the relationship of science and religion and in overlapping areas of philosophy and science like the nature of time, the place and role of consciousness in science and the Gandhian attitude to life and industry. He believed in a holistic approach to the study of the individual, science and society. To many his death is a highly personal loss of a wise and loving father figure. He passed away on 4 February 1993.

Chengalur Raman Narayanan (known as CR to his friends and close associates) was born on 17 December 1916 at Cherpu village of Trichur District, Kerala as the eldest of 10 children of

Shri Raman Ezuthachan and Srimati Mankamma in a traditional and enlightened family.

His education and career started with a concurrent interest in literature as well as science. He completed his graduation in Sagar University and took his doctorate in Chemistry from Allahabad University in 1951. After a brief lecturership at Sagar University, he spent a few years as Research Associate with Prof. L.F. Fieser (Harvard), Prof. D.H.R. Barton (Glasgow), and Prof. E.E. Van Tamelen (Wisconsin).

His independent research career started at National Chemical Laboratory (NCL) in 1959. After his retirement from NCL in 1976, he continued his research activities at the Indian Drug Research Institute, Pune as a Research Scientist and also as a Faculty Member for M.Pharm. courses in Poona University. During his career he built up a strong school of organic chemistry. His main interest was in natural product chemistry. His contribution, in neem chemistry, and conformational/stereochemical studies of complex organic molecules are well-known. His second love was Malayalam literature. He authored several books including an anthology of poems. He was member of the Kerala Sahitya Akademi and his treatise on scientific birth control won him an award in 1950.

In spite of a nagging asthma, his constant companion, he was always genial, hard working and helpful to all. Throughout his long career in science as well as literature, he endeared himself to his associates and students as a man of great sensitivity and as a perfect teacher.

He died of cardiac arrest on January 15, 1993. He is survived by his wife, four daughters and a son.

Bernard Peters, a renowned cosmic ray physicist, passed away at the age of 82 in Copenhagen on 2 February 1993. He will be remembered for his fundamental contributions in a broad range of fields by his students, colleagues and friends in the US, India and Europe where he worked. The story of his life is a long list of adventures, both as a physicist and as a person.

He was born to Bernhard Pietrkowski of Jewish heritage in 1910 in the German city of Posen (now Poznan, Poland), grew up in the Rhine Valley at Freiburg, where his father did research in pharmacology and practised internal medicine. During the latter part of World War I, when food was short, young Bernard was sent up to the Black Forest to stay with a farm family, where he herded sheep and partook of the more abundant peasant diet.

He was a student of the Technical University in Munich in 1933, the year Hitler came to power. As a student activist in the struggle against the Nazis, Bernard was seized within the first few days of Hitler's taking over, and was taken to the concentration camp at Dachau. He escaped from the camp after three months, travelled by night on a bicycle through the Alps and on to Italy. There he joined his girl friend Hannah Lilien, who had gone to Padua to study medicine and then onto England where he remained until he obtained a visa to the US in 1934. Soon he found a job in an import firm in New York during the deepest period of the depression. Hannah moved to the US in 1934 and they were married the same year. Bernard did well in the business firm, but when Hannah finished her medical degree in 1937, he quit. They bought an old Ford car, dubbed it 'Felix', and with hardly any money in hand, the couple set out to the west coast. (Philip Morrison has narrated an interesting anecdote involving Felix in his article on Bernard Peters' science.) Hannah worked as a Research Fellow in the Stanford University Medical School and Bernard as long-shoreman in the San Francisco shipping docks. Then came the change which was to last. At a social occasion he met Robert Oppenheimer who encouraged him to come to the University of California, Berkeley as a graduate student. Thus in 1938, he began his career in physics. He did a theoretical thesis with Oppenheimer, earning his Ph.D in 1942, but then promptly engaged himself with experimental physics at the Radiation Laboratory, under Ernest O. Lawrence, for the next 3 years, working on the Manhattan project.

After World War II, he was part of the team that did experimental and theoretical work to implement the frequency modulated cyclotron concept, using the large magnet at the Radiation Laboratory, that had recently served to separate the isotopes of uranium.

In 1946 he joined the physics faculty at the University of Rochester where he soon entered into a fruitful collaboration with Helmut Bradt, an experimentalist from Zurich. In 1947 they joined with physicists at the University of Minnesota in a two-pronged experiment to look at interactions in matter of the primary cosmic rays near the top of the atmosphere. The Minnesota instrument was a cloud chamber while the Rochester detector was a stack of glass-mounted photographic emulsions, both carried aloft by a high-altitude 'Skyhook' balloon. Both teams showed, from the density of ionization along the particle tracks, that the primary cosmic-rays include the nuclei of heavier elements, along with the much more abundant protons.

The emulsions proved to be a most suitable means for studying these events and in a series of pioneering papers Peters and Bradt explored in detail the chemical composition (up to iron), abundances, energies and interactions of these newly-discovered heavy primary cosmic-rays.

In October of 1949 he met H.J. Bhabha, Director of the Tata Institute of Fundamental Research (TIFR), Bombay, who had an ongoing stratospheric balloon flight programme, to discuss a collaborative experiment between TIFR and the University of Rochester to study this problem. He arrived in Bombay the following August with several orientation platforms, designed to hold stacks of emulsion in a fixed direction in space during a flight. A number of flights were carried out from Madras. Subsequent analysis at TIFR and in Rochester showed that not more than one heavy nucleus in a thousand is anti-matter.

Bhabha invited him to come to TIFR to build what would become a world-class group of cosmic ray research. In 1951 he and his family moved to Bombay and commenced a new phase in his career.

No sooner had he joined TIFR, than he began a series of investigations, partly centered on analyses of nuclear emulsion plates exposed earlier to cosmic-rays at high altitudes, and partly on experiments requiring new balloon flights. The next few years marked the most active scientific era in the history of TIFR. During this period, a great deal of new information was acquired about the nature of nuclear interactions at ultra-high energies: (1) about several types of elementary particles, (2) the property of their 'associated' production, and (3) nature of interactions.

The success of his group was a direct result of his approach to the problem, namely processing a stack of free-floating, large, thin emulsion sheets so that charged particle tracks could be traced forwards on backwards through these emulsion pellicles. The new results, particularly on the masses and modes of decay of the K-mesons, presented at the 1953 Cosmic Ray Conference in Bagneres de Bigorre, served to put TIFR among the top laboratories in the world map of cosmic ray and elementary particle research. A new scientific activity was started by Peters in 1955, namely the search for the cosmic-ray-produced isotopes, ^{10}Be, and ^{7}Be detected in 1955 Bombay rains and in 1956 in Pacific marine sediments. Two other nuclides, ^{35}S and ^{33}P, produced in the atmosphere by cosmic ray spallations of argon were detected in Bombay rains. The capability developed at the TIFR in the field of low-level counting and radiochemistry led to the discovery of six other cosmic-ray-produced radio nuclides during 1955-56. The work carried out at that time is still valid, and forms the basis for a wide variety of cosmic ray geophysical studies.

For personal reasons, Peters left India in 1958 for Copenhagen, where he joined the Niels Bohr Institute of Theoretical Physics first and later established the Danish Space Research Institute and was its first Director. He held this position until his retirement in 1979. He had a small nuclear emulsion group that carried out studies of elementary particle collisions using emulsions exposed to cosmic rays in balloons or to high energy particles in accelerators. When the Proton Synchrotron commenced operation at CERN in 1959 he spent considerable time in Geneva where he was involved, directly or indirectly, in a number of experiments using 28 GeV protons. He wrote extensively, including two review articles on cosmogenic nuclides as geophysical tracers, and a detailed theoretical analysis (with Yash Pal) on the propagation of the nucleonic component of cosmic rays through the atmosphere. The latter inspired the search for 'plutons', the heavy particles later to be identified with 'Quarks'.

The new Danish Space Research Institute undertook work in two areas: (1) the Earth's magnetosphere, and (2) the cosmic radiation. In the magnetosphere area, he organized the first ESRO geostationary research satellite, GEOS. In the cosmic ray field DSRI pioneered the use of spark chambers in balloon instruments for composition studies, making possible detectors of large area since track determination permits non-uniformities in detector response to be calibrated out.

He leaves behind his wife, Dr Hannah Peters, known internationally for her researches in reproductive biology; a son and a daughter and a large number of friends and colleagues, who will miss him for several reasons: for his collaboration and for his fervent and passionate look at the Universe.

Annamalai Ramanathan was born in Madras on 29 August 1946. He belonged to the distinguished Annamalai-Chidambaram Chettiar clan, known for their business acumen as much as for their philanthropy and commitment to education. He studied at the Ramakrishna Mission High School and later at the Vivekananda College and obtained his M.Sc. degree in mathematics from the University of Madras in 1969.

He was interested in sports and athletics while at school. Within a few weeks of the end of High School he had a virulent attack of poliomyelitis which was to cripple him for life.

He did not allow this circumstance to limit his activities including, in later life, professional visits abroad. What is more, he took the misfortune with amazing equanimity and never felt bitter.

His research career began with his joining the Ramanujan Institute of the University of Madras as a Research Assistant in 1970. One year later he decided to shift to the Tata Institute of Fundamental Research, Bombay. His doctoral thesis written under the supervision of S. Ramanan, related to the construction of moduli space of principal bundles with reductive structure groups, on the lines of Seshadri's construction of vector bundles. This work and his study of bundles over the projective line and over the affine space marked him as an expert in the area of algebraic groups and vector bundles. During this formative period he came under the influence of M.S. Narasimhan as well.

He collaborated with Vikram Mehta on two areas of work in which he was interested. One of them pertains to the question whether the restriction of a stable bundle on a smooth projective variety to a general curve is also stable. This has the effect of reducing some problems relating to vector bundles on higher dimensional varieties to those on curves. The second one, which seeks to understand linear systems on homogeneous spaces and Schubert varieties, had a surprise twist, namely that these questions could be more easily dealt with over fields of positive characteristics, thanks to the Frobenius morphism. Here, the key notion turns out to be that of a Frobenius split variety. Ramanathan used his considerable expertise on algebraic groups and homogeneous spaces to study many variants of this theme and showed the power of this concept.

He was awarded the Shanti Swarup Bhatnagar Prize and was elected a Fellow of the Academy, both in 1991. He served as a co-editor of the Mathematical Sciences Proceedings of the Academy during the last year.

He shared his mathematical ideas with colleagues and students freely and was generous with his time.

He was an intellectual of a high order and his interests included, apart from mathematics, a wide range of subjects. He was an admirer of the Tamil writer Jayakantan, whom he considered one of the finest in the world.

While on a visit to the University of Illinois, Urbana, he went for a week-end visit to Chicago when he suffered a massive heart attack. An emergency by-pass surgery and another to stop internal bleeding proved of no avail and he breathed his last on 12 March 1993. During his last days he was working on the relationship of the study of vector bundles with homogeneous spaces, in collaboration with M.S. Narasimhan and Shrawan Kumar.

Lakkaraju Ramachandra Row was born on 12 December 1916 at Ravipadu, West Godavari District, Andhra Pradesh. He had his early education in Rajamundry. Deeply interested in chemistry, he did his B.Sc. (Honours) with chemistry as the main subject at Andhra University, Waltair, during 1935–38. He then joined the research group of Prof. T.R. Seshadri, FRS, and took his M.Sc. (1939) and D.Sc. (1945) degrees.

He joined the Faculty of the Chemistry Department, Andhra University in 1939, first, as a Demonstrator then as a Microanalyst (1943), Lecturer (1945), Reader (1953) and Professor (1963). He was the Head of the Chemistry Department and acting Principal of the newly started Post-Graduate Centre of Andhra University at Guntur during 1967–68. He took over as the Head of the Chemistry Department at Andhra University in 1968 and was appointed as the Principal, College of Science and Technology for about a year during 1976. Soon after his retirement in 1976 he was offered the position as special officer to the newly created post-graduate centre at Nuzvid. During his tenure as special officer (1977–80) he established the Chemistry Department besides a research school in Organic Chemistry.

His research interests on natural products covered a wide variety of compounds such as flavonoids, alkaloids, triterpenoids, lignans, phusalins, etc. The structures of a large number of natural products were established by him using chemical degradation and spectral data and later confirmed by synthesis. These natural products were isolated from plants having medicinal properties. In recognition of his contributions to the chemistry of natural products, he was elected a Fellow of the Royal Institute of Chemistry (London) (1961) and the Indian Academy in 1973.

He passed away on September 22, 1991, leaving behind 5 daughters, a son, and a large number of pupils, admirers and friends to mourn his loss.

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