



# Patrika

January 1986 No. 12 Newsletter of the Indian Academy of Sciences

## 51st Annual Meeting

At the invitation of the Madurai Kamaraj University, Madurai, the Academy held its 51st Annual Meeting in the University Campus at Palkalainagar, Madurai from Thursday 7 to Sunday 10 November 1985.

The Meeting started with the inaugural function on the evening of Thursday 7 November in the Dr Mu Va Auditorium. After a nadhaswaram recital by Thiru Madurai Ayyaswamy and party, Prof. S. Krishnaswamy, Vice-Chancellor, Madurai Kamaraj University welcomed the delegates and guests. He spoke of the ancient Madurai Academy, Tamil Sangham, which had existed many centuries ago in the times of the Pandya kings and which had resisted, though unsuccessfully, even Lord Shiva in its fight for its principles.

Dr (Mrs) Radha Thiagarajan, Vice-Chancellor, Alagappa University, Karaikudi gave the inaugural address. She spoke of the need for science to be tempered with humanism and for scientists to transcend the particular and the limited, in their pursuit of truth and to be humanists as well as scientists.

Prof. Ramaseshan next introduced to the audience the Fellows and Young Associates present. In his introductory remarks he spoke of the last Annual Meeting held in Madurai in 1966, (a brief account of the meeting is given in this issue), and which was presided over by Prof. CV Raman. It was in the first year of the founding of the University and Prof. Ramaseshan spoke of the remarkable progress made since then in the beautiful new campus and the significant achievements of the Department of Biological Sciences of the University.

The Presidential address on "Excursions into

high pressure physics" is summarised in the present issue.

There were two short specialized symposia and thirteen lecture presentations by new Fellows and Young Associates.

The first symposium on **The Genome in Flux** was held on the morning of 8 November 1985 in the Sir CV Raman Hall. In recent years it has been increasingly realized that genetic material is often in a state of dynamic flux. Prof. K Dharmalingam, Madurai Kamaraj University, Madurai, in his introductory remarks spoke of the current state of our understanding of transposable elements and other examples of jumping genes.

He was followed by Prof. H Sharat Chandra of the Indian Institute of Science, Bangalore, who spoke on "Some genetic and evolutionary problems posed by sexuality". Surprising as it may seem, evolutionary biologists have failed to understand why sexual reproduction is so common in nature. Genetically speaking, parthenogenetic reproduction should confer a two-fold advantage over sexual reproduction. The widespread occurrence of sexual reproduction suggests, however, that sexuality must confer some advantages. While genetic recombination, which is always associated with sexual reproduction is expected to produce a wide variety of genotypes to face an uncertain environment, the superiority of the sexual species remains to be firmly demonstrated.

The next speaker was Prof. MS Kanungo of the Banaras Hindu University, Varanasi, who spoke of "Changes in conformation and expression in the genome of the rat during its life span". He described how the specific timings of birth, maturity and cessation of reproductive ability in mammals, the more or less fixed life spans of individuals of a species, the sequential changes in the isoenzymes and the ability of genes to alter their expression under the influence of hormones, show that various components of the genome governing these functions are not static and that genes

undergo continuous and sequential changes in activity during the life span of an organism.

He was followed by Dr D S Pradhan, of the Bhabha Atomic Research Centre, Bombay, who spoke on "Mitochondrial genome: structure and distinctive participation in eukaryotic gene functions". He described research on nucleocytoplasmic inter-relationships, using yeast mitochondria as a model system. He presented the interesting result that the nuclear repair machinery can repair radiation-damaged mitochondrial DNA in anaerobically growing cells but not in aerobically growing cells.

The last talk was by Prof. G Shanmugam of Madurai Kamaraj University, Madurai, on the "Role of oncogenes and growth factors in cell proliferation". Studies with cancer-causing viruses have shown that the genes responsible for converting a normal cell into a cancerous cell, the oncogenes, are in fact present in all normal cells of a variety of organisms, such as humans, other mammals, birds, insects and even other micro-organisms. This suggests that these oncogenes were acquired from viruses millions of years ago. Hopes have been raised in understanding the mechanism by which oncogenes cause cancer, by the discovery that the products of the oncogenes have similarities with normal growth promoting factors in our bodies.

There were three series of lecture presentations by new Fellows and Young Associates, on the afternoons of Friday 8 November and Saturday 9 November and the forenoon of Sunday 10 November.

The first talk on 8 November was by Dr M R Das of the Centre for Cellular and Molecular Biology, Hyderabad on the "Molecular Biology of Cancer". He gave a broad overview of recent studies of the molecular biology of cancer. He also discussed some of his own interesting discoveries. For instance techniques have now been developed that can separate a tumour cell line into two sub-populations, one which kills the host animal and the other which is milder, because it causes tumours that regress in three months. He also described his many years of studies of human breast cancer, involving the isolation of a ribonuclease from human milk, antibodies against which are now used for diagnostic purposes.

The next talk was by Prof. P Babu of the Tata Institute of Fundamental Research, Bombay on "Gene expression in the fruitfly *bithorax* as a model". He described the recent fascinating results obtained with mutants in the fruitfly *Drosophila melanogaster* such as the *bithorax*. He also described a new model that

he has developed to explain mechanisms of gene expression in this organism.

He was followed by Prof. T J Pandian of Madurai Kamaraj University, Madurai who spoke on "Food nitrogen as a predictor of digestive efficiency". Digestive efficiency is an index of the proportion of the consumed food that is transferred from the gut lumen into the body of an animal. Absorption is measured as the difference between ingestion and egestion. He showed that the nitrogen content of food holds a positive correlation to the digestive efficiency of fishes, amphibians, reptiles, aquatic insects and polychaetes, which can be predicted with less than 10% error. He had also found that increasing the food nitrogen content by 1%, results in the increase of the efficiency by a factor of 7% in these animal groups and that amphibians display significantly higher efficiency than fishes and reptiles, when given food with equal nitrogen content.

The last talk in the series was by Dr A S Kolaskar of the Centre for Cellular and Molecular Biology, Hyderabad on "Nucleic acids sequence analysis – structural and biological implications". He elaborated on his analysis of DNA sequences of bacteriophages. His main finding is that certain sequences occur with a much higher frequency in the coding frame than in the non-coding frame. This information has then been used to determine whether a particular DNA sequence will code for a protein or not.

The evening lecture on 8 November was by Prof. R Cowsik of the Tata Institute of Fundamental Research, Bombay on the **Architecture of the universe**. The close interconnection between the physics of elementary particles and the cosmological models of the universe formed the central theme of the evening lecture. Special emphasis was placed on neutrinos which are produced copiously during the early hot phase of the big-bang and which provide today a number density  $\sim 110 \text{ cm}^{-3}$ , far exceeding the mean number of hydrogen atoms (baryons) of  $\sim 10^{-7} \text{ cm}^{-3}$  in the universe. He noted first that the long age of the universe of 15 billion years, together with the minimum expansion rate of the universe given by  $H_0 \approx 50 \text{ km s}^{-1}$  per Megaparsec, implies an upper limit of  $\sim 4 \text{ keV cm}^{-3}$  to the total energy density, so that the sum of the masses of all flavours of neutrinos must be less than  $\sim 35 \text{ eV}$ ; this constraint on their masses is far more restrictive than those placed by measurements in the laboratory. He also noted that if indeed the neutrino mass  $m_\nu \approx 10 \text{ eV}$ , the neutrinos will provide an energy density of a few

$\text{keV cm}^{-3}$ , exceeding substantially the energy density of  $\sim 100 \text{ eV cm}^{-3}$  of the visible forms of matter and thus the neutrinos will dominate the gravitational dynamics of large astronomical structures, constituting an invisible but gravitating component currently called "dark matter". A simple mathematical model developed on this basis reproduces accurately the observed profiles of luminosity of clusters of galaxies and of galaxies, as well as predicts correctly the variation of rotation velocities of stars and gas with distance from the centre of the galaxy. Interestingly such a postulated mass for the neutrinos suffices to ultimately reverse the expansion of the universe.

The second symposium on **Fifth Generation Computers** was held on the morning of Saturday 9 November 1985. The first talk by Prof. V Rajaraman of the Indian Institute of Science, Bangalore, is summarised in the present issue.

The next talk was by Prof. HN Mahabala of the Indian Institute of Technology, Madras on the "Nature of computer applications in the fifth generation" and the last talk by Prof. PVS Rao of the Tata Institute of Fundamental Research, Bombay on "Speech and visual input/output to computers in the fifth generation". He spoke of man-machine interaction and the man-machine interface required, which can accept inputs from the human user and convey it to the machine in a form that it can interpret, and for outputs, information in a form that can be provided by the computer and presented to the user in a form that he can assimilate. One of the main aims of Fifth Generation Computers is to design an ideal machine, which would require a minimum of skills and which will have a comprehensive and powerful speech recognition system for continuous speech. Such systems are being developed for operation in ordinary rooms with reasonable restrictions on noise level and will be invaluable for use in rural areas for insertion of information on land, revenue, population, crops, farm outputs, rainfall, occurrence of diseases in man, animals and crops etc.

The special lecture by Prof. G Neuweiler of the School of Biological Sciences, Madurai Kamaraj University and Department of Zoology, University of Munich, Munich on "Echolocation in South Indian bats", is reported in this issue.

The second series of lecture presentations by new Fellows and Young Associates in the afternoon of 9 November 1985 started with a talk by Prof. VK Gaur of the National Geophysical Research Institute, Hyderabad, on

"Earthquake prediction research". This was followed by two talks by Prof. TN Shorey of the Tata Institute of Fundamental Research, Bombay on "Recursive sequences" and Dr N Mohan Kumar of the Tata Institute of Fundamental Research, Bombay on "Curves in space".

Dr B R Iyer of the Raman Research Institute, Bangalore spoke next on "Black holes are not for ever". He described some of the characteristics of black holes in general relativity, the most important being the event horizon from within which no information can reach the outside world, at least classically. The area of this event horizon resembles the entropy because it can only increase monotonically. The thermodynamics of systems including black holes becomes completely consistent with Hawking's concept of black hole evaporation, i.e., black body radiation emerging from the event horizon. However, this has raised new issues like the definition of a particle being dependent on the observer. The uncertainty or entropy associated with a black hole is over and above that introduced by quantum mechanics.

Prof. V Balakrishnan of the Indian Institute of Technology, Madras next spoke on "Random walks". Random walks find application in numerous and diverse areas, ranging from physics to demography, ecology and economics. In addition to its continuing role in the development of the mathematical theory of probability, random walk theory is relevant in nearly every area, indeed, in which probabilistic and statistical methods are required. Beyond the primary problem of deducing the probability distribution (and its moments) characterizing the random walk, there is a host of problems of physical and mathematical interest: a great deal has been done, but new, interesting and physically relevant questions emerge continually at a rate which indicates no diminution in the freshness of the random walk problem.

The second evening lecture on Saturday 9 November was given by Dr I Mahadevan on **A computer study of the Indus script**. He spoke of the data base for the Indus script, which had been compiled on the CYBER 170/730 computer system at the Tata Institute of Fundamental Research, Bombay. It consists at present of 3573 lines of text found written on 2906 artefacts from 19 Harappan and 5 West Asian sites. The artefacts had been classified broadly into eight types based on the materials of manufacture and modes of writing.

The data base had been divided into two parts, background data and the texts. The

background data provide information on the site, the locus of occurrence within the site, the stratigraphic level, object type, associated field symbols (pictorial motifs), the direction of writing of each line of text and the number of signs in each line. A reference number, which is uniquely defined, is assigned to each line of text. The texts reproduce the Indus signs occurring in the inscriptions in both numerical and literal (pictorial) forms to facilitate statistical study and reporting respectively. The data base also includes a library of signs in the Indus script for graphic reproduction on a CALCOMP drum plotter.

Currently work is being carried out on the study of the inscriptions in their archaeological context of occurrence, the formal analysis of the texts to recognise grammatical features of the language and the evaluation of proposed claims of decipherment, by trying to match the known frequency-distribution characteristics of the Indus signs with the features of the script and the language proposed by would-be decipherers. Preliminary results of the statistical analysis indicate that none of the claims of decipherment of the Indus script made so far is wholly successful.

There were 4 lecture presentations on the morning of the last day, Sunday 10 November 1985. The first was by Dr E D Jemmis of the University of Hyderabad who spoke on a "Theoretical study of an organometallic reaction".

He was followed by Dr M G Kulkarni of the National Chemical Laboratory, Pune who spoke on "Applications of super-absorbent polymers in the separation process". Super-absorbents belong to a family of synthetic and modified natural polymers, which in contact with water absorb 200-600 times their weight of water to form gels. The gels undergo deswelling in the presence of nonsolvents and electrolytes, at appropriate temperatures and values of pH. The reversible swelling and deswelling of super-absorbents forms the basis of the technique of concentration of macromolecules from aqueous and other solutions of proteins such as albumin, myoglobin, haemoglobin and enzymes such as glucose isomerase, alkaline protease, xylanase and is particularly useful for the concentration of biological macromolecules, which undergo deactivation during concentration by conventional techniques, such as precipitation and ultrafiltration.

The next talk was by Dr R A Rajadhyaksha of the University of Bombay, Bombay on "Zeolite catalysts: performance and promise". Zeolite catalysis is now regarded as one of the frontier

areas of heterogeneous catalysis, due to its exceptional catalytic properties such as shape selectivity which is predictable, since the sizes of molecules and the structure of zeolites are known. Considerable promise also exists in the synthesis of new zeolites, which can exhibit new types of shape selective properties and in the application of the catalytic properties of known zeolites for novel catalytic reactions.

The last talk was given by Prof. P Ramachandra Rao of the Banaras Hindu University, Varanasi, on "Synthesis of phase diagrams". He described the concerted effort towards synthesising, analysing, compiling and disseminating all available information on phase diagrams, highlighting the need for accurate phase diagrams of binary, ternary and multi-component alloys in hydrogen storage devices, in understanding the morphology of rapidly solidified alloys and in development of epitaxial crystals for optoelectronics etc.

The Business Meeting of the Fellows was held on the morning of 9 November 1985. During the meeting a copy of the special Commemoration Volume published by the Academy, to honour Prof. C V Subramanian on his Sixtieth Birthday, was formally presented to him by the President, Prof. S Ramaseshan.

There was a classical Carnatic musical concert on the evening of 8 November 1985 by Master U Srinivas and party, which was greatly enjoyed by the audience.

Excellent arrangements were made for 51st Annual Meeting held at Madurai. The Academy is grateful to Madurai Kamaraj University, to the Local Organising Committee and specially to the Vice-Chancellor Prof. S Krishnaswamy for the superb organisation of the Annual Meeting. Our special thanks are also due to Prof. V Rajaraman and Prof. K Dharmalingam for the organisation of the two specialized symposia.

The 51st Annual meeting was attended by 80 Fellows and 21 Young Associates. The group photograph taken during the meeting is reproduced in pages 10 and 11.

thermodynamically significant phenomena like tricritical points etc. Experiments conducted at NAL in collaboration with the Liquid Crystals Group at the Raman Research Institute, showed that pressure did indeed induce liquid crystallinity in the lower homologues. Many new pressure-induced transitions were soon observed, opening up a new avenue of scientific activity.

### Charge transfer complexes

Hassel's pioneering work showed that when certain liquids were mixed in definite molecular proportions, Charge Transfer (CT) complexes are formed. A change in colour is the earliest indication that such a CT complex is formed. When the atom with high electronegativity in a molecule attracts electrons from an atom in the other, the van der Waals distance decreases and the covalent bond involving the electronegative atom lengthens. Hassel showed the existence of these effects, by crystallising these liquids at low temperatures and determining their crystal structures. It occurred to us that these liquids could as well be solidified under pressure in a diamond anvil cell, single crystals grown, and the structure determined. Most of the conclusions of Hassel on his CT complexes were verified: but one could also go much farther. When the electronegativities are not so high, the mixture shows no colour change. However, colour develops as the pressure increases and becomes deeper with further increase of pressure. As the liquid is compressed, the molecules come closer and the propensity to form complexes increases. Again, single crystals could be grown and the structures confirmed the formation of CT complexes.

Under the microscope in a diamond cell, two liquids immiscible at atmospheric pressures, can be seen mixing at higher pressures. Single crystals of these mixed substances can be grown sometimes, and their structures determined. This gives us one more possible technique by which two molecules can be made to crystallise in a single lattice.

This method of growing mixed crystals at high pressures may be another aid to the synthetic organic chemist who uses photo-synthetic techniques to effect a reaction between two molecules fixed in a specific geometry in a crystal. When diamonds transparent to the ultraviolet are used for the anvils, mixed crystals can be grown, their structure determined, photosynthesis effected between the molecules and the structure of the new substance determined, all in the same anvil arrangement.

### Critical point phenomenon in solids

Samarium sulphide is a semiconductor, black in colour, with an NaCl structure. At about 6.5 kb it becomes a metal, with its resistance decreasing by five orders of magnitude, the volume decreasing by 15% and a colour change to that of a metallic solid. In spite of all these drastic changes, it retains its NaCl structure. Much work on this transformation was done at NAL. Since this transformation is iso-structural with no change in symmetry, it occurred to us that it must also show the critical point phenomenon. The critical point for this semiconductor metal iso-structural transformation was discovered to be at 825°C and 10.5 kb, the second solid known at that time to show this effect.

### Coefficient of viscosity

A study of the variation of the viscosity of a liquid with pressure can contribute greatly to the understanding of the liquid state. With pressure, viscosity increases by many orders of magnitude and so its measurement poses many problems. One possibility is to measure the velocity of the shear waves (which according to Raman could exist in these high viscosity liquids) using Brillouin scattering. The other would be to use the well-known Stokes falling sphere method in a diamond cell. By replacing the weak gravitational field by a strong magnetic field and by making the tiny 5 microns radius sphere of special magnetic material, the range of viscosity measurements could be increased by  $10^8$ . The diamond cell, however, has to be made of non-magnetic materials, which limits the pressure to only 20 to 25 kbars.

### Friction

Another important mechanical property is friction and there are very few measurements of the coefficient of friction at high pressures. A simple but elegant modification of the angle of friction method was devised for the measurement of this coefficient at high pressures in a diamond cell. One surprising result in preliminary studies was that in some minerals and rock samples, the coefficient of friction dropped suddenly, by two or more orders of magnitude, at a particular value of pressure, specific to the sample. One possible explanation is that, at these pressures, the bound water in the material is released and lubricates the surfaces of contact, reducing greatly the coefficient of friction. This is a good example of how simple laboratory studies can prove of immense value in the understanding of the mechanics of many geophysical phenomena such as large rock movements, plate tectonics etc.

# Council for the Triennium 1986-88

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The outgoing Council held an election in December 1985, to constitute the Council for the next triennium 1986-88. The composition of the present Council is as follows :

**O Siddiqi**, Tata Institute of Fundamental Research, Bombay – President

**S Ramaseshan**, Raman Research Institute, Bangalore – Past President

**A Chakravorty**, Indian Association for the Cultivation of Science, Calcutta

**S Chandrasekhar**, Raman Research Institute, Bangalore

**S Dhawan**, Department of Space, Bangalore

**CK Majumdar**, Indian Association for the Cultivation of Science, Calcutta

**HY Mohan Ram**, University of Delhi, Delhi – Vice-President

**R Narasimha**, National Aeronautical Laboratory, Bangalore. – Vice-President

**JV Narlikar**, Tata Institute of Fundamental Research, Bombay

**G Padmanaban**, Indian Institute of Science, Bangalore

**V Radhakrishnan**, Raman Research Institute, Bangalore

**MS Raghunathan**, Tata Institute of Fundamental Research, Bombay

**CNR Rao**, Indian Institute of Science, Bangalore

**H Sharat Chandra**, Indian Institute of Science, Bangalore

**MM Sharma**, University of Bombay, Bombay

**BV Sreekantan**, Tata Institute of Fundamental Research, Bombay – Vice President

**G Srinivasan**, Raman Research Institute, Bangalore

**KS Valdiya**, Kumaun University, Nainital

**MS Valiathan**, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum – Vice-President

**S Varadarajan**, Planning Commission, New Delhi.

# Honorary Fellows elected in 1985

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**EBünning**, Institut für Biologie I der Universität, Tübingen, West Germany

**KS Pitzer**, Department of Chemistry, University of California, Berkeley, USA

## Fellows elected in 1985

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**YP Abrol**, Indian Agricultural Research Institute, New Delhi, for his work in agricultural sciences.

**DD Bhawalkar**, Bhabha Atomic Research Centre, Bombay, for his contributions in laser physics.

**UC Chaturvedi**, King George Medical College, Lucknow, for his studies of host defence against viral infections.

**SM Chitre**, Tata Institute of Fundamental Research, Bombay, for his contributions to theoretical astrophysics.

**SG Dani**, Tata Institute of Fundamental Research, Bombay, for his work in ergodic theory and Lie groups.

**KRK Easwaran**, Indian Institute of Science, Bangalore, for his contributions to membrane biology.

**K Kasturirangan**, ISRO Satellite Centre, Bangalore, for his contributions to space sciences and satellite technology.

**UW Kenkare**, Tata Institute of Fundamental Research, Bombay, for his contributions to biochemistry.

**S Krishnaswami**, Physical Research Laboratory, Ahmedabad, for his contributions in nuclear geochemistry.

**RK Lal**, Banaras Hindu University, Varanasi, for his contributions in geothermometry and geobarometry.

**S Lele**, Banaras Hindu University, Varanasi, for his work in physical metallurgy, specially in relation to faulted structures and transformations.

**KC Malhotra**, Indian Statistical Institute, Calcutta, for his work in ecology and population genetics.

**J P Mittal**, Bhabha Atomic Research Centre, Bombay, for his contributions to laser chemistry and chemical dynamics.

**R Nityananda**, Raman Research Institute, Bangalore, for his theoretical contributions to optics and image reconstruction.

**J D Padayatty**, Indian Institute of Science, Bangalore, for his contributions to molecular biology.

**AS Paintal**, Patel Chest Institute, New Delhi, for his contributions to neuro- and cardiorespiratory physiology.

**IBS Passi**, Panjab University, Chandigarh, for his contributions to group-theory.

**MV Pitke**, Tata Institute of Fundamental Research, Bombay, for his work in the fields of computers and communications.

**SK Pradhan**, University of Bombay, Bombay, for his contributions to organic chemistry.

**V Ramamurthy**, Indian Institute of Science, Bangalore, for his contributions to organic photochemistry.

**KR Rao**, Bhabha Atomic Research Centre, Bombay, for his experimental studies of dynamics by neutron scattering.

**S Roy**, Jadavpur University, Calcutta, for his contributions in ore geology, particularly on manganese deposits.

**N Sethunathan**, Central Rice Research Institute, Cuttack, for his work on microbial transformation in soil.

**NKM Singhi**, Mehta Research Institute for Mathematical Sciences, Allahabad, for his work in combinatorial mathematics.

**KB Sinha**, Indian Statistical Institute, New Delhi, for his contributions to mathematical physics.

**SP Sukhatme**, Indian Institute of Technology, Bombay, for his work in heat transfer and thermodynamics.

**Surjit Singh**, Indian Institute of Technology, Madras, for his studies of infrared and Raman spectra.

# Special Theory of Relativity

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Academy lecture given by Prof. Hermann Bondi, Master of Churchill College, Cambridge, at Bangalore on 20 December 1985

Prof. Hermann Bondi is well known for his contributions to cosmology and the theory of gravitational waves as well as for his distinguished services to space science. As was clear from his Academy Lecture on "The Special Theory of Relativity", he is also an outstanding and original teacher. In barely forty minutes, he presented the essentials of this subject to a large and mixed audience including both specialists and laymen, leaving both with the feeling that this was the way special relativity should be taught. The lecture started with the premise that our presentation of a subject should allow for the technology of the times. In this respect, the rigid rod as a tool for measuring length was hopelessly out of date, apart from being disallowed by the special theory itself! (A really rigid rod would transmit a push at one end instantaneously to the other). Distances at least up to the scale of the solar system are now measured by radar, the two-way propagation of light signals. The clock which measures the travel time becomes fundamental. Ultimately our ability to construct clocks and our confidence that two observers have identical clocks, rests on the atomic and quantum nature of matter. Rather than the constancy of the velocity of light, Prof. Bondi preferred to emphasize that light can never overtake light. The strongest evidence for this comes from observing binary stars which orbit around each other. The sequence of events as seen at earth would be hopelessly distorted if, for example, signals from the star moving towards us were able to overtake those from the other. This non-overtaking principle guarantees that the radar method of measuring distances gives consistent results.

Having discussed the underlying physical principles, Prof. Bondi then proceeded to consider two observers studying the same event by radar. The time of arrival of a signal at one observer is related to the time of departure from the other, by the well known Doppler effect. The relativistic formula for this effect was the first by-product of this simple calculation which led to the famous Lorentz transformation in a few steps. Other consequences of the theory such as the

variation of mass with velocity (leading to mass energy equivalence) were outlined briefly.

It was notable that the pace of the lecturer was entirely unhurried and the only visual aid used was a piece of chalk and a black board. In the discussion following the talk, the notorious twin paradox was forcefully dealt with. It would indeed be worthwhile if this simple and physical approach to teaching special relativity is more widely disseminated and used in our universities.

## Baruch S Blumberg, Raman Professor, 1986

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Prof. Baruch S Blumberg, Associate Director of Clinical Research, Fox Chase Cancer Center and University Professor of Medicine and Anthropology, University of Pennsylvania, Philadelphia, is visiting India as Raman Professor for about three months from January 1986. He will visit various laboratories at Delhi, Agra, Madras, Bombay, Bangalore, Pune and Lucknow, lecturing and interacting with many young scientists. Prof. H Sharat Chandra, Microbiology and Cell Biology Laboratory, Indian Institute of Science, Bangalore will be looking after his programme in India.

Prof. Blumberg was awarded the Nobel Prize for Physiology and Medicine in 1976 "for his discoveries concerning new mechanisms for the origin and dissemination of infectious diseases". His remarkable discoveries of the new protein viruses that cause jaundice, the development by him and his colleagues of the new vaccine against hepatitis and his work on filariasis, malaria, intestinal parasites, rheumatoid spondylitis etc, are well-known.

## Fifth Generation Computers

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Summary of a talk given by Prof. V Rajaraman at the 51st Annual Meeting of the Academy at Madurai on 9 November 1985.

The characteristics of the five generations of computers are described on page 13. In the first generation, the electronic devices used were vacuum tubes and the memory consisted of acoustic delay lines and later magnetic drums. The mean time between failures (MTBF) of the computer was about an hour. The machines were programmed using machine codes or assembly languages, which were a one-to-one transformation of the machine code. Early applications were mostly for scientific and engineering calculations.

The second generation of computers was revolutionary in concept and design, due to the advent of transistors. Their reliability increased dramatically. Coupled with the invention of magnetic core memories, the use of high level machine-independent languages such as FORTRAN became feasible, leading to a rapid growth in computer usage in both science and business.

The next step was more evolutionary. Transistors were replaced by integrated circuits with a consequent reduction in cost and a ten-fold increase in reliability. High level languages were improved and standardized. From a user's point of view a major advance was the time-sharing of computers, with consequent interactive use of computers which led to a tremendous increase in the productivity of users, as they could build models in close association with the computer.

Currently we are in the fourth generation which is characterized by the microcomputer revolution. Large numbers of microprocessors are used in personal computers, in sophisticated instruments and even in household appliances. Other major characteristics of this generation are the advent of graphics and of computer networks.

Computers have become faster, smaller and cheaper, but the fundamental feature which has remained invariant throughout the four generations, is the basic logical structure of the computer proposed by Von Neumann in 1946. This logical structure, also known as "architecture", is characterized by the programme being stored in a central main



## Participants at the 51st Annual Meeting Held at Madurai

### Sitting (floor) L to R :

1. S. Banerjee
2. B.S.N. Rao
3. B. Sethumani
4. J. Samuel
5. B.R. Iyer
6. C. Vedamurthy
7. G. Madhavan
8. P. Venkatakrishnan
9. M. Rathnam

### Sitting :

10. A. Abraham
11. R. S. Krishnan
12. O. Siddiqi
13. J. Shankar
14. M. S. Raghunathan
15. Yash Pal
16. C.V. Subramanian
17. S. Dhawan
18. S. Krishnaswamy

19. S. Ramaseshan
20. S. Varadarajan
21. C.N.R. Rao
22. V. Radhakrishnan
23. H.Y. Mohan Ram
24. S. Paramasivan
25. M. Venkataraman
26. R. Ananthkrishnan
27. R.M. Godbole
28. Joy C. David

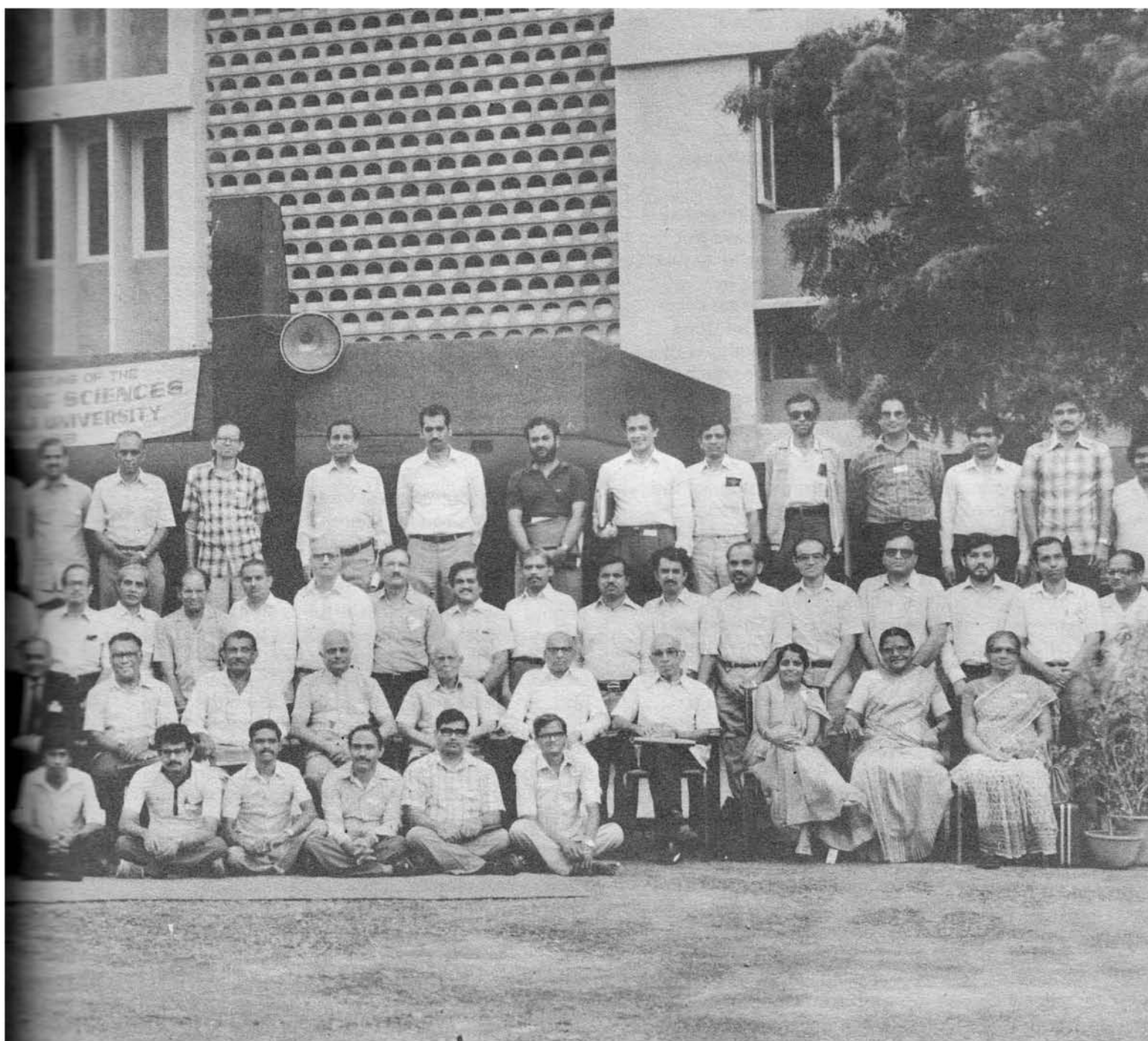
### 29. A. Mani

### Standing 1st row :

30. K. S. Viswanathan
31. K. R. Parthasarathy
32. K.K.G. Menon
33. M.S. Valiathan
34. K.P. Abraham
35. C. Ambasankaran
36. C.J. Saldanha
37. E. S. Raja Gopal

38. C.S. Vaidyanathan
39. M.S. Kanungo
40. D.D. Awasthi
41. F. Ahmad
42. C. Leelanandam
43. K. Naha
44. K. Gopalan
45. R.V. Bhonsle
46. H. Sharat Chandra
47. S.S. Agarwal

48. P. Rama
49. B.L. Deo
50. S.K. Joshi
51. P.T. Mar
52. G. Rajan
53. J.S. Yadav
54. R. Nagarajan
55. M.R. Das
56. M. Barma
57. K.B. Misra



43 P. Rama Rao  
 44 B. L. Deekshatulu  
 45 S. K. Joshi  
 46 P. T. Manoharan  
 47 G. Rajasekaran  
 48 J. S. Yadav  
 49 R. Nagaraj  
 50 M. R. Das  
 51 M. Barma  
 52 K. B. Misra

58 R. Gadagkar  
 59 B. M. Deb  
 60 S. Krishnan  
**Standing 2nd row :**  
 61 G. Padmanaban  
 62 P. R. Adiga  
 63 D. V. S. Jain  
 64 C. R. Narayanan  
 65 G. R. Desiraju  
 66 R. Ramaswamy

67 T. A. Davis  
 68 L. K. Pandit  
 69 N. V. Madhusudana  
 70 T. J. Pandian  
 71 T. N. Ananthakrishnan  
 72 M. K. Chandrashekar  
 73 S. Ranganathan  
 74 N. S. Narasimhan  
 75 T. N. Shorey  
 76 P. Ramachandra Rao

77 E. D. Jemmis  
 78 S. R. Gadre  
 79 S. Swaminathan  
 80 Madhav Gadgil  
 81 P. M. Mathews  
 82 R. A. Rajadhyaksha  
 83 D. Banerjee  
 84 R. Cowsik  
 85 S. Ramanan  
 86 N. Mukunda

87 D. K. Arora  
 88 R. V. Hosur  
 89 M. S. Murali  
 90 Peter Jayaraj

memory and interpreted sequentially by the central processing unit. Another central concept in this architecture is the identification of variables by a storage location, updated by programme overwriting of the contents. As a consequence the algorithms are mostly sequential and the computer languages, designed to represent algorithms efficiently, are also sequential.

Even though machines have become very powerful and highly reliable, they have not become proportionately easier to use. In fact current architectures inhibit thinking in "parallel" i.e., perceiving what could be done simultaneously and what needs to be done sequentially. Further, the current methods of programme development place too much emphasis on how to solve a problem procedurally and mixes up the two concerns: what problem is to be solved and how to solve it. There is a need to shift the emphasis of programming to precise formulation of the problem to be solved, namely problem specifications. A built-in translator must then convert the specification to detailed procedure. Thus new languages are needed to specify algorithms without the inhibition of a pre-conceived logical structure of a computer. This is one of the goals of fifth generation computers, namely to develop specification-oriented languages.

The second major problem with the current computer architectures is the limit to their speed imposed by physical constraints such as the velocity of light. There are two ways of increasing the speed of computers. Both of them involve the use of multiple processors to carry out a single task. One method is to break up a task into a number of independent sub-tasks and allocate each sub-task to one processor in a chain of processors. This is known as pipe lining. Another method would be to do several jobs simultaneously by allocating one job each to many processors. Both these ideas are being explored extensively for building fifth generation computers.

The phrase fifth generation computers was coined by Japanese scientists to set goals for a nationally co-ordinated research and development programme, in order that they would become world-leaders in computer technology by 1990. An organization called ICOT (Institute for New Generation Computing) has been established in Japan with cooperation from industries, research laboratories, universities and the government. Similar groups have been formed in the USA and the Europe. Foreseeing that in the next century knowledge processing industry will be

the dominant industry, the projects have as their main goal the development of tools and techniques for knowledge information processing in addition to data processing. Data bases developed with current computers, combined with a set of inference rules which will allow one to explain the experimentally obtained data base as a consequence of physical law(s), are much more powerful and constitute a knowledge base. The inference rules can be derived only by knowledgeable experts in the area. A collection of such knowledge bases in diverse areas will increase the competitive edge of a nation enormously.

To achieve the main goal of the project, super-speed computers which would be able to process large knowledge bases are required. Architectures known as non-Von Neumann architectures are capable of achieving speeds in the range of billions of inferences per second.

Currently the types of input and output devices which can be connected to a computer are restricted, inputs being mainly via keyboards or magnetically recorded media such as floppy disks and outputs being either printed pages or displays of both alphanumeric information and graphics on video terminals. A more natural way of human communication would be by speech, handwritten documents and pictures. One of the goals of the fifth generation computers is to develop new input/output devices which would recognize speech, pictures and handwritten inputs and give answers in spoken as well as pictorial form, besides printed form. To meet this goal, complex speech and picture recognition systems will have to be built. Such systems require complex inference mechanisms, as most human speech is not well structured and there is considerable difference in speech patterns of individuals.

Lastly to meet the goal of high speed computing, extensive developments in electronic device technology and computer aided design of electronic systems are needed.

The true spirit of the fifth generation computers is to let scientists and engineers concentrate on formulating clearly what questions they want to ask and why they want to ask them, rather than spend time working out in detail how the computations are to be carried out. The more intelligent computers of the future will assist in working out the details of computation by picking the right algorithms, the right programmes and knowledge bases using expertise built into them.

Generation	Years	Switching device	Storage device	Switching time	MTBF* Hours	Software	Applications
First	1949-55	Vaccum tubes	Acoustic delay lines and later magnetic drums. 1 Kbyte memory	0.1 to 1 milli-second	0.5 to 1	Machine and assembly languages. Simple monitors	Mostly scientific. Later simple business systems
Second	1956-65	Transistors	Magnetic core main memory, tapes and disk as peripheral memory. 100 Kbyte main memory	1 to 10 microseconds	About 10	High level languages, FORTRAN, COBAL, Algol. Batch operating systems	Extensive business applications. Engineering, Design optimization scientific research
Third	1966-75	Integrated circuits (IC)	High speed magnetic cores. Large disks (100 MB). 1 Mbyte main memory	0.1 to 1 microseconds	About 100	FORTRAN IV, COBOL 68, PL/I. Timeshared operating system	Data base management systems. Online systems
Fourth	1975-present	Large scale intergrated circuits, Micro processors (LSI)	Semi-conductor memory. Winchester disk. 10 Mbyte main memory. 1000 Mbyte disks	10 to 100 nano-seconds	About 1000	FORTRAN 77, Pascal, ADA, COBOL-74, Concurrent PASCAL	Personal computers, Distributed systems. Integrated CAD/CAM. Real time control. Graphic oriented systems.
Fifth	1990 ?	V <sup>n</sup> LSI, Ga As?	Associative memories. Optical disks. Tens of Giga bytes of distributed storage	~ 0.1 nanoseconds speed measured in Giga Lips	10,000	Functional programming (Specification language), PROLOG, Personalised, Expert systems	Primary knowledge Processing oriented applications

\* MTBF—Mean time between failures of the processor.

# Echolocation in a South Indian bat community

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Summary of a talk given by Prof. GNeuweiler at the 51st Annual Meeting at Madurai on 9 November 1985.

Ever since research in echolocation started, scholars have been puzzled by the rich variety of echolocation sounds emitted by insectivorous bat species, the most common types being brief, frequency modulated pulses covering at least one octave, say from 80 to 40 kHz, for 1-5  $\mu$ s, and constant frequency sounds lasting 6 to 200 ms. Some species combine both to a so-called CF/FM sound and many species even change the type of sound used under different conditions. To determine whether these variations in sound structure are adaptations of the echolocation system to different ecological constraints, one must find out whether the different bat species have different and distinct foraging areas or they opportunistically hunt at any place where insects are abundant.

We studied therefore a community of nine insectivorous bat species living sympatrically around Madurai University Campus in large numbers. We found that these nine species had distinctly different foraging areas which could be divided into three types:

1) Surface gleaner. They preferably fly very low over ground and water or might alight on a low hanging twig, searching the surface for suitable prey, from grasshoppers, spiders and crabs to frogs, birds and mice. They detect their prey by the noise made by the prey when it moves. For detecting even the faintest noise source they have large ear conches, which are fused in the midline, forming a uniform concave receiver antenna for noise coming from the ground, and rendering audition much more sensitive than in any other mammal including echolocation bats. Whereas absolute sensitivity in hearing in bats is not better than in humans, in these bats thresholds go down to  $\approx 25$  dB sound pressure level for frequencies which commonly occur in rustling noises ( $\approx 60$  kHz).

2) Foraging close to and within the foliage: In Madurai two species were found to keep very close to vegetation. The smaller of the two species skilfully flies through the foliage, hedges and even through thorny

bushwork, where they catch flying insects on the wing. The larger species prefer to fly outside around the trees and bushes. Both species, however, emit the same type of echolocation signal, a combined CF/FM-pulse consisting of a  $5 \approx 10$  ms pure tone of about 132 kHz and 155 kHz terminated by a brief FM-sweep. This type of signal is especially suited to cope with the problem of detecting a prey even in the densest of vegetation.

3) Open air forager: Most species prefer to catch insects in open and obstacle-free air. This large foraging zone is again stratified into three distinct heights.

(a) Lower corridor: At lower heights up to about tree top level, two species were found to search for food, skilfully flying between trees and bushes, like butterflies, swaying along verandas, through open halls etc., but usually keeping away from objects by about 1 mm.

(b) Middle corridor: At about tree top level and above, one species was found to fly around in fast sweeps and catching insects continuously on the wing.

(c) Upper corridor: Well above vegetation, the fastest flying bats hunt insects in fast and long sways. These are the swallows among the bats.

Interestingly, all species foraging in open air, no matter at which height, emit two different echolocation signals. While still searching for insects, they often emit long narrow band or even pure tone signals. However, as soon as an insect is detected, they transfer the pure tone into brief FM-signals, while approaching the prey. The long pure tone signal is adapted to the detection of a target, since all sound energy available is put into one frequency band, best suited for hearing. The FM-signal is more suited for location of the prey, since brief broadband signals are better for carrying precise range information. The range between target and bat is read from the time which elapses between emission of the echolocation signal and the arrival of the echo.

It is clear that sympatrically living insectivorous bat species divide the available insect resources by specifically adapting to different foraging zones. They achieve this differentiation by shaping both signal emission and capacities of hearing to the needs of the different foraging zones. In each species the frequency range of highest sensitivity in audition always coincides with that of the echolocation signals containing most sound energy.

The frequency range for best hearing is lowest in the bat species foraging highest up in the air, (e.g. 17 kHz). This frequency becomes

progressively higher with lower levels of flight: 35 kHz foraging in the medium corridor, 54 kHz in flying at low levels and 134 and 155 kHz in the two species which always keep very close to vegetation.

Higher frequencies are better suited for echolocation, but sound energy at higher frequencies is rapidly absorbed and can only be used for echolocation over short distances. Bats which forage high up in the air and have to detect insect preys over long distances, in order to make its fast flights metabolically economical, emit and are most sensitive to low frequencies.

Bats which emit pure tones of high frequencies, combined with a terminal FM-sweep do not echolocate over long distances, the pure tone serving an entirely different purpose; it makes a wing fluttering insect audible in the midst of echo-noise from the surrounding leaves and twigs. The returning echo from a wing-beating insect will no longer be a pure tone, but instead it will be frequency modulated to the rhythm of the wing beat.

Each individual bat uses its own frequency within a species-specific frequency range, matched by an extremely narrow, precisely tuned filter in the inner ear. This narrow frequency band of about 5 kHz around the individual carrier frequency is represented in the cochlea. The acoustical fovea is unique to these bats and has not been found so far in any other animal.

The examples clearly show that echolocation systems of different bat species may indeed be intricately specialized and adapted to the very specific needs of distinct foraging areas such as the spaces within the foliage and canopies of trees and bushes. They comply with the ecological constraints the bat species live in. Such driving forces in evolution reveal themselves when behavioural field studies are combined with neurophysiological studies in the laboratories, as we have tried to do in our investigations on the bats of Madurai.

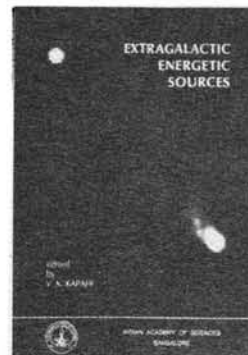
## Special Publications

In addition to the twentyfour special publications described in earlier issues, the following eight volumes were published during 1985.

1. Extragalactic Energetic Sources. Edited by VK Kapahi. Published in 1985. Price Rs.75/-, US\$ 20, pages 180.

The Winter School on Extragalactic Energetic Sources organised by the Tata Institute of Fundamental Research, Bombay, with support from the Raman Research Institute and the Indian Institute of Astrophysics, Bangalore was held at the Indian Institute of Science, Bangalore during January 10-21, 1983. The main purpose of the School was to provide an overview of the developments, both theoretical and observational, that have taken place in this area in the recent past. The principal areas covered were extended radio structures (RA Laing), VLBI and compact radio sources (MH Cohen), optical and infrared studies (PA Strittmatter), X-ray studies (SS Murray and Lvan Speybroeck), models of actual galactic nuclei (MJ Rees) and noncosmological nature of redshifts (GR Burbidge).

The present volume is a record of the Proceedings of the Winter School and the interesting discussions that took place following various lectures.



2. Supernovae, their Progenitors and Remnants. Edited by G Srinivasan and V Radhakrishnan. Published in 1985. Proceedings of the Academy Workshop on Supernovae, their Progenitors and Remnants. Price Rs.75/-, US\$ 20/-, pages 178.

Supernovae are rare events in the history of stars, accompanied by a sudden increase in

their luminosity by a factor of about a hundred billion times and an ejection of matter at thousands of kilometres per second.

The supernovae phenomenon appears to be connected with every branch of astrophysics. While there is a broad consensus regarding its general characteristics, many aspects of it such as the precise origin of the energetic particles, the magnetic field in the remnants, the connection with cosmic rays, the nucleosynthesis leading to the chemical abundances etc., remain poorly understood. This and the fact that many Indian astronomers and astrophysicists are keenly interested in the field was why the Workshop was organized as part of the Golden Jubilee celebrations of the Academy at Bangalore from October 29 to November 2, 1984.

The volume includes a perceptive overview and a final summary by LWoltjer, and interesting articles on Supernovae Progenitors by Virginia Trimble, Radio and X-ray observations of extragalactic supernovae by KWWeiler, Pulsars, Evolution of plerions and radio-supernovae by FPacini, Formation and evolution of neutron stars in binary systems by EPJvan den Heuvel and GMHJHabets, Supernovae remnants by GSrinivasan and Pulsar velocities by VRadhakrishnan and CSShukre.

3. Proceedings of the International Symposium on Biomolecular Structure and Interactions—2 Volumes. Published in 1985. Price Rs.150/-, US\$ 50, pages 528.

There has been tremendous progress in understanding biology at the molecular level during the last two decades. Significant developments and new discoveries have been made in the area of biomolecular structure and interactions, in particular, on systems related to proteins, nucleic acids, polysaccharides and membranes. The approach ranges from theoretical studies to applications of a variety of physicochemical techniques, with novel synthetic methods.

An international Symposium on Biomolecular Structure and Interactions was organised by the Molecular Biophysics Unit of the Indian Institute of Science from 17-22 December 1984, to provide an opportunity to Indian and foreign scientists in this field to meet and discuss topics of mutual interest and also to create an awareness among the international biophysics community about the work being carried out in India.

The Proceedings have been published in two volumes. The first volume contains contributions dealing with protein folding and

solvation, peptides and polypeptides, ion transport and membranes, carbohydrates and lectins, and x-ray studies of biomolecules. Contributions in the areas of DNA structure and polymorphism, drug nucleic acid interactions, RNA ribosomes and viruses are included in the second volume. The contributions present state-of-the-art methodologies and techniques as well as novel results in most fields associated with biomolecular structure and interactions.



4. Photons, Galaxies and Stars, Selected Papers of R Hanbury Brown, Raman Professor 1974, Published in 1985. Price Rs.100/-, US\$ 30/-, pages 428.

The present volume contains 30 selected papers in astronomy and astrophysics by Prof. R Hanbury Brown, who was the first occupant of the prestigious Raman Chair in 1974 and President of the International Astronomical Union from 1982-85. The papers cover 6 main areas, the Emission from Radio sources, the Angular diameters of radio sources, Techniques of measuring angular size, Photon optics, Optical astronomy and Gamma ray astronomy. The volume concludes with four lectures on Measuring the size of the stars, Bosons and stars, Concern about the control of science and Science and faith.

Hanbury Brown's major contributions have been in our understanding of light, techniques for studying it and particularly to the problem of measuring the angular sizes of stars. His original papers on the radio emission from our galaxy and other galaxies, devising and developing long baseline interferometric techniques to achieve high angular resolution and intensity interferometry to measure stellar angular diameters are reproduced in this volume.

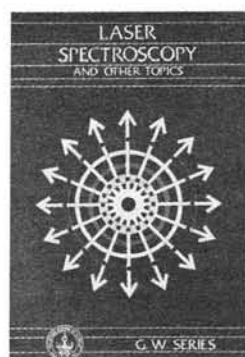
This collection of his papers should enable a wider circle of readers to appreciate his work, which cuts across conventional distinctions like engineer/physicist/astronomer or even experimenter/theorist and leaves us with a picture of a remarkably intergrated scientist.

5. Laser Spectroscopy and other topics, Selected Papers of G W Series, Raman Professor, 1982-83, Published in 1985, Price Rs. 120, US\$ 40, pages 632.

Prof. G W Series has greatly influenced the growth of spectroscopy during the last two or three decades. A pioneer in the field of quantum beat spectroscopy, his optical measurement of the Lamb shift and the hyperfine structure in atomic hydrogen and his precise determination of one of the most basic constants of physics—the Rydberg Constant—have made him a recognised authority in this field.

Prof. Series visited India as Raman Professor during 1982-83. This volume of his selected papers is the fourth in the series of selected papers of Raman Professors published by the Academy, the first three being those of Prof. N Bloembergen, Prof. K R Ramanathan and Prof. R Hanbury Brown.

The present volume also contains some of the lectures he gave in India and together they illustrate the major theme of his classic research work, the interaction of radiation with atoms. The strength and value of this collection lies in the unique record it gives of the growth of this rich field as seen by one of its founders.



6. Topics in Molecular Interactions. Edited by W J Orville Thomas, H Ratajczak and C N R Rao, Published in 1985. Elsevier and Indian Academy of Sciences, pages 461.

At present the field of intermolecular or molecular interactions is one of the major areas of molecular science. One reason for this is that the topic is important in chemistry, physics and biology and even more so at the interfaces of these subjects.

This volume deals with a variety of problems. The first group contains important topics which have not recently been dealt with in an authoritative fashion, such as the information given by studying hindered internal rotation. This group also includes

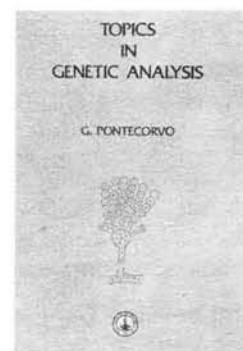
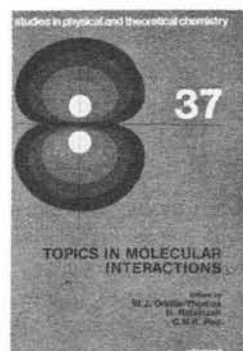
treatment of the crystal and glassy states which are, to some extent, complementary.

The second group contains contributions based largely on nuclear magnetic resonance work. Nuclear spin relaxation studies have led to an intimate knowledge concerning association effects. Hertz *et al* describe the approach developed by them. Also included is a second experimental chapter by Kielich devoted to the way in which light scattering studies provide information on multiple forces in molecular interactions. Other topics based on NMR studies show how this technique yields valuable information on molecular and ion-molecular interactions.

7. Topics in Genetic Analysis. Selected Papers of G Pontecorvo, Raman Professor 1982-83, Published in 1985, Price Rs. 100, US\$ 30, 320 pages.

Professor Guido Pontecorvo visited India for three months from December 1982 to February 1983 as Raman Professor. Among his major contributions to genetics, the two that stand out as most consequential, are one, his discovery of the parasexual cycle in fungi, which led him to develop methods of genetic analysis that were the forerunners of modern somatic cell genetics, an approach to genetics of higher animals, that has revolutionized our knowledge of human genetics. The other is his work on intragenic recombination and the seminal paper on the organisation of the genetic material. He outlined a new theory of the gene, a year before the discovery of DNA structure and the revision of the gene concept.

All Prof. Pontecorvo's important papers on Mutation and Recombination and Somatic Cell Genetics are included in this volume. The essay on "Reminiscences on Genetics, from Mendelism to recombinant DNA" forms the text of the Gandhi Memorial Lecture he gave at the Raman Research Institute on 30 January 1983.



# Obituaries

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In the passing away of **Janardhana Venkatesh Bhat**, Indian microbiology has lost *one of the leaders of the classical school of bacteriology*. Born in Tellicherry on 3 March 1913, he obtained his M.Sc., Ph.D. and D.Sc., degrees from the University of Bombay. In 1935 he joined the Department of Microbiology, St. Xavier's College, Bombay becoming in due course Professor and Head of the Department. From 1945 to 1947 he worked as a Watumull Foundation Research Fellow with Dr H A Baker, one of the pioneers in research in bacterial metabolism, at the University of California, Berkeley. In 1953 he joined the *Indian Institute of Science*, Bangalore as Assistant Professor and later became Professor of Fermentation Technology. He retired as Chairman of the Microbiology and Pharmacology Laboratory in 1973, after which he continued his work first as an Emeritus Scientist of ICAR and later as Director of Research at the Kasturba Medical College, Manipal.

He was elected a Fellow of the Indian Academy of Sciences in 1957 and of the Indian National Science Academy the next year. He was President of the Association of Microbiologists of India, the Association of Food Technologists and Scientists and the Deccan Section of the Royal Institute of Chemistry.

His research encompassed a wide spectrum of microbiology and allied disciplines, his publications covering areas as diverse as the metabolism of lactic acid and phenolics by microorganisms, the chemistry and biology of coir retting, the status of nitrogen in soils, *biological nitrogen fixation* and nutrition and metabolism of mulberry plants in relation to silkworms, silkworm nutrition, with particular reference to silk yield and the role of earthworms in agriculture.

He was also a popular teacher and speaker. He was charming and friendly and known for his ready wit.

He passed away in Madras on 21 December 1985. He leaves behind his wife, two sons and two daughters and a large circle of friends and admirers to mourn his loss.

**Angarai Seshiah Ganesan** was born on 27 May 1900 at Vadakancheri in Kerala and had his school and college education at Tiruchirapalli. He continued his postgraduate study in physics at St. Joseph's college and secured his Master's degree from Madras University in 1922. He

started research under Prof. C V Raman, at the Indian Association for the Cultivation of Science, Calcutta, working on oblique scattering of light in liquids and gases. His papers published with Prof. Raman were on the spectral studies of helium and the polarisation of light scattering by organic vapours.

In 1924 he received the Dominion Science Scholarship, tenable at the Imperial College of Science and Technology, London. Working with Prof. A Fowler in the Department of Spectroscopy, he obtained the Ph.D. Degree of London University in 1926 for his thesis on the second spectrum of neon.

After two years of teaching at the University of Rangoon, he rejoined Prof. Raman for a year at Calcutta, and in 1929 joined the College of Science, Nagpur, where he was to continue for the next 27 years. He started a flourishing research school on Raman spectroscopy and published many papers on various aspects of the Raman Effect. He worked as Principal of Hindu College, Moradabad, for two years after his retirement in 1956. In 1958 he joined as Editor of *Current Science*, a position which he held for the next fifteen years.

It was during his editorship that *Current Science* became a fortnightly journal. A man of strong principles and a strict disciplinarian, he was known for his impartiality as an editor. With the cooperation of the meagre but devoted staff of the Journal, he was able to build up this fortnightly into the major scientific letter journal it is today.

Prof. Ganesan was a Foundation Fellow of the Indian Academy of Sciences. Outstanding as a teacher, he was a source of inspiration to *his students; his remarkable lectures, illustrated with innumerable experiments, were famous*. The meticulous care with which he did everything he touched, his gentle unassuming ways, his graciousness and his subtle sense of humour endeared him to all those who came in contact with him.

In 1974, he went back to Nagpur to live with his son, but till the very end, he was keenly interested in science. It was his deep interest and involvement that brought the Raman Museum and the Raman Science Park at Nagpur into existence.

He passed away at Nagpur on 2 January 1986. In his death we have lost an outstanding teacher in the finest old tradition, an able research worker, an editor of merit and a truly warmhearted friend and colleague.

**Pamadi Raghavendra Rao Krishna Rao** passed away on 7 November 1985 at Bangalore after a very brief illness.

Born on 25 July 1906 at Mulbagal, Kolar District, Karnataka, he studied at Bangalore, taking his B.Sc., degree in Physics and Mathematics from the University of Mysore. In 1927, while a research scholar in physics at the Central College, Bangalore, he was selected for the post of Assistant Meteorologist in the India Meteorological Department. He served the Department with conspicuous distinction in various capacities for 38 years, retiring as Director-General of Observatories in 1965. After his retirement he retained his active interest in meteorology and hydrology and had just completed his magnum opus in several volumes on the Hydrometeorology of Karnataka when he passed away.

His research interests covered all aspects of meteorology. In 1952 he located for the first time the existence of easterly jet stream in the upper troposphere during the monsoons. He was elected a Fellow of the Academy in 1939. He was President of the Indian Meteorological Society for many years.

He was responsible for the rapid growth and transformation of the India Meteorological Department in the late fifties and early sixties. The establishment during the International Indian Ocean Expedition, of the International Meteorological Centre at Bombay, which later became the Indian Institute of Tropical Meteorology, Pune was entirely due to his vision and dynamism and his realisation of the importance of the monsoon studies for the future. The establishment of the Northern Hemisphere Analysis Centre and the Northern Hemisphere Exchange Centre at Delhi, of the Indian Ocean and Southern Hemisphere Analysis Centre at Pune, of the cyclone warning radar network in the country and the Extended Analysis Prognostic Centres at international airports had its genesis under him. He laid the foundations for the expansion and modernisation of the Department and the remarkable developments in India in the sixties in meteorological instrumentation, radiometeorology, hydrometeorology, seismology, astronomy and astrophysics are mainly due to his efficient planning and organisation. The Indian Institutes of Astrophysics and Geomagnetism are indebted to him for his encouragement and support in their formative years.

He was a superb administrator and won the respect and admiration of all those who worked with him by his objectivity and impartiality and the unstinted support he gave to his young colleagues.

He leaves behind his wife, son and three daughters and numerous friends and former colleagues to mourn his loss.

**Ladapuram Srinivasa Sampath Kumar** was

born on 4 June 1903. After taking M.Sc., degree from the University of London in 1927, he joined the Agricultural College, Pune. As Economic Botanist to the Government of Bombay and Principal of the College of Agriculture, he took an active part in the various scientific activities in Poona for nearly three decades. He was closely associated with the work of the Indian Drugs Research Association, and one of the major achievements of the IDRA at this time was the identification of *Spilanthus acmella* as a plant larvicidae.

After his retirement from the Agricultural College, Poona in 1958, he worked for a few years as Additional Director of the Agricultural Research Institute in Kerala.

His research work centred round the breeding of grasses for improved strains as well as on oil-seeds and pulses. He also worked on the induction of polyploidy in grains, crops, fruits, vegetables and flowering plants.

He was elected a Fellow of the Academy in 1939. He was Vice-President of the Indian Drug Research Association, Pune and a member of the Indian Society for Genetics and Plant Breeding.

**Keshava Prabhakar Rode** was born on 8 November 1902 at Chhindwara in a family known for its erudition. After graduating from the Banaras Hindu University, he continued to work there as a lecturer, carrying out research in palaeobotany, mainly on plant fossils and biostratigraphy.

He joined Professor Paul Nigli's laboratory at Zurich in 1937 and obtained his doctorate degree for his thesis on "The geology of Norcote Peninsula and the petrochemistry of the porphyry magma of Lugano". On his return to India, he joined the Andhra University. After a brief stint with the Dalmias as their Chief Geologist, he joined the University of Rajasthan in 1950 as the first head of the Department of Geology. His main work was on the movement and evolution of continents. The fundamental concept of his theory was that the continents have expanded by repeated movement of sheets, which originally were closely packed like playing cards piled together in the region of the Tibetan Himalayan mountain system. He enunciated his theory before the International Geological Congress at New Delhi in 1964. This was also the theme of his Presidential address at the section of Geology and Geography of the 49th Indian Science Congress held at Cuttack in 1962.

It is perhaps too early to evaluate the full impact of his work and philosophy. But he enjoyed his life and work and his dedication to geology was total. He will be sadly missed by his many students and friends.

# 32nd Annual Meeting of the Academy

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The first Annual Meeting of the Academy to be held in Madurai was in 1966, under the Presidentship of Prof. CV Raman. The Madurai Kamaraj University had just come into being and was still located in the city.

The inaugural function and the public lecture on 20 December were held in a specially erected pandal in the University compound and were attended by thousands. The Business Meeting and scientific meetings and public lecture on 22 December were held in the College lecture halls.

Inaugurated by Sardar Ujjal Singh, the then Governor of Tamil Nadu and the Chancellor of the University, the 32nd Annual Meeting was held for three days from 20 to 23 December 1966. The Meeting was attended by 28 Fellows and 22 delegates.

The inaugural session started with an invocation and a formal welcome address by Dr TP Meenakshisundaram, the first Vice-Chancellor of the University, whose pioneering efforts led to the creation of the extensive Palkalainagar Campus, about 13 km outside Madurai City.

Sardar Ujjal Singh in his inaugural speech said that there was a singular appropriateness in choosing the ancient city of Madurai as the venue of the Meeting. He was happy that the Academy had set for itself very high objectives and standards of work and was sure its achievements would be of lasting value to our country.

In accordance with the time-honoured practice at the Annual Meeting, the President introduced to the audience the Fellows who had come from various parts of the country to take part in the proceedings.

Prof. Raman then delivered his Presidential address on "The eye and vision".

On 21 December there was a symposium on "Active Solar Regions" with talks on Active regions of the sun and the interplanetary medium by Vikaram A Sarabhai, Chromospheric active regions by MK Vainu Bappu, The development of active regions on the sun by KR Sivaraman, Solar magnetic fields by JC Bhattacharyya, Sunspot velocity fields by ABhatnagar, High resolution studies of active

solar regions at microwave frequencies by Govind Swarup, Radio burst characteristics by MR Kundu, Ionospheric effects of solar fires by AP Mitra and Solar cosmic rays by RR Daniel.

The second symposium was on "Molecular Biology" held on 22 December, with talks on the Primary structure of proteins by LK Ramachandran, Conformation of nucleotides and nucleic acids by V Sasisekharan, Conformation of polysaccharides by VSR Rao, Physiology of plants under stress by TS Sadasivan, Regulating mechanisms in the living cell by ASreenivasan, Experimental manipulation of chromosomes by TN Khoshoo and Emigration of filarial embryos from the habitat of the parent worms to the blood stream by VC Anguli.

The special lectures given during the meeting were on Monsoons of the world and the general circulation of the atmosphere by CRamaswamy, New perspectives in brackish-water biology by NK Panikkar, Brackish-water characteristics by SZ Qasim, Studies on Benthic fauna of Cochin backwater by BN Desai and MKrishnan Kutty and Regulation mechanism in some brackish-water fauna by SKrishnaswamy.

The benefits of the 32nd Meeting still continue. In commemoration of the 32nd Annual Meeting of the Academy, two endowments were created by the Madurai Kamaraj University from the surplus funds collected for the Meeting. They are the "Sir CV Raman Endowment in Physical Sciences" and the "Indian Academy of Sciences Endowment in Biological Sciences". Eminent scientists in physical and biological sciences are invited in alternate years to deliver these lectures. The following is a list of the endowment lectures given since 1968.

Sir CV Raman Endowment Lectures (Physical Sciences)

1968 – DS Kothari  
1970 – TR Seshadri  
1972 – GN Ramachandran  
1974 – EC G Sudarshan  
1977 – BV Sreekantan  
1979 – BRamachandra Rao  
1982 – R Chidambaram  
1985 – G Swarup

Indian Academy of Sciences Endowment Lectures (Biological Sciences)

1969 – BR Seshachar  
1971 – Joel Mandelstem  
1976 – JR Tata  
1979 – Joseph Kahn  
1981 – SP Tripathy  
1983 – A Daniel