Patrika

July 1991 No. 23 Newsletter of the Indian Academy of Science

57th Annual Meeting

At the invitation of the National Chemical Laboratory, Pune, the 57th Annual Meeting of the Academy will be held at Pune from 8 to 11 November 1991.

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

The two symposia will be on "Astronomy and Astrophysics" and "The state of scientific research".

A visit to Mahabaleshwar will be organised on Sunday, 10 November. The Business Meeting of Fellows will also be held at Mahabaleshwar.

All Fellows and Associates attending the Annual Meeting will be paid First Class railway fare from their place of residence to Pune 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 organisers. During the period of the Annual Meeting the Editorial Boards of the Academy journals and the Sectional Committees will also meet at Pune.

Associates – 1991

A M Kayastha, Banaras Hindu University, Varanasi – Enzyme biochemistry

S Mazumdar, Tata Institute of Fundamental Research, Bombay – Bio-inorganic chemistry

S Ramakrishnan, Indian Institute of Science, Bangalore – Polymer science

M Ramaswami, Tata Institute of Fundamental Research, Bombay – Molecular biology and genetics

D S Ramesh, National Geophysical Research Institute, Hyderabad – Seismology

J B Udgaonkar, Tata Institute of Fundamental Research, Bombay – Protein folding

Mid-Year Meeting

The second Mid-Year Meeting of the Academy will be held on Friday, 26 July 1991, at the Indian Institute of Science, Bangalore.

There will be ten lectures by Fellows and Associates in two sessions in the morning and afternoon and an evening lecture by Prof. M N Srinivas, Institute for Social and Economic Change, Bangalore, on "The caste system and its future". The following is a list of lectures by Fellows and Associates.

Morning Session

M Barma, TIFR, Bombay, "Small Fermi systems"

A V Khare, Institute of Physics, Bhubaneswar, "Quantum mechanics and statistical mechanics of anyons"

N Krishnan, TIFR, Bombay, "Searching for the fifth force"

V S Ramamurthy, Institute of Physics, Bhubaneswar, "New facets of the nuclear quantum fluid"

A D Patel, IISc, Bangalore, "Lattice QCD: How far have we come?"

G Prathap, NAL, Bangalore, "Locking in finite element analysis — From superstition to science"

Afternoon Session

V H Arakeri, IISc, Bangalore, "Some aspects of hydrodynamic cavitation"

Y V R K Prasad, IISc, Bangalore, "Dynamic recrystallization — A chosen domain for processing"

V C Thakur, Wadia Institute of Himalayan Geology, Dehra Dun, "Closing of Tethys ocean and birth of Himalayas"

K V Subbarao, IIT, Bombay, "Deccan volcanism".

Stochastic Differential Equations

Stochastic differential equations has been one of the most active areas of probability theory in recent years, with many fruitful interactions with other branches of mathematics, theoretical physics and engineering. Given the obvious importance of the subject, a need for a Discussion Meeting on the topic was voiced at an earlier Academy Discussion Meeting on Von Neumann algebras in quantum mechanics held in April 1990.

The present Discussion Meeting was held at the Indian Institute of Science from June 10 to 12, 1991, under the auspices of the Academy. N Mukunda (IISc, Bangalore) and K R Parthasarathy (ISI, New Delhi) were the conveners of this meeting, assisted by V S Borkar (IISc, Bangalore) and S Ramasubramanian (ISI, Bangalore). The meeting was attended by over fifty participants. The lectures were each of ninety minutes duration, with extensive discussions after each lecture.

The meeting opened with a brief introductory remarks by N Mukunda and K R Parthasarathy. The first session began with an introduction to stochastic integration and stochastic differential equations by R L Karandikar (ISI, Delhi), describing the construction of the Ito integral, the Ito formula, construction of solutions of s.d.es. by successive approximations and pathwise approximations of these. The second talk by S Ramasubramanian described the connections between stochastic and partial differential equations, focussing upon probabilistic representations of solutions to elliptic and parabolic p.d.e. (including the celebrated Feynman-Kac formula) and touched upon the recent developments in the probabilistic treatment of the Schrödinger operator.

The afternoon session was devoted to parameter estimation in diffusion-type processes. The first talk by B L S Prakasa Rao (ISI, Delhi) gave a brief survey of the maximum likelihood approach, using Girsanov's theorem and presented some results on the local asymptotic normality of these estimates. The second talk by Arup Basu (ISI, Calcutta) treated some specific problems, sketching explicit computations of distributions of the estimates and highlighting some open issues.

The morning session of the second day began with a talk by Alok Goswami (ISI, Calcutta) on filtrations of Ito integrals, in particular, issues such as whether they are generated by the given (or any) Brownian motion. Complete answers were presented for some special cases. In the second talk, B Rajeev (ISI, Calcutta) described local times for Brownian motion, proving via the downcrossing theorem and stochastic integration, the Tanaka formula and the fact that the local time increases only on the zero set of the Brownian motion.

In the first talk of the afternoon session, S Ramaswamy (TIFR Centre, Bangalore) described fundamentals of s.d.es taking values in nuclear spaces, using as an example the infinite dimensional Ornstein-Uhlenbeck process, which can be solved as an infinite system of one-dimensional s.d.es. The second talk by K R Parthasarathy gave a historical account of Brownian motion and Langevin equation and gave a rigorous derivation of the latter from physical principles.

On the third and concluding day, the first talk by V S Borkar gave an overview of controlled diffusions, covering the existence of optimal controls, the Hamilton-Jacobi-Bellman equations, nonlinear filtering and control under partial observations, as well as adaptive control. This was followed by a talk by R L Karandikar describing the interplay between martingale theory and Markov processes, focussing on the Stroock-Varadhan formulation of the martingale problem, useful criteria for weak convergence of processes in this context and criteria for the existence of invariant measures.

The afternoon session opened with a talk by K Rama Murthy (ISI, Bangalore) describing stochastic integration with respect to stable, semistable and infinitely divisible random measures and multiple stochastic integrals in this framework. In the last talk of the meeting, N Mukunda gave a historical account of problems of interpretation of quantum mechanics, with an overview of the Copenhagen approach, the hidden variable controversy and the various fundamental issues thrown up by the seminal work of J S Bell.

Most of the lectures were of an expository or survey nature and some touched upon the current research of the speakers. The meeting served well to familiarize persons working in these areas with each other's work and with the issues that form the centre stage of current research in this field. Many participants working in closely related areas also got a flavour of the mainstream activity in s.d.es. In the concluding session chaired by K R Parthasarathy, the general view was that the meeting should be followed by other similar occasions for the community of Indian probabilists to meet and exchange ideas.

Learning and Memory in Animals

Under the auspices of the Academy, a small group of 18 biologists drawn mainly from the Indian Institute of Science, Bangalore and the University of Agricultural Sciences, Bangalore met quietly for two days on 1 and 2 June 1991 in a small farm house in an obscure village called Heggedihalli near Nandi Hills in Chikaballapur district. The purpose of this meeting was to have a brain-storming session to take stock of recent advances in the area of "Learning and memory in animals". Learning and memory in animals are age-old problems in biology and psychology with an unusually large amount of literature. Nevertheless one has always had the feeling that we understand very little, if anything, about these rather mysterious phenomena. In the last decade, however, there appear to have been truly major advances in our understanding of learning and memory in animals. This meeting was intended to find out if this gut-feeling about progress made in the last decade is correct. The topics discussed included "Orientation in foraging animals" by T Veena, "Cognitive maps in animals" by R Gadagkar, "Perception of shape in insects" by R Uma Shaanker, "Concept of time and number in animal cognition" by A Sinha, "Mental maps in the barn owl" by S Subramanya, "Echolocation in bats" by T R Radhamani, "Do elephants remember?" by K V Devi Prasad, "Self-organized behaviour in social insects" by K N Ganeshaiah, "Decision-making in uncertain environments" by R Uma Shaanker, "Memory in animals" by R Gadagkar, "Search strategies of foraging animals" by K N Ganeshaiah, "Genetics of learning and memory" by S G Hegde, "Learning in host selection" by B Mallik and "Innate behaviour, instinct and learning" by A Sinha. Most participants returned home with the impression that truly significant advances have now been made in our understanding of learning and memory in animals. More importantly, as the discussions proceeded, there was a growing sense of awe at what animals, including insects, can accomplish in orientation, pattern recognition and decision making. It is perhaps fair to say, however, that this field is still in a descriptive phase and it will be a while before a synthesis becomes possible. A rather unusual feature of this meeting was that it was relatively unstructured so that discussions, both during and after the formal presentations were unlimited and extensive. This was possible because of the small size of the group and the fact that most members of the group have known each other for a long time. This informality tended to upset the schedule of lectures somewhat but that was partly made up by continuing the discussions late into the night. Even so, some of the topics listed could not be covered, although the group continues to discuss these after returning to Bangalore. It was altogether an unusual meeting but perhaps one of the few where one could go into great depth in the topics covered.

Special Publications

A Variety of Plasmas – Proceedings of the 1989 International Conference on Plasma Physics (Edited by A Sen and P K Kaw) 1991, pp. 554 + 13. Distributed by Oxford University Press.

The 1989 International Conference on Plasma Physics was held in November 1989 in New Delhi. As a paradigm for systems far from thermal equilibrium which are dominated by nonlinear collective phenomena, plasmas have no parallel and have provided a wealth of experimental information on nonlinear phenomena such as chaos, turbulence, anomalous transport, solitons, vortices etc. leading towards quantitative descriptions of such effects. It has also been possible to use them in a great number of applications ranging from fusion to free electron lasers, plasma processing to novel accelerators and radiation sources and MHD power generation to interpretation of observed space and astrophysical phenomena.

This volume is a collection of the 36 invited talks presented at the Conference under 5 main topics: Novel Plasma Systems, Chaos and Turbulence, Coherent Nonlinear Wave Phenomena, Magnetic Confinement Fusion and Inertial Confinement Fusion. All in all, one comes away with the feeling that plasma physics, "the queen of classical physics", is indeed doing very well and that its frontiers are advancing rapidly in all directions.

Special Issues of Journals

Sadhana – Academy Proceedings in Engineering Sciences, Vol. 15, Part 3, November 1990, pages 129-248, Digital Signal Processing.

Digital Signal Processing (DSP) forms the backbone of many modern applications in such diverse fields as radar and sonar communications, biomedical and aerospace sciences, geophysics etc. The availability of signal processing chips and high speed computing hardware has facilitated the use of DSP in a variety of new areas, hitherto unexplored.

This issue, the first of two parts, consists of six papers on some of the theoretical advances made in the field of DSP in recent years and the editors hope that it will prove to be useful in introducing recent advances in digital signal processing to the engineering community at large.

Special Issue on Geomagnetic Methods and Lithospheric Structure – Proceedings Earth and Planetary Sciences, Vol. 99, No. 4, December 1990, pp. 441-738

Perturbations in the earth's magnetic field have long been studied for deciphering its internal structure. These, like other geophysical probes, received a new impetus over the past three decades from the development of high resolution measuring systems and the availability of large high speed computers. Globally consistent sets of magnetic data yielded by highly sensitive satellite-borne magnetometers (MAGSAT) and the new ocean bottom magnetometers have thus been used to study the lithospheric structure.

Twelve papers are included in this volume, seven being state-of-the-art papers on the practice of geomagnetic exploration and the rest on the lithospheric structure in the Indian region constructed from geomagnetic anomalies. The editors hope that this special issue will serve as a valuable reference to students and professional scientists interested in the principle and practice of using geomagnetic field variations to explore the earth's deep structure.

Merger of Journals in Biology

The Council of the Academy has decided to merge three of the biology journals published by the Academy: *Proceedings: Animal Sciences* and *Plant Sciences* and the *Journal of Biosciences*. For various practical reasons, the name *Journal of Biosciences* has been retained for the merged journal. This will be a quarterly and the first two issues appeared in June 1991. Since this decision reverses an earlier one taken in 1978, it is appropriate to mention some of the reasons underlying this merger.

Since the founding of the Academy in 1934, its main activity has been the publication of scientific journals. The *Proceedings* appeared in two sections: Section A devoted to Physical Sciences and Section B to Life Sciences. In 1978, the *Proceedings* were split into several subjectwise journals. In particular, Section B was split into *Proceedings: Animal Sciences*, *Proceedings: Plant Sciences* and *Proceedings: Experimental Biology*. The section on Experimental Biology was renamed the *Journal of Biosciences* in 1979. At first sight, it seems like a retrograde step to merge these three journals again, particularly in the light of the present preference to have specialized journals. But the overwhelming majority of the better papers published by Indian scientists find their way into journals published abroad, and it has been difficult to maintain high standards with **four** specialized journals in Biology (with 19 issues per year between them). Thus, sadly, the earlier hope that specialized journals are more likely to attract good papers than the *Proceedings* has not been fulfilled. In several editorials published in *Current Science* before the Academy was founded, C V Raman argued that the main objective of the Academy would be to publish journals where the more important results of the Indian scientists would appear, rather than be exported. Only then, he argued, can the Indian scientific community gain international recognition and be freed from a position of semi-dependence. The Council initiated several discussion meetings between active biologists and the concerned Editors and arrived at the eventual decision to merge these three journals.

The new *Journal of Biosciences* will have a broader scope than the three separate journals that are being merged and will include all areas of biology such as Molecular Biology, Genetics, Developmental Biology, Biophysics, Biochemistry, Immunology, Endocrinology, Medical Biology, Neurobiology, Ecology, Physiology, Ethology, Evolutionary Biology, Environmental Biology and Sensory Biology. A new Editorial Board has been constituted whose composition reflects this enlarged scope. This reconstitution also gives an opportunity to a new group of people to share in this important responsibility.

Obituaries

Ragnar Arthur Granit, formerly Professor of Neurophysiology, Karolinska Institute, Stockholm and Director of Neurophysiology Department, Nobel Institute of Neurophysiology, who died in March this year aged 90, made major and pioneering contributions in vision physiology and motor control by muscular afferents. For his discoveries in vertebrate vision physiology he was awarded the Nobel Prize in Medicine and Physiology in 1967, with Prof. Hartline and Prof. Wald.

The perception of light and colour by the visual apparatus involves absorption of radiation energy by chromophores in the sensory cells of the retina, and transduction of this information into nerve impulses, which are directed towards the brain. Ramon Y Cajal's histological studies had shown that the retina is a nervous structure. The receptor and horizontal cells in the outer retinal layer are connected to the bipolar cells. The bipolar and amacrine cells in turn are connected to the ganglion cells. Considering the system of retinal interconnections, the ganglion cells convey the information made up by the total contribution of four cell types. It was Granit's idea to study the electrophysiology of the retina, and Ramon Y Cajal's histological work on the retina formed the basis. Granit's method, which was later utilized by others, consisted of removing the cornea and lens and placing glass-insulated wire electrodes on the retinal tissue. His initial studies in 1932 were on the electroretinogram, and analysis of its components. He provided evidence in 1934 to suggest that light can produce inhibition of signals in addition to excitation. This was another important contribution in vision physiology.

His foremost contribution, for which he was distinguished with the Nobel Prize, was his work related to colour vision. The basic foundation of Granit's work was provided by the Trichromacy theory, which was proposed to explain colour vision by Young and later modified by Helmholtz. The Young-Helmholtz theory proposed that there are three primary colour receptors in the retina — blue, green and red. Any individual colour in the continuous spectrum of colours is perceived on stimulation of these three hypothetical receptors in different proportions. Granit's experimental work on the cat retina using glass-insulated microelectrode studies of neuron activity of the retina exposed to the spectrum of light frequencies, provided the first experimental support for the Trichromacy theory. He found that the neural discharges from the retinal units were grouped around three wavelengths, each unit responding either to the blue, green or red part of the spectrum. The recordings made by Granit (1945) were most likely from ganglion cells of the retina. The retinal elements which responded to a narrow band of the spectrum were designated as "modulators". In addition, he distinguished retinal elements which showed a broad distribution of spectral sensitivity, designated as "dominators".

Granit's research interests subsequently shifted to principles of muscle control and movement by sensory organs in the muscle, sensing muscle length (muscle spindles) and tension (tendon organs). The muscle spindles are widely scattered throughout the fleshy parts of the muscle and attached to extrafusal fibres at both ends. Each spindle contains thin muscle fibres known as intrafusal fibres, which are innervated by axons called gamma fibres, whose capacity for making spindles discharge was demonstrated by L Leskell in Granit's laboratory. Subsequent studies by Granit and his colleagues showed that localized sites in the brain and the cerebellum which excited or inhibited the motor or alpha neurons had parallel actions on the gamma motoneurons. Their experimental work supported the concept of the gamma loop, and the linked alpha and gamma action. Breakdown of this loop was observed after ablation of the cerebellum. The studies led to the clinical differentiation of alpha and gamma rigidities and understanding the clinical symptoms of dysmetria. Other significant findings were the differentiation of tonic from phasic motoneurons and the phenomenon of recurrent inhibition. He defined the muscle spindles as sensory-motor end organs, whose function was related to both the measurement of muscle length and the control of muscle action.

Granit was born on October 30, 1900 in Helsinge, Finland. He graduated from the Swedish Normal-lyceum, Helsinki in 1919, took the Mag. Phil. and M.D. degrees in 1923 and 1927 respectively at Helsinki University, and served there as Professor of Physiology during 1935-1940. The formative years of his research career were spent in Charles Sherrington's laboratory in Oxford, and at the Johnson Foundation, University of Pennsylvania. It was during this period that his interests in retinal physiology were established. In 1940 he was invited to a research chair in neurophysiology at the Royal Caroline Institute in Stockholm. From 1945 onwards he was the Director of the Nobel Institute of Neurophysiology, from where he retired in 1967.

He received honorary degrees from Oslo, Oxford, Chicago, Pisa and Helsinki universities and was honoured with Retzius, Purkinje, Sherrington and Donders distinguished medals.

He was past president of the Royal Swedish Academy of Sciences, Foreign member of the Royal Society (London), National Academy of Sciences (Washington), Danish Royal Society and Academia dei Lincei (Rome). He was elected an Honorary Fellow of the Indian Academy of Sciences in 1964.

His books 'Sensory-mechanisms of the Retina' (1947, 1963), 'Receptors and Sensory Perception' (1955) based on Silliman lectures delivered at Yale University, 'Charles Scott Sherrington: An Appraisal' (1966), 'The Basis of Motor Control' (1970) and 'The Purposive Brain' are held in high regard.

Ennapada Sundaram Ayyar Narayanan was born on February 15, 1904. He was educated in the Victoria College, Palghat (Kerala) and at the Presidency College, Madras, obtaining an M.A. degree with Zoology as the major subject. He joined the Imperial Agricultural Research Institute, Pusa in 1930 and had the privilege of working under Brainbrigge Fletcher.

After some years of work, he went to England for higher studies, taking his Ph.D. degree from the Royal College of Science and DIC from the Imperial College of Science and Technology. While studying at the Imperial College of Science, he received training in analytical organic chemistry and animal physiology at the University College, London, under Prof. J B S Haldane and G P Wells and also underwent a course in statistics, in the Department of Mathematics, Royal College of Science under Prof. Levy. He also spent 3 months in a bee farm in Kent to acquaint himself with the practical aspects of modern bee keeping, especially the breeding of Queen bees by supersedeary impulse. He also passed all the examinations of the British Bee-keepers Association. Before returning to India, he had post-graduate training under Prof. E R Thomson in biological control of insect pests and noxious weeds.

After his return to India he joined the Imperial Agricultural Research Institute, New Delhi, in the Division of Entomology where he worked until his retirement in 1962.

In 1955, he visited the United States of America and Canada to study the progress in the biological control of insects and weeds. On his return to India, he was appointed Principal, Central College of Agriculture, Delhi, in addition to his duties as Head of the Division of Entomology and Dean, Faculty of Agriculture and Forestry, University of Delhi.

On his retirement from the Indian Agricultural Research Institute, he joined the Sericulture Research Institute, Mysore as Director and was entrusted with the task of planning new research laboratories, recruitment of necessary staff, and initiation of research programmes. He carried out a number of experiments in genetics and manipulation of genes, culminating in the evolution of several new races of silkworms with superior commercial characters; one of these is named 'Mysore Princess'.

He was elected a Fellow of the Academy in 1953 and served the Council as a member from 1962–1970. He was a founder member of the Entomological Society of India and was its president for 4 terms from 1953-1960. He was Chief Editor of Indian Bee Journal and Chairman of the Editorial Board of the Indian Journal of Sericulture. He was President of the Agricultural Sciences Section of the Indian Science Congress Association in 1957.

A brilliant and gifted writer, he encouraged young entomologists to take up at least one group of insects of their interest for taxonomic studies and specialisation. He set an example, by his own taxonomic studies of Ichneumonidae (Hymenoptera) and initiating taxonomic research on the hitherto neglected Acarina.

A highly respected educationist and philanthropist, he made two endowments to the Entomological Society of India for the award of two medals for the best research paper published in the *Bulletin of Entomology* and the *Indian Journal of Entomology*.

He passed away peacefully in his sleep on 23 February 1991.

Vishnu Vasudeva Narlikar was born at Kolhapur on 26 September 1908. He had his education at Elphinstone College and the Royal Institute of Science, Bombay. After passing his B.Sc. (Hon.) examination in mathematics of the Bombay University in 1928, he went to Cambridge for higher studies. In 1930 he passed the Mathematics Tripos with distinction. His research career began with a study of Liapounov's famous paper on rotating fluid bodies. On the basis of a written review of Liapounov's method and achievement, he was awarded the Isaac Newton Studentship in 1930.

On his return to India in 1932, the late Pandit Madan Mohan Malviya persuaded him to join the Banaras Hindu University as Head of the Department of Mathematics. He taught mathematics at BHU for the next 28 years. After a stint with Rajasthan Public Service Commission as its Chairman for six years, he joined the University of Poona as the Lokmanya Tilak Professor of Mathematics in 1966 and retired from active service in 1973.

For him teaching and research were complementary. He could best be described as

a 'teacher-mathematician', something more than a teacher and a mathematician, one who uses teaching methods in mathematical research and research methods in mathematics teaching.

At Banaras, in addition to general relativity and Riemannian geometry, he taught modern algebra, groups, characters and their applications, wave mechanics, spinors and their applications, Hilbert's space and quantum mechanics, stellar structure etc. His philosophy of teaching can best be judged from his writings and lectures. He had realized when he started teaching mathematics that there were many gaps and voids in his understanding of the topics he taught. Elsewhere he pointed out the reasons for these gaps.

"Mathematics of the 80's is going to be different from that of the 70's just as the mathematics of the 70's was different from that of the 60's. The mathematics that I learnt as a student differed very much from the mathematics I was called upon to teach".

"The first lesson that I learnt was: One cannot be a good teacher, a successful teacher, without being always absorbed in the research topics concerned with his lectures".

His mathematics classes were always enjoyable and his popular talks on the mathematical topics were always well appreciated because of his research oriented methods of presenting a topic.

He was a pioneer relativist in India. After joining BHU, he established an active research school in relativity at Banaras and later at Poona. The main research areas studied were: exact solutions of Einstein's equations of general relativity, solutions of the unified field equations of Einstein and of Schrödinger, equations of motion as derived from field equations, the fourteen scalar differential invariants of Riemannian metric and their physical significance and the geometrical and physical properties of metrics satisfying Einstein's field equations.

He was generous in dealing with his students, giving them credit where due. He was one of the Founder Fellows of the Academy. He was President of the Calcutta Mathematical Society and of the Indian Mathematical Society. But above all, he was revered by the present generation of Indian relativists as grandpa Narlikar.

He passed away on 1 April 1991 at Pune leaving a large circle of his students and friends to mourn his loss.

In the sad and sudden demise of Shri **K Nagabhushana Rao** at Bangalore on 1 January 1991, the Academy has lost one of its distinguished Fellows in the field of Atmospheric Sciences. Born on 13 September 1913, he had a uniformly brilliant academic career. At the Central College, Bangalore where he had his college education he stood first in the First Class in the B Sc and M Sc degree examinations, securing record marks. He had high mathematical talents combined with a sharp memory and was the recipient of merit scholarships and prizes in the college classes.

After taking his M Sc degree in Mathematics in 1937 he joined the Indian Institute of Science, Bangalore to pursue research work under Professor Sir C V Raman in the Department of Physics. Professor Raman was deeply impressed by his proficiency in mathematics and appointed him as a Research Assistant within a short period of his joining.

After working in the Institute for a couple of years, Shri Rao joined the India Meteorological Department (IMD) in 1939. In IMD he steadily rose to various cadres of increasing status and responsibility until his retirement from service on superannuation in 1971. He was Director of the Regional Meteorological Centre at Bombay; Director of the Colaba and Alibag Geomagnetic Observatories; Deputy Director General in charge of Administration at Delhi; and Deputy Director General in charge of Climatology and Geophysics at the time of his retirement.

His early scientific work in IMD was in the area of atmospheric thermodynamics. He collaborated with Dr C W B Normand, the then Director General of Observatories, in important studies relating to convective instability of the atmosphere, which showed for the first time that the vertical distribution of equivalent potential temperature (EPT) in the tropics has a minimum around the 600 mb level. He prepared extensive tables for the calculation of EPT from aerological sounding data. He also compiled hygrometric tables for evaluation of the relative humidity of the atmosphere from psychrometer data. Some of these tables are still in use in IMD.

His scientific interests during the later years of his career in IMD were in the fields of climatology, hydrometeorology, meteorological statistics and long-range weather forecasting. One of his well-known contributions in collaboration with S K Pramanik relates to the hydrometeorology of the Damodar river catchment published as a Memoir of the IMD. He was also associated with the publication of the revised edition of the Climatological Atlas of India including Rainfall Maps for the country. He had in-depth knowledge of statistical techniques applied in meteorological studies.

The various facets of Indian rainfall with its intra-seasonal and inter-annual variabilities

fascinated him and he had a mastery of the relevant facts and figures. After retirement from IMD he worked for a few years as an expert in this area in the agro-meteorological commission of ICAR. In his last years he was engaged in writing a book on the Rainfall of India, assembling up to date information from various sources. With his scholarship and erudition this should have been an authoritative and valuable contribution to Indian meteorology. It is unfortunate that his end came before he could fulfil this cherished wish.

Coming from a lower middle class family and having lost his father at an early age, he had a hard struggle to educate himself. He owed his success in life to hard work combined with his innate talents. One of his hobbies was to test his mathematical skill by solving problems set for the Cambridge Mathematical Tripos. He had a religious frame of mind with more than ordinary scholarship in the teachings of Adi Sankara of whom he was a great admirer and devotee. The border land between the advaitic teachings of the *Upanishads* and the deep philosophical implications of modern science relating to the unity of Nature behind the apparent diversity fascinated him and in personal conversation he often referred to the writings of Schrödinger drawing parallels between the two. A good speaker and a pleasant conversationist, modest and unassuming, he was an example of plain living and high thinking according to the best Indian traditions.

Meenakshisundaram Venkataraman was born in Cheyyar in North Arcot district of Tamilnadu on 31 December 1923. He completed his high school studies in 1927 and took his M A (Maths) degree in 1943 from the Annamalai University with a first class and first rank. Working under Prof. A Narasinga Rao he took his Ph D (Maths) in 1947 from the Annamalai University with geometry as his speciality. He also learnt *Yajurveda* at this time and most of his public lectures in later years would end with a statement of the *Upanishads* that man is essentially a vast and happy being, and the goal of life is to find this true nature of man.

He was appointed a lecturer in mathematics at Annamalai University in 1945. He joined as lecturer in mathematics in Madras University in 1950 and was promoted as a Reader in 1951. In 1957 he became Professor and Head of the Department of Mathematics in the newly created University Centre at Madurai, which later became the 'Madurai Kamaraj University'. At Madurai, he introduced an M.Phil course, and held summer schools for the development of college teachers and provided facilities to its faculty to visit other institutions of learning.

He had started his research career with his contributions to chain theorems in geometry where he studied chains of the Cox-Grace type, Clifford chains, Langley chains etc. Later he worked on the abstract structures to the theory of functions, spectral theory in Hilberts spaces and to directed sets in topology. He also worked on the structures of the real number system, on the completeness of the Galois theories and on orderable topological spaces.

On his retirement from Madurai, he joined the Central University of Hyderabad as Professor and Dean in the School of Mathematics and Computer/Information Sciences. After retiring from Hyderabad in 1983 he lived at the Sri Aurobindo Ashram at Pondicherry till his death.

He passed away at Pondicherry on 18 November 1990.

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