RAMAN RESEARCH INSTITUTE

Bangalore

Annual Report

1999 - 2000

RAMAN RESEARCH INSTITUTE

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CONTENTS

PREAMBLE

As in the previous years, the Annual Report is a terse account of the main scientific activities of the Institute giving the list of papers published in scientific journals, discussion meetings and seminars/colloquia held, and the Ph.D. degrees awarded during the period 1 April 1999 to 31 March 2000. It also lists the visitors to the Institute – 51 of them from different parts of the world, the conferences attended and institutions visited by the members of the Institute during this period. Prof. Steven Vogel of Duke University, USA, visited the Institute as the first Golden Jubilee Distinguished Professor and delivered a series of lectures at RRI and other institutions, and had discussions with scientists at the Institute and elsewhere.

Other events that took place during the year was conducting of Summer School in Physics & Astrophysics, 28 May - 18 June 1999. Details are given on page 27 of the Report.

Important research highlights of the period are: New detections of Galactic and extragalactic neutral hydrogen using the RRI-developed 21 cm receivers on GMRT, the resolution of a long-standing puzzle of small-scale structures in Galactic HI, and the first ever detection of radio recombination lines from two Blue Compact Dwarf (BCD) galaxies; and the discovery of biaxial smectic A phase in a mixture of bent-core and rod-like molecules.

The collaborative scientific work covered in the Report, the list of visitors, and the list giving conferences attended and institutions visited by the members of the Institute indicate, as in the past, the extent of national and international interactions of the Institute. The list of colloquia given by the members of the Institute, those from the neighbouring institutions, and by the visitors clearly reflect the breadth of the areas covered.

Five Ph.D. degrees were awarded to the students of the Institute, and one has submitted his thesis during the year. Research papers published in refereed journals and in conference proceedings for the same period counted 52 and 16 respectively.

Bangalore
21 August 2000

N. KUMAR
Director

RAMAN RESEARCH INSTITUTE
Bangalore

Annual Report 1999 - 2000

Introduction

The Raman Research Institute founded by Prof. C.V. Raman in the late forties was reorganised, after his death in 1970, as a national Institute for research in basic science and it has been receiving grants from the Department of Science and Technology of the Government of India since 1972. The main fields of research are Theoretical Physics, Optics, Liquid Crystals, and Astronomy & Astrophysics.

1. Theoretical Physics

The two main areas of theoretical physics pursued at the Institute are gravitation and optics. Einstein's general theory of relativity is of great importance in the astrophysics of compact objects like neutron stars and black holes and also in the study of the universe as a whole. While the theory has a beautiful geometrical structure, it is a challenge to analyse the behaviour of the gravitational field and its coupling to matter and other fields because of the nonlinear equations involved. Many conceptual questions and aspects of formal structure continue to be fruitfully investigated more than seventy years after the theory came into being. Over the years, the work at the Institute has ranged over topics such as perturbations, the exploitation of symmetries, rotation and the analogy with magnetic fields, a new Lagrangian formulation, gravitational radiation, etc. One of the challenges in the field is to make contact with quantum theory and some work has emerged in this area.

Coming to optics, two of the main interests have been in propagation in periodic media (like some liquid crystals) and polarisation phenomena, including the now well known geometric phase. There is a pleasing continuity with work in the fifties at the Institute on the optics of crystals and minerals. At the same time, introduction of a more modern viewpoint and techniques, brings about connections with other areas such as quantum theory, differential geometry, etc. In addition, astrophysics throws up a whole range of interesting optical problems in areas like gravitational lenses, scintillation and quantum effects in radiation and detection, making the study of optics in a broad sense particularly appropriate to this Institute.

2. Optics

In view of the rapid and important recent advances made worldwide in modern optics, its enormous potential and taking full advantage of our traditional strength in this field, a modern optics laboratory is being set up at this Institute to address several basic problems, e.g., polarization optics and geometrical phases, interferometry, squeezing and noise, imaging, etc. This will have substantial overlap with our research activities in the field of liquid crystals and astronomy.

3. Liquid Crystals

Liquid Crystals are states of matter intermediate between the liquid and crystalline states. Many organic compounds whose molecules have pronounced shape anisotropy exhibit such phases. The unique combination of fluidity and anisotropic properties of liquid crystals has led to many applications of these materials. The Liquid Crystals Laboratory of the Raman Research Institute has contributed significantly to the development of the field over the past two decades.

The laboratory has been organised to undertake studies of most of the fundamental properties of liquid crystals. Theoretical and experimental work on liquid crystals covers areas like their unique mechanical and electrical properties, defects, X-ray and light scattering and synthesis of new materials. Work on applications such as displays is also carried out. A new dimension to our LC research has now been added – the study of soft condensed matter.

4. Astronomy and Astrophysics

Astronomy, which is one of the oldest sciences, is concerned with the study of heavenly bodies by investigating the radiation received on earth from them. Optical Astronomy deals with the *visible* part (wavelength 3000 Angstroms to 6500 Angstroms, 1 Angstrom $=10^{-8}$ centimetre) of the electromagnetic spectrum. Radio Astronomy, which had its beginnings in 1932 also deals with the study of these heavenly bodies, but the radiation received by radio telescopes on earth is in the radio range of wavelengths (30 metres to 1 millimetre) of the same electromagnetic spectrum. The lower and upper limits in wavelength of the radio spectrum are set by the earth's atmosphere and ionosphere respectively. In spite of these limitations, the radio window is very wide (30,000 to 1 compared to the 2:1 wavelength ratio in the visible part) and studies within it over the years have yielded information leading to many exciting discoveries such as the 3^0 k cosmic background radiation, quasars, pulsars, etc.

The Raman Research Institute has observational programmes in Radio Astronomy extending over most of the available radio spectrum. It has set-up a Decametrewave Radio Telescope at Gauribidanur jointly with the Indian Institute of Astrophysics. It is one of the few largest among the telescopes in the world operating at a wavelength of 10 metre wavelength and is being used to study the radio emission from various types of celestial objects such as the Sun, Jupiter, radio sources of various kinds in our Galaxy, and external Galaxies. Moving to somewhat shorter wavelengths, members of the Institute use the Ooty Radio Telescope operated by the Tata Institute of Fundamental Research (TIFR), Bombay. This instrument operates at a wavelength of approximately 1 metre and is used for carrying out observations of pulsars, and nebulae of various kinds in the Galaxy. There is an active programme under way to build instrumentation for and use the Giant Metre wavelength Radio Telescope (GMRT) being built by TIFR near Pune. Another interactive project is the low frequency (150 MHz) Mauritius Radio Telescope (MRT) built at Mauritius in collaboration with the University of Mauritius and the Indian Institute of Astrophysics

for a radio map of the southern sky at full resolution of 4' × 4'.

During the past two decades, millimetrewave astronomy has assumed great importance because of the discovery of numerous molecules (combinations of Hydrogen, Carbon, Nitrogen, Oxygen, Silicon, etc.) by their emitted line radiations in the shortest wavelength region of the radio spectrum. These molecules are generally found in dense molecular clouds in our own and other Galaxies where star formation is thought to be taking place. The Raman Research Institute has set-up a millimetrewave telescope of diameter 10.4 metre, which is being used for such studies.

In addition, the Institute has theoretical research programmes in many branches of Astrophysics like Pulsars, Supernova Remnants, the interstellar medium, Galaxies and several aspects of General Relativity and Gravitation.

A somewhat more technical, specific and detailed account of the work carried out in the past year is given in the following pages.

PHYSICS (TP)

AREAS OF RESEARCH

Gravitation
Condensed Matter
Optics
Physics in Biology

GRAVITATION

Canonical gravity, diffeomorphisms and objective histories: The meaning of diffeomorphism invariance in a Hamiltonian formulation of gravity is clarified. Diffeomorphism invariance is a crucial property of general relativity and it is very important to preserve this property in any reformulation of the theory. It is shown that diffeomorphism invariance of a constrained Hamiltonian formulation comprises two *distinct* requirements and argued that in a purely Hamiltonian approach the requirement of diffeomorphism invariance should be interpreted to include *both* these properties.

Is Barbero's Hamiltonian formulation a gauge theory of Lorentzian gravity?:
It is shown that in Barbero's Hamiltonian formulation (which is the current basis of loop quantum gravity), a gauge interpretation for the connection variable is inconsistent with the requirement of four dimensional diffeomorphism invariance. While Ashtekar's original formulation is diffeomorphism invariant with a gauge interpretation for the connection variable, Barbero's is not. Thus Barbero's formulation marks a departure from one of the original motivations of the Ashtekar programme: The gauge description of gravity.

A comment on the degrees of freedom in the Ashtekar formulation for 2+1 gravity: The recent claim of Manojlovic and Mikovic that the (2+1)-dimensional Ashtekar formulation for general relativity has a finite number of degrees of freedom has been proved to be erroneous and resulting from the use of incorrect equations. This restores the earlier result that, due to the possibility of considering degenerate `triads', the number of degrees of freedom of the 2+1 Ashtekar formulation is arbitrarily large.

A proposal for analysing the classical limit of kinematic loop gravity: The SU(2) holonomies, on which loop quantum gravity is based, are not suitable for exploring the classical limit at the kinematic level. A new set of related *magnetic flux* operators better suited for analysing the classical limit has been proposed. These operators are based on a physical lattice specified by the quasiclassical states themselves and thus are (spatial) diffeomorphism covariant. The proposal has been worked out in detail in 2+1 dimensions and

also applied to the diffeomorphism invariant Rovelli-Hussain-Kuchař model.

Frequency-domain P-approximant filters for inspiral gravitational wave signals from compact binaries: Frequency-domain filters for time-windowed gravitational waves from inspiralling compact binaries are constructed which combine the excellent performance of the time-domain P-approximants with the analytic convenience of the stationary phase approximation without a serious loss in event rate. These new analytic approximations, the SPP-approximants, are not only *effectual* for detection and *faithful* for parameter estimation, but are also computationally faster to generate. They should provide data analysts the Fourier-domain templates for massive black hole binaries of total mass less than about 40 $M_{\odot}$, the most likely sources for LIGO and VIRGO.

Padé approximants for truncated post-Newtonian neutron star models: Padé approximants to the truncated post-Newtonian neutron star models of Shinkai are constructed. The Padé models converge faster to the general relativistic (GR) solution than the truncated post-Newtonian one. The evolution of initial data using the Padé models approximates better the evolution of full GR initial data than the truncated Taylor models. In the absence of full GR initial data Padé initial data could be a better option than the straightforward truncated post-Newtonian initial data.

Quasi-radial modes of a rapidly rotating neutron star: The quasi-radial modes for a rapidly rotating neutron star have been extracted by taking the Fourier transform of the numerical density and velocity evolution. The rapidly rotating neutron star described by a polytropic equation of state is evolved using an axisymmetric, non-linear, general relativistic hydrodynamical code on a fixed spacetime background. The evolution incorporates all the non-linear hydrodynamical effects.

Easing the fine tuning problem in inflation: The standard inflationary universe scenario suffers from the shortcoming that in order to obtain the amplitudes of density perturbations that match observations, one requires an unnatural fine tuning of the self coupling constant of the inflation field. Using a modified version of the stochastic inflation scenario due to Starobinsky, it is shown that it is possible to achieve a dramatic easing of the fine-tuning of the self-coupling constant by six orders of magnitude, while the spectrum of density perturbations still retains its desirable almost-scale free Harrison-Zelodvich form.

Fluctuation-dissipation relation for radiating black holes: A black hole interacting with a quantum field may be viewed as a dissipative open system. The quantum field acts as a bath whose degrees of freedom are integrated out.

A formulation of a fluctuation-dissipation relation (FDR) for this situation is attempted using closed-time-path effective action methods. A FDR can be established for a simplified toy model in 1+1 dimensions and the more realistic collapsing case is under investigation. Certain misconceptions in an earlier FDR by Candelas and Sciama are pointed out and clarified.

Quasi-local energy: Currently the most successful and physically well motivated definition of quasi-local energy is due to Brown and York, but it requires that it be possible to isometrically embed a given two-dimensional surface into some reference three-dimensional space. A new improved definition of quasi-local energy in general relativity was introduced, which has two main advantages. First, it essentially eliminates the embeddability problem inherent in the Brown-York approach. Second, it provides a geometrically natural way to incorporate angular momentum into the notion of energy, at the quasi-local level.

The Penrose inequality: Work is currently in progress to try to prove (or disprove) the celebrated Penrose mass/area inequality: $M_{ADM} \geq \sqrt{A/16\pi}$, relating the ADM mass and area of a black hole. One approach involves a direct application of a certain component of the dynamical Einstein equations. Integrating this equation over the initial data surface results in an expression closely resembling the Penrose inequality. The other approach is based on Witten's spinorial proof of the positive mass theorem. A violation of the Penrose inequality is likely to lead to a counterexample to the cosmic censorship hypothesis.

Dynamical boundaries in general relativity: Recently, evidence has accumulated highlighting the importance of *boundaries* in general relativity such as dynamical boundaries, microstates responsible for black hole entropy, isolated horizons and boundary conditions in the path integral approach to quantum gravity. The pivotal question around which all of these ideas revolve is: What is the *classical* central extension of the symmetry (i.e., diffeomorphism) algebra of general relativity induced by the presence of a boundary? A general analysis of boundaries and boundary conditions in general relativity is in progress using the covariant phase space approach.

Transport along null curves: A new transport law is defined for null curves (analogous to Fermi transport which is defined only for time-like curves) which permits polarisation vectors to be transported along null curves in a geometrically natural way. Unlike in the time-like case, (I) The transport law does not approach a unique smooth limit as the null curve approaches a null geodesic. (ii) The transport law for vectors is integrable but the transport of spinors is not integrable: there is a global sign of topological origin. Contact is made with the geometric phase of quantum mechanics.

CONDENSED MATTER

Driven diffusive Heisenberg systems: A class of many-body systems whose dynamics and late time steady state behaviour arises as a complex interplay between driving, dissipation and inertia has been investigated. The simplest system is the Heisenberg magnet where the spins precess in response to the local magnetic field. The phase ordering dynamics in the absence of external driving, and the effect of an anisotropic driving have been studied. At low temperatures, this system exhibits spatio-temporal chaos which may be controlled, giving rise to stable steady state spin configurations with broken chiral symmetry. The statistics of the steady state of a Heisenberg magnet driven by a thermal current produced by sandwiching the system between two heat baths having different temperatures has been studied. The nature of the steady state crucially depends on whether the heat baths allow for a spin current or not.

A study of the origin of local thermal equilibrium and the Fourier's law of heat conduction has been initiated by working on a simple 1-dimensional system of alternating hard spheres of masses m_1 and m_2.

Dynamics of solid-solid transformations: The dynamics of solid state transformations in the context of martensites and bainites has been the focus of interest for a while. A molecular dynamics approach in 2-dimensions to study the square to triangular lattice transformation has led to a new understanding of the nucleation phenomenon. Quenches across the structural phase boundary reveal two distinct nucleation mechanisms – a slow quench results in an equilibrium ferrite, while a fast quench obtains a martensite.

Starting from the microscopic description (obtained from the MD simulation), it is possible to arrive at a coarse-grained elastic description in terms of the strain field and defects. A method for calculating elastic constants of a solid in the thermodynamic limit using fluctuations in particle positions has been worked out. Coarse-grained Langevin equations have been derived which describe the nucleation dynamics of solid state transformations. This description has been used to evaluate time-temperature-transformation curves for this structural change.

Statistical mechanics of membranes: The equilibrium statistical mechanics of a two-component monolayer/bilayer membrane has been studied. The mean field theory shows a wide variety of modulated phases which are destabilised by thermal fluctuations.

Statistical mechanics of random heteropolymers: Preliminary studies on the sequence dependence of shape parameters and force-extension curves of a

random, semiflexible heteropolymer like DNA, have revealed a broad distribution in these measurable quantities.

Brownian motion on a sphere: Distribution of solid angles: The diffusion of Brownian particles on the surface of a sphere was studied and the distribution of solid angles enclosed by the diffusing particles computed. This function describes the distribution of geometric phases in two state quantum systems (or polarised light) undergoing random evolution. These results are also relevant to recent experiments which observe the Brownian motion of molecules on curved surfaces like micelles and biological membranes. The theoretical analysis agrees well with the results of computer experiments.

Rotating Bose gas with hard-core repulsion in a quasi-2d harmonic trap: Vortices in BEC: A computational scheme for Exact Diagonalization (ED) and Gross-Pitaeviskii studies was developed and implemented on a system of N Bose particles with hard-core repulsion, contained in a quasi-2d harmonic trap and subjected to an overall angular velocity Ω about the z-axis. The few-body variational ground state wave-function, the corresponding energy and the associated one-particle reduced density-matrix were calculated for different values of the total (quantized) angular momentum.

Social percolation on inhomogeneous network: A computational network study has been done to understand the process of how opinion is formed in a model social system. The study provides insights into the interesting dynamics of social networks comprising of agents with respective opinions.

OPTICS

Super-reflection of light from a random amplifying medium with disorder in the complex refractive index: The probability distribution of the reflection coefficient for light reflected from a one-dimensional random amplifying medium with *cross-correlated* spatial disorder in the real and the imaginary parts of the refractive index is derived using the method of invariant imbedding. The statistics of fluctuations have been obtained for both the correlated telegraph noise and the Gaussian white-noise models for the disorder. In both cases, an enhanced backscattering results because of coherent feedback due to Anderson localization and coherent amplification in the medium. The effect of randomness in the imaginary part of the refractive index on localization and super-reflection is qualitatively different.

Imaginary potential as a counter of delay time for wave reflection from a one-dimensional random potential: The delay time distribution for wave reflection from a one-dimensional random potential is shown to be related directly to that of the reflection coefficient, derived with an arbitrarily small

but uniform imaginary part added to the random potential. Physically, the reflection coefficient, being exponential in the time dwelt in the presence of the imaginary part, provides a natural counter for it. The delay time distribution then follows straightforwardly from earlier results for the reflection coefficient and has all moments infinite. Delay time distribution for a random amplifying medium is then derived but in this case all moments work out to be finite.

A generalization of the telegrapher process to higher dimensions ($d \geq 2$): The telegrapher equation describes exactly the diffusion of particles moving with constant speed in one-dimension. This process has been generalized to higher dimensions ($d \geq 2$) rigorously where the particle can only move along the $2d$ directions of a d dimensional hypercube. Using a stochastic approach, a closed set of coupled linear partial differential equations for the probability distribution function have been derived. In this model, the marginal probability distribution for the projected motion along the cubic axes (important to describe transport in slabs) obeys the original telegrapher equation.

PHYSICS IN BIOLOGY

Mechanisms of endocytosis and structure of rafts: The study of the mechanisms of endocytosis in eukaryotic cells has been an intense field of research, in particular the physical and chemical mechanisms involved in the internalization of GPI-anchored proteins. Experiments using fluorescence energy transfer (FRET) and fluorescence correlation spectroscopy (FCS) reveal that GPI-anchored proteins are clustered in n-mers via cholesterol. These n-mers are further organised in a pool of sphingolipids. This organisation, identified with `rafts', is shown to be directly involved in the endocytosis of GPI.

Work on the physical forces which hold the raft components together has been carried out. A physical model of rafts consisting of sphingolipids and cholesterol on the cell membrane within the framework of a Landau theory has been analysed, to obtain a shape-texture phase diagram of rafts of a prescribed area. These studies indicate how rafts might lead to membrane budding, a necessary precursor to endocytosis.

Non-equilibrium physics of active processes: The phenomena of fission and fusion of membranes in the internal membrane components of the cell are *active processes* requiring the hydrolysis of ATP and a complex protein machinery. The dynamics, shape instabilities and steady states of a membrane subject to active fission and fusion events have been studied using a Langevin approach. The effect of fusion/fission events on a closed membrane using a dynamical triangulation Monte Carlo simulation has also been studied.

OPTICS

AREAS OF RESEARCH : Light scattering in random media
Optical limiting
Laser cooling and trapping
Development of the Optics Laboratory

LIGHT SCATTERING IN RANDOM MEDIA

The study of the light propagation in random media, which has been a topic of study for some time now, has been further pursued. Several interesting results have been obtained.

Experiments and Monte Carlo simulation of the back-scattering 2- and 4-fold patterns in turbid media have helped us determine the origin of these patterns, and enabled us to calculate the scattering intensity profiles, so that these patterns can now be used for remote characterisation of scattering media.

Studies of the quasi-ballistic photons and diffusive photons in multiply scattering media have highlighted some of the inadequacies of the diffusion theory. A new definition of diffusive photons has been proposed.

Extensive experiments and Monte Carlo simulations have led to conclusion that, contrary to current belief, optical depth, defined as the ratio of the length of the sample L to the transport mean-free path l*, is not a correct parameter for quantifying the opacity of a multiply scattering medium to ballistic light.

After having devised a scheme for software-based polarization discrimination for imaging through turbid media, the process has been streamlined to reduce the time required for imaging to a few minutes, as opposed to 2 days, earlier. This has been possible by binary data handling and by parallel processing.

A system for studying coherent-back scattering of light has been set up, with a CCD-based detection system. The novelty of this setup is the technique for measuring and correcting for the dark noise. A signal-to-noise ratio of 1.8 has been achieved.

Earlier experimental work on light scattering in random amplifying media has been complemented by extensive Monte-Carlo simulations. These have helped to further explain the experimentally observed features in terms of simple concepts of spontaneous and stimulated emission, and self-absorption. Using the Monte Carlo code, the spectral emission of any given system of dye and

scatterers can be derived, with minimal inputs.

OPTICAL LIMITING

A new activity initiated early this year has been the study of optical limiting in metal nanoclusters. The experiments showed that the Au, Ag and Au-Ag alloy nanoclusters exhibit a limiting effect much higher than the benchmark materials like C_{60}. These experiments were carried out in collaboration with scientists of the Chemistry Department of IIT, Chennai, who synthesised the samples.

LASER COOLING AND TRAPPING

Work has been carried out towards setting up a magneto-optic trap. Several external-cavity diode lasers that give continuous tuning over a 10nm range have been built. These will be locked to selected transitions in ^{87}Rb.

Optical lattices populated by laser-cooled atoms have been suggested by several groups for use in optical computation. However, due to the difficulty in manipulating individual lattice sites, this idea has not yet been implemented. A method of achieving this by use of the Talbot effect, which allows the addressing of selected lattice sites, without the need for multiple lattice beams, and without the usual stringent requirements on the relative phase between the beams has been proposed.

DEVELOPMENT OF THE OPTICS LABORATORY

An Optics Lab, with the state-of-the art facilities is envisaged, to expand into the realm of experiments that require ultra-fast lasers, like time-domain studies of photon-propagation in turbid media, imaging through turbid media and holograms with pulsed sources, and ultra-fast phenomena in photochemistry, to mention a few. After an extensive survey of the systems available, it was decided to procure a Spectra Physics Ti-S femtosecond laser system, pumped by a 10W cw system. The femtosecond pulses can be amplified by a passive amplifier system, pumped by a 10ns pulsed Nd:YAG laser. The system has been so configured that individual laser modules can be used independently for different experiments. It also provides flexibility and scope for further additions.

LIQUID CRYSTAL LABORATORY (LC)

AREAS OF RESEARCH:

L.C. Synthesis
Phase Transitions
Membranes
Monolayers
STM and Electrochemistry
L.C. Displays
Nonlinear Optics
Instabilities

EXPERIMENTAL STUDIES

Synthesis and physical studies of new compounds exhibiting liquid crystalline phases: A number of compounds composed of banana-shaped molecules have been synthesised and the mesophases exhibited by them have also been characterised using a combination of polarised light microscopy, differential scanning calorimetry, miscibility studies, x-ray diffraction studies, electro-optic switching studies, etc. Attempts have been made to understand the relationship between molecular structure of the compounds and the mesophases exhibited by them. Different liquid crystalline modifications in such compounds are possible due to the various packing arrangements of the bent molecules.

Several compounds exhibiting the undulating twist grain boundary (UTGB) C* phase, twist grain boundary A phase, ferroelectric and antiferroelectric phases have been synthesised and characterised.

Discovery of the biaxial smectic A phase: Many experimental observations have been made on mixtures of compounds composed of banana-shaped molecules and rod-like molecules in order to examine the organisation of these into various structures. A detailed temperature concentration phase diagram of such mixtures has been experimentally constructed. From a careful study of these, the following novel features have been observed in one of the binary systems.

a) The first example of a compound composed of rod-like molecules without a highly polar terminal group to exhibit a bilayer smectic A2 phase.

b) The discovery of an orientational transition of bent-core (BC) molecules in a background anisotropic smectic liquid crystal made of rod-like molecules. Specifically, in the composition range of 4 mol % to 13 mol% of the BC

molecules, an orientational ordering transition of the BC molecules was found to take place in the smectic layers with the relevant director being orthogonal to that of the rod-like molecules. The corresponding phase that is formed is the biaxial smectic A phase (Sm A2b). This is the first observation of such a phase in low molar mass systems and had previously been seen only in a polymeric system.

Systematic experimental investigation of the tilt susceptibility in TGB liquid crystals has been started to understand the origin of this phase formation obtained by the addition of a non-chiral component.

Improvements on high pressure set-up: In order to measure the pressure dependence of orientational order as well as to look for nematic-nematic transition, the high pressure set-up has been improved which would allow measurements of optical path differences in thin liquid crystalline cells.

Symmetric ripple phase of phospholipids: In addition to the stable asymmetric ripple phase exhibited by many phospholipids like DMPC, a symmetric metastable ripple phase is often seen in some of these systems on cooling the samples from the high temperature L_α phase. Many freeze fracture electron microscopic (FFEM) studies have indicated that the shape of these ripples is very different from that of the asymmetric ripples. The structure of this has been established from x-ray studies.

The asymmetric ripple phase of phospholipids is made up of height modulated bilayers, with the lipid molecules within the bilayers having an average tilt in the direction of the modulation wave vector. A Landau theory of this phase has been developed which takes into account the possible anisotropy in the bending modulus of a bilayer with tilt order. A physical reason for the particular sign of the anisotropy of the bending modulus that is necessary to produce the asymmetric ripples has been pointed out.

Rheological properties of the LC phases of surfactants: The influence of the water soluble polymer polyethylene oxide (PEO) on the hexagonal phase of the SDS-water binary system has been studied. In collaboration with scientists of IISc, it has been shown by rheological studies that there is a bridging of the long cylindrical micelles by the polymers. A phase diagram of this system at fixed surfactant concentration is being constructed by replacement of water by the polymer.

Visco-elastic modes in cholesteric liquid crystals: By dynamic light scattering technique, the thermal fluctuation modes in cholesteric liquid crystals like the umbrella and the twist modes have been studied. In the Bragg geometry, these studies have led to the dispersion curves of the twist mode in

a wave vector regime comparable to the equilibrium wavevector of the cholesteric pitch.

Adsorption of alkanethiols and azoles on electrode surfaces: The molecular self-assembly of long-chain alkanethiols on noble metal surfaces such as copper, silver and gold is of importance due to its potential application in the area of nano technology. A new method has been developed based on the measurement of the imaginary component of the impedance to follow the kinetics of adsorption. It has been found that the rate of adsorption follows different mechanisms depending on the concentration of the solution. It has also been shown that the kinetics depend significantly but not systematically on the change in the chain length.

Studies an adsorption of alkanethiols self-assembly in the presence of different organic solvents such as ethanol and hexane have been carried out. It has been found that the solvent influence on the formation of monolayer is considerable. The results are being analysed.

Development of ultramicroelectrode characterisation: An ultramicroelectrode has been developed using 40 μm gold and 50 μm platinum wires. The glass to metal sealing which is a critical factor in the development has been overcome by using low expansion special glass. The electrodes have been tested, and give reproducible characteristics.

Scanning tunneling microscope: An improved model of the STM has been fabricated for general use in the laboratory. An STM micropositioner was developed for providing the same to IIT, Delhi, on a request from them.

Addressing techniques in LCDs: Multiline addressing techniques are an attractive option to drive passive matrix liquid crystal displays. A technique based on sparse orthogonal matrices has been developed. Here the number of rows that are simultaneously selected as well as the number of voltage levels in the column driver are binary values (2^i) so that the controller for the display as well as the column drivers are simple and optimum.

Brightness uniformity of pixels in the displays addressed using Improved Alt and Pleskho Technique (IAPT), a line by a line addressing technique has been enhanced by making the transitions in the drive waveforms to be independent of the patterns displayed in the columns.

Techniques for displaying restricted patterns by selecting a few lines at a time have been developed. These techniques are well suited for displays in logic analyzers. This has been demonstrated using 64 x 64 matrix twisted nematic LCD.

THEORETICAL INVESTIGATIONS

Molecular model for highly polar compounds: In the theoretical investigations involving only attractive interactions between highly polar compounds, it was necessary to invoke a negative deviation from the geometric mean (GM) rule in the interaction between molecular pairs with parallel and antiparallel configurations envisaged in the theory to account for some unusual transitions. Hard rod features of the entities in the model have been included to show that the latter are responsible for effectively causing the apparent deviation from the GM rule.

Nonlinear optical effects in liquid crystals: Two new nonlinear optical processes operating in liquid crystals have been found. These are, (I) the laser suppression of the director fluctuations and (ii) the laser induced tilt angle in smectic liquid crystals. As a consequence of these, self-induced Bragg reflection in a standing wave has been shown to give rise to periodic structures. In cholesteric liquid crystals, at the long wavelength edge of the Bragg band, temporal oscillations in the pitch and the transmitted intensity have been obtained.

Nematics confined between coaxial cylinders: The effect of application of a strong destabilising magnetic field on a nematic liquid crystal confined between coaxial cylinders has been examined theoretically. Transient periodic dissipative structures (TDPS) are observed as striped patterns which evolve into a final non-periodic static deformation. The dependence of the rise time as well as the periodicity wavevector have been studied as functions of the applied field strength and the ratio of radii. It was found that a weakening of director anchoring has a deleterious effect on the formation of TDPS. It was also predicted that materials with opposite signs of diamagnetic susceptibility anisotropy would yield similar patterns for different directions of the magnetic field.

ASTRONOMY & ASTROPHYSICS (AA)

AREAS OF RESEARCH

Extragalactic astronomy
The galaxy and the interstellar medium

Pulsars and neutron stars
Solar wind
Topological phases

EXTRAGALACTIC ASTRONOMY

Radio Observation (H_I & OH, Recombination Lines & Continuum): A detailed study was made of the nuclear starburst region of the Ultra-luminous IR galaxy Arp 220 using recombination lines and continuum observations over the frequency range 300 MHz to 270 GHz. The study revealed the presence of multiple density ionized components and demonstrated the utility of multi-frequency recombination line observations as a tool to study the various density components in starburst regions and also to obtain information on the star formation history in these regions. [with F. Viallefond (Paris), W.M. Goss (NRAO), J.H. Zhao, (CfA)]

Two starburst galaxies - NGC 3628 and IC 694, from which H92α (8.3 GHz) recombination line had been detected, were searched for the H166α (1.4 GHz) and the H76α (15 GHz) recombination lines. While the higher frequency RRL was detected unambiguously, sensitive upper limits were obtained for the lower frequency line. These results confirm the models which favour high densities in the starburst region. [with W.M. Goss, (NRAO)].

New detection of RRLs near 8.3 GHz were made in the starburst galaxy NGC~1808 and in two Blue Compact Dwarf galaxies, NGC 5253 and He 2-10 which are undergoing intense starburst in their central region. [with W.M. Goss (NRAO)].

Higher resolution RRL studies of the prototypical starburst galaxy NGC 253 were begun. RRL and continuum observations were conducted at 15 and 8.3 GHz using the A-configuration of the VLA which provide sub-arc second angular resolution. Analysis of the 15 GHz data showed the presence of recombination lines from a few individual compact regions. [with W.M. Goss, NRAO)].

High frequency (ν > 15 GHz) and high angular resolution (few milliarcsec) radio continuum observations of the bright Seyfert Galaxy 3C 84 (NGC 1275) had revealed the existence of a northern counter-jet and a radio lobe. At lower

frequencies, these features are absent, presumably owing to free-free absorption by foreground ionized gas which may be associated with the accretion disk around the central engine. A search was made using the VLBA for possible stimulated emission recombination line near 22 GHz. No line was detected, and the limits were used to constrain the physical properties of the gas. [with R.C. Walker (NRAO)]

Two giant radio galaxies 0114-476 and 1545-321, were observed using the Australia Telescope Compact Array. Preliminary analysis indicates recurrent activity in the two radio galaxies. [with R. Subrahmanyan (ATNF)]

An observational programme has been started with the GMRT to map the 21cm HI line emission from several interacting galaxies. Four galaxies, NGC 1359, NGC 2718, UGC 2320 and NGC 92 have been observed. NGC 1359 shows all the signatures of an interacting system. Data on other galaxies are being reduced.

Using the VLA, 1665 MHz and 1667 MHz OH lines were both detected in absorption in the early type LINER galaxy NGC 1052. This is the first detection of OH in an elliptical galaxy. [with M. Rupen (NRAO) and J. Rigby (Penn. State)]

A search was made for radio continuum emission at 5 & 1.4 GHz from a population of Extremely Red Galaxies (ergs) which have been detected at sub-mm wavelengths. No detections were made at 5 GHz. Two definite detections were made at 1.4 GHz at a sub-mJy level in two out of the 7 objects observed. The implications of the observed flux densities are being studied. [with H. Rottgerring (Leiden) and C.L. Carrilli (NRAO)]

Radio continuum and HI were imaged over a ~ 25' Southwest region of the Coma cluster using the Giant Meterwave Radio Telescope. No HI was detected to a 3σ limit of 3×10^8 $M_\odot$ in the surveyed volume. Except for NGC 4839, no radio continuum emission was detected from the galaxies in the Coma Southwest region to a 3σ limit of 3×10^{20} W Hz^{-1} of spectral luminosity at 1.4 GHz. [with J. N. Chengalur (NCRA)].

Further sensitive observations of high red-shift RRLs ($z = 0.9$ and 0.2) from the intervening systems towards the gravitationally lensed source PKS 1830-211 did not confirm the possible detection made earlier. The sensitive upper limits obtained at both the redshifts translate into significant constraints on the amount of low-density ionized gas in these systems. A single-epoch radio continuum spectrum over the frequency range 0.3-45 GHz was obtained using the VLA. [with W.M. Goss (NRAO)]

Theoretical Studies: The effect of having a cooling flow in the centre of a

cluster on the Sunyaev-Zeldovich effect and the interpretation of the observed anisotropy of the microwave background radiation temperature was worked out. [with S. Majumdar (IIA / JAP)]

A possible distortion of the microwave background radiation and its angular power spectrum by hot winds from galaxies in the early universe is being worked out. Preliminary results show that the present day observations put a lower limit on the phase of galactic winds at $z > 15$. [with S. Majumdar (IIA / JAP) and M. Chiba (Tokyo)]

Modelling of the gravitational lens system PKS 1830-211 with a possible globular cluster lens at $z = 0.89$ is continued using new constraints from VLBI observations at 15 GHz. The new constraint is expected to lead to a better estimate of the mass of the globular cluster. [with M. A. Garrett (JIVE)]

In an effort to obtain a plausible image configuration of the puzzling gravitationally lensed system B 2114 + 022, a variety of caustic structures with a pair of lens galaxies at the observed redshifts ($z = 0.32$ & 0.59) were generated. This gravitation lens system remains a puzzle owing to possible structure in the source and the consequent difficulties in obtaining unambiguous radio spectra of the various components.

A model for the afterglow spectrum of Gamma-Ray Bursts with multi-component power-law energy distribution of electrons is being studied.

THE GALAXY AND THE INTERSTELLAR MEDIUM

Radio Recombination Lines & Continuum: Data from the Ooty survey of recombination lines near 328 MHz from the Galactic plane with low- ($2^\circ \times 2^\circ$) and high- ($2^\circ \times 6'$) resolutions were analysed. The data was used to derive the distribution of the low-density ionized gas in the Galactic plane as well as to derive the density, temperature and sizes of the ionized regions. The analysis indicate that the low-density ionized gas is associated with the star forming regions in the Galactic plane and that these ionized regions most likely represent outer low-density envelopes of known HII regions. [with Anish Roshi (NCRA)].

Three HII regions, W 51, S 206 and S 209, were imaged using the GMRT at frequencies 232, 327 and 610 MHz respectively. Using these images, the temperature and electron density of these HII regions were estimated. [with J.N. Chengalur (NCRA)]

The Galactic Centre Region: The Galactic centre region was observed using the new 74 MHz system of the Very Large Array (VLA). Data was taken in all

the four configurations of VLA which gives interferometric baselines ranging from 40 m to 35 km. Preliminary images made using a sub-set of the data indicate that the prominent central radio sources (the SgrA complex and the Radio Arc) are completely absorbed by the foreground thermal gas. [with Namir E. Kassim (NRL), T.J.W. Lazio (NRL), W.M. Goss (NRAO), H. Falcke (MPIfR)]

Based on an intriguing linear radio feature observed in a wide-field image of the Galactic center region at 327 MHz, further observations were carried out using the VLA at 20, 6 and 3.6 cm in full polarization mode. These observations led to the discovery of a new filamentary structure which is parallel to the Galactic plane. From the polarization maps, the magnetic field was found to be remarkably aligned along the length of the filament. The new filament, which is named "the Pelican", is unique, since all the other known filamentary structures near the Galactic center region are perpendicular to the Galactic plane. [with Corlenia Lang (NRAO/UCLA), N.E. Kassim (NRL), T.J.W. Lazio(NRL)]

An intriguing point-like source, located about 15' from the Galactic centre and which exhibited peculiar scattering properties was investigated through high resolution continuum observations at several frequencies (1.4 GHz, 8.3 GHz and 15 GHz). This source had been variously identified as a possible young supernova remnant, a pulsar or an extragalactic source. The observations revealed the source to be a typical FR II radio galaxy, probably at a high red-shift. The detection of this source with a small angular diameter at 327 MHz implies that the scattering screen near the Galactic center, which is known from other observations, is patchy on the scale of about 15 arcminutes. [with T.J.W. Lazio (NRL), W.M. Goss (NRAO), N.E. Kassim (NRL), J.M. Cordes (Cornell)]

Radio recombination lines at 1.4 GHz towards the Galactic centre region was imaged using the D-configuration of the VLA. These observations revealed the presence of ionized gas outside the well known SgrA West region and possibly associated with the radio halo which surrounds the SgrA complex. This ionized gas may be responsible for the high free-free optical depth at 327 MHz observed over a large region. [with A. Pedlar (Jodrell), W.M. Goss (NRAO)].

Neutral Hydrogen (HI): A power-spectral description of the interstellar HI opacity and density distributions were obtained using high angular resolution data towards Cas A & Cygnus A. A method of deconvolution, based on CLEAN, was used to take into account the finite extent of the background source and the incomplete sampling of the optical depth. The implication of the non-Kolmogorov nature of the spectrum (slope ~ -2.75 ± 0.25) for key processes in the ISM was discussed. [with W.M. Goss, (NRAO)]

A long-standing puzzle of small scale structure and the consequent over-pressure in interstellar HI gas was resolved. It was shown that all the previous interpretations of the observed differences in the optical depth along adjacent lines of sight did not take into account the contribution from larger spatial scale structures in HI. When this effect is taken into account, the observations can be readily explained on the basis of a single power-law spectrum of irregularities in the HI gas and removes the need for a mysterious small-scale component.

A deep HI 21cm line absorption study was carried out towards 15 sources using the GMRT to search for high random velocity clouds which had been detected in optical absorption lines. For the first time, lines were detected from 6 directions and showed that the high random velocity clouds are weak HI absorbers. Using the GMRT, a high-Galactic-latitude HI absorption survey was made towards 42 extragalactic sources. Data analysis is in progress. [with J. N. Chengalur, (NCRA)].

HI absorption measurements were made towards the Galactic center using the ATCA and towards the Galactic anti-center using the Westerbork Radio Telescope to study the random velocities of interstellar clouds and also to solve the longstanding problem about the existence of a population of weakly absorbing interstellar clouds in the galaxy. The data is being analysed. [with R. Subrahmanyan, (ATCA)].

To estimate the spin temperature, density, and distribution of the Warm Neutral Medium in the Galaxy, sensitive observation of the HI 21 cm-line in absorption were carried out towards several extragalactic radio sources using the Westerbork Synthesis Radio Telescope. Preliminary analysis of the data indicates HI absorption towards one of these sources. [with C. L. Carilli (NRAO), W. M. Goss (NRAO)].

PULSARS AND NEUTRON STARS

Further to the analysis of a stable drift-sequence of the pulsar B0943+10, a careful examination of its emission properties in chaotic "Q" mode and the polarization properties in both the "B" & "Q" modes showed evidence that plasma processes responsible for pulsar emission may be organized into a system of columns. [with J. Rankin (Vermont)].

A sensitive search was conducted using VLA for periodic signals from the recently reported X-ray point source seen close to the centre of the bright SNR Cas A. No detection was made and sensitive upper limits on the strength of possible pulsed emission were obtained at two radio-frequencies. [with T. H.

Hankins (NMIMT), J. Kern (NMIMT), M. McLaughlin (Cornell), J. M. Cordes (Cornell), V. Kaspi (MIT)].

Fluctuation spectral analysis and the Cartographic mapping technique developed in the context of B0943+10, was applied to several pulsars observed at Arecibo, Westerbork and Ooty telescopes. A rich variety is observed in the parameters characterizing the polar emission patterns and its circulation. [with J. Rankin (Vermont), A. Chaitra (IISc./ JAP), M. Kouwenhoven (NFRA), R. Ramachandran (NFRA)]

It was shown that the observed core component-width relation of pulsars leads to constraints on the equation of state of the neutron star matter. The derived constraints indicate that only a few, if any, equations of state are viable which further suggests that pulsars may be strange stars. [with R.C. Kapoor (IIA)]

Leads and lags between core and conal components of the pulsar radio emission was investigated [with R.C. Kapoor (IIA)].

The pulsar timing observations, for long-term monitoring, are continued as an observatory programme with the Ooty Radio Telescope [with V. Balasubramaniam (RAC), Alak Ray (TIFR)].

Observations of four pulsars using the Mauritius Radio Telescope were analysed and calibrated. The observed fluctuation and average-profile properties are compared with the available data from higher radio-frequencies [with Nalini Issur (UOM)].

Strong upper limits on the size of the interstellar electron density irregularities along the lines of sight to two closely pulsars, B0950+08 and B1929+10, were obtained through searches for discrete scattering events.

A re-examination of the available observations ruled out the mechanisms, which were proposed to explain the pulsar velocities and which predict a correlation between the rotation axis and the velocity as well as those mechanisms involving single long-duration radial kicks along "any fixed axis" of the star. The data also show that there is no significant correlation between the magnetic field strengths and velocities of pulsars [with R. Ramachandran (NFRA)].

Using the general purpose Data Acquisition System (DAS), several bright pulsars were observed with the Gauribidanur Telescope at 35 MHz, and the data were analysed. Fluctuation spectra were studied in the case of 7 pulsars and compared with higher frequency observations. Single-pulse sequences at 35 MHz from the pulsars B0943+10 & B0834+06 were analysed. The

fluctuation properties seen at this frequency, and the estimates of the number of subbeams in the polar map and their circulation time agree remarkably well with the reported behaviour at higher frequencies.

Simultaneous observations at 102 MHz at the Puschino Observatory in Russia, and at 35 MHz at Gauribidanur were made to search for the radio counterpart of the Gamma-ray pulsar, Geminga. Initial analysis of the data did not detect the pulsar at 35 MHz.

Studies of the evolution of the magnetic fields of neutron stars are continued. Possible evidence of multipolar magnetic fields in pulsars and the possible effects of field evolution on pulse structure were studied. A study of the effects of ambipolar diffusion, in addition to ohmic dissipation, on the crustal fields of neutron stars is being carried out.

SOLAR WIND

The Very Large Array (VLA) and the Very Long Baseline Array (VLBA) were used to simultaneously observe the angular broadening of the strong radio source 3C 279 when the line of sight to the source passed close to the Sun. These observations were aimed at determining the power spectrum of the density fluctuations on scales of a few tens of kilometres [with K. Desai (NRAO), V. Dhawan (NRAO), P. Gothoskar (NCRA)].

In order to determine the influence of the solar wind on angular broadening of radio sources at large angular separations from the Sun, about 30 point sources, spread over an elongation range of 10 - 100 degrees from the Sun, were observed using the VLBA. Observations were made at two epochs - once when the sources were close to the Sun and once when they were farther away - the latter observations are for determining the intrinsic structure of the sources. [with K. Golap (NRAO), K. Desai (NRAO)].

TOPOLOGICAL PHASES

The relevance of the geometric phase and its singular properties were further explored. The role of geometric phase in determining the interference pattern of partially polarized light from a source observed with a two-element interferometer was pointed out.

It was pointed out that the response of a pair of differently polarized antennas to intensity distribution of radiation in the sky is determined by their polarization states and a phase between them which has a singular behaviour similar to that of the phase of a spin-1/2 particle under rotations in space.

INSTRUMENTATION FOR ASTRONOMY

Collaborative work with ISAC was begun for the development of an X-ray scanning sky monitor for the Indian Astronomy Satellite ASTROSAT. A coded mask imaging element for the camera is being designed. A initial study of the problem and development of the basic software for designing the coded mask are completed.

A collaborative programme between RRI and ISRO has been initiated in the field of space astrometry, with applications both for satellite operations and radio astronomy. As a part of this programme, technology is being developed for a high stability frequency and time transfer via INSAT for use by astronomers and space scientists, as well as for accurate ranging and attitude disturbance measurements for INSAT. Based on this technology, a complete VLBI recording and processing system will be developed, which will be used for kinematic studies of methanol masers at 6.7 GHz by monitoring them through VLBI observations.

As a part of the ISRO-RRI collaboration on frequency transfer via INSAT, a concept proving experiment was performed at the INSAT Master Control Facility (MCF), Hassan to verify a scheme for accurate frequency dissemination by transmitting multiple tones. A pair of tones was generated from a single reference and transmitted to INSAT 2C, which was then received by the ground station. Using PLL-based receivers, a tone corresponding to the difference between the pair of transmitted frequencies was recovered. By comparing the recovered tone with a similar one generated from the transmitted reference, the overall phase stability was monitored. Based on this comparison, it was possible to infer changes in the motion of the satellite of a fraction of a centimetre along the line of sight within a few seconds after an orbit manouvre operation.

Discussions were begun for designing and realizing a Compact Cluster Telescope (CCT) which will consist of a number of antennas operating in the frequency range 0.6 - 6 GHz, and which allows new areas of research in Radio Astronomy. Preliminary work was done in collaboration with NCRA, Pune on the fabrication of a 12 m diameter parabolic dish, with a novel design, which will be a prototype element for the CCT.

A sensitive set-up for pulsar timing was developed for the VLA [with J. Kern (NMIMT), T.H. Hankin (NMIMT)]. A new flexible and portable software package was developed for estimation of pulse-arrival-time.

Classification, quality check and reformatting of 20,000 hours of data obtained

with the Mauritius Radio Telescope was completed. The first full resolution image with a resolution of 4' × 5' covering the entire declination range of the MRT (-79^0 to $+10^0$) was made.

A wideband, multioctave feed with a trapezoidal structure, to be used for interference studies in the frequency range of 0.5 to 8 GHz, was designed and built. This feed is used to monitor the level of radio interference at Gauribidanur.

A 220 GHz radiometer, complete with data acquisition and software modules were built, and tested and were installed at the astronomical site in Hanle (the Himalayas) to monitor the atmospheric opacity.

A high resolution 4096-channel spectrometer was developed using the NASA Correlator chip and installed at the 10.4 m telescope for observing methanol maser lines. Prototype units of the IF subsystem with 160 MHz bandwidth, a two bit, three level sampler and the local oscillator subsystem to be used in the wideband spectrometer using NASA Correlator chips were designed.

Four Low Noise Amplifiers were built at 6.7 GHz for the on going survey of Methanol Masers using the 10.4 m telescope and also to conduct some initial experiments in the VLBI project.

Five L Band (1000 to 1400 MHz) receivers for the Giant Meterwave Radio Telescope (GMRT) were built, thus completing all the 21 cm front-end receivers, including five spare units, for the 30 GMRT antennas . Three of these units were modified to use up to 1700 MHz to observe the OH line.

A GMRT Array Combiner (GAC) and a Pulsar Polarimeter for the second sideband of the GMRT system were installed and tested at the telescope site. The GAC was outfitted with a multi output distribution system. Network control software for remote operation of the Polarimeter was installed.

A Programmable phase locked loop system for generating the local oscillator and sampler clock from a rubidium source for the pulsar receiver at Gauribidanur was developed and installed.

COMPUTERS

All the cabling for the Campus Network upgrade has been completed during this year and phased commissioning of the new network started. All the workstations meant for general use, as well as many computers in users' offices have been moved to the new network. The construction of the new central computing facility has been completed. It is now ready for commissioning.

The hardware and software upgrade for all computing systems, necessary for Y2K compliance, has been carried out before the end of 1999. As a result, no Y2K-related problems have been experienced so far.

A contract has been signed with the Computer Maintenance Corporation (CMC) for providing comprehensive systems administration services at the Institute. CMC has started providing this service to RRI from December 1999.

A powerful dual-CPU Compaq Alpha server with a large memory and storage capacity has been added to the general computing facility to take care of our growing computing needs. Two Intel-based Linux workstations have also been added to the general computing facility to support various softwares, for applications such as astronomical imaging, now available on Linux platforms. A fast, heavy-duty, high quality Tektronix colour printer has been procured and will shortly be installed.

OTHER ACTIVITIES

Ph. D.

Awarded

Name	*Topic of Study*
Sandeep Sachdev	Wide field imaging with the Mauritius Radio Telescope *University of Mauritius*
Sobha R. Warrier	Electrooptic and dielectric investigations on some liquid crystals *Jawaharlal Nehru University, New Delhi*
Amitabha Bhattacharyya	Phase transitions and molecular conformation in Langmuir monolayers *Jawaharlal Nehru University, New Delhi*
P. A. Pramod	New defect structures in liquid crystals *Jawaharlal Nehru University, New Delhi*
Dipanjan Mitra	A study of emission and propagation of radio signals from pulsars *Jawaharlal Nehru University, New Delhi*

Submitted

P.K.Thiruvikraman	Study of electric phase transitions at high pressures *Jawaharlal Nehru University, New Delhi*

Publications

The research work done by the staff of the Institute has been published in a number of journals. A list of publications that have already appeared, as also those submitted and in press, is given at Annexure - I (Page 45).

Summer School in Physics & Astrophysics, 24 May - 18 June 1999

Twenty four students drawn from different parts of the country representing universities, IITs and Colleges were selected from seventy four students who had applied. Finally, 21 students participated in it, of whom 20 were studying for M.Sc. and one for B.Sc. There were seven courses, each with typically three to five lectures (two lectures everyday from Monday to Friday for three weeks) on basic physics (statistical physics and special relativity), non linear and polarization optics, general relativity, soft-condensed matter, signal processing and noise, and light forces.

There were equal number of tutorials in all courses which took place in the afternoons of the first three weeks. The students were offered ten projects on the third day of the School, and they began their project work soon after. The last week of the School was left for the students to concentrate on their projects.

Conferences/Seminars and Meetings

The staff of the Institute visited various institutions in India and abroad and attended conferences and presented papers. In addition, lectures were given by them at other places. In all, 106 lectures were given by them at other places.

Colloquia

The scientists of the Institute and visiting scientists, both from within and outside the country, gave colloquia at the Institute on different topics during the year (Annexure - II, page 56).

Journal Club Meetings

Twenty meetings were held during the year. Preprints as well as recently published papers dealing with topics of great current interest were reviewed in the meetings (Annexure - III, page 63). These included two Special Sessions on the 1999 Nobel Prize in Physics.

And, as in the past, several informal Group meetings in Theoretical Physics, Optics, Liquid Crystals and Radio Astronomy were held throughout the year.

In-House Meeting

An In-House Meeting, which is an annual feature at the Institute, was held on 25 & 26 February 2000 where the staff and students presented their research work. In all 22 oral presentations spread over 5 sessions chaired by Faculty Members were made. There were also 3 poster presentations The presentations were followed by lively scientific discussions with critical comments and suggestions relevant to the reported research from the members.

Gandhi Memorial Lecture

The Gandhi Memorial Lecture for 1999 was given by Dr. H. Sudarshan of Vivekananda Girijana Kalyana Kendra, B.R. Hills, Karnataka, entitled "Message of Swami Vivekananda and Mahatma Gandhi for the development of tribal people in India" on 2 October 1999.

Visit of dignitaries/delegation

A French Delegation, the European Academic Pole of Toulouse, consisting of Mr. Raymond Bastide (Chairman, Paul Sabatier University), Prof. Joseph Noailles (National Polytechnical Institute of Toulouse), Mr. Marc Courvoisier (Director, National Institute of Applied Sciences, Toulouse) and Mrs. Sylvia Desazars de Montgailhard (Delegate for International Cooperation) visited the Institute on 13 May 1999. The purpose of the delegation was to explore and materialize the possibilities of cooperation in Higher Education and Research in India.

Visiting Scientists

Prof. Steven Vogel, Duke Professor, Duke University, North Carolina, USA, was invited to the Institute as **Golden Jubilee Distinguished Professor.** He visited during the period 29 November 1999 to 8 January 2000. He interacted with our scientists and delivered a series of lectures on the general topic "*How the Design of Organisms Reflects their Physical World*" at the Institute. More details are on page 74. Prof. Vogel also visited other institutions where he gave several lectures.

A number of scientists from institutions within the country and from outside visited the Institute during the year. Their names are listed separately (page 36).

Library

As in the previous years, library continued with its basic activities of collecting, organizing and disseminating information. During the year, 597 books were added. Presently it has 20,921 books. It subscribed to 140 scientific journals and has 27,170 bound volumes of periodicals. A database on Liquid Crystals (on CDRom) was also acquired. One more volume of the memoirs of RRI covering publications from the Institute during the second half of 1998 was compiled. With a view to automate circulation procedure (of documents borrowed/ returned), library has bar-coded its collection of books and bound volume of periodicals. In order to keep abreast of the latest developments in the field, library staff participated in training courses, conferences and seminars details of which are given elsewhere.

General

Following grants were received from the Department of Science and Technology during the year:

PLAN (Recurring & Non-Recurring)	Rs. 650.00 lakh
NON PLAN (Recurring)	Rs. 279.00 lakh
Total	Rs. 929.00 lakh

STAFF

N. Kumar
Director

V. Radhakrishnan
Distinguished Professor Emeritus
S. Ramaseshan
Distinguished Professor Emeritus

G.S. Ranganath, *Dean of Research*

THEORETICAL PHYSICS

Research
B.R. Iyer *(Chairman)*
N. Kumar
Joseph Samuel
Madan Rao
Madhavan Varadarajan
R. Nityananda *(on lien at NCRA from 28.3.00)*
G.S. Ranganath

Research Students
S. Anantha Ramakrishna
Jayajit Das
Sarasij Ray Chaudhari

Post-Doctoral Fellows
Abhijit Kar Gupta
Abhishek Dhar *(from 29.2.00)*
MAH Ahsan
Anshu Gupta
Sanjay Kumar *(up to 7.12.99)*
Sukanya Sinha (*CSIR Pool* Officer)

Visiting Professors
S. K. Rangarajan

Secretarial
G. Manjunatha

OPTICS

Research
Hema Ramachandran
Reji Philip *(from 30.12.99)*

Research Students
Sushil Mujumdar
Uday Kumar Khan

Visiting Professors
A. K. Sood
R. Srinivasan

Technical
M.S. Meena *(from 7.6.99)*
P.S. Sasikumar

Post-Doctoral Fellow : Venkatesh Gopal *(from 13.1.00)*

LIQUID CRYSTALS LABORATORY

Research
U. D. Kini
V. Lakshminarayanan
N. V. Madhusudana (*Chairman*)
R. Pratibha
V.A. Raghunathan
G. S. Ranganath
T. N. Ruckmongathan
B. K. Sadashiva
K. A. Suresh
Yashodhan Hatwalne

Scientific/Technical
A. Dhason
Mohammed Ishaq
P.N. Ramachandra
N. Ravi Sankar
S. Seshachala
M. R. Subrahmanyam
K. Subramanya
H. Subramonyam
D. Vijayaraghavan

Research Students
Amarnatha Reddy
Amitabha Bhattacharyya *(up to 30.4.99)*
M. S. Giridhar
Kheya Sengupta
V. Manjula Devi
K.G. Pani Kumar
A. Pramod *(up to 23.8.99)*
Pratiti Biswas *(from 2.8.99)*
Raj Kumar Gupta *(from 3.1.00)*
K. Rema
Sanat Karmakar *(from 3.1.00)*
H.N.Shreenivasa Murthy *(from 3.1.00)*
S. Shubhashree
Sreejith Sukumaran *(up to 7.7.99)*
S. K. Srivatsa
R. Subramanian
Surajit Dhara
P.K.Thiruvikraman
P. Viswanath
Ujjal Kumar Sur

Visiting Scientist
T. G. Ramesh
G.V. Shivashankar *(from 15.2.00)*

Secretarial
K. Radhakrishna

ASTRONOMY & ASTROPHYSICS

Research
K.R. Anantharamaiah
R.Bhandari
Biman Nath
A.A. Deshpande
Dipankar Bhattacharya
K.S. Dwarakanath
C. Indrani *(from 3.1.00)*
V. Radhakrishnan
Rajaram Nityananda *(Chairman up to 27.3.00)*
B. Ramesh
C.S. Shukre
G. Srinivasan
C.R. Subrahmanya *(from 1.6.99)*
N. Udaya Shankar

Research Students
Amitesh Omar
Ashish Asgekar *(JAP)**
Dipanjan Mitra
R. Niruj Mohan *(JAP)**
V.N. Pandey *(from 29.7.99)*
Rekesh Mohan

Post-Doctoral Fellows
C.H. Ishwara Chandra *(from 29.2.00)*
Mousumi Das *(up to 31.7.99)*
Sunita Nair

Secretarial
S. Ramasubramaniyan
V. Vidyamani

**Joint Astronomy Programme*

RADIO ASTRONOMY LAB

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Raju Verghese

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D. Gangappa
Gunashekar
C. Haridas
K. Palani
C. Sampath
R. Sasidharan (*Supervisor*)
S. Sridhar
K.N. Srinivas
T. Subramaniyam Naidu
G. B. Suresh (*Civil Engineer*)

Secretarial: V. Raghunath

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K. M. Lakshmanan (*In-Charge*)
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L. Muthu
V. Ramu
T. Subramani

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Dr. A.R. Pai (*Consultant Physician*)

Lab. Technician
R. Shanthamma

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R. Jayaram
C. K. Mohanan
G. Raja
G. Prakash
Rahamath Pasha
Rahamathulla Khan
M. K. Raju Kutty

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P. C. Prabhakar
N. Puttaswamy
A. Raju
N. Seetharam
Sharadamma
Shivamallu
Uma
K. Velayudhan
V. Yeshodha

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Bylappa
Chikkamunivenkatappa
V. Krishnappa (*Consultant)*
Lakshmamma
Lingegowda
D. Mahalinga
Maiga
Mailarappa
Marappa
Munilakshmi
D. Muniraja
S. Muniraju
P. N. Sachidananda (*Adviser*)
Thimmarayappa

UPKEEP

Hanumantha
Jayamma
K. N. Kawalappa
D. Krishna
C. Lakshamma
T. Murali
A. Ramanna
Rangalakshmi
Ranjithamma
Saroja
Varalakshmi
V. Venkatesh

SECURITY

V. Arputha Raj (*In-charge*)
B. M. Basavarajaiah
U. A. Earappa
H. Gangaiah
Govind K. Kundagol
K. Govindappa
Joseph Kunjachan
Keshavamurthy
K. Krishnappa
Munihobalaiah
K. Pushparaj
O. M. Ramachandra
G. Ramakrishna
M. Sannaiah
Suresha
H. Vaderappa

LIST OF VISITORS

Joanna Rankin University of Vermont Burlington, USA	1 March - 10 June 1999
Silvio Franz Abdus Salam International Centre for Theor. Physics, Trieste, Italy	6 April 1999
Varun Sahni Inter-University Centre for Astronomy & Astrophysics Pune	7 April 1999
M M G Krishna Tata Inst. of Fundamental Research Mumbai	19-23 April 1999
Jerry L. Bona University of Texas Austin, USA	19 May 1999
K B Athreya University of Iowa USA	20 May 1999
A Gopakumar Physical Research Laboratory Ahmedabad	1-7 June 1999
Francis Rondelez Institut Curie Paris, France	10 June 1999
P B Sunil Kumar Institute of Mathematical Sciences Chennai	15 June - 10 July 1999
Jagadish Rai Indian Institute of Technology Kanpur	20 June - 7 July 1999

Rajinder Singh University of Oldenburg Oldenburg Germany	11-25 July 1999
Satyendra Kumar Kent State University Kent USA	22 August - 3 December 1999
M. Muthukumar University of Massachusetts Amherst, USA	27-30 July 1999
A.P. Balachandran Syracuse University USA	31 July - 6 August 1999
T R Govindarajan Institute of Mathematical Sciences Chennai	31 July - 6 August 1999
Kalyana Rama Institute of Mathematical Sciences Chennai	14 July 1999
C. K. Majumdar S N Bose National Center for Basic Sciences Calcutta	14-16 July 1999
Deepak Dhar Tata Inst. of Fundamental Research Mumbai	23-25 July 1999
Krishnaswami Alladi University of Florida Gainesville, USA	27-29 July 1999
Partha Majumdar Institute of Mathematical Sciences Chennai	25 July - 1 August 1999

Suneeta Varadarajan Institute of Mathematical Sciences Chennai	2-7 August 1999
Tapash Chakraborty Institute of Mathematical Sciences, Chennai	12 August 1999
G.V. Shivashankar The Rockefeller University New York, USA	23 August 1999
Y. Sudhakar Saha Inst. of Nuclear Physics, Calcutta	25 August 1999
Anita Richards Jodrell Bank University of Manchester U K	29 August - 2 September 1999
Arun Roy University of Sao Paulo Brazil	9-20 August 1999
Somak Raychaudhury Inter-University Centre for Astronomy & Astrophysics, Pune	28-29 September 1999
Martijn Smit SRON/EOS, Utrecht The Netherlands	24-28 October 1999
Reji Philip Tata Institute of Fundamental Research Mumbai	24-30 October 1999
Thomas Tauris University of Amsterdam The Netherlands	25 October - 11 November 1999
Sushan Konar Inter-University Centre for Astronomy and Astrophysics, Pune	25 October - 13 November 1999

Pier A. Mello Institute of Physics UNAM, Mexico	1 November 1999 - 31 January 2000
Sudeshna Das Gupta Jadavpur University Calcutta	14-17 November 1999
A. Mehta National Centre for Basic Sciences, Calcutta	18 November 1999
Miller Goss National Radio Astronomy Observatory Socorro, USA	18-20 November 1999
Richard Dodson University of Tasmania Australia	20 November - 8 December 1999
N.C. Wikrama Singhe Cardiff University U. K.	21-25 November 1999
G. Rajasekaran Institute of Mathematical Sciences Chennai	23-24 November 1999
P. Shaver European Southern Observatory Garching, Germany	26-29 November 1999
Ron Ekers Australia Telescope National Facility Sydney, Australia	27-29 November 1999
Steven Vogel Duke University Durham, USA	28 November 1999 - 8 January 2000
Debasish Biswas Calcutta University Calcutta	1-3 December 1999

Anders Kastberg Stockholm University Stockholm, Sweden	1-7 December 1999
Stan Kurtz Universidad Nacional Autonoma de Mexico Mexico	6-12 December 1999
Valerij Malofeev Puschino Radio Astronomy Observatory Russia	6-23 December 1999
A.A. Konovalenko Institute of Radio Astronomy Kharkov, Ukraine	6-27 December 1999
Kristy Dyer North Carolina State University Raleigh, USA	7-11 December 1999
Torsten Enblin Max-Planck Inst. fur Astrophysik Garching, Germany	7-11 December 1999
Joseph Lazio Naval Research Laboratory USA	7-11 December 1999
Christine Lacey Naval Research Laboratory USA	7-11 December 1999
Bill Erickson University of Maryland USA	7-11 December 1999
Michael Bietenholz York University Toronto, Canada	7-11 December 1999
Walter Brisekn Princeton University Princeton, USA	7-11 December 1999

Katherine Blundell Oxford University Oxford, UK	7-11 December 1999
Namir Kassim Naval Research Laboratory Washington, USA	8 December 1999
Mukunda P. Das Australian National University Canberra, Australia	12-17 December 1999
Dr. Sanjay Reddy INT University of Washington Seattle, USA	17 December 1999
E C G Sudarshan University of Texas USA	20 December 1999
Sanjay Bhatnagar National Centre for Radio Astrophysics Pune	20 December 1999
P. Gothoskar National Centre for Radio Astrophysics Pune	21-28 December 1999
Ishwara Chandra National Centre for Radio Astrophysics Pune	21-24 December 1999
Ketan Desai National Radio Astronomy Observatory Socorro, USA	21-27 December 1999
Pradeep Gothoskar National Centre for Radio Astrophysics Pune	21-28 December 1999
Hemant Bokil International Centre for Theoretical Physics Trieste, Italy	23-24 December 1999

Sridhar Inter-University Centre for Astronomy and Astrophysics Pune	27-31 December 1999
Debasish Biswas University of California USA	1-3 January 1999
Z. Raszewski Military Univ. of Technology Warsaw, Poland	10-18 January 2000
J. Zielinski Military Univ. of Technology Warsaw, Poland	10-18 January 2000
G. Werth Institute for Physics Johannes Gutenberg University Mainz, Germany	11 January 2000
W. Baan National Foundation for Radio Astronomy Dwingeloo, The Netherlands	14 January 2000
Andy Buchan Millhowe, Bathely, Newark UK	20-24 January 2000
B.C. Joshi National Centre for Radio Astrophysics Pune	21 Jan. - 1 Feb. 2000
Nimesh Patel Harvard-Smithsonian Center for Astrophysics Cambridge USA	27-28 January 2000

F. K. Sutaria Inter-University Centre for Astronomy and Astrophysics Pune	31 Jan. - 2 Feb. 2000
T. Padmanabhan Inter-University Centre for Astronomy and Astrophysics Pune	31 Jan. - 8 Feb. 2000
K. P. Singh Tata Inst. of Fundamental Research Mumbai	31 Jan. - 1 Feb. 2000
A R P Rau Louisiana State University Baton Rouge USA	31 Jan. - 18 Feb. 2000
Dominique Homberger Louisiana State Univ. USA	31 Jan. - 18 Feb. 2000
K. Sreenivasan Inter-University Centre for Astronomy & Astrophysics, Pune	7 February 2000
Govind Swarup National Centre for Radio Astrophysics Pune	24-27 February 2000
Nalini H. Issur University of Mauritius Mauritius	25 Feb. - 24 March 2000
M.S. Nandakumar Physical Research Lab Ahmedabad	29 February 2000
Rajiv Gavai Tata Institute of Fundamental Research Mumbai	2 March 2000

C.S. Unnikrishnan Tata Institute of Fundamental Research Mumbai	20 March 2000
Hemant Dave Physical Research Laboratory Ahmedabad	21-23 March 2000
Judith A.K. Howard University of Durham UK	23-27 March 2000
Sukratu Barve Tata Inst. of Fundamental Research Mumbai	26-29 March 2000

Annexure - I

PAPERS PUBLISHED

In Journals

1 "Life before mean free path" (N. Kumar), *Curr. Sci.*, **76,** 1330 (1999).

2 "Diffusion of particles moving with constant speed" (S. Anantha Ramakrishna and N. Kumar,), *Phys. Rev.* E, **60**, 1381 (1999).

3 "Blocking of inter-subspace tunneling by intra sub-space inelastic scattering" (T.P. Pareek, A.M. Jayannavar and N. Kumar), *Indian Journal of Physics*, **23** 853 (1999).

4 "Electric-field induced melting of the randomly pinned charge-ordered states of rare earth manganates and associated effects" (C.N.R. Rao, A.R. Raju, V. Ponnambalam, S. Parashar and N. Kumar), *Phys. Rev.* B, **61**, 594 (2000).

5 "Imaginary potential as a counter of delay time for wave reflection from a one-dimensional random potential" (S. Anantha Ramakrishna and N. Kumar), *Phys. Rev.*, **B61**, 3163 (2000).

6 "Dynamics of ordering of isotropic magnets" (Jagjit Das and Madan Rao), *Physica A,* **270**, 253 (1999)

7 "A comment on the degrees of freedom in the Ashtekar formulation for 2+1 gravity" (J. Fernando Barbero G. and Madhavan Varadarajan), *Class Quant. Grav.*, **16**, 3765 (1999).

8 "Functional evolution of free quantum fields" (Charles G. Torre and Madhavan Varadarajan), *Class. Quantum Grav.*, **16**, 2651 (1999).

9 "On the metric operator for quantum cylindrical waves" (Madhavan Varadarajan), *Class Quant. Grav.*, **17**, 189 (2000).

10 "Dynamics of ordering of isotropic magnets" (J. Das and M. Rao), *Physica*, **A 270**, 253 (1999).

11 "Arrested states in solids" (M. Rao and S. Sengupta), *Curr. Sci.*, **77**, 382 (1999).

12 "Elastic constants from microscopic strain fluctuations" (S. Sengupta, P. Nielaba, M. Rao and K. Binder), *Phys. Rev.*, **E61**, 1072 (2000).

13 "Ordering dynamics of Heisenberg spins with torque: Crossover, spin waves and defects" (J. Das and M. Rao), *Phys. Rev.*, **E62**, (2000).

14 'Comment on "Neutron Interferometric observation of noncyclic phase"' (Rajendra Bhandari) *Phys. Rev. Lett.*, **83**, 2089 (1999)

15 "Spectral features in emissions from random amplifying media" (Sushil Mujumdar and Hema Ramachandran), *Opt. Comm.*, **176**, 31 (2000).

16 "A simple demonstration of the Pancharatnam phase as a geometric phase" (P. Hariharan, Sushil Mujumdar and Hema Ramachandran), *J. Mod. Opt.*, **46**, 1443 (1999).

17 "Imaging through turbid media" (Hema Ramachandran), *Curr. Sci.*, **76**, 1334 (1999).

18 "Imaging in turbid media using quasi-ballistic photons" (Venkatesh Gopal, Sushil Mujumdar, Hema Ramachandran and A.K. Sood), *Opt. Comm.*, **170**, 331 (1999).

19 "Evidence of electrochemiluminescence as a pumping mechanism for a dye laser" (Sushil Mujumdar), *Curr. Sci.*, **76**, 1176 (1999).

20 "A chiral axial next nearest neighbour xy-model for antiferroelectric liquid crystals" (Arun Roy and N.V. Madhusudana), *European Phys. J. E,* **1**, 319 (2000).

21 "A simple molecular model for N - Sm A_d - N_{dRe} - N_{1Re} - SmA_1 phase sequence in highly polar compounds" (A.S. Govind and N.V. Madhusudana), *Liquid Crystals*, **27**, 215 (2000).

22 "Photonic crystals" (G.S. Ranganath), *Curr. Sci.*, **76**, 1349 (1999).

23 "Diffraction in heterogeneous liquid crystals" (K.A. Suresh, G.S. Ranganath and M.S. Giridhar), *Curr. Sci.*, **76**, 1325 (1999)

24 "Nematic kink states in a laser field" (S.K. Srivatsa and G.S. Ranganath), *Phys. Rev.*, **E60**, 5639 (1999).

25 "Molecular structure and chiral liquid crystalline phases" (B.K. Sadashiva), *Pramana,* **53**, 213 (1999).

26 "Phase transitions in Langmuir monolayers" (K.A. Suresh and A. Bhattacharyya), *Pramana*, **53**, 93 (1999).

27 "Transient periodic dissipative structures in nematics confined between coaxial cylinders" (U.D. Kini), Molec. Cryst. Liquid Cryst., **333**, 79 (1999).

28 "Electric field induced transient effects in a nematic liquid crystal in the presence of a stabilizing magnetic field" (Shila Garg, C. Ditchman, N. Schiffrik and U.D. Kini), Molec. Cryst. Liquid Cryst., **328**, 581 (1999).

29 "Phase transitions in colloidal dispersions in a liquid crystalline medium" (V. A. Raghunathan, P. Richetti, D. Roux, F. Nallet and A.K. Sood), *Langmuir*, **16**, 4720 (2000).

30 "Novel structural features of the ripple phase of phospholipids" (Kheya Sengupta, V.A. Raghunathan and John Katsaras), Europhys. Lett., **49**, 722 (2000).

31 "Driving matrix liquid crystals displays" (T.N. Ruckmongathan), *Pramana*, **53**, 199 (1999).

32 "Simultaneous addressing of two rows in SSFLC displays" (T. Matuszczyk, T.N. Ruckmongathan and S.T. Lagerwall), *Ferroelectrics*, **234**, 251 (1999).

33 "A novel method of growing bulk single crystals" (D. Vijayaraghavan), *Curr. Sci.*, **77**, 1570 (1999).

34 "Pearls and shells" (M.S. Giridhar and S.K. Srivatsa), *Curr. Sci.*, **76**, 1324 (1999).

35 "Moonstones" (M.S. Giridhar and S.K. Srivatsa), *Curr. Sci.*, **76**, 1348 (1999).

36 "G359.87 + 0.18: An FR II Radio galaxy 15 arcminutes from Sgr A*. Implications for the scattering region in the Galactic Center" (T.J.W. Lazio, K.R. Anantharamaiah, W.M. Goss, N.E. Kassim and J.M. Cordes), *Astrophys. J.*, **515**, 196 (1999).

37 "Discovery of a non-thermal galactic center filament (G358.85 + 0.47) parallel to the galactic plane" (C.C. Lang, K.R. Anantharamaiah, N.E.Kassim and T.J.W. Lazio), *Astrophys. J. Lett.*, **521**, L41 (1999).

38 "Cosmology with the intergalactic medium" (B. Nath), *Pramana*, **53**, 1021 (1999).

39 "Revisiting the shapes of pulsar beams" (D. Mitra and A.A. Deshpande), *Astron. & Astrophys.*, **346**, 906 (1999).

40 Determination of linear polarization and Faraday rotation of pulsar signals from spectral intensity modulation" (P. S. Ramkumar and A. A. Deshpande), *J. Astrophys. Astr.*, **20**, 37 (1999).

41 "Pulsar magnetospheric emission mapping: Images and implications of polar-cap weather" (A.A. Deshpande and J.M. Rankin), *Astrophys. J.*, **524**, 1008 (1999).

42 "The observational evidence pertinent to possible kick mechanisms in neutron stars" (A.A. Deshpande, R. Ramachandran and V. Radhakrishnan), *Astron. & Astrophys.*, **351**, 195 (1999).

43 "The effect of magnetic fields on gamma-ray bursts inferred from multi-wavelength observations of the burst of 23 January 1999" (T.J. Gulama *et al.* including D. Bhattacharya), *Nature*, **398**, 394 (1999).

44 "Evolution of multipolar magnetic fields in isolated neutron stars" (D. Mitra, S. Konar and D. Bhattacharya), *Mon. Not. R. Astr. Soc.*, **307**, 459 (1999).

45 "Magnetic field evolution of accreting neutron stars - III" (S. Konar and D. Bhattacharya), *Mon. Not. R. Astr. Soc.*, **308**, 795 (1999).

46 "On the different radio source populations in the Butcher-Oemler clusters Abell 2125 and 2645" (K.S. Dwarakanath and F.N. Owen). *Astrophys. J.*, **118**, 625 (1999).

47 "Constrained violent relaxation to a spherical halo" (A. Mangalam, R. Nityananda and S. Sridhar), *Astrophys. J.*, **524**, 623 (1999).

48 "Changes in the angular separation of the lensed images PKS 1830-211 NE & SW" (C. Jin, M.A. Garrett, S. Nair, R.W. Porcas, and A.R. Patnaik), *New Astronomy Reviews*, **43**, 767 (1999).

49 Constraining cosmologial parameters through Sunyavez-Zel'dovich surveys" (Subhabrata Majumdar and Ravi Subrahmanyan), *Pramana*, **53**, 971 (1999).

50 "Tidally compressed gas in centers of early-type and ultraluminous galaxies" (Mousumi Das and Chanda J. Jog), *Astrophys. J.*, **527**, 600 (1999).

51 "Shock-heated NH, in a molecular jet associated with a high-mass young star" (Qihou Zhang, Todd R. Hunter, T.K. Sridharan and Riccardo Gesaroni), *Astrophys. J.*, **527**, L117 (1999).

52 "Adaptive beam forming system for radio-frequency interference rejection" (M. Goris, A. Joseph, G. Hampson and F. Smits), *IEE Proc. - Radar, Sonar Navig,* **146**, 73 (1999).

In Conference Proceedings

1 "Persistent random walks of photons in forward scattering media" (S. Anantha Ramakrishna and N. Kumar), *Proceedings of the National Laser Symposium,* Hyderabad (1999), p. 225.

2 "Nonlinear transmission of tetraphenyl porphyrin doped glass" (S. Anantha Ramakrishna, K. Divakara and P.K. Gupta), *Proceedings of the National Laser Symposium,* Hyderabad (1999), p. 159.

3 "Kinetics of adsorption of long chain alkanethiol monolayers on noble metal surfaces" (R. Subramanian and V. Lakshminarayanan), *Proceedings of the Golden Jubilee Symposium on Small Scales in Space and Time,* Pune, 3-5 November 1999.

4 "A simple controller for displaying restricted patterns in RMS responding LCDs" (P.Y. Vijaya, D.J. Reddappa and T.N. Ruckmongathan), **in** *SID Digest, Proceedings of SID Conference, 1999*, SID, San Jose, USA, Paper 18.3.

5 "Two-line addressing technique for SSFLC displays" (T.N. Ruckmongathan, T. Matuszczyk and S.T. Lagerwall), **in** *EuroDisplay '99, the 19th International Display Research Conference Proceedings*, 6-9 September 1999, Berlin, Germany, p. 405.

6 "High Rydberg state carbon recombination lines from interstellar clouds" (K.R. Anantharamaiah and Nimisha G. Kantharia), **in** "*New Perspectives on the Interstellar Medium*", ed. A.R. Taylor, T.L. Landecker and G. Joncas, (ASP, San Francisco, 1999), p. 197.

7 "Ionized gas in the Sgr A complex - VLA observations of H168α and H270α recombination lines" (K.R. Anantharamaiah, A. Pedlar and W.M. Goss), **in** "*The Central Parsecs of the Galaxy*", ed. H. Falcke, A. Cotera and F. Melia (ASP, San Francisco, 1999), p. 422.

8 "Hyperstrong radio-wave scattering and free electrons in the galactic center" (T.J.W. Lazio, J.M. Cordes, K.R. Anantharamaiah, W.M. Goss and N.E. Kassim), **in** "*The Central Parsecs of the Galaxy*", ed. H. Falcke, A. Cotera and F. Melia (ASP, San Francisco, 1999), p. 441.

9 "Discovery of a new filamentary structure G358.85+0.47 - The Pelican" (K.R. Anantharamaiah, C.C. Lang, N.E. Kassim, T.J.W. Lazio and W.M. Goss), **in** "*The Central Parsecs of the Galaxy*", ed. H. Falcke, A. Cotera and F. Melia (ASP, San Francisco, 1999), p. 507.

10 "Pulse fluctuation properties at 35 MHz" (Ashish Asgekar and A.A. Deshpande), **in** *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series,* Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 161.

11 "Linear polarization properties of pulsars at 35 & 327 MHz" (Ashish Asgekar and A.A. Deshpande), **in** *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series,* Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 245.

12 "Characteristics of pulsar radio emission at single-pulse resolution" (A.A. Deshpande), **in** *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series*, Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 149.

13 "Polar-fluxtube emission 'weather' of pulsar B0943+10: Polarization, modes and theoretical implications" (J.M. Rankin and A.A. Deshpande), **in** *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series*, Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 155.

14 "Pulse properties of a few Southern pulsars at 150 MHz" (N.H. Issur and A.A. Deshpande), *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series*, Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 149.

15 "Search for single scattering events" (R. Ramachandran, A.A. Deshpande and B.W. Stappers), *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series*, Vol. 202: Proceedings of the 177th Colloquium of IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 565.

16 "Evolution of multipolar magnetic fields in isolated neutron stars and its effect on pulsar radio emission" (D. Mitra, S. Konar, D. Bhattacharya and A.V. Hoensbroech, J.H. Seiradakis and R. Wielebinski), **in** *Pulsar Astronomy - 2000 and Beyond, ASP Conference Series*, Vol. 202: Proceedings of the 177th Colloquium of the IAU held in Bonn, Germany, 30 August - 3 September 1999, eds. N. Kramer, N. Wex and R. Wielebinski (ASP, San Francisco, 2000), p. 265.

Popular Science Articles

1 "The amoral scientist – Notes on the life of Fritz Haber" (S. Ramaseshan), *Curr. Sci.*, **78**, 1110 (1999).

2 "A conversation with Satyendranath Bose about five decades ago - Some recollections" (S. Ramaseshan), *Curr. Sci.*, **78**, 636 (2000).

3 "The amoral scientists – The tragedy of Hiroshima" (M.V.N. Murthy, R. Shankar, Madan Rao, J. Samuel and A. Sitaram), *Curr. Sci.*, **78**, 12 (2000).

4 "Mirrorless lasing in random amplifying media" (S. Anantha Ramakrishna), *Bulletin of the Indian Laser Association*, **10 & 11**, p.28-31 (2000).

5 "Phase transition in a scientist's life" (Rajaram Nityananda), *Curr. Sci.*, **77**, 625 (1999).

6 "The 1998 Physics Nobel Prize" (R. Nityananda), *Resonance* (April 1999), p. 88.

7 "Second Sound-2. The role of elastic waves" (R. Srinivasan), *Resonance,* **4**, 15 (1999).

8 "Dark Matter-1: What you see ain't what you go" (Bikram Phookun and Biman Nath), *Resonance* (September 1999), p. 24

9 "Dark Matter-2: What you see ain't what you go" (Bikram Phookun and Biman Nath), *Resonance* (October 1999), p. 40

10 "Discovery of the future: Science in the last millennium" (B. Nath), *The Hindu, Folio,* January 23, 2000.

11 "Zen and the physics of traffic jams" (B. Nath), *Deccan Herald*, 8 September 1999.

12 "Lurking between the galaxies" (B. Nath), *Mercury* (May-June 1999).

13 "Chandra - The X-rays Observatory" (C.S. Shukre), *Jantar Mantar*, the popular science magazine for school children, February - March 2000.

Others (Non-technical)

1 "A tribute (obituary) of Prof. Bhaskar Datta" (D. Bhattacharya), *Bulletin of the Astronomical Society of India*, **27**, 47 (2000).

Book edited

1 "Liquid Crystals and Other Soft Materials", Proceedings of the Golden Jubilee Discussion Meeting of the Raman Research Institute, Bangalore, ed. N.V. Madhusudana, Special Issue of *Pramana*, Vol. **53** (Indian Academy of Sciences, Bangalore, July 1999).

2 "From White Dwarfs to Black Holes: The legacy of S. Chandrasekhar", ed. G. Srinivasan (The University of Chicago Press, 1999, & also the Universities Press, Hyderabad, 1999).

Book review

1 "Introduction to special theory of relativity" by Somnath Datta (Sukanya Sinha), *Resonance*, 4 (December 1999).

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1 "Reflection of light from a random amplifying medium with disorder in the complex refractive index: Statistics of fluctuations" (S. Anantha Ramakrishna, E. Krishna Day, G.V. Vijayagovindan and N. Kumar), *Phys. Rev. B.*

2 "Frequency-domain P-approximant filters for time-truncated inspiral gravitational wave signals from compact binaries" (T. Damour, B.R. Iyer and B.S. Sathyaprakash), *Phys. Rev.* **D.**

3 "Padé approximants for truncated post-Newtonian neutron star models" (Anshu Gupta, A. Gopakumar, B.R. Iyer and Sai Iyer), *Phys. Rev.* **D.**

4 "Fock representations from U(1) holonomy algebras" (Madhavan Varadarajan), *Phys. Rev.* **D.**

5 "Social percolation on inhomogeneous spanning network" (Abhijit Kar Gupta and Dietrich Stauffer), *Int. J. Mod. Phys. C.*

6 "Photon transport in thin disordered slabs" (Venkatesh Gopal, S. Anantha Ramakrishna, A. K. Sood and N. Kumar) , *Phys. Rev. E* .

7 "Super-reflection of light from random amplifying medium with disorder in the complex refractive index: Statistics of fluctuations" (S. Anantha Ramakrishna, E. Krishna Das, G.V. Vijayagovindan and N. Kumar), *Phys. Rev. B.*

8 "Transport along null curves" (J. Samuel and R. Nityananda), *J. Phys.*

9 "Comparative features of optical limiting in monolayer protected gold, silver and alloy nanoclusters under picosecond and nanosecond laser excitation (Reji Philip, Sushil Mujumdar, Hema Ramachandran, G. Ravindra Kumar, N. Sandhyarani and T. Pradeep), Nonlinear Opt.

10 "An orientational transition of bent-core molecules in an anisotropic matrix" (R. Pratibha, N.V. Madhusudana and B.K. Sadashiva), *Science.*

11 "Experimental studies on the undulated twist grain boundary-C* liquid crystal" (P.A. Pramod, R. Pratibha, Sobha R. Warrier and N.V. Madhusudana), *Ferroelectrics.*

12 "Evidence of columnar structure in compounds composed of banana-shaped molecules" (B. K. Sadashiva, V.A. Raghunathan and R. Pratibha), *Ferroelectrics.*

13 "Twist grain boundary A phase in [R]-[-]-1-methylheptyl-4'-(3"-chloro-4"-n-alkoxybenzoyloxy) biphenyl-4-carboxylates" (N. Kasthuraiah, B.K. Sadashiva, H.T. Nguyen, J.C. Rouillon and N. Isaert), *Ferroelectrics.*

14 "Crystal structure and EPR studies of bis-[1,3-Di(p-n-octylphenyl)propane-1,3-dionato]oxovanadium(IV)" (Sujatha Venkataraman, Babu Varghese, B.K. Sadashiva and S. Subramanian), *Molec. Cryst. Liquid Cryst.*

15 "Synthesis and mesomorphic properties of banana-shaped compounds derived from 2,7-dihydroxynaphthalene" (R. Amaranatha Reddy and B.K. Sadashiva), *Liquid Cryst.*

16 "Hydrogen recombination lines near 327 MHz - I: Distribution of low-density gas in the galactic disk" (D.Anish Roshi and K.R.Anantharamaiah), Astrophys.J..

17 "Starburst in the ultraluminous galaxy Arp 200: Constraints from radio recombination lines and continuum" (K.R. Anantharamaiah, F. Viallefond, Niruj Mohan, W.M. Goss and J.H. Zhao), Astrophys. J.

18 "On cooling flows and the Sunyaev-Zel'dovich effect" (S. Majumdar and B. Nath), Astrophys. J

19 "The small-scale structure in interstellar HI: A resolvable puzzle" (A.A. Deshpande), Mon. Not. R. Astron. Soc.

20 "Power spectrum of cold atomic gas in the Galaxy towards Cas A and Cygnus A" (A.A. Deshpande, K.S. Dwarakanath and W.M. Goss), Astrophys. J.

In Conference Proceedings

1 "Radiation reaction in electrodynamics and general relativity" (B.R. Iyer), in *The Narlikar Festschrift,* Eds. N. Dadhich and A.K. Kembhavi (Kluwer, Dordrecht).

2 "Second post-Newtonian gravitational wave polarizations for inspiralling compact binaries in elliptical orbits" (A. Gopakumar and B.R. Iyer), in *Gravitational Waves and Experimental Gravity*, Ed. J. Dumarchez (Editions Frontieres, France, 2000).

3 "A new type of high field electrooptic response in nematics" (Geetha Basappa and N.V. Madhusudana), **in** *Proceedings of XIII Conference on Liquid Crystals,* Krunica Zdroj, Poland (SPIE Publication).

4 "Low-frequency recombination lines of hydrogen" (K.R. Anantharamaiah), **in** "The Universe at Low Radio Frequencies" IAU Symposium 199, Pune, India, 30 November - 4 December 1999.

5 "Interpretation of galactic carbon recombination lines near 327 MHz" (D. Anish Roshi, Nimisha G. Kantharia and K.R. Anantharamaiah", **in** "The Universe at Low Radio Frequencies" IAU Symposium 199, Pune, India, 30 November - 4 December 1999.

6 "Carbon recombination lines at 34.5 MHz from the galactic plane" (Nimisha G. Kantharia and K.R. Anantharamaiah), **in** "*The Universe at Low Radio Frequencies*" IAU Symposium 199, Pune, India, 30 November-4 December 1999.

7 "A study of low-density ionized gas in the galactic plane" (D. Anish Roshi and K.R. Anantharamaiah), **in** "*The Universe at Low Radio Frequencies*" IAU Symposium 199, Pune, India, 30 November - 4 December 1999.

8 "VLA Observations of the galactic centre at 74 MHz" (K.R. Anantharamaiah, N.E. Kassim, T.J.W. Lazio, W.M. Goss and H. Falcke), **in** "*The Universe at Low Radio Frequencies*" IAU Symposium 199, Pune, India, 30 November - 4 December 1999.

9 "Radio recombination lines from starburst galaxies: High and low density ionized gas" (Niruj R. Mohan, K.R. Anantharamaiah and W.M. Goss), **in** "*The Universe at Low Radio Frequencies*" IAU Symposium 199, Pune, India, 30 November - 4 December 1999.

10 "Search for radio recombination lines towards the gravitational lens PKS 1830-211" (Niruj R. Mohan, K.R. Anantharamaiah and W.M. Goss), **in** *ASP Conference Series*: Proceedings of the IAU Symposium 199 Pune, 30 November - 4 December 1999.

11 "On the ordinary characteristics of the medium responsible for the extreme scattering events" (A.A. Deshpande and V. Radhakrishnan), **in** *Proc. of the IAU Colloquium 182, Guiyang, China, 2000.*

12 "COMA southwest - as seen by the GMRT"(K.S. Dwarakanath and J.N. Chengalur), **in** "*The Evolution of Galaxies on Cosmological Timescales", ASP Conference Series*: Proceedings of the 199 Colloquium of IAU held in Pune, 30 November - 4 December 1999, Eds. J.E. Beckman and T.J. Mahoney.

13 "HI 21-cm line observations with the GMRT towards interstellar clouds previously seen in optical absorption" (Rekesh Mohan, K.S. Dwarakanath, G. Srinivasan and J.N. Chengalur), **in** "*The Evolution of Galaxies on Cosmological Timescales", ASP Conference Series*: Proceedings of the 199 Colloquium of IAU held in Pune, 30 November - 4 December 1999, Eds. J.E. Beckman and T.J. Mahoney.

14 "A low frequency southern sky survey using the Mauritius Radio Telescope" (N. Udaya Shankar), **in** "*The Universe at Low Radio Frequencies", ASP Conference Series*: Proceedings of the IAU Symposium 199, Pune, 30 November - 4 December 1999.

15 "Geometric phase in phasing of antenna arrays", (Rajendra Bhandari), **in** *ASP Conference Series*: Proceedings of the IAU Symposium 199, Pune, 30 November - 4 December 1999.

Annexure - II

COLLOQUIA

Name	Title	Date
S. Ranganathan Indian Inst. of Science Bangalore	Quasi crystals - Progress and promise	1.4.1999
Silvio Franz Abdus Salam International Centre for Theor. Physics, Trieste, Italy	Constrained Boltzmann-Gibb's measures, effective potentials and the glass transition	6.4.1999
Varun Sahni Inter-University Centre for Astronomy & Astrophysics Pune	Understanding the supercluster-void network	7.4.1999
Bhaskar Datta Indian Inst. of Astrophysics Bangalore	What can kilohertz QPOs in x-ray binaries tell us about neutron stars?	9.4.1999
Madhavan Varadarajan 15.4.1999 Raman Research Institute Bangalore	Canonical quantum gravity	
Ratna Phadke Tata Inst. of Fundamental Research, Mumbai	Molecular materials for devices	16.4.1999
M.M.G. Krishna Tata Inst. of Fundamental Research, Mumbai	Diffusion in micelles: Simulations and experiments.	21.4.1999
Jayant B. Udgaonkar National Centre for Biological Sciences, Bangalore	The new and classical views of protein folding	29.4.1999
T.N. Ruckmongathan & N. Udaya Shankar Raman Research Institute Bangalore	Some technologies developed in the areas of liquid crystal displays and radio astronomy	11.5.1999

Name	Title	Date
Jerry L. Bona University of Texas Austin, USA	Solitons and singularities in non-linear waves	19.5.1999
K. B. Athreya University of Iowa USA	Independent identically distributed random iterations as an approach to deterministic chaos	20.5.1999
A. Gopakumar Physical Research Lab Ahmedabad	Constructing search templates for LIGO/ VIRGO	3.6.1999
Francis Rondelez Institut Curie Paris, France	Formation of organic monolayers on solid surfaces: Two-dimensional physics with applications in wetting, electronics and medicine	10.6.1999
Krishnaswami Alladi University of Florida USA	The undying charm of Schur's partition	28.6.1999
Jagadish Rai Indian Inst. of Technology Kanpur	Vortices in light and sound	30.6.1999
Sreeram Valluri Univ. of Western Ontario Canada	Newton's apsidal precession theorem, eccentric orbits and mercury's perihelion	9.7.1999
Kalyana Rama Inst of Mathematical Science, Chennai	AdS-CFT correspondence in string theory	14.7.1999
C.K. Majumdar Indian Statistical Institute Calcutta	Physics research before and after Independence	15.7.1999
K. Srihari Indian Inst. Technology Kanpur	Classical resonances - Quantum manifestations	19.7.1999
Deepak Dhar Tata Inst. of Fundamental Research, Mumbai	Distribution of jump sizes in a model of Barkhausen noise	24.7.1999

Name		Title	Date
Parthasarathi Majumdar Institute of Mathematical Sciences, Chennai	1	Does black hole radiance break supersymmetry	27.7.1999
	2	Parity violating gravitational couplings of the Maxwell field	30.7.1999
Smitha Vishveshwara Univ. of California Santa Barbara, USA		Novel phases in superconductivity	28.7.1999
M. Muthukumar Univ. of Massachusetts, Amherst, USA		Strings of life: Challenges and opportunities in polymers	29.7.1999
T.R. Govindarajan Institute of Mathematic Sciences, Chennai		Knot solitons	4.8.1999
Tapash Chakraborty Institute of Mathematical Sciences, Chennai		Nano physics with artificial atoms	12.8.1999
Arun Roy University of Sao Paulo Brazil		Theoretical model for phases exhibited by achiral bent molecules	13.8.1999
G.V. Shivashankar The Rockefeller University New York, USA		Force-extension measurements of single DNA and DNA-RecA interactions	23.8.1999
Y. Sudhakar Saha Inst. of Nuclear Physics, Calcutta		Screened interaction and self-energy in a polarized electron liquid	25.8.1999
Y.V. Venkatesh Indian Inst. of Sciences Bangalore		Can a machine recognize faces?	26.8.1999
Anita Richards Univ. of Manchester U K		Moving water in stellar winds	30.8.1999
Reji Philip		Nonlinear optics of emerging new new materials: 2-scan and four-wave mixing experiments	26.10.1999

Name		Title	Date
Satyendra Kumar Kent State University USA	1	Liquid crystal gratings and microlenses	3.9.1999
	2	Novel phenomena at interfaces in soft materials	30.11.1999
Anil K. Singh National Aerospace Labs Bangalore		From laboratory experiments to the Earth's inner core	21.10.1999
J. Martijn Smit SRON/EOS, Utrecht The Netherlands		Measuring the Earth gravity field from space	27.10.1999
Thomas Tauris University of Amsterdam Amsterdam, The Netherlands		Aspects of mass transfer in x-ray binaries forming millisecond pulsars	3.11.1999
V.A. Raghunathan Raman Research Institute Bangalore		Self-assembled structures of lipids	4.11.1999
V. V. Sreedhar Dublin Institute for Advanced Studies, Ireland		Spin and Statistics	8.11.1999
Istvan Janossy Research Inst. of Solid State Physics & Optics Budapest, Hungary		Optical reorientation in dye doped liquid crystals	8.11.1999
Reena Sharma Bangalore		Chiral composites for electromagnetic applications	10.11.1999
W.M. Goss National Radio Astronomy Observatory, Socorro USA	1	OH 1720 MHz masers and magnetic fields in supernova remnants	16.11.1999
	2	Ruby Payne-Scott – The first woman radio astronomer	18.11.1999
A. Mehta National Centre for Basic Sciences, Calcutta		Models of competitive learning and implications for coarsening phenomena	18.11.1999

Name		Title	Date
R.D. Ekers Australia Telescope National Facility Epping, Australia	1	Paths to discoveries in radio astronomy	27.11.1999
	2	Observing the epoch of first light	27.11.1999
Pier A. Mello Institute of Physics, UNAM, Mexico		The problem of phase breaking in mesoscopic systems	29.11.1999
Anders Katsberg Stockholm University Sweden		Experiments with optical lattices	1.12.1999
Steven Vogel James B. Duke Professor Department of Zoology Duke University, USA & **Golden Jubilee Distinguished Professor, RRI**	1	Leaves in winds: Problems of heat and drag	2.12.1999
	2	Capitalizing on currents: How organisms use the forces of flow	9.12.1999
	3	How to (and why) twist a lot but bend only a little	16.12.1999
	4	How physics constrains evolution: Circulatory systems	23.12.1999
	5	Using dimensionless numbers to expose life's limits	30.12.1999
Debasish Biswas University of Calcutta Calcutta		Line shape study of atmospheric molecules in the near IR region by diode laser spectroscopy	3.12.1999
A. Konovalenko Inst. of Radio Astronomy Kharkov, Ukraine		Decameter wave radio astronomy activities at the IRA	15.12.1999
Mukunda P. Das The Australian National University, Australia	1	What is new about Bose-Einstein condensation?	15.12.1999
	2	Noise in the realm of physical sciences	16.12.1999
Sanjay Reddy 17.12.1999 INT Univ. of Washington Seattle, USA		Supernova neutrinos: How many? For how long? and What we might learn	

Name	Title	Date
V. Malofeev Pushchino Observatory Lebedev Physical Inst. Moscow	Pulsar observations at the Pushchino Observatory	18.12.1999
E.C.G. Sudarshan University of Texas, USA	Spin and statistics and TCP theorem from rotational invariant field theories	20.12.1999
Ishwar Chandra National Centre for Radio Astrophysics, Pune	Orientation and environmental effects in radio galaxies and quasars	22.12.1999
Hemant Bokil International Centre for Theoretical Physics, Trieste, Italy	Recent results in spin glasses: Is there replica symmetry breaking in the EA model?	23.12.1999
Ketan Desai National Radio Astronomy Socorro, USA	Anisotropic interstellar scattering towards the Cygnus region	24.12.1999
G. Werth Institute for Physics Johannes Gutenberg Univ. Mainz, Germany	Hyperfine spectroscopy with ion traps	11.1.2000
Z. Raszewski Military Univ. of Technology Warsaw, Poland	The sign and magnitude of spontaneous polarization in ferroelectric SmC* liquid crystals	11.1.2000
J. Zielinski Military Univ. of Technology Warsaw, Poland	Optical parameters of TN displays with dichroic dyes	11.1.2000
Anand Yethiraj AMOLF The Netherlands	Experimental studies on the nematic-smectic A phase transition	14.1.2000
Willem Baan NFRA, Dwingeloo The Netherlands	Status of the Westerbork Synthesis Radio Telescope and a report on the ITU working group meeting	14.1.2000
Nimesh A. Patel Harvard-Smithsonian Center for Astrophysics Cambridge, USA	Proper motion of water masers associated with IRAS 21391+5802	28.1.2000

Name		Title	Date
K. Sreenivasan Inter-University Centre for Astronomy & Astrophysics, Pune		A novel approach to particle production in an uniform electric field	7.2.2000
A.R.P. Rau Louisiana State Univ. Baton Rouge, USA	1	Intense lasers and qubits: Solving time dependent operator equations	8.2.2000
	2	Unified view of collisions and spectroscopy *(Series of 3 lectures)*	14-16.1.2000
J.P. Bayle Universite Paris-Sud Orsay, France		Formation of binary liquid crystal mixtures from thermal decomposition studied by C-13 NMR	10.2.2000
Dominique Homberger Louisiana State Univ. USA		Feeding adaptation in birds and application to Cockatoo evolution	17.2.2000
Biman Nath Raman Research Inst. Bangalore		End of the dark age of the Universe	17.2.2000
Abhishek Dhar Indian Institute of Science Bangalore		Equilibrium and dynamical properties of the *ANNNI* chain at the multiphase point	18.2.2000
M.S. Nandakumar Physical Research Lab Ahmedabad		Near-IR studies of star forming regions	29.2.2000
Rajiv Gavai Tata Inst. of Fundamental Research, Mumbai		The little big bangs in our Universe: Relativistic heavy ion collisions	2.3.2000
C. S. Unnikrishnan Tata Inst. of Fundamental Research, Mumbai		Resolution of the Einstein-Podolsky-Rosen non-locality puzzle	20.3.2000
Sukratu Barve Tata Inst. of Fundamental Research, Mumbai		Some aspects of gravitational collapse	27.3.2000

Annexure III

JOURNAL CLUB

Discussed by	Paper discussed	Date
Srivatsa S.K.	Quantized Röntgen effect in Bose-Einstein condensates U. Leonhardt and P. Piewnicki, Phys. Rev. Lett. **82**, 2426 (1999)	8.4.1999
Anantha Ramakrishna S	Random lasing action in semiconducting powder H. Cao *et al.*, Phys. Rev. Lett., **82**, 2278 (1999)	8.4.1999
Mousumi Das	Measurements of Ω and Λ from 42 high-Redshift supernovae S. Perlmutter *et al.*, Astrophysical J., Ref: astro-ph/9812133 (1998)	22.4.1999
Sreejith Sukumaran	Jamming, force chains, and fragile natter M. E. Cates *et al.*, Phys. Rev. Lett., **81**, 1841 (1998)	22.4.1999
Ashish Asgekar	Two-dimensional mapping of the electrostatic Potential in transistors by electron holography W.D. Rau *et al.*, Phys. Rev. Lett., **82**, 2614 (1999)	6.5.1999
Sunita Nair	Search for time variation of the fine structure constant John K. Webb *et al.*, Phys. Rev. Lett., **82**, 884 (1999)	6.5.1999
Udaya Shankar N	Molecular-scale electronics Mark A. Reed, Proceedings of the IEEE, **87**, 652 (1999), A special issue on Quantum Devices and Applications	8.7.1999
Samuel J	Does the generalized second law require entropy bounds for a charged system? T. Shimomura and S. Mukohyama, Ref: gr-qc/99066047 (1999)	8.7.1999
Dwarakanath K S	A Sunyaev-Zeldovich map of the massive core in the luminous x-ray cluster RX J1347-1145 Pointecouteau *et al.*, Astrophysical J., **519**, L115 (1999)	22.7.1999

Discussed by	Paper discussed	Date
Kumar N	Universality of the Wigner time delay distribution for one-dimensional random potentials C. Texier and *A. Co*mtet Phys. Rev. Lett., **82,** 4220 (1999)	22.7.1999
Ruckmongathan T N	High-density data storage based on the atomic force microscope H. Jonathon Mamin *et al.* Proc. of the IEEE, **87**, 1014 (1999)	5.8.1999
Ashish Asgekar	A dusty pinwheel nebula around the massive star WR104 Peter G. Tuthill, Nature, **398,** 487 (1999)	5.8.1999
Lakshminarayanan V	Carbon nanotube actuators Ray H. Baughman *et al.* Science, **284,** 1340 (1999)	19.8.1999
Shukre C S	Is SGR 1900+14 a magnetar? D. Marsden *et al.* The Astrophysical Journal, **520,** L107 (1999)	19.8.1999
Raghunathan V A	Entropic trapping and escape of long DNA molecules at submicron size constriction, J. Han *et al.*, Phys. Rev. Lett., **83**, 1688 (1999)	2.9.1999
Amitesh Omar	A geometric distance to the galaxy NGC4258 from orbital motions in a nuclear gas disk, Hernstein *et al.*, Nature, **400**, 538 (1999)	2.9.1999
Thiruvikraman P K	High-temperature weak ferromagnetism in a low-density free-electron gas D.P. Young *et al.*, Nature, **397**, 412 (1999)	16.9.1999
Niruj R. Mohan	Cosmological constant or intergalactic dust? Constraints from the cosmic far infrared background Anthony Aguirre *et al.* Astrophysical Journal (Submitted)	16.9.1999
Ranganath G S	A thermo-acoustic stirling heat engine S. Backhaus and G.W. Swift Nature, **399**, 335 (1999)	14.10.1999

Discussed by	Paper discussed	Date
Madhavan Varadarajan	Black holes, bandwidths and Beethoven Achim Kempf, gr-qc/9907084 (1999)	14.10.1999
Samuel J	Cost of exactly simulating quantum entanglement with classical communication Gilles Brassard *et al.* Phys. Rev. Lett., **83**, 1874 (1999).	28.10.1999
Anantha Ramakrishna S	Liquid crystal photonic-band-gap materials: The tunable electromagnetic vacuum Kurt Busch and Sajeev John Phys. Rev. Lett., **83**, 967 (1999).	11.11.1999
Giridhar M S	Switchable tackiness and wettability of a liquid crystalline polymer Guillaume de Crevoisier *et al* Science, **285**, 1246 (1999).	11.11.1999
Rajasekaran G Inst. of Mathematical Sciences, Chennai	**Special Session on the 1999 Nobel Prize in Physics:** Martinus Veltman and Gerard 't Hooft	24.11.1999
Pratibha R	Electrical conduction through DNA molecules Hans-Werner Fink and Christian Schonenberger Nature, **398**, 407 (1999)	25.11.1999
Rekesh Mohan	A confirmed location in the galactic halo for the high-velocity cloud 'Chain A' Hugo Van Woerden *et al.*, Nature, **400**, 138 (1999)	25.11.1999
Sushil Majumdar	Coherent backscattering of light by cold atoms G. Labeyrie *et al.*, Phys. Rev. Lett., **83**, 5266 (1999)	13.1.2000
Thiruvikraman P K	Use of behavioural stochastic resonance by paddle fish for feeding David F. Russel *et al.*, Nature, **402**, 291 (1999)	13.1.2000
Panikumar K G	Characterization of a bistable TN-LCD for matrix-addressed operation G-D Lee *et al.*, SID 99 Digest, 862 (1999)	27.1.2000
Sarasij R C	Thermodynamic control of hurricane intensity Kerry Emanuel, Nature, **401**, 665 (1999).	27.1.2000

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Abhijit Kar Gupta	Flowing sand: A physical realization of directed percolation Haye Hinrichsen *et al.*, Phys. Rev. Lett., **83**, 4999 (1999)	10.2.2000
Biman Nath	Circular polarization in star-formation regions: Implications for biomolecular homochirality Jeremy Bailey *et al.*, **281**, 672 (1998)	10.2.2000
Ashish Asgekar	A spatially resolved plerionic X-ray nebula around PSR B0540-69 E.V. Gotthelf and Q. Daniel Wang Astrophysical J. Lett. (2000) Ref: arXive: astro-ph/0002166 (in press)	9.3.2000
Rajaram Nityananda	"Weighing" A closed system and the time-Energy uncertainty principle Y. Aharonov and B. Reznik Phys. Rev. Lett., **84**, 1368 (2000).	9.3.2000
Dipankar Bhattacharya	Ball lightning . . . . . . J Abrahamson and James Dinniss Nature, **403**, 519 (2000)	23.3.2000
Richard James Epp	Gott time machines, BTZ black hole formation, and Choptuik scaling Danny Birmingham and Siddhartha Sen Phys. Rev. Lett., **84**, 1074 (2000)	23.3.2000

ABBREVIATIONS USED

ADM	Arnowit-Deser-Misner
ATCA	Australia Telescope Compact Array
ATP	Adenosine triphosphate
BC	Bent Core
ED	Exact Diagonalization
FCS	Fluorescence Correlation Spectroscopy
FDR	Fluctuation-Dissipation Relation
FFEM	Freeze Fracture Electron Microscopic
FRET	Fluorescence Energy Transfer
GM	Geometric Mean
GPI	glycosyl phosphatidylinositol
GR	General Relativistic
IAPT	Improved Alt & Pleshko Technique
ISAC	ISRO Satellite Centre
JAP	Joint Astronomy Project
LCD	Liquid Crystal Display
LIGO	Laser-Interferometric Gravitational Wave Observatory
MD	Microscopic Description
NCRA	National Centre for Radio Astrophysics
NFRA	Netherlands Foundation for Radio Astronomy
PEO	Polyethylene Oxide
RRL	Radio Recombination Lines
SDS	Sodium dodecyl sulphate
STM	Scanning Tunneling Microscope
STR	Stray Nova Remnant
TDPS	Transient Periodic Dissipative Structures
UTGB	Undulating Twist Grain Boundary
VLA	Very Large Array
VLBA	Very Large Baseline Array