RAMAN RESEARCH INSTITUTE

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Annual Report

2001 – 2002

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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. Unlike in the previous years, however, it also gives, as part of the introduction, a general background to and the flavour of the research activities at the Institute, written in plain language for an uninformed but interested reader. The Annual Report gives the list of papers published in scientific journals, discussion meetings and seminars/colloquia held, and of the Ph.D. degrees awarded during the period 1 April 2001 to 31 March 2002. It also lists the visitors to the Institute – 47 of them from different parts of the world during this period.

As in the past a "Summer Programme in Physics" was held, 14 May - 24 June, 2001. Details are given on page 32 of the Report.

A new initiative, namely, a Theorist's Laboratory has been started at the Institute. It can address, and, indeed has already addressed, some deep conceptual problems at the research level through simple table-top experiments. Summer students loved these experiments.

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

Four Ph.D. degrees were awarded to the students of the Institute two have submitted their theses during the year. Research papers published in refereed journals and in conference proceedings for the same period counted 75 and 9 respectively, apart from an invited review article and a monograph.

Bangalore
30 August 2002

N. KUMAR
Director

RAMAN RESEARCH INSTITUTE
Bangalore

Annual Report 2001-2002

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 have been, and continue to be, Theoretical Physics (gravitation and polarization optics), Liquid Crystals (thermotropic and polymeric), Astronomy & Astrophysics (radioastronomy, interstellar medium, and pulsars). More recently, the Liquid Crystals research has been expanded so as to include soft-condensed matter and biological physics (studies on membranes and single-DNA segments). Also, an Optics Lab has been set up for studying laser cooling and trapping of atoms, imaging through turbid media, and ultra-fast atomic processes using femtosecond (10^{-15} s) laser pulses.

1. Theoretical Physics

Here research is focussed on two main areas – gravitation and polarization optics. Gravitation is known to be the weakest of all known forces of nature, but it dominates all structure and motion on the astronomical scale because of its attractive universality (everything gravitates everything else), its long range, and the fact that matter on the large scale is essentially neutral. The correct theory of gravitation is now believed to be Einstein's General Theory of Relativity (GTR). One of the fundamental predictions of GTR is that of gravitational waves – waves of distortion of spacetime itself - propagating at a finite speed (of light). This replaces the Newtonian gravitational force which was instantaneous. Such waves are expected to be emitted when, e.g., two massive inspiralling stars tend to coalesce under their mutual gravitational attraction. Accurate calculation of this gravitational radiation – its waveform – has been one of the major research programmes in the Theoretical Physics Group at the Institute, and is expected to be a crucial input towards its eventual detection. It is hoped that these gravitational waves, though abysmally weak in strength, will be detected by the ultra-sensitive gravitational wave detectors expected to become operational in a few years in different parts of the world.

Einstein's General Theory of Relativity is central to the study of universe as a whole (cosmology) as also to the study of compact self-gravitating objects, such as the black holes – yet another prediction of Einstein's General Relativity. While the theory has a beautiful geometrical structure, it is a challenge to analyse the behaviour of gravitational field and its coupling to matter and other fields as the equations involved are nonlinear – interactions too interact! Many conceptual questions and aspects of the 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, and a new Lagrangian formulation. One of the challenges in the field is to make contact with quantum theory, i.e., to combine consistently the two great framework theories of the twentieth century – the general theory of relativity and quantum mechanics. This is a long term programme. But some work on Quantum Gravity has already emerged.

Coming now to optics, two of the main interests have been in propagation of light waves in periodic media (like some liquid crystals) and the associated polarization 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 that of gravitational lensing (i.e., bending and focussing of light rays by the strong gravitational fields of massive stars and galaxies which, therefore, act as lenses), scintillation and quantum effects in radiation and detection, making the study of optics in a broad sense particularly appropriate to this Institute. RRI is home to Optics!

2. Optics

In view of the rapid and important recent advances happening worldwide in modern optics, its clearly enormous potential, and taking full advantage of our proven traditional strength in this field, a modern optics laboratory has been set up at the Institute with facilities to address several interesting and basic questions involving, e.g., cooling and trapping neutral atoms using laser lights, studying fast atomic processes using ultra-short light pulses barely 10^{-15} second wide, polarization optics and geometrical phases, interferometry, and imaging through turbid media. This is expected to have substantial overlap with our research activities in the field of liquid crystals and astronomy.

3. Liquid Crystals

Liquid Crystals are states of condensed matter showing a variety of orderings of molecular positions and orientations intermediate between those of liquids and crystalline solids. Thus, for example, we may have a crystalline periodicity along one direction and a liquid-like, albeit viscous, fluidity in the planes perpendicular to that direction – the so-called smectic (soap-like) liquid crystals. We can also have the nematic liquid crystals in which the rod-like molecules are orientated parallel to a certain direction on the average, but without any positional order. Yet another kind of liquid crystal is the discotic one in which the disc-like molecules form liquid-like parallel columns which are, however, arranged periodically in the plane perpendicular the columns. Many other complex forms of ordering are known. Many organic compounds whose molecules have pronounced shape anisotropy exhibit such phases. The unique combination of fluidity, softness and anisotropic properties of liquid crystals makes them readily respond to even a weak external stimulus, for example, an applied electric field. This has led to many technological applications of these materials, e.g., the very common liquid crystal displays. The Liquid Crystals Laboratory of the Raman Research Institute has contributed significantly to the development of this field over the past three 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 the liquid crystal displays is also being carried out. A new dimension has now been added to our LC research – the study of soft-condensed matter including membranes and the single-DNA molecules which are of great biological-physical significance.

4. Astronomy and Astrophysics

Astronomy, which is one of the oldest sciences, studies heavenly bodies, i.e., planets, stars, galaxies, clusters of galaxies, and the intervening matter such as gas and dust. This, it does by investigating the radiation received on earth from or through them. Optical Astronomy deals with the *visible* part (wavelength 300 nm to 650 nm, 1 nm $\equiv$ 1 nanometre = 10^{-10} metre) of the electromagnetic spectrum. Radioastronomy, which had its beginnings in 1932 also deals with the study of these heavenly bodies, but the radiation received by the 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 degree kelvin cosmic background radiation (a relic from the hot big bang origin of the universe which is estimated to have taken place about 15 billion years ago, and indeed, contributes some of the noise on our TV channels even today!); quasars (very bright but very distant quasi-stellar sources of radiation), pulsars (rotating neutron stars barely 10 kilometres in diameter, but still about as massive as the Sun); and now almost certainly the black holes (gravitationally collapsed objects from which even light cannot escape).

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 about 80 km from Bangalore, 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 and is being used to study radio emission from various types of celestial objects such as the Sun, Jupiter, and the 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 (ORT) 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 make observations using the Giant Metre wavelength Radio Telescope (GMRT), built by TIFR near Pune. In fact, RRI was and is deeply involved in the GMRT instrumentation. Another interactive project is the low-frequency (150 MHZ) Mauritius Radio Telescope (MRT) built at Mauritius by RRI in collaboration with the University of Mauritius and the Indian Institute of Astrophysics. A radio map of the southern sky at full resolution of 4 arcminute × 4 arcminute is getting ready.

During the past two decades, millimetrewave astronomy has assumed great importance because of the discovery of numerous molecules in the vastness of the interstellar space (combinations of Hydrogen, Carbon, Nitrogen, Oxygen, Silicon, etc.). These are identified by their emitted line radiation (spectra) 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 on campus, which is being used for such studies.

In addition to the above observational programmes, the Institute has theoretical research programmes in many areas of Astrophysics, e.g., Pulsars, their evolution, structure and the emission mechanism; Supernova Remnants; the Inter-Stellar Medium; Galaxies and large-scale structure in the universe and cosmology.

A detailed, but admittedly technical account of the work carried in the past year at RRI is given in the pages that follow.

THEORETICAL PHYSICS (TP)

AREAS OF RESEARCH: Condensed Matter & Statistical Physics
Physics in Biology
Optics, Quantum Mechanics & General Physics
Gravitation

CONDENSED MATTER AND STATISTICAL PHYSICS

Zeno blocking of interplanar tunneling by intraplane inelastic scattering in layered superconductors: A generalized spin-Boson analysis: Following our earlier proposal that the observed temperature dependence of the normal-state c-axis resistivity of oxide superconductors can be understood as arising from the inhibition of electron transport along the c-axis due to in-plane incoherent inelastic scatterings suffered by the tagged electron, a specific form for the interaction Hamiltonian was considered. In this the tagged electron was coupled to bosonic baths at adjacent planes (the baths at any two planes being uncorrelated) and was coupled also to the intra-plane momentum-flip degree of freedom via the bath degrees of freedom. Thus, the model Hamiltonian incorporated the earlier proposed picture that each in-plane inelastic scattering event is like a measurement of which plane the electron is in, and this, as in the Quantum Zeno Effect (QZE), leads to the suppression of inter-plane tunneling. In the present scenario it is the baths which bring about a coupling between the intra-plane and the inter-plane degrees of freedom. For simplicity, the treatment was confined to dynamics in two adjacent planes and allowed for two states only as far as momentum flips due to scattering are concerned. In the case when the intra-plane dynamics is absent, the model reduces effectively to the usual spin-Boson model. The reduced tunneling dynamics of the electron was solved using a non-Markovian master equation approach. The numerical results on the survival probability of the electron in the initial plane show that the intra-plane momentum flips lead to further inhibition of the inter-plane tunneling over and above the inhibition effected by pure spin-Boson dynamics. [N. Kumar + M. Sanjay Kumar and S. Dattagupta (*S N Bose National Centre for Basic Sciences, Kolkata*)].

Study of non-equilibrium steady states in energy-current-carrying systems: In equilibrium physics, the Gibbs ensemble theory enables derivation of macroscopic physical properties of a system from its microscopic properties. In non-equilibrium physics, there is no equivalent procedure for going from the microscopic to the hydrodynamic picture and several phenomenological assumptions are needed to make this transition. Two important assumptions are:

(i) local thermal equilibrium and (ii) linear response (Fourier's law). Through a study of the non-equilibrium state of heat conduction in simple models such as the hard sphere system and disordered harmonic chains, attempts have been made to understand the basis of these two assumptions. (Abhishek Dhar).

PHYSICS IN BIOLOGY

Elasticity of semi-flexible polymers: The elastic properties of semi-flexible polymers (of which DNA, actin and microtubules are biological examples) is a fast emerging field. Unlike flexible polymers which can be modeled as random walks, semi-flexible polymers are random walks with memory. This makes them much harder to understand. Using analytic methods and simulations, we have obtained some new predictions on forms of the force-extension curves of semi-flexible polymers. Our results have also been independently verified by exact numerical calculations done by colleagues at RRI. [Abhishek Dhar + Debasish Chaudhuri (*S N Bose National Centre for Basic Sciences, Kolkata*)].

Studies on semi-flexible polymers: The elasticity of semi-flexible polymers is studied within the framework of the worm like chain model. A numerical solution of the Worm-Like Chain (WLC) model for semi-flexible polymers is presented. Graphs are displayed for the end-to-end distance distribution and the force-extension relation expected from the model. The expected level of fluctuations around the mean value in force-extension curves is predicted. The *entire range of polymer lengths* is analysed and interesting qualitative features seen in recent computer simulations (some by colleagues at RRI) for polymers of intermediate length are reproduced. These results can be tested against experiments on single molecules. This study is relevant to mechanical properties of biological molecules. (J. Samuel and S. Sinha).

Molecular elasticity and the geometric phase: Analogies between the twist elasticity of semi-flexible polymers, depolarised light scattering and the geometric phase were noticed. These analogies lead to an exact numerical solution of the Worm-Like Chain (WLC) model for twisting semi-flexible polymers. The elastic response of a single molecule to an applied torque was graphically displayed. This study is relevant to the mechanical properties of biologically important molecules like DNA. (J. Samuel and S. Sinha).

OPTICS, QUANTUM MECHANICS AND GENERAL PHYSICS

Distribution of the delay time and the dwell time for wave reflection from a long random potential: Earlier derivation of the distribution of the Wigner phase delay time for wave reflection from a long one-dimensional disordered conductor, treated in the continuum limit, was re-examined and corrected. The

distributions of the Wigner phase delay time and the dwell time is compared numerically. Here the latter was obtained by the use of an infinitesimal imaginary potential as a clock. The effects of strong disorder and a periodic (discrete) lattice background were investigated. The two distributions were found to coincide even for strong disorder, but only for energies well away from the band-edges. [N. Kumar + S. Anantha Ramakrishna (*Imperial College, London*)].

Theorist's laboratory: A new initiative in the theory group is an attempt to set up a theorist's laboratory. Such a laboratory serves several useful purposes. At the pedagogical level, it has been used for developing demonstrations as teaching and presentation aids. Summer students were given an opportunity to do experiments with a conceptual basis and understand the theoretical description concretely in a specific application. At a research level, some simple table top experiments have been set up, which despite their simplicity, address deep conceptual problems in statistical mechanics. These aim at testing the predictions of statistical mechanics of gases in systems like granular materials, which are similar to gases in that they contain a large number of particles but are different in that the particle constituents are themselves macroscopic and dissipation is important. (Abhishek Dhar, S. Sinha, Y. Hatwalne and J. Samuel).

Topological phases for three state systems: The pattern of three state topological phases that appear in systems with real Hamiltonians and wave functions is studied. A simple geometric construction for representing these phases is given. For systems with real Hamiltonians, Berry phases are topological rather than geometrical. For three state systems, the Berry phase has been understood in abstract differential geometric language but is still far from being accessible to experimenters. It is pointed out that the topological phases can be made quite accessible to visualisation by means of a geometrical construction. The results are then applied to understand previous work on three state phases. It is pointed out that the *mirror symmetry* of wave functions noticed in microwave experiments can be simply understood in this framework. The overall aim of this work is to bring the three state topological phase down to earth and into the laboratory. (J. Samuel and Abhishek Dhar).

Microwave cavities: Microwave cavities provide a simple and powerful method of simulating single particle time-independent quantum mechanics in two dimensions. This follows from the fact that under appropriate geometrical constraints, Maxwell's equations in a cavity reduce to the Schrödinger equation. Using this equivalence, various quantum mechanical phenomena such as quantum chaos, localization, isospectrality, etc., have been investigated. Some

experimental investigations on microwave cavities have been performed. (Abhishek Dhar and Udaya Shankar).

GRAVITATION

Gravitons from a loop representation of linearised gravity: It was shown that the standard Fock space gravitons are associated with distributional states in a loop representation of linearised gravity. Since the latter is structurally similar to the representation used in full loop quantum gravity, there is hope that these results may illuminate certain aspects of the much deeper (and as yet unknown,) relation between gravitons and states in non-perturbative loop quantum gravity.

Loop quantum gravity is based on a classical formulation of 3+1 gravity in terms of a real $SU(2)$ connection. Linearization of this classical formulation about a flat background yields a description of linearised gravity in terms of a *real* $U(1) \times U(1) \times U(1)$ connection. A *loop* representation, in which holonomies of this connection are unitary operators, can be constructed. These holonomies are not well defined operators in the standard graviton Fock representation. In this work, the author's recent results on photons and $U(1)$ holonomies were generalised to show that Fock space gravitons are associated with distributional states in the $U(1) \times U(1) \times U(1)$ loop representation.

Earlier seminal work by Ashtekar, Rovelli and Smolin (ARS) on the loop representation of linearised gravity used *complex* connections. In the last part of this work, it was shown that the loop representation based on the *real* $U(1) \times U(1) \times U(1)$ connection also provides a useful kinematic arena in which it is possible to express the ARS complex connection-based results in the mathematically precise language currently used in the field. (Madhavan Varadarajan).

Gravitational waves from inspiralling compact binaries: Energy flux to third post-Newtonian order: The multipolar-post-Minkowskian approach to gravitational radiation is applied to the problem of the generation of waves by the compact binary inspiral to investigate the third post-Newtonian (3PN) approximation in the total energy flux. Technical inputs in this computation include a model of point particles for describing the compact objects, and the Hadamard self-field regularization. Because of a physical incompleteness of the Hadamard regularization at the 3PN order, the energy flux depends on one unknown physical parameter, which is a combination of a parameter in the equations of motion, and a new parameter coming from the quadrupole moment.

The new result is the computation of the mass quadrupole moment of the binary to the 3PN order and the current quadrupole, and mass octupole to 2PN order. Wave tails and tails of tails in the far zone are included up to the 3.5PN order. The recently derived 3PN equations of binary motion are used to compute the time-derivatives of the moments. Perfect agreement is found to the 3.5PN order with perturbation calculations of black holes in the test-mass limit for one body. [Bala R. Iyer + Luc Blanchet and Benoit Joguet (*IAP, Paris*)].

Gravitational-wave inspiral of compact binary systems to 7/2 Post-Newtonian order: The inspiral of compact binaries, driven by gravitational-radiation reaction, is investigated through 7/2 post-Newtonian (3.5PN) order beyond the quadrupole radiation. The analysis consistently includes the relativistic effects in the binary's equations of motion and multipole moments, as well as the contributions of tails, and tails of tails, in the wave zone. However, the result is not fully determined because of some physical incompleteness, present at the 3PN order, of the model of point-particle and the associated Hadamard-type self-field regularization. The orbital phase, whose prior knowledge is crucial for searching and analyzing the inspiral signal, is computed from the standard energy balance argument. [Bala R. Iyer + Luc Blanchet, Benoit Joguet (*IAP, Paris*) and Guillaume Faye (*Theoretisch-Physikalisches Institut, Jena, Germany*)].

Second post-Newtonian gravitational wave polarizations for compact binaries in elliptical orbits: The second post-Newtonian (2PN) contribution to the *plus* and *cross* gravitational wave polarizations associated with gravitational radiation from non-spinning, compact binaries moving in elliptic orbits is computed. The computation starts from earlier results on 2PN generation, crucially employs the 2PN accurate generalized quasi-Keplerian parametrization of elliptic orbits by Damour, Schäfer and Wex and provides 2PN accurate expressions modulo the tail terms for gravitational wave polarizations incorporating effects of eccentricity and periastron precession. [Bala R. Iyer + A. Gopakumar (*University of Guelph, Canada*)].

Appearance of the central singularity in gravitational collapse: The structure of non-radial non-spacelike geodesics terminating in the past at a naked singularity formed as the end state of inhomogeneous dust collapse was analysed and the spectrum of outgoing non-spacelike geodesics examined analytically. The local and global visibility of the singularity was also examined by numerically integrating the null geodesic equations. (Shrirang S. Deshingkar).

OPTICS

AREAS OF RESEARCH — Laser cooling and trapping of atoms
Ultrafast processes

LASER COOLING AND TRAPPING OF ATOMS

The building of the Magneto-Optic Trap (MOT) for laser cooling and trapping of rubidium (Rb) atoms has been successfully completed. The two isotopes of rubidium, ^{85}Rb and ^{87}Rb, can routinely be cooled and trapped, to temperatures of a few hundred microkelvin. (Andal Narayanan, C.M. Chandrashekar,. Hema Ramachandran, N. Kamaraju, M.S. Meena, R. Sreenivasan and Uday Kumar Khan).

ULTRAFAST PROCESSES

Measurements of the nonlinear optical properties of phthalycyanines doped in polyphenylene-vinylene (PPV) matrix and oxide-protected metal nano-clusters have been carried out. Interesting optical limiting behaviour has been observed in the metal nanoclusters. [(Reji Philip and Navinder Singh + T. Pradeep (*IIT, Chennai*)].

LIQUID CRYSTALS (LC)

AREAS OF RESEARCH:
- L.C. Synthesis
- Phase transitions
- Wetting-dewetting transition
- Monolayers
- Electrochemistry
- Studies on biological physics
- L.C. Displays
- Mean-field and other theoretical studies

EXPERIMENTAL INVESTIGATIONS

Synthesis and characterization of new compounds exhibiting liquid crystalline phases: Research and scientific investigations were pursued on the design, synthesis and characterization of a large number of compounds composed of banana-shaped molecules. The mesophases exhibited by these compounds were analyzed by a number of different techniques. The significant results obtained from these are outlined below.

The effect of lateral substituents on the mesophases formed by several homologous series of compounds composed of banana-shaped molecules were investigated. All these compounds are non-Schiff' bases and are esters. The effects of substituents such as fluoro, methyl and ethyl groups indicate that there is a strong influence on the reduction of the clearing temperatures. The larger ethyl substituent has a greater effect in depressing the clearing temperature and suppressing the occurrence of a layered mesophase such as B_2, while enhancing the existence of the intercalated B_6 phase. It is also found that the *ortho*-fluoro substituted compounds give rise to wide thermal ranges of the B_1 and B_2 mesophases, as compared with the *meta* substituted analogues. [H.N. Shreenivasa Murthy and B.K. Sadashiva].

The effect of 2-methylresorcinol as the central unit on the mesomorphic properties of five-ring esters were also examined in detail. The antiferroelectric B_2 phase or the two-dimensional B_1 phase were observed in many of the compounds. This study indicates that 2-methylresorcinol as the central unit has a destabilizing effect on the formation of mesophases. [S. Shubashree, B.K. Sadashiva and Surajit Dhara].

Biaxial smectic A phase in pure compounds: The discovery of the biaxial smectic A phase in pure compounds reported earlier, encouraged to continue this

work for a systematic evaluation of the compounds synthesized. This work has shown that the mesophases exhibited are partial bilayer smectic A phase as well as a partial bilayer biaxial smectic A phase. A structural model for the biaxial smectic A phase in which four molecules form a quartet whose aromatic moeities form a structure which is biaxial but apolar in both longitudinal and transverse directions has been proposed. This is a significant contribution. [B.K. Sadashiva, R. Amaranatha Reddy, R. Pratibha and N.V. Madhusudana].

Phase transitions investigations on binary mixture of compounds made up of rod-like and bent-core molecules: The physical studies on binary mixtures of rod-like and bent-core molecules have been pursued. These studies have resulted in the observation of a very striking stripe-structure in the biaxial smectic A phase of very thin samples. This has been interpreted as arising from the polar order of the molecules near the glass surface. Optical investigations on the stripes indicate that they are composed of alternate regions of uniaxial and biaxial smectic phases. Also, new phase sequences not obtained previously have been observed. In a certain concentration range, a direct transition from the nematic phase to the biaxial smectic A phase occurs without the intervention of the uniaxial smectic A phase. Also, in a very narrow range of compositions, the biaxial smectic A phase undergoes a transition to the two-dimensional B_1 phase on cooling. [R. Pratibha, N.V. Madhusudana and B.K. Sadashiva].

Free-standing films of undulating twist grain boundary C^* phase: An unusual periodic radial pattern in the meniscus region of free-standing films of a mixture exhibiting the undulating twist grain boundary C* phase has been found. Many optical studies including confocal microscopy point towards an undulation instability of smectic layers to be responsible for the radial structures. [N.V. Madhusudana, R. Pratibha and O.D. Lavrentovich and I.I. Smalyukh (*Liquid Crystal Institute, Kent State University, Kent, Ohio, U.S.A.*)].

Experimental studies on Type II chiral liquid crystals: Further experimental investigations have been carried out on binary mixtures which exhibit the twist grain boundary A (TGB_A) and the undulating twist grain boundary C^* phases. The optical reflectivity measurements in the cholesteric phase indicate that the chiral strength decreases as the concentration of the nonchiral compound is increased. Electroclinic measurements in the smectic A phase show that the elastic constant decreases rapidly with concentration, thus enhancing the type II character of the mixture. Under the action of a low frequency electric field, an irreversible transition from TGB_A phase to smectic A phase takes place. [Surajit Dhara, R. Pratibha and N.V. Madhusudana].

Phase transitions in liquid crystals under negative pressures: An experimental technique of embedding aligned liquid crystal drops in sucrose, which is a glass-forming carbohydrate has been found. Using this technique the first measurements of orientational order parameters and phase transition temperatures in nematic and smectic A liquid crystals under negative pressures generated by an isochoric cooling of small droplets embedded in a glass forming material have been made. The drops go over to the high density stable phase by cavitation at about -250 bars. [V. Manjuladevi, R. Pratibha and N.V. Madhusudana].

Wetting-dewetting transition and conformal to non-conformal interfacial roughness transition: High resolution X-ray reflectivity has been employed to study the structure, wetting properties, and interfacial roughness of ultra-thin liquid crystal films. The films were prepared at the air-water interface and transferred on to glass substrates by a modified horizontal deposition technique. A 3-layer film was found to partially wet the substrate in the nematic and isotropic phases and dewet upon cooling to the crystalline phase. The surface roughnesses at the air-film and the film-glass interfaces exhibited a gradual, reversible but hysteretic conformal to nonconformal transition between the isotropic and smectic A phases. [K.A. Suresh, A. Bhattacharyya and Y. Shi, Satyendra Kumar (*Kent State University, Kent, Ohio, USA*)].

Polar head group interaction in the mixed monolayers of cholesterol, cholesteryl acetate with 4-n-octyl-4'-cyanobiphenyl: Mixed Langmuir films are of considerable interest as model systems to mimic biological membranes. Cholesterol and cholesteryl acetate and other lipids are contained within water soluble carriers called lipoproteins and transported in our body. In a lipoprotein, the presence of cholesterol between phospholipid molecules makes the membrane stiffer, altering the barrier properties of the membrane. The mixed monolayer properties of cholesterol with 4-n-octyl-4'-cyanobiphenyl are being investigated. This work is in progress to probe the polar head group interaction which has not been explored. [K.A. Suresh and P. Viswanath].

Studies on wetting properties of alkanethiols, dithiols and hydroxy terminated thiol monolayers: A study of the electron transfer properties of self-assembled monolayers on gold, silver and copper is of considerable importance due to the potential application in molecular electronics, nanotechnology and studies of wetting and lubrication properties. Electrochemical studies have been carried out to understand the wetting properties of thiol molecules when they are chemisorbed on metal surfaces. The interfacial capacitance of different thiols has been measured using electrochemical impedance spectroscopy. The results show that the interfacial

capacitance which is a measure of the wettability as evaluated in different solvents indicate correspondence with the bulk structural properties of the solvents. [V. Lakshminarayanan and Ujjal Kumar Sur].

Existence of thin water vapour layer at the interface of a highly hydrophobic monolayer and water: It has been shown that there is an unusual lowering of interfacial capacitance when the monolayer is prepared using neat thiol as against the normal method of using a solvent like ethanol as the absorbing medium. The electrochemical impedance studies carried out and modeling the system to equivalent circuit, show that the capacitance lowering of this magnitude can only be explained by proposing the existence of thin water vapour layer between the alkanethiol monolayer and the aqueous phase. A model has been proposed for the alkanethiol water interface that is in conformity with the Lum, Chandler and Weeks theory of length scale dependent hydrophobicity. This model will be useful in explaining biologically important phenomenon such as protein folding and water conduction through nanopores and nanomembranes. [V. Lakshminarayanan and Ujjal Kumar Sur].

Scanning Tunneling Microscopy (STM): The necessary hardware control circuit for the in-house built STM has been developed. Work on suitable software for the data acquisition and control is in progress. STM studies are being conducted to understand the adsorption of surfactant molecules on graphite surface. It has been shown that Aerosol-OT, an anionic surfactant forms a well ordered film on graphite. The structure of the film formed on the substrates can be correlated with the surface morphology of electro deposited coating when the surfactants are used as templates. Also the STM image of Langmuir-Blodgett film of cholesterol on graphite shows molecular resolution pictures of cholesterol adsorbed on graphite. [V. Lakshminarayanan and K.A. Suresh].

Structure of polymer-surfactant complexes: From earlier X-ray studies it has been shown that the complex formed by sodium salt of deoxyribose nucleic acid (DNA) with the cationic surfactant, cetyltrimethylammonium bromide (CTAB) has a hexagonal structure. However, it was not possible to unambiguously determine the packing of the molecules within the hexagonal structure. An hydrotope sodium hydroxynaphthoate (SHNC) has been added to this system and examined the influence of SHNC concentration on the complex structure. From these studies, it has been shown that the complex structure is determined by the shape of the micellar aggregates formed by the surfactants. It has therefore been concluded that the hexagonal DNA-CTAB complex consists of DNA strands intercalated between surfactant cylinders. The presence of such a

structure has not been well established in any of the polyelectrolyte-surfactant complexes reported in the literature.

The structure of the complex formed by the anionic polypeptide polyglutamic acid (PGA) with CTAB and SHNC has also been examined. The persistence length of PGA determined is about 2nm, whereas that of DNA is 50nm. [V.A. Raghunathan and K. Rema].

Structure of lipid-cholesterol membranes: It is believed that the plasma membranes of biological cells consist of cholesterol rich domains called rafts, which take part in cellular processes like endocytosis. In order to understand the functioning of this process, phospholipids like dipalmitoyl phosophatidyl choline (DPPC) which is a major component of cell membranes, is mixed with cholesterol and the same probed by X-rays. These studies have shown the existence of a new modulated phase in these mixtures and further work is in progress to determine the role of cholesterol in stabilizing this phase. [V.A. Raghunathan and Sanat Karmakar].

Thermal unbinding of a membrane stack: Many non-ionic lipids like dimyristoyl phosophatidyl choline (DMPC) self assemble in water to form stacks of fluid bilayers, with liquid-like in-plane order. Theoretical studies have indicated the possibility of a continuous transition from the stack to a dispersion of individual bilayers in water. Such an unbinding transition has been observed only in some isolated multilamellar vesicles, but has not been seen in any experimental system in the bulk. Such experiments were carried out, but do not show an unbinding transition, but the adsorbed layer is found to become thinner with time due to the peeling off of the bilayers into the surrounding water, especially at higher temperatures. [V.A. Raghunathan + G. Pabst (*Institute of Biophysics and X-ray Structure Research, Austrian Academy of Sciences, Austria*) and J. Katsaras (*National Research Council, Steacie Institute of Molecular Sciences, Canada*)].

Pretransitional swelling of lipid bilayers above the chain melting transition: The pretransitional swelling in a phospholipid has been studied using both oriented and unaligned samples. It has been found that the thickening of the bilayers leads only to a linear increase of the lamellar spacing close to the transition. The sharper increase comes from the water layer. From a detailed analysis of the experimental data, an independent evidence is found for the softening of the bilayers close to the chain melting transition, thus providing a consistent explanation of the pretransitional swelling behaviour. [V.A. Raghunathan + G. Pabst and J. Katsaras] .

Phase transitions in a binary lipid system with long and short chains: A novel sequence of phase transitions has been observed in a lipid water system consisting of long and short chain phospholipids. As the temperature is increased, a solution containing disc-like micelles is transformed first into a phase characterized by a rectangular unit cell, and then into a lamellar phase consisting of bilayers. Due to the affinity of the short chain lipid molecules for regions of high positive curvature, the ribbon-like aggregates in the rectangular phase are metastable at higher temperatures, and are found to eventually relax into bilayers. [V.A. Raghunathan + J. Katsaras and M.P.Nieh, C.J. Glinka, and H. Wang (*Materials Science and Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, USA*)].

Electronic transport and self-assembly of individual DNA molecules: The optical tweezer experiment has been set up for the micromanipulation study of the dynamics of DNA-membrane interactions. The mechanics of tether formation in multi-lamellar vesicles made of cationic surfactants has been studied and a novel phase transition has been observed. The experimentally measured force extension curves reveal a sharp increase in the force required to pull out a tether from the vesicle and a saturation of the same beyond a tether length of about 5 microns. Further, addition of DNA results in the absence of the phase transition with the force increasing linearly with the tether length. When a large amount of DNA has integrated on the membrane tether, the tether breaks, the membrane now being completely in-elastic. Within about a minute of addition of DNA, the integration of the negatively charged DNA polymer on the membrane vesicle leads to formation of lipid-DNA complexes. [T. Roopa and G.V. Shivashankar (*Visiting Scientist, National Centre for Biological Sciences*)].

LIQUID CRYSTAL DISPLAYS (LCD)

Reducing the hardware complexity of column drivers and the supply voltage of LCD drivers: The supply voltage of the drive electronics can be reduced by using liquid crystals with steeper electrooptic characteristics than necessary for the matrix display. This has been achieved by matching the selection ratio of the addressing technique to the electro-optic characteristics of the display. Addressing techniques with low hardware complexity have been used to achieve the goal in which the supply voltages are lower by (30 to 50%) than previously reported values. [T.N. Ruckmongathan and K.G. Panikumar].

Duty cycle control for the Binary Addressing Technique: The Binary Addressing Technique (BAT) needs just two voltage levels in the row and column waveforms to drive a matrix LCD. This allows the possibility of integrating the controller as well as the drivers into a single chip as in Field

Programmable Gate Arrays (FPGA) or Complex Programmable Logic Devices (CPLD). However, the liquid crystal mixture has to be chosen such that the supply voltage for the addressing technique is the same as that used for FPGA or CPLD. This constraint can be removed by introducing duty cycle in the addressing waveforms. This has been achieved and integrated into displays developed in the laboratory. [T.N. Ruckmongathan and K.G. Panikumar].

THEORETICAL INVESTIGATIONS

Mean-field theory of smectic C liquid crystals. The detailed calculations, based on the mean-field theory of smectic C liquid crystals which was developed in the previous year has been completed. This has led to the prediction of a smectic C-Smectic C transition in a narrow range of parameter space. [N.V. Madhusudana and A.S. Govind].

Prediction of the cone-phase. Based on the arguments in the above mean-field theory, it has been shown that tilting of molecules can occur in all azimuthal directions and not just in one as in the smectic C phase. A phenomenological model has been developed in which it is shown that it is possible to get a *cone-phase* in which the conical structures with tilted layers are interspersed with regions in which the medium is in the nematic phase. [Yashodhan Hatwalne and N.V. Madhusudana].

A phenomenological theory of the $UTGB_{C^*}$ phase. A simple theory has been developed to account for the stability of the undulating twist grain boundary C* ($UTGB_{C^*}$) phase. The grain boundaries have been treated as interfaces with an anisotropic interfacial tension favouring the director to be parallel to the interface. For moderate chiral interaction strengths, the sequence TGB_A - TGB_C - SmC* is predicted, while for higher chiral strengths, the sequence is TGB_A - $UTGB_{C^*}$ - SmC*. The undulations arise to lower the mismatch of the director orientation at the interface. The chiral energy gain in the smectic C* like blocks compensates for the excess energy due to the increase in the interfacial area. [P.A. Pramod, Yashodhan Hatwalne and N.V Madhusudana].

Optical diffraction in nonuniform cholesteric liquid crystals phase-grating mode. The diffraction pattern in the phase-grating mode of a cholesteric liquid crystal with a pitch gradient has been worked out. The pitch gradients considered are symmetric and asymmetric with respect to the sample center. For a uniform input beam, the intensity profile of each diffraction order becomes broad. In the symmetric gradient, the profile of each order is irregular, while in the asymmetric gradient it is nearly flat. For a Gaussian input beam, for the

symmetrically deformed structure, the profile for each order is asymmetric, while for the asymmetrically deformed structure, the profiles just become broad. It has also been found that even a 5% nonuniformity in the pitch can drastically alter the diffraction profiles. [M.S. Giridhar, K.A. Suresh and G.S. Ranganath].

ASTRONOMY AND ASTROPHYSICS (AA)

AREAS OF RESEARCH:
- Extragalactic Astronomy
- The Galaxy and the Interstellar Medium
- Neutron Stars and Pulsars
- Instrumentation and Observational Techniques
- Others

EXTRAGALACTIC ASTRONOMY

Galaxy clusters. Recent X-ray observations of low mass clusters of galaxies have shown that their X-ray properties are not simple scaled down versions of those of high mass clusters. Although the dark matter in clusters is supposed to have a universal profile, the hot baryonic gas seems to have had a more complicated thermodynamic history than the dark matter. A popular hypothesis is that the gas was *pre-heated* before or during the infall into the cluster potential, although the exact nature and sources of this *pre-heating* have been controversial. Possible sources for the heating are supernova driven galactic winds and outflows from active galaxies.

Supernova driven winds do not seem energetic enough. By using extensions of the structure formation models to first quantify the abundance of quasars in clusters (as a function of the cluster mass) and then to quantify the amount of energy the outflows impart to the ambient diffuse gas, and finally calculating the total heating rate, it was shown that quasar outflows can be a source of the above mentioned deviation from self-similarity and explain the observations. (Suparna Roychowdhury and B. Nath).

Recently it has also been shown that radiative cooling can also rid the intracluster gas of its low entropy part and as a result raise the mean entropy level of the gas. Radiative cooling in the central region, however, would set the gas in the outer regions in motion towards the centre. Work is in progress on the implications of such a flow with regard to the observations of entropy and X-ray luminosity. (B. Nath).

Radio observations (HI and OH, recombination lines). Previously detected radio recombination lines using the Very Large Array from a few nearby starburst galaxies were modelled. Detailed modelling of NGC 253 indicates that the radio nucleus of this galaxy is not powered by a supernova-remnant or a young star cluster but a weak optically obscured active galactic nucleus. [Niruj Mohan, K.R. Anantharamaiah + W.M. Goss (*NRAO*)].

With a view to studying the evolution of gas content in galaxy clusters over the redshift range 0 - 0.5, the rich galaxy cluster Abell 2192 at a redshift of 0.185 was imaged in the HI 21 cm-line using the GMRT. This cluster was observed for 4×10 hours with the full available bandwidth of 16 MHz and 128 channels. This bandwidth resulted in a velocity coverage of ~3800 km s^{-1} with a velocity resolution of ~30 km s^{-1}, both of which are appropriate for detection of HI in cluster galaxies. Both spectral line and continuum images of this cluster field were produced with observed sensitivities close to the expected values. The 3σ detection limit of the HI mass was ~3×10^9 $M_\odot$ and that of the spectral luminosity at 21 cm was ~6.6×10^{21} W Hz^{-1}. At these limits, no detections of cluster galaxies were made either in continuum or in HI emission. The implications are being explored [K.S. Dwarakanath + Marc Verheijen (*University of Wisconsin, Madison*), and J. H. Van Gorkom (*University of Columbia, New York*)].

HI absorption in the red quasar 3C 190 at a redshift of 1.1946 has been detected using GMRT. The most interesting result is that the peak of the HI absorption is blueshifted by ~250 km s^{-1} with respect to the optical emission lines. The HI absorption profile indicates the presence of multiple components and the peak absorption is at 647.728 MHz. The FWHM of this absorption feature is 185±7 km s^{-1} and the peak optical depth is 0.012. The corresponding atomic hydrogen column density is 3.98×10^{20} (T_s/100 K) cm^{-2}. The implications are being explored. [K.R. Anantharamaiah, K.S. Dwarakanath + C.H. Ishwara-Chandra (*ISAC*)].

The GMRT and the VLA were used to detect HI 21 cm-line and OH line absorptions from the active galaxy Mrk 1. The HI and OH absorption lines which appear at the same velocity within errors of measurement, are blueshifted by ~100 km s^{-1} relative to the systemic velocity. A possible scenario to explain this situation is one in which HI and OH absorptions arise in a dense molecular cloud that is shocked and pushed toward the observer due to jets from Mrk 1. The ratio of optical depths in HI and OH is consistent with this picture. In addition, using the GMRT, HI 21 cm-line emission was detected from both Mrk 1 and its interacting companion NGC 451. The estimated HI masses of Mrk 1 and NGC 451 are ~8×10^8 $M_\odot$ and 1.3×10^9 $M_\odot$ respectively. Both the total HI image and the velocity field in HI clearly indicate signs of interaction between the two galaxies [A. Omar, K. S. Dwarakanath, K. R. Anantharamaiah + M. Rupen (*NRAO*)].

A comprehensive study of the nearby (~20 Mpc) group of galaxies, Eridanus, was started with radio continuum and HI 21 cm-line observations from the GMRT. The motivation is to estimate rotation curves of galaxies in the group, to

obtain a better Tully-Fisher relation for them, estimate star formation rates in the disk galaxies, image the radio continuum morphologies of these galaxies, and comprehend the evolutionary state of the system. To this end, about half the required observations have already been carried out with the GMRT and most of the data have been analysed. Interpretation is in progress (A. Omar and K.S. Dwarakanath).

Radio observations (continuum): Full resolution imaging with the Mauritius Radio Telescope (MRT) has been completed for the region between 19-20 hours in right ascension and between -70° and -10° in declination. [V.N. Pandey, N. Udaya Shankar + R. Somannah (*University of Mauritius*)].

After incorporating the annual relativistic aberration of light from a distant astronomical source in the 43 GHz multi-epoch VLBA observations of PKS1830-211, the trend in the time variation of the separation between two cores which are seen has become apparent. [Sunita Nair + C. Jin (*BAO*), M.A. Garrett (*JIVE*), R. W. Porcas & A. R. Patnaik (*MPIfR*)].

Gamma Ray Burst: Expected asymptotic slopes of Gamma Ray Burst light curves in the case of hard electron energy spectrum were derived. In certain afterglows of gamma ray bursts the energy spectrum of electrons responsible for synchrotron radiation appears to be unusually hard. The afterglow light curve in these cases would depend on the upper cut-off of the electron energy spectrum, which is normally ignored. Assuming a power-law dependence of this upper energy cut-off with the bulk Lorentz factor of the relativistically expanding blast wave, the expected behaviour of the light curve was derived. (D. Bhattacharya).

THE GALAXY AND THE INTERSTELLAR MEDIUM

The possible contamination due to HI-emission structure that one would expect to see in synthesis images in HI-line channels was estimated, and its effect on the HI-opacity estimation was assessed. Using these results, one will be able to readily assess the *limiting* angular resolution and the gain from better u-v sampling. (A.A. Deshpande and V. Radhakrishnan).

The survey of the galactic plane (longitude 320° to 80°, |latitude| <0.5°) for methanol masers at 6.7 GHz is being continued with the 10.4 m telescope. (N. Udaya Shankar and K. R. Vinod).

NEUTRON STARS AND PULSARS

The recent identification of the perpendicular mode of radio polarization as the primary one in the Vela pulsar was interpreted in terms of the maser mechanism earlier proposed in the literature. It was suggested that such a mechanism may also be operative for the parallel mode which may account for all types of polarization observed in pulsars. It was found that the arcs in the nebular X-radiation observed with the Chandra Observatory could be interpreted as traces of the particle beams from the two magnetic poles at the shock front (rather than the equatorial wind as proposed in the literature). It was also suggested that the alignment with the rotation axis of the jet-like feature bisecting the arcs is a projection effect with no physical jet along the axis of rotation. (A. A. Deshpande and V. Radhakrishnan).

An observational programme has been initiated with the Gauribidanur Telescope to record direct signal voltages (about 1 MHz bandwidth) from about 3000 fields covering the entire accessible sky, with about 20 minutes per field. Although the initial analysis of the data will be aimed at a detection of dispersed period signals from these directions, the archival of raw data will enable future investigators to analyse them with different goals. About a sixth of the visible sky has so far been covered. (A. A. Deshpande).

The pulsar timing observations are continued as part of a collaboration for long-term monitoring, with the Ooty Radio Telescope. A menu-driven software package was developed for automated reduction/analysis of the Ooty timing data, and was used for the first-stage processing of data collected over the last 3 years. [A.A. Deshpande + V. Balasubramaniam & Ravikumar (*RAC*) and A. Ray (*TIFR*)].

Observations using the Australia Telescope Compact Array at a wavelength of 6 cm have uncovered the radio counterpart to the compact X-ray nebula surrounding the Vela pulsar. Two lobes were found oriented about the spin axis of the pulsar; starting at the edge of X-ray emission, they extend to three times the size. The northern lobe has a bright, defined edge and an integrated flux of 0.14 Jy, while the southern lobe of 0.12 Jy is more diffuse. [A.A. Deshpande, + D. Lewis & R. Dodson (*University of Tasmania*), and D. McConnell (*ATNF*)].

The Australia Telescope Compact Array was used to measure the integrated radio flux from all the pulsars in the core of the globular cluster 47 Tucanae. An extended radio emission was detected whose flux density was calibrated with respect to the flux density distribution of the known pulsars in the cluster. Using the measured total flux density of about 2 mJy for the pulsars in the clusters, a lower limit of about 0.5 (mJy kpc)^2 was obtained for the luminosity distribution

while the size of the pulsar population was found to be ~30. [A. A. Deshpande + D. McConnell (*ATNF*), J.G. Ables (*CSIRO*), T. Connors (*University of Sydney*)].

Based on single-pulse observations using the Parkes telescope, refined estimates of dispersion measures and periods were obtained for a set of 50 relatively bright southern pulsars. Further analysis of the dedispersed pulse-sequences with a view to conduct a preliminary search for periodic modulations is in progress. [A.A. Deshpande + D. McConnell (ATNF), J. M. Rankin (University of Vermont)].

As a part of the initial phase of the Indo-Ukraine collaboration for pulsar and recombination line studies at low radio frequencies, extensive coordinated observations were conducted using the Gauribidanur (GBD) & UTR-2 (Ukraine) telescopes. Data analysis procedures were developed for high spectral and time resolution spectrometer modes as well as for pulsar-specific processing. The first-level reduction of all of the data collected at GBD was completed recently. Further analysis of the data is in progress. [A.A. Deshpande, N. Udaya Shankar + O. Ulyanov & S. Stepkin (*IRA, Ukraine*) and N. Kantharia (*NCRA/TIFR*)].

The work on longitude offsets between core and conal pulse components of radio pulsars has been completed with a much enlarged scope. This consists of a method to investigate radio pulsar emission altitudes by attributing different altitudes to core and conal pulse components. The frequently observed phase offsets between them find a natural explanation in terms of differential aberration and magnetic field line sweepback. Comparison of calculations with observations lead to several interesting conclusions like (i) the core emission does not necessarily come from the stellar surface, (ii) for a large number of pulsars the emission altitudes of core and conal components are close when compared to the light cylinder radius but not necessarily relative to the stellar radius, (iii) widely differing altitudes, some a large fraction of the light cylinder radius occur in some pulsars and allow a novel and natural explanation of the precursors in the Crab and similar pulsars, (iv) the part of the open flux tube emitting radiation varies with altitude. [C.S. Shukre + R. C. Kapoor (*IIA*)].

OTHERS

Topological Phases. The topological phases associated with evolution of mixed states of two-state systems were investigated further and an interesting structure of phase singularities revealed. The singularities are of two types, one that can be identified with a pair of orthogonal states, i.e., with a direction on the state sphere and the other associated with unpolarized states that cannot be so identified. These are being investigated further. (R. Bhandari).

A simple optical interferometer configuration that yields zero fringe contrast with incident linearly polarized light and full contrast with incident circularly polarized light, was discovered. Unlike a similar device proposed in literature in the context of super-luminal communication, the present one does not require a phase conjugate mirror and uses only linear devices. Possible applications of this interferometer are being explored. (R. Bhandari).

Intercollegiate honours course in space sciences. In an effort to attract bright students to science, a week-end course was started in St. Joseph's College as a collaborative effort between the Raman Research Institute, St. Joseph's College and the Indian Space Research Organisation. Forty students were selected from over three hundred students from the various colleges in Bangalore for the course. The lectures covered topics in astronomy and astrophysics, remote sensing, atmospheric science, etc., and were supplemented by visits to places such as the ISRO Satellite Centre, Satellite Tracking Centre, Sriharikota Rocket Range and the MST Radar near Tirupati. Lectures were arranged at these centres on topics relevant to the activities of that centre, such as the physics of rockets, satellites and communication with satellites, orbital dynamics, etc. At the end of the course, the students wrote a dissertation on a topic of their choice. Based on the unanimous response of the students, the course is being offered again during the academic year 2002-03. (G. Srinivasan).

INSTRUMENTATION AND OBSERVATIONAL TECHNIQUES

12-m Radio telescope. Fabrication of the 12m antenna using the concept of pre-stressed parabolic dish is in progress. The backup structure has been assembled in the main campus and a few parabolic shaped panels with two sectors have been installed. The panels use stainless steel wire mesh with a grid size of 6 mm x 6 mm. A root-mean-square deviation of about 2 mm has been measured for the surface with respect to an ideal parabola. A consultancy firm has been identified to carry out the design of the mount to our specifications. A control system using brushless motors and a programmable multi-axis motion controller is being developed in-house. The telescope will eventually be commissioned at Gauribidanur. (N. Udaya Shankar, M. Modgekar, C.M. Ateequlla + N.V.G. Sarma).

A multi-octave feed has been designed and fabricated using a trapezoidal structure, which was used to carry out interference measurement at Gauribidanur site over a wide range of frequencies between 0.5-10 GHz, within which the 12m telescope is expected to operate initially. A single stage low noise amplifier was built to cover the frequency range 3-9 GHz, and is being tuned for obtaining optimum performance. (A. Raghunathan).

System integration has been completed for the wide band auto-correlation spectrometer based on a combination of an analog filter bank and a set of digital auto-correlator sections capable of handling 40 MHz bandwidth each. A system comprising of a pair of 4096-channel auto-correlation spectrometers catering to 160 MHz bandwidth each, has been installed on the 10.4m telescope in the main campus. The initial tests were conducted using observation of methanol maser line at 6.7 GHz. (B.S. Girish, D.K. Ravindra).

Portable pulsar receiver. A portable version of the pulsar receivers operational at Gauribidanur and Mauritius was developed. The receiver consists of compact modules for IF-processing, sampling and data recording, and is configurable through software. The data are archived on compact discs. The system can process two IF-channels with a choice of 1 or 2 bits per sample during pass-band sampling. Supported signal bandwidth depends on the quantization option, and the instrument can handle up to 3.6 MHz bandwidth in the single-channel 1-bit mode. The first portable system has been commissioned at the Pushchino Observatory in Russia, and the second is expected to be operational soon at the UTR-2 telescope in Ukraine. In view of the compatibility of data formats, the off-line software developed for Gauribidanur data can be directly used for data analysis. (A.A. Deshpande, C. Vinutha, Gurushant, T. Prabu).

Coded mask imaging for Astrosat. A technique has been developed for a limited two-dimensional source location capability with a single module of the Astrosat Scanning Sky Monitor Camera, which was originally designed for one-dimensional use. The Astrosat Scanning Sky Monitor consists of three modules with crossed field of view. Each module is a one-dimensional coded mask camera built with eight position sensitive wires, with the mask encoding along the length of the wires. The field of view of the camera is 10 degrees in the coded direction and 90 degrees in the perpendicular direction. The design of the camera has been made with six linearly independent mask segments, joined side-by-side along the uncoded direction. A technique has been developed to obtain a limited angular resolution in the uncoded direction by identifying the specific mask pattern which casts a shadow on a given wire. The nominal resolution obtainable with a single module then works out to be 10 arcmin by 2 degrees. (D. Bhattacharya, B.T. Ravishankar).

Frequency transfer and satellite ranging. In the ISRO-RRI collaborative program on high stability frequency transfer via INSAT, the uplink system at Hassan has been upgraded to incorporate a facility for satellite ranging from multiple stations. The master reference at Hassan has been tied to a GPS-disciplined rubidium standard to improve the absolute stability. A linear

frequency modulation on a third tone synchronised with a one-second pulse from the GPS-disciplined standard provides the necessary signal for accurate ranging of the satellite. This enables a direct determination of round-trip path (transmitter-satellite-receiver) from any ground station by using a one-second pulse from a GPS receiver as a reference.

A 2.4 m antenna is being commissioned at the RRI main campus to help conduct simultaneous ranging experiments from Bangalore and Hassan. Local oscillators and intermediate-frequency converters have been built for use at Bangalore with the 2.4 m antenna. The frequency recovery system has been refined by introducing a phase-locked-loop based on a voltage-controlled crystal oscillator at the final stage. Two sets of frequency recovery systems have been commissioned – one at Hassan and the other at RRI. (C. R. Subrahmanya, R. Somasekhar + N.V.G. Sarma, D. Ravindranath (MCF), Athani (MCF).)

Satellite astrometry. A pilot project supported by ISRO has been taken up to apply the techniques of radio interferometry to problems related to accurate location of a geosynchronous satellite. Receivers have been built for a two-stage conversion of standard satellite signals to frequencies centred at 70 MHz intermediate frequency. A data acquisition system comprising of dual high-speed (up to 80 million samples/sec) analog-to-digital converters (ADC) has been built and interfaced with a reconfigurable/reprogrammable signal processing module based on a combination of 20000-gate field programmable gate array (FPGA) and a 16-bit digital signal processor (DSP). A local small scale industry was involved in the design and fabrication of these units. Firmware/software development is in progress for a variety of applications, including the real-time estimation of range and Doppler shift. For higher speed signal processing, it is proposed to employ the concepts of reconfigurable computing system using both in-house developed FPGA/DSP modules and those based on systems being developed by the Centre for Development for Advanced Computing. (C.R. Subrahmanya, R. Somasekhar + N.V.G. Sarma).

While examining the available software related to orbit estimation and prediction, it was noticed that the accuracy of software available in literature/public domain is not sufficient to analyse the data expected from the systems developed under ISRO-RRI collaboration. In view of this, and faced with the need for having a suitable library customised for local algorithm development, complete software has been developed for the evolution of the state vector incorporating the effects of the gravitational influence of the Earth (including rotation effects), the Sun and the Moon as well as the effects of solar radiation pressure. The predictions agree with direct determination of Doppler motions on INSAT 2A to an accuracy of a few mm/s. (C. R. Subrahmanya).

COMPUTERS

The activities related to campus network enhancement and promotion of Linux operating system and related public domain applications continued during the year. Many new Pentium-based workstations have been installed. Many of the old Dec-Alpha/Sun-Sparc based workstations are being phased out in view of their limited capabilities and uneconomic maintenance costs. New rackmount servers have been installed for Proxy and Mail servers. Work was initiated to extend connectivity to the optics and satellite astrometry laboratories by extending the fibre-optic backbone to the new building. Provision for experimenting with high speed point-to-point links has been made by leaving spare optical fibres between this building and the telescope building.

Enhanced bandwidth of 512 kilobits/second for internet traffic from/to the main campus has been operational routinely. A set of four dedicated Pentium PCs in a dual rack-mount configuration has been procured for development of cluster computing and the Dolphin cards for interconnection of these processors have been connected to these machines.

Several new packages have been installed from public domain on an experimental basis to enhance the overall efficiency of system maintenance and administration. These include: (a) a journalled filesystem called the Reiser filesystem; (b) Procmail Sanitizer on the mail-server to filter out junk mails and spam; (c) Squirrelmail, a web mail interface to read and send mails using web browsers. Users have been encouraged to install and use OpenOffice on their desktops.

Problems related to network security and internet-abuse are being addressed. As a first step, access restrictions have been introduced on the servers connected to the internet on individual services and unwanted services have been disabled where necessary. Similarly, unnecessary and unwanted software have been removed from these workstations.

LIBRARY

The library continued with its basic activities of collecting, organizing and disseminating information; maintaining liaison with local and outside libraries in resource sharing and information exchange and providing current awareness service using internet and facilitating on-line access to external database and on-line journals.

The Library procured 414 books out of which 43 received gratis. The total book collection is 21,792. Journals usage survey was made during 2001 and further scrutiny by each division resulting in dropping of two journals and 10 titles are kept under further review. Now 156 journals are subscribed of which print + on-line = 80; on-line = 5; on-line under consortium = 5; and 13 titles are received by air-mail. 1,446 bound volumes were added and bound volumes collection is 30,525 and total library collection is 52,317.

Modernisation

The library software Libsys *Version 4* with web OPAC on Linux platform was procured and library database is available on web (within the campus) and will soon be available to outside users. The bar-coding task has been completed for both books and journals. Bar-coded Ids have been issued to users as an aid to automate circulation section.

Consortium

Subscription of 23 Kluwer journals under "Indian Astrophysics Consortium" was initiated with other 4 libraries, viz., IIA, IUCAA, SO, and HCRI, where RRI contributes for 5 journals (print + on-line) and this facilitates on-line access to 18 additional journals.

Other activities

Compilation work of Memoirs of RRI and maintaining database of RRI publications continued and subjectwise volumes were brought out, viz., Theoretical Physics (6 volumes), Astronomy & Astrophysics (10 volumes), and Liquid Crystals (15 volumes). RRI Serials Holding List for 2001 was compiled for ready reference by library users.

Prof. Satish Dhawan had transferred his personal collection to RRI Library. This collection consisting of books, reports, lectures, and newspaper cuttings has been organized for easy access and retrieval and is kept open for library users.

FORSA Libraries Directory was compiled and a copy was passed on to each member. Action was also initiated for merging 5 of 8 FORSA Libraries catalogues and compilation of Directory of Bangalore Special Libraries Group.

OTHER ACTIVITIES

Ph. D.

Awarded

Name	*Topic of Study*
S.Anantha Ramakrishna	Wave propagation and diffusion in active and passive random media *Jawaharlal Nehru University, New Delhi*
Ashish Asgekar	Single-pulse studies of pulsars at decameter wavelengths *Jawaharlal Nehru University, New Delhi*
Jayajit Das	Dynamics of driven dissipative Heisenberg spins with inertia *University of Madras, Madras*
R. Subramanian	Studies on adsorption of azoles and alkanethiols onto some electrode surfaces *Jawaharlal Nehru University, New Delhi*

Submitted

S. Shubashree	Synthesis and physical properties of compounds exhibiting ferro-, ferri-, anti-ferroelectric and twist grain boundary phases. *Bangalore University, Bangalore*
Sushil Mujumdar	Some investigations of light scattering in active and passive random media *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 49).

Summer Programme in Physics, 14 May - 24 June 2001

The Summer Programme has been an important annual event in the Institute over the last few years. This year twenty students drawn from different parts of the country representing universities, IITs and Colleges were selected out of the ninety five who had applied. Fifteen M.Sc. and three B.Sc. students, a total of eighteen finally participated. There were twenty four lectures covering statistical physics, structure and stability of stars, pulsars, diffuse matter in space, liquid crystals, interaction of light with atoms and with Bose-Einstein condensates, interaction of intense light with matter, cosmology, random walks and polymers, DNA elasticity, Flory theory and semiflexible polymers. A few special lectures on unusual topics were also included. The students worked on one of the fourteen projects offered by the faculty. Educational films were screened as part of the programme. Presentation by students of their project work was held in the last week. Visits were also arranged to Labs, to Gauribidanur Observatory and to the ISRO Satellite Centre.

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 61).

Journal Club Meetings

Nineteen 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 67).

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 also an annual feature at the Institute, was held on 1-2 March 2002 where the staff and students presented their research work. In all 30 oral presentations spread over 8 sessions chaired by Faculty Members were made. There were also 15 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 2001 was given by Mr. M.C. Mehta, Advocate, Supreme Court of India, New Delhi, entitled "Environmental Justice, Equity and Sustainable Development" on 2 October 2001.

Visits of Dignitaries

Professor Sir Robert May, President, Royal Society, London, visited along with Miss Ling Thompson, Head, International Affairs, on 1 February 2002, and had discussion with the Director and the faculty of the Institute.

Dr. Ivo Slaus, Member of Parliament in Croatia, looking after the Education, Science & Technology Policy in the country visited the Institute on 19 March 2002.

Visiting Scientists

A number of scientists from institutions within the country and from outside visited the Institute during the year. Their names are listed separately (pages 41-48).

General

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

PLAN (Recurring & Non-Recurring)	Rs. 610.00 lakh
NON PLAN (Recurring)	Rs. 345.00 lakh
Total	Rs. 955.00 lakh

COUNCIL (2000 – 2004)

Dr. K. Kasturirangan *Chairman*	*Chairman, Space Commission* *Government of India, Bangalore 560 094*
Mr. Arun Sharma	*Joint Secretary & Financial Adviser* *Ministry of Science & Technology* *Government of India, New Delhi 110 016*
S. Dhawan *(until 3.1.2002)*	7/11, Palace Cross Road *Bangalore 560 020*
Prof. O. Siddiqi *(from 10.1.2002)*	*TIFR National Centre for Biological Sciences* *GKVK Campus, Bangalore 560 065*
Prof. P. K. Kaw	*Director, Institute of Plasma Research* *Gandhinagar 382 248,*
Prof. N. Kumar	*Director, Raman Research Institute* *Bangalore 560 080*
Prof. G. Mehta	*Director, Indian Institute of Science* *Bangalore 560 080*
Prof. V.S. Ramamurthy	*Secretary, Ministry of Science & Technology,* *Government of India* *New Delhi 110 016*
Prof. S. Ramaseshan	*Member-Secretary* *Raman Research Institute Trust* *Bangalore 560 080*

FINANCE COMMITTEE (2000 – 2004)

Dr. K. Kasturirangan *Chairman*	*Chairman, Space Commission* *Government of India, Bangalore 560 094*
Mr. Arun Sharma	*Joint Secretary & Financial Adviser* *Ministry of Science & Technology* *Government of India, New Delhi 110 016*
Prof. S. Ramaseshan	*Member-Secretary* *Raman Research Institute Trust* *Bangalore 560 080*
Prof. N. Kumar	*Director, Raman Research Institute* *Bangalore 560 080*

STAFF

N. Kumar
Director

V. Radhakrishnan
Distinguished Professor Emeritus

S. Ramaseshan
Distinguished Professor Emeritus

N.V. Madhusudana, *Dean of Research*

THEORETICAL PHYSICS

Research

B.R. Iyer *(Chairman up to 24.10.2001)*
Joseph Samuel (*Chairman from 25.10.2001*)
Madan Rao
Madhavan Varadarajan
G.S. Ranganath
Abhishek Dhar

Research Students

Azam Gholami (*from 7.1.02*)
K.G. Arun (*from 31.7.01*)
Debashish Chaudhuri (*up to 30.7.01*)
Sarasij Rai Chaudhari
Sudipto Muhuri

Post-Doctoral Fellows

Shrirang Deshingkar

Research Associate

Supurna Sinha (*from 15.2.02*)

Visiting Professor

S.K. Rangarajan

Secretarial

G. Manjunatha

OPTICS

Research

Hema Ramachandran
Reji Philip
N. Kumar
A.A. Deshpande
C.S. Shukre
N. Andal (*from 11.5.01*)

Visiting Professors

A. K. Sood
R. Srinivasan

Research Students

M.Anija (*from 2.1.02*)
Divya Sharma (*from 24.8.01*)
Navinder Singh
Sushil Mujumdar (*up to 31.12.01*)
Uday Kumar Khan

Technical Assistants

N. Kamaraju (*from 27.3.02*)
M.S. Meena
P.S. Sasi Kumar

LIQUID CRYSTAL LABORATORY

Research

U.D. Kini (up to 30.4.2001)
V. Lakshminarayanan
N. V. Madhusudana
R. Pratibha
V.A. Raghunathan
G.S. Ranganath
T.N. Ruckmongathan
B.K. Sadashiva (*Chairman*)
K.A. Suresh
Yashodhan Hatwalne

Scientific/Technical

A. Dhason
S. Lakshmanan (from 18.2.02)
Mohammed Ishaq
B.P. Neena
P.N. Ramachandra
N. Ravi Sankar
A.R. Shashidhara (from 4.7.01)
M.R. Subrahmanyam (up to 31.3.02)
H. Subramonyam
D. Vijayaraghavan

Visiting Scientist

G.V. Shivashankar
Anand Kumar

Research Students

Amaranatha Reddy
Amit Kumar Agarwal (*from 30.7.01*)
Debashish Chaudhuri (*up to 30.7.01*)
Debashish Kumar Har (*from 5.9.01*)
Dipanjan Bhattacharya (*from 17.8.01*)
V. Ganesh (*from 30.7.01*)
M.S. Giridhar (*up to 17.4.01*)
V. Manjula Devi
K.G. Pani Kumar
Pratiti Biswas
Raj Kumar Gupta
K. Rema
T. Roopa
Samir Mandal (*up to 14.5.01*)
Sanat Karmakar
K.L. Seetharamachar
H.N.Shreenivasa Murthy
S. Shubashree (*up to 3.5.01*)
S. K. Srivatsa (*up to 12.7.01*)
R. Subramanian (*up to 19.5.01*)
Sudipto Muhuri
Surajit Dhara
Ujjal Kumar Sur
Utpal Chatterjee (*up to 10.8.01*)
P. Viswanath

Secretarial : K. Radhakrishna

ASTRONOMY & ASTROPHYSICS

Research

K.R. Anantharamaiah (*Chairman (up to 29.10.2001)*
R.Bhandari
Biman B. Nath
A.A. Deshpande
Dipankar Bhattacharya
K.S. Dwarakanath
V. Radhakrishnan
B. Ramesh
D.K. Ravindra (*up to 31.12.01*)
C. S. Shukre
G. Srinivasan
C. R. Subrahmanya (*Chairman from 31.10.01*)
N. Udaya Shankar
R. Nityananda (*up to 30.4.01*)

Research Students

Amitesh Omar
Ashish Asgekar *(JAP)**
Atish Kamble (*from 10.8.01*)
Chandrayee Sengupta (*from 31.7.01*)
Kaustav Moni Basu (*up to 7.7.01*)
R. Niruj Mohan (*JAP*)*
V.N. Pandey
Rekesh Mohan
L. Resmi (*JAP*)*
Suparna Roychowdhury

**Joint Astronomy Programme*

Visiting Scientists
P. Sreekumar

Post-Doctoral Fellow
Sunita Nair (*up to 31.1.02*)

Research Associate
Sunita Nair (*from 1.2.02*)

Secretarial
V. Vidyamani

RADIO ASTRONOMY LAB

Technical
T. Anantha Prakash (*from 30.7.01*)
P. G. Ananthasubramanian
M.S. Ezhilarasi
B.S. Girish
M. R. Gopala Krishna
Gurushant Y. Tadasalur (*from 1.8.01*)
M. Jayadevaiah (*from 2.7.01*)
P.A. Kamini
S. Kasturi
M. Krishna Murthy (*from 4.1.02*)
S. Madhavi
T.S. Mamatha (*from 18.7.01*)
T. Prabu
Pushpa Jain (*from 30.4.01*)
K.B. Raghavendra Rao
S. Raghunandan (*from 8.1.02*)
A. Raghunathan
D.K. Ravindra(*Head, up to 1.12.01*)
P. Sandhya
G. Sarabagopalan
S. Siva
R.Somashekar (*from 27.4.01*)
M. Soumya (*from 3.1.02*)
S. Sujatha
S.R. Swaroopa (*from 7.1.02*)
N. Udaya Shankar (*In-Charge from 1.1.02*)

Visiting Scientist
A. Krishnan

Secretarial
Mamatha Bai
Anand Kumar (*from 11.10.01*)

OBSERVATORY

R. Ganesan (*up to 28.9.01*)
D. Madhusudhana Rao
Manohar O. Modgekar
P.V. Rishin
A. Satish Jadhav
Sunil Castroe
K.R. Venkatesh
K.R. Vinod

ELECTRONICS & INSTRUMENTATION

Technical
K. Chandrashekara
S. Krishnamurthy
H. N. Nagaraja
M. Selvamani (*Head*)
S. Shameem
G. Suresh
C. Vinutha

COMPUTERS

C.R. Subrahmanya (*Head*)
Jacob Rajan
R. Nanda Kumar
B. Sridhar
B.T. Ravishankar

LIBRARY

Geetha S.
Girija Srinivasan
M. Manjunath
M. N. Nagaraj
Y. M. Patil (*Librarian)*
Vrinda J. Benegal

Support Staff

K. Chowdasetty
C. Elumalai
Hanumappa

MECHANICAL & ENGINEERING SERVICES

S. Abdul Rahim
M. Achankunju
I. Charles Paul
V. Dhamodaran
R. Duraichelvan (*from 26.12.01*)
R. Elumalai
K.O. Francis
K. T. Gangadharan
(*In-Charge, General Workshop*)
V. Gokula Chandran
N. Gopal
G. Gopi
I. Henry
M. Mani
K.M. Mohandas
C. Mohammed Ateequlla
(*In-Charge, Basement Workshop*)
V.K. Muthu
V. Nagaraja
N. Narayanaswamy
T. Puttaswamy
M. Selvamani (*Head*)
D. Sunand
P. Srinivasa
S. Sundaraj
M. Suresh Kumar
V. Venu

GAURIBIDANUR TELESCOPE

Technical

H.A. Aswathappa

Support Staff

Bheema Naik
Gangaram
M. Muniyappa (*Nandi Hills*)
Papanna
Prahallada Rao
N. Raja Rao
R.P. Ramji Naik
Ranoji Rao
Shivarudraradhya
Thippanna
Venkataswamy

ADMINISTRATION

G. V. Srinivasa (*Administrative Officer up to 30.9.2001)*
K. Krishnama Raju (*DAO up to 29.9.2001 & Admn. Officer from 30.9.2001*)
K. Raghunatha (*Dy. Admn. Offr. from 16.9.2001*)
S. Raghavachar (*Asst. Admn. Officer*)
Marisa D'Silva
S.R. Ramasubramaniyan
L.P. Kumar
K. Radha
V. Raveendran
R. Ganesh

ACCOUNTS

R. Ramesh
K. R. Shankar (*Accounts Officer*)
S. Srinivasa Murthy
P.V. Subramanya

PURCHASE

Lakshmi Rajagopal (*Purchase Offr.*)
Sowjanya Kumar
Sujatha Anil Kumar
B. Srinivasa Murthy

STORES

S. Rajasekharan Nair (*Stores Officer*)
C. N. Ramamurthy
M.V. Subramanya

GRAPHIC ARTS

Raju Varghese

ESTATE & BUILDINGS

S. Anantha Raman
R. Anantha Subba Rao (*Consultant*)
K. Bhoopalan
D. Gangappa
Gunashekar
C. Haridas
K. Palani
M. Rajagopal
C. Sampath
R. Sasidharan (*Supervisor*)
S. Sridhar
K.N. Srinivas
T. Subramaniyam Naidu
G. B. Suresh (*Civil Engineer*)

Secretary: V. Raghunath

CARPENTRY

M. Gopinath
K. M. Lakshmanan (*Supervisor*)
L. Muthu
V. Ramu
T. Subramani

MEDICAL

Dr. M.R. Baliga (*Consultant Paediatrician*)
Dr. A.R. Pai (*Consultant Physician*)

Lab. Technician
R. Shanthamma

TRANSPORT

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

AMENITIES (Canteen, Guest House and Hostels)

C. V. Bharghavan
T. V. Janardhanan
Mangala Singh
Muniratna
T. Naganna
N. Narayanappa
P. C. Prabhakar
N. Puttaswamy
A. Raju
N. Seetharam
Sharadamma
Shivamallu
Uma
K. Velayudhan
V. Yeshodha

HORTICULTURE

Bylappa
Chikkamunivenkatappa
V. Krishnappa (*Consultant)*
Lakshmamma
Lingegowda
Maiga
Mailarappa
Marappa
Munilakshmi
D. Muniraja
D. Mahalinga
S. Muniraju
Rangalakshmi
Thimmarayappa
Varalakshmi

UPKEEP

Hanumantha
Jayamma
K. N. Kawalappa
D. Krishna
C. Lakshamma
T. Mahadeva
Narayana
T. Murali
A. Ramanna
Rangalakshm
Ranjithamma
Saroja
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

G.V. Vijayagovindan Mahatma Gandhi University Kottayam, Kerala	3 April - 4 July 2001
Jatush V. Sheth Inter-University Centre for Astronomy and Astrophysics Pune	8 April – 20 April 2001
B.S. Sathyaprakash Cardiff University Cardiff, UK.	11-28 April 2001
G. Swarup National Centre for Radio Astrophysics Pune	10-14 April 2001 & 5-8 November 2001
Durgesh Tiwari University of Massachusetts Amherst, USA	22-29 April 2001
Ravi Sankrit Johns Hopkins University Baltimore, USA	27 April 2001
C.S. Unnikrishnan Tata Institute of Fundamental Research Mumbai	26 April 2001
G. Baskaran Institute of Mathematical Sciences Chennai	21 May & 29 Dec. 2001 - 1 Jan. 2002
Raymond Blundell Harvard-Smithsonian Center for Astrophysics Cambridge, USA	11 May 2001
T.K. Sridharan Harvard-Smithsonian Center for Astrophysics Cambridge, USA	11-12 May 2001

Shami Chatterjee Cornell University Ithaca, USA	16-19 May 2001
D. Suresh Madurai Kamaraj University Madurai	20-21 May 2001
Gopal Krishna National Centre for Radio Astrophysics Pune	27 May-3 June 2001& 18-19 October 2001
Herbert Weber Fraunhofer Institute for Software and Systems Engineering, Berlin, Germany	30 May 2001
Paul Alexander Mills INNOVA GmbH Germany	30 May 2002
A.M. Jayannavar Institute of Physics Bhubaneswar	27-31 May 2001 & 31 Aug.-12 Sept. 2001
Ajit Kembhavi Inter-University Centre for Astronomy & Astrophysics, Pune	7-16 June 2001
S. Sridhar Northeastern University Boston, USA	11-30 June 2001 & 18 Feb. - 18 March 2002
A.R.P. Rau University of Louisiana USA	12-29 June 2001
Arun V. Thampan Inter-University Centre for Astronomy & Astrophysics, Pune	25-26 June 2001

Vikram Soni National Physical Laboratory, New Delhi	26 June-2 July 2001 & 8-17 December 2001
Rukmani Dey Indian Standards Institute Calcutta	1-7 July 2001
Arun Paramekanti Tata Institute of Fundamental Research Mumbai	2-4 July 2001
Katheryn Becker Oberlin College Oberlin, USA	9-14 July 2001
Ralf Gerbig Georg-August University of Goettingen Germany	10-24 July 2001
Ray Jayawardhana University of California Berkeley, USA	13 July 2001
Romila Thapar Jawaharlal Nehru University New Delhi	17 July 2001
T. Padmanabhan Inter-University Centre for Astronomy and Astrophysics Pune	18-20 July 2001 & 7 November - 3 December 2001
S.A. Rangwala Institut d'Optique Orsay, France	23-24 July 2001
Sreejith Sukumaran Max-Planck-Institute of Colloids & Interfaces Berlin, Germany	23-27 July 2001

Krishnaswami Alladi University of Florida Gainesville, Florida USA	24 July 2001
Sushan Konar Inter-University Centre for Astronomy & Astrophysics, Pune	26 July 2001
P.B. Sunil Kumar Indian Institute of Technology Chennai	27-30 July 2001
A.P. Balachandran Syracuse University USA	29 July–1 August 2001
K.B. Athreya Louisiana University USA	1 August 2001
E.C.G. Sudarshan University of Texas Texas, USA	9 August 2001
Shiv K. Sethi Harish-Chandra Research Institute Allahabad	10 August 2001
Surajit Sengupta S.N. Bose National Centre for Basic Sciences, Kolkata	16-31 August 2001
S. Ramadurai Tata Inst.of Fundamental Research Mumbai	19 Aug. - 14 Oct. 2001
Dion Lewis Australian Telescope National Facility Sydney, Australia	26-30 August 2001

P. Venkatakrishnan Udaipur Solar Observatory Udaipur	28 Aug. – 2 Sept. 2001
N.M. Ashok Physical Research Laboratory, Ahmedabad	29 Aug. – 2 Sept. 2001
Kaushik Bhattacharya California Institute of Technology Pasadena, USA	29 August 2001
Anantha Ramakrishna Blackett Laboratory Imperial College, London, U K	30 August - 4 Sept. 2001
Katalin Fodor-Csorba Hungarian Academy of Sciences Budapest, Hungary	11 September 2001
Eugenia Karitskaya Russian Academy of Sciences Russia	16-21 September 2001
M.C. Mehta Advocate, Supreme Court New Delhi	1 October 2001
Pawan Kumar Institute of Advanced Studies Princeton, USA	3-4 October 2001
P. Hariharan CSIRO Division of Applied Physics Sydney, Australia	11-18 October 2001
Asim Ghosh Scottish Church College Kolkata	22 October – 16 Nov. 2001
Jasjeet Singh Bagla Harish-Chandra Research Institute Allahabad	25 Oct. - 5 Nov. 2001

Albert Libchaber Rockefeller University USA	2-17 November 2001
Oleg Ulyanov Institute of Radio Astronomy Kharkov, Ukraine	25 Nov. - 22 Dec. 2001
Sergiy Stepkin Institute of Radio Astronomy Kharkov, Ukraine	25 Nov. - 22 Dec. 2001
S.K. Ghosh Tata Institute of Fundamental Research Mumbai	2-3 December 2001
D.A. Green Mullard Radio Astronomy Observatory Cambridge, U K	10-13 December 2001
Ananth Chikkatur Massachusetts Inst. of Technology USA	26 December 2001
David McConnell Australian Telescope National Facility Sydney, Australia	1-31 January 2002
Zoltan Haiman Princeton University Observatory Princeton, USA	4 January 2002
E.P.J. van den Heuvel Astronomical Institute University of Asmsterdam The Netherlands	3-5 January 2002
K. S. Govinder University of Natal Durban, South Africa	2-17 January 2002

Jayajit Das Virginia Polytechnic Institute & State University, USA	6-10 January 2002
D.V.G.L.N. Rao University of Massachusetts Boston, USA	8-11 January 2002
Devendra Lal Scripps Institute of Oceanography La Jolla, USA	13-17 January 2002
U. Chummum University of Mauritius Mauritius	15 Jan. – 30 April 2002
Richard P. Riesz Peasant Hill, USA	17-19 January 2002
Subhabrata Majumdar University of Illinois Urbana Champaign, USA	26-30 January 2002
A. Salnikov Pushchino Radio Observatory, Russia	30 Jan. - 15 Feb. 2002
Konstantin Lapaev Pushchino Radio Observatory Russia	30 Jan - 15 Feb. 2002
Anirban Pathak Visva Bharati University Santiniketan	5-8 February 2002
K.Y. Sandhya Regional Research Laboratory Thiruvananthapuram	6-9 February 2002
Dominique Langevin Lab. Physique des Solides Universite Paris Sud, France	12-15 February 2002

A. Bhattacharyya Institut Francaise du Petrole Rueil Malmaison France	17-20 February 2002
S. Sridhar Inter-University Centre for Astronomy and Astrophysics, Pune	18 Feb. - 18 March 2002
Shyamalendu Bose Drexel University University USA	24-27 February & 13-15 March 2002
Nimisha Kantharia National Centre for Radio Astrophysics Pune	25 March - 4 April 2002
Afsar Abbas Institute of Physics Bhubaneswar	13 March 2002
Sukratu Barve Institute of Mathematical Sciences Chennai	12-16 March 2002
G. Date Institute of Mathematical Studies Chennai	18-22 March 2002

Annexure I

PAPERS PUBLISHED

In Journals

1. Comment on: "Can disorder induce a finite thermal conductivity in $1D$ lattices?" (***A.Dhar***), *Phys. Rev. Lett.*, **87**, 069401 (2001).

2. "Solution of a generalized Stieltjes problem" (B.S.Shastry and ***A.Dhar***), *J.Phys.A.*, **31**, 6197 (2001).

3. "Topological phases near a triple degeneracy" (***J.Samuel*** and ***A.Dhar***), *Phys. Rev. Lett.*, **87**, 260401 (2001).

4. Comment on: "A simple one-dimensional model of heat conduction which obeys Fourier's Law" (***A.Dhar***), *Phys. Rev. Lett.*, **88**, 249401 (2002).

5. "Appearance of the central singularity in spherical collapse" (***S.S.Deshingkar***, P.S.Joshi and I.H.Dwivedi), *Phys. Rev. D.*, **65**, 084009 (2002).

6. "Gravitational collapse and the cosmological constant" (***S.S.Deshingkar***, S.Jhingan, A.Chamorro and P.S.Joshi), *Phys. Rev. D.*, **63**, 124005 (2001).

7. "Gravitational waves from inspiralling compact binaries: energy flux to third post-Newtonian order" (Luc Blanchet, ***B.R.Iyer*** and B.Joguet), *Phys. Rev. D.*, **65**, 064005 (2002).

8. "Gravitation-wave inspiral of compact binary systems to 7/2 post-Newtonian order" (Luc Blanchet, G.Faye, ***B.R.Iyer*** and B.Joguet), *Phys. Rev. D.*, **65**, 061501 (R) (2002).

9. "Second post-Newtonian gravitational wave polarisations for compact binaries on elliptical orbits" (A.Gopakumar and ***B.R.Iyer***), *Phys. Rev.D.*, **65**, 084011 (2002).

10. "Landau diamagnetism revisited" (Sushanta Dattagupta, Arun M.Jayannavar and ***N.Kumar***) *Curr. Sci.*, ***80***, 861 (2001).

11."Photons from quantized electric flux representations" (***Madhavan Varadarajan***), *Phys. Rev. D.*, **D64**, 104003 (2001.)

12. "Comment on 'Immirzi parameter in quantum general relativity'" (***J.Samuel***), Phys. *Rev. D.*, **64**, 048501 (2001).

13."Tilt texture domains on a membrane and chirality induced budding" (***R.C.Sarasij*** and ***Madan Rao***), *Phys. Rev. Lett.*, **88**, 088101 (2002).

14."Rotating Bose gas with hard-core repulsion in a quasi-two-dimensional harmonic trap: Vortices in Bose-Einstein condensates" (***M.A.H. Ahsan*** and ***N.Kumar***), *Phys. Rev. A.", **64**,* 013608 (2001).

15."Distribution of the delay time and the dwell time for wave reflection from a long random potential" (***S. Anantha Ramakrishna*** and ***N.Kumar***), *Eur. Phys. J.B.*, **23**, 515 (2001).

16."Photon transport in thin disordered slabs" (***Venkatesh Gopal, S.Anantha Ramakrishna***, A.K.Sood and ***N.Kumar***), *Pramana*, **56** No.6, 767 (2001).

17."Zeno blocking of interplanar tunnelling by intraplanar inelastic scattering in oxide superconductors – a generalized spin-Bonson analysis" (M.Sanjay Kumar, S.Dattagupta and ***N.Kumar***), *Phys. Rev.*, **B 65**, 134501 (2002).

18."The conditional tunnelling time for reflection using the WKB wave-function" (***S. Anantha Ramakrishna*** and A.M.Jayannavar), *Intl. J. Mod. Phys. B*, **16**, 615 (2002).

19."Active fusion and fission processes on a fluid membrane" (***Madan Rao*** and ***R.C. Sarasij***), *Phys. Rev. Lett.*, **87**, 128101 (2001).

20."The physics of active membranes" (S. Ramaswamy and ***Madan Rao***), *C. R. Acad. Sci. Paris*, **2,IV**, 817 (2001).

21."Axisymmetric modes of rotating relativistic stars in the Cowling appoximation" (Jose A. Font, Harald Dimmelmeier, ***Anshu Gupta*** and Nikolaos Stergioulas), *Mon. Non. R.Astron. Soc.*, **325**, 1463 (2001).

22. "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 and J.Pradeep), *Nonlinear Optics*, **27**, 357 (2001).

23."Excited state dynamics in tetra tolyl porphyrins studied using degenerate four wave mixing with incoherent light and ps Pulses" (S.Venugopal Rao, N.K.M.Naga Srinivas, D.Narayana Rao, L.Giribabu, Bhaskar G. Maiya, ***Reji Philip*** and Ravindra Kumar G.), *Optics Commun.*, **192**, 123 (2001).

24."Small worlds: How and why" (Nisha Mathias and ***Venkatesh Gopal***), *Phys. Rev.*, **63**, 021117 (2001).

25. "Use of a graded gain random amplifier as an optical diode" (***Sushil Mujumdar*** and ***Hema Ramachandran***), *Opt. Lett.*, **26**, 929 (2001).

26."Mirrorless lasers" (***Hema Ramachandran***), *Pramana*, **58**, 313 (2002).

27."Effect of adsorption of some azoles on copper passivation in alkaline medium" (***R.Subramanian*** and ***V.Lakshminarayanan***), *Corro. Sci.* **44**, 535 (2002).

28."Effect of bulk structure of some non-aqueous solvents on the barrier properties of alkanethiol monolayer" (***Ujjal Kumar Sur*** and ***V.Lakshminarayanan***), *J. Electroanal Chem.*, **516**, 31 (2001).

29."Corrosion inhibition of mild steel in sulphuric acid by n-octylamine and iodoacetic acid" (S.Shabanna Begum, ***R.Subramanian***, ***V.Lakshminarayanan*** and S.M.Mayanna), *Ind. J. Chem. Tech.*, **8**, 463 (2001).

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38."Role of tilt order in the asymmetric ripple phase of phospholipid bilayers" (***Kheya Sengupta, V.A.Raghunathan*** and ***Yashodhan Hatwalne***), *Phys. Rev. Lett.*, **87**, 55705 (2001).

39."Enhancement of steric repulsion with temperature in oriented lipid multilayers" (G.Pabst, J.Katsaras and ***V.A.Raghunathan***), *Phys. Rev. Lett.*, **88**, 128101 (2002).

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45."Banana-shaped mesogens: observation of a direct transition from the antiferroelectric B_2 to nematic phase" (***R.Amaranatha Reddy***, ***B.K.Sadashiva*** and ***Surajit Dhara***), *Chem. Commun.*, **19**, 1972 (2001).

46."FT-IR and FT-Raman spectroscopic studies of 1-(p-n-alkylphenyl) 3-(p-n-alkyloxyphenyl) propane 1, 3-diones" (P.Raveendran, ***B.K.Sadashiva***, K.V.G.K.Murthy and T.K.K.Srinivasan), *Mol. Cryst. Liq. Cryst.*, **363**, 19 (2001).

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61. "Heating of the intergalactic medium as a result of structure formation" (***Biman Nath*** and J.Silk), *Mon. Not. R. Astron. Soc.*, **327**, L5 (2001).

62."Heating of the intracluster medium by quasar outflows" (***Biman Nath*** and ***S. Roychowdhury***), *Mon. Not. R. Astron. Soc.*, **333**, 145 (2002).

63."Sunyaev-Zel'dovich distortion from early galactic winds" (Subhabrata Majumdar, ***Biman Nath*** and Masashi Chiba), *Mon. Not. R. Astron. Soc.*, **324**, 537 (2001).

64."VLA observations of the H92alpha line from NGC 5253 and Henize 2-10: ionized gas around super star clusters" (***R.Niruj Mohan, K.R.Anantharamaiah*** and W..M.Goss), *Ap. J.*, **557**, 659 (2001).

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66."Search for sub-mm, mm and radio continuum emission from extremely red objects" (***R.Niruj Mohan***, A.Cimatti, H.J.A.Röttgering, P.Andreani, P.Severgnini, R.P.J.Tilanus, C.L.Carilli and S.A.Stanford), *Astron. & Astrophys.*, **383**, 440 (2002).

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68."Observable Dirac-type singularities in Berry's phase and the Monopole" (***Rajendra Bhandari***), *Phys. Rev. Lett.*, **88**, 100403 (2002).

69. "Are radio pulsars strange stars?" (R.C.Kapoor and ***C.S.Shukre***), *Astron. & Astrophys.*, **375**, 405 (2001)

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72."Wide-field imaging with the Mauritius Radio Telescope" (S.Sachdev and **N.Udaya Shankar**), *J. Astrophys. Astr.*, **22**, 229 (2001).

73."Detection, excision and statistics of interference at the Mauritius Radio Telescope" (S.Sachdev and ***N.Udaya Shankar***), *J. Astrophys. Astr.*, **22**, 213 (2001).

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75."A case for renewed activity in the giant radio galaxy J0116-473" (Lakshmi Saripalli, Ravi Subrahmanyan and ***N.Udaya Shankar***), *Ap. J.*, **565**, 256 (2002).

Invited Review Article

1. "Nematic liquid crystals: molecular statistical theories and their applications" (***N.V.Madhusudana***), *Encyclopedia of Materials: Science and Technology*, Ed. K.H.J.Buschow *et al.*, Elsevier Science, Oxford, Vol.6, 6094 (2001).

Monographs

1. "Mysterious motions and other intriguing phenomena in physics" (***G.S.Ranganath***), Universities Press, Hyderabad (2001).

In Conference Proceedings

1. "Detecting binary black holes with efficient and reliable templates" (T.Damour ***B.R.Iyer*** and B.S.Sathyaprakash), **in** *Gravitational Wàves, A Challenge to Theoretical Physics* (2001), Eds. V.Ferrari, J.Miller and L.Rezello.

2. "Padé approximants for gravitational waves from inspiralling compact binaries" (T.Damour, ***B.R.Iyer*** and B.S.Sathyaprakash) **in** *Proc. 10th Workshop on General Relativity and Gravitation in Japan*, 2001) Eds.M.Sasaki, J.Yokoyama, T.Nakamura and K.Tomita.

3. "The Zeno effect and an inter-layer pairing mechanism for high-temperature superconductivity in layered materials" (***N. Kumar***) **in** *Proc. Eighth Asia-Pacific Physics Conference*, Eds. Yeong-Der Yao, Hai-Yang Cheng, Chia-Seng Chang and Shang-Fan Lee (World Scientific Publishing Co., 2001) p.24.

4. "The Vela pulsar wind nebula at 6 cm" (D.Lewis, R.Dodsar, D.McConnell and ***A.A.Deshpande***) **in** *Neutron Stars in Supernova Remnants* (ASP Conference Series, **271**, 2002), Eds. Patrick O. Slane and Bryan M. Gaensler), p.191.

5. "A study of low-density ionised gas in the galactic plane" (D.A.Roshi and ***K.R.Anantharamaiah***), **in** *Tetons 4: Galactic Structure, Stars and the Interstellar Medium* (ASP Conference Series, **231**, 2001) Eds. Charles E. Woodward, Michael D. Bicay and J.Michael Shull.

6. "High velocity ionised component – A counter-rotating circumnuclear disk in NGC 253" (Jun-Hui Zhao, W.M.Goss, J.A.Ulvestad and ***K.R.Anantharamaiah***), **in** *Gas & Galaxy Evolution* (ASP Conference Series, **240**, 2001) Eds. J.E. Hibbard, M.P. Rupen and J.H. van Gorkom.

7. "On the origin of metallicity in Lyman-alpha forest systems" (M.Chiba and ***Biman Nath***), **in** *Cosmic Chemical Evolution (Proc. 187th Symp. of the International Astronomical Union*) Eds. K. Nomoto and J.W. Truran; (Dordrecht: Kluwer Academic Publishers, 2001) p.123.

8. "High stability frequency broadcast through INSAT" (***C.R.Subrahmanya, R.Ganesan, N.V.G.Sarma,*** S.Rangarajan and S.Sukumar), **in** *Proc. ICTF* (2001), p.6.

9. "Radio evidence for evolution of galaxies in rich clusters" (Frazer Owen, Glenn Morrison, ***K.S.Dwarakanath***, Michael Ledlow and Neal A. Miller), **in** *Gas & Galaxy Evolution* (ASP Conference Series, **240**, 2001), Eds. J.E. Hibbard, M.P. Rupen and J.H. van Gorkom.

PAPERS IN PRESS

In Journals

1. Comment on "Geometric phases and hidden symmetries in simple resonators" (***J.Samuel*** and ***A.Dhar***), *Physs. Rev. Lett.*

2. "Triple minima in free energy of the worm-like chain model of semi-flexible polymers" (***A.Dhar*** and D.Chaudhuri), *Phys. Rev. Lett.*

3. "Gravitational wave astronomy: probing physics and unravelling astrophysics" (***B.R.Iyer***), *Bull. Astro. Soc. India.*

4. "Gravitons from a loop representation of linearised gravity" (***Madhavan Varadarajan***), *Phys. Rev. D.*

5. "Elasticity of semi-flexible polymers" (***J.Samuel*** and Supurna Sinha), *Phys. Rev. Lett.*

6. "Molecular elasticity and the geometric phase" (***J.Samuel*** and Supurna Sinha), *Phys. Rev. Lett.*

7. "A note on the generalization of the Telegrapher process to describe photon migration in higher dimensions" (S. Anantha Ramakrishna and ***N. Kumar***), *Phys. Rev.E.*

8. "Soluble Au@TiO2, Au@ZrO2, Ag@TiO_2, core-shell nano particles: one step synthesis, characterization, spectroscopy and optical limiting properties (Renjis T.Tom, A.Sreekumaran Nair, Navinder Singh, M.Aslam, C.L.Nagendra, ***Reji Philip***, K.Vijayamohanan and T.Pradeep) *Chemistry of Materials.*

9. "Existence of a hydrophobic gap at the alkanethiol – water interface – an interfacial capacitance study" (***V.Lakshminarayanan***), *J. of Colloid & Interface Sci.*

10. "Some experimental investigations on type II liquid crystals" (***Surajit Dhara, R.Pratibha*** and ***N.V.Madhusudana***), *Ferroelectrics.*

11. "Pretransitional swelling of phospholipid bilayers above the main transition (G.Pabst, J.Katsaras, ***V.A.Raghunathan*** and M.Rappolt), *Phys. Rev. Lett.*

12. "Novel chiral fluoro substituted benzoyloxybenzoates exhibiting anti-ferroelectric mesophase" (***S.Shubashree, B.K.Sadashiva*** and ***Surajit Dhara***), *Mol. Cryst. Liq. Cryst.*,

13. "Banana-shaped mesogens: effect of lateral substituents on seven-ring esters containing a biphenyl moiety" (***H.N.Shreenivasa Murthy*** and ***B.K.Sadashiva***), *Liq. Cryst.*

14. "Topology and polarisation of subbeams associated with pulsar B0943+10's 'drifting'-subpulse emission – III. Analysis of Pushchino 103/40-MHz observations" (J..Rankin, S.A.Suleymanova and ***A.A.Deshpande***), *Mon. Not. R.Astron. Soc.*,

15. "General relativistic spectra from accretion disks around rapidly rotating neutron stars" (Sudip Bhattacharyya, ***D.Bhattacharya***, Ranjeev Misra, Arun V.Thampan), *Proc. The Physics of Cataclysmic Variables and Related Objects*, ASP Conference Series.

16. "Evolution of the magnetic fields of neutron stars" (***D.Bhattacharya***), *Proc. Multicolour Universe.*

17. "Constraints on mass ejection in black hole formation derived from black-hole x-ray binaries far from the galactic plane" (G.Nelemans, E.P.J. van den Heuvel, ***D.Bhattacharya***), *Jan van Memorial Symposium*, ASP Conference Series.

18. "GMRT and VLA observations of HI and OH from Markarian 1" (***A.Omar, K.S.Dwarakanath***, M.Rupen and ***K.R.Anantharamaiah***), *Astron. & Astrophys.*

19. "Multifrequency GMRT observations of the HII regions S201, S206 and S209" (***A.Omar***, J.N.Chengalur and D.A.Roshi), *Astron. & Astrophys.*

20. "Changes in the measured image separation of the gravitational lens system PKS 1830-211" (Jin C., M.A.Garrett, ***S.Nair***, R.W.Porcas and A.R.Patnaik), *Mon. Not. R.Astron. Soc.*

21. "Phase offsets between core and conal components of radio pulsars and their emission altitudes" (***C.S.Shukre***), *Astron. & Astrophys.*

22. "Radio pulsar emission altitudes" (***C.S.Shukre***), *Bull. Astr. Soc. India.*

23. "VLA detection of RRLs from the radio nucleus of NGC 253: Ionization by a weak AGN, an obscured SSC or a compact SNR?" (***R.Niruj Mohan, K.R.Anantharamaiah*** and W..Goss), *Ap. J.*, (2001).

In Conference Proceedings

1. "GMRT detection of HI absorption in the high-redshift red quasar 3C 190" (C.H.Ishwara-Chandra, ***K.R.Anantharamaiah*** and ***K.S. Dwarakanath***) **in** *Bull. Astro. Soc India..*

2. "GMRT HI imaging survey of the Eridanus group of galaxies" (***A.Omar, K.S.Dwarakanath*** and ***K.R.Anantharamaiah***), **in** *Bull. Astro. Soc. India.*

3. "Heating of the intracluster medium by quaser outflows" (Roychowdhury S. and ***Biman Nath***), **in** *Proc. of the Conf. on Multicolour Universe*, Mumbai, India, (Poster presentation).

4. "GMRT HI imaging survey of ERIDANUS group of galaxies" (A.Omar, K.S.Dwarakanath and K.R.Anantharamaiah), **in** *Bull. Astr. Soc. India.*

5. "CLASS1359+154: Modelling lensing by a group of galaxies" (S.Nair), **in** *Proc. Conf. on Multiwavelength Astrophysics*, Mumbai, India.

Annexure - II

COLLOQUIA

Name	Title	Date
Ravi Sankrit Johns Hopkins University Baltimore, USA	Ultraviolet spectroscopy of supernova remnants using FUSE	06. 4.2001
N. Kumar Raman Research Institute Bangalore	Left-handed medium is just right	19. 4.2001
C.S. Unnikrishnan Tata Inst. Fundamental Research, Mumbai & Indian Inst. of Astrophysics Bangalore (& Kastler-Brossel Lab, ENS, Paris, France)	A new 'Hot' BEC: Bose-Einstein condensation of metastable helium	26. 4.2001
Andal Narayanan Raman Research Institute Bangalore	Manipulation of cold atoms by light	27. 4.2001
Bala R. Iyer Raman Research Institute Bangalore	Picking up strains of the gravitational wave symphony	03. 5.2001
Raymond Blundell CfA USA	The submillimeter array – Receivers and antennas	11. 5.2001
Shami Chatterjee Cornell University Ithaca, USA	Neutron star kinematics: Probing the interstellar medium with radio pulsars	18. 5.2001
D. Suresh Madurai Kamaraj University	High temperature solar concentrators employing non-imaging devices	21. 5.2001
Mark Walker University of Sydney & ATNF, Australia	Macroscopic effects from Microlensing	01. 6.2001

Name	Title	Date
Ajit K. Kembhavi Inter-University Centre for Astronomy & Astrophysics Pune	The formation of galactic bulges and the photometric plane	08. 6.2001
S. Sridhar Northeastern University Boston, USA	Quantum chaos: Explorations using microwaves	26. 6.2001
A. R. P. Rau Louisiana State University Baton Rouge USA	Astronomy-inspired atomic and moleculalr physics	28. 6.2001
Arun Paramekanti Tata Institute of Fundamental Research Mumbai	Strongly correlated superconductors: A variational wavefunction approach	02. 7.2001
Rukmini Dey Indian Statistical Institute Calcutta	Surfaces interpolating between minimal surfaces	04. 7.2001
Shrirang Deshingkar Raman Research Institute Bangalore	Some issues related to stability of numerical evolution schemes in general relativity	11. 7.2001
Vikram Soni National Physical Laboratory New Delhi	Plantations without planting	12. 7.2001
Ray Jayawardhana University of California Berkeley, USA	Probing planet formation in the solar neighbourhood	13. 7.2001
Avinash Deshpande Raman Research Institute Bangalore	Vela, its X-ray nebula, and the polarization of pulsar radiation	16. 7.2001
S.A. Rangwala Institut d'Optique Orsay, France	Experimental studies on Bose-Einstein condensates and atom lasers	23. 7.2001
Krishnaswami Alladi University of Florida Gainesville, USA	New weighted Rogers-Ramanujan partitions and their implications	24. 7.2001

Name	Title	Date
Sreejit Sukumaran Max Planck Institut of Colloids and Interfaces, Berlin, Germany	Influence of shear flow on vesicles near a wall	25. 7.2001
Sushan Konar Inter-University Centre for Astronomy- Astrophysics Pune	Effective neutrino-photon interaction in a magnetised thermal medium	26. 7.2001
K. B. Athreya Cornell University USA	Random iterations: An alternative paradigm to deterministic chaos	01. 8.2001
T. Pradeep Indian Inst. of Technology Chennai	Chemistry of molecular surfaces: From monolayers to ice	03. 8.2001
E.C.G. Sudarshan University of Texas USA	Purification and quantum entanglement	09. 8.2001
Shiv K. Sethi Harish-Chandra Research Institute, Allahabad	CMBR anisotropies and cosmological parameters	10. 8.2001
Kaushik Bhattacharya California Instiute of Technology, Pasadena USA	Thin films mde of shape memory alloys	29. 8.2001
S. Ananthara Ramakrishna Blackett Laboratory Imperial College London, U. K.	Perfect lens action and the role of surface states	04. 9.2001
Katalin Fodor-Csorba Research Institute for Solid State Physics, Hungarian Academy of Sciences Budapest, Hungary	Recent results in the synthesis of deuterium labelled calamitic compounds for 2H NMR investigations and in banana mania	11. 9.2001
N. Kumar Raman Research Institute Bangalore	Making sense out of nonsence (Noise)	12. 9.2001

Name	Title	Date
B. Viswanathan Indian Inst of Technology Chennai	Carbon nanotubes and their recent developments	03.10.2001
Pawan Kumar Institute for Advanced Study Princeton, USA	The enigmatic cosmic gamma-ray bursts	04.10.2001
Asimkumar Ghosh Scottish Church College Kolkata	Spin dynamics of a one-dimensional spin-1/2 fully anisotropic ising-like antiferromagnet in a transverse magnetic field	31.10.2001
Jasjeet Singh Bagla Harish-Chandra Research Institute, Allahabad	A parallel N-body code for cosmological simulations: Method and applications	02.11.2001
A. Libchaber Rockefeller University New York & NEC Institute Princeton, USA	Directed evolution	15.11.2001
T. Padmanabhan Inter-University Centre for Astronomy & Astrophysics Pune	Cosmology and structure formation (Six lectures)	19-28.11.2001
D. Bhattacharya Raman Research Institute Bangalore	Coded mask imaging in X-ray astronomy	29.11.2001
C. Sivaram Indian Inst.of Astrophysics Bangalore	Gravity on large and small scales	06.12.2001
D.A. Green Cavendish Laboratory Cambridge, U. K.	A power spectrum analysis of neutral hydrogen in the galaxy	12.12.2001
Zoltan Haiman Princeton University Observatory, Princeton, USA	Probing the end of the cosmological dark age	04. 1.2002
K.S. Govinder 1 University of Natal 2 Durban, South Africa	Spacetime symmetries and separability A group theoretic approach to differential equations	07. 1.2002 08. 1.2002

Name	Title	Date
D.V.G.L.N. Rao University of Massachusetts Boston, USA	Optical information processing using biological materials	09. 1.2002
A. Madhukar University of Southern California, USA	Semiconductor nanostructures: Nature's way	09. 1.2002
Manoj Pal Saha Institute of Nuclear Physics Kolkata	Phase transitions in atomic nuclei	17. 1.2002
David McConnell Australia Telescope National Facility Narrabri, Australia	Radio emission from the core of 47 Tucanae	18. 1.2002
Supurna Sinha Bangalore	Elasticity of semi-flexible polymers	22. 1.2002
Anand Kumar Centre for Mathematical Modelling and Computer Simulation, Bangalore	An averaging for spinodal decomposition simulation	23. 1.2002
K. Guruswamy National Chemical Lab. Pune	Novel photonic materials from self- assembly of coated colloids	25. 1.2002
Subhabrata Majumdar University of Illinois Urbana-Champaign, USA	Can we do precision cosmology with Galaxy Clusters?	28. 1.2002
Anirban Pathak Visva-Bharati Santiniketan	Operator solutions of anharmonic oscillators: Application to quantum optics	06. 2.2002
K.Y. Sandhya Regional Research Lab Trivandrum	Polymers: Nonlinear optical properties and liquid crystalline behaviour	07. 2.2002
Dominique Langevin Universite d'Orsay Orsay, France	Foams, films and surface layers	14. 2.2002

Name	Title	Date
Amitabha Bhattacharyya Institut Francais du Petrole France	Mixed surfactant-polyelectrolyte systems	18. 2.2002
Dharam Vir Lal Indian Institute of Astrophysics Bangalore	Seyfert galaxies on milli-arcsecond scales	22. 2.2002
Anthony J. Leggett University of Illinois Urbana-Champaign USA	BEC: A 'tapas' of topics	22. 2.2002
S. M. Bose Drexel University Philadelphia, USA	Collective excitations in fullerenes and carbon nanotubes	25. 2.2002
Srinivasu Vallabhapurapu (till recently working in Mie University, Japan)	Low field microwave absorption in CMR manganite powders and High-T_c superconducting materials	27. 2.2002
Afsar Abbas Institute of Physics Bhubaneswar	What particle physics has to say about the early universe	13. 3.2002
Sukratu Barve The Institute of Mathe- matical Sciences Chennai	Naked singularities and cauchy horizons	14. 3.2002
Anil Kumar Indian Institute of Science Bangalore	Quantum computing by NMR	14. 3.2002
S. Sridhar Inter-University Centre for Astronomy & Astrophysics Pune	Dynamical processes in galactic nuclei	15. 3.2002
N. Udaya Shankar Raman Research Institute Bangalore	Measuring the size of the stars	28. 3.2002

Annexure III

JOURNAL CLUB

Discussed by	Paper discussed	Date
C.R. Subrahmanya	Alignment of noisy signals Kevin J. Coakley and Paul Hale *IEEE Trans. Instrum. Meas.*, **50**, 141 (February 2001).	12. 4.2001
Madhavan Varadarajan	Experimental test of quantum gravity using gamma ray bursts G. Amelino-Camelia *et al.* *Nature*, **393**, 763 (1998).	12. 4.2001
S.K. Srivatsa	Self-focussing and defocussing in waveguide arrays R Morandotti *et al.* *Phys.Rev.Lett.*, **86**, 3296 (9 April 2001)	26. 4.2001
K. Rema	Spinning a good yarn: Liquid crystaline spinning of spidersilk Fritz Volrath & David P. Knight *Nature*, **410**, 541 (29 March 2001)	26. 4.2001
Shrirang S. Deshingkar	Static friction between elastic solids due to random asperities J.B. Sokoloff *Phys. Rev. Lett.*, **86**, 3312 (9 April 2001)	10. 5.2001
Reji Philip	The roe of chaotic resonances in the solar system N. Murray and M. Holman *Nature*, **410**, 773 (12 April 2001).	10. 5.2001
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Ujjal Kumar Sur	Superconductivity at 39 K in magnesium diboride Jun Nagamatsu *et al.* *Nature*, **410**, 63 (1 March 2001)	05. 7.2001

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ABBREVIATIONS

ADC	Analog-to-Digital Converter
ASTROSAT	Astronomical Satellite (of ISRO, India)
ATCA	Australia Telescope Compact Array (Australia)
ATNF	Australia Telescope National Facility (Australia)
BAO	Beijing Astronomical Observatory (China)
BAT	Binary Addressing Technique
CPLD	Complex Programmable Logic Devices
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CTAB	Cetyltrimethylammonium Bromide
DMPC	Dimyristoyl Phosphatidyl Choline
DNA	Deoxyribose Nucleic Acid
DPPC	Dipalmitoyl Phosphatidyl Choline
DSP	Digital Signal Processor
ERGs	Extremely Red Galaxies
FPGA	Field Programmable Gate Array
FWHM	Full Width at Half Maximum
GPS	Global Positioning System
GHz	Giga Hertz
GMRT	Giant Meterwave Radio Telescope (Pune, India)
HCRI	Harish-Chandra Research Institute (Allahabad, India)
HI	Neutral Atomic Hydrogen
HII	Ionized Hydrogen
IF	Intermediate Frequency
IIA	Indian Institute of Astrophysics (Bangalore, India)
INSAT	Indian National Satellite
IRA	Institute of Radio Astronomy (Ukraine)
ISRO	Indian Space Research Organisation (Bangalore, India)
IUCAA	Inter University Centre for Astronomy & Astrophysics (Pune, India)
JIVE	Joint Institute for VLBI in Europe
Jy	Jansky (Unit of flux density)
LCD	Liquid Crystal Display
MCF	(INSAT) Master Control Facility (Hassan, India)
MHz	Mega Hertz
MPIfR	Max-Planck Institut für Radio Astronomie (Germany)
MRT	Mauritius Radio Telescope (Mauritius)
MST	Mesosphere Statosphere Troposphere Radar Facility (Gadanki, India)
$M_\odot$	Solar Mass

NAO	National Astronomical Observatory (Japan)
NCRA	National Centre for Radio Astrophysics (TIFR, Pune, India)
NeII	Singly Ionized Neon
NRAL	National Radio Astronomical Laboratory (UK)
NRAO	National Radio Astronomical Observatory (USA)
OH	Hydroxyl Radical
OIII	Doubly Ionized Oxygen
ORT	Ooty Radio Telescope
PGA	Polyglutamic Acid
PPD	Pre-stressed Parabolic Dish
PSF	Point Spread Function
QZE	Quantum Zeno Effect
RAC	Radio Astronomy Centre (TIFR, Ooty, India)
SHNC	Sodium Hydroxynaphthoate
SmC*	Smectic C* Phase
SO	State Observatory (Nainital, India)
STM	Scanning Tunneling Microscopy
TGB_A	Twist Grain Boundary A phase
TGB_C	Twist Grain Boundary C Phase
TIFR	Tata Institute of Fundamental Research (Mumbai, India)
UOM	University of Mauritius (Mauritius)
$UTGB_{C*}$	Undulating Twist Grain Boundary C* Phase
VLA	Very Large Array (USA)
VLBI	Very Long Baseline Interferometry