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RAMAN RESEARCH INSTITUTE

Bangalore

Annual Report

1998 - 99

# RAMAN RESEARCH INSTITUTE

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## PREAMBLE

As in the previous years, the Annual Report is a terse account of the main scientific activities of the Institute giving the list of papers published in scientific journals, discussion meetings and seminars/colloquia held, and the Ph.D. degrees awarded during the period 1 April 1998 to 31 March 1999. It also lists the visitors to the Institute – 48 of them from different parts of the world, the conferences attended and institutions visited by the members of the Institute during this period.

1998 was the Golden Jubilee Year of the Institute, and the 7<sup>th</sup> day of November was observed as the Golden Jubilee Day to formally mark this auric event. A 43 volume Memoirs of RRI was released on that day. Other events that took place during the Jubilee Year were conducting of Summer School in Physics & Astrophysics, 25 May - 20 June 1998; Advanced School on Liquid Crystals and Soft Condensed Matter, 21-25 December 1998; Discussion Meeting on Liquid Crystals and Other Soft Materials, 28-31 December 1998; XIX Annual Meeting of the Astronomical Society of India, 1-4 February 1999; and an Open Day on 28 February 1999 coinciding with the National Science Day. Details are given on page 13 of the Report. The Jubilee Year necessarily had a diffuse beginning and a diffuse ending in time.

Important research highlights of the period are the first ever mapping of the pulsar (PSR B0943+10) radio-emission sites on the polar cap; the making of the high resolution (4'x9') wide-angle southern sky map at 150 MHz from the MRT data; and the first successful recording of optical afterglow of the Gamma-ray burst (GRB 990123) by an Indian observatory (UPSO) which was coordinated locally by RRI.

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

Six Ph.D. degrees were awarded to the students of the Institute, and three have submitted their theses during the year. Research papers published in refereed journals and in conference proceedings for the same period counted 52 and 19 respectively.

Bangalore  
16 August 1999

N. KUMAR  
Director

# RAMAN RESEARCH INSTITUTE

## Bangalore

Annual Report 1998 - 99

### Introduction

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

### 1. Theoretical Physics

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

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

### 2. Optics

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

### 3. Liquid Crystals

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

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

### 4. Astronomy and Astrophysics

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

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



frequency (150 MHz) Mauritius Radio Telescope (MRT) built at Mauritius in collaboration with the University of Mauritius and the Indian Institute of Astrophysics for a radio map of the southern sky at full resolution of  $4' \times 4'$ .

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

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

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

## THEORETICAL PHYSICS (TP)

AREAS OF RESEARCH : Gravitation  
Condensed Matter  
Optics

### GRAVITATION

**Decoherence and Semiclassicality of Cosmological Perturbations:** The problem of quantum-to-classical transition of cosmological density perturbations in an inflationary universe was studied in a model of a self-interacting scalar field. The results show that there is efficient noise induced decoherence of modes of the scalar field with wavelengths greater than the horizon size and that the short wavelength modes contribute to the noise source.

**Loop quantization and the Turaev-Viro model:** Earlier results by Turaev and Viro were used to make 3D gravity a concrete model for *covariant loop quantization* in the continuum.

**Functional evolution of free quantum fields:** It is shown that dynamical evolution of a free scalar field on flat spacetime of dimension greater than 2, in the context of curved slicings is not unitarily implemented on the standard Fock space of the theory. Implications for canonical quantum gravity are discussed.

**Quantum cylindrical wave geometry:** A crucial error in a previous work of Ashtekar and Pierri regarding existence of the metric operator has been corrected and some properties of the spectrum of the operator are explored. It is shown that a large class of evolutions in the context of curved slices are unitarily implementable.

**Representations from Abelian Holonomy algebras:** It is shown that the crucial structure determining whether a Fock representation of an Abelian Holonomy algebra is obtained, is the choice of positive linear functional on the algebra.

**Classical limit of kinematic loop quantum gravity:** It is shown that holonomy variables are not suitable to exploring the classical limit of kinematic loop quantum gravity. Different, but related operators are proposed, for the analysis of the classical limit, and their properties are explored.

**Zero-Point (Vacuum) Energy and the Dark Matter:** In this admittedly highly speculative work, it was suggested that the otherwise infinite zero-point energy of a bosonic quantum field (e.g., the physical vacuum of the photonic field), when corrected self-consistently for self-gravitation, gives a finite background energy density that corresponds closely to the critical cosmological mass density for closure.

**Gravitational wave polarisations for inspiralling compact binaries on elliptical orbits:** Alternative forms have been explored to express the *plus* and the *cross* gravitational wave polarisations associated with gravitational radiation from inspiralling, non-spinning, compact binaries moving on elliptical orbits. The effects of orbital inclination and eccentricity are explored and compared with earlier results. The detailed analytical results presented here could be useful in applications, e.g., gravitational wave detection.

The refined balance procedure to constrain the reactive acceleration is further generalised to explore the effects of linear momentum flux on the motion of the center of mass of the binary. This should impose restrictions on the individual accelerations of the two bodies of the compact binary moving on general orbits. The analysis at the 2.5PN order is complete and work on the 3.5PN order is under investigation.

## CONDENSED MATTER

**Blow Torch Effect:** Using the supersymmetric (SUSY) approach, the effect of local heating, i.e., of non-thermal injection of noise, on the Kramer escape rate over a potential barrier was studied in detail with several interesting results. Most interesting of them was the pronounced effect of the location of the 'blow-torch' along the reaction-coordinate.

**Diffusion on spheres:** This work deals with diffusion on spheres. The distribution of solid angles on the spheres was computed and the answer checked against numerical simulations.

## OPTICS

**Diffusion-at-Constant-Speed of Photons in Random Media:** The local constraint of constant speed was imposed exactly and dynamically. This study has bearing on photonic transport in random media with restricted geometries. Our treatment goes beyond the Wiener and the Ornstein-Uhlenbeck approximations.

**Quantum Zeno Effect:** Application to high-temperature super-conductivity in layered cuprates. The blocking of inter-subspace tunneling by intra-subspace inelastic electron-electron scattering was studied for a simple tractable pseudo-spin model. Our treatment reveals the blocking effect very clearly.

**Quantum Brownian motion with initial correlations and decoherence at zero temperature:** The question (that has become controversial in the literature recently) of whether there can be decoherence of a system initially in its ground state coupled to a zero-temperature bath has been re-examined. An alternative method has been developed for calculating the exact time evolution and master equation for the system oscillator evolving from such an initial condition.

**Quantum effects in four-wave mixing in a cavity in the presence of non-cooperative atomic relaxation processes:** Quantum effects of atom-cavity field interaction on four-wave mixing have been studied using a momentum method. The advantage of this method compared to the usual methods is that the number of equations to solve depends only on the order of perturbation theory and not on the system size.

**A computation scheme for solving the Gross-Pitaevskii investigation:** A computational scheme for the Gross-Pitaevskii (GP) as well as an Exact Diagonalization (ED) study on a system of interacting bosons trapped in an external harmonic potential has been developed and partly implemented.

**Critical review of geometric phase experiments:** A critical analysis of an earlier experiment at the Institute concerning geometric phases from pure projections was made concluding that dynamical phases were not excluded. The possibility of  $2\pi$  phase jumps near singularities in such experiments was pointed out.

## OPTICS

AREAS OF RESEARCH : Imaging  
Scattering  
Laser Cooling and Trapping

**Imaging in turbid media:** Extending the polarisation discrimination technique devised here earlier, stereoscopic images have been obtained of objects immersed in turbid media, thereby providing information of depth. The technique is now being tried out in some biological samples.

**Light scattering in random media:** An extensive study of quasiballistic photons in turbid media, experimentally by the polarisation-discrimination imaging technique and numerically by Monte-Carlo simulation, has been carried out. The data are now being analysed to determine how the photons turn diffusive. In a related study, the two- and four-fold patterns in the backscattered light, when viewed between co- and cross-polaroids, were examined, both experimentally and numerically. A quantitative derivation of the patterns is being attempted, so that these patterns may be used for remote characterisation of turbid media.

**Laser cooling and trapping:** A vacuum chamber of glass for the magneto-optic trap has been fabricated, and tested. An external cavity laser with grating feed-back has been built, and has been found to have a tuning range of more than 10 nm. A thermo-electric cooling device with feed-back has also been built and tested. Diode lasers, close to 780 nm are being awaited, so that fluorescence in rubidium may be observed and the frequency of the laser locked.

**Simple demonstration and measurement of optical biaxiality:** The conoscopic figures exhibited by a stack of overhead transparency sheets were observed by a very simple method and analysed to illustrate principles and obtain optical constants. This experiment is suited to an instructional context.

## LIQUID CRYSTALS (LC)

<b>AREAS OF RESEARCH</b>	:	L. C. Synthesis Phase Transitions Monolayers Instabilities Non-linear optics Membranes LC Displays STM Electrochemistry
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### EXPERIMENTAL STUDIES

**Electrooptic and dielectric studies on  $UTGB_{C^*}$  liquid crystals:** Electro-optic studies at a low frequency ( $\sim 400$  Hz) have been conducted on an LC mixture in which the Undulating Twist Grain Boundary  $C^*$  ( $UTGB_{C^*}$ ) phase was earlier discovered in the laboratory. The electro-optic signal decreases initially as the temperature is raised in the smectic  $C^*$  phase, due mainly to a reduction in the polarization, then increases steeply in the  $UTGB_{C^*}$  phase to exhibit a maximum, and finally goes to zero at the  $UTGB_{C^*}$  to  $TGB_A$  transition point. The results have been interpreted in terms of the proposed structure of the  $UTGB_{C^*}$  phase.

Dielectric measurements have also been conducted on this system, both in homeotropic and planar geometries. The results again clearly show sharp changes near the  $SmC^*$  to  $UTGB_{C^*}$  and the  $UTGB_{C^*}$  to  $TGB_A$  transitions.

**Free standing films of the system exhibiting the  $UTGB_{C^*}$  phase:** Observations have been made on free standing films of the above mixture, formed in a hole in a glass plate. Several different textures like periodic stripes, regular arrays of focal conic domains and stepped drop like formations have been found, depending on the thickness of the film.

**Viscoelastic modes in chiral liquid crystals:** The viscoelastic modes in chiral liquid crystals like smectic  $C^*$  and cholesterics are being investigated using the dynamic light scattering technique. In the former case a slow mode has been observed which is being studied as function of sample thickness to find the effect of surface anchoring on this mode.

**Hydrogen-bonded liquid crystals:** In a collaborative work with scientists of Regional Research Laboratory, Trivandrum, the hydrogen bonded mesogens with 4, 4' - azobipyridine and 4-alkoxy benzoic acid have been studied to find the influence of the photo-isomerization of the azo moiety. Some mixtures have been found to exhibit the nematic phase over a narrow temperature range.

**Synthesis and physical studies of new compounds exhibiting liquid crystalline phases:** A number of compounds exhibiting ferroelectric, antiferroelectric and twist grain boundary phases have been synthesised. In particular, a single compound has been synthesised which exhibits the  $UTGB_{C^*}$  phase which was discovered in the laboratory earlier in a binary mixture.

A large number of compounds made of banana-shaped molecules have been synthesised. Most of them exhibit the layered smectic phases. However in a couple of compounds, a columnar structure has been found using both optical texture and X-ray investigations. Further studies to establish the molecular arrangement in this columnar phase are in progress. In a collaborative work with the scientists of RSIC of IIT, Chennai, crystal structure and EPR studies on a metallomesogen synthesised at the Institute have been carried out.

**Electrochemical and STM investigations on adsorption of alkanethiols on noble metal surfaces:** A new method has been developed to study the adsorption kinetics of monolayers of organic compounds like alkanethiols using impedance measurements in an electrochemical cell. Using this technique, the adsorption properties of five alkanethiols have been compared. The kinetics of adsorption have been found to depend on the chain length. It has also been found that the surface morphology significantly affects the results.

Using STM, self-assembled domains of octadecanethiol on an evaporated gold surface have been imaged. The adsorption studies clearly show that a surface polished with  $0.05 \mu\text{m}$  alumina has a significantly larger number of defect sites compared to a surface treated with coarse emery. These studies have been used to establish a correlation between surface roughness and barrier efficiency.

## THEORETICAL STUDIES

**A Phenomenological theory of the  $UTGB_{C^*}$  phase:** A simple theory has been developed to account for the stability of the  $UTGB_{C^*}$  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.

**Phase transitions in liquid crystals of banana shaped molecules:** Compounds with banana shaped molecules exhibit a surprisingly rich variety of liquid crystalline phases. In a collaborative work with scientists at the University of Saõ Paulo, Brazil, a phenomenological theory has been developed for such liquid crystals to point out that five different configurations can be found in layers with tilted banana shaped

molecules. Some of these structures can exhibit longitudinal polarization.

**Stability of a lyotropic liquid crystal doped with magnetic grains:** In a collaborative work with scientists at the Politecnico di Torino, Italy, the stability of a uniform alignment of a lyotropic doped with magnetic grains (ferro-nematics) has been analysed to find that above a critical concentration, a spatially distorted medium results due to the magnetic interactions.

**Nematic kink states in a laser field:** The nonlinear optical interactions of both the uniform and kink states of nematic and ferronematic liquid crystals with laser fields have been investigated. The transition between the permitted uniform orientational states has been found to be first order for nematics and second order for ferronematics, the latter also exhibiting reentrant transitions. In a magnetic field, new kink states with a topological winding different from  $p$  in nematics and  $2p$  in ferronematics have been found. In ferronematics, grain segregation leads to a structural transformation from a simple kink to a pair of kinks. A rich variety of kink states has been found as the intensity of laser field is increased.

**Electric field induced walls in a nematic:** In a collaborative work with scientists at the College of Wooster, USA, an experiment done by the latter on electric field induced walls in a nematic in homeotropic geometry has been theoretically analysed. The AC electric field is applied in the plane of the glass plates. As the field is non-uniform near the two electrodes, a deformation is induced in the nematic of positive dielectric anisotropy, creating walls, between the deformed and undeformed regions. The walls approach each other as the voltage is increased, and coalesce at a threshold voltage  $V_c$ . A hysteresis is observed on decreasing the voltage and is interpreted as arising from an adhesion energy, comparable to typical anisotropic surface energies in nematics. The effects of a magnetic field and of changing the frequency of the AC field on the walls have also been studied.

**Scale-dependence of elastic constants in tethered membranes:** The effect of thermal fluctuations on the elastic constants of the decoupled lamellar phase of tethered, crystalline membranes has been theoretically investigated in a collaborative work with scientists of the Indian Institute of Science. Using a momentum-shell renormalisation technique, it has been shown that the smectic-A like compressional elastic constant, the in-plane Lamé coefficients and the cross coupling elastic constants vanish as  $(\ln q)^a$ , while the bend constant diverges as  $(\ln q)^b$ , with  $a, b > 0$  as the wavevector  $q$  tends to zero.

**A Landau theory of the ripple phase in lipid membranes:** Experimentally it has been found that achiral lipids can exhibit asymmetric ripple phases. Recent analysis of electron density maps made in the laboratory shows that the asymmetry may result from a mean tilt of the hydrocarbon chains along the rippling direction. As the available theory cannot account for the asymmetry, it has been extended to include a symmetry permitted term proportional to the 4<sup>th</sup> power of the gradient in the scalar



order parameter in the Landau expansion. In addition, the bending modulus of the bilayer is also assumed to be anisotropic. A detailed phase diagram has been constructed to get the stability region of the asymmetric ripple phase.

**Optical diffraction in non-uniform cholesteric liquid crystals:** Computations have been made on the optical diffraction pattern of a cholesteric with a linear gradient in its pitch. Even relatively small gradients alter the diffraction pattern, whose intensity decreases significantly and the profile changes from a delta function like peak to a flat topped one.

**New drive wave forms for ferroelectric and other liquid crystal displays:** In a collaborative work with scientists at the Chalmers University of Technology, Sweden, three new drive wave forms have been developed for ferroelectric LCDs in which two rows can be selected simultaneously. Two of the waveforms require only two voltage levels on the columns so that standard drivers can be used to drive matrix displays.

The possibility of generating gray shades in nematic LCDs by varying both column and row waveforms has been investigated to overcome some disadvantages in the available techniques. The results obtained have been encouraging.

## ASTRONOMY and ASTROPHYSICS (AA)

AREAS OF WORK : Neutron stars and pulsars  
Galactic and extragalactic astronomy  
Instrumentation for radio astronomy

### Neutron stars and pulsars

The evolution of multipolar magnetic fields in pulsars, caused by ohmic dissipation of crustal currents, was modelled to examine the implications for the variation of integrated pulse profiles with age. This mechanism is probably too slow to play a significant role.

Trains of pulses from the pulsar B0943+10 showing striking coherent temporal variations have been fitted to a model of sub beams in a ring on the polar cap. The circulation of these beams brings them into and out of the line of sight and allows an annulus to be mapped. Variation of these maps ("pulsar weather") has been seen. (+Joanna Rankin).

A search for radio emission from a recently discovered binary X-ray millisecond pulsar proved negative. Pulsar timing studies at Ooty continue (+V.Balasubramaniam, Alak Ray). 0943+10 was detected at 840 MHz in spite of its steep spectrum. (+R.Ramachandran).

The conventional belief that core emission is from close to the pulsar while cone emission is from higher up was re-examined keeping in mind the different effects of aberration and field line sweepback on the direction of the emission. Observationally, there does not seem to be a large offset, and this requires revision of the conventional model. (+R.C.Kapoor).

### Galactic and extragalactic astronomy

The effect of compressive tidal fields in the central regions of elliptical galaxies and ultraluminous galaxies on molecular gas was examined. High densities consistent with available observations are predicted. (+C.J.Jog). The kinematics of gas in the central regions of starburst galaxies M82 (+Wills, Pedlar, Muxlow) and NGC 253 was successfully modelled using closed orbits in a bar potential.

A dynamically motivated model for violent relaxation to a spherical halo incorporating a cutoff in the pericentres of stellar orbits and a partial filling at long periods was shown to reproduce the density profiles resulting from cold collapse simulations rather well. (+S.Sridhar, A.Mangalam).

The radio source populations in the Abell clusters 2125 and 2645 were compared, using optical data on the galaxies. In the first, many of the galaxies showing radio emission also show signs of star formation, while this effect is absent in the second. The different dynamical state of these two clusters is a possible cause of the systematic differences seen. (+F.N.Owen)

The potential of a proposed space array operating at wavelengths longer than 10 metres for studies of external galaxies, pulsars, supernova remnants, the interstellar medium of our galaxy, etc, was assessed.

Radio recombination lines from damped Lyman-alpha systems were looked for but only upper limits were established (+R.Srianand). The implications are being examined.

The implications of cooling flows on the Sunyaev-Zeldovich effect (decrement of the cosmic microwave background radiation ) towards clusters of galaxies is being worked out.

Multiepoch dual polarisation 43 GHz VLBI of the gravitational lens system 1830 -211 has been carried out with the VLBA, and has revealed many novel features such as centroid shifts of tens of microarcseconds, the need for a globular cluster like mass to account for the transformation matrix relating sub-images, and a time delay of 22 days between the core images. (+M.A.Garrett, R.W.Porcias, A.R.Patnaik, J.Chengijn). Modelling and code development work continues to handle this and other complex, multilens systems.

RRI was a part of the co-ordinated effort to rapidly relay information on the gamma ray burst 9900123 to optical observatories to study the afterglow. This made it possible to obtain very useful data at the UPSO (Naini Tal). The implications of the observations (of a broken power-law spectrum) for models of the ill-understood burst phenomenon were examined.

The Mauritius Radio Telescope (MRT) survey of the southern sky at a wavelength of 2 metres continues. Data corrupted by solar and man-made interference is being identified and reobserved. A map of a one-hour wide strip over the full declination range of +10 to -70 degrees has been made, with the expected noise level. The positional accuracy determined by comparison with another survey is approximately a quarter beamwidth.

## INSTRUMENTATION FOR RADIO ASTRONOMY

All thirty of the L band (1000 to 1400 MHz receivers for the Giant Metrewavelength Radio Telescope (GMRT) of TIFR in Pune were completed and delivered during this period and they have performed as per specifications. Three of them were modified for use at a somewhat higher frequency, up to 1600 MHz, so that interstellar hydroxyl (OH) could be observed.

A wide band digital correlator system for a 640 MHz bandwidth to be used at the 10.4 metre telescope was designed. The prototype sub- units built were adapted as a high resolution spectrometer for methanol maser observations. 6.7 GHz low noise amplifier systems were built and tested both on the 10.4 metre telescope and on the ISRO antennas at Hassan. The panels of the 10.4 metre telescope which are nearly fifteen years old were removed, reconditioned, and replaced. A collaboration with the Indian Institute of Astrophysics and the University of Tokyo to measure water vapour over the high altitude site at Hanle using millimetre wave techniques has been started.

## COMPUTERS

The upgradation of the campus-wide network has been taken up during this year. Optical fibres for the network backbone have been laid, and the implementation of the UTP cabling to desktops as well as the work relating to installation of hubs, switches and routers is going on. The central computing facility is being moved to a new location. The necessary equipment to build up the new infrastructure has been procured and the required civil work is in progress. An exercise has been undertaken to test the Y2K compliance of all the computer systems and the software used in the Institute. The areas needing hardware replacement have been identified and most of the replacements have been carried out. Many software upgrades have also been implemented. For the few cases where this is pending, action has been initiated to procure appropriate hardware and software to make the systems Y2K compliant latest by October '99. Two new and powerful analytical software tools - IDL and Mathematica - have been added to our existing facilities. A CD-writer has also been procured for the purpose of archiving valuable data.

## OTHER ACTIVITIES

Ph. D.

### Awarded

#### Name

#### Topic of Study

Geetha Basappa	Experimental studies on the relationship between order and physical properties in liquid crystals <i>University of Mysore, Mysore</i>
C.R.Gopalakrishnan	Synthesis and physical properties of some mesogenic chiral polysiloxanes <i>Bangalore University, Bangalore</i>
N. Kasthuraiah	Synthesis and liquid crystalline properties of some homologous series of optically active compounds <i>Bangalore University, Bangalore</i>
Jayadev K. Rajagopal	Some investigations of interstellar clouds <i>Jawaharlal Nehru University, New Delhi</i>
Sushan Konar	Evolution of the magnetic field in accreting neutron stars <i>Indian Institute of Science, Bangalore</i>
Sreejith Sukumaran	On the elastic and dynamical properties of biaxial liquid crystals <i>Jawaharlal Nehru University, New Delhi</i>

### Submitted

Sobha R. Warriar	Electrooptic and dielectric investigations on some liquid crystals <i>Jawaharlal Nehru University, New Delhi</i>
Amitabha Bhattacharyya	Phase transitions and molecular conformation in Langmuir monolayers <i>Jawaharlal Nehru University, New Delhi</i>
P. A. Pramod	New defect structures in liquid crystals <i>Jawaharlal Nehru University, New Delhi</i>

## 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 34).

## Golden Jubilee Year

Apart from the two events

- Discussion Meeting on Gravitational Radiation and General Quantum Relativity 11-14 December 1997
- Open Day - National Science Day 28 February 1998

that were reported in 1997-98, the following scientific and related activities took place during this year as part of the Golden Jubilee Year of the Institute:

- ***Summer School in Physics & Astrophysics*** 25 May - 20 June 1998

Twenty seven students drawn from different parts of the country representing universities, IITs and Colleges were selected from the sixty nine students who had applied. Finally, 20 students participated in it – 13 of whom were studying for M.Sc., and the rest were either studying for B.Sc., or had just finished the course. There were 6 courses, each with 5 lectures (2 lectures everyday from Monday to Friday for three weeks) – basic physics (statistical physics and special relativity), optics, general relativity, soft condensed matter, diffuse matter and compact objects. There were 15 tutorials which took place in the afternoons of the first three weeks.

The students were offered projects on the third day of the School, and they began their project work soon after. The last week of the School was left for the students to concentrate on the projects.

- ***Golden Jubilee Day*** 7 November 1998

The formal celebration of the Golden Jubilee was held on 7 November 1998, the Birthday of Prof. C.V. Raman, Founder of the Institute. All former students of the Institute (dating back to 1949), all the former members of staff, present and past Members of the Council, present and past members of the Raman Research Institute Trust, persons who have been closely associated with the Institute, as well as some from the neighbouring institutions were invited. The programme consisted of:

Welcome by Prof. N. Kumar, Director, RRI;

Remarks by Prof. M.G.K. Menon, Chairman, RRI Trust, and

Prof. S. Dhawan, Chairman, RRI Council;

Reminiscences by Prof. A. Jayaraman, former student of Prof. C.V. Raman, now Senior Scientist at Hawaii Institute of Geophysics, University of Hawaii, USA;

Keynote address by Prof. G. Venkataraman, former Vice-Chancellor of Sri Sathya Sai Institute of Higher Learning;

Remarks by Prof. S. Ramaseshan, Member-Secretary, RRI Trust, and Concluding Remarks by Prof. M.G.K. Menon.

A 43 Volume Memoirs of RRI was released by Prof. S. Ramaseshan.

- ***Advanced School on Liquid Crystals and Soft Condensed Matter***

***21-25 December 1998***

The main purpose of the School was to provide the background material on various topics which were to be discussed in the meeting held during the following week. About 70 young participants who were either advanced Ph. D. Students or fresh Post-Docs, were selected from all over the country. Twenty five pedagogical lectures were given on the following topics: Various aspects of liquid crystals, polymers, colloids, water, monolayers, fluctuations and hydrodynamics and optics of helical structures. The speakers were mainly from RRI but included a few scientists from other institutions as well.

- ***Discussion Meeting on Liquid Crystals and Other Soft Materials***

***28-31 December 1998***

The main purpose of the meeting was to expose the young participants to invited talks by leading experts who gave an hour long lecture each on some chosen topic. In all 17 scientists, 10 of them from overseas, and 3 from RRI delivered the lectures. The last hour of the meeting was devoted to a general discussion. The students by themselves arranged with some of the speakers, additional discussion sessions during the evenings. The topics included various aspects of liquid crystals, polymers, the complex behaviour of water and many topics of biological interest. In addition, a public lecture by Prof. R. Libchaber of Rockefeller University on '*Biology and Information Theory*' was also arranged, and was attended by a large gathering.

- ***XIX Annual Meeting of the Astronomical Society of India (hosted by RRI)***

***1-4 February 1999***

The Astronomical Society of India (ASI) held its nineteenth meeting in Bangalore during 1-4 February 1999. The meeting was hosted by the Raman Research Institute as part of its Golden Jubilee celebrations. It was attended by over 225 participants, the largest attendance recorded in an ASI meeting so far. There were more than 40 oral and over 120 poster presentations during the meeting. In addition, there was a

lively discussion and debate on upcoming new facilities in astronomy in the country. Dr. Sarbani Basu, the 1996 M K. Vainu Bappu Gold Medal awardee, received her medal at the opening session of the meeting, and delivered her award lecture on "The Seismic Sun". Apart from scientific sessions, the Society also held its business meetings of the Executive Council and the General Body during this meeting.

- ***Open Day/National Science Day 28 February 1999***

An 'Open Day' feature introduced in 1998 as part of the events during the Golden Jubilee Year was continued in 1999. The second of the 'Open Days' was held on the 28 February 1999, the National Science Day. The programme was planned along the lines of the previous year Open Day.

On that Day, about 100 students from the Poorna Prajna High School, Bangalore, were invited to participate. Director, RRI, welcomed the students and talked to them about the Institute and its present activities. He also demonstrated an interesting experiment on Foucault Pendulum during his talk.

During the two and a half hours before lunch, the students went in small groups around the campus for viewing posters displayed in various buildings/ laboratories. About 40 posters/displays including a few demonstrations were prepared by the staff members of the Institute. These were designed to present the general themes/topics that are closely related to our research interests and supporting activities of the Institute. The staff members and the research students at the Institute were present in the poster areas to explain to the students the details and excitement of the work.

The post-lunch session began with the screening of two short movies, one of which was on Raman's life. This was followed by a slide show in which the students were introduced to a variety of astronomical objects and their wonders.

The last two hours or so were devoted to a very lively Question-Answer session wherein faculty members responded to a variety of questions from the students.

As an extension to this event, students from the Sri K. V. English School, Chickaballapur, also visited the Institute on 3 March 1999.

- ***Memoirs of Raman Research Institute***

As part of the Golden Jubilee Celebrations of the Institute, the Library compiled the publications of the Institute from 1948 - 1998 (June) as ***Memoirs of Raman Research Institute***. The Memoirs contains 1415 articles (272 of them belong to Raman era) in 43 Volumes.



## Conferences/Seminars and Meetings

The staff of the Institute visited various institutions in India and abroad and attended conferences and presented papers. In addition, lectures were given by them at other places. In all, 135 lectures were given by them at other places.

## Colloquia

The scientists of the Institute and visiting scientists, both from within and outside the country, gave colloquia at the Institute on different topics during the year (Annexure II, page 44).

## Journal Club Meetings

Twenty meetings were held during the year. Preprints as well as recently published papers dealing with topics of great current interest were reviewed in the meetings (Annexure III, page 49). These included two Special Sessions on the 1998 Nobel Prize in Physics and Chemistry.

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

## In-House Meeting

An In-House Meeting, which is an annual feature at the Institute, was held on 27 March 1999 where the staff and students presented their research work. In all 15 oral presentations spread over 4 sessions chaired by Faculty Members were made. There were also 5 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 1998 was given by Bharat Ratna C. Subramanian entitled "Mahatma Gandhi - The Sage of the Scientific Age" on 2 October 1998.

## Visit of Parliamentary Standing Committee for Science and Technology

A Department-Related Standing Committee of the Parliament on Science & Technology, Environment and Forests led by Mr. S. R. Bommai, Chairman, visited the Institute on

17 August 1998. The Director briefed the Committee of the on-going research activities at the Institute. Some of the Members of the Committee made additional visits to the labs on 18 August 1998.

## 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 (page 28).

## Library

RRI library has been continuing with its basic objectives and functions of collecting, processing and disseminating information, both in the traditional form and using the newly evolving technologies like ONLINE ACCESS TO JOURNALS, remote access to RRI Library Catalogue and use of internet facility for accessing nascent information.

During the year, 524 new books were added to the library bringing its book collection to 20,324. It subscribed to 137 scientific journals out of which 15 journals were received by air mail. It has ONLINE Access to 33 journals. Currently there are 25,593 bound volumes of periodicals.

Apart from meeting the normal requirements of the staff and students of the Institute and those working in the field stations at Gauribidanur and Mauritius, library has been, as in the past, providing reading and borrowing facilities to other institutions in the city (selectively to libraries at IISc, IIA and TIFR). A number of Ph. D. Students doing research in Liquid Crystals at neighbouring universities make use of our facilities.

As part of the Golden Jubilee Celebrations of the Institute, the library compiled the publications of our Institute from 1948 - 1998 (up to June) as "**Memoirs of Raman Research Institute**".

The library contributed significantly in initiating and creating a combined database of catalogues of three important libraries in the City — at IISc, NAL and RRI. This database has been hosted on the server at the National Centre for Science Information (NCSI) at IISc campus. As the initial effort has proved successful, more libraries are being drawn into this network. Earlier, the library initiated two other projects — a Union Catalogue of Currently Subscribed Journals in Bangalore Libraries (about 20 are participating in this). This database is also hosted on the server at NCSI. The other project is making available a combined catalogue of four libraries participating in the Forum for Resource Sharing in Astronomy. The combined book catalogue of the Indian Institute of Astrophysics, the Physical Research Laboratory, Ahmedabad, the Raman Research Institute and the Tata Institute of Fundamental Research, Bombay, is now

available on the NETWORK. Plans are being worked out to keep these databases/catalogues up-to-date and also to widen their scope by including more libraries in these networks.

Realising the social responsibility of the libraries and librarians, the staff of this library is participating in the activities of the Karnataka State Library Association and the Bangalore Special Libraries Group. This is helping to a great extent closer interaction with the other librarians in the city that in turn smoothens inter-library cooperation.

### General

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

PLAN (Recurring & Non-Recurring)	Rs. 484.00 lakh
NON PLAN (Recurring)	Rs. 287.00 lakh
	<hr/>
Total	Rs. 771.00 lakh
	<hr/>

## STAFF

**N. Kumar**  
*Director*

**V. Radhakrishnan**  
*Director-Emeritus*  
**S. Ramaseshan**  
*Distinguished Professor Emeritus*

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### THEORETICAL PHYSICS

#### Research

B.R. Iyer (Chairman, from 1.11.98)  
N. Kumar  
Joseph Samuel  
Madan Rao (from 31.12.98)  
Madhavan Varadarajan  
R. Nityananda (Chairman up to 31.10.98)

#### Post-Doctoral Fellows

Abhijit Kar Gupta (*from 1.2.1999*)  
M.A.H. Ahsan (*from 26.6.98*)  
Anshu Gupta (*from 1.12.98*)  
Jose Antonio Zapata (*from 24.8.98*)  
Sanjay Kumar  
Sukanya Sinha (*CSIR Pool Officer*)

#### Research Students

S. Anantharamakrishna (*from 7.8.98*)  
A. Gopa Kumar (*up to 18.9.98*)  
Jayajit Das (*from 1.2.99*)  
Sarasij Ray Chaudhari (*from 2.1.99*)

#### Visiting Professors

S. K. Rangarajan

#### Secretarial

G. Manjunatha

### OPTICS

#### Research

Hema Ramachandran

#### Research Students

Sushil Mujumdar  
Uday Kumar Khan (*from 31.7.98*)  
Trainee: Ranita Roy Chowdhury (*up to 19.2.99*)

#### Visiting Professors

A. K. Sood  
R. Srinivasan

#### Technical

P. S. Sasikumar

### LIQUID CRYSTALS LABORATORY

#### Research

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

#### Scientific/Technical

A. Dhasan  
Mohammed Ishaq  
P.N. Ramachandra  
N. Ravi Sankar  
S. Seshachala  
G. R. Seshadri  
M. R. Subrahmanyam  
K. Subramanya  
H. Subramonyam  
D. Vijayaraghavan

**Research Students**

Amarnatha Reddy (*from 11.8.98*)  
 Amitabha Bhattacharyya  
 Arun Roy (*up to 26.6.98*)  
 M. S. Giridhar  
 C. R. Gopalakrishnan (*up to 14.5.98*)  
 Kheya Sengupta  
 V. Manjula Devi (*from 30.7.98*)  
 K.G. Pani Kumar  
 P. A. Pramod  
 K. Rema (*from 29.7.98*)

**Trainees**

C.L. Aradhana (*from 4.3.99*)  
 N. G. Nagendra Prasad (*up to 17.8.98*)  
 C. Nisha  
 Rajeshree Ayyangar (*up to 29.9.98*)  
 Ravi Revankara (*from 4.3.99*)  
 H.N. Shreenivasa Murthy (*from 13.1.99*)

S. Shubhashree  
 Sobha R. Warriar (*up to 10.2.99*)  
 Sreejith Sukumaran  
 S. K. Srivatsa  
 R. Subramanian  
 Surjit Dhara (*from 1.8.98*)  
 P. K. Thiruvikraman  
 P. Viswanath (*from 31.7.98*)  
 Ujjal Kumar Sur (*from 4.8.98*)

**Visiting Scientist**

T. G. Ramesh

**Secretarial**

K. Radhakrishna

**ASTRONOMY & ASTROPHYSICS****Research**

K.R. Anantharamaiah  
 R. Bhandari  
 Biman Nath  
 A.A. Deshpande  
 Dipankar Bhattacharya  
 K. S. Dwarakanath  
 N. Kumar (*Chairman up to 31.10.98*)  
 V. Radhakrishnan  
 Rajaram Nityananda (*Chairman from 1.11.98*)  
 B. Ramesh  
 Ravi Subrahmanyam  
 (*on leave at ANTF, Australia*)  
 C. S. Shukre  
 T.K. Sridharan (*on leave at Smithsonian  
 Astrophysical Observatory,  
 Cambridge, USA*)  
 G. Srinivasan  
 N. Udaya Shankar

**Trainee**

S. Ashwin (*from 4.9.98*)  
 Florita D'Sa (*up to 2.9.98*)

**Research Students**

Amitesh Omar (*from 1.8.98*)  
 Ashish Asgekar (*JAP*)  
 Dipanjan Mitra  
 C. Indrani (*up to 30.6.98*)  
 Jayadev K. Rajagopal (*up to 12.2.99*)  
 Nimisha G. Kantharia (*up to 26.9.98*)  
 R. Niruj Mohan (*JAP*)\*  
 Raka D. Ray (*up to 31.8.98*)  
 Rekesh Mohan  
 Sandeep Sachadev  
 Sushan Konar (*up to 1.8.98*)

**Post-Doctoral Fellows**

Mousumi Das  
 Sunita Nair

**Visiting Professors**

Bhaskar Datta  
 C. R. Subrahmanya (*up to Jan.99*)

**Secretarial**

S. Ramasubramanian

---

\*Joint Astronomy Programme

**RADIO ASTRONOMY LAB****Technical**

P. G. Ananthasubramanian  
 B.S. Girish (*from 1.10.98*)  
 M. R. Gopala Krishna  
 P.A. Kamini  
 S. Kasturi  
 S. Madhavi  
 T. Prabu  
 K.B. Raghavendra Rao  
 A. Raghunathan  
 P. S. Ramkumar  
 D. K. Ravindra (*Head*)  
 P. Sandhya  
 G. Sarabagopalan  
 M. Seethalakshmi (*up to 14.1.99*)  
 B.K. Udaya Shankar

**Visiting Scientist**

A. Krishnan (*from 7.10.98*)

**Trainees**

N. T. Madhusudana  
 S.P. Raghavendra (*up to 29.8.98*)  
 K.S. Raghavendra Prasad (*from 1.3.99*)  
 K. S. Srivani  
 S. Subhas Chandra  
 S. Sujatha (*from 30.11.98*)

**Secretarial**

V. Vidyamani  
 Mamata Bai

**TELESCOPE****Technical**

Antony Joseph (*on leave at Inter-  
 University Microelectronics Centre,  
 Leuven, Belgium*)  
 R. Ganesan

K. Gurukiran

K. Ramesh

S. Swarna

K. R. Vinod

**Trainee:** Bhupinder Misra

**ELECTRONICS & INSTRUMENTATION****Technical**

K. Chandrashekara  
 M. S. Ezhilarasi  
 S. Krishnamurthy  
 H. N. Nagaraja  
 A. Santhosh Kumar (*up to 16.11.98*)  
 M. Selvamani (*Head*)  
 C. Vinutha

**Trainees**

A. Atmacharan (*from 4.3.99*)  
 N. J. Kiran  
 Ranganatha  
 R. Srivatsa (*from 4.3.99*)

**COMPUTERS**

D. Bhattacharya (*Head*)  
 V. Devadas (*up to 25.9.98*)  
 Jacob Rajan (*from 14.9.98*)  
 Laxmish G. Bhat (*up to 8.6.98*)  
 R. Nanda Kumar  
 B. Sridhar

**Trainees**

S. Gangadhar Singh (*from 17.3.99*)  
 B. S. Jayatheertha (*up to 10.3.99*)

**LIBRARY**

Geetha S.  
Girija Srinivasan  
Hanumappa  
M. Manjunath  
M. N. Nagaraj  
A. Ratnakar (*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. Elumalai  
K.O. Francis  
K. T. Gangadharan  
(*In-Charge - General Workshop*)  
V. Gokula Chandran  
N. Gopal  
G. Gopi  
I. Henry  
P. Jayavelu  
M. Mani  
K. M. Mohandas

Manohar O. Modgekar  
(*In-Charge, Basement Workshop*)  
C. Mohammed Ateequlla  
(*In-Charge, Precision Workshop*)  
V. K. Muthu  
V. Nagaraja  
N. Narayanaswamy  
T. Puttaswamy  
M. Selvamani (*Head*)  
D. Sunand  
P. Srinivasa  
S. Sunderaj  
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*)  
K. Krishnama Raju (*Dy. Admn. Officer*)  
S. Raghavachar (*Asst. Admn. Officer*)

R. Ganesh  
L.P. Kumar  
Marisa D'Silva  
K. Radha  
V. Raveendran  
A. Savitha Rao

**ACCOUNTS**

R. Ramesh  
K. R. Shankar (*Accounts Officer*)

S. Srinivasa Murthy  
P.V. Subramanya

**PURCHASE**

Lakshmi Rajagopal (*Purchase Officer*)  
Sowjanya Kumar

B. Srinivasa Murthy  
Sujatha Anil Kumar

**STORES**

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

M.V. Subramanya

**GRAPHIC ARTS**

Raju Varghese  
C. Ramachandra Rao  
(*Consultant up to 31.12.98*)

**ESTATE & BUILDINGS**

S. Anantha Raman  
R. Anantha Subba Rao (*Consultant*)  
K. Bhoopalan  
P.S. Damodara Raju  
D. Gangappa  
Gunashekar  
C. Haridas

K. Palani  
C. Sampath  
R. Sasidharan (*Supervisor*)  
S. Sridhar  
K.N. Srinivas  
T. Subramaniam Naidu  
G. B. Suresh (*Civil Engineer*)

**Secretarial**

V. Raghunath

**CARPENTRY**

M. Gopinath  
K. M. Lakshmanan (*In-Charge*)  
V. Muniraju  
L. Muthu

P. Navaneetha Raju (*up to 15.3.99*)  
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 (*Horticulture Supervisor*)  
 Lakshamma  
 Lingegowda  
 Maiga  
 Mailarappa

Marappa  
 Munilakshmi  
 D. Muniraja  
 S. Muniraju  
 P. N. Sachidananda (*Consultant*)  
 Thimmarayappa

**UPKEEP**

Hanumantha  
 Jayamma  
 K. N. Kawalappa  
 D. Krishna  
 C. Lakshamma  
 Munihobalaiah  
 T. Murali

A. Ramanna  
 Rangalakshmi  
 Ranjithamma  
 Saroja  
 Varalakshmi  
 V. Venkatesh

**SECURITY**

V. Arputha Raj (*In-charge*)  
 B. M. Basavarajaiah  
 U. A. Earappa  
 H. Gangaiah  
 Govind K. Kundagol  
 K. Govindappa  
 Joseph Kunjachan  
 Keshavamurthy

K. Krishnappa  
 D. Mahalinga  
 K. Pushparaj  
 O. M. Ramachandra  
 G. Ramakrishna  
 M. Sannaiah  
 Suresha  
 H. Vaderappa

## VISITORS

G.V. Vijayagovindan School of Pure & Applied Physics Mahatma Gandhi University Kottayam, Kerala	9-23 April 1998
P. Hariharan CSIRO Division of Applied Physics Sydney, Australia	15-20 April 1998 & 4-12 March 1999
J. H. Seiradakis University of Thessaloniki Greece	18 April - 31 May 1998
Sai Iyer Physical Research Laboratory Ahmedabad	1-31 May 1998
R. A. Vora M. S. University of Baroda Vododara	7-8 May 1998 & 15-16 November 1998
Govind Swarup National Centre for Radio Astrophysics TIFR, Pune	21-24 May 1998
Krishnaswamy Alladi University of Florida U S A	13 July 1998
J. V. Narlikar Inter-University Centre for Astronomy & Astrophysics, Pune	16-18 July 1998
T. R. Anantharaman National Physical Laboratory New Delhi	16-20 July 1998
R. Ramachandran Institute of Mathematical Sciences Chennai	17-19 July 1998

Madan Rao Institute of Mathematical Sciences Chennai	29 July - 4 August 1998
Shiv Sethi Mehta Research Institute Allahabad	11 Aug - 10 Sept. 1998
Jagat B. Shakya Tribhuban University Kritipur, Kathmandu, Nepal	1 Sept. - 31 Dec. 1998
Puragra Guhathakurta UCO/LICK Observatory University of California Santa Cruz, U S A	3-4 September 1998
Bill Sutherland University of Utah Salt Lake City, USA	21-23 September 1998
S. Sachdev Department of Physics Yale University New Haven, USA	13-19 September 1998
Pier A. Mello Institute of Physics Universidad Nacional Autonoma de Mexico, Mexico	19 Oct. - 18 Nov. 1998
Hideo Takezo Tokyo Institute of Technology Japan	15-21 October 1998
J. Watanabe Tokyo Institute of Technology Japan	15-21 October 1998
J. Yamamoto University of Tokyo Japan	16-20 October 1998

- G. Baskaran 28 October 1998  
Inst. of Mathematical Sciences, Chennai
- Agnes Buka 1-5 November 1998  
Hungarian Academy of Sciences  
Budapest, Hungary
- L. Kramer 1-5 November 1998  
University of Bayreuth, Germany
- Kapeeshwar Krishna 3 November 1998  
University of Pennsylvania  
U S A
- A. Jayaraman 6-7 November 1998  
Hawaii Institute of Geophysics  
University of Hawaii at Manoa  
Honolulu, USA
- Alexander A. Salnikov 10 November 1998 -  
Lebedev's Physical Institute 31 March 1999  
Moscow, Russia
- Sankar Ghosh 12-14 November 1998  
Yale University  
New Haven, USA
- Horia Metiu 18 November 1998  
University of California  
Santa Barbara, USA
- Arjun Yodh 20 November 1998  
University of Pennsylvania  
U S A
- P. Pincus 20 November 1998  
University of Pennsylvania  
U S A
- Huang Keliang 9 December 1998  
Li Xioqing  
Peng Qiuhe  
Qiu Yuhai  
Qiao Guojun **Chinese Delegation**

Darrel Emerson National Radio Astronomy Observatory Tucson, USA	9-18 December 1998
Philippe Raffin ASIAA Taipei, Taiwan	10-20 December 1998
M. Muthukumar University of Massachusetts Amherst, USA	22 Dec. 1998 - 1 Jan. 1999
Yashwant Singh Banaras Hindu University Varanasi, India	23-31 December 1998
W. Helfrich Institut für Theoretische Physik FB Physik Berlin, Germany	26 Dec. 1998 - 5 Jan. 1999
A.J. Libchaber The Rockefeller University, New York, USA	26 Dec. 1998 - 1 Jan. 1999
C. Oldano Politecnico di Torino, Torino, Italy	26 Dec. 1998 - 2 Jan. 1999
G. Durand Laboratoire Physique des Solides, Orsay, France	26 Dec. 1998 - 13 Jan. 1999
H. Eugene Stanley University of Boston, USA	27-31 December 1998
J. Prost Institut Curie, Paris, France	27 Dec. 1998 - 2 Jan. 1999
Satyendra Kumar Kent State University, Kent, Ohio, USA	27-31 December 1998
M. Kleman Universite de Paris, Paris, France	28 Dec. 1998 - 3 Jan. 1999
S. Kobayashi Science University of Tokyo, Japan	28-31 December 1998

- L. Woltjer  
Observatoire de Haute Provence  
St. Michel l'Observatoire  
France  
29 Dec. 1998 - 11 Jan. 1999
- Thierry Courvoisier  
Geneva Observatory  
Switzerland  
2-15 January 1999
- N. Kenkre  
University of New Mexico  
U S A  
3-5 January 1999
- Philip Campbell  
Editor, Nature, U. K.  
5-8 January 1999
- A. Peerially  
Pro-Vice Chancellor  
Mauritius University  
Mauritius  
11-14 January 1999
- E. P. J. van den Heuvel  
Astronomical Institute  
University of Amsterdam  
The Netherlands  
12-13 January 1999
- N. Panchapakesan  
Delhi University  
15-16 January 1999
- Richard P. Riesz  
Pleasant Hill, USA  
18-19 January 1999
- Arun Mangalam  
Inter-University Centre for Astronomy &  
Astrophysics, Pune  
24 Jan. 14 Feb. 1999
- Maurice Dodson  
University of York, UK  
26-28 January 1999
- S. Raychaudhury  
Inter-University Centre for Astronomy &  
Astrophysics, Pune  
31 Jan. - 5 Feb. 1999

- Yoseph Imry  
Weizmann Institute  
Rehovot, Israel  
1-3 February 1999
- G. Rajasekaran  
Institute of Mathematical Sciences  
Madras  
1-3 February 1999
- Alak Ray  
Tata Institute of Fundamental Research  
Bombay  
9-11 February 1999
- P.B. Sunil Kumar  
Max-Plank Institut für Kolloid- und  
Grenzflächenforschung Abteilung Theorie  
Teltow, Germany  
11-18 February 1999
- Jouteux Stephane  
University of Nice-Sophia Antipolies  
Nice Cedex, France  
16 Feb. - 10 May 1999
- Radhika Vatsan  
Institute of Mathematical Sciences  
Chennai  
18 Feb. - 18 March 1999
- Joanna Rankin  
University of Vermont in Burlington  
USA  
1 March - 10 June 1999
- Gautam I. Menon  
Institute of Mathematical Sciences  
Chennai  
17-26 March 1999

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- 2 "Geometric phase for a dimerized disordered continuum: Topological shot noise" (Prabhakar Pradhan and N. Kumar) *Europhys. Lett.*, **44**, 131 (1998).
- 3 "Effect of Landauer's blow-torch on the equilibration rate in a bistablepotential" (Mulugeta Bekele, S. Rajesh, G. Ananthakrishna and N. Kumar) *Phys. Rev. E*, **59**, 143 (1999).
- 4 "Temperature measurement of the cold cloud of atoms" (Ramachandran) *Current Science*, **76**, 213 (1999).
- 5 "Four-photon interference: A realizable experiment to demonstrate violation of EPR postulates for perfect correlations" (P. Hariharan, J. Samuel and Supurna Sinha), *J. Opt. B: Quantum and Semiclassical Optics*, **1**, 199 (1999).
- 6 "Lippmann photography or Lippmann holography?" (P. Hariharan), *J. Mod. Opt.*, **45**, 1759 (1998).
- 7 "Laser cooling and trapping of ions and atoms" (R. Srinivasan), *Current Science*, **76**, 183 (1999).
- 8 "Quantum fields at any time" (Charles G. Torre and M. Varadarajan) *Phys. Rev.*, **D 58**, 064007 (1998).
- 9 "Quantum theory of geometry: III. Non-commutativity of Riemannian structures" (Abhay Ashtekar, Alejandro Corichi and Jose A. Zapata) *Class. Quantum Grav.*, **15**, 2955 (1998).
- 10 "Longitudinal spontaneous polarization and longitudinal electroclinic effect in achiral smectic phases with bent-shaped molecules" (Arun Roy, N.V. Madhusudana, P. Toledano and A.M. Figueiredo Neto) *Phys. Rev. Lett.*, **82**, 1466 (1999).



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- 12 "Stability of the uniform alignment of lyotropic nematic liquid crystals doped with magnetic grains" (G. Barbero, A.M. Figueiredo Neto and N.V. Madhusudana) *Physics Letters*, **A251**, 373 (1999).
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- 14 "Hydrodynamics of smectic C liquid crystals: Field and flow induced instabilities in confined geometries" (Sreejith Sukumaran and G.S. Ranganath) *Phys. Rev.*, **E57**, 5597 (1998).
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- 18 "Visco-elastic modes in some ferroelectric liquid crystals" (Yuvaraj Sah and K.A. Suresh) *Liquid Crystals*, **24**, 701 (1998).
- 19 Synthesis and mesomorphic properties of some esters of *trans*-4-*n*-alkoxy-cinnamic and *trans*-4-*n*-alkoxy- $\alpha$ -methylcinnamic acids exhibiting ferroelectric and antiferroelectric phases" (N. Kasthuraiah, B.K. Sadashiva, S. Krishna Prasad and Geetha G. Nair) *Liquid Crystals*, **24**, 639 (1998).
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- 45 "Limits on dust and metallicity evolution of Lyman- $\alpha$  forest clouds from COBE" (A. Ferrara, B. Nath, S. Sethi and Y. Shchekinov) *Mon. Not. Roy. Astron. Soc.*, **303**, 301 (1999).
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- 47 "Modelling the 10-image lensed system B1933+503" (S. Nair) *Mon. Not. R. Astron. Soc.*, **301**, 315 (1998).

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- 7 " $2n\pi$  anholonomies in phase of an evolving wavefunction" (Rajendra Bhandari) **in** *Annual Meeting of the Division of Atomic, Molecular and Optical Physics of the American Physical Society, Santa Fe, New Mexico, May 1998 - Bull. Am. Phys. Soc.*, **43**, 1248 (1998).
- 8 "Detection of radio emission from pulsars" (D. Bhattacharya) **in** *Proceedings of the Nato ASI on the Many Faces of Neutron Stars*, eds. R. Buccheri, M.A. Alpar and J. Van Paradijs (Kluwer Academic Publishers, 1998), p.103
- 9 "Applications of radio pulsar population synthesis" (F. Verbunt, J.W. Hartman, D. Bhattacharya, R.A.M.J. Wijers and G. Nelemans) **in** *Proceedings of the Academy Colloquium on Pulsar Timing, General Relativity and Internal Structure of Neutron Stars*, eds. Z. Arzoumanian *et al.* (Royal Netherlands Academy of Arts and Sciences, Amsterdam, 1999), p.215.
- 10 "Kinematics of low-mass X-ray binaries and millisecond pulsars" (R.Ramachandran and D. Bhattacharya) **in** *The Many Faces of Neutron Stars*, eds. R. Buccheri *et al.* (Kluwer Academic Publishers, 1998), p. 229.
- 11 "Models for the evolution of neutron star magnetic fields" (D. Bhattacharya) **in** *Proceedings of the Academy Colloquium on Pulsar Timing, General Relativity and Internal Structure of Neutron Stars*, eds. Z. Arzoumanian *et al.* (Royal Netherlands Academy of Arts and Sciences, Amsterdam,1999), p.235.
- 12 "Shape of pulsar beams revisited" (D. Mitra and A.A. Deshpande), **in** *Proceedings of the 18<sup>th</sup> meeting of the Astronomical Society of India, Ahmedabad, 1997 - Bull. Astron.Soc.India*, **27**, 203 (1999).
- 13 "New pulsar observations using the Gauribidanur Radio Telescope" (Ashish Asgekar and A.A. Deshpande) **in** *Proceedings of the 18<sup>th</sup> meeting of the Astronomical Society of India, Ahmedabad, 1997 - Bull. Astron.Soc.India.*, **27**, 209 (1999).
- 14 "Geometrical constraints on pulsar emission-II" (R.C. Kapoor and C.S. Shukre) **in** *Proceedings of the 18<sup>th</sup> meeting of the Astronomical Society of India, Ahmedabad, 1997 - Bulletin of Astron. Soc. India*, **27**, 207 (1999).
- 15 "Detection of 6 new 107 GHz methanol masers" (B. Ramesh) **in** *Proceedings of the 18<sup>th</sup> meeting of the Astronomical Society of India, Ahmedabad, 1997 - Bulletin of Astron. Soc. India*, **27**, 199 (1999).

- 16 "Noise and interferometry" (V. Radhakrishnan) in *Synthesis Imaging in Radio Astronomy, ASP Conference Series, Vol. XXX*, eds. G.B. Taylor, C.L. Carilli and R.A. Perley (1998)
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- 18 "Photoelectric heating for dust grains at high redshift" (B.B. Nath, S. Sethi and Y. Shchekinov) in *Proceedings of the Thirteenth IAP Colloquium "Structure and Evolution of the Intergalactic Medium from QSO Absorption Line Systems"*, eds. P. Petitjean and S. Charlot (Nouvelles Frontieres, Paris, France, 1998)
- 19 "qq' → qq' A second look at the IR-divergences" (Sushan Konar and A.K. Ganguly) in *Physics and Astrophysics of Quark-Gluon Plasma*, eds. B.C. Sinha, D.K. Srivastava and Y.P. Viyogi (Narosa Publishing House, New Delhi, 1998), p. 581.

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- 3 "Can great discoveries be orchestrated?" (S. Ramaseshan) *Current Science*, **76**, 273 (1999).
- 4 "Vibrations of a fractal membrane" (G.S. Ranganath) *Resonance*, **3**, 58 (October 1998).
- 5 "Crossing bridges" (J. Samuel) *Resonance*, **4**, 23 (January 1999).

- 6 "Farthest ever galaxy discovery: When the universe was young" (Biman Nath) *Resonance*, 3, 76 (June 1998)
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- 5 "Diffraction in heterogeneous liquid crystals" (K.A. Suresh, G.S. Ranganath and M.S. Giridhar) *Current Science*
- 6 "A simple demonstration of the Pancharatnam phase as a geometric phase" (P. Hariharan, Sushil Mujumdar and Hema Ramachandran) *J. Mod. Opt.*
- 7 "Two-dimensional imaging through turbid media using a continuous wave light source" (Hema Ramachandran and Andal Narayanan) *Opt. Comm.*, **154**, 255 (1998).
- 8 "The effect of magnetic fields on  $\gamma$ -ray bursts inferred from multi-wavelength observations of the burst of 23 January 1999" (G.J. Galama *et al.*, 41 authors including D. Bhattacharya) *Nature*
- 9 "Evolution of multipolar magnetic field in isolated neutron stars" (D. Mitra, S. Konar and D. Bhattacharya) *Mon. Not. R. Astron. Soc.*
- 10 "Magnetic field evolution of accreting neutron stars - III" (S. Konar and D. Bhattacharya) *Mon. Not. R. Astron. Soc.*
- 11 "Revisiting the shape of pulsar beams" (D. Mitra and A.A. Deshpande) *Astron. & Astrophys.*
- 12 "Pulsar magnetospheric emission mapping: Images and implications of polar-cap weather" (A.A. Deshpande and J.M. Rankin) *Astrophys. J.*
- 13 "On the different radio source populations in the Butcher-Oemler clusters Abell 2125 and 2645" (K.S. Dwarakanath and F.N. Owen) *Astrophys. J.*
- 14 "What does the sky look like at long wavelengths?" (K.S. Dwarakanath) - Invited article - *American Geophysical Union*



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- 1 "On the origin of metallicity in Lyman- $\alpha$  forest systems" (M. Chiba and Biman Nath) IAU Symposium 187 'Cosmic Chemical Evolution', Kyoto, Japan, 1997.
- 2 "Cosmology with the intergalactic medium" (B. Nath) Invited - Observations confront theories: Workshop on Cosmology, IIT, Kharagpur, January 1999 - *Proceedings as an issue of Pramana.*

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

COLLOQUIA

Name	Title	Date
Chandan Dasgupta Indian Inst. of Science Bangalore	Thermodynamic and structural properties of randomly pinned vortices in layered superconductors	2.4.1998
Marc-Oliver Mewes Ecole-Normale Superiore Paris, France	Atom lasers and experiments with Bose- Einstein condensation	7.4.1998
M. S. Valiathan Manipal Academy of Higher Education Manipal	<b>Golden Jubilee Colloquium:</b> The British view of India: Science and Technology in early 18 <sup>th</sup> century	17.4.1998
P.S. Ramkumar Raman Research Inst. Bangalore	Reconfigurable circuits in signal processing	30.4.1998
John H. Seiradakis University of Thessaloniki Greece	Probing the structure of the cone of radiation of pulsars	1.5.1998
S. Dattagupta Jawaharlal Nehru Univ. New Delhi	Quantum-classical crossover in orbital Magnetism	22.5.1998
S. Ramaseshan Raman Research Inst. Bangalore	Why materials are weak?	22.5.1998
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Kiran Kolwankar Indian Inst. of Science Bangalore	From fractional differentiability to fractional Fokker-Planck equation	20.7.1998
Rohan Mahadevan Institute of Astronomy Cambridge, U K	A supermassive black hole at the galactic centre: Advection and the need for a two temperature plasma	28.7.1998
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J. L. Osborne University of Durham U K	Recent results from the Durham atmospheric Cherenkov telescopes	7.8.1998
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L. Kramer University of Bayreuth Germany	Travelling roll electroconvection in nematic liquid crystals	3.11.1998
Kapileshwar Krishna Univ. of Pennsylvania U S A	One- and two-dimensional ordered aggregates in a particle-mixed surfactant system	4.11.1998
Pier A. Mello Instituto de Fisica UNAM, Mexico	Some results in the theory of quantum chaotic scattering	9.11.1998
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Albert J. Libchaber The Rockefeller University U S A	<b>Golden Jubilee Colloquium:</b> Biology and information theory	30.12.1998
N. Kenkre Univ. of New Mexico U S A	Four stages in the theory of electron- phonon interaction: Description of nonlinear Schrödinger equation and memory formulation	4.1.1999
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Alain Aspect Institut d'Optique Orsay, France	Experimental tests of the foundations of quantum mechanics	7.1.1999
E.P.J. van den Heuvel Astronomical Institute Univ. of Amsterdam The Netherlands	Cosmic Gamma-ray bursts and the BEPPO-SAX Satellite	12.1.1999
Hema Ramachandran Raman Research Institute Bangalore	Imaging through turbid media	21.1.1999
Mark Pitter Univ. of Nottingham The Netherlands	Heterodyne detection of coherent back-scattering	22.1.1999
R. Ramachandran Univ. of Amsterdam The Netherlands	First results from PuMa, the Westerbork pulsar machine	15.2.1999
P.B. Sunil Kumar Max-Planck Institut für Kolloid- und Grenzflächen- forschung Abteilung Theorie, Germany	Dynamics of budding in a two- component fluid membrane	18.2.1999

Name	Title	Date
Radhika Vatsan Inst. of Mathematical Sciences, Chennai	1 Many-particle clusters in two- dimensions: Classical ground semi- classical states and corrections	23.2.1999
	2 Generalized black-hole mechanics for 'Isolated horizons'	8.3.1999
Arun Mangalam Inter-University Centre for Astronomy & Astro- physics, Pune	Formation of proto-quasars	26.2.1999
P. Hariharan CSIRO, Sydney Australia	Interferometric measurements of deviations from flatness: Some new techniques	9.3.1999
V. Balakrishnan Indian Institute of Technology, Chennai	Quantum revivals and classical recurrences	19.3.1999
Gautam I. Menon Institute of Mathematical Sciences, Chennai	Interacting Brownian motors	23.3.1999

JOURNAL CLUB

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V. A. Raghunathan & D. Bhattacharya	Liquid crystals in the mantles of neutron stars C.J.Pethick & A.Y. Potekhin, Astro-Ph./9803154 (1998)	9.4.1998
C. Indrani	Two distinct populations of Kuiper-belt objects S.C.Tagler & W. Romanishin, Nature, <b>392</b> , 49 (1998)	23.4.1998
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## ABBREVIATIONS USED

GRB	Gamma Ray Burst	
GMRT	Giant Metrewavelength Radio Telescope	
IDL	Interactive Display Language	
LCD	Liquid Crystal Display	
MRT	Mauritius Radio Telescope	
M82	Messier 82	Refer to diffused non-stellar objects, e.g., nebulae, galaxy, etc.
NGC253	New General Catalogue 253	
PSR	Pulsating Source of Radiation	
0943+10	Right Ascension 9 hours 43 minutes and Declination 10 degrees north	
STM	Scanning Tunneling Microscope	
SUSY	SuperSymmetric	
3.5PN	3.5 order Post-Newtonian	
TGB	Twist Grain Boundary	
TGB <sub>C*</sub>	Undulating Twist Grain Boundary Chiral smectic C	
UPSO	Uttar Pradesh State Observatory	
UTP	Unshielded Twist Pair	
VLBA	Very Large Baseline Array	
VLBI	Very Large Baseline Interferometry	