# RAMAN RESEARCH INSTITUTE
## Bangalore

## Annual Report 1996-97

The work carried out in the Institute during the year 1996-97 is summarized below. It has been broadly classified under Theoretical Physics, Experimental Optics, Liquid Crystals, Astronomy and Astrophysics and Instrumentation for Radio Astronomy.

# THEORETICAL PHYSICS (TP)

AREAS OF RESEARCH
General Relativity
Quantum Physics
Optics

**General relativity**: One of the longstanding problems of general relativity has been the consistent description of the generation of gravitational waves and the reaction on the motion of the source, order by order in perturbation theory. This has acquired new significance with the worldwide efforts to detect gravitational waves with laser interferometers, in particular those emitted by binary star systems of two inspiraling compact objects. The balance between the loss of energy and angular momentum from a binary system with the flux of these quantities carried by gravitational waves at infinity is an important constraint on the post-Newtonian formalism. This was already used earlier to determine the structure of the radiation reaction terms in the equations of motion, and this work has now been refined to two orders beyond the Newtonian.

The waveforms predicted by this formalism are expressed as a series in powers of (v/c) and any inaccuracies translate into loss of detection efficiency, when these "templates" are cross correlated with observational data. It has been shown that appropriate change of variables and Pade approximants make good use of the available terms in the series to obtain better and more stable results than simple truncation at a given order.

Quantum Physics: The physical states of a quantum system are rays in its Hilbert space, i.e. collections of vectors differing only by an overall phase factor.

Such a ray space of a quantum system admits transformations preserving the natural notion of distance between two physical states, viz the probability of being detected in one when prepared in the other. Wigner's basic theorem classifying such transformations has now been given a concise proof in a framework involving the geometric phase, a concept which has received wide attention and application since its introduction by Berry in 1984.

The ray space of a three-state system was represented in a manner analogous to the Poincaré sphere, using spinorial methods. The essential idea is that such a system can be thought of as a spin one system and built up from two spin half systems. Useful geometric properties of the representation were derived.

The dynamics of a free scalar field in Minkowski space was studied in an arbitrary foliation (time-slicing). The motivation was to use this system as a toy model to study more general issues which arise when quantum mechanics combines with general relativity.

There has been considerable interest in random matrix models which seem to capture universal features of complex quantum systems such as atomic nuclei, mesoscopic electronic systems, etc. One important property of such a model is the fluctuation in the density of eigenvalues, described by correlation functions. These eigenvalue correlators were derived for a random matrix model with two symmetric and separate humps in its average density of states (the so called two-cut model).

The high temperature superconductors based on layered cuprates have remarkable and anisotropic properties in the normal state as well. An earlier phenomenological treatment of c-axis normal state resistivity in these systems was confirmed via the Kubo formalism applied to a model of interlayer tunneling and intralayer scattering.

There is now considerable interest in mesoscopic systems, in which the finite size and specific random configuration show their effects in measurable fluctuations in their electronic properties. These are distinct from the more familiar thermal fluctuations. The sample-to-sample fluctuations of the capacitance of disordered coherent conductors were studied. These were related to the probability distribution of the inverse level spacing. There are possible applications to 1/f noise and the spectrum of relaxation times in these systems.

# EXPERIMENTAL OPTICS (EO)

A comprehensive review of geometric phases in polarisation optics was completed. A half wave retarder for a general pair of orthogonal elliptic states was proposed using a configuration consisting of a rotator between two quarter-wave plates. There is a parallel between the action of Lorentz transformations on the directions of light beams and the action of complex birefringence (i.e., including absorption) on polarisation states represented on the Poincaré sphere. This was exploited to demonstrate the equivalent of the well known "Thomas precession" of special relativity in polarisation optics.

**The geometric phase:** A Sagnac interferometer was set up to demonstrate the Pancharatnam phase. This work was novel in that the shift in the interference pattern resulted purely from a change in the geometric phase and that a cholesteric liquid crystal was used as a circular analyser. While most earlier experiments are confined to special trajectories on the Poincaré sphere, the use of the cholesteric liquid crystal, which can act as a circular, elliptic, or linear analyser, permits any trajectory on the Poincaré sphere.

**Lasing in random amplifying media:** With the recent observation of enhanced emission and significant line narrowing from a dye with suspended submicron-sized scatterers, there has been a growing interest in what is popularly termed "mirrorless lasing". The multiple scattering of the photon in the random medium enhances its path length in the amplifying medium, resulting in increased emission, and associated gain narrowing. In collaboration with the Department of Physics, Indian Institute of Science, emission from the rhodamine-water system with polystyrene microspheres was investigated. Despite this system being a poor candidate for "mirrorless lasing" from gain and scattering considerations, the highest reported enhancement of emission (of a factor of over 1000) and significant line narrowing were found. This was seen even in systems of size smaller than the transport mean free path of the photon, in which the diffusion approximation is not valid. A probabilistic model was developed where the statistically rare sub-meanfree path scatterings (which are normally neglected) become important because of the gain of the medium.

Coherent Back-scattering: As a first step towards studying coherent backscattering in systems of anisotropic scatterers like liquid crystals, the necessary apparatus has been set up and coherent back-scattering from a colloidal suspension of polystyrene microspheres was measured.

Imaging through turbid media: A light pulse of short duration on traversing a turbid medium gets elongated in time because the photons take varying times to traverse the medium, depending on whether they travel through unscattered (ballis-

tic photons), or are slightly scattered (snake photons) or are significantly scattered (diffuse photons). Imaging through the turbid medium is possible by gating the emergent pulse so as to separate the information-carrying ballistic photons from the diffusive. However, this requires ultrashort pulses and fast switching electronics. Recently, the polarization characteristics of the scattered light has been used to image through turbid media using low power continuous wave sources like He-Ne lasers. Such a system has been set up, and modification of this to permit rapid two-dimensional imaging instead of the pin-hole scan is underway.

# LIQUID CRYSTALS LABORATORY (LC)

## Experimental Studies

**Electric field-temperature phase diagram of a reentrant mixture:** It is now well established that several compounds with highly polar cyano end groups exhibit the phenomenon of *reentrance*. Typically the phase sequence on cooling is isotropic-nematic-smectic A-reentrant nematic. In the previous year, a new technique was developed for measuring high electric field ($\sim$ 600esu) phase diagrams of liquid crystals, in which the *local* temperature of the sample is measured using an evaporated nickel sensor to take into account the inevitable heating due to ionic flow in the medium. The first measurement of the electric field phase diagram on a reentrant liquid crystalline mixture was conducted using light scattering, dielectric and resistance measurements to detect the smectic A to nematic transition temperatures. The temperature range of the smectic A phase was found to shrink with field implying that it would get bounded at higher fields.

**Effect of a strong electric field on a highly polar nematogen: Evidence for polar short range order:** High electric field experiments on a compound with a very large dielectric anisotropy ($\delta\epsilon \sim 20$) have yielded many new results. As the temperature was lowered, the dielectric anisotropy under a low field was found to increase much faster than warranted by that of the order parameter as measured by the magnetic susceptibility data on the same compound. The orientational order parameter was found to be strongly enhanced by the external field even at low temperatures, i.e, the relevant apparent susceptibility was unusually large. The third harmonic signal which is a measure of the susceptibility was used to locate the electric field induced critical point of the nematic to field induced paranematic phase transition. The electrical conductivity was found to exhibit a peak, but at a temperature $\sim 0.4^oC$ below the critical temperature. The result was interpreted in terms of the critical slowing down of *polarised domains* in the nematic. Indeed the observation of a weak but measurable peak in the second harmonic signal at the critical point confirms that a fraction of molecules in the medium have a *polar short range order*, which has been observed for the first time. This result indeed agrees with the prediction of a molecular theory of such polar compounds developed in the laboratory sometime ago, which requires the presence of such a polar order.

**A new AC technique to measure flexoelectric coefficients of nematics:** The flexoelectric properties of nematics were shown to significantly influence the electrohydrodynamic instabilities in work reported from the laboratory some years ago. As the felexoelectric energy density depends linearly on the director curvature, its influence is felt only as a surface torque and in the usual samples with fixed boundary

conditions it does not influence the director profile. As such there have been very few attempts to measure them. A new technique was proposed from the laboratory some time ago in which the AC electrooptic response of a hybrid aligned liquid crystal cell is measured. A detailed theoretical analysis of the time dependent response of the director profile has been made to demonstrate that it is indeed a good technique to measure (i) the flexoelectric coefficient (ii) the surface anchoring energies at both the plates and (iii) the rotational viscosity coefficient. The temperature variations of all the parameters have been measured to illustrate the usefulness of the new technique.

**Chiral symmetry breaking in smectic C drops:** In smectic C liquid crystals long axes of achiral molecules are tilted with respect to the layer normal and the structure itself is nonchiral. A unique type of spontaneous chiral symmetry breaking was discovered in the laboratory in 3D *domains* of smectic C liquid crystals, in which a bent configuration of the C-director field in each layer produces a twist across the layers. The sign and magnitude of the relevant coupling coefficient could be determined by this experiment. The effect of an external chiral bias field was shown to favour domains of one handedness.

**Liquid crystals at the air-water interface:** Many liquid crystal compounds have amphiphilic character and can be spread as monolayers at the air water interface. In the siloxane polymer 1-methyl propyl 4(4′ - hexyloxy benzoyloxy) benzoate with about 40 monomer units each unit has amphiphilic character. Earlier pressure area studies on the monomers had indicated many steps interspersed with plateaus, which were attributed to monolayer formation. In the studies conducted on the polymer, however, no evidence for the formation of a liquid crystalline phase was found. On the other hand, new structures which are sensitive functions of temperature and surface pressure have been found. At room temperature, striations which changed to a melted stripe structure were seen. Detailed studies on this system are in progress.

In order to explore the influence of mixing on the formation of monolayers, studies on mixtures of 4′-n-octylcyanobiphenyl and stearic acid have been undertaken. Over a wide range of compositions the mixtures exhibit a liquid condensed phase which is not seen in either of the pure components. Further studies on this system are in progress.

**Structure of ripple phase in lipid water systems:** The ripple phase is a stack of undulating bilayers exhibited by many lipid-water systems. In the recent past two theoretical models have been proposed to explain such a phase, and predict different shapes of the bilayers. However no detailed comparisons with experiments are available as yet. The structure factors for different shapes of the bilayers in the ripple phase are now being calculated in the laboratory to make contact with experimental observations and hence to test the validity of different theories.

**Xray scattering studies on columnar mesophases:** These studies were undertaken on some rufigallol derivatives synthesised by scientists at the Inorganic and Physical Chemistry Department of IISc. The monomeric compounds were found to exhibit 2D hexagonal ordering. On the other hand the main chain polymers show an additional mesophase whose structure is now being investigated.

**Synthesis of mesogenic compounds:** Several different types of compounds have been synthesised during the year in an attempt to get different types of mesogens. In particular some compounds have been shown by texture studies to exhibit the columnar *and* the cubic phases. The cubic phases are 3 dimensionally organised supramolecular structures which occur usually between the smectic C and smectic A phases. Only a handful of compounds are known to exhibit this phase and a detailed structural characterisation has not yet been possible. The availability of new compounds exhibiting this phase gives on opportunity to take up detailed x-ray and other physical studies in the hope of understanding the detailed molecular organisation in the cubic phase.

A new homologous series of chiral compounds has been synthesised. Some of the homologues exhibit the twist grain boundary TGBA phase, in addition to other mesophases. Studies are in progress to identify these mesophases.

**New addressing techniques for liquid crystal displays:** Liquid Crystal Displays (LCDs) are ideally suited for use in portable oscilloscopes, wave form synthesisers and other instruments in which only restricted patterns are displayed. One scheme for addressing such displays was proposed in a work done in the laboratory some years ago. This scheme has now been further improved by selecting *all* the lines simultaneously with orthogonal wave forms derived from pseudo random binary sequences. The advantage of the new technique is that the supply voltage can be rather low, and further, the contrast ratio is independent of the matrix size but depends only on the number of patterns displayed. Another new scheme in which only a few lines are selected at a time (the multiline selection scheme) is also being developed for displaying restricted patterns.

Indeed a multiline addressing technique for use with the usual LCDs was proposed in a work done in the laboratory long ago, and is now being used in addressing commercial STN displays which have a short relaxation time. A controller for exploiting this technique has been designed and developed in the laboratory. Flexibility in choosing the number of lines selected simultaneously, the number of lines multiplexed and the refresh rate has been incorporated in the design and a controller card compatible with IBM PC has been fabricated and tested.

**Electrochemical studies:** In a collaboration with Johns Hopkins University,

USA, detailed studies have been conducted on the kinetics of oxidation of methanol in acid media on platinum and platinum-ruthenium electrodes which act as catalysts. It has been found that the rate determining step in the electrochemical reaction is the dissociative chemisorption of methanol on the electrode. These studies were undertaken for developing a direct methanol fuel cell.

In another project under the above collaboration, a commercial STM has been used to obtain surface corrugation data to measure the true surface area of electrocatalysts like polished polycrystalline platinum.

The STM which was fabricated in RRI during the previous years is now being modified to improve the elimination of electrical noise so that a higher resolution can be obtained. It is also being modified to fabricate an electrochemical STM.

Studies on adsorption characteristics of azole compounds on the surface of copper in both neutral and alkaline media are being continued. The method is based on studying the transient relaxation using an interfacial capacitance measurement, a technique which was developed in the previous years.

The electroplating laboratory is providing service as usual in metal finishing jobs for a variety of components needed particularly in the GMRT project.

# Theoretical Studies

**A Chiral ANNNXY model for antiferroelectric liquid crystals:** Smectic C liquids with chiral molecules exhibit ferroelectric properties. In the past few years, many compounds have been found to exhibit a rich variety of phase transitions as they are cooled: Smectic A - smectic $C^*_\alpha$ - smectic $C^*_\beta$ - smectic $C^*_\gamma$ - smectic $C^*_A$. The $C^*_\beta$ phase is the ferroelectric phase. The $C^*_A$ phase is an antiferroelectric phase in which the molecules in successive layers tilt in opposite directions. The structures of the ferrielectric $C^*_\gamma$ phase and $C^*_\alpha$ are not yet clearly established. Indeed there was no theoretical model to account for the entire sequence of phase transitions exhibited by such systems. A phenomenological discrete model which can be described as a chiral axial next nearest neighbour XY (ANNNXY) model has been developed to predict for the first time the entire sequence of phases. Further, the effect of an external DC electric field has been calculated on various structures to demonstrate that the ferriphases exhibit a 2:1 structure under the action of field which accounts for the plateau observed in apparent tilt angle measurements in these phases. Detailed calculations have been made to construct the expected conoscopic figures on the basis of the model and they agree extremely well with the experimental observations. The results also demonstrate that the Ising models used in the literature to describe these phases are quite inappropriate.

**Molecular theory of liquid crystals made of highly polar compounds:** A molecular theory of the reentrant nematic phase exhibited by highly polar compounds was developed in the laboratory some years ago. The basic idea was that while dipolar interactions lead to an antiparallel interaction between neighbouring molecules which gives rise to a structure with a length $d$ between $l$ and $2l$ where $l$ is the length of the molecules, the dipole-induced dipole and the dispersion interactions between the chains favour a parallel configuration at higher densities. The model has been now been extended to obtain various other phase transitions: (i) a first order smectic $A_1$ to smectic $A_d$ phase transition across which the layer spacing jumps. As an appropriate parameter is varied, this transition ends in a critical point. (ii) nematic *lake* as a function of a parameter which is a measure of the strength of layering interaction. This lake is surrounded on all sides by the smectic phase. These phase diagrams are in broad accord with the available experimental data.

The theory has been recently extended to include the effect of an external electric field to obtain phase diagrams in which the smectic phase gets bounded as a function of the field, in accordance with the experimental results obtained in our laboratory as mentioned earlier.

**Dynamics of solitary waves in smectic C liquid crystals:** Subjecting liquid crystals to a rotating electric or magnetic field is a convenient way of studying their dynamics. Theoretical investigations have been taken up on the dynamics of kink states in smectic C liquid crystals under a rotating field. These are the permitted solitary waves in these systems. It was found that in the synchronous regime the solitary waves can undergo structural and dynamical instabilities. On the other hand in the asynchronous regime the solitary waves can end up in a chaotic state in certain ranges of the frequency of the rotating field. In a particular geometry, a rotating field leads to an oscillatory drift in the solitary wave.

**Optics of tapered lattices:** In some dynamical situations a solitary wave with a tapered lattice is found as a solution. These have a periodic structure superimposed on a gradual decrease in the director distortion. The optical properties of such structures have been investigated theoretically. The computed diffraction spectra are unusual and rather different from those of the usual periodic structures. The optical reflection is also highly asymmetric.

**Periodic instabilities in nematic liquid crystals:** When a destabilising electric or magnetic field is applied to a well aligned nematic liquid crystal sample, a periodic distortion can result above a threshold in some geometries. This arises either due to a large anisotropy in elastic constants or if the applied field is electric, either due to flexoelectric coupling or due to nonuniformity in the field arising from the dielec-

tric anisotropy of the medium. Continuing earlier theoretical calculations on such systems, the effect of a director pretilt on the threshold and other characteristics of the instabilities when both electric and magnetic fields are applied simultaneously to the cell have been investigated. If the pretilt from a homeotropic alignment is sufficiently large, the periodic instability is suppressed and a homogeneous deformation is favoured. The influence of a weak anchoring on such an instability has also been calculated to construct a detailed phase diagram of the instability threshold as functions of the electric and magnetic fields, the angle between them and the strength of anchoring energy.

# ASTRONOMY and ASTROPHYSICS (AA)

## Pulsars

*Pulse profiles*: Single-pulse studies on a few pulsars were continued using the available data from the Arecibo telescope along with a software package developed here for this purpose. Several interesting properties related to the pulse-drift phenomena were found. In particular, a tertiary modulation was found in the case of a well known "drifter" PSR 0943+10. Based on this and many other considerations, it was possible to estimate *the exact number of sparks on the polar cap ring that would explain the drift pattern observed.* More work on this and other aspects of phase and amplitude fluctuation properties is in progress (in collaboration with Joanna M.Rankin).

*Pulsar timing program with the Ooty Radio Telescope*: With a view to studying the *timing noise* in the pulse-arrival times of relatively long-period pulsars, a pulsar timing program was started with the Ooty Radio Telecsope. Observations of about 30 pulsars were made at monthly intervals over one year beginning from July 1995. This data was analysed and improved rotational periods, period derivatives (measured for the first time), as well as refined positions of 16 pulsars were estimated (in collaboration with V. Balasubramaniam).
Based on similar observations, and a comparison with some earlier data obtained during the last 20 years, it was possible to get a more accurate estimate of the proper motion of the pulsar PSR 1952+29. A more detailed investigation to assess if this pulsar is a member of a binary system is in progress (in collaboration with Joanna M. Rankin).
The new timing data on the 16 pulsars was examined for the presence of significant contribution from *timing noise.* In 8 cases the observed timing residuals showed variations more than that expected from the measurement uncertainty.

*Interstellar scattering*: Interstellar scatter broadening in the directions of 26 distant pulsars was estimated using the Ooty Radio Telescope. These measurements significantly improve on the available set of measurements for pulsars with dispersion measures in the range 100 to 250 pc $cm^{-3}$. These also sample an important section of the galactic volume which should enable better modelling of the electron density distribution. The dependence of the scatter broadening on the dispersion measure was modelled based on the new data combined with earlier similar measurements and a useful description for the turbulence level in the interstellar medium was suggested (in collaboration with D.M. McConnell & J.G. Ables).

*Radio emission from the* Geminga *pulsar*: Attempts were made to detect radio emission from the gamma ray pulsar *Geminga* at 327 MHz and 35 MHz

(from Ooty and Gauribidanur, respectively) and upper limits for the average flux density at these two frequencies were obtained. The limits of 0.4 mJy and 100 mJy at 327 MHz and 35 MHz, respectively, suggest that the flux density at 100 MHz is more likely to be about 8 mJy on the average, much lower than reported at that frequency by some Russian observers. The non-detection in our observations is probably due to the high variability in the emission from this pulsar. Alternatively, the spectral behaviour of this pulsar must be very unusual. Observations at 35 MHz are being continued.

*Ooty-Parkes simultaneous pulsar observations*: Simultaneous observations with the Ooty Radio Telescope and the Parkes telescope in Australia were made in the directions of 4 pulsars with a view to studying possible correlation in the pulse microstructure at 327 MHz and 610 MHz. The primary motivation, however, was to investigate the spectral characteristics of the narrow and intense features in the emission from the millisecond pulsar J0437-4715 which were detected in our earlier observations. This investigation is in progress (in collaboration with J.G. Ables & D.M. McConnell).

*Pulsar studies at 150 MHz*: Pulsar observations using the **Mauritius Radio telescope** were initiated with a new fast data acquisition system (DAS) and a tracking facility added to the telescope. Data analysis software was developed to allow flexible processing of the pulsar signals. The data reduction is in progress. The preliminary results, which include successful detections of nine pulsars, are very encouraging (in collaboration with Nalini Issur).

*Pulsar studies at 35 MHz revisited*: A Data Acquisition System, similar to the one for the Mauritius Radio Telescope, was built and installed at the Gauribidanur Radio Telescope and is being used for a more detailed study of pulsars at 35 MHz. The objective is to study about 40 pulsars at such a low radio-frequency. This goal may be attainable considering that the new system (with a 1 MHz bandwidth) is more sensitive – by a factor of 5 – compared to the earlier set up which could detect only about 8 pulsars.

*Coherent dedispersion of pulsar signals*: An expression for the phase corruption of pulsar signals due to dispersion in the interstellar plasma was derived in a closed form for very large signal bandwidths. This is a improvement upon expressions available so far in the literature which are correct only to the first order in Taylor expansion. Using this new expression, a coherent dedispersion software was developed and applied to baseband-sampled data collected using the Ooty Telescope. This software is now being used to analyse data obtained with the Mauritius and Gauribidanur telescopes.

*The electron density distribution in the Galaxy*: Attempts were made to

refine the model for the electron density distribution in the galaxy by re-examining the correlation obtained earlier between the pulsar distribution and the spiral structure in the Galaxy. The analysis indicates that the electron density within a few kiloparsec distance from the Sun may be significantly under-estimated in the model of Taylor & Cordes.

*Galactic magnetic field*: Modelling of the structure of the large-scale magnetic field in our galaxy using the available Faraday rotation measures in directions of pulsars and extra-galactic sources was undertaken. The new ingredient in the modelling is the recent description by Taylor & Cordes for the distribution of the electron density. Preliminary results suggest that the magnetic field structure may not mimic the electron density distribution.

*Methods for estimation of pulsar distances*: Possibilities of using different observables, related to the scattering of pulsar signals in the interstellar medium and the proper motion of pulsars, were examined for independently estimating distances to pulsars. This method was applied to pulsar PSR 1642-03 in the direction to which the distance to a possible dominant scatter is known. The distance to this pulsar estimated in this manner turns out to be about 2.5 times shorter than that implied by the dispersion measure. A more general description of these methods is being worked out.

*Pulsar velocities*: A careful re-examination of pulsar velocities and their possible correlations with other pulsar parameters was undertaken to assess the predictions implied by a recent suggestion for the origin of pulsar velocities. According to this the space velocity of pulsars may be due to asymmetry in the neutrino emission during the formation of a neutron star. In this model the magnitude and the direction of the asymmetric kick is determined by the star's magnetic field. This basic prediction was refined by taking into account several simple geometric considerations. It was found that the observed weak correlation between the magnetic field strength and the velocities of the pulsars does not contradict the model prediction. However, the tight match of the direction of the proper motion with the orientation of the rotation axis of the star expected in an earlier model was absent in the present case. A more quantitative assessment of these issues is being considered.

*Magnetic field evolution of neutron stars*: Influence of mass accretion on the magnetic flux expelled from the interior of a neutron star into the crust was investigated. Preliminary results indicate that it would be difficult to achieve a reduction in the surface magnetic field by more than a couple of orders of magnitude unless the impurity concentration in the inner crust is very high.

The possibility of the flow of a diamagnetic plasma on the surface of an accreting neutron star "screening" the magnetic field of the star was studied. Results indi-

cate that very strong Rayleigh-Taylor instabilities prevent such a screening. The net result is a flow of the matter across the magnetic field without any significant modification in the magnetic field structure.

A population synthesis study of the evolution of the isolated pulsar population in the Galaxy was performed. This is an update of an earlier study with better numerical code, much less restrictive assumptions and new data. The main results of the study were: (i) the population of isolated pulsars does not exhibit a significant decay of magnetic field strength during their active life time, (ii) the local OB associations can account for the entire pulsar birth rate in the solar neighbourhood, and (iii) a significant fraction of pulsars have space velocities below 100 km/s.

The novel model for the magnetic field evolution of neutron star that was advanced earlier viz., the expulsion of the magnetic flux frozen in the superconducting core in response to the spinning down of the neutron star was investigated in detail. Particular attention was paid to various forces acting on the fluxoids as they are dragged through the degenerate electron sea in the core. This included the viscous drag force due to electron scattering, buoyancy force, curvature forces on the fluxoids due to the pinning of their extremities in the core crust boundary. The final conclusions arrived at may be summarized as follows:

- Old solitary neutron stars are expected to have surface dipole field strengths $\sim 10^{11}$ G.

- Magnetic fields $\sim 5 \times 10^8$ G observed in millisecond pulsars can be understood in terms of the flux expulsion model.

- The observed fact that the overwhelming majority of millisecond pulsars have magnetic fields $\sim 5 \times 10^8$ G can be understood in terms of the maximum spin periods to which neutron stars in low mass binary systems are spun down. It turns out that the spin periods of neutron stars with low mass companions never exceed a value $\sim 10^4$ sec irrespective of the initial parameters of the binary system. It is this fact that results in a well defined lower limit to the magnetic fields of millisecond pulsars.

- The inclusion of various forces acting on the fluxoids as they are dragged out does not qualitatively alter the conclusions stated above. But they bring out the surprising result that if it were not for the pinning between the fluxoids in the proton superconductor and the vortices in the neutron superfluid, very old neutron stars – such as the progenitors of millisecond pulsars – will hardly have any residual magnetic fields. This is because of the efficacy of the buoyancy force; *it is the pinning of the fluxoids that acts as a brake.*

*Rotational dynamics of neutron stars*: In the standard theory of secular slowing down of neutron stars, as well as post-glitch relaxation, it is assumed in the literature that the neutron superfluid in the core will very quickly respond to changes in the angular velocity of the crust. This belief is predicated on the short coupling timescale between the core superfluid and the crust due to the magnetic scattering of the electrons off the vortex cores on the one hand, and the crust on the other. But this assumes that the vortex lattice in the core can rearrange itself in arbitrarily short timescales in response to the torque acting on the crust. It was pointed out that this is an over-simplification if the vortices in the neutron superfluid are strongly pinned to the quantized fluxoids in the proton superconductor. As suggested by an independent investigation referred to above, the observed magnetic fields of millisecond pulsars provide strong evidence for such an interpinning between the vortices and the fluxoids. If one takes this picture seriously then there are several interesting consequences for the rotational history of a neutron star. Indeed the phenomenon of glitch itself may be intimately related to the unpinning and repinning of the core vortices and the fluxoids. The observed phenomenon of timing noise in pulsars may also be related to this. Further investigations of this promising line of research are in progress.

**Recombination lines from starburst galaxies**: Using the parameters of the H92$\alpha$ recombination line detected towards NGC 660 and also other continuum measurements, constraints were derived for the properties of the ionized gas in the nuclear starburst region. The total ionized mass is $\sim 7 \times 10^4 M_\odot$ and the rate of production of UV photons is $N_{Lyc} \sim 10^{53}$ s$^{-1}$. The observed velocity field of the ionized gas indicates a rotating disk with an average velocity gradient of 15 km s$^{-1}$ per arcsecond. The dynamical mass within the central 500 pc is $\sim 4 \times 10^8 M_\odot$, and may be $\sim 6 \times 10^7 M_\odot$ within the central 120 pc (in collaboration with B. Phookun & W.M. Goss).

Two starburst galaxies – NGC 3628 and IC 694 – from which H92$\alpha$ recombination line was detected earlier were observed with higher angular resolution using the VLA. The new data was used to further constrain the properties of the ionized gas in the nuclear regions of these galaxies. The derived parameters suggest the presence of $\sim$ 100 high density compact HII regions ($n_e \sim 10^4$ cm$^{-3}$, size $\sim$ 1 – 2 pc) in the central region. The observed kinematics indicate a total dynamical mass of $3 \times 10^8 M_\odot$ within 120 pc in NGC 3628 and $7 \times 10^8 M_\odot$ within 200 pc in IC 694 (in collaboration with J.H. Zhao, W.M. Goss & F. Viallefond).

Three starburst galaxies – NGC 3628, NGC 4151, and Arp 220 – were searched for recombination lines at millimeter wavelengths using the 30 m IRAM telescope at Granada, Spain. Lines were detected near 2 mm and 1 mm in all the three galaxies (in collaboration with F. Viallefond, J.H. Zhao & W.M. Goss).

**High redshift recombination line towards the gravitational lensed source PKS 1830-211**: Much interest was generated recently in the gravitationally lensed source PKS 1830-211 due to the discovery of two intervening systems at redshifts of 0.9 and 0.2 by the detection of several molecular lines and the 21 cm line. The two systems are believed to be intervening galaxies, one or both of which may be responsible for gravitationally lensing the background source PKS 1830-211. The presence of a strong continuum background source and the existence of two intervening galaxies suggested the unique possibility of searching for recombination lines in the 20 cm band at both the redshifts. A positive detection was made of an emission line at $z = 0.19$, and a possible absorption line at $z = 0.89$. The emission line provides direct evidence for stimulated emission and further observations of this line at other frequencies will lead to the determination of the properties of the intervening cloud (in collaboration with W.M. Goss).

**Recombination line survey using the Ooty Radio Telescope**: Hydrogen recombination lines near 328 MHz detected in almost every direction in the Galactic plane using the Ooty Radio telescope was used to derive constraints on the properties of the distributed ionized gas in the inner Galaxy. Preliminary results indicated that the lines are produced in ionized gas with densities in the range $1 - 10$ cm$^{-3}$, and emission measures of $500 - 3000$ pc cm$^{-6}$. The variation of radial velocity and width of the lines as a function of galactic longitude indicates that the low-density gas is concentrated in a ring between 3 and 7 kpc from the Galactic centre (in collaboration with Anish Roshi).

**Low-frequency recombination lines of carbon**: Carbon recombination lines observed in absorption near 34.5 MHz, and in emission near 328 MHz, towards the supernova remnant Cas A and six other directions in the galactic plane were used to obtain constraints on the partially ionized gas where these lines originate. Models with gas temperatures $\sim 100$ K and electron densities $< 0.1$ cm$^{-3}$ can fit the observed line parameters. The observed line velocities, line widths and the derived pathlengths through the gas suggest that these lines could arise in the cold neutral HI clouds in the Galaxy.

**Interstellar clouds**: Interstellar clouds are known to produce absorption lines in the optical spectrum towards bright OB stars. Diffuse clouds are also seen in emission, as well as absorption in the 21 cm line of atomic hydrogen. Although the existence of interstellar clouds have been known for more than four decades it has not been clear as to whether the optical absorption lines and the 21 cm emission and absorption arise from the *same* population of clouds. Early observations revealed that neutral hydrogen gas is indeed associated with some of the interstellar clouds, particularly those with small random velocities. This inference was drawn from emission measurements in the 21 cm line of neutral hydrogen. Why no hydro-

gen was seen in emission from the high velocity clouds has remained a major puzzle. To clarify this a systematic investigation was undertaken to identify radio sources in the vicinity of bright stars (towards which optical absorption studies have been made), *and attempt to see the intervening clouds in absorption at 21 cm against the background radio sources.* Such an attempt was made in the direction towards approximately 20 bright stars. This investigation reveals that neutral hydrogen is associated with low velocity clouds; it can be seen both in absorption, as well as in emission. But in the case of interstellar clouds with random velocities greater than $\sim$ 20 km/s (as deduced from optical absorption studies) no absorption was detected at 21 cm down to an optical depth of 0.1. This raises an interesting question as to whether these high random velocity clouds form a distinct population or whether the mechanism which accelerated them to relatively high velocities also resulted in depletion of neutral hydrogen in these clouds. A detailed investigation is under way to clarify this.

**Small-scale structure in the interstellar neutral hydrogen**: The available 21 cm absorption measurements in the direction of Cas-A were analysed with a view to obtaining a power spectrum description of the structure in the interstellar neutral hydrogen. A modified version of the CLEAN algorithm was used successfully to obtain the spectrum of the HI distribution with high dynamic range. The spectrum shows a power-law with an index of $-3$ which is inconsistent with the hydrogen at different scales being in pressure equilibrium.

**The interstellar medium of the Galaxy towards Cygnus A**: Very deep absorption measurements in the 21 cm line of neutral hydrogen towards Cygnus A was done with the Very Large Array. These observations were sensitive optical depth variations down to 0.001 with a resolution $\sim 10''$ over $2'$. The absorption by neutral hydrogen gas in the outer spiral arm of the Galaxy, and even beyond, was clearly seen. The largest galactocentric-distance at which hydrogen gas was seen in absorption was at $\sim$26 kpc. Optical depth variations in the nearby neutral hydrogen clouds imply variations in the atomic hydrogen density $\sim$ 100 cm$^{-3}$ over distances $\sim$0.2 pc (assuming a constant spin temperature). The warm neutral intercloud medium of the Galaxy was not detected through 21 cm absorption; the $3\sigma$ upper limit to the optical depth of this intercloud medium is $\sim 5 \times 10^{-4}$ (in collaboration with C.L. Carillin & W.M. Goss).

**A thermal plume in the galactic ionized region NGC 2024**: Radio images of the galactic HII region NGC 2024 with 1 arcminute resolution were made at 0.33 GHz and 10.55 GHz with the Very Large Array and the Effelsberg 100 metre telescope, respectively. These represent the highest dynamic range images of this nebula to date, and reveal the structure of the thermal plume that is directed north from the HII region, and opposite to a unipolar molecular outflow found in the molecular cloud near the HII region. The detection of H91$\alpha$ recombination lines

from the plume confirms that the plume is blue-shifted relative to the molecular cloud. Three possible explanations were advanced for the plume (in collaboration with W.M. Goss, Megeath & Barnes).

**IRAS Vela shell**: The investigation of the intriguing 'shell'-like feature in the Gum nebula was continued. This feature is clearly discernible in the distribution of the point sources obtained with the Infrared Astronomical Satellite (IRAS). The 10.4 metre telescope at RRI was used to look for molecular gas associated with this infrared shell. Carbon monoxide was detected in approximately 50 of the 100 or so infrared point sources towards which the observations were made. An analysis of the radial velocities of this molecular gas revealed a systematic expansion. Since the distribution of the Southern Dark Clouds (seen as opaque patches in visible light) also showed a shell-like feature, an attempt was made to see if these dark clouds were physically associated with the shell seen in the infrared. To this end data from a recent carbon monoxide survey of these clouds from Australia was also analyzed. This clearly showed that the Southern Dark Clouds are indeed associated with the infrared shell. Further, this system of small molecular clouds appear to be expanding with a velocity $\approx$ 13 km/s about a centre which happens to coincide with the morphological centre of the cometary globules in the Gum nebula. This velocity of expansion is also consistent with the conclusion arrived at earlier that the cometary globules themselves are expanding about a common centre with a velocity $\sim$ 11–13 km/s. The kinematics of this system of clouds, and its relation to larger shell-like features in the Galaxy is being investigated.

**Massive Young Stellar Object**: The Young Stellar Object IRAS 18507+0121 was modelled using a radiative transfer code to "fit" various spectral lines observed towards this source in a consistent manner. It was found that only a model of a collapsing core hidden behind a cold, dense "screen" could explain the observed spectra satisfactorily. Of the few cases established so far to have a "screen" in front, this is the only one hiding a *massive-star* forming core. This has important implications to the process of massive star formation. Further, while the velocity field is as expected, the density structure in the core differs substantially. This, if confirmed, would imply that the collapse of the core to form massive stars is different in nature from the collapse in which low mass stars form (in collaboration with Bronfman and Deguchi).

**Imaging of four galaxy clusters in the 21 cm line of hydrogen**: As a beginning of a more systematic study of the neutral hydrogen content of galaxies in clusters in the redshift range $0 < z < 0.5$, four clusters were imaged using the Very Large Array. These four clusters are Abell 154, Abell 592, Abell 3558, and Abell 3571, and span a redshift range $0.04 < z < 0.06$. Most of the clusters observed prior to this have redshifts $< 0.03$. The present observations yielded a $3\sigma$ upper limit to the mass of neutral hydrogen $\sim 4 - 7 \times 10^8 M_\odot$ in each of

the four clusters. One Galaxy each was detected in Abell 592 and Abell 3558, and none in Abell 154 and Abell 3571. In the individual galaxies detected in the 21 cm line the mass of hydrogen was very close to that expected for *field spirals* of similar optical luminosity and seems hardly affected by the cluster environment. But the fact that most of the spiral galaxies in the clusters were not detected through their emission at 21 cm implies that the mass of neutral hydrogen in the overwhelming majority of the spirals in clusters must be 3–5 times less than expected for field spirals of the same luminosity. This conclusion about the depletion of neutral hydrogen in Abell 154 is at variance with conclusions arrived at earlier (in collaboration with J.H. van Gorkom, P. Guhathakurtha & S. Raychaudhury).

**150 MHz sky survey**: A low resolution survey ($1/4^\circ \times 1/4^\circ$ angular resolution) of roughly half the observable sky from Mauritius was completed. Approximately 12 hours a Right Assention from 17:00 hours to 5:00 hours and 50 degrees of declination range $-65^\circ$ – $-15^\circ$ was imaged. This was used to produce a preliminary point source catalogue. More than 800 point sources with flux densities more than 3 Jy were identified. A $\log N$ *vs* $\log S$ plot was also made. A spectral index study of these sources with a view to identifying steep spectrum sources as possible candidates for pulsars is in progress.

Data collection for the $4' \times 4'$ resolution survey was completed by expanding the baseline coverage up to 880 metres by moving the trolleys in the North-South arm. The analysis of this data is in progress. A second complete set of observations were also undertaken in the recirculator board.

**Cosmic microwave background radiation**: The detection of anisotropy in the sky temperature of the relict cosmic microwave background radiation on the scale of 10 degrees by the COBE satellite has led to considerable interest in measurements of the anisotropy on smaller angular scales in order to determine the nature of the anisotropy spectrum. The Australia Telescope Compact Array is being used to image sky regions with arcminute angular resolution to address this key problem. An image of a region of the sky with a sensitivity of about 23 micro Kelvin has been carefully analyzed and compared with simulations to separate the contributions from discrete foreground sources and telescope thermal noise, and relate any excess variance to parameters of models that may describe cosmic microwave anisotropy. Work during the last year has been directed at determining relationships between the images produced in a Fourier synthesis telescope and the parameters of plausible models that may describe CMB anisotropy on arcminute scales.

# Instrumentation for Radio Astronomy

## 1. GMRT Pulsar receiver

(a) *Array combiner for GMRT*: Software simulations of the critical stages of signal quantization in the array combiner were carried out and the parameters of the combiner were optimized based on the results of these simulations.

A new version of the GMRT array combiner to cater for 8 antennae has been completed and installed successfully at the GMRT site. Efforts are on to initiate pulsar observations using the GMRT 8-dish system.

The upgradation of the 8-dish combiner to a 30-dish array combiner for one sideband is under progress.

(b) *Polarimeter and Signal processor for known pulsars*: A polarimeter/pulsar processor for a 8-MHz band has been fabricated and lab tests successfully completed. Initial field tests would be conducted using the Ooty Radio Telescope. Work on the full 32-MHz bandwidth pulsar polarimter/processor is in progress.

**2. GMRT 21 cm Receiver**: After successfully completing the field testing of the improved version of the 21 cm receiver at the GMRT dish, fifteen units were fabricated, tested and sent to Pune during the year. The remaining fifteen units are at various stages of production in the lab.

A narrow band notch filter around 940 MHz is being designed to be used at two or three dishes at GMRT to partially overcome interference from local cellular communication.

**3. General purpose Data Acquisition System**: A general purpose data acquisition system was designed for pulsar and spectral line observations at low radio frequencies. Two such systems were built and installed successfully at the Mauritius and Gauribidanur Radio Telescopes, and are being used for pulsar observations at 150 MHz and 35 MHz, respectively.

**4. Tracking system for MRT**: A system was built at RRI and installed at the Mauritius Radio Telescope to add a limited tracking capability. It consists of 32 phase shifter modules that are controlled from a PC. The system is being used for pulsar observations with the telescope.

**5. 10.4m Millimeter wave telescope**: Some improvements were made at the telescope. These include the development and installation of (a) a new PC based interactive telescope control software, (b) a new Unix based data acquisition sys-

tem for all the back-end receivers (Correlator, Filter Bank, AOSs and Total Power Receiver), (c) a 21 cm feed and receiver, (d) low-noise HEMT amplifiers for the IF system.

# COMPUTERS

Two major additions were made this year to the computing facilities. The first is the acquisition of a 10-CPU Enterprise-4000 server with 2 GB of memory, 40 MB Cache, and 20 GB disk capacity. This server which has a throughput of over 1 Gigaflop is intended for processing pulsar data mainly from GMRT and also from other radio telescopes. The second addition to the computing facilities is leasing a dedicated 64 KBps link to the VSNL gateway in Bangalore for faster Internet and E-mail connectivity. The existing connection via the ERNET centre in IISc is also continued. The Novell file server which was based on a 386 server was replaced by a Pentium-processor based server.

## Ph.D.

### Awarded

| Name | Topic of Study |
|---|---|
| R. Ramachandran | Progenitors of Pulsars<br>*Osmania University, Hyderabad* |

### Submitted

| | |
|---|---|
| N. Andal | Some studies on defect lattices in liquid crystals<br>*Jawaharlal Nehru University, New Delhi* |
| M. Jahan Miri | The evolution of the magnetic fields of neutron stars: The role of the superfluid states in their interiors<br>*Indian Institute of Science, Bangalore* |

## 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 and those submitted and in press is given at Annexure - I (Page 32).

## 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 (Annexure II, page 43).

## Colloquia

The scientists of the Institute and visiting scientists both from within and outside the country, gave 45 colloquia at the Institute on different topics during the year (Annexure III, page 57).

## Journal Club Meetings

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

## Visits of Dignitaries

Mr. Ong-Keng-Yong, High Commissioner of Singapore in India accompanied by the First Secretary and Deputy Head of Mission, Mr. N.G.Lang, visited the Institute on 13 December 1996.

The Science Counsellors of the Embassies in India of Germany (Dr. S.F. von Welck), Italy (Dr. Giusto Sciarabba), Israel (Mr. Meir Eshet), Poland (Dr. Tomasz Gerlach), British High Commission (Mr. Michael White) along with Mr. R. Sudarshan of UNDP visited the Institute on 18 February 1997.

## Visiting Scientists

Sir Aaron Klug, President of Royal Society, London, and recipient of Nobel Prize in Chemistry in 1982 for his development of crystallographic electron microscopy and his elucidation of the structures of protein-nucleic acid complexes of biological importance visited the Institute on 21 December 1996.

Also, a number of scientists from institutions within the country and outside visited the Institute during the year. Their names are listed following those of the scientific and technical staff of the Institute given towards the end of the report.

## Library

During the year, 405 new books were added to the library out of which 86 were received as gratis. This brings the total book collection to 19441. The library subscribed to 139 journals out of which 22 were received by air mail. Some of these are available online as part of our subscription to the print edition. In addition to this, we are also subscribing to one online journal. A programme for keeping the

library open in the evenings with the help of students was started during the year. As a part of upgrading the facility for information work, the library acquired a new pentium computer. One of the existing PCs has also been upgraded. A new photo-copying machine has also been acquired.

The library continues to participate in inter-library cooperation activities. Periodic internal meetings have been started among the staff to exchange new developments in the library and information fields. Some of the staff members regularly take part in the professional meetings held in the city. Three members of staff have acquired professional qualifications, two of them degrees from the Indira Gandhi Open University, New Delhi and the other a certificate from the Institute of Information Studies, Bangalore.

## Others

*General*

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

| | |
|---|---|
| PLAN – RECURRING AND NON-RECURRING | Rs.502.00 lakhs |
| NON PLAN – RECURRING | Rs.267.00 lakhs |
| Total | Rs.769.00 lakhs. |

# STAFF

The scientific and technical staff of the Institute is listed below. Additions during the year are marked with an asterisk.

N. Kumar (Director)

K.R. Anantharamaiah
P.G. Ananthasubramanian
Anirvan Sengupta*
Antony Joseph†
Ashima Rani
R. Bhandari
D. Bhattacharya
K. Chandrasekhara
S. Chanthrasekharan
A.A. Deshpande
V. Devadas
K.S. Dwarakanath
M.S. Ezhilarasi
R. Ganesan
K.T. Gangadharan
B.S.Girish
M.R. Gopalakrishna
K. Gurukiran
Hema Ramachandran
B.R. Iyer
Jacob Rajan
P.A. Kamini
S. Kasturi
U.D. Kini
S.Krishna Murthy
S. Krishnan
V. Lakshminarayanan
Lakshmy P. Usha
Laxmish Ganesh Bhat
Madhavan Varadarjan*
S.Madhavi
N.V. Madhusudana
M.O. Modgekar
Mohd. Ateequlla
H.N. Nagaraja
R. Nandakumar
R. Nityananda
T. Prabu
R.Pratibha
E. Palanichamy
V.Radhakrishnan+
S.P.Raghavendra
K.B. Raghavendra Rao
A. Raghunathan
V.A.Raghunathan
K.P. Rajasree*
P.S. Ram Kumar
P.N. Ramachandra
C. Ramachandra Rao
S.Ramaseshan
B. Ramesh
K. Ramesh*
K. Ramesh Kumar
G.S. Ranganath
N. Ravi Sankar
Ravi Subrahmanyam
D.K. Ravindra
T.R. Ravindran*
K.N. Ravishankar*
T.N.Ruckmongathan
D. S. Rupa*
B.K. Sadashiva
P.Sandhya
J. Samuel

A. Santosh Kumar
G. Sarabagopalan
N.V.G. Sarma
S. Sarala
P.S. Sasi Kumar
M. Seethalakshmi
M. Selvamani
S. Seshachala
C.S. Shukre
B. Sridhar
T.K.Sridharan[++]
G. Srinivasan
K.S. Srivani
Subha P.S. Raju
K. Subramanya
M.R. Subramanyam
H. Subramonyam
K.A. Suresh
S. Swarna
B.K.Udaya Shankar
N. Udaya Shankar
K.R. Vinod*
C. Vinutha
Yashodhan Hatwalne*

**Research Fellows**

Amitabha Bhattacharya
N. Andal
Arun Roy
Ashish Asgekar[1]
Debnarayan Jana
Dipanjan Mitra
Geetha Basappa
M.S.Giridhar
A. Gopakumar
C.R. Gopalakrishnan
C. Indrani
Jayadev Rajagopal
Kheya Sengupta
Mehdi Jahanmiri[1]
Nimisha G. Kantharia[1]
P.A.Pramod
Raka Dona Ray
S. Subhashree*
Sobha R. Warrier
K.S.Srivatsa
Subramanian Raman
Sushan Konar[1]
Sushil Mujumdar*
Sreejith Sukumaran
P.K. Thiruvikraman

**Post-Doctoral Fellows**

Gungwong Kang
Kanti Jotania
Mousami Das*
Nivedita Deo
M. Sanjay Kumar*
D. Vijaya Raghavan*

**Visiting Professors/Scientists**

Bhaskar Datta
T.G.Ramesh
A.K.Sood
R.Srinivasan

**Consultant Physicians**

M.R. Baliga
A.R. Pai

**Resignations**

Aditi Mitra
S. Anil
Anirvan Sengupta
Chitra Gokhale
Gangasharan
N.Kasthuraiah
Mohd. Imtiaz
M. Nagesh
H. Narayanan
Prashanth M. Gade
Nirmalya Karar
R. Ramachandran
P.Ramadurai
T.R. Ravindran
G. Rengarajan
D. S. Rupa
P.B. Sadik
K.V. Satyaprakash
Shaji Parol
K.R. Shanthi
Somnath Bharadwaj
Subha P. S. Raju
V. Suresh Rao

---

†On leave with the Netherlands Foundation for Research in Astrophysics, Dwingeloo, The Netherlands

+On leave with the Institute of Astronomy, University of Amsterdam, The Netherlands.

++On leave with the Smithsonian Astrophysical Observatory, Washington, D.C., USA

[1]Under the Joint Astronomy Programme at the Indian Institute of Science.

# LIST OF VISITORS

| | |
|---|---|
| William Blanpied<br>National Science Foundation<br>Arlington, USA | April 4, 1996 |
| Sai Iyer<br>Physical Research Laboratory<br>Ahmedabad | May 10-24, 1996 |
| Abir Bandyopadhyay<br>Indian Institute of Technology<br>Kanpur | May 13-16, 1996 |
| Janaki Balakrishnan<br>Delhi University<br>Delhi | May 21-24, 1996 |
| R. S. Arora<br>National Physical Laboratory<br>New Delhi | 20-28 June 1996 |
| Biman Nath<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | July 1-13, 1996 |
| T. Padmanabhan<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | July 18-23, 1996 |
| Joanna Rankin<br>University of Vermont<br>Canada | July 18 -<br>August 20, 1996 |
| Sumati Surya<br>Syracuse University<br>U S A | July 28 -<br>August 3, 1996 |
| Jeeva S. Anandan<br>University of South Carolina<br>U S A | August 1-7, 1996 &<br>January 26 -<br>March 24, 1997 |

| | |
|---|---|
| N.K.Rahman<br>University of Trieste<br>Trieste, Italy | August 1, 1996 |
| H.S. Schulz<br>Laboratoire de Physique des Solides<br>Paris, France | August 12 -<br>September 4, 1996 |
| C. Manohar<br>Bhabha Atomic Research Centre<br>Bombay | August 26-27 , 1997 |
| Jayaram Chengalur<br>National Centre for Radio Astrophysics<br>Pune | September 9-13, 1996 |
| Jihad Touma<br>University of Texas<br>Austin, USA | September 9-11, 1996 |
| S. Sridhar<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | September 9-11, 1996 |
| G. V. Subba Rao<br>C E C R I, Karaikudi | September 26 -<br>October 1, 1996 |
| B.I. Halperin<br>Harvard University<br>U S A | October 3, 1996 |
| Pier A. Mello<br>Institute of Physics<br>UNAM, Mexico | October 18, 1996 -<br>January 14, 1997 |
| Ray Ladbury<br>Editor, Physics Today<br>American Institute of Physics<br>U S A | October 31, 1996 |
| A. Jakli<br>Research Institute for Solid<br>State Physics, Hungarian<br>Academy of Sciences, Budapest<br>Hungary | November 4-10, 1996 |
| Ellen Bouton<br>National Radio Astronomy Observatory<br>Charlottesville, USA | November 12 -<br>December 5, 1996 |

| | |
|---|---|
| S.D. Mohanty<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | February 6-7, 1997 |
| Sukanta Bose<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | February 8-9, 1997 |
| G. Rajasekaran<br>The Institute of Mathematical Sciences<br>Madras | February 6, 1997 |
| R. Balasubramanian<br>Inter-University Centre for Astronomy<br>&Astrophysics, Pune | February 11-13, 1997 |
| G.T.G.Mohammedbhai<br>Vice-Chancellor<br>University of Mauritius<br>Mauritius | February 17-19, 1997 |
| Ramdeen Goorah<br>Ministry of Education Science & Technology<br>Chairman, Staff Committee of University of<br>Mauritius, Mauritius | February 17-19, 1997 |
| Morrel Cohen<br>University of Chicago<br>USA | February 22-28, 1997 |
| D.P.McKenzie<br>University of Cambridge<br>U. K. | February 23 -<br>April 1, 1997 |
| Shanta Chaudhuri<br>Indian Association for the Cultivation<br>of Science, Calcutta | March 24, 1997 |
| Manas Sardar<br>University of Regensburg<br>Germany | March 27, 1996 -<br>April 4, 1997 |
| Wolfgang Kundt<br>University of Bonn<br>Bonn, Germany | March 31, 1997 |

| | |
|---|---|
| Pablo A. Alemany<br>International Centre for Theoretical Physics<br>Trieste, Italy | December 2-4, 1996 |
| S. Pottasch<br>University of Groningen<br>The Netherlands | December 4-11, 1996 |
| Jörg Eichler<br>Hahn-Meitner Institute<br>Berlin, Germany | December 6-9, 1996 |
| Vijay Sheorey<br>Physical Research Laboratory<br>Ahmedabad | December 5 - , 1996 |
| Y. Kuramoto<br>Tohoku University<br>Sendai, Japan | December 9, 1996 |
| Y. Kato<br>Tokyo University<br>Tokyo, Japan | December 9, 1996 |
| Ranjan Mukhopadhyay<br>California Institute of Technology<br>Pasadena, USA | December 30, 1996 -<br>January 3, 1997 |
| B.S.Sathyaprakash<br>University of Wales College,<br>Cardiff, U.K. | December 23, 1996 -<br>January 8, 1997 |
| Srinandan Dasmahapatra<br>City University, London<br>U. K. | January 7, 1997 |
| Subodh R. Shenoy<br>International Centre for Theoretical Physics<br>Trieste, Italy | January 15-17, 1997 |
| Wolfgang Haase<br>Reinheim<br>Germany | January 31 -<br>February 7, 1997 |
| L. Sriramkumar<br>Inter-University Centre for Astronomy &<br>Astrophysics, Pune | February 5-6, 1997 |

*Annexure - I*

## PAPERS PUBLISHED

*In Journals*

1. "Tunneling conductance of Luttinger liquids: Resonances" (V.Ashvin, G.V. Vijayagovindan and N.Kumar) *Phys. Rev. B (Rapid Communications)*, **53**, R13 239 (1996).

2. "Optimal barrier subdivision for Kramers' escape rate" (Mulugeta Bekele, G. Ananthakrishna and N. Kumar) *Pramana*, **46**, 403 (1996).

3. "Statistics of mesoscopic fluctuations of quantum capacitance" (N.Kumar and A.M.Jayannavar) *Mod. Phys. Lett.*, **B11**, 53 (1997).

4. "The nature of charge ordering in rare earth manganates and its strong dependence on the size of the *A*-site cations" (N. Kumar and C.N.R. Rao) *Journal of Solid State Chem.*, **129**, 363 (1997).

5. "Hall angle in high-$T_c$ cuprates: Anomalous temperature dependence and anisotropic scattering" (N. Kumar) *Curr. Sc.*, **73**, 64 (1997).

6. "Gravitational waveforms from inspiralling compact binaries to second-post-Newtonian order (L. Blanchet, B.R. Iyer, C.M. Will and A.G. Wiseman) *Class. Quant. Grav.*, **13**, 575 (1996).

7. "Charged scalar fields in an external magnetic field: Renormalization and universal diamagnetism" (Debnarayan Jana) *Nuclear Physics*, **B473**, 659 (1996).

8. "Black hole area in Brans-Dicke theory" (G.Kang) *Phys. Rev. D*, **54**, 7483 (1996)

9. "Poincaré sphere representation for three state systems" (J.Samuel) *Pramana*, **47**, 361 (1996).

10. "Decoherence at absolute zero" (Supurna Sinha) *Physics Letters A*, **228**, 1 (1997).

11. "Polarization of light and topological phases" (R.Bhandari) *Phys. Rep.*, **281**, 1 (1997).

12. "A simple model for phase transitions in antiferroelectric liquid crystals" (Arun Roy and N.V. Madhusudana) *Europhys. Lett.*, **36**, 221 (1996).

26. "Electron temperatures in the Galactic HII regions W43 and M17" (Ravi Subrahmanyan and W.M. Goss) *Mon. Not. R. astron. Soc.*, **281**, 239 (1996)

27. "Magnetic fields in cometary globules – I. CG 22" (T.K. Sridharan, H.C. Bhatt and Jayadev Rajagopal) *Mon. Not. R. astron. Soc.*, **279**, 1191 (1996).

28. "Stars: their structure and evolution" (G. Srinivasan) *J. Astrophys. Astr.*, **17**, 53 (1996).

29. "Magnetic and spin evolution of pulsars" (M. Jahan Miri) *Mon. Not. R. astron. Soc.*, **283**, 1214 (1996).

30. "New HI absorption measurements towards six pulsars" (T.P. Saravanan, A.A. Deshpande, W. Wilson, E. Davies, P.M. McCulloch and D. McConnell) *Mon. Not. R. astron. Soc.*, **280**, 1027 (1996).

31. "Radio recombination lines from the nuclear regions of starburst galaxies" (Jun-Hui Zhao, K.R. Anantharamaiah, W.M. Goss and F. Viallefond) *The Astrophys. J.*, **472**, 54 (1996).

32. "Application of 'CLEAN' in the power spectral analysis of non-uniformly sampled pulsar timing data" (A.A. Deshpande, F.D. Alessandro and P.M. McCulloch) *J. Astrophys. Astr.*, **17**, 7 (1996).

33. "A survey of the Galactic plane for 6.7 GHz methanol masers – I. $l = 325° - 335°$; $b = -0°.53 - 0°.53$" (S.P. Ellingsen, M.L von Bibra, P.M. McCulloch, R.P. Norris, A.A. Deshpande and C.J. Phillips) *Mon. Not. R. astron. Soc.*, **280**, 378 (1996).

34. "Coherent radiation patterns suggested by single-pulse observations of a millisecond pulsar" (J.G. Ables, D. McConnell, A.A. Deshpande and M. Vivekanand) *The Astrophys. J.*, **475**, L33 (1997).

35. "Power spectral analysis of the timing noise in 18 southern pulsars" (F. D'Alessandro, A.A. Deshpande and P.M. McCulloch) *J. Astrophys. Astron.*, **18**, 5 (1997).

36. "The evolution of correlation functions in the Zeldovich approximation and its implications for the validity of perturbation theory" (Somnath Bharadwaj) *The Astrophys. J.*, **472**, 1 (1996).

37. "Reliable Galaxy-wide identification of ultracompact HII regions" (B. Ramesh and T.K. Sridharan) *Mon. Not. R. astron. Soc.*, **284**, 1001 (1997).

38. "Orthogonal rotating gaseous disks near the nucleus of NGC 253" (K.R. Anantharamaiah and W.M. Goss) *The Astrophys. J.*, **466**, L13 (1996).

39. "A model for pulsar nullings" (A. Kazbegi, G. Machabeli, G. Melikidze and C. Shukre) *Astron. Astrophys.*, **309**, 515 (1996).

40. "Ohmic decay of magnetic flux expelled from neutron star interiors" (D. Bhattacharya and B. Datta) *Mon. Not. R. astron. Soc.*, **282**, 1059 (1996).

41. "Magnetic field evolution of accreting neutron stars" (S. Konar and D. Bhattacharya) *Mon. Not. R. astron. Soc.*, **284**, 311 (1997).

## Book Reviews

1. "Games with Bubbles" – Review of Boys book on Soap Bubbles (G.S. Ranganath) *Resonance*, **1(4)**, 90 (1996).

2. "The enchanting soft materials" – Review of a three volume series on application of liquid crystals (G.S. Ranganath, K.A. Suresh and T.N.Ruckmongathan) *Current Science*, **70**, 944 (1996).

3. "Magic of light" – Review of Minnaert's book *A light and colour with outdoors* (G.S. Ranganath) *Resonance*, **1(12)**, 74 (1996).

13. "Effect of a strong electric field on phase transitions in some liquid crystals" (Geetha Basappa and N.V. Madhusudana) *Molec. Cryst. and Liquid Cryst.*, **288**, 161 (1996).

14. "A novel standard calomel electrode with an integral standard ground glass joint and luggin capillary system" (A. Dhasan) *Journal of the Electrochemical Socicty of India*, **45**, 119 (1996).

15. "Magnetic and electric field induced periodic deformations in nematics – Effect of director pretilt" (U.D.Kini) *Molec. Cryst. and Liquid Cryst.*, **289**, 181 (1996).

16. "Crossed fields induced periodic deformations in nematics" (U.D. Kini) *Liquid Crystals*, **21**, 713 (1996).

17. "Power-law forces between particles in a nematic" (S. Ramaswamy, R. Nityananda, V.A. Raghunathan and J. Prost) *Molec. Cryst. Liquid Cryst.*, **288**, 175 (1996).

18. "Colloidal dispersions in a liquid crystalline medium" (V.A. Raghunathan, P. Richetti, D. Roux, F. Nallet and A.K. Sood) *Molec. Cryst. Liquid Cryst.*, **288**, 181 (1996).

19. "Dispersions of latex particles in a nematic solvent: Phase diagram and elastic properties" (V.A. Raghunathan, P. Richetti and D. Roux) *Langmuir*, **12**, 3789 (1996).

20. "$L_{\beta'} \rightarrow L_{c'}$ phase transition in phosphatidylcholine lipid bilayers" (V.A. Raghunathan and J. Katsaras) *Phys. Rev. E*, **54**, 4446 (1996).

21. "Field induced chiral - achiral transitions in liquid crystals" (N. Andal and G.S. Ranganath) *Journal de Physique*, **6**, 639 (1996).

22. "Ferroelectric and antiferroelectric liquid crystalline phases in some pyridine carboxylic acid derivatives" (N.Kasthuraiah, B.K. Sadashiva, S. Krishna Prasad and Geetha G. Nair) *Journal of Mater. Chem.*, **6**, 1619 (1996).

23. "Optical diffraction in chiral liquid crystals" (K.A. Suresh and Yuvaraj Sah) *Modern Phys. Lett. B*, **10**, 305 (1996).

24. "Modulations in the diffracted intensity in chiral smectic C liquid crystals" (Yuvaraj Sah, P. B. Sunil Kumar and K.A. Suresh) *Physical Review E*, **54**, 3025 (1996).

25. "Formation of liquid crystalline phases from a Langmuir monolayer" (K.A.Suresh and A.Bhattacharyya) *Langmuir*, **13**, 1377 (1997).

*In Conference Proceedings*

1. "Gravitational waves from inspiralling compact binaries" (B.R. Iyer) in *Classical and Quantum Aspects of Gravitation and Cosmology*, eds. G.Date and B.R. Iyer, The Institute of Mathematical Sciences, Madras (1996), p. 23.

2. Report on the "Workshop on gravitational waves" (B.R.Iyer and K.D.Kokkotas) in *Gravitation and Cosmology*, eds. S.V. Dhurandhar and T. Padmanabhan (Kluwer, 1997), p. 261.

3. "Quantum ergoregion instability" (G.Kang) *Proceedings of the Winter School on Duality of String Theory*, Korea, 17-28 February 1997

4. "Observation of topological phase by use of a laser interferometer" (R.Bhandari and J.Samuel) in *Selected Papers on Interference, Interferometry and Interferometric Metrology*, eds. P.Hariharan and D.Malacara, Vol. MS 110 in Milestones in Optics (SPIE, Bellingham, 1995).

5. "Geometric phases in physics" (R. Bhandari) in *Horizons of Physics*, Vol. 2, eds. N. Nath and A.W. Joshi (New Age International, New Delhi, 1996), p. 1.

6. "Visual illusions: Role of the eye" (G.S. Ranganath) in *Horizons of Physics*, Vol. 12, eds. N. Nath and A.W. Joshi (New Age International, New Delhi, 1996).

7. "Flicker-free restricted-pattern addressing techniques with low supply voltage" (T.N. Ruckmongathan) *SID International Symposium Digest of Technical Papers*, (1996), p. 562.

8. "Morphologies in Mpc-size radio galaxies" (L. Saripalli, R. Subrahmanyan, and R.W. Hunstead) in *Extragalactic Radio Sources*, eds. R. Ekers *et al.*, (Kluwer, 1996) p.313.

9. "Butcher-Oemler effect and radio continuum" (K.S. Dwarakanath and F.N. Owen) in *Proc. of the Workshop on Cold Gas at High Redshift*, eds. M.N. Bremer *et al.*, (Kluwer, 1996), p.183.

10. "Dependence of properties of molecular clouds on their galactic location" (B. Ramesh) in *Proc. of the Third East-Asian Meeting on Astronomy: Ground-based Astronomy in Asia* ed. Norio Kaifu, (National Astronomical Observatory, Japan, 1996), p. 127.

11. "Periodic changes in intensity and arrival time of pulses from the Vela pulsar: evidence for free precession?" (A.A. Deshpande and P.M. McCulloch) in *Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996), p.101.

12. "A geometrical origin of the pulsar core and conal emissions" (R.C. Kapoor and C.S. Shukre) in *Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105, (1996), p.229.

13. "On polarisation of high intensity pulses in radio pulsars" (N. Rathnasree and Joanna M. Rankin) in*Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996), p.265.

14. "Geometry of emission is PSR 1929+10" (Joanna M. Rankin and N. Rathnasree) in *Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996) p.227.

15. "A study of polarisation modes in PSR 0823+26" (Joanna M. Rankin and N. Rathnasree) in *Pulsars: Problems and Progress*, eds. S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996), p.263.

16. "Single pulse profiles and the Lorentz factor of emitting particles in pulsar magnetospheres" (N. Rathnasree) in *Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996), p.221.

17. "The origin of millisecond pulsars" (D. Bhattacharya) in *Pulsars: Problems and Progress*, eds.S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996) p.221.

18. "The case for no field decay from improved population synthesis" (J.W. Hartman, F. Verbunt, D. Bhattacharya and R. Wijers) in *Pulsars: Problems and Progress*, eds. S. Johnston, M.A. Walker and M. Bailes, ASP Conference Series, Vol. 105 (1996) p.47.

Books

1. "Deterministic chaos: Complex chance out of simple necessity" (N.Kumar) (Orient Longmans Ltd., 1996).

Monographs

1. The section on "Neutron Stars" (G. Srinivasan) in *Stellar Remnants*: Saas-Fee Advanced Course 25, eds. Georges Meynet and Daniel Schaerer (Springer-Verlag) (1997).

**Books edited**

1. "Classical and quantum aspects of gravitation and cosmology", eds. G. Date and B.R.Iyer (IMSC Report 117) (1996).
2. "Geometry, Fields and Cosmology", eds. B.R.Iyer and C.V. Vishveshwara (Kluwer, 1997)
3. *A Tribute to Subrahmanyan Chandrasekhar*, A Special Publication of the Indian Academy of Sciences, ed. G. Srinivasan, (1996).

# Papers in Press

*In Journals*

1. "Lasing inactive sub-meanfree path sized systems with dense random weak scatters" (B. Raghavendra Prasad, Hema Ramachandran, A.K. Sood, C.K. Subramanian and N. Kumar) *Applied Optics.*

2. "Normal-state c-axis resistivity of the high-$T_c$ cuprate superconductors (N. Kumar, T.P. Pareek and A.M. Jayannavar) *Modern Phys. Lett. B.*

3. "Second post-Newtonian gravitational radiation reaction for two-body systems: Non-spinning bodies" (A.Gopakumar, B.R. Iyer and Sai Iyer) *Phys. Rev. D.*

4. "The Pancharatnam phase as a strictly geometric phase: A demonstration using pure projections" (P.Hariharan, Hema Ramachandran, K.A.Suresh and J. Samuel) *Journal of Modern Optics*

5. "The Lense-Thirring effect and Mach's principle" (Hermann Bondi and J. Samuel) *Phys. Lett.*

6. "The geometric phase and ray space isometries" (J.Samuel) *Pramana.*

7. "Thomas rotation and polarized light: A non-Abelian geometric phase in optics" (J. Samuel and Supurna Sinha) *Pramana.*

8. "The coaxial cable: How cable TV operators use the Laplacian operator" (Supurna Sinha and J. Samuel) *Resonance.*

9. "Effect of fluctuations on the freezing of a colloidal suspension in an external periodic potential (J.Chakrabarti and Supurna Sinha) *Journal de Physique II.*

10. "Halfwave retarder for all polarization states" (R.Bhandari) *Applied Optics.*

11. "The phase in quantum evolution" (R.Bhandari) in *Bulletin of the American Chapter of the Indian Physics Association.*

12. "An ANNNXY model for transversely polarized non-chiral smectic liquid crystals" (Arun Roy and N.V.Madhusudana) *Europhys. Lett..*

13. "A simple molecular theory of the $S_{A1}$ - $S_{Ad}$ critical point and nematic lake in highly polar compounds" (A.S. Govind and N.V. Madhusudana) *Liquid Crystals.*

14. "Liquid crystal displays" (N.V. Madhusudana) *IETE Journal of Research*, (invited review article).

15. "Effect of a strong electric field on the reentrant nematic to smectic $A_d$ phase transition" (Geetha Basappa, A.S. Govind and N.V. Madhusudana) *Journal de Physique.*

16. "On some elastic instabilities in biaxial nematics" (Sreejith Sukumaran and G.S. Ranganath) *Journal de Physique.*

17. "Biaxial nematic liquid crystals" (B.K. Sadashiva) *Handbook of Liquid Crystals* (VCH Verlaggsgeselleschaft mbH, Weinheim).

18. "High density, compact HII regions in the starburst galaxies NGC 3628 and IC 694: High-resolution VLA observations of the H92$\alpha$ radio recombination line" (J.H. Zhao, K.R. Anantharamaiah, W.M. Goss and F. Viallefond) *Astrophys. J.*

19. "Hydrogen and carbon recombination lines towards the galactic centre near 328 MHz" (D. Anish Roshi and K.R. Anantharamaiah) *Mon. Not. R. astron. Soc.*

20. "A study of the evolution of radio pulsars through improved population synthesis" (J.W. Hartman, D. Bhattacharya, R.A.M.J. Wijers and F. Verbunt) *Astron. and Astrophys.*

21. "Modelling the variance of dispersion measures of radio pulsars" (G. Nelemans, J.W. Hartman, F. Verbunt, D. Bhattacharya and R.A.M.J. Wijers) *Astron. and Astrophys.*

22. "Kinematics of low-mass X-ray binaries and millisecond pulsars" (R.Ramachandran and D. Bhattacharya) *Mon. Not. R. astron. Soc.*

23. "A thermal plume in NGC 2024" (Ravi Subrahmanyan, W.M. Goss, S.T. Megeath and P.J. Barnes) *Mon. Not. R. astron. Soc.*

24. "New timing parameters and positions for 16 southern radio pulsars" (C. Indrani, A.A. Deshpande and V. Balasubramanian) *Mon. Not. R. astron. Soc.*

25. "Measurement of scatter broadening for 27 pulsars at 327 MHz" (R.Ramachandran, D. Mitra, A.A. Deshpande, D.M. McConnell and J.G. Ables) *Mon. Not. R. astron. Soc.*

In Proceedings

1. "Coherent wave transport in low dimensional random media" (N. Kumar) *Proceedings of the Tenth Summer School on Physics of Novel Materials, Australian National University, Canberra, January 1997* (World Scientific Publishing, Singapore).

2. "Growth patterns of smectic C liquid crystals in some binary mixtures" (R. Pratibha, Geetha Basappa, N.V. Madhusudana and B.K. Sadashiva) *Proceedings of the European Symposium on Molecular Orientations at Interfaces*, ed. A. Strigazzi (World Scientific).

3. "Optics of some chiral liquid crystals" (K.A. Suresh) (Invited) Sixteenth International Conf. on Liquid Crystals, Kent, USA, June 1996 - *Molecular Crystals and Liquid Crystals.*

4. "Phase diagram of a liquid crystalline siloxane polymer at the air-water interface" (A.Bhattacharyya and K.A.Suresh) Sixteenth International Conference on Liquid Crystals, Kent, June 1996 – *Molecular Crystals and Liquid Crystals.*

5. "EPR study of weak exchange in some copper (II) metallomesogens" (V.Sujatha, B.K. Sadashiva, K. Ohta, M. Bose and S. Subramanian) *Proceedings of the Asia pacific EPR/ESR Symposium, January 1997, Kowloon, Hong Kong,* (Springer-Verlag).

6. "New results from high resolution recombination line observations of NGC 253" (K.R. Anantharamaiah and W.M. Goss) in *Proceedings of the Conference on Starburst Activity in Galaxies*, Puebla, Mexico, April-May 1996, eds. J. Franco and G. Tenario-Tagle.

7. "Models for the evolution of neutron star magnetic fields" (D. Bhattacharya) in *Pulsar Timing, General Relativity and the Internal Structure of Neutron Stars*, Proceedings of a Colloquium held at the Royal Netherlands Academy of Arts and Sciences, September 1996.

8. "Applications of radio pulsar population synthesis" (F. Verbunt, J.W. Hartman, D. Bhattacharya, R. Wijers and G. Nelemans) in *Pulsar Timing, General Relativity and the Internal Structure of Neutron Stars*, Proceedings of a Colloquium held at the Royal Netherlands Academy of Arts and Sciences, September 1996.

9. "Detection of radio emission from pulsars" (D. Bhattacharya) in *Proceedings of the NATO ASI 'Many Faces of Neutron Stars'*, Lipari, Italy, eds. R. Buccheri, M.A. Alpar and J. van Paradijs (Kluwer).

10. "$qq' \rightarrow qq'$: A second look at the IR-divergences" (Sushan Konar and A.K. Ganguly) in *Proceedings of the International Conference on Quark-Gluon Plasma*, Jaipur, March 1997.

11. "Microwave background radiation related evidence in favour of the standard model" (Ravi Subrahmanyan) in *Proceedings of the Discussion Meeting on Big Bang and Alternative Cosmologies*, Bangalore, January 1997.

12. "Kinematics of low-mass X-ray binaries and millisecond pulsars" (R. Ramachandran and D. Bhattacharya) in *Proceedings of the NATO ASI 'Many Faces of Neutron Stars'*, Lipari, Italy, eds. R. Buccheri, M.A. Alpar and J. van Paradijs.

*Annexure - II*

# CONFERENCE ATTENDED

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Anantharamaiah,K.R. | Institute de Radio Astronomy Millimetrique, Granada, Spain, April 13 - 19, 1996 | |
| | Starburst Activity in Galaxies, Puebla, Mexico, 29 April - 4 May 1996 | Recombination lines from NGC 253 |
| | National Radio Astronomy Observatory, Socorro, USA, 6-21 May 1996 | Galactic and extragalactic recombination lines |
| | Dominion Radio Astrophysical Observatory, Penticton, Canada, 26-27 May 1996 | Study of ionized gas in the galactic plane and in external galaxies |
| | Netherlands Foundation for Radio Astronomy, Dwingeloo, The Netherlands, 4-7 June 1996 | Radio recombination lines from Starburst galaxies |
| | University of Mauritius, Mauritius, 14-24 December 1996 | |
| | Conf. on Dust in the Universe, Bangalore December 1996 | Central regions of Starburst galaxies-IS the dust in the nuclear region under-estimated (*Invited*) |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Anantharamaiah,K.R. (*contd.*) | Discussion Meeting on Universe at High Redshifts, Orange County, Coorg, Indian Acad. of Sciences 22-28 February 1997 | Starburst galaxies (*invited*) |
| | Workshop on Astrophysical Spectroscopy, Ananthapur, February 1997 | Spectroscopy at radio wavelengths (*Invited*) |
| Ananthasubramanian,P.G. | Workshop on Cryogenic Technology for R&D and Engineering Applications, Indian Institute of Technology, Kharagpur, 20-22 August 1996 | |
| Andal, N. | Institute of Theoretical Physics, Helsinki, Finland 9 February - 1 March 1997 | |
| | Winter College in Quantum Optics, International Centre for Theoretical Physics, Trieste, Italy 3-21 March 1997 | |
| Ateequlla,C.M. | Seminar on Thermal Spraying (Plasma Spray) Coating, Central Manufacturing Technology Inst., Bangalore, 2 December 1996 | |
| | Eleventh Engg.Congress, Institution of Engineers, Bangalore, 21-23 December 1996 | |
| | Composite Group Centre, Vikram Sarabhai Space Centre, Trivandrum, 12 August 1996 | |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Bhattacharyya, Amitabha | Short-Term Course on Soft-Condensed Matter, M.S.University,Vadodara, 11-16 March 1997 | Phase diagram of a liquid crystalline siloxane polymer at the air-water interface |
| Bhattacharya,Dipankar | Summer School in Astronomy & Astrophysics, Inter-University Centre for Astronomy and Astrophysics, Pune, 26-30 May 1996 | Stars (*4 lectures*) |
| | Perspectives in High Energy Astronomy and Astrophysics, T.I.F.R., Mumbai, 12-17 Aug. 1996 | |
| | Pulsar Timing, General Relativity & Internal Structure of Neutron Stars, Royal Netherlands Academy of Arts and Sciences, Amsterdam, 24-28 September 1996 | 1. Models for the evolution of neutron star (*invited*)<br>2. Applications of radio pulsar population synthesis |
| | NATO Advanced Study Institute on 'Many Faces of Neutron Stars' Lipari, Sicily, 1-10 October 1996 | Detection of radio emission from pulsars (*2 lectures, Invited*) |
| | Osservatorio Astronomica di Brera, Milan, Italy, 12-15 October 1996 | Supersoft X-ray sources |
| | Arcetri Astrophysical Observatory, Florence, Italy, 16-22 Oct. 1996 | The origin of milli-second pulsars |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Bhattacharya, Dipankar (*contd.*) | National Centre for Radio Astrophysics, GMRT Site, Khodad. 25 Oct. - 6 Nov. 1996 | |
| | Nuffield Radio Astronomy Observatory, Jodrell Bank, UK, 23-28 Feb.1996 | Strange Stars |
| | Institute of Astronomy, Cambridge University, Cambridge, UK, 1-15 March 1997 | |
| | Netherlands Foundation for Research in Astronomy, Dwingeloo, 16-31 March 1997 | |
| Deshpande,A.A. | University of Mauritius Mauritius, 3-25 July 1996 | Observing Radio Pulsars |
| | NFRA/Westerbork Telescope, Netherlands, 9-10 September 1996 | |
| | URSI General Assembly, Lille, France, 28 August - 5 September 1996 | Spatial distribution of pulsars and electron density models |
| Dwarakanath,K.S. | University of Mauritius, Mauritius, June 1996 | Radio continuum emission from galaxies |
| | Discussion Meeting on High Redshift Universe, Indian Acad. of Sciences Orange County, Coorg, 22-28 February, 1997 | 1. Butcher-Oemler effect<br>2. HI in clusters |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Giridhar, M.S. | SERC School on Nonlinear Optics and Laser Spectroscopy, Indian Institute Technology, Delhi, 10-28 March 1997 | Dynamic light scattering from nematic liquid crystals, photon correlation spectroscopy |
| | School of Physical Sciences, Jawaharlal Nehru University, New Delhi, March 1997 | |
| Hatwalne, Y. | Indian Inst. of Science, Bangalore | Chiral symmetry breaking in smectic C liquid crystal domains |
| Hema Ramachandran | Seminar on Current Trends in Optics, Calcutta, 14-17 January 1997 | |
| | Winter College in Quantum Optics, I.C.T.P.,Trieste, Italy, 3-21 March 1997 | |
| | International Centre for Theoretical Physics, Trieste, Italy March 1997 | Lasing in random amplifying media |
| Iyer,B.R. | Bangalore Association for Science Education, Bangalore | Vector analysis and electromagnetic theory (25 lectures) |
| | Indian Institute of Science, Bangalore, | Lectures on special relativity (for B.Sc. students) (4 lectures) |
| | Golden Jubilee Symposium on Gravitation and Particle Physics, Physical Res. Lab., Ahmedabad, 1996 | |
| | Physical Research Lab. Ahmedabad, 9 December 1996 | Gravitational wave astronomy: A new window to the universe |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Iyer, B.R. (*contd.*) | Indian Institute of Astrophysics, Bangalore, 9 January 1997 | Algebraic computations in gravitational radiation |
| | Physics Department, Bangalore University, 14 March 1997 | Gravitational wave astronomy |
| Kang, Gungwon | Hanyang Univ., Korea 2 October 1996 | Black hole area in Brans-Dicke theory |
| | Konkuk University, Korea, 3 October 1996 | Black hole area in Brans-Dicke theory |
| | Sogang University, Korea, 10 February 1997 | Quantum aspects of ergoregion instability |
| | Cheonbuk University, Korea, 7 March 1997 | Quantum aspects of ergoregion instability |
| | APCTP Winter School on Dualities in String Theory, Seoul, Korea, 17-28 February 1997 | Quantum aspects of ergoregion instability |
| Kumar, N. | A.C.Joshi Memorial Lecture, Dept. of Physics, Panjab Univ.,Chandigarh, 5 April 1996 | Quantum conductance fluctuations: From kilo-ohms to kilo-bytes |
| | INSA Jawaharlal Nehru Birth Centenary Lecture Award, 1996, University of Pune, 22 April 1996 | Conductance fluctuations: From kilo-ohms to kilo-bytes |
| | Physical Research Lab. Ahmedabad, 2 May 1996 | Light propagation through amplifying disordered medium: Random lasers |
| | Centre for Theoretical Studies, Indian Inst. of Science,Bangalore, 14 August 1996 | Sir Nevil Mott |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Kumar, N. (*contd.*) | Annual Meeting of the Indian Acad. of Sciences, Jodhpur, 1-3 Nov. 1997 | |
| | Condensed Matter Research Activity, International Centre for Theoretical Physics, 16 May-22 June 1996 and 13 Sept. - 19 Oct. 1997 | |
| | World Scientific Pub.Co. Pte.Ltd., Singapore 17-22 November 1997 | |
| | National University of Singapore, Department of Physics, 20 November 1996 | Disordered amplifying medium: Random lasers (*Invited*) |
| | Summer School on Physics of Novel Materials, The Australian National Univ. Canberra, Australia 21-30 January 1997 | Low dimensional disordered systems (*5 lectures, Invited*) |
| | Royal Society/Ciba Foundation Discussion Meeting "Metal-Non Metal Transitions in Reduced Dimensions, 7 March 1997 | Interplanar transport of weakly coupled 2-dimensional layers with strong intrapalanar scattering (*Invited*) |
| Madhusudana,N.V. | Politecnico di Torino, Torino, Italy, 1-24 July 1996 | Phase transitions in antiferroelectric liquid crystals |
| | Dept. of Physics, Univ. Mangalore, Mangalore, 29-30 December 1996 | Liquid crystals and their applications (*two lectures*) |
| | Department of Physics, Bangalore University, Bangalore, 18 March 1997 | Liquid crystals |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Modgekar, M. | Seminar on Thermal Spraying (Plasma Spray) Coating, Central Manufacturing Tech. Inst., Bangalore, 2 December 1996 | |
| | Eleventh Engg.Congress, Institution of Engineers Bangalore, 21-23 December 1996 | |
| | Composite Group Centre, Vikram Sarabhai Space Centre, Trivandrum, 12 August 1996 | |
| Nivedita Deo | Spring College in Condensed Matter on Disorder and Chaos in Quantum Systems, International Centre for Theor. Phys., Trieste, Italy, 6 May-7 June 1996 | Random matrix models: Universal correlations in quantum chaos, disordered systems and the $Y_{r^2}$ integrable models (I) & (II) *2 lectures* |
| | Mesoscopic Phenomena in Complex Quantum Systems, Int. Centre for Theor. Physics, Trieste, Italy 11-14 June 1996 | Quantum chaos, disordered systems and $Y_{r^2}$ integrable models |
| | Danube Workshop, 1996 3-11 June 1996 | Random matrix models I & II (*invited*) |
| | Centre d'Etudes Nucleaires de Saclay, France 17-21 June 1996 | Universal correlations in quantum chaos, disordered systems and the $Y_{r^2}$ integrable models |
| | DAMTP, Silver Street, Cambridge, U.K. 24-28 June 1996 | Random matrix models: Quantum chaos, disordered systems and the $Y_{r^2}$ integrable models |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Nityananda, R. | National College, Bangalore, 19 March 1997 | S.Chandrasekhar, Giant of astro-physics |
| Prabu, T. | Seminar on DSP Chips, Texas Instruments, Bangalore, 5 May 1997 | |
| Radhakrishnan, V. | Middle East Technical University, Ankara, Turkey, 6-19 April 1996 | The physics of sailing craft |
| | University of Baharian & Bahrain Astronomical Society, Bahrain, 21 April 1996 | Recent advances in astronomy |
| | Indian Physics Association Bangalore University, Bangalore, 14 August 1996 | Pulsars – the tiniest and most enigmatic stars in the sky |
| | XXV General Assembly of URSI, University of Lille, Lille, France, 28 August - 5 September 1996 | Convenor of the session on Pulsars and Inter-stellar Matters |
| | Colloquium on Pulsar Timing, General Relativity and the Internal Structure of Neutron Stars, Royal Netherlands Academy of Sciences, The Netherlands 24-27 September 1996 | Conference Summary |
| | National Radio Astronomy Observatory, Green Bank, USA, 10-11 October 1996 | |
| | Eighteenth Texas Symposium on Relativistic Astrophysics, Chicago, USA, 15-20 December 1996 | |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Raka Dona Ray | Institute of Physics, Bhubaneswar, 7-27 May 1996 | Some interesting aspects of pulsar radio emission *(Group Talk)* |
| | Young Astronomers' Meet, Bangalore, 3-5 September 1996 | A phenomenological study of pulsar polarization properties |
| | XI DAE Symposium on High Energy Physics, Guwahati, 26 December 1996 - 2 January 1997 | A phenomenological study of pulsar glitches and possible existence of glue-balls in pulsar core |
| Ramachandran R. | NATO-ASI Meeting: Many Faces of Neutron Stars, Lipari, Italy, October 1996 | Kinematics of Low-Mass Binaries and Milli-second Pulsars |
| | Astronomical Institute, University of Amsterdam, Amsterdam, The Netherlands, November 1996 | Modelling Scattering in the Local Interstellar Medium |
| | Max Planck Institute for Radio Astronomy, Bonn, Germany, December 1996 | 1. Modelling Scattering in the Interstellar medium - Distances to pulsars<br>2. Kinematics of Low-Mass X-ray Binaries and Millisecond Pulsars |
| | Department of Astronomy, Osmania University, Hyderabad, February 1997 | Progenitors of Pulsars (Thesis Colloquium) |
| Ramaseshan, S. | Physical Research Lab., Ahmedabad, 26 April 1996 | S.Chandrasekhar: Some reminiscences |
| | Kodaikanal Observatory, Indian Institute of Astro-physics, 7 May 1996 | S. Chandrasekhar: Some reminiscences |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Ramaseshan, S. (*contd.*) | Central Food Technological Research Inst., Mysore 22-24 May 1996 | |
| | Dr. Vikram Sarabhai 75th Birth Anniversary, Vikram Sarabhai Space Centre, Thiruvananthapuram, 12-15 August 1996 | On Vikram Sarabhai (*invited*) |
| | Third Golden Jubilee Lecture, Birbal Sahni Inst. of Paleobotany, Lucknow, 9 Sept. 1996 | Shells, Corals and Geophysics (*invited*) |
| | 62nd Annual Meeting of Indian Acad. of Sciences, Jodhpur, 1-3 November 1996 | |
| Ramkumar,P.S. | Matlab's (Signal Processing) User's Conference, Bangalore,20 November 1996 | |
| Ranganath, G.S. | Bangalore Association for Science Education, Jawaharlal Planetarium, Bangalore, 15 May 1996 | Light propagation |
| | Sri Bhagawan Mahaveera Jain College, Bangalore, 17 August 1996 | Surprises in the sky |
| | Scientific Programme of Y A M, Bangalore, 4 September 1996 | Camera vision in animals |
| Ratnakar,A. | Karnataka Library Association, Bangalore, 4 March 1997 | Professional bodies and information sources in industry |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Ravi Subrahmanyan | Discussion Meeting on Big Bang and Alternative Cosmologies, Bangalore, January 1997 | Microwave background related evidence in favour of the standard model *(Invited)* |
| | Discussion Meeting on High Redshift Universe, Orange County, Coorg, Indian Acad. of Sciences 22-28 February 1997 | Cosmic background radiations *(two talks)* |
| | Mauritius Radio Telescope, Mauritius, November 1996 | |
| | Giant Meter Radio Telescope Site, Khodad, 1996 | |
| | National Centre for Radio Astronomy, Pune, 1996 | |
| Sadashiva,B.K. | Discussion Group Meeting on Novel Liquid Crystals, with Special Reference to Transition Metal Discotics and Smectics, S.N.Bose National Centre for Basic Sciences, Calcutta, 8-10 Jan. 1997 | Metallomesogens: Occurrence of smectic and columnar and mesophases *(invited)* |
| | Department of Chemistry, Mangalore University, Mangalore, 27-28 January 1997 | Liquid crystals: Chemistry and applications *(3 lectures)* |
| Samuel J. | Indian Inst. of Astrophysics, Bangalore, 18 June 1996 | Mach's principle and the Lense-Thirring Effect |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Sanjay Kumar | Seminar on Current Trends in Optics, Calcutta, 14-17 January 1997 | Phase properties of correlated two-mode squeezed coherent states (*Invited*) |
| Srinivasan G. | Perspectives in High Energy Astronomy and Astrophysics, (Golden Jubilee Colloquium of the Tata Institute of Fundamental Research) Mumbai, August 1996 | The Magnetic Fields of Neutron Stars - Their Origin and Evolution (*Invited*) |
| | Pulsar Timing, General Relativity and the Internal Structure of Neutron Stars, Amsterdam, The Netherlands, 24-27 September 1996 | Physics of Neutron Star Interiors - The fundamentals (*Plenary Talk*) |
| | Astronomical Institute, University of Amsterdam, Amsterdam, The Netherlands, 28 Sept.- 31 October 1996 | Can Stars Find Peace? |
| Suresh, K.A. | Sixteenth Int. Liquid Crystal Conf., Kent,USA, 26-28 June 1996 | 1. Optics of some chiral liquid crystals (*invited*)<br>2. Phase diagram of a liquid crystal siloxane polymer at air-water interface<br>3. Optics of some absorbing defect lattices |
| | Liquid Crystal Institute, Kent State Univ., Kent, USA, 28 June - 4 Aug.1996 | Modulations in the diffracted intensity in chiral smectic C |
| | Physics Department, Kent State Univ., Kent,USA, 10 July 1996 | 3D Molecular aggregation at air-water interface |

| Name | Conference Attended/ Institutions visited | Title of paper/ talk |
|---|---|---|
| Sushan Konar | Institute of Plasma Research, Gandhinagar, 26 February 1997 | Evolution of magnetic field in accreting neutron stars |
| | Physical Research Lab., Ahmedabad, 26-28 Feb. 1997 | Story of the millisecond pulsars |
| | Mehta Research Institute, Ahmedabad, 4-7 March 1997 | Evolution of magnetic field in accreting neutron stars |
| | Indian Inst. Technology, Kanpur, 8-11 March 1997 | Can strange stars masquerade as pulsars? |
| | Delhi University, Delhi, 12-14 March 1997 | Story of the millisecond pulsars |
| | Int. Conf. on Physics & Astrophysics of Quark-Gluon Plasma, Jaipur, 17-21 March 1997 | 1. Infrared divergences in $qq'$ scattering: A second look<br>2. Can strange stars masquerade as pulsars? |
| | Tata Institute of Fundamental Research, Mumbai, 27 March - 3 April 1997 | Evolution of the magnetic field in accreting neutron stars |
| Udaya Shankar,N. | XXV General Assembly of URSI, Lille, France, 28 August - 5 September 1966 | MRT - A new southern hemisphere metre wave radio telescope: First results |
| | Department of Physics, Univ. of Durham, U.K. 7-30 September 1996 | Mauritius Radio Telescope |
| | Department of Astronomy, Univ. of Cambridge,U.K. 26 September 1996 | Mauritius Radio Telescope |

Annexure - III

# COLLOQUIA

| Name | Title | Date |
|---|---|---|
| P. Durganandini<br>Pune University, Pune | Kondo Effect in a Luttinger Liquid – A Conformal Field Theory Approach | 26. 4.1996 |
| Abir Bandyopadhyay<br>Indian Institute Technology, Kanpur | Angular Momentum Squeezed States: Application to Interferometry | 15. 5.1996 |
| Janaki Balakrishnan<br>University of Delhi<br>Delhi | On the Effective Potential in Quantum Field Theory | 21. 5.1996 |
| Mangal Mahato<br>Institute of Physics<br>Bhubaneswar | Synchronised passage in two-well systems | 30. 5.1996 |
| R.S. Arora<br>National Physical Laboratory<br>Delhi | XIII Indian Antarctic Expedition | 21. 6.1996 |
| Sumati Surya<br>Syracuse University<br>Syracuse, USA | An Analysis of the Theta Sectors in Quantum Gravity | 29. 6.1996 |
| N.K. Rahman<br>University of Trieste<br>Trieste, Italy | High Order Harmonic Generation with Strong Laser and Chaos | 1. 8.1996 |
| Shrinivas Kulkarni<br>California Institute of Technology, Pasadena, USA | Discovery of a Cool, Brown Dwarf | 13. 8.1996 |
| M. Sanjay Kumar<br>Hyderabad | Radiation Pressure Forces on Mirrors in the Presence of Squeezed Light | 20. 8.1996 |
| C. Manohar<br>Bhabha Atomic Research Centre, Bombay | Solid-Fluid Micelles and their Importance in Material Research | 26. 8.1996 |

| Name | Title | Date |
|---|---|---|
| H. Schulz<br>Universite de Paris-Sud<br>France | 1-Dimensional Interacting Fermions | 2. 9.1996 |
| Gopi Krishna S. Garge<br>Indian Institute of Science<br>Bangalore | The Internet: Irresistible,<br>Intellectual, Criminal<br>or simply RADICAL | 5. 9.1996 |
| Jayaram Chengalur<br>National Centre for<br>Radio Astrophysics,<br>Pune | Deuterium in the Outer Galaxy | 10. 9.1996 |
| Jihad Touma<br>Canadian Institute for<br>Theoretical Astrophysics<br>IUCAA, Pune | The Phase Space Adventure of<br>Earth and Moon | 11. 9.1996 |
| Rong Wang<br>Institute of Biophysics<br>Academia Sinica, Beijing | Biomembranes and Liquid Crystals | 23. 9.1996 |
| B.I. Halperin<br>Harvard University<br>USA | Why is the Quantized Hall<br>Effect Exact? | 3.10.1996 |
| S.Ramakrishnan<br>Indian Inst. of Science<br>Bangalore | Asymmetric discotic liquid crystals | 8.10.1996 |
| Pier A. Mello<br>Institute of Physics<br>UNAM, Mexico | Surprises in wave scattering: From the<br>atomic nucleus to microwave cavities | 29.10.1996 |
| A. Jakli<br>Research Inst. for Solid<br>State Physics, Budapest<br>Hungary | Piezoelectricity and ferroelectricity in<br>columnar liquid crystals | 6.11.1996 |

| Name | Title | Date |
|---|---|---|
| P.A. Alemany<br>International Centre for<br>Theoretical Physics<br>Trieste, Italy | Models of Reaction Limited by<br>Anomalous Diffusion | 3.12.1996 |
| Pablo A. Alemany<br>International Centre for<br>Theoretical Physics<br>Trieste, Italy | Models of Reaction Limited by<br>Anomalous Diffusion | 3.12.1996 |
| Pier A. Mello<br>Institute of Physics,<br>UNAM, Mexico | Scattering by Complex Systems:<br>An Information-Theoretic<br>Approach | 4.12.1996 |
| Vijay Sheorey<br>Physical Research Lab.<br>Ahmedabad | Chaos, Bifurcation and<br>Exponential Localization<br>in Smooth Quantum Systems | 5.12.1996 |
| Pier A. Mello<br>Institute of Physics,<br>UNAM, Mexico | Scattering by Complex Systems:<br>An Information-Theoretic<br>Approach – Part II | 6.12.1996 |
| Jörg Eichler<br>Hahn-Meitner-Institut Berlin<br>and Friei Universität Berlin,<br>Germany | New Atomic Physics with<br>Highly-charged Heavy Ions | 9.12.1996 |
| J.S. Prakash<br>Institute of Mathematical<br>Sciences, Chennai | Two applications using the calculus<br>for SU(3) | 24.12.1996 |
| B.S. Sathyaprakash<br>Department of Physics<br>and Astronomy,<br>University of Wales,<br>College of Cardiff, UK | Gravitational Waves from<br>Compact Binaries:<br>What Physics and Astrophysics<br>Can We Learn? | 31.12.1996 |

| Name | Title | Date |
|---|---|---|
| Ranjan Mukhopadhyay<br>California Institute of<br>Technology,<br>Pasadena, USA | Equilibrium & Non-Equilibrium<br>Behaviour of the<br>Normal-Superfluid Interface<br>in Liquid Helium | 31.12.1996 |
| B.S. Sathyaprakash<br>Department of Physics<br>and Astronomy,<br>University of Wales,<br>College of Cardiff, UK | Filaments, Sheets and Voids<br>in the Universe | 2. 1.1997 |
| D. Vijayaraghavan<br>Indian Institute of Science,<br>Bangalore | Field Cycling NMR in Solids | 6. 1.1997 |
| Srinandan Dasmahapatra<br>City University,<br>London, UK | Stochastic Models with<br>Boundaries and<br>Quadratic Algebras | 7. 1.1997 |
| G. Srinivasan<br>Raman Research Institute<br>Bangalore | Can Stars Find Peace? | 9. 1.1997 |
| Bijay Bal<br>Saha Institute of<br>Nuclear Physics,<br>Calcutta | Immiscible Liquid Flow<br>in an Hour Glass | 16. 1.1997 |
| P. Balaram<br>Molecular Biophysics Unit<br>Indian Institute of Science,<br>Bangalore | Protein Folding | 23. 1.1997 |
| W. Haase<br>Institut für Physika-<br>lische Chemie, Technische<br>Hochschule, Darmstadt<br>Germany | Ferroelectric liquid crystals<br>with unexpected new properties | 31.1.1997 |
| S.D.Mohanty<br>I U C A A, Pune | Detection of gravitational waves:<br>Efficient data analysis techniques | 4.2.1997 |

| Name | Title | Date |
|---|---|---|
| L. Sriramkumar<br>I U C A A, Pune | Aspects of quantum field theory in non-trivial classical backgrounds | 6.2.1997 |
| G. Rajasekaran<br>The Institute of<br>Mathematical Sciences,<br>Madras | Is There a Final Theory? | 6. 2.1997 |
| B.P. Das<br>Indian Institute of<br>Astrophysics,<br>Bangalore | Atomic Tests of Unification<br>of Fundamental Forces | 20. 2.1997 |
| Bhaskar Datta<br>Indian Institute of<br>Astrophysics<br>Raman Research Institute<br>Bangalore | Quark Matter! | 6. 3.1997 |
| Carsten van de Bruck<br>University of Bonn,<br>Bonn, Germany | Baryonic Cosmological<br>Models and<br>Structure Formation | 14. 3.1997 |
| Jeeva S. Anandan<br>University of South Carolina,<br>USA | Casuality Cosmology and<br>Parity Violation | 19. 3.1997 |
| Alain Lecavelier<br>Institut d'Astrophysique,<br>Paris, France | $\beta$-Pictoris Circumstellar<br>Disk | 21. 3.1997 |
| Shanta Chaudhuri<br>Indian Association for<br>the Cultivation of<br>Science, Calcutta | Liapunov Exponent:<br>A New Way of Viewing It | 24. 3.1997 |
| Wolfgang Kundt<br>University of Bonn,<br>Bonn, Germany | Massive Accretion Disks | 31. 3.1997 |