

RAMAN RESEARCH INSTITUTE
BANGALORE

ANNUAL REPORT - 1976-77

Contents

	<u>Page No.</u>
1. Liquid Crystals	1
2. Theoretical Physics and Astrophysics	4
3. Radio Astronomy and Associated Electronics	7
4. Publications	11
Annexure I	15
5. Conferences/Seminars/Meetings	11
Annexure II	19
6. Colloquia	11
Annexure III	23
Annexure IV	25
7. Visiting Scientists	12
8. Library	12
9. General	12
Annexure V - Major items of equipment procured	26
10. Staff	13

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The work carried out by the various groups in the Institute during the year 1976-77 is summarised below:

LIQUID CRYSTALS

1. X-ray studies: X-ray diffraction studies have been carried out on the twisted smectic C and the twisted nematic phases. These studies have led to the discovery of a new skew-cybotactic type of cholesteric structure in which the molecules are inclined at an acute angle with respect to the helical axis (and not normal to it as in the classical cholesteric). Further, as a part of the continuing programme of study of the molecular conformation of these materials, the crystal structures of some more mesogenic compounds have been solved.

2. Hydrodynamics: The hydrodynamic instabilities in nematic liquid crystals induced by shear have been studied theoretically in terms of the continuum theory. The effect of stabilizing/destabilizing electric and magnetic fields on the threshold for the instability and the types of distortion produced in various geometries have been calculated.

3. Pressure studies: Experimental phase diagrams have been obtained for a number of mesomorphic and poly mesomorphic materials.

Preliminary drawings have been prepared for setting up a 100 ton hydraulic press at RRI and cells have been designed for making the following physical measurements:

- (a) Differential thermal analysis up to 20 kbar.
- (b) Optical, infrared, Raman and fluorescence studies up to 20 kbar.
- (c) Compressibility measurements up to 20 kbar.
- (d) X-ray studies up to 15 kbar.

4. Dielectric studies: Static and dynamic dielectric measurements have been made on a number of positive as well as negative dielectric anisotropy nematics. The interesting result has been established for the first time that the dielectric relaxation frequency of successive members of a homologous series exhibits the so-called odd-even effect. It has also been shown that in contrast to what is observed in weakly positive or negative materials the dielectric anisotropy of strongly positive materials like the cyanobiphenyls does not follow this odd-even effect. This is interpreted as due to the effect of antiparallel short range correlations.

5. Surface studies: Further measurements have been made on the surface tension of nematic and smectic liquid crystals. Apparatus is being set up to investigate the surface structure by direct ellipsometric studies of reflected and scattered light.

6. Spectroscopic studies: The new method developed earlier of determining the absolute orientational order from infrared absorption has been used to measure the order parameter as function of temperature of a number of compounds. Far-infrared measurements spectra have been studied for TBBA which exhibits 6 mesophases. The changes in the spectra have thrown some light on the nature of the structural transformations accompanying these different phase transitions.

The design is complete for a pressure scanned Fabry Perot interferometer for Brillouin scattering studies, and the apparatus is being fabricated.

7. Electric and magnetic field effects: Using a new optical arrangement for detecting minute changes of phase, Leslie's expression for the threshold field for the twisted nematic device has been verified for the first time.

Extensive measurements have been made of the elastic constants, order parameters, etc. for a large number of newly synthesized compounds and a systematic attempt has been made to correlate and interpret the data.

8. Chemical studies: The aim of these studies has been two-fold: (a) The synthesis of new compounds with a view to elucidating the basic chemistry of these materials. A large number of new homologous series have been prepared and their properties investigated. (b) The development of new processes for the preparation of materials of importance is display technology. The final specifications have been drawn up for the patents filed last year.

9. NMR Studies: The work on the application of NMR spectroscopy of oriented molecules to more complicated conformational problems of biological importance has been continued. Studies on isotopically enriched model systems containing a peptide unit indicate definite non-planar distortions of about 10° around the nitrogen atom. Quantum chemical and NMR investigations have been undertaken to establish the conformation of phenyl maleimide.

Structure and conformation of butadiene-sulphone, phthalazine and quinoxaline in a lyotropic liquid crystal solvent have been determined. The results when compared with those obtained by other techniques provide information on molecular interactions in lyotropic liquid crystals which are models for more complicated biological systems. Such studies, therefore, provide definite information on the interaction of small molecules with bio-molecules.

10. Technology: Using the liquid crystal materials prepared in the laboratory the RRI group in collaboration with BEL has succeeded in fabricating an engineering model of a liquid crystal watch display, whose performance is found to be extremely satisfactory.

11. Complete specifications for the following patents (the preliminary specifications for which were filed in December 1975) have been submitted:

- 1) Patent application No.196/MAS/75 dated 9.12.1975
- 2) Divisional patent application No.196/MAS/75 dated 9.12.1975
- 3) Patent application No.198/MAS/75 dated 9.12.1975
- 4) Divisional patent application No.198/MAS/75 dated 9.12.1975.

12. Three Ph.D. theses have been completed and submitted; the details may be found after the list of publications from the Institute (page 18).

THEORETICAL PHYSICS AND ASTROPHYSICS

1. Renormalisation Group techniques: The problem of an electron moving in a random potential was shown to be equivalent to the Wilson-Fisher ϕ^4 -field theory if one lets the dimensionality of the order parameter, (n) tend to zero, and also analytically continues the results of the field theory to negative values of the coupling constant. This equivalence was further exploited to derive various properties of the configuration-averaged electron green's function in the vicinity of the mobility edge. The relevance of the Wilson fixed point and the question of localization in four dimensions are being presently investigated.

2. Formation of a Wigner Lattice: The interesting possibility of observing electron crystallization in a

semiconductor inversion layer was investigated in detail. The stability of the electron lattice was studied and the melting curve calculated.

It was suggested that the application of an intense magnetic field perpendicular to the inversion layer will aid the 'localization'. A detailed study was carried out and the results confirm the above conjecture.

3. Pulsars: The continuation of work based on the correlation between pulsar proper motions and radio polarization data has been used to find associations between pulsars and supernova remnants. The associations proposed on this basis are faced with discrepancies in the ages of the pulsars and the supernova remnants. One method of resolving this discrepancy is by assuming for example that pulsars are born in close binary systems, a conclusion also suggested by the previous investigation.

The theory of the orbit of a binary pulsar including a constant force due to asymmetric radiation was investigated. The predicted periodic oscillations of the orbital parameters were, however, found to be too small to give rise to observational consequences.

4. H₂O Maser Sources: The cross section for stimulated Raman scattering was estimated in order to test the suggestion that this mechanism could give rise to features in the spectra of interstellar H₂O maser sources hitherto attributed to high velocity motions. The estimates were not basically favourable to the mechanism, although they do allow an attainable range of physical parameters, like the density and the path length of the scattering molecules.

5. Maximum entropy spectral analysis: A study was undertaken of the resolution and reliability properties of

the MEM spectral estimator using computer experiments and some theory. Some useful conclusions were reached which place the value of this data analysis technique in a somewhat better perspective than provided by previously published work on the subject.

Interest generated during this work led to studies of some more general aspects of data analysis, in particular time-series analysis, elements of statistical analysis and stochastic processes.

6. Gravitation and Elementary Particle Physics: Gravitational interactions are being studied from a microscopic point of view within the source theory framework of Schwinger. New tests of the equivalence principle for quantum systems based on discrete symmetry violations in gravitation and their theoretical consequences, have been studied in detail. Further tests based on high precision time and frequency methods are under study.

A search has been made for measurable parity violation effects due solely to the recently discovered neutral currents. In particular, the decays of pseudoscalar mesons and multi-electron phenomena in atoms have been chosen for study.

7. General Relativity: A previously derived method for obtaining the general differentially rotating dust metric was applied to the cylindrically symmetric case. The dust metric, the exterior vacuum metric and the matching conditions at the boundary were worked out explicitly. The global properties of the resulting space time were examined in detail.

RADIO ASTRONOMY AND ASSOCIATED ELECTRONICS

1. Decameter wave Astronomy - a joint project of RRI and IIA: The decameter wave antenna system which was in the final phase of construction last year is now complete. The present dimensions of the East-West and the North-South arms are 1.5 km and 0.5 km respectively. The total effective area is now approximately 30,000 square metres. In order to electrically steer the antenna response within $\pm 45^\circ$ of the zenith in the N-S direction, about 100 amplifiers and phase shifters have been made and installed along the N-S arm. The half power beamwidths in the E-W and N-S directions are 32 arc minutes and 50 arc minutes respectively, at the zenith for uniform illumination of the array.

A small building to house the receiving system for the telescope has been constructed on a portion of the land belonging to BARC Seismic Array Station with their kind permission. The building will also contain facilities for the repair and maintenance of the electronics system associated with the telescope. An elaborate cabling system has been laid to enable the signals to be brought in from the different sections of the array to this building. During the last few months several tests have been made to check the performance of the telescope and to determine the errors in the collimation of the beam, its shape and the relative sidelobe level. An electronic system for gain and phase calibration of the array has also been developed and built.

The antenna practically meets its design specifications. It will be possible now to employ this instrument in some interesting investigations of decametric wavelength phenomena. For this purpose a correlation receiving system has been designed, constructed and installed at Gauribidanur. At the moment the output of the receiver is in the form of analog

chart records, requiring manual digitisation and processing in a computer. The full exploitation of the potentialities of the telescope will, however, have to await the completion of the sophisticated digital Fourier Transform System, work on which was already started last year.

The implementation of this system has been delayed mainly due to the introduction of a number of new ideas and schemes into the earlier design. Various requirements like phase corrections, grading, beam selection, integration time control etc. were incorporated in the system. Direct multiplication will be done using recent LSI chips in place of ROM tables to give faster processing thereby enabling real time computation. The computed data will be finally stored on magnetic tape in addition to having a display of the sky corresponding to any hour angle. A one bit correlator system in the front-end will dispense with Analog to Digital Conversion, since the data processing is done digitally. Delay corrections necessary for different beams, will be done by a single scheme using shift registers.

The detailed circuit design up to the display and output system has been completed. Some of the circuits were also built and tested before finalising the art-work for the P.C. Boards. It is hoped that the full system will be in operation in six to eight months from now.

2. Millimeter wave Astronomy

a. 1.5 meter millimeter-wave pilot telescope. Construction of the 1.5 meter millimeter-wave telescope (a pilot project) has been started. The reflector of fibre glass has been manufactured at the National Aeronautical Laboratory. Several methods of measuring the surface accuracy of the reflector have been devised and the measurements are under progress.

We wish to achieve a surface accuracy of 100 microns (r.m.s.) on the prototype reflector.

The design for a high precision mount to carry the above reflector was initially entrusted to Tata Consulting Engineers, but subsequently the design as well as the fabrication was taken over by the Raman Research Institute. The mount design is nearing completion and incorporates several novel features. One of them is the use of an aerostatic bearing for the Azimuth motion. A prototype bearing was tested and the performance found to be satisfactory.

The telescope will be housed in the dome on top of the mm-wave laboratory building. Some modifications to the dome are necessary and these are being taken up.

Design of the electronic control system for the telescope is under progress and procurement of the necessary components has already started. A basic receiver system to test the telescope performance has been designed and the components are on order. This pilot project has been financed by the Indian Space Research Organisation.

b. 10 meter mm-wave telescope: Work on the 10 meter mm-wave telescope has started. A comprehensive proposal giving the various aspects of construction of such a telescope was prepared and submitted to the Department of Science and Technology. A team consisting of Prof. V. Radhakrishnan, Dr. S. Ramaseshan and Mr. R.V. Ramani visited the California Institute of Technology in September 1976 to study the mechanics and problems involved in the development of high accuracy reflectors by Prof. Leighton's method. The Raman Research Institute in collaboration with the National Aeronautical Laboratory has undertaken to develop these reflectors and work on the initial set up has just begun.

A mount to take the above reflector is to be designed and manufactured. Indian Design Centre, Bangalore have been given a contract to act as consulting engineers to help RRI in the above tasks.

A back-end receiver for molecular line studies has been designed and the individual components of this receiver are under development. The receiver consists of 256 channels of 250 KHz resolution, each separated by 250 KHz from the adjacent channels. To record the outputs of these 256 channels, we require a fast data acquisition system, the design of which is under progress.

The selection of a proper site to locate the 10 meter mm-wave telescope requires collection of meteorological data at the proposed sites. Meteorological observations have been started at the Raman Research Institute campus and also at Nandi Hills. We are also building an infra-red spectral hygrometer and a water vapour radiometer to determine the total precipitable water content at these two sites among others

3. Electronics

The acquisition of a number of advanced items of test equipment and the familiarization of the staff with them has made it possible to undertake the development of projects of increasing complexity and sophistication. Periodical group meetings (approximately twice a month) were held in which the various projects and problems encountered were discussed.

The Group was involved in a number of areas of work most of which formed part of either the decimeter-wave or the millimeter-wave astronomy projects. In addition, work has been continuing on the development and fabrication of equipment designed for use in meter-wave observations with

the TIFR Telescope at RAC, Ooty.

4. Summer School, May 17-June 11, 1976

Members of the staff of the Institute participated actively in the Summer School on Astronomy, Astrophysics and Space Physics organised jointly by the TIFR Radio Astronomy Centre, the Indian Institute of Astrophysics, the ISRO Satellite Centre and the Raman Research Institute.

Lectures during two of the four weeks were held at the Raman Research Institute and several members of the staff were involved both in giving lectures and in supervising the projects.

PUBLICATIONS

The work done by members of the Institute has been published in a number of journals. A list of publications is given at Annexure I (page 15).

CONFERENCES/SEMINARS/MEETINGS

Members of the staff of the Institute participated in a number of conferences held within and outside the country. Annexure II (page 19) gives a list of conferences/meetings attended by our staff with titles of papers or talks presented if any.

COLLOQUIA

Twentyone colloquia on various topics were held at the Institute during the year, most of them given by visiting scientists from other institutions both Indian and foreign. In addition, a series of informal talks and discussions mostly on topics in theoretical physics were held during the year. Lists may be found at Annexure III and IV (pages 23 & 25).

VISITING SCIENTISTS

A number of scientists from institutions both 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 at the end of this report.

LIBRARY

The library acquired 501 new books during the year. Its present book collection is 9949 ^{of} bound volumes of periodicals 14,124. It subscribes to 110 journals and continues to receive about 350 periodicals as a 'gift' from Current Science and the Indian Academy of Sciences. About 208 books and 26 back volumes of periodicals were received from the British Council as a gift under their ODA scheme.

Two students from the Library School of Women's Polytechnic, Bangalore, were given four months training at our library. The Inter-Library cooperation activity between the Indian Institute of Science Library, the National Aeronautical Laboratory Library and our library is being continued. The project of compilation of a Master Index (author) to volumes 1 to 33 of 'Molecular Crystals and Liquid Crystals' was completed.

GENERAL

1. The Institute received the following grant from the Department of Science and Technology during the year:

<u>Plan</u>	Recurring	:	Rs. 11.0 lakhs
	Non-recurring	:	Rs. 37.5 lakhs
<u>Non-plan</u>	Recurring	:	Rs. 10.5 lakhs
	Total	:	<u>Rs. 59.0 lakhs</u>

2. A list of major items of equipment procured during the year is given in Annexure V (page 26).

STAFF

The Scientific and Technical Staff of the Institute is listed below. Those who are under deputation are indicated by +. Those marked with an asterisk are additions during the year.

- | | |
|----------------------------------|--------------------------------|
| 1. Prof. V. Radhakrishnan | 20. Mr. D.K. Ravindra |
| 2. Prof. S. Chandrasekhar | 21. Mr. K.M. Chandra Kumar |
| 3. Dr. S. Krishnan ⁺ | 22. Mr. R.S. Arcera |
| 4. Mr. N.V.G. Sarma ⁺ | 23. Mr. K.R. Anantharamaiah |
| 5. Dr. C.L. Khetrapal | 24. Mrs. Jayanthi Ramachandran |
| 6. Dr. N.V. Madhusudana | 25. Mr. M.O. Modgekar |
| 7. Dr. G. Srinivasan | 26. Mr. M.R. Subrahmanyam |
| 8. Dr. R. Shashidhar | 27. Mr. P.N. Ramachandra |
| 9. Dr. S. Venugopalan | 28. Mr. B.S. Prasanna |
| 10. Dr. V. Surendranath | 29. Mr. U. Devappa Kini |
| 11. Dr. A.C. Kunwar | 30. Mr. K.A. Suresh |
| 12. Dr. G.S. Ranganath | 31. Mr. B.K. Sadashiva |
| 13. Dr. Rajendra Bhandari | 32. Mr. S.G. Siddesh* |
| 14. Dr. C.S. Shukre | 33. Mr. N. Nandakumar* |
| 15. Dr. Rajaram Nityananda | 34. Mr. K. Subramanya* |
| 16. Dr. N.D. Hari Dass* | 35. Mr. T. Ramachandran* |
| 17. Dr. C.V. Vishveshwara* | 36. Mr. Smiles Mascarenhas* |
| 18. Mr. J. Padmanabhan | 37. Mr. K.M. Doraiswamy* |
| 19. Mr. K.T. Balakrishnan | 38. Mr. S. Gopal Rao* |

Visiting positions

1. Dr. S. Ramaseshan
2. Dr. G.S.R. Subba Rao
3. Dr. Anand Kumar
4. Miss A. Mani*

Medical Consultant

Dr. A. R. Pai

Resignations

1. Mr. A.K. Ravindranath (resigned on 23.7.1976)
2. Mr. N.S. Dinesh (resigned on 31.3.1977)
3. Mr. K.V. Balachandra (resigned on 20.1.1977)
4. Mr. P.R. Ramraj (resigned on 28.9.1977)
5. Mr. Anand V. Gumaste (joined on 25.11.1976 & resigned on 29.8.1977)

Pre-Doctoral Research Fellows

- | | |
|-------------------------|---------------------------|
| 1. Mr. J.R. Fernandes | 5. Mr. S. Krishnaswamy |
| 2. Mrs. B.R. Ratna | 6. Mr. K.L.Venkatakrishna |
| 3. Mrs. G.V. Vani | 7. Mr. M.N.Ramanuja. |
| 4. Miss K.L.Savithramma | |

A list of short period visiting scientists is given below:

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|---|----------------------------------|
| 1. Dr. W.A.Coles
CSIRO Division of Radiophysics
Epping, N.S.W., Australia | May 16-21, 1976 |
| 2. Dr. A.R.P. Rau
Louisiana State University
Baton Rouge, Louisiana, USA | June 21-Aug.7, 1976 |
| 3. Dr. J.L. Osborne
Physics Department
Durham University, Durham,U.K. | July 27-Aug.13, 1976 |
| 4. Mr. A.Watkinson
School of Electrical Engineering
University of Sydney, Sydney | Novr.17, 1976 to
May 27, 1977 |
| 5. Prof. Sir Sam Edwards, FRS
Chairman, Science Research Council
State House, High Holborn
London WC1R 4TA | January 2-4, 1977 |
| 6. Mr. Mats Johnson
Institute of Theoretical Physics
Goteborg, Sweden | March 17-May 15, 1977 |

Following is a list of the supporting staff of the Institute both Administrative and Technical, in a salary scale of Rs.425-700 or above.

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|-------------------------------|----------------------------|
| 1. Mr. Mathew Sebastian | 8. Mrs. Sowjanya Mahesh |
| 2. Mr. P.K. Ramakrishnan | 9. Mr. H.H.J. Pereira |
| 3. Mr. A. Ratnakar | 10. Miss S. Giriya |
| 4. Mr. V.S.Ramaswamy | 11. Mrs. Ahalya Kumar |
| 5. Mr. G.V. Srinivasa | 12. Mr. P.S. Somasundaram* |
| 6. Mr. Sreenivasa Raghavachar | 13. Mr. K.R. Srinivasan* |
| 7. Mrs. Lakshmi Rajagopal | 14. Mr. Mohamed Khasim |

*New addition

In addition there is a total of 47 other staff not listed here.

Papers published in 1976-77

1. Pressure dependence of the pitch of cholesteryl oleyl carbonate (S. Chandrasekhar and B.R.Ratna) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS, 35, 109 (1976).
2. Dielectric properties of the 4'-n-alkyl-4-cyanobiphenyls in their nematic phases (B.R.Ratna and R.Shashidhar) - PRAMANA 6, 278 (1976).
3. Infrared spectroscopic study of orientational order and phase transformations in liquid crystalline CBOOA (J.R. Fernandes and S.Venugopalan) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 35, 113 (1976)
4. An experimental study of the anomalous transmission (Borrmann effect) in absorbing cholesteric liquid crystals (K.A.Suresh) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 35, 267 (1976).
5. Experimental studies of the surface tension of nematic liquid crystals (S.Krishnaswamy and R. Shashidhar) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 35, 253 (1976).
6. Elastic and optical properties of some 4'-n-alkyl-4-cyanobiphenyls (P.P. Karat and N.V.Madhusudana) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 36, 51 (1976).
7. Mesomorphic properties of some α -methyl cinnamic acids and their esters (B.K.Sadashiva) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 35, 205 (1976).
8. The effect of magnetic fields and boundary conditions on the shear flow of nematics (U.D.Kini) - PRAMANA 7, 378 (1976).
9. The effect of magnetic fields and boundary conditions on the Couette flow of nematics (U.D. Kini) - PRAMANA 7, 223 (1976).
10. On dislocations and disclinations (G.S.Ranganath) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS LETTERS 34, 71 (1976).
11. NMR spectra of isotopically enriched N-methyl formamide in isotropic and nematic media (C.L.Khetrapal, A.C.Kunwar and S. Ramaprasad) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS LETTERS 34, 123 (1976).

12. The amide planarity as studied by NMR of oriented molecules - The spectrum of N-methyl acetamide (S. Ramaprasad, H.P. Kellerhals, A.C.Kunwar and C.L. Khetrapal) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 34, 19 (1976)..
13. NMR spectra of π -cyclopentadienyl manganese tricarbonyl in nematic and isotropic solvents (C.L.Khetrapal, A.C. Kunwar and A. Saupe) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS 35, 215 (1976).
14. Short range order in nematic liquid crystals (N.V.Madhusudana, K.L.Savithramma and S.Chandrasekhar) - PRAMANA 8, 22 (1977).
15. A coaxial DTA cell for the study of liquid crystalline transitions at high pressures (A.S. Reshamwala and R. Shashidhar) - JOURNAL OF PHYSICS, E. SCIENTIFIC INSTRUMENTS 10, 180 (1977).
16. Molecular orbital studies on the conformation of N-phenyl maleimide (G. Govil and C.L.Khetrapal) - CURRENT SCIENCE 46, 250 (1977).
17. On the rotatory dispersion in cholesteric liquid crystals (G.S.Ranganath) - OPTICS COMMUNICATIONS 16, 369 (1976).
18. Non-planar distortions in a peptide unit as studied by NMR in liquid crystal solvents (C.L.Khetrapal and S.Ramaprasad) - JOURNAL OF THE INDIAN INSTITUTE OF SCIENCE 59, 53 (1977).
19. The density of states of electron in a disordered material (S.F.Edwards, M.B.Green and G.Srinivasan) - PHILOSOPHICAL MAGAZINE 35, 1421 (1977).
20. A new spin test for the equivalence principle (N.D. Hari Dass) - JOURNAL OF GENERAL RELATIVITY AND GRAVITATION 2, 89 (1977).
21. Equivalence principle, stress tensor and long range behaviour of gravitational interaction (N.D. Hari Dass and C.F. Cho) - PHYSICAL REVIEW, D14, 2511 (1976).
22. Photon Decay into Neutrino Pairs in External Magnetic fields (N.D.Hari Dass, K.A.Milton and L.L. De Raad) - PHYSICAL REVIEW D.14, 3326 (1976).
23. Calculation of parity violating Compton amplitudes (N.D.Hari Dass) - NUCLEAR PHYSICS 'B' 113, 336 (1976).
24. Binary Pulsar (N.D.Hari Dass) - Proc. First Marcel Grossman Meeting on General Relativity, Ed.R.Ruffini, 1977 (North Holland).

25. The Observer in the World View of Physics (R.Bhandari) -
CURRENT SCIENCE 45, 817 (1976).

Papers submitted and in press (1976-77)

1. Optical and X-ray studies on the twisted smectic C and twisted nematic phases: Evidence for a skew-cybotactic type of cholesteric structure (K.A.Suresh and S.Chandrasekhar) MOLECULAR CRYSTALS & LIQUID CRYSTALS.
2. A study of the dielectric relaxation in nematic liquid crystals using the Freedericksz transition technique (P.P. Karat and N.V.Madhusudana) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
3. Elasticity and Orientational order in several cyanobiphenyl compounds and their mixtures (P.P. Karat and N.V.Madhusudana)- MOLECULAR CRYSTALS & LIQUID CRYSTALS.
4. Verification of Leslie's expression for the threshold field for a twisted nematic cell (P.P. Karat and N.V. Madhusudana) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
5. A convenient method for the preparation of 4-n-alkyl-4''-cyano-p-terphenyl (B.K.Sadashiva and G.S.R. Subba Rao) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS.
6. Measurement of the surface tension of CBOOA (S.Krishnaswamy and R.Shashidhar) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS.
7. Singularities in nematics - the effect of elastic constant variations (U.D. Kini and G.S. Ranganath) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
8. Crystal structures of two mesogenic compounds (G.V.Vani and Kalyani Vijayan) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
9. Dielectric studies on liquid crystals of strong positive dielectric anisotropy (B.R. Ratna and R. Shashidhar) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS.
10. High pressure studies on mesomorphic and polymesomorphic transitions (R. Shashidhar) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
11. Interaction between a hole and a disclination in nematics (G.S. Ranganath) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
12. Far-Infrared absorption in the highly ordered smectic phases of TBBA (S.Venugopalan, J.R.Fernandes and V. Surendranath) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.

13. Structure and conformation of N,P-chlorophenyl-maleimide in a nematic solvent by proton magnetic resonance (C. L. Khetrpal, A.C. Kunwar and A. Saupe) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
14. PMR spectrum of butadiene sulphone oriented in a lyotropic solvent (C.L.Khetrapal, A.C. Kunwar and A.V. Patankar) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
15. PMR spectra of N-Phenylmaleimide in isotropic and nematic phases (C.L. Khetrpal, P. Diehl and A.C. Kunwar) - ORGANIC MAGNETIC RESONANCE.
16. The crystal and molecular structure of the nematogenic n-p-methoxybenzylidene-p-phenylazoaniline (MBPAA) (G.V. Vani and Kalyani Vijayan) - ACTA CRYSTALLOGRAPHICA
17. Dielectric dispersion in 4'-n-alkyl-4-cyanobiphenyls (B.R. Ratna and R. Shashidhar) - MOLECULAR CRYSTALS & LIQUID CRYSTALS.
18. Magnetic field induced Wigner transition in inversion layers (M. Jonson and G.Srinivasan) - SOLID STATE COMMUNICATIONS.
19. Experimental tests for some quantum effects in gravitation (N.D. Hari Dass) - ANNALS OF PHYSICS
20. Relativistically rotating dust cylinders (C.V.Vishveshwara and J. Winicour) - JOURNAL OF MATHEMATICAL PHYSICS.
21. Four possible pulsar supernova remnant associations (D. Morris, V.Radhakrishnan and C.Shukre) - BULLETIN OF ASTRONOMICAL SOCIETY OF INDIA.
22. Master index (Author) to Volumes 1 to 33 of Molecular Crystals and Liquid Crystals (Library Staff) - MOLECULAR CRYSTALS AND LIQUID CRYSTALS.

Ph.D. Theses submitted

	<u>Name</u>	<u>Title</u>
1.	Mr. K.A.Suresh	Experimental studies on the optical properties of cholesteric liquid crystals
2.	Mr. U.Devappa Kini	Theoretical studies on the properties of liquid crystalline state
3.	Mr. Prakash P. Karat	Electric and magnetic field effects in liquid crystals.

ANNEXURE II

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
1. Sixth International Liquid Crystal Conference, Kent State University, Ohio, USA, Aug. 1976	Prof.S.Chandrasekhar	Optical & X-ray studies on the twisted smectic C and twisted nematic phases: Evidence for a skew cybotactic type of cholesteric structure (S.Chandrasekhar & K.A. Suresh)
2. -do-	-do-	A study of the dielectric relaxation in nematic liquid crystals using the Freedericksz transition technique (P.P. Karat & N.V. Madhusudana)
3. -do-	-do-	Elasticity and Orientational order in several cyano-biphenyl compounds and their mixtures (P.P.Karat & N.V. Madhusudana)
4. -do-	-do-	Verification of Leslie's expression for the threshold field for twisted nematic cell (P.P.Karat & N.V. Madhusudana).
5. -do-	-do-	A convenient method for the preparation of 4-n-alkyl-4"-cyano-p-terphenyl (B.K.Sadashiva & G.S.R. Subba Rao)
6. -do-	-do-	Measurement of the surface tension of CBOOA (S.Krishnaswamy and R. Shashidhar).
7. -do-	-do-	Singularities in nematics - the effect of elastic constant variations (U.D.Kini & G.S.Ranganath).
8. -do-	-do-	Crystal structures of two mesogenic compounds (G.V. Vani & Kalyani Vijayan).

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
9. Sixth International Liquid Crystal Conference, Kent State University, Ohio, USA, August 1976	Prof. S. Chandrasekhar	Dielectric studies on liquid crystals of strong positive dielectric anisotropy (R. Shashidhar & B.R. Ratna)
10. -do-	-do-	High pressure studies on mesomorphic and poly-mesomorphic transitions (R. Shashidhar).
11. -do-	-do-	Interaction between a hole and a disclination in nematics (G.S. Ranganath)
12. -do-	-do-	Far-infrared absorption in the highly ordered smectic phases of TBBA (S. Venugopalan, J.R. Fernandes and V. Surendranath).
13. -do-	Dr. C.L. Khetrapal	PMR study of N-methyl acetamide oriented in a nematic solvent (S. Ramaprasad, H.P. Kellerhals, A.C. Kunwar and C.L. Khetrapal).
14. -do-	-do-	The amide planarity from NMR in nematic solvents (C.L. Khetrapal, A.C. Kunwar and S. Ramaprasad).
15. -do-	-do-	Structure and conformation of p-chlorophenyl maleimide in a nematic solvent by proton magnetic resonance (C.L. Khetrapal, A.C. Kunwar and A. Saupe).
16. IAU Symposium No. 74 - Radio Astronomy and Cosmology, Cambridge, England, Aug. 16-20, 1976	Prof. V. Redhakrishnan	
17. IAU General Assembly, Grenoble, France Aug. 24-Sept. 2, 1976	-do-	
18. IAU Colloquium No. 37 and CNRS Colloquium No. XXX - Redshifts and Expansion of Universe, Paris, France Sept. 6-9, 1976	-do-	

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
19. Third Meeting of Astronomical Society of India, Naini Tal, Nov. 7-10, 1976	Dr. C. Shukre Prof. V. Radhakrishnan	Four possible pulsar supernova remnant associations
	Dr. N. D. Hari Dass	Binary pulsar
	Mr. K. R. Anantharamaiah Mr. R. S. Arora	
20. Annual meeting of the Indian Academy of Sciences, Baroda, Novr. 14, 1976	Dr. G. Srinivasan	Electrons in Amorphous Materials
21. Time and Frequency Seminar, National Physical Laboratory, New Delhi, Novr. 18-20, 1976	Mr. R. S. Arora Mr. K. R. Anantharamaiah	Frequency synthesizer for a line receiver for Radio Astronomy (R. S. Arora, K. R. Anantharamaiah, D. K. Ravindra, P. R. Ramaraj).
	Mr. R. S. Arora	A precision solar and sidereal clock (S. Krishnan, K. M. Chandrakumar, K. V. Balachandra & M. Selvamani).
22. DAE Symposium on Nuclear and Solid State Physics, Ahmedabad, Dec. 29, 1976	Dr. G. Srinivasan	Electron Crystallization in Inversion Layers.
23. National Conference on Crystallography, Madras, January 1977	Mrs. G. V. Vani	Crystal structures of cholesteryl bromide and cholesteryl chloride (G. V. Vani & Kalyani Vijayan)
24. International Conference on Frontiers of Theoretical Physics, New Delhi, January 6-12, 1977	Dr. R. Bhandari Dr. R. Nityananda	

Other Lectures given by Members of the Institute's Staff

1. CTS, Indian Institute of Science, Bangalore, April 1976	Dr. N. D. Hari Dass	Discrete symmetries in gravitation.
2. Summer School on Astronomy, Astrophysics and Space Physics, Bangalore, May 17-June 11, 1976.	Dr. C. S. Shukre Prof. V. Radhakrishnan Dr. R. Bhandari Dr. R. Nityananda	Pulsars Neutron Stars Radio Spectroscopy Spectral Analysis. Gravitational Collapse Astrophysical Masers

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
3. National Institutes of Health, Bethesda, Maryland, USA, September 9, 1976	Dr. C.L. Khetrupal	Biological applications of NMR of oriented molecules.
4. University of Florida, USA, Septr. 10, 1976	-do-	Application of NMR to chemical engineering problems related to improved oil recovery.
5. CTS, Indian Institute of Science, Bangalore, October 1976	Dr. R. Bhandari	Does the world exist if I don't?
6. BARC, Trombay, Bombay, November 13, 1976	Dr. G. Srinivasan	Anderson Localisation as a zero dimensional Heisenberg magnet.
7. Department of Physics, Delhi University, Delhi, November 20, 1976	Dr. N.D. Hari Dass	Is parity violated by gravitation?
8. Indian Petrochemical Laboratory, Baroda, February 9, 1977	Dr. C.L. Khetrupal	A critical discussion on the merits and demerits of various NMR spectrometers.
9. Winter School on Plasma Physics & Astrophysics, Radio Astronomy Centre, Ooty, March 14-25, 1977	Dr. C.S. Shukre	Review of models and observed properties of pulsars.
	Dr. R. Nityananda	Radio Recombination Lines.

ANNEXURE IIICOLLOQUIA HELD AT RRI

<u>Date</u>	<u>Name and address</u>	<u>Title</u>
<u>1976</u>		
April 6	Dr. G. Srinivasan Raman Research Institute Bangalore	The Anderson transition as a zero dimensional Heisenberg magnet
April 7	-do-	Electron correlation in inversion layers
April 29	Sir Harrie S.W. Massey, FRS Quain Professor of Physics & Chairman, British National Committee for Space Research University College, Univer- sity of London, London, UK	Research in Astronomy in Britain
May 18	Dr. W.A. Coles CSIRO Division of Radiophysics Epping, N.S.W.2121, Australia	Use of interplanetary scintillations to probe the solar wind.
June 23	Dr. M.D. Srinivas Bangalore	Quantum Counting Processes
July 14	Dr. A.R.P. Rau Louisiana State University Baton Rouge, Louisiana, USA	Non-Statistical Branching Ratios
July 19	Prof. E.C.G. Sudarshan Centre for Theoretical Studies Indian Institute of Science Bangalore	Zeno's Paradox
July 21	Dr. A.R.P. Rau Louisiana State University Baton Rouge, Louisiana, USA	H Atom: From the laboratory to the Pulsar
July 23	Dr. N.D. Hari Dass Raman Research Institute Bangalore	Discrete symmetries in gravitation
July 27	Dr. A.R.P. Rau Louisiana State University Baton Rouge, Louisiana, USA	Why some things are the way they are - The study of forms.
July 29	Dr. J.L. Osborne Physics Department University of Durham Durham, U.K.	An interpretation of the galactic continuum radiation.

<u>Date</u>	<u>Name and address</u>	<u>Title</u>
<u>1976</u>		
July 30	Dr. N. D. Hari Dass Raman Research Institute Bangalore	Topics in Neutrino Astrophysics
August 4	Dr. M. V. Berry University of Bristol Bristol, U.K.	Waves as catastrophies
October 25	- do -	Surface tension of liquids
November 3	Prof. Giancarlo Setti Laboratorio di Radio- astronomia C/o Istituto di Fisica "A.Righi" Bologna, Italy	The Hubble diagram and the luminosity function for quasars
November 19	Dr. E. B. Ergma Executive Secretary Astronomical Council Academy of Sciences, USSR Moscow, USSR	Pre-supernova models
December 15	Dr. G. Venkataraman Head, Materials Science Lab. Reactor Research Centre Kalpakkam	Fluctuations and mechanical relaxation
December 27	Dr. F.T. Last Head, Unit of Tree Biology Bush Estate, Penicuik Scotland	Do helpful microbes colonize living plants?
December 29	Dr. V. L. Pokrovsky Landau Institute of Theoretical Physics Moscow, U.S.S.R	Phase transitions
<u>1977</u>		
January 3	Prof. Sir S.F. Edwards, FRS Chairman, Science Res. Council, London, England	The nature of the amorphous state
January 24	Prof. A. G. Massevitch Vice-President Astronomical Council USSR Academy of Sciences	Stellar evolution

THEORETICAL PHYSICS MEETINGS

1.12.1976	Dr. N. D. Hari Dass Raman Research Institute Bangalore	Supersymmetry and Superfluid
8.12.1976	"	Super (Symmetric) Gravitation
22.12.1976	Dr. C. Shukre Raman Research Institute Bangalore	Pulsar Acceleration Mechanism and its implications for Pulsar-supernova Remnant Associations
12.1.1977	Dr. G. Srinivasan Raman Research Institute Bangalore	Electron Crystallization in Inversion Layer - A two dimensional system
2.2.1977	Dr. D.C.V.Mallik Indian Institute of Astrophysics, Bangalore	Planetary Nebulae and galactic Evolution
9.2.1977	Dr. Rajaram Nityananda Raman Research Institute Bangalore	Report on the International Conference on Frontiers of Theoretical Physics and the Winter School, Delhi January 1977
16.2.1977	Dr. R. Rajaraman Centre for Theoretical Studies, Indian Institute of Science, Bangalore	Introduction to solitons
23.2.1977	Dr.G.S.Ranganath Raman Research Institute Bangalore	Continuum theory of Liquid Crystals - Hydrostatic theory
2.3.1977	U.D.Kini Raman Research Institute	Continuum Theory of Liquid Crystals - Hydrodynamics
9.3.1977	Dr.C.Shukre Raman Research Institute Bangalore	Detection of optical Pulses from the Vela Pulsar and its implications
30.3.1977	Dr. M. Jonson Institute of Theoretical Physics, Goteborg, Sweden	On the Surface energy of Metals.

MAJOR ITEMS OF EQUIPMENT PROCURED
DURING 1976-77

ANNEXURE V

Sl.No.	Description	Quantity	Cost in Rs.
1.	Ultra stable high voltage power Supply	1 No.	8,500
2.	Monoblock pumps	3 Nos.	5,035
3.	Meteorological Instruments	1 set	44,000
4.	Gaussmeter	1 No.	33,000
5.	Aplab Transistorised power supply 0-5A	2 Nos.	6,306
6.	Refrigerated thermostat	1 No.	5,000
7.	Aplab digital panel meter type DPM 35	3 Nos.	8,000
8.	Regulated DC Power supply rack mounted type	1 No.	3,025
9.	ECIL Oscilloscope type OS 7685 with plug-in, probe etc.	1 Unit	76,577
10.	Standard Voltage Source	1 No.	5,690
11.	Toshniwal DC power supply 0-30V/5Amps	1 No.	2,500
12.	Myers self oiling reciprocating pump 1/2 HP with pressure tank	1 Unit	3,700
13.	HP Digital multimeter with spares	1 No.	8,000
14.	Philips 7 MHZ AC Millivoltmeter type PP 9001X	1 No.	3,860
15.	Beacon Monoblock pump 1 HP	1 No.	2,235
16.	Mobile Carts for Oscilloscopes	4 Nos.	3,765
17.	Hot Air oven	1 No.	1,221
18.	Bourdon pressure gauge	1 No.	668
19.	SAX Unit and Auto Telephones	1 Set	59,155
20.	Multipen Recorder	1 No.	17,000
21.	RF Unit, Hewlett Packard make	1 No.	39,000

22.	Precision IF Amplifier	2 Nos.	20,465
23.	Elgi Air compressor	1 No.	3,500
24.	Pulse generator	1 No.	9,000
25.	Zeiss Cassegrain Reflecting Telescope	1 No.	37,800
26.	AC/DC Meter calibrator HP Type 6920B	1 No.	9,400
27.	Digital probe multimeter HP Type 970A	2 Nos.	15,000
28.	UHF Noise source HP Model 349A	1 No.	4,000
29.	VHF Noise source HP Model 343A	1 No.	1,800
30.	Audio function Generator .005 Hz - 5 MHz HP type 3310A	1 No.	7,000
31.	Signal generator/sweeper 0.1 - 110MHz HP Type 8601A	1 No.	30,000
32.	Sweeper Oscillator Main Frame HP Type 8690B	1 No.	20,950
33.	Plug-in Model 8696A	1 No.	32,850
34.	Power Meter HP Model 432A with thermistor head	1 No.	9,000
35.	Multipen Recorder Model B 381 with plug-in	1 No.	18,000
36.	Visible Collimator Model RC-41 of Burleigh Instruments	1 No.	3,900
37.	Line Scanner solid state	2 Nos.	4,000
38.	Power supply, transistor stablized 0-350V/300mA	1 No.	2,310
39.	Power supply, DC, regulated 24V, 5V 48V, 9V 1 amp	1 No.	3,025
40.	Ultra stable high voltage power supply Keithley Model 246	1 No.	7,650
41.	Keithley nano volt source (bench model) type 260	1 No.	10,620
42.	Keithley precision nanovolt DC amplifier model 140	1 No.	28,800
43.	Keithley model 261 PICA ampere source with output cable	1 No.	10,620
44.	Wideband RF amplifier Model C-300-10	1 No.	3,600