

RAMAN RESEARCH INSTITUTE
BANGALORE

ANNUAL REPORT - 1975-76

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FOREWORD

The following annual report is a rather condensed account of the various research studies and development projects that have been carried out in the last year at the Institute. As it is now almost 5 years since the revival of the Institute, it is perhaps an appropriate time to make an assessment of the way things are developing, and which are not obvious from just reading the report.

Activity was started in 1971 by Prof. S. Chandrasekhar and two of his colleagues from Mysore who formed the nucleus of the present Liquid Crystals Group. This group has now grown to over 20, roughly half the present research staff of the Institute. The important contributions made by it in the first two years were highlighted at the International Conference on Liquid Crystals held at the Institute in December 1973. Some of the more recent work was presented at the Gordon Conferences on 'Liquid Crystals' and on 'Plastic Crystals and Molecular Freedom' by Prof. Chandrasekhar and two of his collaborators. Not only did this work receive acclaim, but it was a feature of both conferences that the Bangalore work figured constantly in the lectures and discussions.

The next activity to be initiated a year or two later was astronomy. Pending the setting up of an astronomical instrument of its own, the Institute entered into collaborative projects with the TIFR Radio Astronomy Centre and the Indian Institute of Astrophysics. It was felt that the Institute could make a major contribution in these collaborative projects by setting up an electronics group that could build advanced instrumentation for astronomy whether radio, optical or other. Such a group has been set up with the help of Dr. S. Krishnan, on deputation from the National Aeronautical Laboratory, and we are now able to build high quality equipment of advanced design. As one example, I would like to cite the sophisticated on-line Fourier transform receiver system which has been designed and is about to be

built for the Gauribidanur decameter telescope project, a joint venture with the Indian Institute of Astrophysics.

In theoretical physics and astrophysics, the number of scientists has now reached the point where a group could be said to exist, and three more members will be joining this calendar year. Some topics on which work has been done recently may be found in the report, and these include some important contributions by young members of the staff.

The millimeter wave astronomy project, which has remained in the discussion stage for almost 4 years, has at last got under way. We have entered into a collaborative project with the National Aeronautical Laboratory for the development of highly accurate reflectors for antennas, and a 5' reflector for the mm-wave pilot project is presently being manufactured. Construction of the millimeter wave laboratory is almost complete, and we should be starting very soon on the development of receivers to be used first on the pilot telescope and later on the larger instrument for which a detailed proposal has just been submitted.

The interaction between theoretical and practical scientists at the Institute has been of great help even in our development projects. An example is the beam-waveguide optics system proposed for the 5' telescope. This will permit the use of receivers of any size and complexity in conjunction with the 5' mirror, and will enable the development and testing of cryogenic receivers needed for high sensitivity observations in the millimeter band.

It is only this year that funds have been requested for our major building programmes to provide much needed space for the library, workshop, stores, etc. Campus development so far has consisted mainly of remodelling or building on top of the existing buildings, and this phase has now almost reached completion. We will soon have a

much needed canteen for the staff, as also overnight accommodation for visiting scientists. Two of the units in the Vyalikaval quarters of the Institute are being combined to provide a hostel, mainly for students working at the Institute towards their doctoral degrees and other junior research staff.

Registration for the Ph.D. degree has so far been either with the Indian Institute of Science, the Bangalore University, or the Mysore University which are the institutions that have recognised RRI as a centre for pre-doctoral research. A visiting team from the Jawaharlal Nehru University in Delhi was sent out some time ago for setting up a similar arrangement with RRI, and it is expected that the Institute will soon be recognised by JNU.

Collaboration at both the institutional and individual levels has been a prominent feature of the Institute's pattern of action, and one of its main sources of strength. Such collaboration would never have been possible but for the goodwill and enthusiasm for cooperation shown by both directors and staff of a number of institutions, notably the Indian Institute of Science, the National Aeronautical Laboratory, the Tata Institute of Fundamental Research and the Indian Institute of Astrophysics.

Following is a list of minor grants received from various agencies for some projects carried out by the Institute:

| | |
|--|------------|
| 1. Department of Space | Rs. 47,000 |
| 2. Council of Scientific & Industrial Research | 1,25,000 |
| 3. Atomic Energy Commission | 24,675 |

Our major source of funding has been and continues to remain the Department of Science & Technology without whose **unstinting** cooperation the Institute would never have been able to develop in the way it has over the last four years. I would like to record my appreciation of this fact, as also my thanks to all of the members of the Governing Council, and the staff of the Institute, who have extended me their confidence and provided me with constant support.

V. Radhakrishnan
Director

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The work carried out by various groups of the Institute is summarised below:

LIQUID CRYSTALS

1. Hydrodynamics: The effect of boundary conditions and magnetic fields on shear flow and Couette flow of nematics have been solved theoretically. Velocity and orientational profiles for various geometries have been computed.

2. Disclinations (defects): A mathematical analogy has been discovered between disclinations in nematics and screw dislocations in crystals. This has important consequences in elucidating the properties of disclinations. Another remarkable result that has been proved theoretically is that an air bubble (hole) behaves like a disclination of unit strength and attracts a disclination of opposite sign.

3. Dielectric properties: Systematic studies have been carried out of the dielectric anisotropy as a function of temperature of a number of nematics. These studies are now being extended to measure the dielectric dispersion. The results are being interpreted on the basis of the molecular theory of nematics.

4. Pressure Studies: Further studies are being carried out on the effect of pressure on phase transitions in mesomorphic compounds. On the theoretical side, an explanation has been given of the remarkable fact that the pitch of cholesteryl oleyl carbonate increases very rapidly with rise of pressure, approaching infinity at a certain critical pressure.

5. Elastic properties: Extensive measurements of all three elastic constants have been carried out on several cyanobiphenyls in the nematic phase. The twist and bend elastic constants of these materials are far greater than in the classical nematics. This result has been interpreted in terms of the experimentally determined orientational order parameters for these compounds.

6. Surface studies: The anomalous surface tension-temperature characteristics of a number of liquid crystals have been measured under very precise equilibrium conditions, confirming the existing of negative entropy states at the surface of these fluids. The effect of a magnetic field is also proposed to be investigated.

7. Spectroscopic studies: Detailed infrared and Raman studies have been carried out on some compounds, particularly with a view to throwing light on the dynamics of phase transitions in these substances. A new method has been developed for the determination of the absolute order parameter from the intensity of the infrared absorption in homeotropically aligned samples.

8. X-ray studies: The crystal structures of two mesogenic compounds have been solved to high precision using three-dimensional X-ray data and direct methods of analysis. These are probably the largest light atom structures ever to have been worked out by direct methods. X-ray studies of the liquid crystalline phases have also been started.

9. NMR studies: The work on isotopically enriched model compounds containing a peptide bond has been undertaken. The results are being interpreted and it is expected to provide the first conclusive experimental evidence on the peptide planarity. The studies providing information on the conformation around the nitrogen atom have been extended to more complicated systems like p-chloro phenyl maleimide. This is a step forward in handling more complicated conformational problems of biological importance.

Lyotropic liquid crystals having fairly well defined physical and chemical properties serve as models for more complicated biological systems. Consequently, the problem of investigating the molecular structure and arrangement, and the mechanism of binding of small ions or molecules in such systems is of great importance. Work on these lines has been undertaken. Such experiments have been performed with sodium dodecyl sulphate soaps (containing sodium sulphate, decanol and water) and dissolved molecules like phthalazine, quinoxaline and butadiene sulphone. The results are being interpreted.

10. Organic synthesis: Two new series of liquid crystalline compounds have been prepared. Also the processes for the preparation of materials suitable for liquid crystalline display devices have been developed and patent applications have been filed.

THEORETICAL PHYSICS AND ASTROPHYSICS

Ultrasonic diffraction: The intermediate case in the diffraction of light by ultrasonic waves (lying between the Raman-Nath phase grating picture and the opposite regime of two beam diffraction valid for short ultrasonic waves, or for oblique incidence of light), has been investigated theoretically. Using a method based on an analogy with an electron moving in a one-dimensional lattice in a slowly varying potential, it has been possible to determine the number of orders excited in the intermediate case, and to obtain good agreement with known experimental results.

Binary liquid systems: A study based on the theory of the resistivity of a randomly inhomogenous medium has led to a possible explanation for seeing both positive and negative cusps in the resistivity-temperature curve above the critical solution temperature of binary liquid systems.

Quantum mechanics: The study of the foundations of quantum mechanics, thermodynamics and irreversibility was continued. A part of the work completed during the year has been published.

Maximum Entropy Method: The maximum entropy method of spectral analysis, which has been advocated as a method of obtaining better resolution in the computed spectra from incompletely known autocorrelation functions has been studied in computer experiments with both real experimental data and precisely known analytical autocorrelation functions. As a result of these experiments, considerable insight has been gained into the limits of applicability of this method.

Pulsar Acceleration Mechanisms: A study of several pulsars for which fairly accurate proper motion measurements were available has led to a remarkable correlation between the polarisation characteristics of the radiation from these pulsars and their directions of proper motion in the sky. This correlation points to an origin (for these pulsars) in close binary systems where the spin axes of the components were perpendicular to the orbital plane, and leads to the conclusion that the proper motion observed is due to the runaway velocity from the system. This investigation has raised a host of interesting questions which are being investigated now.

RADIO ASTRONOMY AND ASSOCIATED ELECTRONICS

Decameter Wave Telescope: The 30 MHz antenna array, - a joint project with the Indian Institute of Astrophysics - construction on which was started in September 1974 is almost complete. The configuration of the telescope as outlined in last year's report is in the form of a 'T' with the lengths of the East-West and North-South arms 1 km. and 500 meters respectively. The erection of poles, installation of dipoles and the reflector systems for both arms is in the final phase of completion.

There are a variety of receiving systems that could be used with such an array and these systems vary greatly in speed, efficiency, cost and complexity. A detailed consideration of the kind of system most suited from the point of view of the scientific objectives and useful life of the instrument has led to the choice described below.

Fourier Transform System: A Fourier transform system capable of working on-line and simultaneously producing 180 beams in the North-South direction is currently in an advanced stage of detailed design. The system uses digital techniques almost exclusively and will incorporate standard integrated circuits mostly of the COS/MOS family. It is expected that the system will be built and in operation within a year; when completed it will provide both an on-line display and provision for storage of data in those cases where further computer processing is required and justified.

Frequency Synthesiser: The complete synthesiser has been assembled and tested and its performance is generally satisfactory; efforts are under way to further reduce the level of spurious frequencies which are already below the acceptable limit. New techniques are being tried out for this purpose.

A programmable phase-lock loop system for generating a number of 2nd local oscillator frequencies also required for the total receiving system is under design and development. It is expected that these units will be used for observations with the Ooty telescope in a few months time.

PUBLICATIONS

The work done by members of the Institute has been published in a number of scientific journals. A list of publications is given at Annexure I (page 9).

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 11) gives a list of conferences/meetings attended by our staff with titles of papers or talks presented if any.

COLLOQUIA

During the year about 22 colloquia on various topics were held at the Institute. A list may be found in Annexure III. (page 13).

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 regular staff of the Institute given at the end of this report.

LIBRARY

The various services introduced by the library in the previous year like the Current Awareness List, reprography and interlibrary loan facilities etc. were continued during 1975-76. Six hundred and fifty six books were added to the library. The library is presently subscribing to one hundred and ten periodicals and receives as a gift three hundred and fifty periodicals from the Current Science Association and the Indian Academy of Sciences. Apart from these periodicals, the library also displays every week certain periodicals received by the National Aeronautical Laboratory Library by air mail. The compilation of an author index for volumes 1 to 33 of the journal 'Molecular Crystals and Liquid Crystals' was started.

The British Council has confirmed the sanction of a grant for books and back volumes of periodicals under their ODA scheme which was applied for last year.

The library was a co-sponsor of a 'Seminar on information for industry' organised during November 14 to 16, 1975.

GENERAL

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

| | |
|---------------|-----------------|
| Recurring | Rs. 16.34 lakhs |
| Non-Recurring | 16.30 " |

2. A list of major items of equipment procured during the year is given in Annexure IV (page 16).

STAFF

The Scientific and Technical[#] staff of the Institute is listed below; those marked with an asterisk are additions during the year.. Those holding visiting positions are indicated by @. Those who are under deputation are indicated by + .

- | | |
|-----------------------------|------------------------------|
| 1. Prof. V. Radhakrishnan | 19. Mr. J. Padmanabhan |
| 2. Prof. S. Chandrasekhar | 20. Mr. K.T. Balakrishnan |
| 3. Dr. S. Ramaseshan@ | 21. Mr. D.K. Ravindra |
| 4. Dr. G.S.R. Subba Rao@ | 22. Mr. K.M. Chandra Kumar |
| 5. Dr. Anand Kumar@ | 23. Mr. R.S. Arora |
| 6. Dr. S. Krishnan+ | 24. Mr. K.V. Balachandra |
| 7. Mr. N.V.G. Sarma+ | 25. Mr. P.R. Ramraj |
| 8. Dr. C.L. Khetrapal | 26. Mr. K.R. Anantharamaiah |
| 9. Dr. N.V. Madhusudana | 27. Miss Jayanthi Mahalingam |
| 10. Dr. R. Shashidhar | 28. Mr. M.O. Modgekar |
| 11. Dr. S. Venugopalan | 29. Mr. M.R. Subramanya |
| 12. Dr. V. Surendranath | 30. Mr. K. Kumar* |
| 13. Dr. A.C. Kunwar | 31. Mr. P.N. Ramachandra* |
| 14. Dr. G.S. Ranganath | 32. Mr. B.S. Prasanna* |
| 15. Dr. Rajendra Bhandari | |
| 16. Dr. C.S. Shukre | |
| 17. Dr. G. Srinivasan* | |
| 18. Mr. Rajaram Nityananda* | |

Resignations

1. Dr. M.S. Vijaya (resigned on 10.6.1975)
2. Dr. Shyam Singh (resigned on 14.7.1976)
3. Mr. V. Sasthamani (resigned on 24.7.1976)
4. Mr. C.J. Chacko (resigned on 1.7.1976)

Pre-Doctoral Research Fellows

- | | |
|------------------------|-----------------------------|
| 1. Mr. U. Devappa Kini | 7. Miss K.L. Savithramma |
| 2. Mr. K.A. Suresh | 8. Mr. S. Krishnaswamy |
| 3. Mr. B.K. Sadashiva | 9. Mr. Prakash P. Karat** |
| 4. Mr. J.R. Fernandes | 10. Mr. S.G. Siddesh |
| 5. Mrs. B.R. Ratna | 11. Mr. K.L. Venkatakrishna |
| 6. Miss G.V. Vani | 12. Mr. M.N. Ramanuja |

(** Mr. Karat left the Institute on 25.6.1976)

Only those technical staff involved in research/scientific projects have been listed here.

A list of short period visiting scientists is given below:

- | | |
|--|------------------------|
| 1. Dr. Hugo van Woerden Kapteyn Astronomical Laboratory Groningen, The Netherlands | April 29-May 11, 1975 |
| 2. Dr. A.R.P. Rau Louisiana State University Baton Rouge, Louisiana, USA | June 16-July 31, 1975 |
| 3. Dr. C.V. Vishveshwara University of Pittsburgh Pittsburgh, PA, USA | July 7-August 21, 1975 |
| 4. Dr. D.M. Chitre University of California Santa Barbara, CA, USA | July 21-31, 1975 |
| 5. Dr. B.B. Jones Max-Planck Institute for Radioastronomy Bonn | August 5-16, 1975 |

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.

1. Mr. Mathew Sebastian
2. Mr. P.K. Ramakrishnan
3. Mr. A. Ratnakar
4. Mr. V.S. Ramaswamy
5. Mr. G.V. Srinivasa
6. Mr. Sreenivasa Raghavachar
7. Mrs. Lakshmi Rajagopal
8. Mrs. Sowjanya Mahesh
9. Mr. H.H.J. Pereira
10. Miss S. Girija
11. Mrs. Ahalya Kumar*

* New addition

P U B L I C A T I O N SPAPERS PUBLISHED IN 1975-76

1. Nuclear Magnetic Resonance Studies in Lyotropic Liquid Crystals (C.L.Khetrapal, A.C.Kunwar, A.S.Tracey and P.Diehl)-
NMR-Basic Principles and Progress, Vol.9, 1975.
2. NMR Studies of molecules oriented in thermotropic liquid crystals (C.L.Khetrapal and A.C.Kunwar) - Advances in Magnetic Resonance Vol.9, Academic Press.
3. An optical high pressure cell for liquid crystals (R.Shashidhar, S.Ramaseshan and S.Chandrasekhar) - Current Science 45, 1 (1976)
4. Optical activity in 1,1'-Binaphthyls (Shyam Singh) - Current Science 44, 873 (1975)
5. Dielectric properties of the 4'-n-alkyl-4-cyanobiphenyls in their nematic phases (B.R. Ratna and R.Shashidhar) - Pramana 6, 278 (1976)
6. On the rotatory dispersion in cholesteric-liquid crystals (G.S.Ranganath) - Optics Communications 16(3), 369 (1976)
7. Wide Spectrum H₂O Sources - Astrophysical Raman Masers, V.Radhakrishnan, W.M.Goss and Rajendra Bhandari, Pramana, 5(2),(1975) p. 49-58
8. Theoretical Intensities of low frequency recombination lines, P.A.Shaver, Pramana 5(1),(1975), 1-28
9. A high resolution map of the Supernova Remnant 3C 400.2 at 610 MHZ, W.M. Goss, S.G.Siddesh and U.J.Schwarz. Astron. Astrophys. 43, 459-463(1975)
10. Characteristics of the interstellar medium as deduced from low-frequency recombination line observations, P.A.Shaver. Astron. Astrophys. 43, 465-468(1975)
11. Entropy, information and Maxwell's demon after quantum mechanics, Rajendra Bhandari, Pramana, 6, 135 (1975)
12. Test of Pulsar acceleration mechanism, D.Morris, V.Radhakrishnan, C.Shukre, Nature, 260, 124 (1976)
13. The new binary pulsar and the observation of gravitational spin precession. N.D. Hari Dass, V.Radhakrishnan. Astrophysical Letters. 16, 135 (1976)

1. Pressure dependence of the pitch of cholesteryl oleyl carbonate (S. Chandrasekhar and B.R.Ratna) - Molecular Crystals and Liquid Crystals (in press).
2. An experimental study of the anomalous transmission (Bormann Effect) in absorbing cholesteric liquid crystals (K.A.Suresh) - Molecular Crystals and Liquid Crystals (in press).
3. Experimental studies of the surface tension of nematic liquid crystals (S.Krishnaswamy and R.Shashidhar) - Molecular Crystals and Liquid Crystals (in press).
4. Infrared spectroscopic study of orientational order and phase transformations in liquid crystalline CBOOA (J.R.Fernandes and S. Venugopalan) - Molecular Crystals and Liquid Crystals (in press).
5. A coaxial DTA cell for the study of liquid crystalline transitions at high pressures (A.S.Reshamwala and R.Shashidhar) - J. Phys. E. Scientific Instruments (Submitted)
6. Elastic and optical properties of some 4'-n-alkyl-4-cyanobiphenyls (P.P.Karat and N.V.Madhusudana) - Molecular Crystals and Liquid Crystals (in press).
7. Mesomorphic Properties of some *L*-methyl cinnamic acids and their esters (B.K.Sadashiva) - Molecular Crystals and Liquid Crystals (in press).
8. The effect of magnetic fields and boundary conditions on the shear flow of nematics (U.D.Kini) - Pramana (Submitted)
9. The effect of magnetic fields and boundary conditions on the Couette flow of nematics (U.D.Kini) - Pramana (submitted)
10. On dislocations and disclinations - (G.S.Ranganath) - Molecular Crystals and Liquid Crystals Letters (in press)
11. Liquid Crystals (S.Chandrasekhar) - Reports on Progress in Physics (in press)
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 letters, Vol.I (in press)
13. NMR-Spectra of -cyclopentadienyl manganese tricarbonyl in nematic and isotropic solvents (C.L.Khetrapal, A.C.Kunwar and A.Saupe)Molecular Crystals and Liquid Crystals(in press)

BOOKS/MONOGRAPHS ETC.

1. Liquid Crystals (S.Chandrasekhar) - Cambridge Monograph on Physics, Cambridge University Press (in press)
2. Phase Transition and Pretransition Phenomena in Liquid Crystals (S.Chandrasekhar and N.V.Madhusudhana) - Progress in Liquid Physics (John Wiley & Sons)(in press)

ANNEXURE II

| <u>CONFERENCES, MEETINGS, LECTURES</u> | <u>ATTENDED BY</u> | <u>TITLE OF PAPER/TALK</u> |
|---|--|---|
| 1. Gordon conference on 'liquid crystals' held at Santa Barbara, California, U.S.A. Jan 5-9, 1976 | Prof.S.Chandrasekhar Dr.C.L.Khetrapal Dr.R.Shashidhar Mrs.B.R.Ratna | Optical properties of cholesterics Dielectric studies |
| 2. Gordon conference on 'Plastic crystals and molecular freedom' at Santa Barbara, California, U.S.A. Jan 12-16, 1976 | Prof.S.Chandrasekhar Dr.R.Shashidhar | Effects of orientational disorders of the thermodynamics of melting |
| 3. National conference on Crystallography held at National Physical Laboratory New Delhi, December 4-6, 1975 | Miss. G.V.Vani | Disorder in the molecular structure of a liquid crystalline material |
| 4. Princess Leelavathi Memorial Lectures, University of Mysore, March 1976 | Prof.S.Chandrasekhar | New states of matter |
| 5. Department of Physics Purdue University, Lafayette U.S.A, Jan 19, 1976 | Prof.S.Chandrasekhar | Order-disorder phenomena in molecular crystals |
| 6. Special Lecture, Dept. of Physics, University of Mysore Feb 1976 | Prof.S.Chandrasekhar | Theory of melting |
| 7. Summer school on molecular biophysics, Indian Institute of Science, Bangalore May 10, 1975 | Dr.C.L.Khetrapal | Recent development in Nuclear Magnetic Resonance |
| 8. Illinois Institute of Technology, Chicago, Illinois Jan 23, 1976 | Dr.C.L.Khetrapal | Bio-organic applications of NMR Spectroscopy |
| 9. Liquid Crystal Institute Kent, U.S.A. Feb. 2, 1976 | Dr.C.L.Khetrapal | Recent work done at the Raman Research Institute on NMR spectroscopy of molecules oriented in liquid crystalline phases |
| 10. National Institute of Health, Bethesda, Maryland U.S.A. Feb 4, 1976 | Dr.C.L.Khetrapal | NMR spectroscopy as applied to problems of biological importance - scope and limitations |

| <u>CONFERENCES, MEETINGS, LECTURES</u> | <u>ATTENDED BY</u> | <u>TITLE OF TALK/PAPER</u> |
|---|---|---|
| 11. Conference on Jupiter Tucson, Arizona, U.S.A. May 15-24, 1975 | Prof.V.Radhakrishnan | |
| 12. Thirteenth General Assembly of URSI, Lima, Peru August, 11-19, 1975 | Prof.V.Radhakrishnan | Wide spectrum H ₂ O sources - Astro- ² physical Raman Masers |
| 13. Winter school on High Energy Astrophysics Bombay, January 4-16, 1976 | Prof.V.Radhakrishnan Dr.C.Shukre Mr.R.Nityananda Mr.S.G.Siddesh Mr.K.L.Venkatakrishna | Proper motions of pulsars |
| 14. Nuclear Physics and solid state physics symposium, Calcutta December 22-26, 1975 | Mr.R.Nityananda | A theory of critical resisti- vity of a binary mixture |

ANNEXURE III

LIST OF COLLOQUIA HELD AT THE INSTITUTE DURING 1975-76

| <u>S.No.</u> | <u>Date</u> <u>1975</u> | <u>Title</u> | <u>Speaker</u> |
|--------------|----------------------------|---|--|
| 1. | April 15 | Cosmology from angular sizes of radio sources | V.K.Kapahi, TIFR Radio Astronomy Centre, Doty. |
| 2. | May 7 | New insights into structure dynamics and evolution of galaxies | Dr.Hugo van Woerden Kapteyn Astronomical Lab. Groningen |
| 3. | June 17 | Computer graphics in research | Dr.D.Raj Reddy, Computer Science Dept.Carnegie-Mellon Univ. Pittsburgh, Pa. USA |
| 4. | July 7 | Variational principles and slowly rotating stars | Dr.A.R.P.Rau, Louisiana State Univ.Baton Rouge, Louisiana,USA |
| 5. | July 17 | The state of matter under high pressures | Prof.R.Pratap, Physical Research Lab.Ahmedabad |
| 6. | July 18 | Non linear optics of liquid crystals | Prof.D.V.G.L.N.Rao, Univ. of Massachusetts, USA |
| 7. | July 23 | Simple models of atoms in the laboratory and on pulsars | Dr.A.R.P.Rau, Louisiana State Univ.Baton Rouge, Louisiana,USA |
| 8. | July 25 | The charges and currents in black hole physics | Dr.D.M.Chitre, University of California, Santa Barbara California, USAA |
| 9. | July 31 | Black holes | Dr.C.V.Vishveshwara University of Pittsburgh Pittsburgh, PA, USA |
| 10. | August 6 | An aperture synthesis instrument to survey the galactic plane at 30 MHz | Dr.E.B.Jones Max-Planck Institut for Radio Astronomie Bonn West Germany |
| 11. | Sept.26 | Mechanical properties of ice | Anand Sivaramakrishnan Kings College Cambridge, U.K. |

| <u>Sl. No.</u> | <u>Date</u> | <u>Title</u> | <u>Speaker</u> |
|----------------|-------------|--|---|
| 12. | October 22 | An optimum deconvolution method | Mr.C.R.Subrahmanya TIFR Radio Astronomy Centre, Ooty |
| 13. | October 30 | Radio astronomical studies of our galaxy | Prof. F.J.Kerr Astronomy Programme University of Maryland College Park, Maryland, USA |
| 14. | November 19 | Black holes | Prof.S.Chandrasekhar FRS, Morton D.Hull Distinguished Service Professor Laboratory for Astrophysics & Space Research, University of Chicago, Chicago Ill. USA |
| 15. | November 21 | Transport properties near the critical point of a binary liquid mixture | Rajaram Nityananda Raman Research Institute, Bangalore |
| 16. | December 23 | Fleurs Synthesis Telescope | Dr.R.H.Frater School of Electrical Engg.University of Sydney, Australia |
| 17. | December 26 | The reduction of data obtained with a synthesis radio telescope | -do- |
| <u>1976</u> | | | |
| 18. | January 19 | The riddle of the red shifts | Prof.G.R.Burbidge,FRS Department of Physics University of California La Jolla, Calif,USA |
| 19. | January 20 | The interpretation of line spectra from quasars | Dr.Judith J.Perry Institute for Astrophysics Munich, W.Germany |
| 20. | March 11 | Big bang: A possible explanation of the missing mass phenomena in galaxies | Prof. G.Marx Head of the Dept. Atomic Physics Eotvos University Budapest |

21. March 12

"Fizeau Amongst the Pulsars: Is
what you get what I sent?"

Dr. Ian Lerche
Laboratory for
Astrophysics &
Space Research
The Enrico Fermi
Institute
The University
of Chicago
Chicago, Ill, USA

22. March 17

Blackhole explosion

Dr. G.Srinivasan
Raman Research
Institute
Bangalore

MAJOR ITEMS OF EQUIPMENT PROCURED/ORDERED

| <u>Sl.No.</u> | <u>Description</u> | <u>Quantity</u> | <u>Amount</u> |
|---------------|---|-----------------|---------------|
| 1. | Philips Transistorised DC Microvoltmeter Type PP 9004 | 1 No. | Rs. 6,000 |
| 2. | Attenuator Variable WE Model 905 | 1 No. | Rs. 4,000 |
| 3. | Oscilloscope Dual Beam Philips type 3231/90 DC | 1 No. | Rs. 16,900 |
| 4. | Gaussmeter type GH 867A | 1 No. | Rs. 2,750 |
| 5. | Universal Milling Machine | 1 No. | Rs. 205,000 |
| 6. | Bench Grinder | 1 No. | Rs. 1,146 |
| 7. | Drilling Machine | 1 No. | Rs. 3,116 |
| 8. | 13mm RMT Drilling Machine | 1 No. | Rs. 3,365 |
| 9. | Water Cooling Unit | 1 No. | Rs. 3,500 |
| 10. | Cylinder gas with valve, neck ring etc. | 4 Nos. | Rs. 1,064 |
| 11. | Oven, Hot Air | 1 No. | Rs. 2,420 |
| 12. | Microvoltmeter DC Aplab type TFM 12 | 1 No. | Rs. 2,195 |
| 13. | Power Supply Transistor Stabilized 0-60 V 5 amps | 2 Nos. | Rs. 7,592 |
| 14. | AC Millivoltmeter with probe | 1 No. | Rs. 3,786 |
| 15. | Philips 15 MHz portable Single Beam Oscilloscope Type PM 3200 x /90 | 1 No. | Rs. 11,300 |
| 16. | Volt ohmmeter Digital with Testing Probes | 1 No. | Rs. 7,500 |
| 17. | Power Supply Digireg 5 amps | 2 Nos. | Rs. 7,128 |
| 18. | Welder Mini Indarc with accessories | 1 No. | Rs. 2,393 |
| 19. | Lock-in amplifiers Model 186 and 124 with accessories | 2 Nos. | Rs. 1,13,400 |
| 20. | RF Unit HP Type 8699B | 1 No. | Rs. 38,585 |
| 21. | Monoblock pumpsets | 2 Nos. | Rs. 2,635 |
| 22. | Liquid Chromatograph | 1 Unit | Rs. 3,01,468 |
| 23. | Elgi Air Compressor | 1 No. | Rs. 3,500 |
| 24. | IC Power Supply | 2 Nos. | Rs. 1,800 |

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| 27. | Photophone superlite 16mm Projector | 1 No. | Rs. 9,050 |
| 28. | Precision IF Amplifier | 2 Nos. | Rs. 25,000 |
| 29. | Digireg Power Supply | 2 Nos. | Rs. 6,000 |
| 30. | Monoblock Pump set 1/2 HP with Motor | 1 No. | Rs. 1,350 |
| 31. | Multipen Recorder | 1 Unit | Rs. 14,600 |
| 32. | Differential Scanning Calorimeter | 1 Unit | Rs. 1,75,000 |
