RAMAN RESEARCH INSTITUTE

ANNUAL REPORT - 1974-1975

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

LIQUID CRYSTALS

A new theory has been developed of the very high viscosity of a cholesteric liquid crystal at low shear rates - (about a million times greater than at high shear rates). It is shown that this behaviour follows as a natural consequence of the continuum theory without having to make any arbitrary assumptions, as has been done in the literature, regarding the anchoring of the molecules at the boundaries.

The effect of an axial field on the Poiseuille Flow of a nematic liquid crystal has been investigated in terms of the continuum theory. The viscosity coefficient, the velocity and orientational profiles are shown to be strongly dependent on the strength of the magnetic field.

The optical analogue of the X-ray Borrmann effect discovered recently by us in cholesterics has been studied experimentally in a more detailed fashion. The observed curves confirm the features predicted by the theory.

The dielectric anisotropy of a number of strongly polar nematic materials have been studied and it is shown that the results confirm the model of antiferroelectric short range order proposed by us recently (Bangalore Conference, 1973).

The crystal structures of some nematogenic compounds have been investigated. The analysis is complete for n-p-methoxybenzylidene-p-phenylazoaniline and it is established that their nearest neighbours in the crystal structure are antiparallel.

Surface tension of some nematic liquid crystals have been investigated experimentally under equilibrium conditions, i.e., with the

liquid in equilibrium with its saturated vapour. The surface tension temperature characteristics show anomalies as predicted theoretically by Croxton and Chandrasekhar (Bangalore Conference, 1973).

Systematic far-infrared studies have been carried out in the crystalline and liquid crystalline phases of PAA and CBOOA. The studies have revealed the existence of two phases in the crystalline state in these compounds, and have thrown light on the nature of the changes occurring at the solid-liquid crystalline transitions. The studies have been supplemented by Raman spectroscopy and by differential scanning calorimetry.

The new method of determining the twist elastic constants of nematic liquid crystals proposed by us recently (Bangalore Conference 1973) has been applied to study the elastic behaviour of a number of compounds particularly in the vicinity of phase transitions. The frequency dependence of the Freedericksz threshold has also been investigated.

The NMR studies have been aimed at the enlargement of the scope of the method of determination of molecular structure and conformation using NMR spectroscopy in liquid crystal solvents: (a) The use of the techniques in basic problems of biological importance has been suggested, and is being applied to investigate the planarity of the peptide unit; (b) the use of the paramagnetic shift reagents in NMR spectroscopy of oriented molecules has been suggested. As a by-product of these investigations, an anomalous orientation behaviour of the solute molecules was observed which has now been shown to serve as a caution to the determination of molecular geometries using this technique; (c) a new composition of a lyotropic liquid crystalline phase has been suggested; (d) structures of some systems which cannot be determined in thermotropic solvents due to the dominating nature of some of the dipolar couplings have been determined using the lyotropic phase suggested in (c) above; (e) work was continued on the extension of the

method to bicyclic compounds like benzo(b)thiophene, on the application of the vibrational corrections to the cyclopentadienyl moiety and on conformational problems involving rotation about the C-C bond.

Chemistry: New series of liquid crystalline compounds have been synthesized in the Laboratory. A number of compounds of technological importance have been prepared.

Applications of Liquid Crystals: Bharat Electronics Limited in collaboration with RRI has developed a prototype of liquid crystal display. (This was exhibited at the Seminar on Design and Development activities organized by BEL on 28th July 1975).

A programme is being worked out with the National Tuberculosis Institute for the use of liquid crystal thermal sensors in solving medical problems; preliminary studies have established the efficacy of this technique.

Prof. S. Chandrasekhar has been invited to be a member of the Editorial Advisory Board of the International Journal "Molecular Crystals and Liquid Crystals". He was also invited to deliver the Malaviya Memorial Lectures by the University of Varanasi. Prof. Chandrasekhar spoke on "Some new states of matter".

COSMIC PHYSICS

Decametre Wave Telescope: The construction of the 30 MHz antenna system, a joint project with the Indian Institute of Astrophysics, was started in September 1974. The aim is to build antenna array which will give a circular beam of width about 1° and have enough sensitivity to detect radio sources with flux densities of more than 30 Janskys. The antenna will also be capable of detecting brightness temperature variations of the order of 1000°K; with this sensitivity we will be able to see selected HII regions with emission measures greater than about 1000.

The location of the telescope is adjacent to the BARC Seismic Array Station and its exact positioning was determined after surveying an area of 100,000 sq.m. and precisely determining the East-West and North-South directions by measurements on stars. About 1500 Eucalyptus poles (half of the total required for the telescope) have been erected after treatment with anti-termite compound. The reflector system (about 10 km of aluminium wire on 700 poles) has been installed, and 128 dipoles have been mounted. Five kilometres of transmission line have been laid, and the fabrication of 500 ferrite core transformers needed for the system has been completed.

Accurate adjustment of the phase and amplitude in each dipole has been achieved using the Swarup technique and electronic equipment designed and constructed for the purpose. A correlation receiver has been built and a check on the total performance of the East-West array made by recording selected radio sources. These tests indicate satisfactory antenna performance and some useful observations have been obtained on the occultation of the radio source Taurus A by the solar corona.

A paper on the design aspects of the antenna was presented at the Second Annual Meeting of the Astronomical Society of India held in Kodaikanal in March 1975.

Radio Astronomy: Observations of a large supernova remnant obtained with the Westerbork Synthesis Radio Telescope were reduced and properties of the shell distribution obtained by two different methods. The brightness temperature spectral index is found to be constant over most of the sources except at the centre where there is a tendency to steepen. It has been possible to study the correlation of optical filaments with the radio structure of the supernova remnant.

The results of earlier work on the consequences of non-equilibrium conditions in interstellar plasmas (Shaver 1975) were applied to interpret available low frequency recombination-line observations. The

observed upper limits for the intensities of these lines imply upper limits on the filling factor for the cold cloud component of the interstellar medium; also, the observed low frequency continuum absorption in the directions of the sources Sag. A and W49B imply lower limits on the electron density in the interstellar medium.

A detailed investigation was undertaken to explain the anomalously large velocity spread observed in the water vapour spectrum of the source W49A. An observational programme was also undertaken in collaboration with the Naval Research Laboratory in Washington using the Haystack Observatory operated by the North-East Radio Observatory Corporation, Massachusetts and a maser radiometer. The main purpose of the investigation was to search for possible Raman scattering of water vapour maser radiation by the OH molecules also found in the same interstellar regions. No radiation was observed that could be attributed to scattering by OH molecules, but a number of new spectral features with large apparent velocities were observed in the spectrum of the source W51. These new features have since been interpreted as due to stimulated Raman scattering by unidentified molecules.

In a programme jointly undertaken with the Radio Astronomy Centre, Ooty, the analysis of several hundred occultations of radio sources by the moon is in progress.

ELECTRONICS

A course on digital design with integrated circuits consisting of 15 lectures was given by Dr. S. Krishnan, National Aeronautical Laboratory and Visiting Professor at the Raman Research Institute. These lectures were attended by a large number of staff and were of considerable help in our programme of designing and building radio astronomical equipment. Such a programme has been undertaken to build the instruments necessary for our collaborative projects with the Radio Astronomy Centre at Ooty, the Indian Institute of Astrophysics, and for the mm-wave programmes of this Institute. Following are some

details of work undertaken or completed during the year 1974-75.

(1) Frequency Synthesizer: The system design was completed for a remotely controllable fast switching frequency synthesizer with output frequency around 300 MHz. This will form a versatile local oscillator system to be used with the TIFR Radio telescope at Ooty for spectral line observations. Among the subunits of the synthesizer that have been fabricated and are undergoing final tests are the frequency driver unit, the mixer and filter units and the frequency selection unit. Other subsystems like the Frequency Multiplier and the second local oscillator are under design/fabrication.

(2) Multichannel Autocorrelator: The frequency synthesizer referred to above is to be used in the first instance with a conventional filter bank for making spectral line observations with the TIFR Radio telescope at Ooty. Later, it is proposed to replace the filter bank unit with a multi-channel autocorrelator employing digital techniques. The system design for a 64 channel receiver of this type with provision for expansion to 256 channels using CMOS technology has been completed. The various sub-units are now under fabrication.

(3) Astronomical Clock: A proto-type of a crystal clock displaying both sidereal and solar time for use in astronomical observatories has been developed. The basic clock unit functions with CMOS circuitry and consumes negligible power. There is provision for the use of an external 1 MHz signal input where an atomic or other high stability signal is available. The design of the clock incorporates special features like the ability to switch back automatically to the internal oscillator on failure of the external signal, and controls for making extremely fine adjustments of the setting with great ease.

The first unit which will be used at the Radio Astronomy Centre in Ooty has been fabricated and tested with the active collaboration of the National Aeronautical Laboratory. Interface units for connection to the on-line-computer at the Ooty observatory are in various stages of design/fabrication.

THEORETICAL PHYSICS & ASTROPHYSICS

Work on the problem of irreversibility and quantum measurement started during the previous year was continued. This has led to a paper entitled 'Entropy, Information and Maxwell's Demon after Quantum Mechanics' which is under process of publication.

The feasibility of stimulated Raman scattering of maser radiation from astrophysical water vapour sources has been studied. It appears that this mechanism is the most likely explanation for the observed anomalous velocity widths of the radio spectra of some of these maser sources. Further implications of this hypothesis are being studied.

Work on the mechanism of emission of radiation from pulsars was initiated, and two specific problems relevant to pulsar radiation mechanisms were considered. (a) The observed proper motion of pulsars has recently been conjectured to be due to off-centred dipole magnetic fields in these pulsars. An investigation of the likelihood of this mechanism being operative was undertaken and is almost complete. (b) The statistical distribution of the duty cycles of pulsars (i.e. the ratio of the width of the pulse to the period) is being studied to determine the distribution of inclinations between the rotational and magnetic axes of pulsars. This work is also near conclusion.

The recent discovery in the U.S. of a pulsar in a binary system has provided a laboratory for a number of relativistic gravitational effects that were otherwise unavailable for study. The consequences of gravitational spin precession of this pulsar was investigated from the point of view of observable effects. The importance of this analysis, apart from providing another test for gravitational theories is in providing a method of testing pulsar models. This work has been submitted for publication.

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.

CONFERENCES/SEMINARS/MEETINGS

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

Two sessions (on July 23 and July 24, 1975) of the National Symposium on Statistical Physics to celebrate the Fiftieth Anniversary of Bose Statistics were held at this Institute. A colloquium on Fourier Transform Applications sponsored by Computer Society of India (Bangalore Chapter), Indian Institute of Science, Society of Electronic Engineers (LRDE) and Institution of Electronic and Radio Engineers (UK) was also held at the Institute on August 24, 1974.

COLLOQUIA

During the year about ~~25~~ 22 colloquia on various topics were held at the Institute. A list may be found in Annexure III.

VISITING SCIENTISTS

Prof. R. Hanbury Brown, Head of the Chatterton Astronomy Department came as the first Raman Visiting Professor and spent a period of just over 3 months. A report on his visit can be found at Annexure IV.

A number of ~~other~~ 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. A list of other visitors to the Institute during the year may be found at Annexure ~~IV~~ V

RECOGNITION OF RRI

The Institute was recognised as a centre of research by the Bangalore University for the purpose of awarding Ph. D. degrees

LIBRARY

The work of classification and cataloguing of books begun last year was continued. About six hundred and fifty seven books were added to the library. The British Council has been approached for a grant of books and back volumes of periodicals under their ODA scheme.

The number of periodicals subscribed to during the year was around one hundred and ten. The library continued to receive three hundred and fifty periodicals, as a gift from the Current Science Association and the Indian Academy of Sciences.

The Library was a cosponsor of a seminar on Inter Library Cooperation held at the Indian Institute of Science on the 15th and 16th November 1974. As part of our plans to cooperate with other libraries, an arrangement was made with the Indian Institute of Science Library whereby they could display for a week certain periodicals received here by Air Mail. TIFR, Bombay has agreed to donate duplicate reprints and periodicals which may be of use to us; one set of each has already been received. Cataloguing of reprints was continued.

A new documentation service, i.e. a fortnightly publication called "Current Awareness List in Astronomy and Astrophysics" was started. These lists are being mailed every fortnight to about forty interested libraries and scientists who have commended this service.

A Korestat machine was acquired during the year.

One of the library staff was deputed to a certificate course in library science and has completed it with distinction. Two students

from the Women's Polytechnic Library School were given four months post-apprenticeship training here.

GENERAL

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

Recurring	Rs.	13.61 lakhs
Non-Recurring		19.82 "

16.34 lakhs
16.30 lakhs

A copy of the audited statement of accounts for the year 1974-75 is given in Annexure VI.

2. A list of major items of equipment procured during the year is given in Annexure VII.

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 @.

1. Prof. V. Radhakrishnan
2. Prof. S. Chandrasekhar
3. Dr. S. Ramaseshan@
4. Dr. S. Krishnan@
5. Dr. G.S.R. Subba Rao@
6. Dr. P. A. Shaver@
7. Dr. Anand Kumar@
8. Dr. C. L. Khetrapal
9. Dr. N. V. Madhusudana
10. Dr. R. Shashidhar
11. Dr. S. Venugopalan
12. Dr. V. Surendranath
13. Dr. A. C. Kunwar
14. Dr. G. S. Ranganath
15. Dr. Shyam Singh*
16. Mr. D. K. Ravindra*
17. Mr. K. M. Chandra Kumar*
18. Mr. J. Padmanabhan
19. Mr. K. T. Balakrishnan
20. Mr. R. S. Arora
21. Mr. K. V. Balachandra*
22. Mr. P. R. Ramraj*
23. Mr. K. R. Anantharamaiah*
24. Mr. M. R. Subramanya*
25. Miss Jayanthi Mahalingam*
26. Mr. C. J. Chacko*
27. Mr. M. Modgekar*.

Post-Doctoral Fellows

1. Dr. Rajendra Bhandari
2. Dr. M. S. Vijaya
3. Dr. C. S. Shukre*

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Pre-Doctoral Research Fellows

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

A list of short period visiting scientists is given below:

1. Dr. V. S. Venkatavaradan Tata Institute of Fundamental Research Bombay	April-May, 1975
2. Mr. Sasadhar De Visva Bharati Santiniketan	May 1975
3. Dr. M. H. Engineer Tata Institute of Fundamental Research Bombay	July-August, 1975
4. Dr. G. P. Agrawal Indian Institute of Technology Delhi	July-August, 1975
5. Dr. W. M. Goss Kapteyn Astronomical Laboratory Groningen	August-December 1975
6. Dr. N. D. Hari Dass Max-Planck Institute for Physics Munich	December 1974-January 1975

ANNEXURE I

PUBLICATIONS

PAPERS PUBLISHED IN 1974-75

1. Spectral width of reflexion from cholesteric liquid crystals, S.Chandrasekhar and G.S.Ranganath, Mol.Cryst. Liquid Cryst. 25, 195 (1974)

2. The conformation of 2,2'-bithiophene as determined from PMR studies in a nematic solvent, C.L.Khetrapal and A.C.Kunwar, Mol. Phys. 28, 441 (1974)

3. NMR Spectra of molecules oriented in a lyotropic mesophase, II. Spectra of Pyridine and pyridine-N-oxide, C.L.Khetrapal, A.C.Kunwar and A.V.Patankar, J.Mag. Res. 15, 219 (1974)

4. NMR Spectroscopy of molecules dissolved in liquid crystal solvents, C.L.Khetrapal, J.Ind. Inst. of Science 56 (4), 15(1974).

5. Pressure studies on liquid crystalline materials, R.Shashidhar and S.Chandrasekhar, presented at the Fifth International Conference on Liquid Crystals, Stockholm, 1974 - Journal de Physique, Coll. C1-48,(1975)

6. Effect of an axial magnetic field on the Poiseuille flow of a nematic liquid crystal, U.D.Kini and G.S.Ranganath, Pramana, 4(1), 19.(1975).

7. NMR spectra of molecules oriented in a lyotropic mesophase III. The spectrum of γ-Hydroxypyridine, C.L.Khetrapal, A.C.Kunwar and A.V.Patankar, Organic Magnetic Resonance 6, 556 (1974).

8. PMR spectra of methyl alcohol in a nematic solvent with and without a lanthanide shift reagent, C.L.Khetrapal and A.C.Kunwar, J.Magnetic Resonance, 15, 389 (1974).

9. NMR Spectra of π-cyclopentadienyl manganese tricarbonyl in nematic and isotropic solvents, C.L.Khetrapal, A.C.Kunwar and A.Saupe, Fifth International Conference on Liquid Crystals, Stockholm, 1974 - Proceedings of the Conference.

ANNEXURE I (Contd.)

10. NMR spectroscopy in the liquid crystal solvents as applied to the study of the planarity of the peptide unit, C.L.Khetrapal, A.C.Kunwar and Mathew John, VI International Conference on Magnetic Resonance in Biological systems, Kanderstag, Switzerland, 1974, Proceedings of the Conference.

11. PMR spectra of 'cis' and 'trans' N-methyl formamide oriented in a lyotropic phase, C.L.Khetrapal, A.C.Kunwar and S.Ramaprasad, VII Annual Conference of Magnetic Resonance Spectroscopists, New Delhi, January 1975, Proceedings of the Conference.

12. Mesomorphic properties of some biphenyl benzoates, B.K.Sadashiva and G.S.R.Subba Rao, Current Science 44 (7), 222 (1975).

13. A unified approach to the theory of anomalous scattering - Some novel application of the multiple wavelength method, S.Ramaseshan, T.G.Ramesh and G.S.Ranganath, Presented at the International Conference on Anomalous Scattering, Madrid, Spain 1974 - Proceedings of the Conference.

14. X-ray studies on some mesogenic compounds, G.V.Vani and Kalyani Vijayan, National Conference on Crystallography, December 1974, Indian Institute of Science, Bangalore, Proceedings of the Conference.

15. Irreversibility and Quantum Measurement - The Observer's Role, R.Bhandari, Pramana 3 (1), 1974.

PAPERS PRESENTED AT THE INTERNATIONAL LIQUID CRYSTAL CONFERENCE, BANGALORE 1973 AND PUBLISHED IN THE PROCEEDINGS OF THE CONFERENCE

16. The role of permanent dipoles in nematic order, N.V.Madhusudana, and S.Chandrasekhar, Pramana Supplement, 1, 57 (1975).

17. Experimental studies of short range order in nematogens of strong positive dielectric anisotropy, B.R.Ratna, M.S.Vijaya, R.Shashidhar and B.K.Sadashiva, Pramana Supplement 1, 69 (1975).

18. Pressure induced mesomorphism, S. Chandrasekhar, S.Ramaseshan, A.S.Reshamwala, B.K.Sadashiva, R. Shashidhar and V.Surendranath, Pramana Supplement 1, 117 (1975)

19. Far-infrared absorption spectrum of p-azoxyanisole, S.Venugopalan, Pramana Supplement 1, 167 (1975).

ANNEXURE I (Contd.)

20. Experimental determination of twist elastic constants of nematic liquid crystals, N.V.Madhusudana, P.P.Karat and S.Chandrasekhar, Pramana Supplement 1, 225 (1975).

21. Statistical thermodynamics of the nematic liquid crystal surface, C.A.Croxton and S.Chandrasekhar, Pramana Supplement 1, 237 (1975)

22. Measurement of surface tension (γ) of nematic liquid crystals, S.Krishnaswamy and R.Shashidhar, Pramana Supplement 1, 247 (1975).

23. Some new types of electrohydrodynamic flow patterns in nematic liquid crystals P.P.Karat and N.V.Madhusudana, Pramana Supplement 1, 285 (1975).

24. The theory of reflexion and transmission by plane parallel cholesteric films, R.Nityananda and U.D.Kini, Pramana Supplement 1, 311 (1975).

25. Anomalous transmission (Borrmann Effect) in absorbing cholesteric liquid crystals, R.Nityananda, U.D.Kini, S.Chandrasekhar and K.A.Suresh , Pramana Supplement 1, 325 (1975).

26. Dynamical theory of reflexion from cholesteric liquid crystals, S.Chandrasekhar, G.S.Ranganath and K.A.Suresh, Pramana Supplement 1, 471 (1975).

27. Circular dichroism in absorbing mixtures of right- and left-handed cholesterics, G.S.Ranganath, K.A.Suresh, S.R.Rajagopalan and U.D.Kini, Pramana Supplement 1, 353 (1975)

28. NMR spectra of molecules oriented in a lyotropic mesophase I. The spectra of pyridazine, pyrimidine and pyrazine, C.L.Khetrapal, A.C.Kunwar and A.V.Patankar, Pramana Supplement 1, 471 (1975)

29. PMR studies on N-methyl formamide oriented in a liquid crystalline nematic phase, C.L.Khetrapal, A.C.Kunwar and K.R.K.Easwaran, Pramana Supplement 1, 483 (1975).

30. NMR spectra of bicyclic compounds oriented in the nematic phase III. The spectrum of benzo(b)thiophene, C.L.Khetrapal, A.C.Kunwar and A.Saupe, Pramana Supplement 1, 495 (1975).

ANNEXURE I (Contd.)

PAPERS SUBMITTED FOR PUBLICATION IN 1974-75

1. Flow of cholesteric liquid crystals I. Flow along the helical axis, U.D.Kini, G.S.Ranganath and S.Chandrasekhar, (has since been published - Pramana 5 101 (1975).

2. Far-infrared and Raman spectra of the solid phases of CBOOA, S.Venugopalan, J.R.Fernandes and G.V.Vani, Molecular Crystals and Liquid Crystals (in press)

3. Theoretical intensities of low frequency recombination lines, P.A.Shaver (has since been published - Pramana 5 (1), (1975).

4. The New Binary Pulsar and Observation of Gravitational Spin Precession, N.D.Hari Dass and V.Radhakrishnan (in press).

5. Characteristics of the Interstellar Medium as deduced from Low-Frequency Recombination Line Observations, P.A. Shaver.

6. Entropy, Information and Maxwell's Demon after Quantum Mechanics, R.Bhandari.

BOOKS/MONOGRAPHS, ETC.

1. 'Liquid Crystals' S.Chandrasekhar - Cambridge Monography on Physics, ed. M.M. Woolfson and J.M.Ziman, Cambridge University Press (about 400 pages) (in press).

2. Nuclear Magnetic Resonance Studies in Lyotropic Liquid Crystals, C.L.Khetrapal, A.C.Kunwar, A.S.Tracey and P.Diehl - Volume 9 of the Series entitled 'NMR-Basic Principles and Progress, Springer-Verlag, Germany (in press).

ANNEXURE II.

CONFERENCES, MEETINGS, ETC.	ATTENDED BY	TITLE OF PAPER/TALK
1. Fifth International Liquid Crystal Conference (Stockholm, Sweden, June 1974)	Prof.S.Chandrasekhar	Pressure studies on liquid crystalline materials (With R.Shashidhar).
2. Sixth International Conference on Magnetic Resonance in Biological Systems (Kanderstag Switzerland, Sept. 1974)	Dr.C.L.Khetrapal	NMR spectroscopy in the liquid crystal solvents as applied to the study of the planarity of the peptide unit (with A.C.Kunwar and Mathew John).
3. Nuclear Physics and Solid State Physics Symposium (BARC, Bombay Dec.27, 1974)	Prof.S.Chandrasekhar	Liquid Crystals (invited talk)
4. Symposium on Vibrational Spectroscopy (IISc. Feb. 28, 1975)	Dr.S.Venugopalan	Vibrational spectra of liquid crystals (invited talk)
5. Seminar on 'Recent advances in experimental techniques in spectroscopy and their application to problems in physics and chemistry' (Indian Science Congress Association, New Delhi, Jan. 4, 1975).	Dr.S.Venugopalan	Infra-red Fourier Transform Spectroscopy (invited talk)
6. Convention of Spectroscopists (India) (New Delhi, Jan.2, 1975)	Dr.S.Venugopalan	Raman Scattering from crystals under uniaxial stress (invited talk)
7. Seminar on 'Recent Advances in Experimental Techniques in Spectroscopy (BARC, Aug, 8, 1974)	Dr.S.Venugopalan	Infrared Fourier Transform Spectroscopy (invited talk)

ANNEXURE II (Contd.)

CONFERENCES, MEETINGS, ETC.	ATTENDED BY	TITLE OF PAPER/TALK
8. Annual Meeting of the Astronomical Society of India (Kodaikanal, March 12-14, 1975)	Prof.V.Radhakrishnan	Interstellar velocities and the 22 GHz spectrum of W49A (with W.M.Goss)
- do -	Mr. S.G.Siddesh	Some results of a recent study of Supernova Remnant 3C400.2 at 49 cm (with W.M.Goss & U.J.Schwarz)
- do -	Dr. C. Shukre	
- do -	Mr.K.L.Venkatakrishna	
- do -	Mr.K.R.Anantharamaiah	

ANNEXURE III.

LIST OF COLLOQUIA HELD AT THE INSTITUTE DURING 1974-75

Sl. No.	DATE	TITLE	SPEAKER
	1974		
1	April 4	Some Aspects of Interstellar Grains	Dr.G.A.Shah Indian Inst. of Astrophysics Bangalore.
2	April 9	Solid State Memories - A New Concept	Prof.K.V.Ramanathan Tata Inst. of Fundamental Research, Bombay.
3	April 11	Ionised Regions in the Galaxy	Dr.D.C.V.Mallik Indian Inst. of Astrophysics Bangalore.
4	April 18	Coherent Optical Fourier Transformation of Infra-red interferograms	Mr.M.Singh Indian Inst.of Astrophysics Bangalore
5	April 25	Review of Black Hole Theory	Mr.R.C.Kapoor Indian Inst.of Astrophysics Bangalore.
6	May 2	Distribution of Elements in the Universe	Dr.V.S.Venkatavaradan Tata Inst.of Fundamental Research, Bombay
7	May 9	Cosmic Ray Studies with the Moon and Meteorites	- do -
8	May 16	Nuclear Techniques in Geo- and Astrophysics	- do -
9	May 21	Wave Propagation in Crystalline Media	Mr.Sasadhar De Department of Physics Visva Bharati, Santiniketan
10	June 27	Supernova Remnants	Dr.D.K.Milne CSIRO Radiophysics Divn. Epping, N.S.W., Australia

ANNEXURE III (Contd.)

Sl. No.	DATE 1974	TITLE	SPEAKER
11	July 12	Giant Atoms in Astronomy	Dr.P.A.Shaver Raman Research Institute Bangalore.
12	July 20	Piezo-Spectroscopy of the Raman Effect in Crystals	Prof.A.K.Ramdas Dept. of Physics Purdue University, Lafayette, Indiana, USA.
13	Aug. 2	S-Matrix Theory and Regge Poles	Dr.R.Shankar Dept. of Physics University of California Berkeley, California.
14	Aug. 5	Electron Dynamics in Crystal Lattices	Dr.M.H.Engineer Tata Inst. of Fundamental Research, Bombay.
15	Aug. 8	Non-Linear Optics	Dr.G.P.Agrawal Indian Inst. of Technology New Delhi.
16	Sept. 5	Detection of High Energy Gamma Rays by Cerenkov Light	Prof.R.Hanbury Brown, FRS Raman Visiting Professor
17	Sept.30	Recent Information on the Origin of our Solar System	Prof.D.Lal, Director Physical Research Laboratory Ahmedabad
18	Oct. 9	A Resonance Model for Pion Electro-Production	Dr.Chandrakant S.Shukre Raman Research Institute Bangalore.
19	Nov. 14	Origin of Light Elements	Dr.S.Ramadurai Tata Inst. of Fundamental Research, Bombay
20	Nov. 19	New Results on the Textures of Smectic Liquid Crystals	Dr.D.Demus University of Halle German Democratic Republic

ANNEXURE III (Contd.)

Sl. No.	DATE	TITLE	SPEAKER
	1974		
21	Dec. 19	Radio Exploration of the Sun with Seconds of Arc Resolution	Dr.M.R.Kundu Astronomy Department University of Maryland College Park, Maryland, U. S. A.
	1975		
22	Jan. 16	Optical Models for Nuclear Reactions	Dr.M.R.Bhat Brookhaven National Lab. U.S.A.
23	Jan. 24	Gravitation Theories and the Newly Discovered Binary Pulsar	Dr.N.D.Hari Dass Max-Planck Inst. for Physics & Astrophysics Munchen, W.Germany
24	Feb. 13	Intergalactic Obscuration	Prof. K.Nandy Royal Observatory Edinburgh, Scotland
25	March 31	Electron Density Dependence of line Intensities from Boron-Like Coronal Ions	Dr.P.K.Raju Indian Inst. of Astrophysics, Bangalore.

ANNEXURE IV

REPORT ON THE VISIT OF THE FIRST RAMAN PROFESSOR

Prof. and Mrs. Hanbury Brown arrived in Bangalore on July 3, 1974 and stayed for a period of just over three months leaving India on October 6, 1974. Approximately 2 months of this period were spent at the Raman Research Institute where they were residing in the quarters provided for them. Prof. Brown's visit was timed to enable him to participate in the Bose Symposium organised jointly by several institutions and held in Bangalore. As a pioneer in the measurement of Bose Statistics, and the leading figure in its application to astronomy, his presence was a major factor in the success of the symposium.

Prof. Brown's stay at the Raman Research Institute provided a source of stimulation particularly to those interested in astronomy. All the members of the Raman Research Institute whose activities are connected with astronomy and all of the members of the Indian Institute of Astrophysics presently based at R.R.I. took part in a number of discussions with him and were able to benefit from his knowledge and experience.

From Bangalore he made visits to the following centres around the country:

The Kavalur and Kodaikanal Stations of the Indian Institute of Astrophysics	July 27-August 1, 1974.
TIFR Radio Astronomy Centre, Ootacamund	August 19-23, 1974
Tata Institute of Fundamental Research and Bhabha Atomic Research Centre, Bombay	September 10-14, 1974
Physical Research Laboratory and Space Applications Centre, Ahmedabad	September 15-18, 1974
While in Ahmedabad he also visited the Vikram A. Sarabhai's Community Science Centre	
Jaisingh's Observatory in Jaipur	September 19-20, 1974

ANNEXURE IV (Contd.)

Indian Institute of Technology, Delhi	September 20-22, 1974
U. P. State Observatory, Naini Tal	September 24-25, 1974
Centre of Advanced Study in Astronomy Osmania University, Hyderabad	September 27, 1974
Centre of Advanced Study in Physics Madras University, Madras	October 4-5, 1974

Accounts received from these centres speak highly of the visit of the Raman Professor. For their part Prof. and Mrs. Brown also greatly appreciated the opportunity to visit these places and the enjoyment they derived as a result of the arrangements made by their various hosts.

During his stay in India Prof. Brown delivered a total of 15 lectures including one on "A New Look at the Stars" at the Homi Bhabha Auditorium, Bombay, presided over by the President of the Indian Academy of Sciences. A representative selection of these lectures is being typed up and it is intended to make them into a book to be kept at the Raman Research Institute. Tape recordings were made of some of his lectures and these will also be preserved.

ANNEXURE V

OTHER VISITORS

1. Academician Saverin
   USSR Academy of Sciences, Moscow, USSR
2. Dr. Eugene Garfield
   President, Institute for Scientific Information
   Philadelphia, PA, USA
3. Academician A. P. Vinogradov
   Vice-Chairman of the USSR Academy of Sciences
4. Academician D. K. Belyaev
   Director of the Institute of Cytology and Genetics of the Siberian Division of the USSR Academy of Sciences
5. Academician A. S. Borovik-Romanov
   Deputy Director of the Institute of the Physical Problems of the Academy of Sciences, USSR
6. Mr. A. M. Kunaev, Corresponding Member of the USSR Academy of Sciences
   President of the Kazak Republican Academy of Sciences
7. Academician S.I. Subbotin, Ukraine Republican Academy of Sciences,
   Secretary of the Earth Sciences Division
8. Academician S.A. Asimov, Uzbek Republican Academy of Sciences,
   Director of the Physical and Technological Institute of the Uzbek Republican Academy of Sciences
9. Dr. G.G. Kotovsky, Head of Indian Department of the Institute of Oriental Studies of the Academy of Sciences, USSR
10. Mr. V. I. Tkatchenko, Senior Adviser of the Foreign Relations Department of the USSR Academy of Sciences
11. Dr. G. A. Edwards
    National Science Foundation, Washington, DC, USA

ANNEXURE VI

RAMAN RESEARCH INSTITUTE

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31ST MARCH 1975

Dr.

OPENING BALANCE		
a) Recurring		2,320.00
b) Non-recurring		13,111.66
I. GOVERNMENT GRANTS - Dept. of Science & Technology		
a) Recurring	13,61,000.00	
b) Non-recurring	19,82,000.00	
		33,43,000.00
II. DEPT. OF ELECTRONICS		
a) Recurring	67,500.00	
b) Non-recurring	3,20,000.00	3,87,500.00
III. CSIR SILVER JUBILEE AWARD		
1.a) Recurring	25,000.00	
Non-recurring	1,00,000.00	
2.a) Recurring	25,000.00**	
b) Non-recurring	1,00,000.00**	
		2,50,000.00
IV. Indian Inst. of Science (for Liquid Crystal Conf.)		10,000.00

Cr.

I. RECURRING	
P.1. Pay of Officers	2,43,942.24
P.2. Establishment	2,21,000.53
P.3. Travelling Allow.	38,361.10
P.3. Allowance, Honoraria, etc.	1,53,478.13
P.4(a) Stationery	12,359.80
(b) Wages	36,669.71
(c) Cartage, cooly	928.17
(d) Garden	6,071.63
(e) Office Equipment	15,126.51
(f) Telephones	41,487.80
(g) Electricity	35,285.69
(g) -do- deposit	15,665.85
(h) Water supply	4,705.45
(i) Advertisement charges	2,016.42
(j) Transport	15,030.31
(k) Conferences	7,549.02
(l) Miscellaneous	4,122.98
(m) Freight, Customs, etc.	1,606.64
(n) Printing charges	2,030.33
(o) Liveries	3,169.91
(p) Postage	7,800.25
(q) Publications	62,396.97
(s) Washing charges	1,102.30
(t) Bank charges	973.95
(v) Refreshments	580.35
(w) Guests	1,388.19
(z) Book binding charges	3,591.22
(z) Audit Fee	1,400.00

Dr.			Cr.	
V. a) House Rent receipts	9,885.67		P.6. Maintenance	58,828.97	
b) Provident fund and other recoveries from staff	50,514.16		P.7(1) Minor apparatus & equipment	36,081.29	
c) Income-tax recoveries from staff	16,780.52		(2) Chemicals	60,079.35	
d) Earnest money deposits	60,138.00		(3) Workshop stores	19,529.75	
e) Fellowships	20,990.32		(4)(i) Misc. Non-consumable stores	34,931.92	
f) Misc. Receipts	3,635.56		(ii) Misc.consumable stores	2,97,711.94	
		1,61,944.23	Fellowships	17,600.00	14,64,604.67
			Advances	7,650.48	
			Deposits	4,000.00	
			P.F. & other payments of staff	5,058.45	
			Income-tax payments of staff	18,611.80	
			Earnest Money deposits refund	51,656.00	86,976.73
			II. NON-RECURRING		
			P.5(1) Works	6,57,538.71	
			P.5(2) Services	1,72,953.37	
			P.5(3) Capital Equipment	14,47,155.67	
			P.5 (4)(i) Furniture	45,664.68	
			P.5(4)(ii) Books	39,036.03	
			P.5(4)(iii) Vehicles	1,01,115.05	24,63,463.51
					40,15,044.91
			Closing Balance		1,52,830.98@
		41,67,875.89			41,67,875.89

ANNEXURE VI (Contd.)

** Silver Jubilee Award

Recurring	Rs. 25,000.00	
Non-Recurring	1,00,000.00	1,25,000.00

(received on 31st March 1975)

@ Break-up details for Rs.1,52,830.98 (closing balance)

1. CSIR Silver Jubilee award (received on 31.3.1975)	Rs.1,25,000.00
2. Earnest Money and security deposits of contractors payable	26,918.42
3. Recurring account balance	495.91
4. Non-recurring account	416.65
Rs.	1,52,830.98