

RAMAN RESEARCH INSTITUTE

BANGALORE

ANNUAL REPORT - 1977-78

Contents

	<u>Page No.</u>
1. Liquid Crystals	1
2. Theoretical Physics and Astrophysics	4
3. Radio Astronomy, Optical Astronomy and Associated Electronics	7
4. Publications	13
Annexure I	21
5. Conferences/Seminars/Meetings	13
Annexure II	26
6. Colloquia	13
Annexure III	32
Annexure IV	34
7. Visiting Scientists	14
8. Library	14
9. Governing Council	15
10. General	17
Annexure V - Major items of equipment procurd/ordered	36
11. Staff	17

The work carried out by the various groups in the Institute during the year 1977-78 is summarised below:

LIQUID CRYSTALS

1. A new type of liquid crystals: Probably the most interesting result obtained this year has been the discovery of an entirely new type of liquid crystalline system. Since the first observations of liquid crystalline behaviour by Reinitzer in 1888, several thousands of pure compounds have been found to exhibit thermotropic mesomorphism. The distinctive feature common to all of them is the rod-like shape of the molecule. Studies in the laboratory have established for the first time the occurrence of thermotropic mesomorphism in pure compounds consisting of relatively simple disc-like molecules. Based on thermodynamic, optical and X-ray studies, the suggestion has been put forward that the mesophase has a structure with translational periodicity in two dimensions and liquid-like disorder in the third.

2. Electrohydrodynamics: The effect of an electric field on a nematic liquid crystal contained in a 'sandwich' cell with asymmetrically treated electrodes has been studied and a remarkable new effect has been observed. When the electric field is applied one way, there is vigorous electrohydrodynamic motion; when it is applied the other way, the motion is very subdued. In other words, the electro-optic response is strongly sensitive to the polarity of the field and an appreciable contrast ratio is achieved by merely reversing the applied voltage. This new effect may have important applications in display technology. Detailed studies of the characteristics of the cell are under way.

3. Disclinations: Investigations of defects in liquid crystals are being continued. A theoretical calculation has been carried out of the interaction between a surface disclination and a body disclination in a nematic. It has been found that there is an attraction between the two, the magnitude of which is insensitive to the sign and strength of the latter. However, as the body disclination approaches the surface, an image force of repulsion develops which prevents the two disclinations from merging together. The theoretical results explain the observations of Kleman and Williams.

4. Pressure studies: A 100-ton hydraulic press has been fabricated and installed, and a number of experimental phase diagrams have been obtained using differential thermal analysis. Further examples of pressure induced mesomorphism and tricritical behaviour have been established. An 'odd-even' effect has been observed in dP/dT of the alkyl-cyanobiphenyl series of compounds.

A high pressure X-ray camera has been designed and constructed and preliminary work has started.

5. X-ray studies: The crystal and molecular structures of cholesteryl chloride and the isomorphous cholesteryl bromide have been solved by X-ray analysis. In addition, a systematic study has been made of the disorder of molecules in the crystal structures of mesogenic compounds. X-ray studies are also being carried out of the liquid crystalline phases themselves. For example, the structure of the mesophase of disc-like molecules was elucidated by X-ray methods.

With the expertise available at NAL, the old Seifert continuously evacuated X-ray generator has been redesigned and a new Philips X-ray tube has been installed. The set is now working satisfactorily and is being used for X-ray studies.

6. Spectroscopic studies: Infrared studies have been extended to a number of other materials. Orientational order parameters have been determined for a new series of compounds and tricritical behaviour has been observed. Another interesting new observation is

the occurrence of a highly ordered smectic phase in the well known compound POAB. This result is of particular significance as it is at variance with accepted empirical rules concerning the behaviour of homologous series.

The Cary-81 Raman spectrometer, gifted to RRI by Hunter College, New York, has arrived safely. Some minor components need to be acquired to get the instrument operational and steps are being taken to do so.

7. Chemical studies: Further chemical studies are in progress. A number of new compounds showing liquid crystalline phases (particularly noteworthy being the compounds composed of disc-like molecules) has been synthesized. The search for new materials of technological importance is also continuing.

8. NMR work: Research problems: The techniques of 2-dimensional NMR has been applied for the first time to oriented systems. The lines with negative intensities in the NMR spectra of oriented molecules have thus been predicted for the first time. The results show that such a method provides additional information on the spin system which cannot be derived from 1-dimensional spectroscopy. Such studies may have a promising future in NMR oriented molecules particularly in order to obtain additional information and the simplification of the spectra. Such work will be continued.

The work on the determination of structure and conformation of organic and organometallic compounds using NMR spectroscopy of oriented molecules has been continued. The conformation of systems like 1,3-butadiene iron tricarbonyl, acetophenone, anisole, dimethyl selenide and tetramethyl tin has been established.

9. Technology: A team of 2 RRI scientists and 2 BEL engineers visited a number of LCD and equipment manufacturers in Japan, USA and Europe and made a critical survey of the specific equipment and facilities required for large scale manufacture of liquid crystal displays in Bangalore. BEL has accepted the suggestions of the team and has already taken steps to acquire the necessary equipment and to set up a manufacturing facility.

The patents for the preparation of liquid crystal materials have been accepted by the Patent Office.

A Multiplexed matrix liquid crystal display capable of displaying several digits and characters is in the final stages of assembly.

Mr. J. R. Fernandes submitted a thesis entitled 'Infrared Studies on Liquid Crystals' for the Ph.D. degree of University of Mysore.

Projects supported by other organizations

1. 'Generation of Graphics using Liquid Crystal Matrix Displays - A Feasibility Study' supported by the Indian Space Research Organization (continued from previous year).
2. 'Influence of short range order on the physical properties of liquid crystals' supported by the Department of Atomic Energy (continued from previous year).

THEORETICAL PHYSICS AND ASTROPHYSICS

1. Maximum Entropy Spectral Analysis: Some interesting results on the behaviour of the resolution properties of the Maximum Entropy Method as a function of background white noise in the spectrum were obtained. The resolution obtainable by the method was found to be a

strong function of this quantity and in a certain regime, a kind of 'super resolution' was observed, the term referring to the resolution of two peaks that are merged even in the true spectrum of a source.

2. Pulsars: Work is continuing on the statistical analysis of pulsar data. The doubling of the total number of known pulsars as a result of a recent survey carried out in Australia has provided a much larger sample to work on, and necessitated a reanalysis of some trends noted with the earlier and smaller sample.

3. Atomic Physics and its application to Astrophysics: Reliable spectroscopic data is usually available only for the low angular momentum states of atoms. In low energy electron-ion scattering, the knowledge about higher angular momentum states is required. It is being attempted to apply the Regge-pole techniques of particle physics to this problem. The investigation, which is presently in its initial stages, may also be useful in the construction of model potentials for complex atoms.

4. Spacetime Symmetries and the Energy - Momentum Tensor: The energy - momentum tensor of a meson-field and a perfect fluid has been analysed based on a study of the behaviour of the electromagnetic field under motions of space - time. Constraints on the lie-derivative of the fields due to the structure of the lie-group of killing vectors have been derived.

5. Interior solutions in General Relativity: A previously derived formalism for rotating perfect fluid interiors was applied to a fluid with equation of state $p = \rho$ in the cylindrically symmetric case. The matching conditions to the exterior vacuum metric were shown to give rise to a skin. The properties of the resulting spacetime were examined.

6. Exact vacuum solutions and their properties: a) It was shown, that the poles of the so called Voorheesmetrics, which were believed to be directional singularities, are in fact well behaved two-surfaces.

b) A new solution of Ernst's equation for stationary axially symmetric space times has been found.

c) In a sequence of two papers, a classification scheme for solutions of Einstein's equations with one killing vector was proposed. All type S solutions in this scheme have been derived.

7. Charged Particles & Black Holes: The motion of charged particles in electro-magnetic fields surrounding Kerr black holes is being studied. The fields are either due to local sources such as current discs or of more global nature, e.g. galactic magnetic fields. A detailed analysis of the orbits of the test charges is being carried out. This could constitute the first step towards the study of possible plasma processes in the vicinity of black holes.

8. Event Horizons in Cosmological Backgrounds: Recently, Vaidya has derived generic forms of cosmological metrics which could incorporate time dependent event horizons. However, careful analysis shows that the event horizon does not always exist. A specific case, where a horizon evolving with time is actually present, has been worked out. Various properties of this spacetime are being investigated.

9. Neutrinos in Gravitational Fields: The behaviour of neutrinos in spherically symmetric gravitational fields is being examined. In the particular example of a spherical mass distribution, represented by the Schwarzschild interior-exterior metric, neutrinos are found to move in a potential well within an attached barrier. The well depth and the barrier height increase with the angular momentum of the neutrino. The analysis of quasi-bound states, leakage through the barrier and other related phenomena is in progress.

10. The mobility edge problem: The study of the Anderson transition using the Renormalization Group technique was continued. It was concluded that the nontrivial fixed point obtained by Wilson (for u_4 positive) was not relevant for determining the scaling behaviour of the Green's functions at the mobility edge. The relevant fixed point for this problem could not be obtained by an expansion.

11. The conductivity of a Wigner Lattice: The ac and dc conductivity of a Wigner lattice was studied. The model adopted was analogous to the Frenkel model of a liquid. In this model the main contribution to the dc conductivity arises from defects such as vacancies. Attempts to relate these calculations to experiments in MOSFET inversion layers are in progress.

12. Weak Neutral Current: An intensive study has been made of the structure of weak neutral currents with special emphasis on the parity violating aspects of such phenomena. Parity violation in atomic physics, accelerator experiments and particle decays has been studied in detail.

13. Strong Magnetic Fields in Astrophysics: The study of physical phenomena associated with strong magnetic fields is continued. As a realistic extension of previous work, the calculations are being redone for an electron gas in the presence of strong magnetic fields.

RADIO ASTRONOMY AND ASSOCIATED ELECTRONICS

Decameter-wave Astronomy - a joint project of RRI and IIA:

During the early part of the year 1977-78, the Decametric Wave Radio Telescope was used to observe various selected regions of the sky. It was found that the designed sensitivity due to point sources was achieved but the characteristics of the main beam and the distribution and level of side lobes were not satisfactory, as a result of errors in the illumination of the EW and NS arrays. In addition to these random errors in phase and amplitude a systematic phase error between the two arms of the "T" was also detected. A detailed investigation has established that the open wire transmission line system and the design of the phase shifters were responsible.

The transmission line system has now been changed to underground cables, and the hybrid phase shifters replaced by diode phase shifters, where binary lengths of cables can be switched in or out. At the

moment the entire christmas tree feeder system in the NS array uses underground cables. Diode phase shifters using a minimum number of components and a per stage loss of about 0.3 dB have been designed and tried out. Mass production of these phase shifters will be started as soon as the diodes are received from Phillips, Holland. Thirty phase shifters using 360 diodes have already been made and installed in the EW array for steering the EW beam in the NS direction. In the EW array we have used a combination of open wire transmission lines and underground cables and the outputs of the Eastern and Western arrays are separately available in the laboratory building. Low noise amplifiers have been installed at appropriate places and in addition we have also installed grading attenuators both in the EW and NS arrays. The expected side lobe level due to this grading is of the order of five percent. Repeated and prolonged measurements have shown that the achieved r.m.s. phase deviations lie in the range of 5 to 10° for both EW and NS arrays.

Work on the digital receiving system for the array has progressed further and is expected to be installed in the period 1978-79.

Metre-wave Astronomy:

1. Radio Sources: Lunar occultation data for 120 Radio sources have been analysed. Accurate position, structure and flux density have been derived for the sources and searches have been made on prints of the palomar sky survey for optical counterparts. The source structures have also been determined for a part of the sample using the Optimum Deconvolution Method of Restoration. A comparison is being made between this method and the conventional method and the conclusions are being written up for publication.

The optical identification data for a large sample of Extragalactic Radio Sources, spanning a flux density range of over 5000 to 1, were statistically analysed. The variation of the optical identification content of Extragalactic Radio Sources as a function

of flux density at 408 MHz was compared with the theoretical prediction from the evolutionary model 4b of Wall et al.,. This leads to some conclusions about the form of the Radio Luminosity Function required to fit the observations.

The above two investigations were carried out at the Radio Astronomy Centre, Ooty under the supervision of the senior staff of that organisation.

2. Deuterium in the Galaxy: A search for Deuterium in interstellar clouds was carried out by observing the 327 MHz absorption line in the direction of ^{the} galactic centre using the Ooty telescope in a joint investigation with R.A.C. Ooty. No positive detection was made, but a low limit of 2.7×10^{-4} for the Deuterium to Hydrogen abundance along this line of sight was obtained.

Millimetre-wave astronomy:

A) 1.5 metre millimetre-wave pilot telescope: This pilot project is being financed by the Indian Space Research Organisation. The fibre-glass reflector was manufactured by the Materials science division of the National Aeronautical Laboratory. Trial measurements of the surface of the reflector showed that the measurement accuracy should be improved in order to achieve an overall surface accuracy of 0.1mm r.m.s. A linear transducer with a measurement accuracy of 10^{-4} mm is being incorporated into a measuring system which is under development. The HP laser measurement system which has been procured recently will be also used for the above purpose.

Based on a novel design for a mount to take the above reflector, fabrication has started at the National Aeronautical Laboratory. A 2.5 metre diameter annular ring of granite which will form the lower bed for an aerostatic bearing has been fabricated and finishing of the surface to a flatness of one thou or less is under progress.

A novel azimuth position encoding system has been bench tested and the final version which go on the telescope is under production. Most of the components required for the control system of the telescope have been procured including two 16-bit absolute encoders. Various components required for the mm-wave receiver have been obtained and the construction of the front-end receiver will be undertaken shortly.

B) 10-metre millimetre wave telescope: Final approval for the above telescope was received in March 1978 from the Department of Science and Technology. The infrastructure facilities required to develop high accuracy reflectors have been set up in collaboration with the National Aeronautical Laboratory. A 1.5 metre diameter aerostatic bearing was developed, manufactured and tested. This will be used to machine the smaller diameter secondary reflector required for the main telescope. A 3 metre diameter aerostatic bearing has been fabricated and hand lapping of the mating surfaces is under progress. This bearing will be used to machine the main reflector of the telescope. The guide rail structure has been fabricated and the final measurement of the required arc and grinding of the surface is soon to be undertaken.

The design of a mount to take the above reflector has been completed by our consulting engineers, Indian Design Centre Pvt Ltd and the tender documents for the various components of the mount are under preparation. According to present indications, the fabrication of the mount should start by September 1978. All the components which are to be imported for the mount are in the process of procurement.

A electronic control system to control the motion of the telescope is under design and some of the key components are on order. A 256-channel filter bank receiver for the spectral work has been designed and the development of individual components of the receiver is complete. The construction of the receiver is also under way. The design of a data acquisition system to record the outputs of the filter bank receiver is complete and the individual components of the system are on order.

Meteorological observations at the Raman Research Institute campus and Nandi hills are continuing. An infrared spectral hygrometer (IRSH) was obtained on loan from the French Radio Astronomy group and observations of the total water content of the atmosphere have been continuing since September 1977. Another IRSH instrument has been borrowed from the Physical Research Laboratory, Ahmedabad and simultaneous measurements of water vapour content of the atmosphere at RRI campus and Nandihills have been undertaken since December 1977. A water vapour radiometer operating at 22.25 GHz is under development and this will be also used to measure the total water content of the atmosphere, especially during night time. The location of the mm-wave telescope will be decided on the basis of the above measurements.

Optical Astronomy:

A new approach to making large telescope mirrors: It has recently been suggested that large astronomical mirrors can be made by electrochemical machining of metal blanks. A detailed examination of the method has led to the conclusion that this process is not only feasible but has several remarkable advantages over existing techniques. Papers describing the principle and the results of the first tests done with it were presented at the ESO (European Southern Observatory) conference on Optical Telescopes of the future, (December 1977) and the annual meeting of the ASI (Astronomical Society of India) March 1978. This was a joint investigation with the National Aeronautical Laboratory, Bangalore.

ELECTRONICS

The frequency synthesiser built for use with the Ooty telescope for making spectral line observations was installed at Ooty and regular spectral line observations are in progress.

The digital autocorrelation receiver, also for use with the Ooty telescope, is now complete. Most of the sub-systems for this

unit including an SSB generator, filters and digital circuits have been tested, and it is proposed to instal this unit at Doty by August 1978.

The precision solar/sidereal clock designed at RRI was installed at Doty and is working satisfactorily.

Work on the FT system for the decameter telescope was continued and most of the sub-assemblies have been finalised and tested during the year.

ESTABLISHMENT OF THE BANGALORE NMR FACILITY

The Institute collaborated with the Indian Institute of Science, the Tata Institute of Fundamental Research, Bombay and the National Aeronautical Laboratory, Bangalore, in the establishment of the Bangalore NMR Facility, an inter-institutional NMR centre, established by the Department of Science and Technology. This centre is functioning satisfactorily.

SUMMER SCHOOL/WORKSHOP, etc.

A summer school in Physics for National Science Talent Scholars of NCERT was organized from May 30 to June 25, 1977. 44 NST Scholars from all parts of India attended the school. The programme included lectures in the mornings, project work in the afternoons, film shows and visits to scientific institutions, etc.

Special lectures were arranged between May 31 and June 14, 1977 in commemoration of the 250th Death Anniversary of Sir Isaac Newton. A display of books and photographs of Newton (lent by the British Council) was also arranged.

SERVICE TO OTHER LABORATORIES

As in previous years, a large number of infrared spectra, differential scanning calorimetric records were run free of charge for other

laboratories from different parts of the country. The number of spectra, etc. recorded this year is as follows:

FIR (external service)	..	60 Nos.
IR (external service)	..	50 Nos.
DSC (external service)	..	45 Nos.

TRAINING OFFERED TO COLLEGE TEACHERS

The following college teachers have joined as Teacher Fellows to do research work leading to Ph.D. under the UGC Faculty Improvement Programme:

1	Mr. G. Venkatesh	AES National College Gauribidanur
2	Mr. K.P.L. Moodithaya	Vivekananda College Puttur
3	Mr. K. Venkatachala Rao	St. Aloysius College Mangalore
4	Mr. S.N. Prasad	Regional College of Education Mysore

PUBLICATIONS

The research work carried out by the staff of the Institute has been published in a number of journals. A list of publications is given at Annexure I (page 21)

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 26) gives a list of conferences/meetings attended by our staff with titles of papers or talks presented if any. Lectures given by the members of the Institute elsewhere are also listed towards the end of Annexure II.

COLLOQUIA

Ten colloquia on different topics were held at the Institute during

the year. These were given by visiting scientists from Institutions both within and outside the country. Apart from these colloquia, about seventeen topics were discussed in a series of discussion meetings mostly on topics in theoretical physics. Annexure III and IV (pages 32 & 34) give lists of colloquia and informal talks.

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 492 new books during the year bringing the total number of books to 10419. Subscriptions to four new periodicals were also taken out raising the total number of periodicals subscribed to 114. Three of these new periodicals are received by air mail, making the total number of periodicals received by air mail nine. We continue to receive about 350 periodicals as a gift from the Current Science Association and the Indian Academy of Sciences. Attempts are being made to fill up the gaps in the back volumes collection. Some periodicals were gifted to us by TIFR for this purpose. At present the total number of bound volumes in our collection is 14,250.

The library has also been arranging the translation of technical articles in other languages into English. Twelve translations have been supplied so far. Inter-library cooperation among our library and those of NAL and IISc is continuing.

A start has been made on compiling a list of scientific journals received by air mail at various libraries in the city. This is a pilot project for compiling a list for the whole country, which will be done in collaboration with some other libraries. The author index to Molecular Crystals and Liquid Crystals started last year was completed this year and was published in September 1977 by Gordon & Breach.

GOVERNING COUNCIL

The tenure of the first governing council of the Institute comprising of the following expired on 31st December 1977:

Members of the first Governing Council

1. Prof. S. Dhawan : Director
Indian Institute of Science
Bangalore
2. Dr. A. Ramachandran : Secretary
Department of Science and
Technology
New Delhi
3. Dr. S. Ramaseshan : Deputy Director
National Aeronautical Laboratory
Bangalore
4. Dr. R. Ramanna : Director
Bhabha Atomic Research Centre
Bombay
5. Dr. Yash Pal : Director
Space Application Centre
Ahmedabad
6. Dr. M.K. Vainu Bappu : Director
Indian Institute of Astrophysics
Bangalore
7. Mr. P.K. Ramanujam : Joint Secretary (Finance)
Department of Science and
Technology
New Delhi
8. Prof. V. Radhakrishnan : Director
Raman Research Institute
Bangalore

A new Governing Council came into being on 1st January 1978 composed of the following:

1. Prof. S. Dhawan : Director
Indian Institute of Science
Bangalore
2. Dr. A Ramachandran : Secretary
Department of Science and
Technology
New Delhi
3. Dr. S. Ramaseshan : Deputy Director
National Aeronautical Laboratory
Bangalore
4. Prof. B.V. Sreekantan : Director
Tata Institute of Fundamental
Research
Bombay
5. Dr. D. Lal : Director
Physical Research Laboratory
Ahmedabad
6. Prof. A.N. Mitra : Department of Physics
University of Delhi
Delhi
7. Mr. P.K. Ramanujam : Joint Secretary and Financial
Adviser
Department of Science and
Technology
New Delhi
8. Prof. V. Radhakrishnan : Director
Raman Research Institute
Bangalore

GENERAL

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

<u>Plan</u>	Recurring	:	Rs. 11.50 lakhs
	Non-recurring	:	Rs. 13.40 lakhs
<u>Non-plan</u>	Recurring	:	Rs. 16.60 lakhs
Millimeter Wave Project:			Rs. 20.00 lakhs
New Building		:	Rs. <u>22.30</u> lakhs
	Total		Rs. <u>83.80</u> lakhs

2. A list of major items of equipment procured during the year is given in Annexure V (page 36)

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	12. Dr. G.S. Ranganath
2. Prof. S. Chandrasekhar	13. Dr. A.C. Kunwar
3. Dr. S. Krishnan+	14. Dr. V. Surendranath
4. Mr. N.V.G. Sarma	15. Dr. Rajendra Bhandari
5. Dr. C.V. Vishveshwara	16. Dr. C.S. Shukre
6. Dr. C.L. Khetrapal	17. Dr. Rajaram Nityananda
7. Dr. N.V. Madhusudhana	18. Mr. J. Padmanabhan
8. Dr. G. Srinivasan	19. Mr. K.T. Balakrishnan
9. Dr. N.D. Hari Dass	20. Mr. D.K. Ravindra
10. Dr. R. Shashidhar	21. Mr. K.M. Chandrakumar
11. Dr. S. Venugopalan	22. Mr. R.S. Arora

- | | |
|--------------------------------|----------------------------|
| 23. Mr. K.R. Ananthramaiah | 31. Mr. B.K. Sadashiva |
| 24. Mrs. Jayanthi Ramachandran | 32. Mr. N. Nandakumar |
| 25. Mr. M.D. Modgekar | 33. Mr. K. Subramanya |
| 26. Mr. M.R. Subrahmanyam | 34. Mr. T. Ramachandran |
| 27. Mr. P.N. Ramachandra | 35. Mr. Smiles Mascarenhas |
| 28. Mr. B.S. Prasanna | 36. Mr. K.M. Doraiswamy |
| 29. Mr. U. Devappa Kini | 37. Mr. N. Udaya Shankar* |
| 30. Mr. K.A. Suresh | 38. Mr. U.N. Maiya* |

Visiting Positions

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

Medical Consultant

Dr. A.R. Pai

Resignations

1. Mr. S.G. Siddesh
2. Mr. Gopal Rao

Pre-Doctoral Research Fellows

- | | |
|----------------------------|-----------------------------|
| 1. Mrs. B.R. Ratna | 8. Mr. K.P.L. Moodithaya* |
| 2. Mrs. G.V. Vani | 9. Mr. K. Venkatachala Rao* |
| 3. Mrs. K.L. Savithramma | 10. Mr. S.N. Prasad* |
| 4. Mr. S. Krishnaswamy | 11. Mr. N. Kedarnath* |
| 5. Mr. K.L. Venkatakrishna | 12. Mr. Satyendra Kumar* |
| 6. Mr. M.N. Ramanuja | 13. Mr. M. Vivekanand* |
| 7. Mr. G. Venkatesh* | |

A list of short period visiting scientists is given below:

1. Dr. B.E. Jones, June 16-July 4, 1977
Max Planck Institute for Radioastronomy,
Bonn, W. Germany.
2. Dr. A.R.P. Rau, June 20-July 9, 1977
Louisiana State University,
Louisiana, U.S.A.
3. Dr. Jayanth R. Banavar July 11-Aug 12, 1977
University of Pittsburgh,
Pittsburgh, U.S.A.
4. Dr. P. Dierich, Sept 9-26, 1977
Observatoire de Paris,
Meudon, Paris.
5. Dr. Cornelius Hoenselaers, Oct 13-May 1978
Karlsruhe, W. Germany.
6. Prof. F. Graham Smith, Oct 19-24, 1977
Director,
Royal Greenwich Observatory,
Hailsham, England.
7. Prof. J.M. Hirst, Nov 19-21, 1977
Director,
Long Ashton Research Laboratory,
Long Ashton, England.
8. Prof. E.P.J. van den Heuvel, Jan 30-Feb 2, 1978
Astronomical Institute,
Netherlands.
9. Prof. N. Lebovitz March 1-6, 1978
University of Chicago,
Chicago, Illinois, U.S.A.
&
Visiting Professor,
Centre for Advanced Study in Mathematics,
Punjab University, Chandigarh.

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 | 8. Mrs. Sowjanya Mahesh |
| 2. Mr. P.K. Ramakrishnan | 9. Mr. H.H.J. Pereira |
| 3. Mr. A. Ratnakar | 10. Miss S. Girija |
| 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. Mohamed Khasim |
| 7. Mrs. Lakshmi Rajagopal | |

PUBLICATIONS

Published in 1977-78

1. Liquid Crystals (S. Chandrasekhar) - CAMBRIDGE MONOGRAPH ON PHYSICS (Cambridge Univ. Press) 1977
2. 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) MOL. CRYSTL. LIQUID CRYST. 40, 133 (1977)
3. A study of the dielectric relaxation in nematic liquid crystals using the Freedericksz transition technique (P.P. Karat and N.V.Madhusudana) - MOL. CRYST. LIQUID CRYSTS. 42, 579 (1977)
4. Elasticity and orientational order in several cyano-biphenyl compounds and their mixtures (P.P. Karat and N.V.Madhusudana) - MOL.CRYST.LIQUID CRYST. 40,259 (1977).
5. Verification of Leslie's expression for the threshold field for a twisted nematic cell (P.P. Karat and N.V. Madhusudana) MOL. CRYST. LIQUID CRYST. 40, 171 (1977)
6. A convenient method for the preparation of 4-n-alkyl-4'-cyano-p-terphenyl (B.K.Sadashiva and G.S.R.Subba Rao) - MOL. CRYST. LIQUID CRYST. 38, 703 (1977)
7. Measurement of the surface tension of CBOOA(S.Krishnaswamy and R. Shashidhar) - MOL.CRYST.LIQUID CRYST. 38,711 (1977)
8. Singularities in nematics - the effect of elastic constant variations (U.D.Kini and G.S.Ranganath) - MOL. CRYST. LIQUID CRYST. 38, 311 (1977)
9. Crystal structures of two mesogenic compounds (G.V.Vani and Kalyani Vijayan) - MOL.CRYST.LIQUID CRYST. 42, 349 (1977)
10. Dielectric studies on liquid crystals of strong positive dielectric anisotropy (B.R.Ratna and R.Shashidhar) - MOL. CRYST. LIQUID CRYST. 42, 113 (1977)

11. High pressure studies on mesomorphic and poly mesomorphic transitions (R. Shashidhar) - MOL. CRYST. LIQUID CRYST. 43, 71 (1977)
12. Interaction between a hole and a disclination in nematics (G.S. Ranganath) - MOL.CRYST. LIQUID CRYST. 40, 143 (1977)
13. Far-infrared absorption in the highly ordered smectic phases of TBBA (S.Venugopalan, J.R. Fernandes and V.Surendranath) - MOL.CRYST. LIQUID CRYST. 40, 149 (1977)
14. The crystal and molecular structure of the nematogenic n-p-methoxybenzylidene-p-phenylazoaniline (MBPAA) - (G.V. Vani and Kalyani Vijayan) - ACTA CRYST. B33, 2236 (1977)
15. Dielectric dispersion in 4'-n-alkyl-4-cyanobiphenyls (B.R.Ratna and R.Shashidhar) - MOL CRYST. LIQUID CRYST. 42, 185 (1977)
16. Liquid crystals of disc-like molecules (S.Chandrasekhar, B.K.Sadashiva and K.A.Suresh) - PRAMANA 9, 471 (1977)
17. Homogeneous instabilities in nematic liquid crystals (U.D. Kini) - PRAMANA 10, 143 (1978)
18. Differential dichroic spectroscopy in liquid crystals (J.R.Fernandes and S.Venugopalan) - CHEMICAL PHYSICS LETT. 53, 407 (1978)
19. Liquid Crystals (N.V.Madhusudana) - SCIENCE TODAY, 11, 11 (1977)
20. Nuclear Magnetic Resonance Studies of Molecules Oriented in Thermotropic Liquid Crystals - review article - (C.L. Khetrapal and A.C.Kunwar) - ADVANCES IN MAGNETIC RESONANCE, Vol. 9, 301-422 (1977) (Academic Press)
21. Structure and conformation of N,P-chlorophenyl maleimide in a nematic solvent by proton magnetic resonance (C.L. Khetrapal, A.C.Kunwar and A.Saupe) - MOL.CRYST. LIQUID CRYST. 40, 193 (1977)
22. PMR Spectrum of butadiene sulphone oriented in a lyotropic solvent (C.L.Khetrapal, A.C.Kunwar and A.V.Patankar) - MOL.CRYST. LIQUID CRYST. 34, 219 (1977)
23. PMR spectra of N-phenylmaleimide in isotropic and nematic phases (C.L.Khetrapal, P.Diehl and A.C.Kunwar) - ORGANIC MAG. RES. 10, 213 (1978)

24. The structure of the proton skeleton in 1,3-butadiene iron tricarbonyl as determined by oriented molecules (P. Diehl, A.C.Kunwar and H.Zimmerman) - J.ORGANOMET. CHEM. 135, 205, (1977)
25. Anisole, acetophenone and benzoic acid methyl ester oriented in a nematic phase: Structure and internal motion (P. Diehl, H. Huber, A.C.Kunwar and M.Reinhold) - ORG. MAG. RES. 9, 374 (1977)
26. The proton spectrum including ^{13}C -satellites of π -benzene chromium tricarbonyl in a nematic solvent (P. Diehl and A.C. Kunwar) - ORG. MAG. RES. 11, 47 (1978)
27. NMR Studies of dimethyl selenide and dimethyl telluride oriented in a nematic phase of a liquid crystal (P. Diehl, A.C.Kunwar and H.Bosiger) - J.ORGANOMET. CHEM. 145, 303 (1978)
28. Relativistically rotating dust cylinders (C.V.Vishveshwara and J.Winicour) - J. MATH.PHY. 18, 1280 (1977)
29. Charged particle trajectories in an electromagnetic field on curved space-time (A.R. Prasanna, R.K. Verma, and C.V.Vishveshwara) BULLETIN OF THE EIGHTH INTERNATIONAL CONFERENCE ON GENERAL RELATIVITY AND GRAVITATION, 1977
30. Experimental tests for some quantum effects in gravitation (N.D Hari Dass) ANN. PHYS. 107, 337 (1977)
31. A new approach to making large telescope mirrors. (S.Ramaseshan, S.R. Rajagopalan, R.Nityananda and V.Radhakrishnan) - PROCEEDINGS OF ESO CONFERENCE ON OPTICAL TELESCOPES OF THE FUTURE, GENEVA, 1977 Ed. by F.Pacini et. al. 1978 Page 371
32. Master Index (Author) to volumes 1 to 33 of Molecular Crystals and Liquid Crystals (Library Staff) MOL. CRYST. LIQUID CRYST.

Papers submitted and in press (1977-78)

1. Phase transitions and pretransition phenomena in liquid crystals (S. Chandrasekhar and N.V. Madhusudana) - a review article - Progress in liquid Physics. Ed. C.A. Croxton (John Wiley & Sons)
2. High pressure studies on liquid crystals - review article (S. Chandrasekhar and R. Shashidhar) - ADVANCES IN LIQUID CRYSTALS (Academic Press)
3. Equivalence of the Krieger-James approximation and the constant coupling approximation in magnetism (K.L. Savithramma and N.V. Madhusudhana) PRAMANA
4. Dielectric properties of some nematics of positive dielectric anisotropy (B.R. Ratna and R. Shashidhar) MOLECULAR CRYSTALS AND LIQUID CRYSTALS
5. Orientational order and elastic constants of some of cyanobiphenyls: Part III (P.P. Karat and N.V. Madhusudhana) MOLECULAR CRYSTALS AND LIQUID CRYSTALS
6. Two dimensional NMR application to oriented molecules (Anil Kumar and C.L. Khetrpal) JOURNAL OF MAGNETIC RESONANCE
7. ^1H , ^{115}Sn , ^{117}Sn , ^{119}Sn -NMR-studies on tetramethyltin in nematic and isotropic phases (P. Diehl, A.C. Kunwar and M. Reinhold) JOURNAL OF MAGNETIC RESONANCE
8. Proceedings of the National Symposium on biological membranes and model systems Ed. S.V. Talekar, P. Balaram, S.K. Podder and C.L. Khetrpal
9. Maximum entropy spectral analysis - some comments (R. Bhandari) ASTRONOMY AND ASTROPHYSICS SUPPLEMENT SERIES
10. Three proposed pulsar/supernova remnant associations and their possible origin in close binary systems (D. Morris, V. Radhakrishnan and C.S. Shukre) ASTRONOMY AND ASTROPHYSICS

11. On the effect of motions on energy-momentum tensors (C.Hoenselaers) PROGRESS OF THEORETICAL PHYSICS.
12. Directional singularities re-examined (C.Hoenselaers) PROGRESS OF THEORETICAL PHYSICS.
13. A relativistically rotating fluid cylinder (C.Hoenselaers and C.V.Vishveshwara) GENERAL RELATIVITY AND GRAVITATION JOURNAL
14. A new solution of Ernst's equation (C. Hoenselaers) JOURNAL OF PHYSICS 'A'.
15. A classification system for one killing vector solutions of Einstein's equations (C.Hoenselaers) PROGRESS OF THEORETICAL PHYSICS.
16. Algebraically special one killing vector solutions of Einstein's equations (C.Hoenselaers) PROGRESS OF THEORETICAL PHYSICS.
17. The Mosfet inversion layer - The conductivity of localized, highly correlated phase. (M.Jonson and G.Srinivasan) PHYSICA SCRIPTA
18. Search for the Deuterium absorption line at 327 MHz in the direction of the galactic centre. (N.V.G.Sarma and D.K.Mohanty) MONTHLY NOTICES OF ROYAL ASTRONOMICAL SOCIETY.

Ph. D. Theses submitted:

NAME	TITLE
1. J.R. FERNANDES	Infrared studies on liquid crystals.

ANNEXURE II

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
1. Sixth International Symposium on Magnetic Resonance. Banff, Canada May 1977	Dr. C. L. Khetrapal	PMR of heterocyclic system in lyotropic solvents. (C. L. Khetrapal, A. C. Kunwar and A. V. Patankar)
2. Eighth International Conference on General Relativity and Gravitation Waterloo, Canada August 7-12, 1977	Dr. C. V. Vishveshwara	-
3. Seminar on Magneto hydrodynamics and plasmandynamics. Mathematics Dept. Punjab University, Chandigarh Sep. 26-30, 1977	Dr. C. S. Shukre	Problems in Pulsar electrodynamics
4. Eleventh IASLIC Conference. Dharwar Nov. 2-5, 1977	Ms. S. Girija	-
5. Optical Telescopes of the future. European Space Observatory, Geneva December 12-15, 1977	Dr. R. Nityananda	A new approach to making large telescope mirrors (S. Ramaseshan, S. Rajagopalan R. Nityananda & V. Radhakrishnan)
6. Round Table Conference on Training Requirements of Astronomers in India. Astronomy Department, Osmania University Hyderabad December 27-30, 1977	Dr. C. S. Shukre	Training requirements of Astronomers in India
7. Varian Workshop on FT-NMR IIT, Madras December 1977	Dr. A. C. Kunwar	NMR of oriented molecules

<u>CONFERENCES/MEETINGS</u>	<u>ATTENDED/PRESENTED BY</u>	<u>TITLE OF PAPER/TALK</u>
8. Winter School on Binaries in Astrophysics. Tata Institute of Fundamental Research Bombay. January 16-25, 1978	Dr. N. D. Hari Dass Dr. C. S. Shukre Dr. C. V. Vishveshwara Prof. V. Radhakrishnan	
9. Symposium on Chemical Evolution, origin of Life and Evolution of Life Process. Reg. Res. Lab. Hyderabad. January 28-31, 1978	Dr. C. L. Khetrapal	Liquid Crystals and their relation to life processes.
10. National Conference on Crystallography. Sardar Patel University, Vallabh Vidyanagar. February 13-16, 1978	Ms. G. V. Vani	Studies on partial positional disorder in some azo- and azoxy compounds.
11. Schwinger Symposium. University of California at Los Angeles. February 18-19, 1978	Dr. N. D. Hari Dass	-
12. Golden Jubilee Celebrations of the discovery of the Raman Effect. Andhra Akademi of Sciences, Hyderabad. February 28, 1978	Dr. S. Venugopalan	-
13. Fourth Meeting of the Astronomical Society of India. Radio Astronomy Centre, Ooty. March 7-10, 1978	Dr. C. S. Shukre Dr. C. Hoenselaers Dr. R. Nityananda Mr. K. L. Venkatakrishna Mr. K. R. Anantharamaiah	

OTHER LECTURES GIVEN BY MEMBERS OF THE INSTITUTE'S STAFF

- | | | |
|--|---------------------------|---|
| 1. Karnataka Science College, Dharwar
10 February 1978 | Prof.S.Chandra-
sekhär | The golden jubilee of the discovery of the Raman Effect (1928-1978) |
| 2. University of Roorkee, Roorkee
20th May - 2nd June 1977 | Dr.N.D.Haridass | <ol style="list-style-type: none"> 1. General Relativity and microphysics 2. Discrete symmetry violations in gravitation 3. Lectures on quantum electrodynamics from the source theory point of view (four lectures) |
| 3. Summer School in Physics, Raman Research Institute Bangalore
June-July 1977 | Dr.N.D.Haridass | Special relativity (four lectures) |
| | Dr. R.Bhandari | Quantum Mechanics (Three lectures) |
| | Dr.C.V.Vishvesh-
wara | Calculus of Variation |
| 4. Chemistry Department University of Waterloo Canada, June 1977 | Dr.C.L.Khetrapal | Analysis of complicated NMR spectra of oriented molecules |
| 5. Nuclear theory Workshop, Central College, Bangalore July 1977 | Dr.N.D.Hari Dass | Structure of elementary particles |
| 6. Solid State and Structural Chemistry Group, Indian Institute of Science, Bangalore, August 1977 | Dr.G.Srinivasan | Magnetic field induced Wigner lattice in inversion layers |
| 7. Indian Institute of Science, Bangalore August 23, 1977 | Dr.R.Nityananda | Restivity of binary mixtures near the critical point |
| 8. Madura College Madurai September 1977 | Dr.G.Srinivasan | <ol style="list-style-type: none"> 1. A course of lectures on critical phenomena 2. Black holes in general relativity 3. Thermodynamics of black holes. |

- | | | | |
|-----|---|----------------------|--|
| 9. | Electronics Industries Association of Japan, Tokyo
29 Sept. 1977 | Prof.S.Chandrasekhar | Liquid Crystals |
| 10. | Special University Lecture, Birkbeck College, University of London
31 October 1977 | Prof.S.Chandrasekhar | X-ray analysis of liquid crystals |
| 11. | Indian Institute of Astrophysics Bangalore
November 1977 | Dr.C.S.Shukre | The slow down rate of the binary pulsar |
| 12. | Science Circle, Indian Institute of Science
Nov 8, 1977 | Dr.C.V.Vishvesh-wara | Gravitation and Spacetime |
| 13. | 43rd Annual Meeting of the Indian Academy of Sciences, Calcutta
Nov 26, 1977 | Dr.C.V.Vishvesh-wara | Spacetime and Gravitation |
| 14. | Physical Research Laboratory, Ahmedabad
Feb.1-3, 1978 | Dr.C.S.Shukre | 1.Problems in pulsar electrodynamics
2.New pulsar/supernova remnant associations. |
| 15. | Institution of Electronics and Telecommunication Engineers, Bangalore
Feb.4, 1978 | Dr.N.V.Madhusudana | Liquid Crystals |
| 16. | Indian Institute of Technology, Madras
February 1978 | Dr.C.V.Vishvesh-wara | 1. Elements of General Relativity
2. Black Holes |
| 17. | Bangalore Mathematical Association Central College Bangalore
February 17, 1978 | Dr.C.V.Vishvesh-wara | Inagural Address |
| 18. | University of California at Los Angeles
February 24, 1978 | Dr.N.D.Hari Dass | Lepton polarisation experiments as probes of weak neutral currents |

- | | | |
|---|--------------------------|--|
| 19. Literary Society
Sharada Vilas College
Mysore
March 10, 1978 | Dr.C.V.Vishvesh-
wara | Relativity and
Gravitation |
| 20. University of
California at
Santa Barbara
March 14, 1978 | Dr.N.D.Hari Dass | Is parity violated by
gravitation? |
| 21. University of Texas
at Austin
Austin
March 28, 1978 | Dr.N.D.Hari Dass | Parity violation
reaches for the
weak neutral currents |
| 22. Lousiana State
University
Baten Rouge
March 30, 1978 | Dr.N.D.Hari Dass | 1. Does gravitation
conserve P&T?
2. Structure of weak
Neutral currents |

SPECIAL LECTURES GIVEN DURING THE NEWTON
COMMEMORATION PROGRAMME

- | | | |
|-----------|--|---------------------------------|
| 31.5.1977 | Dr. S. Ramaseshan
National Aeronautical
Laboratory, Bangalore | Newton and his Opticks |
| 2.6.1977 | Dr. M.K. Vainu Bappu
Director
Indian Institute of
Astrophysics,
Bangalore | Newton and astronomy |
| 6.6.1977 | Dr. U.R. Rao
Director
Indian Scientific
Satellite Project
Bangalore | From Apples to Apollo |
| 8.6.1977 | Dr. B.S. Madhava Rao
Retired Professor of
Mathematics
Central College
Bangalore | Newton and the Calculus |
| 10.6.1977 | Dr. C.V. Vishveshwara
Raman Research Institute
Bangalore | Gravitation |
| 13.6.1977 | Dr. N. Mukunda
Centre for Theoretical
Studies
Indian Institute of
Science, Bangalore | Three Centuries of
Mechanics |

ANNEXURE IIICOLLOQUIA

- | | | |
|----------------------|---|--|
| April 5 1977 | Prof Saburo Miyake
Director
Cosmic Ray Laboratory
University of Tokyo
Japan | International collabora-
tion work in cosmic ray
research |
| September 14
1977 | Prof A.W. Wolfendale
Dept of Physics
University of Durham
Durham, England | The origin of cosmic
rays |
| October 20 1977 | Prof F. Graham Smith
Director of the Royal
Greenwich Observatory
Hailsham, England | Pulsars |
| November 19 1977 | Prof J.M. Hirst
Director
Long Ashton Research Stn.
Long Ashton.
Bristol, U.K. | Aerobiology of fungus
spores |
| January 12 1978 | Dr. A.V. Tutukov
Astronomical Council
USSR Academy of Science
Moscow, U.S.S.R. | Early stages of
evolution of stellar
clusters |
| January 31 1978 | Prof E.P.J. van den Heuvel
Astronomical Institute
University of Amsterdam
Amsterdam, The Netherlands | The rotational history of
a neutron star in a close
binary system |
| February 22 1978 | Dr. Norman Cohen
The Open University
U.K. | Teaching science at a
distance |
| February 24 1978 | Prof A. Bauer
Lichttechnisches Institut
der Universitat
Karlsruhe, West Germany | Absolute spectral
radiance of a light
source without inversion
of population in an optical
resonator |
| November 19 1977 | Prof J.M. Hirst
Director
Long Ashton Research Stn.
Long Ashton
Bristol, U.K. | Aerobiology of fungus
spores |
| January 12 1978 | Dr. A.V. Tutukov
Astronomical Council
USSR Academy of Science
Moscow, U.S.S.R. | Early stages of
evolution of stellar
clusters |

March 2 1978

Prof Norman R. Lebovitz
University of Chicago
Chicago, Illinois
U.S.A.

Bifurcation theory and
double-star formation

&

Visiting Professor
Centre for Advanced study
in mathematics
Punjab University
Chandigarh

March 3 1978

Dr. Robert S. Anderson
Institute for Asian Research
University of British
Columbia
Vancouver, Canada

World implication of the
rice revolution in the
southern United States
since 1870

ANNEXURE IVTHEORETICAL PHYSICS MEETINGS

April 6 1977	Dr. N.D. Hari Dass Raman Research Institute Bangalore	Physical processes in strong magnetic fields
April 13 1977	Dr. Rajaram Nityananda Raman Research Institute Bangalore	The Rees mechanism for radio bursts from black holes
April 20 1977	Dr. A.R. Prasanna Physical Research Laboratory Ahmedabad	Einstein-Cartan theory: foundation and equations
May 11 1977	Dr. A.K. Kembhavi Tata Institute of Fundamental Research Bombay	Singularities in cosmology and conformal gravitation
June 1 1977	Dr. R. Shankar Dept. of Physics Harvard University Cambridge, U.S.A.	Application of topology to liquid crystals and He-3
July 6 1977	Dr. A.R.P. Rau Louisiana State University Baton Rouge, Louisiana U.S.A.	Strong mixing of fields
July 20 1977	Dr. Jayanth R. Banavar University of Pittsburgh Pittsburgh, U.S.A.	Superfluidity and helicity modulus
July 28 1977	-do-	A new effect observed in a pin photo-diode
August 3 1977	Prof Cecile de Witt- Morette University of Texas Austin, U.S.A.	Catastrophe theory
September 7 1977	Dr. Sastri Vemury Institute for Space Studies, New York, U.S.A.	Bump Cepheid masses

- October 5 1977 Dr. N.D. Hari Dass
Raman Research Institute
Bangalore The physical basis of
quantum theory
- November 2 1977 Dr. R.K. Kochhar
Indian Institute of
Astrophysics
Bangalore Supernova explosions in
close binary systems
- November 15 1977 Dr. Cornelius Hoenselaers
Raman Research Institute
Bangalore Killing vectors, Petrov
classification and
all that
- December 8 1977 Dr. G. Srinivasan
Raman Research Institute
Bangalore The Anderson-Mott
Transition
- January 6 1978 Dr. R. Isaacson
Programme Director for
Theoretical Physics
National Science Foundation
Washington D.C. U.S.A. Trends in the support of
U.S. basic research in
physics
- February 3 1978 Dr. N.D. Hari Dass
Raman Research Institute
Bangalore Structure of weak
neutral currents
- February 24 1978 Dr. Rajaram Nityananda
Raman Research Institute
Bangalore Report on the ESO
Conference on 'Optical
Telescopes of the future'
Dec 1977

MAJOR ITEMS OF EQUIPMENT PROCURED/ORDERED

1. Transistor Stabilized Power Supplies Dual Type	6 Nos	Rs.	15,700
2. Special Furnace	1 No	Rs.	4,000
3. KLENZAIDS Console Model Horizontal Laminar Clean Air Work Station	1 No	Rs.	18,140
4. Mobile Cart for Oscilloscope	1 No	Rs.	1,300
5. Quartz Crystal Type Thickness Monitor	1 Unit	Rs.	12,810
6. Perkin Elmer Auto Balance	1 No	Rs.	45,035
7. Digital Panel Meters	2 Nos	Rs.	11,190
8. Programmable Scientific Calculators	2 Nos	Rs.	4,000
9. Solid State Noise Source Lars Microwave Type NCR P120-25	1 No	Rs.	4,300
10. Solid State Noise Source MS Model MC 5182	1 No	Rs.	11,500
11. Galvanometric Recorder	1 No	Rs.	20,200
12. Grade I Accuracy High Speed Drilling Machine	1 No	Rs.	7,055
13. Optical Bench etc	1 set	Rs.	3,100
14. Regulated Power Supplies 5V/10 Amps with dual range meter to read voltage or current	2 Nos	Rs.	3,223
15. Philips DC Microvoltmeter with Probes	1 No	Rs.	6,520
16. Avery Portable Platform Scale Capacity 1000 Kgs	1 No	Rs.	7,890
17. Digital Multimeter 3 1/2 Digit	1 No	Rs.	6,522
18. DC Voltage & Current Standard	1 No	Rs.	16,000
19. Vernier Potentiometer having 3 range multipliers of X1, X0.1 & X0.01	2 Nos	Rs.	10,335
20. Power supply 0-30 V, 0.5 Amps (Dual)	1 No	Rs.	5,750
21. Digiscribe 5000 Strip Chart Recorder	1 No	Rs.	31,239
22. Static Inverter	1 No	Rs.	20,000
23. Mosaic Printer & Character Generator	1 No	Rs.	6,200
24. Controlled Energy Spot Welding Unit	1 No	Rs.	5,344
25. High Voltage Power Supply	1 No	Rs.	7,330
26. Hydraulic Hoist 4 ton Capacity	1 No	Rs.	7,400
27. Hand operated Pressure Test Pump	1 No	Rs.	5,700

28	APLAB DC Microvoltmeter	1 No.	Rs.	2,340
29	Simpson Multimeter	1 No.	Rs.	1,040
30	Multi-output Regulated Power Supplies & Dual Independent Tracking Logic Supply	6 Nos	Rs.	22,000
31	Travelling Trolley Type Drafting Machine with accessories	2 sets	Rs.	9,700
32	Self contained cold water circulating system for X-ray set	1 Unit	Rs.	40,600
33	Solarimeter Integrator	1 No.	Rs.	5,700
34	Multivalve Postal Franking Machine	1 No.	Rs.	6,180
35	TV Monitor	1 No.	Rs.	6,300
36	Photomultiplier Tube with Socket & Magnetic shield	1 No.	Rs.	18,810
37	Incremental Magnetic Tape Recorder	1 No.	Rs.	62,800
38	Cooled Photomultiplier Housing with accs.	1 No	Rs.	27,200
39	Ultra High Sensitive XYT Recorder with accs	1 set	Rs.	22,500
40	Princeton Model 1120 Amplifier	1 No.	Rs.	16,000
41	Princeton Model 1105 Data Converter	1 No.	Rs.	22,000
42	Anritsu F Band Power Measuring Element TC Mount Type MP 82B4.	1 No.	Rs.	15,192
43	Aplab Solid State Regulated Power Supply 0 - 300V, 0.3A	2 Nos	Rs.	8,800
44	APLAB Digital Multimeter with LED Display	2 Nos	Rs.	14,000
45	Digital Panel Meters 4 1/2 Digit, LED Display	2 Nos	Rs.	11,000
46	Astronomical Clocks, Interface Unit & Remote Display Unit	2 Nos	Rs.	17,000
47	Marconi AM Signal Generator	1 No	Rs.	22,000
48	Electronic Integrator	1 No	Rs.	6,237
49	Coaxial Crystal Detectors	2 Nos	Rs.	5,000
50	Low Pass Filter HP Model 360C	1 No	Rs.	1,900
51	HP Model 360A Low Pass Filter	1 No.	Rs.	3,000
52	Wave Guide Mixer HP 11517A	1 No.	Rs.	2,750

53	Taper Section HP Model 11519A	1 No.	Rs.	2,050
54	Thermistor Mount HP Model 478A	1 No.	Rs.	2,700
55	HP423B Crystal Detector	1 No.	Rs.	2,100
56	Crystal Detector HP Model 423B	1 No.	Rs.	2,100
57	Variable Attenuator	1 No.	Rs.	4,000
58	Low drift FET Instrumentation Amplifier	3 Nos	Rs.	2,800
59	ESSCOLAM 6 Shear	1 sht	Rs.	4,000
60	Elmecca Micro Boring & Facing Head Model SDCM 350	1 No.	Rs.	3,200
61	Incremental Encoder 200 counts	1 No.	Rs.	2,600
62	Millimeter Wave Isolator	1 No.	Rs.	16,000
63	Power Meter Type ML81A & TC Mounts	1 set	Rs.	34,480
64	Spacekom Mixer Type F-22.3V	1 No.	Rs.	23,900
65	Variable Attenuators etc	1 set	Rs.	1,44,000
66	EH Tuner etc	1 set	Rs.	98,300
67	Horn Gain Standard	1 No.	Rs.	3,000
68	Vernier Height Gauge 18"	1 No.	Rs.	1,388
69	Slip Gauges	1 set	Rs.	4,418
70	Copper Shaping Machine	1 No.	Rs.	37,000
71	Radial Drilling Machine	1 No.	Rs.	1,01,000
72	Sheet Bending Machine	1 No.	Rs.	12,180
73	Grade I Power Operated Guillotine Sheering Machine	1 No.	Rs.	20,000
74	Super Cut Hand Sheet	1 No.	Rs.	3,000
75	High Speed Drilling Machine	1 No.	Rs.	6,000
76	Granite Surface Plate with Stand	1 No.	Rs.	3,537
77	GMT Make Steel Section Parallel Straight Edge	2 Nos	Rs.	12,000
78	TESA Swiss Make Electronic Linear Measuring Instrument	1 No.	Rs.	18,700
79	Crimp Tools & Dies	1 set	Rs.	3,000
80	Laser Transducer System	1 set	Rs.	3,90,000

81	Hindustan Unified High Speed Lathe NH22/1500 with accessories	1 No.	Rs.	1,59,300
82	APLAB Power Supply Type 7152	4 Nos	Rs.	10,576
83	Philips Dual Trace Oscilloscope	1 No.	Rs.	12,390
84	Philips Digital Multimeter	1 No.	Rs.	7,030
85	Praga Machine Vice with handle & Micro Boring attachment for HMT RM 61 Radial Drilling M/c	1 set	Rs.	5,300
86	Micrometer with sliding anvil & dial indicators	1 No	Rs.	33,000
87	Standard Band Coaxial Noise Source	1 No	Rs.	5,500
88	Harmonic Mixers	3 Nos	Rs.	18,600
89	Frequency Synthesizers	2 Nos	Rs.	11,800
90	HP Signal Generator	1 No.	Rs.	49,500
91	Digital Recorder	1 No.	Rs.	24,000
92	Directional Couplers	2 Nos	Rs.	9,400
93	Aciera Milling Machine Type F1	1 No	Rs.	1,03,000
94	Capacitance Bridge Boonton Model 75D	1 No.	Rs.	41,300