

RAMAN RESEARCH INSTITUTE

BANGALORE

ANNUAL REPORT—1978-79

The work carried out by the various groups in the Institute during the year 1978-79 is summarised below :

Liquid crystals

1. *Liquid crystals of disc-like molecules*

The discovery reported by us in 1977 of a new type of liquid crystal composed of pure compounds of disc-like molecules has been confirmed recently by two French groups, one group in Paris (College de France/Thomson CSF) and the other in Talence (Domaine University) in similar disc-like systems. The structure we had proposed has also been confirmed by the Orsay x-ray group, except that their compounds, having a larger central core, seem to have a partial ordering of the cores, which is not apparent in our compounds.

Further studies using NMR and other techniques are in progress. Pressure induced mesomorphism has been discovered in one of the disc-like compounds (the hexanoate). The virtual mesophase isotropic transition for this compound derived from the P-T phase diagram is in excellent accord with that estimated from the miscibility studies carried out subsequently by J. Billard at College de France.

2. *Pressure studies*

The 200-ton hydraulic press installed last year has been used to investigate a number of materials. New instances of pressure induced mesomorphism, tricritical behaviour, etc., have been obtained. High pressure x-ray studies—in particular, the pressure dependence of the lamellar spacings in smectic A and C phases—are also in progress.

A high pressure optical cell capable of going up to 20 kbars has been designed and fabricated, and preliminary experiments are under way.

3. *Flow properties*

A rigorous theory has been developed of cholesteric flow normal to the helical axis, and detailed calculations have been made of the apparent viscosity, orientation and velocity profiles as functions of the shear rate and sample thickness. A remarkable feature predicted by theory is that the apparent viscosity should exhibit oscillations with increasing pitch. Viscometric measurements carried out very recently by a group at the University of Rhode Island, USA, have confirmed the occurrence of such oscillations (private communication).

4. *Infrared and Raman spectroscopy*

The submillimetre wave absorption of the *p*-azoxyanisole series of liquid crystals was investigated in the 30–200 cm^{-1} range. These studies have shown for the first time that the libration of the entire molecule around its long axis *as well as* the torsional motion of the end alkoxy groups contribute to the observed absorption, the latter being the dominant factor for the lower homologues.

The external optics and detection parts of the Cary-81 Raman spectrometer were redesigned and the necessary modifications have been completed. These modifications have led to a substantial improvement in the performance of the instrument, as compared to Cary's original design. A Raman scattering study of the orientational order in some liquid crystals has been initiated.

5. *Electrohydrodynamic instabilities*

Electrohydrodynamic instabilities have been observed in nematic liquid crystals with new combinations of physical properties. When an appropriate low frequency voltage is applied to a homeotropically aligned sample electrohydrodynamic flow patterns are seen having circular symmetry unlike the usual Williams domains which are in the form of long stripes. These observations are now being interpreted in detail.

6. *Surface studies*

The studies on the anomalous behaviour of the surface tension of nematic liquid crystals have been extended to smectic liquid crystals. Pronounced anomalies have been noted in these cases also, confirming the existence of lamellar ordering near the surface of the fluid, even in the isotropic phase.

7. *Chemical studies*

The search for new liquid crystalline materials of interest to both basic and applied studies is in progress. Two new homologous series, benzoyloxy benzoates (12 compounds) and biphenyl benzoates (24 compounds) have been synthesized and their mesomorphic properties characterized. Some of these compounds show quite unusual liquid crystalline behaviour and may turn out to be of importance both from the fundamental and practical points of view.

8. *NMR work*

(a) A new method to determine the van der Waals radii of atoms using NMR spectroscopy of oriented molecules has been proposed and used. A study of NMR spectra of 5-membered aromatic ring systems containing a heteroatom (whose van der Waals radius is to be determined) reveals that the distances between the protons closest to the heteroatom are related to the van der Waals radii and can be used to provide them.

(b) Software for 2-dimensional NMR spectroscopy has been developed by the Bangalore NMR Facility and used to obtain 2-dimensional NMR spectra of oriented molecules for the first time; the lines with negative intensities have been observed for the first time (as predicted theoretically and reported in the previous year's

report). Spectroscopic information which cannot be obtained from normal 1-dimensional spectra has been derived. The concept of 'deceptive simplicity' in 2-dimensional NMR has been advanced and the conditions of the appearance of such spectra in 3 and 4 spin systems have been obtained.

(c) NMR has been used to determine the quality and the quantity of edible oils in Sunflower seeds. The time development of the oil in the crops after the seeds are sown has been studied with a view to determining the optimum time for getting the maximum oil output from the crops. The influence of seasonal variations on the time development of the oil is being investigated. Such studies are being extended to seeds of other varieties also.

(d) A study of ^{13}C - ^1H satellites in the natural abundance of ^{13}C , in the proton NMR spectra of oriented molecules has been used to determine ^{13}C -isotopic effects on proton chemical shifts and direct dipolar couplings. In acetone, the effects have been determined for the protons not only when a ^{13}C is directly bonded to it but also when the ^{13}C -substitution is 2 or 3 bonds away. Such information cannot be obtained from normal NMR spectra in isotropic media.

(e) Efforts have been made to use NMR to derive structural and conformational information including studying the influence of nuclei with low natural abundance and poor sensitivity for NMR experiments. For such a purpose, proton NMR spectroscopic studies including ^{13}C - ^1H and ^{77}Se - ^1H satellites in the natural abundance of ^{13}C and ^{77}Se in selenium compounds have been made. The systems have been shown to provide unusually sharp lines under comparable conditions and hence are very suitable for such studies. ^{77}Se - ^1H distances have been obtained.

9. Applications

Stringent tests have been carried out to ascertain the performance and stability against chemical/photochemical/electrochemical decomposition of the liquid crystal materials prepared in this Laboratory for use in display devices for clocks, watches, etc. It has been established that our materials compare very well with the best commercially available materials used by LCD manufacturers throughout the world. Based on these tests, we can guarantee that our materials will be stable against decomposition/degradation for a period of five years of continuous operation in hermetically sealed LCD cells. Clearance is awaited from the Department of Electronics to pass on the know-how to a manufacturer for large scale production.

The electronic circuitry for addressing a multiplexed matrix liquid crystal display capable of displaying 16 characters is complete. The liquid crystal cell has been made so far only for a 4-character display but work is going on for making cells for the remaining 12-characters.

Circuitry for a 32-character matrix display is in progress.

Theoretical physics and astrophysics

1. Poincaré sphere representation of polarised light

The possibility of enlarging the Poincaré sphere representation (which describes the state of polarisation) to include phase was investigated. A topological argument revealed that any phase convention runs into discontinuities.

2. *Line defects in liquid crystals*

A theoretical study was made of the effect of elastic anisotropy on line defects in nematic liquid crystals. Apart from giving results valid for high anisotropy, the analysis revealed that force computations can essentially be reduced to calculating the energies of isolated defects, by exploiting the scale invariance of the problem.

3. *A new theory of repulsion and structural stability in ionic crystals*

An ionic crystal is viewed as a collection of compressible ions in polyhedral, space-filling cells. Repulsion arises solely from the increased compression energy at the cell faces. Eighteen parameters (2 per ion) were determined from the lattice spacings and compressibilities of the 20 alkali halides. These explain for the first time the observed structures of all these crystals as also their thermal and pressure transitions—a significant advance over previous semi-empirical theories.

4. *A simple theory of thermal expansion in ionic crystals*

On the basis of a very simple picture, it has been shown that the force of repulsion between two neighbouring ions in an ionic crystal is increased when the ions are thermally vibrating, thus leading to lattice expansion. Taking the high temperature classical limit, the coefficients of thermal expansion of the alkali halides have been calculated without introducing any adjustable parameters. The values are in relatively good agreement with experiment (rms error of 14.3%).

5. *A novel approach to the electronic transition in the samarium chalcogenides*

The samarium ion is considered to be compressible with an anomalously high compressibility for a critical range of compressible force. The compressibility variation with force has been fitted to the PV data of SmS. Using this, and assuming the same variation to be operative in all other samarium crystals, most of the experimental observations on these crystals have been explained. This is probably the first theory to emphasize the role of the lattice which unifies the whole phenomenon.

6. *Positivity constraint in fourier transforms*

Komesaroff and Lerche (1978) have recently shown the intimate relation of the "maximum entropy method" of spectral analysis to the positivity constraint. Their theory has here been studied in detail and many interesting properties of the one-dimensional problem have been worked out for the fully constrained limit as well as the less constrained case. A beginning has been made towards understanding the two-dimensional problem.

7. *Atomic physics*

Work is continuing on extrapolation properties of quantum defects and phase shifts of electron ion system with respect to angular momentum.

8. *Parity violations in atomic physics*

These processes are of great interest in view of the recent schemes for unifying weak and electromagnetic forces. Detailed study of such parity violations was carried

out and the following cases have been singled out as feasible candidates for experimental study: two photon transitions between $np_{1/2}$ and $n's_{1/2}$ states of hydrogenic systems, autoionisation transitions in multielectron atoms and $3P_0-1S_0$ one photon transitions in external electric fields. A detailed report of this work will be submitted for publication shortly.

9. *Strong magnetic fields*

As an application of the earlier work on strong magnetic fields to realistic situations, work is under way on elucidating the properties of an electron gas in strong fields.

10. *Soliton solutions*

Soliton solutions play an important role in many physical phenomena. Certain Hamiltonian methods are being used to find exact soliton solutions to various coupled non-linear field equations. In particular, they are applied to (a) the interaction of the order parameter field of a super-conductor and the electromagnetic field, (b) Yang-Mills-Higgs field equations and (c) coupled relativistic scalar field equations in $1 + 1$ dimensions.

11. *Pulsars*

The statistical analysis of pulsar data has been concluded. A report based on the results is in course of preparation. Data on second period derivatives of pulsar periods has become available recently. Values of these quantities differ substantially compared to those expected from previously proposed theories. Work on this problem is in progress. Work is in final stages on a proposal to correlate pulse structures with periods of pulsars. Damage caused to the polar cap region of a pulsar by continuous sparking which takes place there to sustain the pulsar radiation is proposed to modulate the radiation intensity, *i.e.*, the pulse structure.

First part of the observational programme consisting of accurate declination determination of new pulsars is nearing conclusion. This would form the basis of any future observational work on these pulsars.

12. *On the history of the binary pulsar*

An attempt was made to understand the anomalous behaviour of the binary pulsar (a very small period and, yet, a vanishingly small slowdown rate) in terms of its evolutionary history in a close binary. It was argued that the magnetic field of the pulsar has decayed over the course of time, and that it was spun-up during the x-ray phase. A simple formula was derived for the minimum period to which a neutron star can be spun-up by accretion.

13. *Supernovae and the interstellar medium*

It has long been recognised that supernovae explosions have a very important effect on the interstellar medium. A recent analysis of the data on 21 cm absorption by neutral hydrogen clouds has revealed that the energy of motion in the high velocity clouds far exceeds the previous estimates. It is almost certain that these random motions of clouds is due to impact by supernova shocks. A re-examination

of the interaction of supernova shocks with the interstellar medium was undertaken with a view to explaining the energy in these high velocity clouds. This research is still in progress.

14. *Infrared bursts from x-ray bursters*

Recently, infrared bursts were observed from the rapid burster MXB 1730-333. None of the existing models of x-ray bursters can explain these observations at the infrared. Research is in progress to construct a model which will explain both the x-ray bursts and the infrared bursts.

15. *Particle creation in the early universe*

A time-varying gravitational field gives rise to particle creation. It is proposed to apply the path integral quantization method to compute the particle production in the early universe. A successful application of this method to more complex models, like the anisotropic universes would throw light on possible damping anisotropy through particle creation.

16. *Stationary, axisymmetric solutions of Einstein's equations*

Very few solutions representing the gravitational field of a rotating star are known. A scheme is being developed to construct a stationary solution starting from any static Weyl metric. The transformations used for the construction preserve asymptotic flatness. This method, would thus yield an exterior solution corresponding to a rotating star of arbitrary multiple moments.

17. *Interior solutions in general relativity*

Using a previously derived formalism for differentially rotating perfect fluids, new interior solutions to Einstein's equations were obtained. These are characterized by zero pressure (dust) and the existence of three Killing vectors. The interiors were matched to vacuum exteriors and some of the properties of the resulting space-times were studied.

18. *Electromagnetic fields in curved space-times*

The Debye potential formalism was applied to electromagnetic fields superposed on perfect fluid space-times with local rotational symmetry. A decoupled equation for the potentials was obtained and its general properties were studied. Further, fields superposed on some particular space-times, namely, Kantowski-Sachs universes, Taub-spaces, anisotropic spatially homogeneous cosmological models and the Godel universe were examined in detail.

19. *Charged particles in strong gravitational backgrounds*

A detailed analysis of orbits of charged particles in electromagnetic fields surrounding a Kerr black hole was completed. Similarly, trajectories of charges in the Ernst static metric, which represents a static black hole immersed in a uniform magnetic field, were investigated. This work has been published as two papers.

20. *Neutrinos in gravitational fields*

The Dirac equation for neutrinos in a spherically symmetric metric has been studied. The matched Schwarzschild interior-exterior metric of a spherical mass distribution was taken as a particular example. The equivalent potential in which neutrinos move, quasibound states and leakage through the potential barriers have been analyzed. Some of the results were presented at the Einstein Centenary Symposium, Ahmedabad; a detailed paper is in preparation.

21. *Production of gravitational radiation*

Gravitational radiation produced during the scattering of two unequal masses is being studied. A systematic perturbation analysis of the process including the second order terms and radiation reaction will be carried out within the framework of general relativity. The same process is also being investigated by using semi-classical methods in quantum gravity as well as in the formalism of Schwinger's source theory. These calculations would probably be a first step towards the study of the bound state problem.

Radio astronomy and associated electronics

1. *Decameter-wave astronomy—a joint project of RRI and IIA*

We have incorporated diode phase shifters in the NS array of the decameter wave telescope at Gauribidanur. It is now possible to point the beam instantaneously to any declination in the range -30° to $+60^\circ$. We have also developed soft-ware-techniques for eliminating the effects due to phase errors in the data obtained with the telescope. The technique is suitable for both point sources and extended features.

The following observing programmes are being carried out:

(i) Mapping of selected regions of the galaxy.

In this programme we are trying to observe some extended supernovae (Cygnus Loop, Monoceros Nebula etc.) and Ionised Hydrogen Regions (Rosette Nebula).

(ii) Interplanetary scintillations.

We are observing about thirty sources from the 3C catalog which are known to be scintillators at high frequencies. We are also observing the Crab Nebula (3C 144) during its occultation by the sun.

(iii) Sun.

We are taking daily scans of the Sun to determine the angular extent of the quiet Sun and also to detect the variations due to the slowly varying component. We are also interested in the time and frequency structure of weak solar radio bursts. For this purpose we are recording the radio bursts with high time and frequency resolutions of the order of 10 milliseconds and 50 KHz respectively.

Metre-wave astronomy

Radio spectral line observations at 327 MHz using the Ooty radio telescope were started in the beginning of 1978. For this purpose a Frequency synthesizer producing frequencies from 291 MHz to 299 MHz built at the Institute has been installed as the first local oscillator system for the Ooty receiver. Also, a 64 channel autocorrelation spectral line receiver (operable up to 256 channels on a time sharing basis) built at the Institute has been installed at Ooty. Computer software for acquiring and analysing data from the Autocorrelator on the Varian 620 *i* computer at Ooty has been developed.

The combined system of the local oscillator and the autocorrelator has been tested for satisfactory functioning by observing the H271-*a* radio recombination line in the direction of the galactic centre.

Using an earlier existing 40-channel filter bank spectral line receiver 84 hours of observations were made at the deuterium line frequency viz. 327.3843 in the direction of the galactic centre. These observations have yielded an upper limit of 5.8×10^{-5} for the abundance ratio of deuterium to hydrogen for the interstellar gas in the intervening medium and do not confirm a report of possible detection of this line in the same direction by a Cal. Tech. group.

Observations are presently in progress at the H272-*a* and H271-*a* recombination line frequencies in the direction of the galactic centre.

1. Millimeter-wave astronomy

10 meter millimeter-wave radio telescope project. The detailed design of the individual parts of the mount for the millimeter-wave radio telescope has been completed by our consulting engineers, M/s. Indian Design Centre (P.) Ltd. and the contract for the fabrication of the same has been awarded to M/s. Richardson and Cruddas of Bombay in January 1979. Fabrication of component parts is according to schedule and it is expected to be completed by November, 1979. All the components which are to be procured from abroad for this mount are being purchased or are available on hand.

The development and manufacture of a 10.4 meter reflector in collaboration with the Material Sciences Division of the National Aeronautical Laboratory, Bangalore, is progressing very well. Air bearings have been manufactured and tested. The guide rail to be used for cutting the surface of the reflector has been set up and an initial survey completed. Setting of the final contour to the required accuracy (~ 20 microns) will be undertaken shortly. The central portion of the back-up structure of the reflector has been assembled and the accuracies of drilling methods have been investigated. Other components of the back-up structure such as spiders, posts, etc., have been manufactured and accurate drilling of holes is under progress. It is expected that the reflector will be ready by the end of 1979.

Site selection tests for locating the mm-wave telescope at a convenient site are still under progress. It was felt that the initial location should be in the Institute campus so that all tests and rectification of initial troubles can be carried out quickly. Later on it can be shifted to the chosen site if necessary. Hence, foundations for the telescope, and a small receiver building have been set up in the Institute campus.

Construction of a 256-channel back-end spectral line receiver is progressing well and it will be ready for testing by September 1979. A data acquisition system to collect and store the data from the above receiver is also under construction. A mini-computer (PDP-11|34), required to control the telescope and also to acquire the output data has been procured and is undergoing initial tests.

An infrared-spectral hygrometer (IRSH) has been built and is being operated at present to determine the total precipitable water content in the atmosphere. In addition, a frequency-switched microwave radiometer operating in the 22.235 GHz water vapour absorption band has been constructed and initial tests are going on. Data from these two instruments is being compared with that obtained from a borrowed (French) IRSH instrument and also simultaneous radiosonde observations. These will provide calibration of the locally-built instruments.

A step recovery diode multiplier was developed to generate a signal around 2 GHz from an input signal around 160 MHz obtained from a synthesiser. This multiplier will be used to phase-lock a klystron operating at a frequency of 22 GHz through a harmonic mixer.

A low noise amplifier operating at 1.4 GHz and using a Bipolar transistor has been developed. It has a large bandwidth (~ 800 MHz) and a gain of about 14 dB per stage. A minimum noise figure of 1.6 dB has been measured and efforts to improve this figure are underway.

1.5 Meter millimeter-wave pilot telescope : This project is being financed by the Indian Space Research Organisation. Surface measurements on the fibre glass reflector which was manufactured in collaboration with the Material Sciences Division of the National Aeronautical Laboratory, Bangalore, are still in progress. Methods of surface measurement to the required accuracy have been developed and trial runs are progressing. A mount to take the above reflector is under assembly in the dome on top of the mm-wave laboratory building. The dome is also being modified to give a clear aperture of 1.6 m^2 at zenith.

The design of a horn-reflector feed at 22.5 GHz for the above telescope was completed and the fabrication of the same is to be taken up shortly.

Electronics

Work on the digital FT system continued during the year. The digital processor part was completed and tested. A microprocessor controlled data acquisition scheme to record transformed data on a magnetic tape was designed and implemented.

Work on a digital autocorrelator was completed and the system installed at the Radio Astronomy Centre, Ooty. Observations on recombination lines were carried out using this autocorrelator.

An improved version of the Precision Solar|Sidereal clock was fabricated and installed at the Radio Astronomy Centre, Ooty.

Sixth International Conference on Raman Spectroscopy

As a tribute to the discoverer of the Raman Effect on the 50th Anniversary of its discovery, Bangalore was chosen as the venue for the Sixth International Conference on Raman Spectroscopy. Prof. S. Chandrasekhar, as Secretary of the National Organising Committee, was responsible for the detailed organisation of all the local arrangements. The conference was an unqualified success. Appreciations of the superb nature of the arrangements were expressed in writing by members of the International Organising Committee and other distinguished scientists who participated in the conference.

Bangalore NMR facility

The Institute has continued to participate effectively in the operation of the Bangalore NMR facility.

Services to other laboratories

As in previous years, a large number of differential scanning calorimetric records, infrared spectra, etc., were run for laboratories from different parts of the country and the staff of the Liquid Crystals Laboratory helped the users in the interpretation of the data. The number of spectra, etc., recorded this year are as follows:

Fat-infrared spectra	..	50 samples
Infrared spectra	..	46 samples
Optical rotatory dispersion	..	28 samples
Differential scanning calorimetry	..	24 samples

Training offered to teachers and scientists

Advanced training in research was offered to the following teachers/scientists from other organisations:

<i>Name</i>	<i>Topic of study</i>	
G. Venkatesh AES National College Gauribidanur	High pressure studies on liquid crystals	UGC Faculty Improve- ment Programme (leading to Ph.D. degree)
K. P. L. Moodithaya Vivekananda College Puttur	Optical and elastic properties of liquid crystals	do.

<i>Name</i>	<i>Topic of study</i>	
S. N. Prasad Regional College of Education Mysore	Vibrational spectra of liquid crystals	UGC Faculty Improve- ment programme (leading to Ph.D. degree)
K. Venkatachala Rao St. Aloysius College Mangalore	High Pressure X-ray studies on liquid crystals	do.
Dr. Yeswant Singh Banaras Hindu Univer- sity Varanasi	Molecular dynamics and Monte Carlo calculations on molecular liquids and liquid crystals	4 April to 7 May 1979
Dr. R. C. Mathur T. V. Ranganath Sarma Defence Laboratory Jodhpur	Cholesteric liquid crystals and their applications to thermography	4 January to 10 January 1979
Dr. D. S. Parmar Aligarh Muslim University Aligarh	Pressure-temperature phase diagrams for liquid crystal- line compounds	5 January to 22 February 1979

Theses submitted

The following candidates who had submitted their Ph.D. Thesis to the University of Mysore in 1977 have been declared eligible for the award of the Ph.D. Degree:

- | | |
|--------------|--|
| P. P. Karat | Electric and magnetic field effects in liquid crystals |
| | External Examiners: Dr. Gerhard Meier (Inst. Ange-
wandte Festkoerperphysik, Freiburg, W. Germany)
and Dr. H. Gasparoux (Domaine University, Talence,
France) |
| U. D. Kini | Theoretical studies on the properties of the liquid
crystalline state |
| | External Examiners: Dr. B. A. Finlayson (University
of Washington, Seattle, U.S.A.) and Dr. W. Helfrich
(Freie University, Berlin, West Germany) |
| K. A. Suresh | Experimental studies on the optical properties of chole-
steric liquid crystals |
| | External Examiners: Dr. M. Brunet (Laboratoire
Mineralogie et de Cristallographie, Univ. des Sciences
et Techniques du Languedoc, Montpellier, France)
and Dr. A. S. Marathay (Optical Sciences Center,
University of Arizona, Tucson, U.S.A.) |

Reports are still awaited on the following three theses submitted later :

- | | |
|-----------------|---|
| J. R. Fernandes | Infrared studies on liquid crystals |
| G. V. Vani | X-ray analysis of the crystal structures of some meso-genic compounds |
| B. R. Ratna | Dielectric properties and short range order in liquid crystals |

Publications

The research work done by the staff of the Institute has been published in a number of journals. A list of publications that have already appeared and those in press is given at Annexure I (page 18).

Conferences/seminars/meetings

A list of conferences/meetings attended by the staff of the Institute and titles of papers or talks presented if any, by them is given in Annexure II (page 22). Lectures given by the staff elsewhere is also listed towards the end of Annexure II.

Colloquia

During the year the scientists of the Institute and visiting scientists both from within and outside the country gave seventeen colloquia at the Institute on different topics. In addition fifteen discussion meetings were held mainly in the field of theoretical physics. The titles of colloquia and topics of discussion are listed in Annexures III and IV (page 31, 34).

Visiting scientists

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

Institute's scientists' visits to other institutions abroad

Some of the scientists of the Institute visited laboratories/observatories abroad. Details of their visits are given in Annexure V (page 36).

Library

The library acquired 566 new books this year. This brings the total number of books to 10,986. We have subscribed to 4 new journals this year bringing the total number of periodicals subscribed to 118. The total number of bound volumes in our collection at present is 14,361. Two more journals are being received by air mail. Journals published by Elsevier/North Holland have been received by air freight through their agents Allied Publishers since January 1979.

A new photocopying machine (Nashua 1210) has been acquired. This machine produces copies much faster than the Korestat machine.

A part of the library holdings—bound volumes of periodicals has been shifted to the new library building.

General

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

<i>Plan</i> :	Recurring	..	Rs. 18·00 lakhs
	Non-recurring	..	Rs. 17·00 lakhs
	Non-Plan-Recurring	..	Rs. 12·00 lakhs
<i>Millimeter wave project :</i>			
	Recurring	..	Rs. 6·00 lakhs
	Non-recurring	..	Rs. 19·00 lakhs
	New building-phase I and II	..	Rs. 4·00 lakhs
	Total	..	<u>Rs. 76·00 lakhs</u>

2. Major items of equipment procured during the year is given in Annexure VI (page 38).

Staff

The Scientific and Technical staff of the Institute is given below. Additions during the year are marked with an asterisk.

Scientific Staff of the Institute :

1. Prof. V. Radhakrishnan
2. Prof. S. Chandrasekhar
3. Dr. S. Krishnan
4. Mr. N. V. G. Sarma
5. Dr. C. V. Vishveshwara
6. Dr. C. L. Khetrapal
7. Dr. N. V. Madhusudana
8. Dr. G. Srinivasan
9. Dr. N. D. Hari Dass
10. Dr. R. Shashidhar
11. Dr. S. Venugopalan
12. Dr. G. S. Ranganath
13. Dr. A. C. Kunwar
14. Dr. V. Surendranath
15. Dr. Rajendra Bhandari
16. Dr. C. S. Shukre
17. Dr. Rajaram Nityananda
18. Mr. J. Padmanabhan
19. Mr. K. T. Balakrishnan
20. Mr. D. K. Ravindra
21. Mr. K. M. Chandrakumar
22. Mr. R. S. Arora
23. Mr. K. R. Anantharamaiah
24. Mrs. Jayanthi Ramachandran
25. Mr. M. O. Modgekar
26. Mr. M. R. Subramanyam
27. Mr. P. N. Ramachandra
28. Dr. U. Devappa kini
29. Dr. K. A. Suresh
30. Mr. B. K. Sadashiva
31. Mr. N. Nandakumar
32. Mr. K. Subramanya
33. Mr. T. Ramachandran
34. Mr. Smiles Mascrenhas
35. Mr. N. Udaya Shankar
36. Mr. U. N. Maiya
37. Mr. M. Selvamani*
38. Dr. Ramesh Narayan*
39. Dr. D. M. Chitre*
40. Mr. T. N. Ruckmangathan*
41. Mr. A. Iftigarudeen*

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. D. N. Nagarajan
2. Mr. Satyendra Kumar
3. Mr. Vijaya Kumar
4. Mr. A. K. Sekhar
5. Mr. Ravindra Savanur
6. Mr. K. M. Doraiswamy

Research Fellows :

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

42. Mr. P. A. Johnson*
43. Mr. N. Gopal*
44. Mr. Saraba Gopal*
45. Mr. L. B. Susairaj*
46. Mr. G. Gopi*
47. Mr. Gokulachandran*
48. Mr. B. V. Nataraja*
49. Mr. R. Ganesan*
50. Mr. H. Subramaniam*

10. Dr. Ruth Williams
Director of Studies and Lecturer in
Mathematics
University of Cambridge
Cambridge, U.K. January 9–February 19, 1979
11. Prof. E. T. Newman
Professor of Physics
University of Pittsburg
Pittsburgh, USA January 10–January 28, 1979
12. Prof. Philip Morrison
Massachusetts Institute of
Technology
Cambridge, USA January 24–January 28, 1979
13. Dr. Judith Perry
Max–Planck Institute for Physics
and Astrophysics
Munche, FRG February 10–February 13, 1979
14. Dr. M. M. Komesaroff
Radiophysics Division
CSIRO, Australia January 31–April 21, 1979
15. Dr. Bevan Jones
Max–Planck Institute, Bonn February 8–February 26, 1979
16. Prof. A. Papapetrou
Institut Hanri Poincare
Paris, France February 13–February 17, 1979
17. Dr. P. A. Shaver
ESO, Geneva
Switzerland March 17–March 21, 1979

Publications—1978-79

1. Phase transitions and pretransition phenomena in liquid crystals (S. Chandrasekhar and N. V. Madhusudana)—Chapter 14, in *Progress in Liquid Physics* (John Wiley and Sons), pp. 539-584, (1978).
2. Dielectric properties of some nematics of positive dielectric anisotropy (B. R. Ratna and R. Shashidhar)—*Molecular Crystals Liquid Crystals* **45**, 103 (1978).
3. Orientational order and elastic constants of some cyanobiphenyls: Part III (P. P. Karat and N. V. Madhusudana)—*Mol. Cryst. Liquid Cryst.* **47**, 21 (1978).
4. Equivalence of the Krieger-James approximation and the constant-coupling approximation in magnetism (K. L. Savithamma and N. V. Madhusudana)—*Pramāṇa* **10**, 349 (1978).
5. X-ray analysis of liquid crystals (S. Chandrasekhar)—Special Lecture, University of London—Delivered at the Birkbeck College, London, on 31 October 1977—*Current Science* **47**, 523 (1978).
6. Orientational order and tricritical behaviour in the *n*-OMCPC series of liquid crystals (J. R. Fernandes and S. Venugopalan)—*J. Chem. Phys.* **70**, 519 (1979).
7. Disc-like mesogens (S. Chandrasekhar, B. K. Sadashiva, K. A. Suresh, N. V. Madhusudana, S. Kumar, R. Shashidhar and G. Venkatesh)—Presented at the Seventh International Liquid Crystal Conf., Bordeaux, July 1978—*Journal De Physique* **40**, C3-120 (1979).
8. High pressure studies on 4'-*n*-alkyl-4-cyanobiphenyls (R. Shashidhar and G. Venkatesh)—Presented at the Seventh International Liquid Crystal Conf., Bordeaux, July 1978—*Journal De Physique* **40**, C3-396 (1979).
9. Shear flow of cholesterics normal to the helical axis (U. D. Kini)—Presented at the Seventh International Liquid Crystal Conf., Bordeaux, July 1978—*Journal De Physique* **40**, C3-62 (1979).
10. Interaction between surface and bulk disclinations in nematic liquid crystals (G. S. Ranganath)—Presented at the Seventh International Liquid Crystal Conf., Bordeaux, July 1978—*Journal De Physique* **40**, C3-87 (1979).
11. Two-dimensional NMR: Application to oriented molecules (Anil Kumar and C. L. Khetrapal)—*Journal of Magnetic Resonance* **30**, 137 (1978).
12. ^1H , ^{115}Sn , ^{117}Sn and ^{119}Sn -NMR studies on tetramethyltin in nematic and isotropic phases (P. Diehl, A. C. Kunwar and M. Reinhold)—*Journal of Magnetic Resonance* **30**, 621 (1978).
13. Biomembranes (C. L. Khetrapal, S. V. Talekar, P. Balaram and S. K. Podder) *Proceeding, of National Symposium on Biological Membranes and Model Systems* (Phoenix Press, Bangalore, 1978).
14. Impossibility of a continuous phase convention for polarised light (R. Nityananda)—*Pramāṇa* **12**, 257 (1979).
15. Repulsion parameters of ions and radicals—Application to perovskite structures (Ramesh Narayan and S. Ramaseshan)—*Journal of Physics and Chemistry of Solids* **39**, 1287 (1978)

16. 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* **68**, 289 (1978).
17. Training requirements of astronomers in India (C. S. Shukre)—In *Proceedings of the round table discussion on training requirements of astronomers in India*. Edited by K. D. Abhyankar and N. B. San Wal (Centre of Advanced Study in Astronomy, Osmania University, 1978).
18. Symmetries of Stationary Einstein-Maxwell field equation IV, transformations which preserve asymptotic flatness (D. M. Chitre and W. Kinnersley)—*Journal of Mathematical Physics* **19**, 2037 (1978).
19. Charged particle motion in an electromagnetic field on Kerr background geometry (C. V. Vishveshwara and A. R. Prasanna)—*Pramānā*, **11**, 359 (1978).
20. A relativistically rotating fluid cylinder (C. Hoenselaers and C. V. Vishveshwara)—*General Relativity and Gravitation Journal* **10**, 43 (1979).
21. Interiors with relativistic dust flow (C. Hoenselaers and C. V. Vishveshwara)—*Journal of Physics 'A'*, **12**, 209 (1979).
22. Trajectories of charged particles in the static Ernst spacetime (N. Dadich, C. Hoenselaers and C. V. Vishveshwara)—*Journal of Physics 'A'*, **12**, 215 (1979).
23. Directional singularities re-examined (C. Hoenselaers)—*Progress of Theoretical Physics* **59** 1170 (1978).
24. On the effect of motions on energy momentum tensors (C. Hoenselaers)—*Progress of Theoretical Physics* **59**, 1518 (1978).
25. A Classification system for one Killing vector solutions of Einstein's equations (C. Hoenselaers)—*Progress of Theoretical Physics* **60**, 158 (1978).
26. Magnetic field induced Wigner transition in inversion layers (G Srinivasan and M. Jonson)—*Solid State Communications* **24**, 61 (1977).
27. The Mosfet inversion layer—the conductivity of a localized highly correlated phase (G. Srinivasan and M. Jonson)—*Physica Scripta*, **18**, 476 (1978).
28. 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* **184**, 181 (1978).
29. Albert Einstein and the quantum (R. Bhandari)—*Science Today* **13**, 21 (1979).
30. Maximum entropy spectral analysis—some comments (R. Bhandari)—*Astronomy and Astrophysics* **70**, 331 (1978).

Papers submitted and in press (1978-79)

1. High pressure studies of liquid crystals (S. Chandrasekhar and R. Shashidhar)—review article—*Advances in Liquid Crystals*, Academic Press, New York and London.
2. Crystal and molecular structure of isomorphous cholesteryl chloride and cholesteryl bromide (G. V. Vani and Kalyani Vijayan)—Presented at the Seventh International Liquid Crystal Conference, Bordeaux, July 1978—*Molecular Crystals and Liquid Crystals*.

3. The electrooptic characteristics of a nematic liquid crystal cell with asymmetrically treated electrodes (N. V. Madhusudana and K. P. L. Moodithaya)—Presented at the Seventh International Liquid Crystal Conference, Bordeaux, July 1978—*Molecular Crystals and Liquid Crystals*.
4. Mesomorphic properties of a homologous series of substituted benzoyloxy benzoates (B. K. Sadashiva)—Presented at the Seventh International Liquid Crystal Conference, Bordeaux, July 1978—*Molecular Crystals and Liquid Crystals*.
5. Biphenyl benzoates: Synthesis and thermodynamic properties (B. K. Sadashiva)—*Molecular Crystals and Liquid Crystals*.
6. Submillimetre wave absorption in a homologous series of liquid crystals (S. Venugopalan and S. N. Prasad)—*Journal of Chemical Physics*.
7. NMR of bicyclic diazines oriented in a lyotropic mesophase (C. L. Khetrapal, A. C. Kunwar and A. V. Patankar)—*Molecular Crystals Liquid Crystals*.
8. NMR of oriented monosubstituted amides—*cis* and *trans* N-methyl formamide (S. Ramaprasad, A. C. Kunwar and C. L. Khetrapal)—*International Journal of Peptide and Protein Research*.
9. The structure of phosphacymantrene (C. L. Khetrapal, A. C. Kunwar and F. Mathey)—*Journal of Organometallic Chemistry*.
10. Oriented molecules (C. L. Khetrapal and A. C. Kunwar)—*Specialist Periodical Reports: NMR* Volume 8, Chemical Society, London.
11. Two-dimensional NMR spectra of oriented molecules (C. L. Khetrapal, Anil Kumar, A. C. Kunwar, P. C. Mathias and K. V. Ramanathan)—*Journal of Magnetic Resonance*.
12. Elasticity and orientational order in some *trans-p-n*-alkoxy-*a*-methyl cyanophenyl cinnamates (P. P. Karat and N. V. Madhusudana)—*Molecular Crystals and Liquid Crystals*.
13. Anomalous smectic mesomorphism of 4,4'-di-*n*-pentyloxy-azoxybenzene (S. N. Prasad, S. Venugopalan and J. Billard)—*Molecular Crystals and Liquid Crystals Letters*.
14. Miscibility studies of disc-like molecules (J. Billard and B. K. Sadashiva)—*Pramāṇa*.
15. Electromagnetic fields in the Godel Universe (C. V. Vishveshwara, S. V. Dhurandhar and J. M. Cohen)—*Journal of Physics 'A'*.
16. Electromagnetic fields in spacetimes with local rotational symmetry (S. V. Dhurandhar, C. V. Vishveshwara and J. M. Cohen)—*Physical Review*.
17. Black holes for bedtime (C. V. Vishveshwara)—*Proceedings of the Einstein Centenary Symposium, Ahmedabad, 1979*.
18. *Proceedings of the Einstein Centenary Symposium, Ahmedabad, 1979* (Edited by C. V. Vishveshwara, A. R. Prasanna and J. V. Narlikar).
19. On the rotational history of the binary pulsar (G. Srinivasan and E. P. J. Van den Heuvel)—*Astronomy and Astrophysics*.
20. A new upper limit to the abundance ratio of deuterium to hydrogen in the direction of the galactic centre (K. R. Anantharamaiah and V. Radhakrishnan)—*Astronomy and Astrophysics*.

21. A New theory of repulsion and structural stability in ionic crystals (Ramesh Narayan and S. Ramaseshan)—*Physical Review Letters*.
22. A method of reducing termination errors in radial distribution functions (Ramesh Narayan and S. Ramaseshan)—*Journal of Applied Crystallography*.
23. On the quantum dynamics of black holes (N. D. Hari Dass)—*Proceedings of the Einstein Centenary Symposium, Ahmedabad, 1979*.
24. On Supersymmetry (N. D. Hari Dass)—*Proceedings of the IV High Energy Physics Symposium held at Jaipur, 1978*.
25. Stationary, axially symmetric solutions of Einstein's equations (D. M. Chitre)—*Proceedings of the Einstein Centenary Symposium, Ahmedabad, 1979*.

Conferences/Seminar/Meetings

Annexure II

Conferences/Meetings	Attended/Presented by	Title of paper/Talk
1. Indian Academy of Sciences Discussion Meeting on phase Transitions, Bangalore June 19-22, 1978	S. Chandrasekhar R. Shashidhar N. V. Madhusudana G. Srinivasan	Phase transitions and pre-transition phenomena in liquid crystals (invited talk) Anderson transition (invited talk)
2. Seventh International Liquid Crystal Conference, Bordeaux, France July 1-5, 1978	S. Chandrasekhar (Prof. Chandrasekhar also presented the following papers at the Poster Sessions):	<ol style="list-style-type: none"> 1. Disc-like mesogens 2. High pressure studies on 4'-n-alkyl-4-cyanobiphenyls (R. Shashidhar and G. Venkatesh) 3. The electro-optic characteristics of a nematic liquid crystal cell with asymmetrically treated electrodes (N. V. Madhusudana and K. P. L. Moodithaya) 4. Shear flow of cholesterics normal to the helical axis (U. D. Kini) 5. A theory of the short range order effects in nematic liquid crystals including the hard rod features as well as attractive forces between the molecules (K. L. Savithramma and N. V. Madhusudana) 6. Orientational order and tricritical behaviour in the trans-<i>p</i>-n-alkoxy-<i>c</i>-methyl <i>p'</i> cyanophenyl cinnamate (<i>n</i>-OMCPC) (J. R. Fernandes and S. Venugopalan)

7. Mesomorphic properties of a homologous series of substituted benzoyloxy benzoates (B. K. Sadashiva)
8. Interaction between surface and bulk disclinations in nematic liquid crystals (G. S. Ranganath)
9. Crystal and molecular structure of isomorphous cholesteryl chloride and cholesteryl bromide (G. V. Vani and Kalyani Vijayan)

3. Seminar on Document reproduction and handling system.
A. Ratnakar
Department of Science and Technology and DRTC, Bangalore
July 5-7, 1978

4. International Conference XIX General Assembly of URSI, Helsinki, Finland
July 31-August 8, 1978
V. Radhakrishnan
N. V. G. Sarma

5. Gordon Research Conference on High Pressure Physics and Chemistry, Meriden, USA
August 7-11, 1978
R. Shashidhar

6. Colloquium on the formation of images from spatial coherence functions in Astronomy
Groningen, Netherlands
August 10-12, 1978
V. Radhakrishnan

7. Symposium on very long baseline interferometry, Heidelberg F.R.G.
August 14-17, 1978.
V. Radhakrishnan

The Radio Emission from pulsars—An invited Review

High pressure studies on liquid crystals

Maximum Entropy Spectral Analysis—some comments
(Rajendra Bhandari)

Conferences/Meetings	Attended/Presented by	Title of paper/Talk
8. Symposium on Interaction of Electromagnetic Waves with Metal Surfaces. International Centre for Theoretical Physics, Trieste August 1978	G. Srinivasan	
9. Seminar on Primary Communication in Science and Technology, DRTC and PID, Bangalore December 4-8, 1978	A. Ratnakar	Role of Scientific Societies in Primary Communication (A. Ratnakar and S. Girija)
10. IAU Regional Meeting, Wellington December 5-8, 1978	V. Radhakrishnan	<ol style="list-style-type: none"> 1. A. review of recent work on the interstellar hydrogen (invited talk) 2. Supernova remnants (invited talk)
11. Eighth IASLC Seminar, IIT, Madras December 26-29, 1978	K. Bina S. Geetha	
12. Indian Chemical Society Meeting Waltair December 27-31, 1978	C. L. Khetrapal	NMR of oriented molecules at the symposium on 'Structural Chemistry—New Horizons'
13. High Energy Physics Symposium, Jaipur December 1978	N. D. Hari Dass	<ol style="list-style-type: none"> 1. Supersymmetry (invited talk) 2. Renormalization problems in unified theories of weak and electromagnetic interactions 3. Parity violations in deep inelastic electron scattering —a source theory view point. 4. Alternative searches for parity violations in atomic physics

5. Lepton polarisation experiments to probe weak neutral current parity violations.

(a) Molecular structure and interactions of small molecules in liquid crystals

(b) The structure of phosphacyclopentane

(c) The structure and isotopic effects in acetones oriented in a nematic phase

(d) Non-planar distortions in substituted amides

Quantum dynamics of black holes (invited talk)

Stationary, axially symmetric solutions of Einstein's equations (invited talk)

1. Black hole physics—Review (invited talk)

2. Electromagnetic fields in spacetimes with local rotational symmetry (S. V. Dhurandhar, C. V. Vishveshwara and J. M. Cohen)

3. Neutrinos in spherically symmetric gravitational fields (C. V. Vishveshwara and A. K. Kembhavi)

A new theory of repulsion and structural stability in ionic crystals

Death and transfiguration of a star (invited talk)

A. C. Kunwar

14. First Anniversary Symposium
of the Bangalore NMR Facility
January 22, 1979

N. D. Hari Dass

15. Einstein Centenary Symposium
Ahmedabad
January 1979

D. M. Chitre

C. V. Vishveshwara

Ramesh Narayan

16. National Conference on
Crystallography, Banaras
February 21–23, 1979

C. V. Vishveshwara

17. Einstein Birth Centenary Conference
Indian Statistical Institute,
Calcutta
March 1979

Conferences/Meetings	Attended/Presented by	Title of paper/Talk
Other talks given by the scientists of the Institute		
1. Louisiana State University Baton rouge, U.S.A. April 2, 1978	N. D. Hari Dass	Parity violations in atomic physics
Niels Bohr Institute Denmark April 10, 1978	N. D. Hari Dass	Parity violations in atomic physics
3. Max-Planck Institute Munich April 20, 1978	N. D. Hari Dass	Parity violations in atomic physics
4. Indian Physics Association Kalpakkam Chapter Kalpakkam April 1978	G. Srinivasan	Black hole explosion
5. Reactor Research Centre Kalpakkam April 1978	G. Srinivasan	Renormalisation group and critical phenomena (set of 8 lectures)
6. Indian Institute of Technology Kanpur April 1978	C. V. Vishveshwara	Spacetime and gravitation
7. Summer School for Pre-University students, Bangalore Science Forum, National College Bangalore May 1978	R. Nityananda C. S. Shukre	Electromagnetic spectrum (2 lectures) 1. The Copernican Revolution 2. The Universe

8. Summer School in Astronomy and Astrophysics, T.I.F.R., Centre Bangalore May-June 1978	C. V. Vishveshwara R. Nityananda N. D. Hari Dass C. V. Vishveshwara V. Radhakrishnan	Introduction to modern astronomy (2 lectures) Stellar dynamics (5 lectures) The early universe 1. Introduction to general relativity 2. Cosmology (3 lectures) 3. Gravitational collapse (2 lectures) Pulsars (2 lectures)
9. Thomson CSF Research Laboratory Orsay, France June 30, 1978	S. Chandrasekhar	Recent work on liquid crystals in Bangalore
10. Institution of Engineers Bangalore Chapter July 1978	N. V. Madhusudana	Liquid crystals and their applications
11. Ruhr Universitat Bochum West Germany July 24, 1978	R. Shashidhar	High pressure studies on liquid crystals
12. Inst. fur Erdolforschung Hannover West Germany July 25, 1978	R. Shashidhar	Recent results of our high pressure researches on liquid crystals
13. Bell Laboratories Murray Hill, U.S.A. August 2, 1978	R. Shashidhar	High pressure studies on liquid crystalline materials
14. University of Massachusetts Department of Physics Boston, U.S.A. August 4, 1978	R. Shashidhar	Behaviour of liquid crystals under pressure

Conferences/Meetings	Attended/Presented by	Title of paper/Talk
15. International Centre for Theoretical Physics Trieste August 1978	G. Srinivasan	1. Thermodynamics of black holes 2. The mobility edge problem
16. Chemistry Division Bhabha Atomic Research Centre Bombay September 29, 1978	S. Venugopalan	Orientational order and phase transitions in liquid crystals
17. Department of Physics University of Geneva Geneva September 1978	G. Srinivasan	Renormalisation group approach to Anderson localisation
18. Guru Nanak Dev University Amritsar UGC Visiting Professor October 1978 and March 1979	C. L. Khetrpal	A series of 5 lectures on various aspects of NMR
19. Chalmers Institute of Technology Goteborg, Sweden October 1978	G. Srinivasan	1. The rotational history of a neutron star 2. Thermodynamics of black holes
20. Royal Institute of Technology Stockholm October 1978	G. Srinivasan	The rotational history of a neutron star
21. Linkoping University Sweden October 1978	G. Srinivasan	The possible connection between electron localisation and self avoiding random walks

22. Bangalore Science Forum
National College
Bangalore
October 1978
N. D. Hari Dass
Left-right symmetry
23. Indian Institute of Science, Bangalore
Workshop on Wide-line NMR
December 7-8, 1978
C. L. Khetrapal
Dipole-dipole interactions and molecular structure
(2 lectures)
24. Winter School in Solid State
Chemistry,
I.I.Sc., Bangalore
December 7, 1978
S. Chandrasekhar
Physics of Liquid Crystals—analogs with solid state
physics
25. Indian Petrochemical Corporation
Baroda
December 19, 1978
C. L. Khetrapal
Recent advances in NMR
26. Delhi University
Delhi
December 1978
N. D. Hari Dass
Hawking radiation
27. Science Association
National College
Bangalore
December 12, 1978
C. V. Vishveshwara
Cosmic mysteries
28. Indian Chemical Society
Bangalore Chapter
Central College
March 5, 1979
C. L. Khetrapal
NMR as a tool for structure elucidation with emphasis
on recent advances
29. Science Association
National College
Bangalore
March 1979
N. D. Hari Dass
Albert Einstein
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Conferences/Meetings	Attended/Presented by	Title of paper/Talk
30. Shivaji University Kolhapur March 1979	C. V. Vishveshwara	Stationary space-times
31. Indian National Science Academy Indian Institute of Science Bangalore March 1979	C. V. Vishveshwara	Centenary tribute to Albert Einstein
32. International Conference on Fracture Mechanics in Engineering Applications Bangalore March 29, 1979	S. Chandrasekhar	Liquid Crystals

Date	Speaker	Title
1978		
April 18 20	Prof. Clive A. Croxton Department of Mathematics University of Newcastle New South Wales, Australia	Configurational properties of polymer chains—A diagrammatic approach
June 8	Dr. J. L. Casse Head of the Laboratory Netherlands Foundation for Radioastronomy Dwingeloo, Netherlands	The present situation and plans for the future of radioastronomy in the Netherlands
July 12 13 15	Prof. Lawrence H. Aller University of California in Los Angeles Los Angeles, Calif. USA	Physics of gaseous nebulae and the ionized component of the interstellar medium
July 17	Dr. J. L. Osborne Department of Physics University of Durham Durham, England	Implications of the spiral shock model for synchrotron emission from the galaxy
August 10	do.	Interpretation of gamma-ray data from COS-B satellite
November 21	Dr. Peter Hoyng The Astronomical Institute Space Research Laboratory Utrecht, The Netherlands	Electron acceleration processes in solar flares.

Date	Speaker	Title
1979		
January 10	Prof. F. T. Haddock Director University of Michigan Radio Astronomy Observatory University of Michigan Ann Arbor, Michigan USA	Polarisation and intensity variability of quasars and extragalactic radio sources—A report of studies carried out in Michigan.
January 11	Prof. E. T. Newman Professor of Physics University of Pittsburgh Pittsburgh, USA	Is spacetime complex?
January 16	do.	What is a Twistor?
January 18	Prof. V. Radhakrishnan Raman Research Institute Bangalore	Interstellar hydrogen
January 19	Prof. E. T. Newman Professor of Physics University of Pittsburgh Pittsburgh, USA	The theory of gravitational radiation
January 22	do.	Source free Yang-Mills theories
January 24	Prof. Philip Morrison Massachusetts Institute of Technology Cambridge, Mass., USA	Supernova Remnants

1979

January 25	do.	Cosmology
February 9	Prof. M. M. Komesaroff Radiophysics Division CSIRO, Australia	Fourier transforms and the positivity constraint
February 14	Prof. A. Papapetrou Institut Henri Poincare Paris, France	The problem of motion in general relativity
March 19	Dr. P. A. Shaver European Southern Observatory Geneva, Switzerland	Stimulated Radio Recombination Lines

Theoretical physics meetings

Date	Speaker	Title
1978		
May 24	Dr. Vikram Soni Raman Research Institute Bangalore	Possible topological excitations in superfluid ^3HeA .
May 26	Dr. Cornelius Hoenselaers Raman Research Institute Bangalore	What happens at galactic centres?
June 1	Dr. Jayanth Banavar University of Pittsburgh Pittsburgh, Pa. USA	Renormalization group and Monte Carlo Analysis of Magnetic Phase diagrams
June 15	Dr. C. R. Subrahmanya TIFR Radio Astronomy Centre Ooty	Recent techniques for image restoration
September 25	Dr. Ajit Kembhavi Tata Institute of Fundamental Research Bombay	Dirac Cosmology
November 4	Dr. Ch. V. Sastry Indian Institute of Astrophysics Bangalore	Radio astronomy at Clarks Lake and other Radio Observatories
December 13	Dr. T. S. Shankar Department of Mathematics IIT, Madras	Supersonics, space-like particles and special relativity

December 26	Dr. Arnold Rosenblum Temple University and University of Pennsylvania Philadelphia	Radiation problems in classical electromagnetism
December 27	do.	Binary pulsar and radiation reaction in general relativity
December 30	Dr. M. Beltrametti Max-Planck Institute for Physics and Astrophysics Munich, FRG	Expanding quasar envelopes
1979		
January 3	Dr. Martin Walker Max-Planck Institute for Physics and Astrophysics Munich, Germany	Gravitational radiation from isolated systems
January 9	V. B. Johri Gorakhpur University Gorakhpur	Thermodynamic evidence for a non-chaotic big bang universe
February 8	Dr. Rajaram Nityananda Raman Research Institute Bangalore	Theory of line defects in nematic liquid crystals
February 12	Dr. Judith Perry Max-Planck Institute for Physics and Astrophysics Munich, FRG	Can absorption be intrinsic in quasars ?
February 15	Dr. Ruth Williams Director of Studies and Lecturer in Mathematics University of Cambridge Cambridge, U.K. and Visiting Scientist, RRI	How to build curved space-times from flat blocks

Visits of Institute Scientists to Other Institutions/Laboratories Abroad

- | | |
|---|---|
| 1. N. D. Hari Dass
(April 1-26, 1978) | .. 1. Louisiana State University
Baton Rouge
USA |
| | 2. Niels Bohr Institute
Denmark |
| | 3. Max Planck Institute
W. Germany |
| 2. C. V. Vishveshwara
(July 18-August 3, 1978) | .. 1. University of Pennsylvania
USA |
| | 2. Temple University, Philadelphia
USA |
| 3. G. Srinivasan | .. 1. International Centre for Theoretical Physics
Trieste. (Attended Solid State Physics Workshop,
July 17-September 16, 1978) |
| | 2. Institute of Theoretical Physics
Chalmers Institute of Technology
Göteborg, Sweden |
| | 3. Department of Physics
University of Geneva
Geneva
(September 22, 1978) |
| | 4. Department of Astronomy
University of Amsterdam
Netherlands
(October 18-24, 1978) |
| 4. N. V. G. Sarma
(August 1978) | .. 1. Max Planck Institute for Radio
Astronomy, Bonn
West Germany |
| | 2. Dwingeloo Observatory
Netherlands |
| | 3. Chalmers Institute of Technology
Göteborg
Sweden |
| | 4- National Radio Astronomy Observatory
Charlottesville, USA |
| | 5. California Institute of Technology and Owens
Valley Radio Observatory |

5. S. Chandrasekhar
(June 28-29, 1978)
6. R. Shashidhar
(July-August 1978)
7. V. Radhakrishnan
(July 24-30, 1978)

(August 18-19, 1978)

(December 13-20, 1978)
6. NRAO millimetre wave Observatory
Kittpeak, Tucson, USA
7. Institute for Space Studies
New York
8. Bell Telephone Laboratory
Holmdel
New Jersey
USA
- .. 1. Thomson—CSF, Research Laboratory
Paris
- .. 1. Department of Physical Chemistry
Ruhr Universitat, West Germany
(July 1978)
2. Institut fur Erdolforschung
Hannover, West Germany
(July, 1978)
3. Laboratoire de Physique des solides
Universite Paris
Centre D'ORSAY
Batiment 510
91405 ORSAY
FRANCE
(July 1978)
4. Department of Physics
University of Massachusetts, Boston
(August 1978)
5. Bell Laboratories
New Jersey, USA
(August 1978)
6. G.T.E. Laboratories
40, Sylvan Road
Waltham, Mass. 02154, USA
(August 1978)
7. Holmdel Laboratory
New Jersey 07963, USA
(August 1978)
8. Department of Physics
University of Paderborn, Postfach 1621
Paderborn, West Germany
(July 1978)
- .. 1. Chalmers Institute of Technology
Goteborg, Sweden
2. Max Planck Institute for Radio Astronomy
Bonn
3. CSIRO Division of Radiophysics, Epping
Australia

Annexure VI

List of capital goods received/ordered during 1978-79

		Rs.
1. MARCONI AM Signal Generator Type TF 144H/6S with accessories	1 No.	22,344
2. Aplab Digital Multimeter Model 1004	1 No.	4,196
3. Minimaster BPL India Multimeter Model AM 11008	2 Nos.	1,800
4. RF Electronic Millivoltmeter Model TF 2603	1 No.	20,564
5. Aplab Multi output Regulated Power Supply 0-15 V DC +5 V/10 A	2 Nos.	9,923
6. TV Monitor Type TM 936 Product code 10-100-0017	1 No.	6,483
7. Incremental Magnetic Tape Recorder Model 1610/360	1 No.	52,163
8. Astronomical Clock Mark I	1 No.	} 17,672
Astronomical Clock Mark II	1 No.	
Computer Interface Unit	1 No.	
Remote Display Unit	1 No.	
9. Power Supply (Digireg) + 12 V-12 V \pm 1 V adjustable 230 V AC/50 Hz	1 No.	2,530
10. Power Supply + 12 V \pm 1 V adjustable 2 Amps	1 No.	1,265
11. Power Supply, fixed 5 V 10 A, 230 V. 50 Hz	3 Nos.	6,204
12. Pulse Generator, Word Generator, Signature Analyser, etc.	..	79,153
13. Kerry Super 8 Drilling Machine with accessories	1 No.	5,559
14. EG 2C 6 mm (1/4") Low Weight Production Drill	1 No.	842
15. Bullows No pump Spray Booth with accessories	1 Unit	23,645
16. Kejearc Wonder weld Portable Spot Welding machine with automatic electronic timer	1 No.	7,425
17. Slosyn Translator Type ST 103 X	1 No.	5,800
18. Mysore Kirloskar make Enterprise 1330 All geared Lathe with extra equipment	1 No.	55,500
19. Teletypewriter Model ASR 3320/SWE with spares	2 sets	28,890
20. Mini Drilling Machine Model DM 103	1 No.	2,084
21. Dual Trace Amplifier, Time Base, Digital Counter, etc.	..	75,000
22. Motwane Avometer Model 8X with carrying case	2 Nos.	3,652
23. Digital Multimeter, Signal Generator, etc.	..	27,700
24. Slosyn Motor Type M092-FC08	4 Nos.	5,500
25. Modular Power Supply \pm 15 V at 0.5 A	1 No.	688

		Rs.
56. NIKON F2 Camera body and accessories	1 Unit	16,400
57. HUGHES Model 47326H-1100 Flat Broad Band Detector	1 No.	18,500
58. Model DRC 70C Digital Cryogenic Thermometer	1 No.	17,500
59. 1.5 KVA Diesel Generating Set Greaves Lombardini Model 520 Engine with delmo alternator	1 No.	8,900
60. MOTWANE Multimeter Model 8X MK III with carrying case	2 Nos.	3,652
61. Air Compressor Model BDPL-10 complete with tank, etc.	1 No.	7,500
62. OMNISCRIBE Series 5000 3 Pen Potentiometric Strip chart Recorder	2 Nos.	64,000
63. Mount for 10M Telescope	..	14,52,000
64. Capacitance Bridge Boonton Model 75D	1 No.	41,300
65. ACIERA Precision Universal Milling Machine Type F1	1 Unit	1,07,300
66. HP 8614 A Signal Generator, Digital Recorder Directional Couplers, Power Splitters, etc.	..	74,284
67. Hindustan Unified High Speed Lathe NH 22/1500 with accessories	1 Unit	1,59,300
68. Laser Transducer System	1 Unit	3,73,370
69. Unexpanded Honeycom Block	300 Hobe Slices	2,67,500
70. Paper Cutting Machine PECO Rapid	1 No.	25,300
71. Liquid Toner Transfer Process Copier NASHUA 1210 PPC with accessories and Spares	1 Unit	54,000
72. Electronic Timer BRV/110 Analog Range 0-110 Sec.	1 No.	550
73. Vertical Camera with accessories	1 Unit	39,410
74. PSG Make 3 HP Pump and Motor and with starter	1 No.	1,875
75. 6 mm (1/4") Wolf Low weight production drill type EG 2C	3 Nos.	2,314
76. Beacon Make 1/2 HP Monobloc pump set	2 Nos.	2,360
77. MYERS 1909 self oiling reciprocating type pump 1/2 HP with pr. switch and air volume control	1 No.	2,810
78. Megger 1000 V	1 No.	1,045
79. Nirbhay 1500 voltage stabilizers	10 Nos.	4,290
80. Photomultiplier tube with socket and Mag. shield	..	18,810
81. Cooled photo multiplier housing with accs.	..	27,200
82. Model 1120 Amplifier and Model 1105 Data Converter	..	38,000
83. APLAB Solid State Regulated Power Supply Type 7331 0-300 V, 0.3 A	2 Nos.	9,980
84. APLAB Digital Multimeter with LED display Model 1005	2 Nos.	15,876

		Rs.
85. High Voltage Function Generator	1 No.	4,000
86. High Pressure Industrial Argon Gas cylinder with valve	1 No.	1,800
87. PHILIPS 3 KW X-ray Generator with accs. and spares	1 Unit	3,35,000
88. APLAB Multiple output Power Supply Model 7711	3 Nos.	13,268
89. Empty Liquid N ₂ Container 5 ltrs. capacity	1 No.	1,145
90. Remi Model Ru. 56-1-1 1/20 HP Motor for Stirrer	2 Nos.	654
91. Precision X-ray Monochromator with crystal fixture	1 Unit	16,000
92. Digital Photometer with Power Supply	1 No.	33,000
93. Keithley Model 260 Nanovolt Source with cable	1 Unit	15,000
94. Toshniwal Heating Mantles of various cap.	..	2,160
95. Spares for Differential Scanning Calorimeter	..	31,200
96. Digital Panel Meter Type 1008, 4½ digit	2 Nos.	11,546
97. Keithley Model 174 Digital Multimeter with spares	1 Unit	19,750
98. METLER FP/5/52 for Thermo Microscopic investigation	1 No.	30,000
99. Period Programmable Digital Power Supply 100 V 3.5 Amps	2 Nos.	28,270
100. Pressure Generator 60000 psi type 37-5-75-60	1 No.	10,000
101. Neon Sign Transformer	1 No.	649
102. BDS Regulated DC Power Supply Dual 0-3 Amps, 0-30 V	2 Nos.	8,159
103. BDS Stabilized DC Power Supply 0-60 V, 0.5 Amps	3 Nos.	12,375
104. Digital Multimeter 3½ digit Model 2101 LCD Version	1 No.	2,967
105. High Sensitive XY Recorder Model F 43P with accessories	1 Unit	25,000
106. High Pressure Generator with accs.	1 Unit	25,900
107. APLAB DC Voltage and Current Standard Model 4002	1 No.	15,650
108. Torque Motors, Servomotors, etc.	..	1,44,400
109. Roller Bearings, Timken	2 Nos.	87,171
110. SKF Spherical Bearings	3 Nos.	9,600
111. Torrington Camfollower Bearings	96 Nos.	3,200
112. Fabry Perot Spectrometer, etc. with accessories	1 Unit	1,23,850
113. Klystron Power Supply Model KS-7	1 No.	49,327
114. MIXER Preamplifier, Spacekom Model	1 No.	19,027
115. Multipen Recorder	1 No.	23,017
116. Heise Pressure Gauge	1 No.	5,964