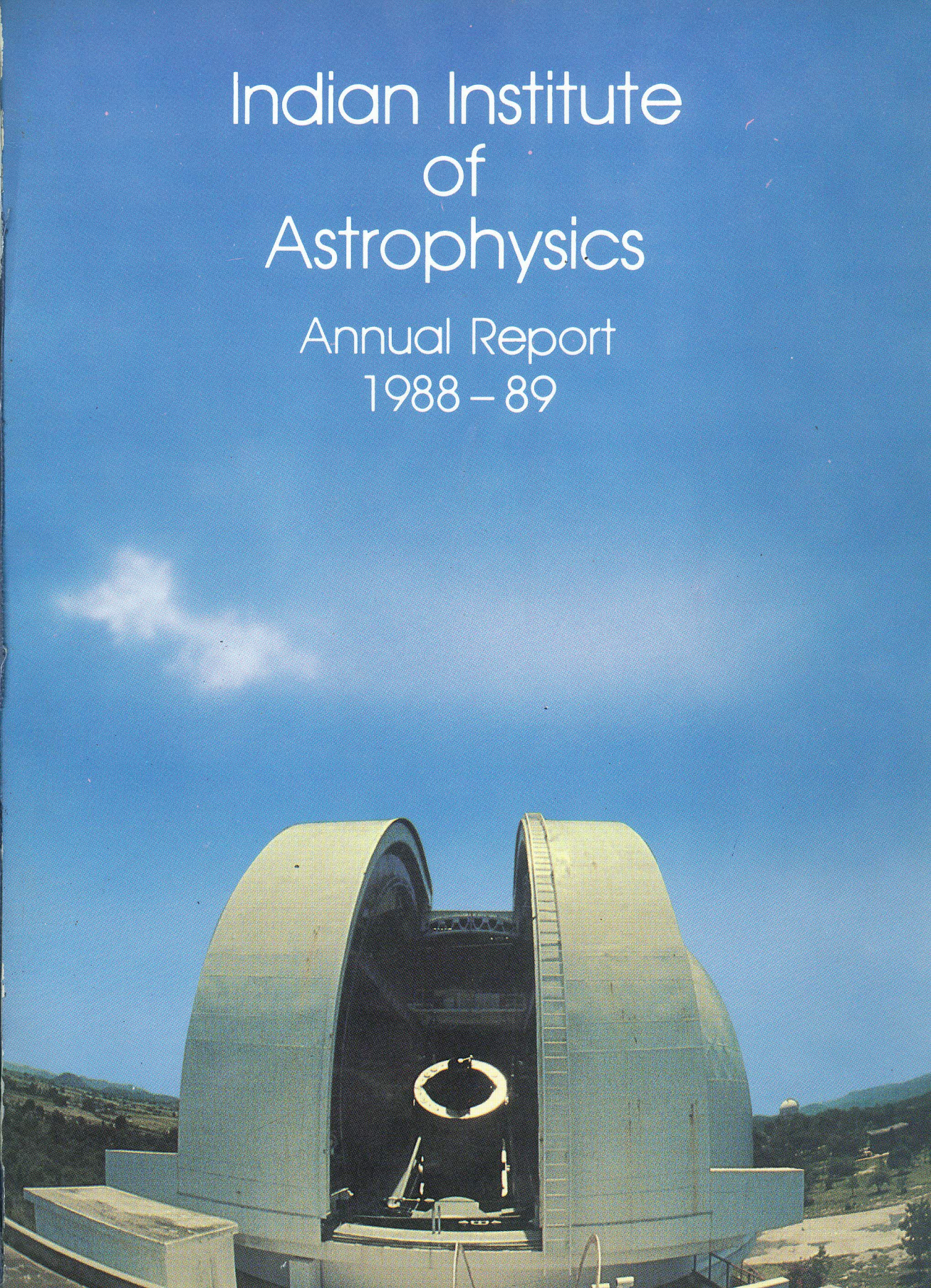
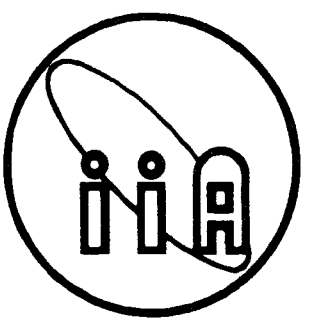
Indian Institute of Astrophysics

Annual Report 1988 – 89



INDIAN INSTITUTE OF ASTROPHYSICS



Annual Report 1988-89

Front Cover : Aerial view of the 2.34m Vainu Bappu Telescope at Kavalur

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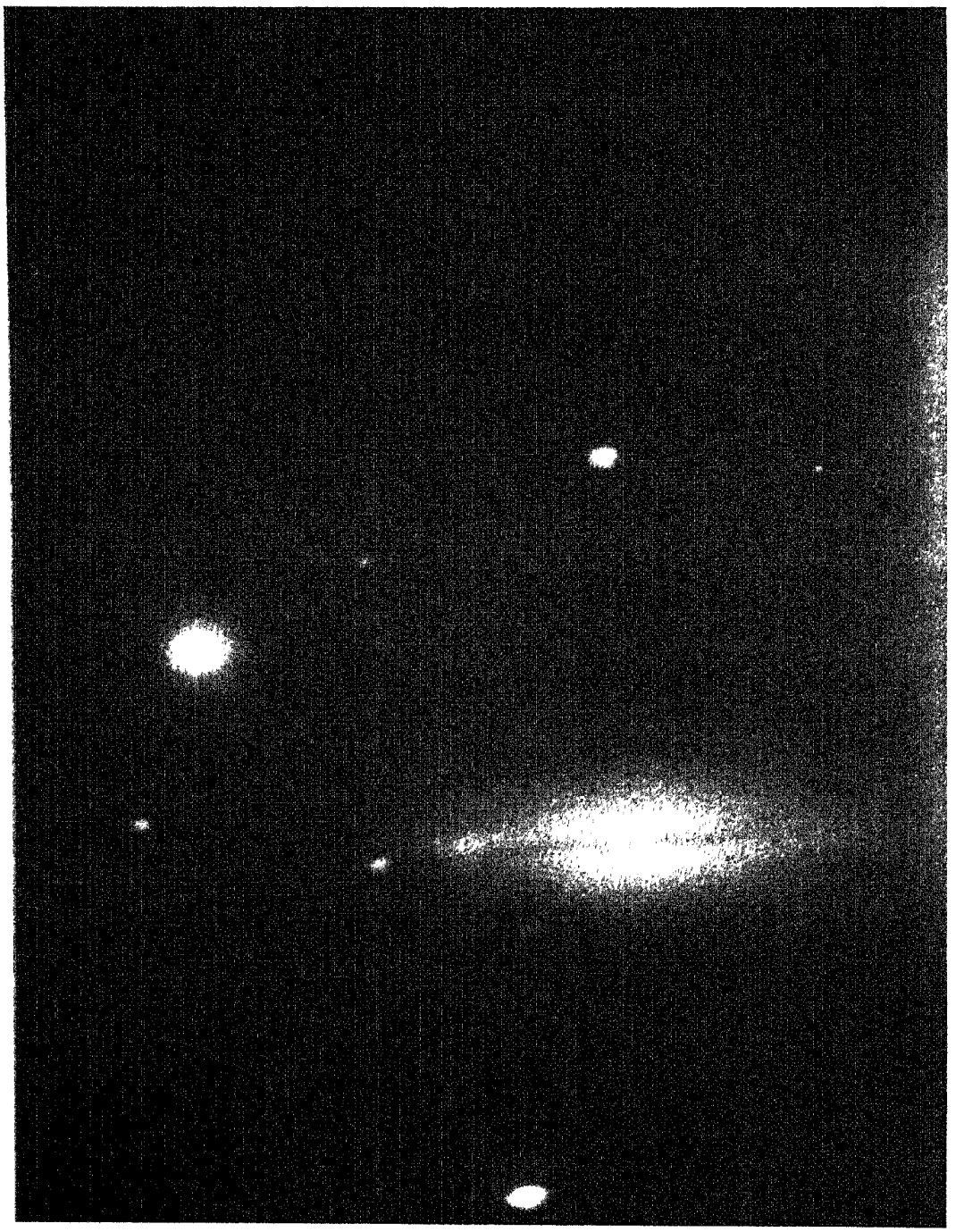


So galaxy M 102 in the V filter showing the dark dust lane in the centre Image obtained with the 2.34m VBT on 1 April 1989. (N.K.Rao)

The Year in Review

Major problems faced by the scientists during the year were the erratic behaviour of the drive system of the Vainu Bappu Telescope (VBT) and difficulties associated with image data acquisition from the new CCD detectors. Both were solved; the new systems started producing large volumes of observational data from two telescopes at the Vainu Bappu Observatory (VBT). The large aperture VBT was able to reach the dark sky limit in about fifteen minutes.

Drive systems of two other telescopes showed signs of old age and suffered from problems due to use of obsolete technology. With the experience gained during fabrication of the VBT, these two were updated. The solar tower telescope at Kodaikanal and the one metre Zeiss Telescope at VBO were equipped with digitally controlled drive systems, which were more reliable than before. The automatic electromechanical star changing device attached to the latter telescope was thoroughly overhauled; the new device employed state of the art solid state circuitry under the command of a dedicated PC, thereby improving its performance to a very high level.

The coordinate display system of the 76 cm telescope was completed and put into operation. It will not be out of context to recall that this telescope was entirely built in the laboratories of the Institute, and thus became the first indigenous medium sized modern optical telescope operating in the country.

Further achievements in the field of instrumentation were possible during the year. The new polarimeter, designed and constructed in the Institute's laboratories, produced excellent observational results, first on the telescopes at VBO, then at the focus of Sampurnanand Telescope at Nainital. The near IR photometer, developed earlier in the Institute, was also employed at the field station at Leh to measure the infrared extinction and sky brightness at the high altitude station.

In our observational activities, the availability of new high efficiency detectors gave us a tremendous advantage. The shell of the nova GK Persei could be clearly detected through emission line filters: also detected were the circumstellar dust shells around RV Tau, and the peculiar structures of the F and G supergiants in the proto-planetary nebula stage. In the studies of Be stars, rapid variability and H-alpha bursts in several others were found. Utilising facilities elsewhere, some other important results were obtained. Stellar population in galaxies were estimated from sets of spectra obtained at the telescopes at La Silla in Chile. Data from the International Ultraviolet Explorer satellite was used to compute energy distributions in selected Wolf-Rayet stars. One of our scientists participated in the CERGA interferometry experiment with the French group in determining the emission envelope of a star Gamma Cas, as well as the component stars of Algol. In a novel experiment aiming to detect stellar pulsations with a hitherto unattained resolution, VBO joined in a 'Whole Earth Telescope' scheme of coordinated observations around the world.

The possibility of serious extra-galactic observations has just opened up with the availability of a CCD at the focal plain of VBT. But still, by using the one metre telescope, the spectrum of a supernova in an external galaxy could be recorded and hence, the expansion velocities of the envelope could be estimated. A program to map star formation in late type galaxies and another to monitor properties of active galactic nuclei was started.

Two major programs in solar physics, aiming to uncover information about the sun's behaviour in

the recent past, have commenced through two international joint collaborative ventures. The first one is with Pulkovo Observatory, where H-alpha dark markings on old Kodaikanal plates are traced to located movements of magnetic regions. The second one is with the Hale Observatories, aiming to determine accurate measures of solar rotation from combined Mount Wilson and Kodaikanal photoheliograms. Both projects progressed during the year.

Considerable activities were noticed in theoretical investigations on the sun. The structure and the composition of the outer layers may have important implications on the energy transport mechanism, several aspects of this problem were investigated; also attempted was an analysis of the observed behaviour of solar features and its possible link with magnetohydrodynamical processes. Observations, using telescopes at Kodaikanal and Bangalore, were continued.

In solar system astrophysics, search for new minor bodies and structures of ring systems around the giant planets were vigorously pursued. Detailed investigations on the nature of spectra of comets resulted in a new model satisfying the reflection properties of dust grains in them. Effects of the solar wind on our earth's outer envelope was also the subject of another series of studies.

Theoretical investigations in astrophysics at the institute this year covered a wide range of topics, from stellar envelopes to distant quasars and the very early universe. Voluminous computations, modelling late type supergiant stars' chromospheres, were completed; detailed results of the polarization along stellar line profiles were obtained. Equations of state of high density neutron star matter were worked out from particle physics theory; it is speculated from these principles that the pulsar at the core of supernova 1987 A is not likely to be a fast one. In one paper, problems concerning movements of neutrinos in a dense medium were considered, while, in another, the question of the hadronization process in quark gluon plasma in the very early universe was discussed. We really see that a wide variety of problems in astrophysics have engaged the minds of our scientists.

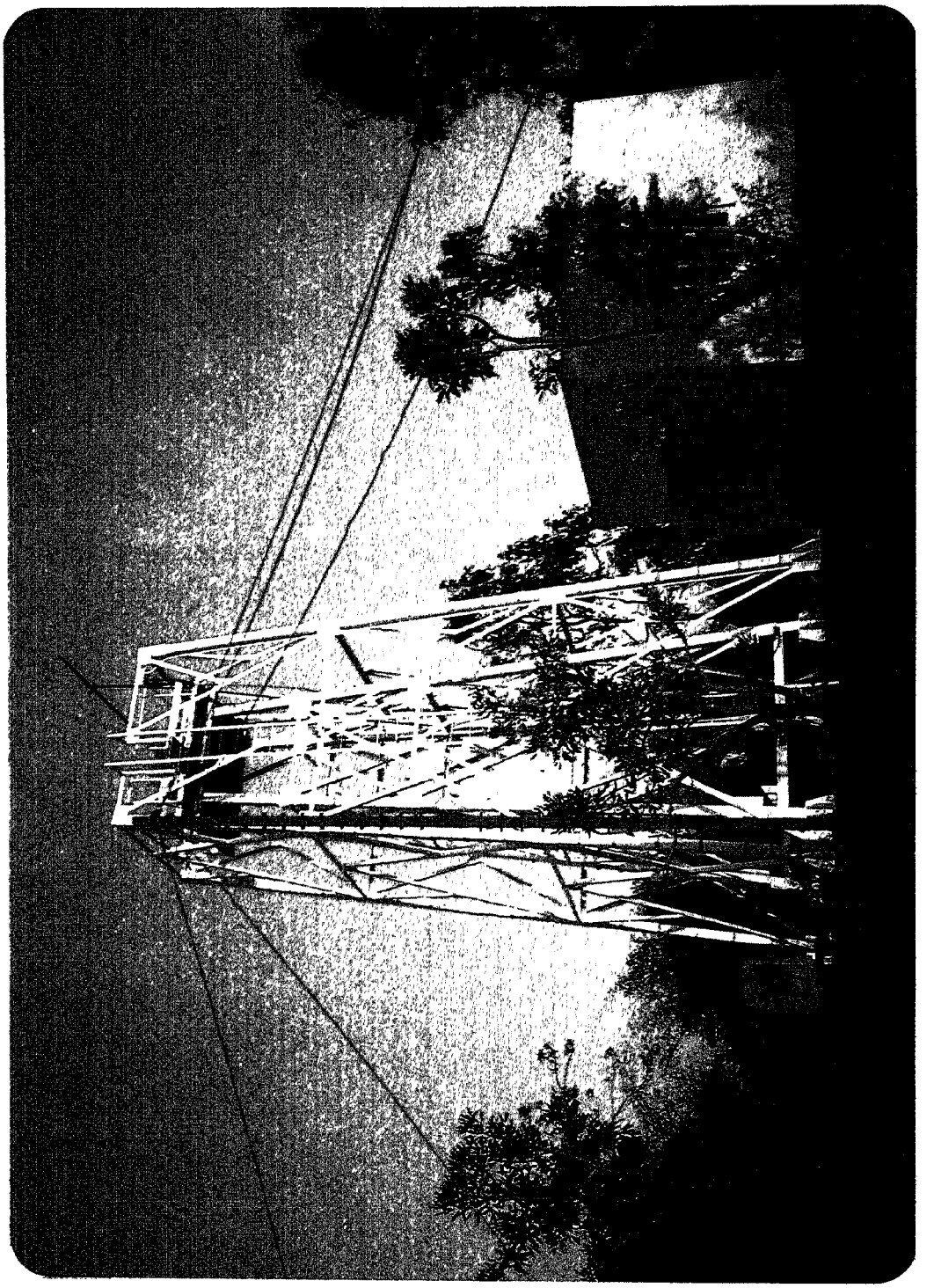
One important task which fell on our scientists this year was to draw up the IIA development plans for the next plan. Besides making provisions for maintenance and essential development of the existing facilities, we also projected a few national facilities for the development of astronomy in the country.

The Institute's residential complex, to house 30 staff members, was completed. The long felt need for our own residential accommodation could be met partially.

A fairly large group of scientists from the Institute attended the 20th General Assembly of the International Astronomical Union held at Baltimore, USA, and its associated meetings, covering various topics of present day astronomy. They have brought back new ideas, new directions and a renewed confidence in our endeavours in the science of astronomy.

J.C.Bhattacharyya
Director

Research Highlights



Solar Tower at Kavalur

The Sun

Activity and the solar cycle

Global solar cycle

Using the H_α spectroheliograms of Kodaikanal, synoptic charts were constructed for the years 1915-1982 and used to derive the poleward migration of the filament bands a few years ago (Makarov and Sivaraman, Solar Phys. 1983, **85** , 227). This poleward migration of filaments (or the magnetic neutral lines) establishes the poleward migration of the unipolar regions, which affects the reversal of the magnetic polarity at the N and S poles on the sun. Submerged in these large scale unipolar regions are the polar faculae (seen in photoheliograms and in Ca K spectroheliograms) in the zones of latitudes >40° and the sunspots in zones of latitudes <40°. A study of the polar faculae for 4 cycles (1940-1985) show that they appear in latitude zones 40°-60° in the northern and southern hemispheres, immediately after the reversal of the field at the poles. Furthermore, the zones of appearance migrate progressively and reach higher latitudes (70°-80°) in the course of 10 years as the solar cycle progresses. The polar faculae in general appear in pairs with polarities characteristic of the next following sunspot cycle and thus herald the commencement of the new sunspot cycle. After 4-5 years from the appearance of the polar faculae, the sunspots of the new cycle make their appearance at latitudes ± 40° and the zones of sunspot appearance proceed towards the equator giving rise to the well known butterfly diagram. What was not known before this investigation was the pattern of migration of the polar faculae towards the poles in the two hemispheres on the sun. The picture that emerges from this study is as follows: The global solar activity commences soon after the polar field reversal in the form of two components in each hemisphere. The first component is the polar faculae with poleward migration and the second and the more powerful component, the sunspot with equatorward migration. The two components occur at different latitude belts with the polar faculae leading the sunspots of the same cycle by 5-6 years (Fig.1). Thus the solar cycle, which should be reckoned from the first appearance of the solar faculae to the last appearance of sunspots, lasts for 16-18 years as against the traditional value of 11-years, which has come about only from sunspots. In addition, it has been shown in this study how the two components (polar faculae and sunspots) match with the pattern of the coronal emission in the 5303Å line recorded for several solar cycles by French astronomers and also with the pattern of excess shear associated with the torsional oscillations of the sun. This study thus provides a unification between the torsional oscillations, 5303Å coronal emission and global magnetic activity. (K.R. Sivaraman & V.I. Makarov*)

Calcium K emission

The programme of monitoring Ca II K line profiles in the integrated sunlight at the solar tower telescope was continued on a regular basis. (K.R. Sivaraman, S.S.Gupta, K.Sundararaman & R.Kariyappa).

The monitoring of Calcium K line profiles of the sun as a function of latitude and integrated over the longitude has been continued. The data have been obtained on about 150 days during this period. Analysis of the data is being done to study the chromospheric rotation and differential rotation and variability with the phase of the solar cycle (J.Singh).

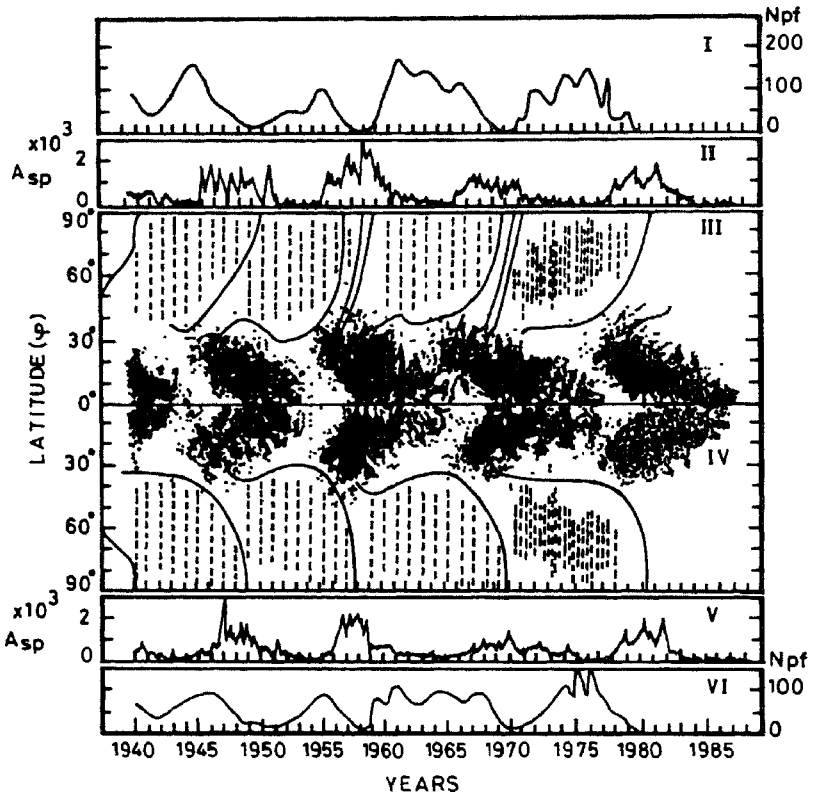


Fig.1. Boxes III and IV show the latitude distribution of polar faculae and sunspots (butterfly diagram) during 1940-1985. The faculae make their appearance first between 40^0-70^0 latitudes in the northern and southern hemispheres and then migrate towards the respective poles as the cycle advances. The superposed lines are the migration trajectories of filaments showing epochs of polar reversals. Notice that the polar faculae make their appearance immediately after every polar reversal Boxes II and V are sunspot areas Asp for these years. In boxes I and VI the continuous line represents the polar faculae counts (Npf) in the northern and southern hemispheres. (K.R. Sivaraman, V.I. Makarov)

Calcium K plage

The Calcium K plage area measurements of Kodaikanal for the period 1951-77 have been analysed to detect short period variations in the data. The data were divided in three groups - two corresponding to 10-20° N and 10-20° S latitude belts and one corresponding to total plage area. Power spectrum and autocorrelation techniques were used for the analysis. Both the techniques clearly show the 27-day periodicity due to solar rotation modulation in all the data sets. A 12-13 day periodicity is seen in only 3 out of a total of 57 data sets when an autocorrelation technique is used. A generally weak peak around 12-13 days is, however, seen in the power spectrum of all the data sets. The relative power in the 12-13 day peak is found to be significantly higher in those three data sets where the autocorrelation also shows this periodicity. At these two epochs, the sunspot area distribution showed the existence of two distinct active longitudes separated by about 140-170 degrees. This seems to be the cause for the existence of a periodicity of around 12-13 days in the autocorrelation function and enhancement in the relative power of the 12-13 day peak in the power spectrum of these two epochs. (J. Singh & S. K. Jain).

Photosphere

Photospheric lines

A programme for measuring line asymmetries of photospheric lines using the Fourier Transform Spectrometer at the McMath solar telescope (Kitt Peak National Observatory) was initiated in late 1983. The line profiles were obtained in the wavelength range of 4000-7000Å at the solar disc centre as well as at other positions along the N-S meridian along the equator. The aims were to measure the asymmetries of as many photospheric lines as possible and detect changes in the asymmetries with positions and finally to detect meridional motions on the sun. Spectral lines in the 5000Å to 6000Å region were analysed. The line asymmetries were computed and the C-curves were derived. The difference between the meridional and the equatorial values shows a positive residual value indicating the presence of meridional motion on the sun with an average value of 20-30 m sec^{-1}. (K.R.Sivaraman, R.Kariyappa, W.C.Livingston* & Grey Ladd*)

Chromosphere

CO instability in the solar chromosphere

The observations of low radiation temperatures (T_R~3500 K) in the infrared rotation-vibration bands of carbon monoxide (CO), have led to a rethinking on the temperature structure of the chromosphere. It was demonstrated by Kneer(1984) that an atmosphere with CO, which is in radiative equilibrium, will develop a steep temperature gradient, which is convectively unstable. In the presence of a magnetic field, overstable oscillations can occur, which can provide a source of energy for heating the upper chromosphere and corona. This hypothesis is currently being investigated in quantitative detail to ascertain the effect of the CO instability on energy transport as well as on the thermodynamic structure in the chromosphere. (S.S. Hasan & F.Kneer*)

Corona

Diagnostic studies

Emission line intensities due to the transitions among the ground term levels of coronal ions are sensitive to variations in electron density and temperature. Theoretical line intensity ratios for the coronal ions Fe X, Fe XI, Fe XIII, Fe XIV, Ca XII and Ca XIII and Ca XV have been used to derive the physical parameters for a coronal condensation. The coronal condensation had been observed during the eclipse of May 30, 1965. A simple model consisting of two emission regions of equal path length seems to explain the observed emission line intensities. One of the emitting region is at an electron temperature of 1.25 x 10^6K and the other at an electron temperature of 2.5 x 10^6 K. Both the regions are assumed to have an electron density of 5 x 10^8 cm^{-3}. The analysis also indicates that the observed Ca XIII line intensity at 4088Å appears to be high by about a factor of 4. (P.K.Raju)

Radio emission

Type III bursts

The broadband array and a four channel receiver system was used for the study of type III radio bursts. The flux of type III bursts at 38, 45.7, 55.5 and 64.25 MHz was obtained by calibrating the amplitude of type III bursts with that of strong radio sources 3C144, 3C274 and 3C348. The spectrum of type III bursts is calculated from the peak flux at

four frequencies. The time profiles were integrated to obtain the energy of the bursts and the energy spectrum was also calculated. (K.R.Subramanian & Ch. V. Sastry)

An acoustic optic spectrograph with 1760 channels having a total bandwidth of 30 MHz and resolution of 30 MHz was used along with the broadband array for high frequency and time resolution studies of solar bursts (K.R.Subramanian & Ch. V. Sastry).

Outer corona

The data obtained with the broadband antenna in the frequency range 35 to 65 mHZ during the quiet period, May-September 1985, were used to determine the spectral index and its variations. It is found that the spectral index varied from +1.6 to +3.6 during this period. The large positive spectral indices can be due to the existence of temperature gradients in the outer corona. (Ch.V.Sastry).

The compound grating interferometer was used to obtain high resolution (3 arc sec) one dimensional scans of the continuum emission from the sun. These scans revealed large scale short term structural changes in the outer corona and the analysis of the data is in progress. (Ch.V.Sastry).

Magnetic fields

Foot points of magnetic structures

In the search for foot points of magnetic structures on the quiet sun, observations were obtained during July 1987 with the Vacuum Tower Telescope (VTT) at Sunspot, USA. An examination of the filtergrams obtained in the narrow band pass of the Mg b line, using the Universal Birefringent Filter and the simultaneous K-line filtergrams, showed that a majority of the foot points appear to lie in the intergranular lanes. The result was very encouraging, but in order to uniquely establish the location of the foot points, the need was felt for a larger number of excellent quality filtergrams. Further observations, with an addition of simultaneous filtergrams in CN 3883 Å band were obtained at the VTT during August 1988. The study of all these data is now nearing completion. (K.R.Sivaraman & S.P.Bagare)

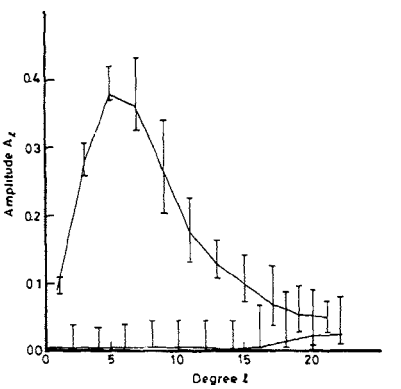


Fig.2. The spectrum of the relative amplitude (A_l) of the odd degree (l) axisymmetric (m = 0) SHF modes of 22 y periodicity at which the 'nominal toroidol field' (determined from sunspont data) yields maxima of SHF power. For each l the bar represents the scatter of the values of A_l corresponding to the 82 intervals. The continuous curve represents the spectrum obtained from the whole data series for the 103 years. (M.H. Gokhale)

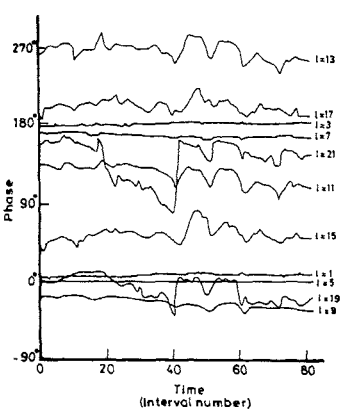


Fig.3. The relative phase (ϕ_r - ϕ_s) of the odd degree axisymmetric modes of 22y periodicity as a function of time represented by the interval number. (M.H Gokhale)

Sunspots

A spherical harmonic fourier (SHF) analysis of the sunspot data during 103 years (1874-1976) comprising 1,00,300 data points has been completed. The amplitudes and phases of the sun's axisymmetric global magnetic oscillations of odd degrees were determined. The spectrum of relative amplitudes and the relative phases of all such modes up to $l \approx 23$ were found to be nearly constant but undergoing small secular coherent variations.

Analysis of simulated data sets shows that there is no randomness at least on scales down to ~ 9° in latitudes. The amplitude spectrum can be fitted to a formula $\sim l^3 \exp(-\beta l)$ or $l^3/[\exp(\beta l)-1]$. These results may provide a simple dynamical explanation for the "sunspot butterfly diagrams" and also provide extremely useful quantitative constraints for theoretical models of the solar cycle. (M.H.Gokhale & J. Javaraiah)

Sunspot Measurement

Measurements of 5 years sunspot data were completed with digitising equipment. From these data, several parameters like rotation rates and spot size distribution were computed. Using a pattern recognition algorithm, the positions and areas of spots measured on any one day were compared with the next day's measures and their identity established. By carrying on in the same way for the following days, the rotation rates as well as the distribution of spot areas were precisely derived. These reductions show a fair amount of internal consistency. Measurements starting from the very beginning of the data set have commenced. (K.R. Sivaraman, S.S. Gupta, S.M. Aleem, A.V. Ananth & R. Howard*)

Magnetic flux tubes

It has been shown that for a given amount of the longitudinal magnetic flux and a given set of 'initial' conditions, the equations for equilibrium of a thin force-free magnetic flux tube in a stratified atmosphere leads to a unique geometrical configuration of the tube and a unique variation of density and pressure differences from the surrounding atmosphere . These depend neither on the structure of surrounding atmosphere nor on the depth of the 'initial' point. The structure of the surrounding atmosphere and the depth of the initial point are needed only for determining the density and pressure of the inner plasma. (Prasannalakshmi & M.H.Gokhale).

Magnetic structure

The time of travel of slow MHD modes along the field lines of assumed field structures inside the sun has been calculated, as a first step in understanding the equality of periods of the modes of different wave number l in the SHF analysis of the sunspot data. The three dimensional structure of the main magnetic field on the sun has been determined. This field is described by modes $l \leq 11$, which is in an approximately stationary oscillation.

The field lines seem to simulate isorotation curves, indicated by helioseismology and the main gross features of the coronal field (M.H. Gokhale & K. M. Hiremath)

Oscillations in sunspots

This study is a further continuation of work, that was begun last year, on the determination of wave modes and their classification in magnetic flux tubes. A mathematical technique was developed and applied to photospheric flux tubes on the sun. The analysis has now been extended to studying the nature of oscillations in the umbrae of sunspots. An equilibrium stratification,based on a model atmosphere in a sunspot, was used. Approximating the umbra as a vertical thick flux tube, its normal

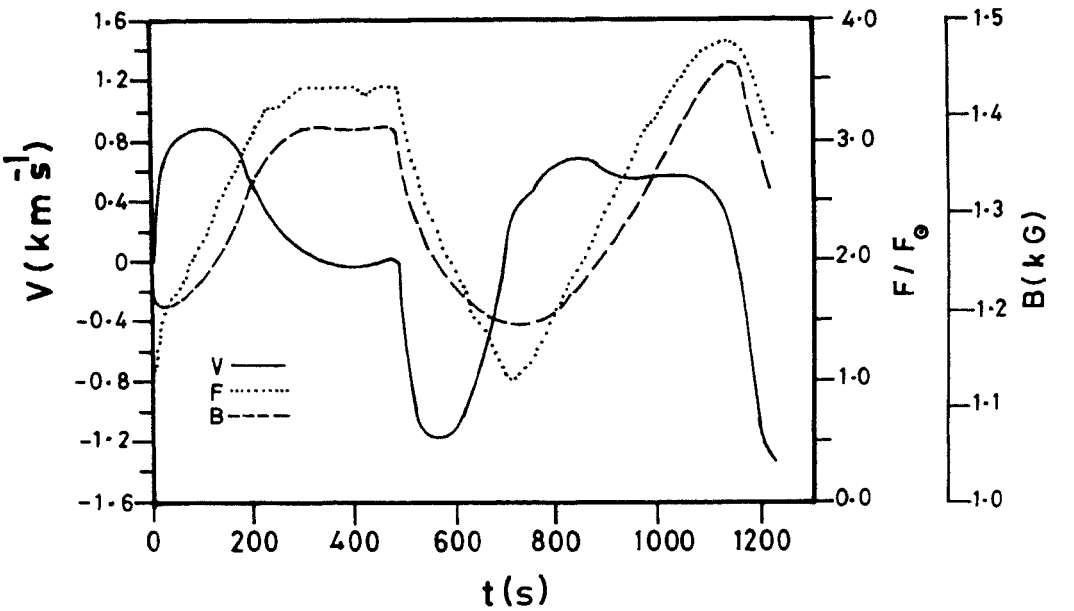


Fig.4 Numerical simulation showing oscillatory behaviour in an intense flux tube, extending vertically in the solar photosphere Shown is the time variation of V, the vertical velocity (solid line) ; F, the vertical energy flux in solar units (dotted line) and B, the magnetic field (dashed line) at optical depth unity (S.S. Hasan)

mode spectrum was determined. The modes were classified by decomposing the eigenvectors into irrotational and solenoidal components and comparing their magnitudes. It was shown that in certain limits, these modes can be related to the fast and slow modes in an homogeneous medium. However, in general, this is not possible, owing to a continuous transformation of the modes. A diagnostic diagram was calculated and compared with observations. Oscillations in the 2-3 min range were interpreted as slow and mixed modes. It was suggested that modes with periods close to 5 min might be Alfven waves. (S.S.Hasan & Y.Sobouti*).

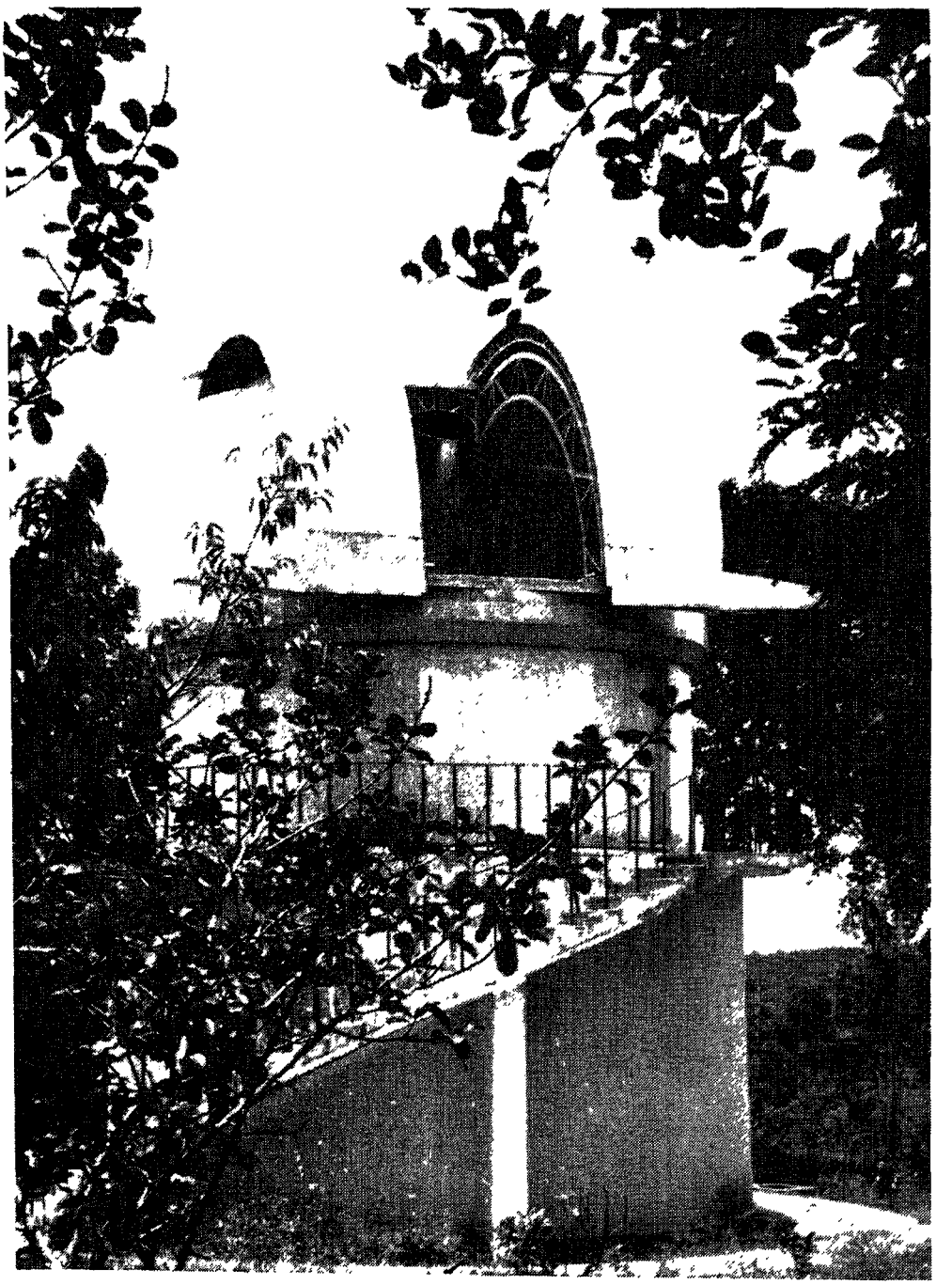
Dynamical effects in photospheric flux tubes

The dynamical response of a thin flux tube, extending vertically in the photosphere and convection zone of the sun was examined, when its equilibrium is perturbed by a small downflow. In contrast to the previous adiabatic or simplified non-adiabatic treatments, in which horizontal heat exchange was included using Newton's law of cooling, the three dimensional radiative transfer equation, in the Eddington approximation, was solved in the present investigation. Furthermore, convective energy transport was also incorporated in the analysis. The nonlinear time dependent MHD equations were solved in the thin flux tube approximation. The main results are : after a transient phase, lasting a few hundred seconds, the flux tube exhibits oscillatory behaviour. The flow in the tube does not appear to have a simple sinusoidal time dependence, but rather a fairly complicated one. For instance, the upflow and downflow phases do not appear to be symmetric. An impor-

tant finding is that the vertical radiative energy flux at optical depth unity increases by a factor of two to three over the ambient value. This could have important observational consequences. A comparison of the model calculations with semi-empirical models showed reasonable agreement. (S.S.Hasan).

Solar flares

It was long recognized that solar flares generally occur at the centre of a bipolar sunspot group, where the magnetic field component normal to the solar surface changes from positive (N) to negative (S) polarity. Later, it was seen that the flare sites coincided with regions of strong transverse field and large magnetic "shear" on the polarity inversion line. Recently, this magnetic "shear" was physically interpreted as a loss in downward magnetic tension. The tension-free state of the field was then seen to be vulnerable to instabilities that alter the gas density. If the density is decreased by enhanced heating, the "sheared" portion of the magnetic structure has to expand vertically. This expansion exerts additional pressure on the higher unsheared portion of the structure. If sufficient magnetic tension is not available there then a non-equilibrium could result leading to a flare. This scenario attempts to explain the association of flares with " sheared" fields. (P.Venkatakrishnan).



The 45cm Schmidt telescope at Kavalur used for asteroid studies

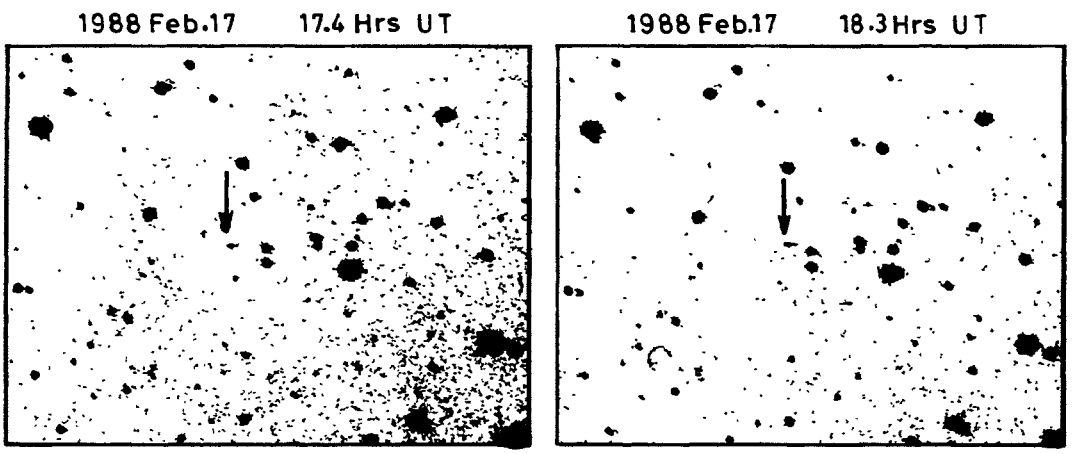
Solar System

Planetary occultations

The spatial distribution and composition of possible material at 12.5 and 19 Saturn radii around the planet is still not well understood. In this context, the program, undertaken in 1987, to search for possible occultations by the planet's magnetosphere of stars listed in the SAO catalogue has been continued. The computer code has been modified to calculate the instantaneous values of the angle of inclination of line of sight to the plane of the planets's ring and position angle of the projection of the north pole of the planet on the sky plane. Results of the search program for the period 1989-1990 indicate that saturn's magnetosphere will be occulting nine stars during this period. The times of occultations and the positions of the points of occultations in the sky plane, with respect to the planet centre, as seen from the centre of earth, have been calculated (R.Vasundhara)

Comets : dust grains

A study of the nature of dust grains in several Comets including Comets Bowell, Stephan-Oterma and Cernis has been completed. The model calculations are based on the assumption of homogeneous and smooth spherical grains so that Mie theory is pplicable. The real and imaginary parts of the empirical index of refrac-



Asteriod 4130 discovered with the 45cm Schmidt telescope at Kavalur on February 17, 1988. It has been named Ramanujam after the famous Indian mathematician Srinivasa Ramanujam (1887-1920). (Rajamohan et al.)

tion ($m = m' - im''$) for the grains are taken to be $m \sim 1.38$ and $m'' \sim 0.039$, respectively. The model also incorporates the recent *in situ* measurements of the size distribution function obtained from the Vega and Giotto spacecraft missions to Comet Halley.It is possible to derive the observational quantity $Af\rho$ where A, f and ρ represent the albedo, the filling factor and field-of-view aperture size projected on the comet, respectively. It is found that $Af\rho$ should be proportional to the theoretically calculated mean quantity $\langle \frac{iQ_{ext}}{K^2} \rangle$ where K, Q_{ext} and i are the propagation constant, the extinction efficiency of the grains and the net intensity scattering function averaged over the size spectrum of the grains, respectively. This consideration should lead to proper interpretation of the albedo of the grains in the comet Comae.

The results of calculation on reddening in the wavelength range $0.26\ \mu m \leq \lambda \leq 2.2\ \mu m$ show the general observational trends of the variation of increasing intensity of light from ultraviolet to infrared wavelengths. Simultaneously, it has been possible to explain the observations of the linear polarization of light from Comae as function of the scattering phase angle and visual wavelengths. The model can also satisfy the geometric albedo of the grains (G.A. Shah & K.S. Krishnaswamy*)

Asteroids

Computer programmes for calculating orbital elements from observed position of asteroids and for generating ephemerides for minor planets were written. These programmes were utilised to compare the observed positions of the numbered asteroids with their expected (calculated) positions. The residuals indicate that the adopted methods give positional accuracies of $\pm$ 2 arc seconds in right ascension and declination. (R. Vasundhara & R. Rajamohan).

The sky survey with the 45cm Schmidt telescope to detect asteroids was continued. Analysis of the observations is in progress. (R. Rajamohan & J.C. Bhattacharyya).

Stellar Physics

Novae and Supernovae

RS Ophiuchi

Spectroscopic data obtained during the 1985 outburst of the recurrent nova RS Ophiuchi has been analysed. Assuming that the ejected envelope decelerated due to its interaction with circumstellar matter, the size of the shell was deduced as a function of time. Observed fluxes in permitted lines would then imply that the electron density in the ejected envelope decreased from 3×10^9 cm $^{-3}$ on day 32 (since outburst) to 2×10^8 cm^{-3} on day 108, for an assumed filling factor of 0.01. The helium abundance in the ejecta was 0.16 by number, and the mass of the ejecta was 3×10^{-6} $M_\odot$. The coronal emission lines originated in the shocked ejecta of comparable mass, at a temperature varying from 1.5×10^6 K on day 32 to 1.1×10^6K on day 108. The radius and temperature of the source of ionizing radiation varied from 2×10^{12} cm and 3×10^4K on day 32 to 6×10^9 cm and 3.6×10^5 K respectively on day 204.

Spectroscopic monitoring of RS Oph as well as another recurrent nova, T CrB, has been continued during their quiescent phases. (G.C.Anupama & T.P.Prabhu)

Nova Shells

The shells of some old novae present detectable images a few decades after outburst. A programme has been initiated to image these shells in the light of emission lines, using the CCD camera on the 1-m Zeiss reflector. The shell of GK Persei has been imaged in Ha + [N II] and in [OIII], whereas the shell of T CrB has been imaged in the light of Ha + [N II]. (G.C.Anupama, T.P.Prabhu & A.K.Pati)

Supernova 1989B in NGC 3627

Low resolution spectra of SN 1989B in NGC 3627 have been recorded in the range 5000-8800Å using the UAG Spectrograph and image intensifier on the 1-m Zeiss reflector, in 1989 February and March. The supernova had reached its maximum at 12 mag in February and declined to 14.5 mag by the end of March. The spectrum is typical of Type Ia supernovae. The derived expansion velocities are in the range of 9000-10000 km s^{-1}. (T.P.Prabhu)

Hydrogen deficient stars

R CrB stars

The absorption spectrum of R CrB during the 1986 minimum has been studied. Spectra show enhancement of molecular bands of the C_2, CN and 4050Å feature. The feature at 4050Å is probably due to the C_3 molecule and this phase identifies a phase intermediate between monoatomic gas and dust formation during the minimum. It appears that regions with enhanced molecular absorptions are required to explain the absorption spectrum during the light minimum. (N.K.Rao, S.Giridhar & B.N.Ashoka)

Coude spectra of R CrB during its current 1988-89 minimum show shell lines of Na I, which show a change in radial velocity during the minimum. These spectra are under investigation. (N.K.Rao, D.L.Lambert* & S.Giridhar)

The spectrum of the hot R CrB star MV Sgr obtained in 1987 July shows an interesting phase in its spectral variation. The emission spectrum in the blue is very advanced; it also shows the presence of λ 4068 of [SII], indicative of low

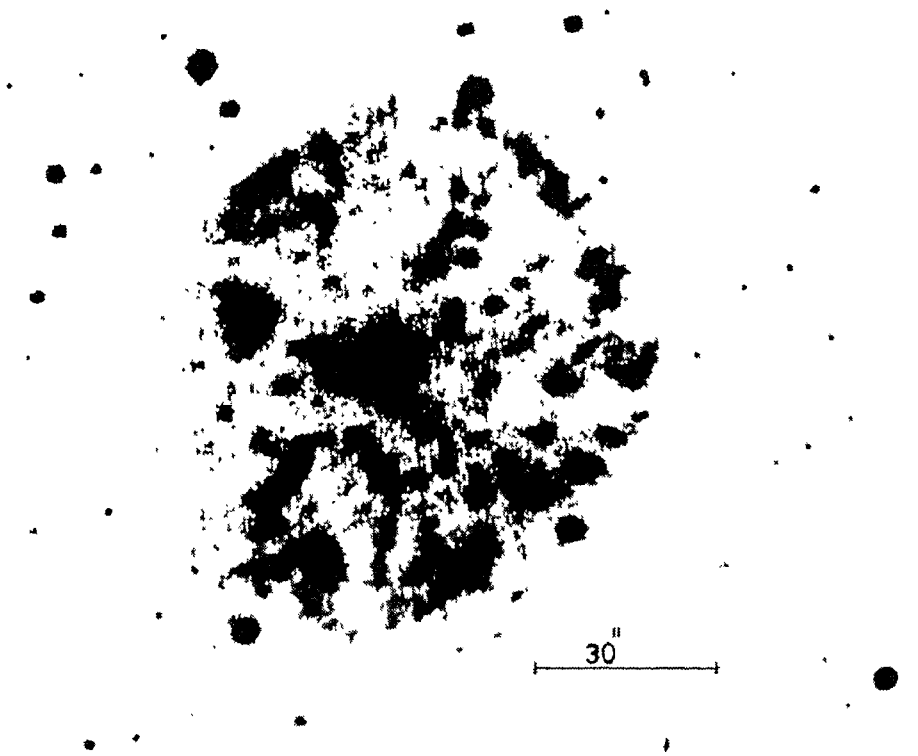


Fig.1 Unprocessed CCd image of the shell of nova GK Persei 1901, observed through an $H\alpha$ + [NII] interference filter of 160 Å bandpass. Observed on 1988 December 8 at the Cassegrain Focus of the 1-metre Zeiss reflector using the Photometrics CCD system. Integration time : 30 minutes. North is at the top, and west is to the right. The shell has expanded by 3" along the major axis (NW_SE) compared with the 1984 image obtained by E.R. Seqquist et al. (1988, preprint), whereas the expansion is $\leq$ 1 " along the minor axis. (G.C. Anupama, T.P. Prabhu & A K Pati)

density nebula. The radial velocity behaviour is being investigated. (N.K.Rao, L Houziaux* & S. Giridhar)

WC 10 & WC 11 Stars

The relationship between WC 11 stars like CpD -56°8032 V348 Sgr etc. with R CrB type stars is under investigation. The spectrum of CpD -56°8032 obtained with the IUE satellite is being investigated. The continuum flux in the UV (also in the optical region) varies between $0^m.3$ - $0^m.4$. whereas the flux in emission lines of CII etc and Hβ (nebular) remains constant. The energy distribution seem to be affected by circumstellar reddening, which varies in addition to the interstellar reddening. The presence of amorphous carbon particles of about 80Å size seem to be required to explain the UV energy distribution. The stellar temperature from the UV energy distribution is estimated to be 2300 K ± 2000. From the P-Cygni profiles in the UV the mass loss is being estimated. (N.K.Rao, S.Giridhar & K.Nandy*)

Several spectra using a B&C spectrograph with a CCD have been obtained with the 1.5m and 3.6m telescopes of ESO of WC 11, WC 10 stars CpD-56°8032, V 348 Sgr, He 2-113 etc, at various resolutions. The higher resolution echelle spectra were also obtained for some of these stars. Analysis of the data is in progress. (N.K.Rao, L Houziaux* & S.Giridhar)

Hydrogen poor binary HD 30353 (K S Per)

The ultraviolet (IUE) high and low resolution spectra (from 1175Å to 3200Å) of the hydrogen-poor star HD 30353 are analysed. The low resolu-

tion spectra show ultraviolet excess flux shortward of 1800 Å , when compared with the flux distribution of normal late B-early A supergiants. The low resolution spectra obtained at different epochs show no evidence of eclipses and no significant variations in the flux level.

The high resolution spectra show shortward-shifted stellar wind profiles of NV, CIV, Si IV, CII, Si II, Al III, Mg II and Fe II resonance lines. The terminal velocity from NV, C IV and Si IV lines is about - 650 Km s^{-1}. The Mg II resonance doublet shows P Cygni profiles and the emission strength may be variable. The average terminal velocity is -415 Km s^{-1}. The subordinate lines of Mg II and the Fe II lines of UV multiplets 1, 2, 8, 9, 40, 41, 62, 63 and 68 also show shortward shifts (about - 200 Km s^{-1}.) These lines show variations in strength and profiles and multiple narrow absorption components. The Fe III lines also show shortward shifts by about -260 Km s^{-1} and the lines of multiplet 34 present multiple absorption components.

Several strong lines of Ti II, VII, Cr II, Mn II and Fe II in the region 2850-3140 Å give orbital radial velocity shifts, in agreement with the radial velocity data obtained from the optical spectrum.

The stellar wind profiles and the narrow multiple components suggest the presence of extended and multiple shells. The ultraviolet excess shortward of 1800Å and the presence of NV and C IV lines suggest the presence of a source at temperature equal to or greater than 30000 K. This source might be a late O or early B star, as suggested by the far UV flux distribution. (M.Parthasarathy. M.Hack* & G.Tektunali*)

Be Stars

Rapid spectral variability

Presence of short-term optical photometric variability of Be stars on a time scale of 0.5 - 2 days has been established, but the variability of optical flux on a shorter time scale still remains controversial. In order to search for such variability, several thousands of profiles of Balmer and Fe II lines of many Be stars were observed with high time resolution. It has been found that Be stars earlier than B2 displayed rapid (on the time scales of minutes) and irregular continuum level variability, which were absent in Be stars later than B2. Also, rapid variations of total emission strengths of those lines were absent in most of the studied stars. Only very few stars displayed such variations in a particular epoch (during the active phase of the Be stars).

Observed rapid and irregular continuum level variability were explained in the frame work of a theoretical model of Be stars (Huang S.S., 1972, Ap. J., 171, 549) and it was shown that the mass loss from early type Be stars (earlier than B2) is time-dependent and non-uniform whereas that is not the case for late type Be stars (later than B2) (K.K.Ghosh)

Rapid V/R variability

Certain Be stars (η Cen and 27 CMa) have shown rapid V/R variability of H_α emission profiles and these variations were in close concert with the radial velocity variations of the H_α line. This fact suggest that the material circulation (both inflow and outflow of matter) is present in the envelope of these stars. Detailed theoretical modelling of these results is in progress and it is expected that these results may provide information regarding the latitude-dependent mass loss phenomena of Be stars. (K.K.Ghosh)

Hα outbursts of HD 91120

The Be star HD 91120 is known to be a stable

shell star. This star was regularly monitored during the year 1987-88 and an outburst of $H\alpha$ emission was observed on 11 May, 1987. The increase was observed on May, 1987 and lasted until 7 June, 1987 peaking to an equivalent width around 5.0 Å. This short-term outburst is interpreted as due to the presence of a compact object in binary motion around the Be star, which accretes the matter ejected by the Be star to radiate X-rays, which in turn produce ionisation in the gas to emit $H\alpha$ radiation.The broad line at 6577.5Å observed to accompany $H\alpha$ emission during outburst is suggested to be emission from dielectronic recombination from C III ions in a C II-region around the H II region formed by the X-ray radiation (K.K.Ghosh).

Simultaneous radio and optical observations

Radio continuum observations of 18 Be stars were carried out with the VLA radio telescope on 7 February 1988. The same night 12 of them were observed in the $H\alpha$ region with the 102 cm reflector of VBO using the scanner instrument. Subsequently the rest of the Be stars were also observed in the same region at VBO. The radio observations were made at 2 cm and no flux was observed from any of the stars. An upper limit of 0.5 mJy for the radio flux density at 2 cm was obtained. Most of the observed stars were in an emission phase (at $H\alpha$), which suggests the presence of an ionised gas envelope. In spite of this, no radio flux was observed. The reason for it is as follows : strong $H\alpha$ emission implies a gas density and size, which is optically thick at 2 cm radio wavelength. Then the observed flux is proportional to the area of the gas envelope. When $H\alpha$ flux is strong, the envelope is close to the Be star ($\leq 10^{12}$ cm) and the radio flux emitted is below the observable threshold. Radio flux can be observed only when the envelope, in its expansion, reaches a sufficiently large size. (K. M. V. Apparao*, T.N.Rengarajan*, S.P.Tarafdar*, & K.KGhosh).

A program of observing Be stars in JHK infrared bands was started and twenty five Be stars were observed. (K.K.Scaria, R.Muraleedharan Nair & K.R.Sivaraman)

Polarization measurements

Polarization measurements in U, B, V, R, I of several early type stars, close binary systems and Herbig Ae & Be stars were made with the star, and sky chopping polarimeter. Analysis of the data is in progress. (S.K.Jain, Ram Sagar, H.C.Bhatt, & A.Peraiah).

Interferometry

Optical interferometric observations of binary stars, Be stars and standard stars were made with the GI 2 T interferometric telescope in France. The emission envelope of the Be star γ cas and the components of Algol system were resolved. Analysis of the interferometric data is in progress. (I.Bose* , D.Mourad *, A.Labeyrie,*L.Koechlin * & S.K.Saha)

Ap stars

The chemically peculiar stars are broadly divided into magnetic and non magnetic sequences. The Mercury Manganese stars as a class are supposed to be non magnetic, non variable peculiar stars and an extension of the Am phenomenon to higher temperatures. The stars which show Silicon, Chromium, Europium and Strontium anomalies are in general magnetic stars that behave as rigid rotators with associated light and spectrum variations.

However, from theories of the origin of magnetic fields in such stars, one expects a distribution of magnetic fields and hence a division into magnetic

and non magnetic sequence of magnetic fields are related to spectrum variability, we looked at this problem indirectly, i.e., to observe as many objects as possible of both classes, which could probably be spectrum variables. If Mercury Manganese stars turn out to be rigid rotators with a magnetic field, the magnetic field itself could be below detectable limits by conventional techniques.

Our observations indicate that the following objects are spectrum variables:

HR 149 (Hg Mn), HR 234 (Cr), HR 1194 (Si), 56 Tau (Si), μ Lep (Hg Mn),HR 3500 (Hg Mn), 25 Sex (Si Cr), 45 Leo (Si Cr) , 84 U Ma (Eu Cr), π^2 Boo (A6 V), μ Lib (Sr Cr Eu), HR 5619 (Si), ω Her (Cr),ω Oph (A7P), HR 7416 (Cr Eu Sr), HR 7817 (Hg Mn), 69 Peg (Hg Mn). (R.Rajamohan)

The variations in the broad absorption band around 5200 Å are being monitored in a few selected Ap stars. This feature is probably caused by the non-uniform distribution of the chemical compositions on the respective stellar surfaces (G.S.D.Babu & J.S.Nathan)

F,G & K stars

Li abundance

In order to have a better understanding of the connection between lithium dilution rotational velocity decay and age, several field F and G giants and subgiants were observed with the CCD echelle spectrograph. The data are being analysed to determine lithium and Fe abundances of these stars. (M. Parthasarathy, A.K. Pati & S.G.V. Mallik).

A photometric study of F-type stars of high-galactic latitude.

The OI 7774Å line Photometry and in uvby b have been done for a group of high galactic latitude F-type stars, classified as luminosity type I.The OI 7774Å line photometric index Λ(16) has been calibrated in terms of luminosity, using F-G supergiants belonging to open clusters.This Λ(16) index indicates high luminosity for these high latitude stars, which is consistent with the luminosity type I ascribed to them and places these objects far away from galacticplane. However, uvby photometric indices indicate almost solar abundances and gravities larger than 3.0. The absolute magnitude M_V estimated using the reddening free indices [ml] and [cl] does not suggest very high luminosity for these star, hence they would not be very distant from the galactic plane. Their location on the H-R diagram suggests that they occupy a region near the AGB.It is possible that the OI 7774Å photometric index Λ(16)is being contaminated by neighbouring lines of the OI 7774Å feature that has become abnormally strong due to contribution from the extended atmospheric layers. That being the case, these stars seem to be neither very luminous objects nor to be situated much above the galactic plane and, therefore, are not tracers of recent star formations in the halo. Instead, most of these stars appear to be low mass stars of the old disk population and, therefore, do not conform to the UU Her class.

The only exception to the above conclusions is the star BD 45 Å (V = 10.2 mag.) for which the distance and gravity derived from different methods point to Z~9.5 Kpc., log g ~ 2 and [Fe/H]~ -2. It is probably of low mass (~ $0.6M_\theta$) and very similar to some members of the UU Her group (A. Arellano Ferro*,S. Giridhar*, M. Chavez*, L.E. Parrao*).

Spectroscopy of G and K supergiants in the red region

Spectra of about 20 cool giants and supergiants have been obtained with the echelle spectrograph at the coude focus of the 40-inch telescope using a

79 l mm^{-1} echelle grating and a 10-inch camera with CCD system. Each spectrum obtained at a dispersion of 7Åmm^{-1} corresponds to a range 5500-8000Å, in particular it covers the $H\alpha$ line and the KI line at 7699Å. Both lines have been observed to be asymmetric, indicating mass outflow from the stars. With a CCD, the signal to noise ratio and the dynamic range are much higher than with photographic plates. It is, therefore, hoped that small emission components lying within or outside the absorption line will be detected easily, thus providing clues to the velocity structure and the density distribution in chromospheres (S.V.Mallik).

Supergiant chromospheres

Calculations of $H\alpha$ radiative transfer in non-LTE spherically symmetric expanding chromospheres have been continued. The recent computations reveal that much higher values of microturbulence ($\geq$ 25 km sec^{-1}) are required to fit the observed widths of $H\alpha$ profiles in G and K supergiants. The range of velocity gradients satisfying the constraint that the observed blue shifts of the $H\alpha$ profiles match the computed ones, cannot reproduce the observed width. Several numerical experiments have also been performed for a variety of temperature structures and chromospheric extents to show that an increasing optical depth does not increase the width of the Hα absorption line (assuming a Doppler profile function) beyond about 3.5 $\Delta\upsilon_D$ where $\Delta\upsilon_D$ is the Doppler width at $\tau = 1$ (Hα). Using these estimates of opacity broadening and also the thermal broadening, limiting values of micro-turbulence for different stars have been determined. Based on these calculations, plausible models of Hα forming regions of 6 G-K supergiant (λ Vel, η Per, ∈ Gem, ζ Cep and ξ Cyg) have been proposed (S.V. Mallik & D.C.V. Mallik).

At the temperatures prevailing in chromospheres, the Lyman continuum optical depth is not too large to assume radiative detailed balance and is not too low to ignore radiative transfer effects. In an attempt to make more realistic calculation of $H\alpha$ transfer in supergiant chromospheres, the assumption of radiative detailed balance in Lyman continuum was relaxed and a detailed calculation of transfer in Lyman Continuum is in progress. Preliminary results show the radiative rate from level 1 to the continuum transfer on the formation of the $H\alpha$ line for a range of parameters. New calculations have been started on a more realistic model for $H\alpha$ formation where a 3 level atom with continuum is considered. (S.V. Mallik & D.C.V.Mallik).

Variable stars

RV tauri stars

It has been well established that RV Tauri stars possess infrared emission far in excess of their blackbody continuum, due to their extended cool dust envelopes. An analysis of the Infrared Astronomy Satellite data indicates that in the [12-25] mm and [25-60] mm colour - colour diagram, RV Tauri stars populate cooler temperature regions ($T < 600$ K), distinctly different from those occupied by the oxygen and carbon Miras. Using a simple model assuming that (i) the envelope is spherically symmetric, (ii) the IR emitting grains are predominantly of the same kind and (iii) in the infrared, the absorption efficiency is proportional to frequency, it is found that the IRAS fluxes are consistent with the following density law in the envelope $\rho(r) \alpha r^{-2}$ where r is the radial distance. Such a dependence for the density implies, that the grain formation processes in these objects are continuous and not sporadic as suggested in the literature. It also implies that the

mass loss rates in RV Tauri stars have not reduced considerably during the recent past, contrary to the suggestions existing in the literature.

In a two colour diagram, the spectroscopic group A (oxygen-rich) and B (carbon-rich) are well separated,with group B objects having systematically cooler dust envelopes. If only the objects detected by IRAS are considered, it is found that stars belonging to group B show systematically larger excess at L band for a given excess. Apparently, there is no correlation between the light curve types, RVa (with constant mean brightness) and RVb (with variable mean brightness) and the far infrared behaviour of these objects. It is fairly certain that the physical properties, including the chemical composition of the embedded stars, can be deduced from the nature of the dust grains. (A.V.Raveendran).

AC Herculis

BVRI polarimetry of RV Tauri stars shows that the wavelength dependence of polarization is weak, with a marginal increase towards blue and that the position angle of polarization is nearly independent of wavelength. The interstellar component of polarization in the direction of AC Her is probably negligible (< 0.1 %). The polarimetric behaviour of AC Her is, most likely, regular like its (B-V) colour curve. The near flat wavelength dependence rules out the possibility of the origin of polarization due to scattering by molecules or atoms. The polarization observed in AC Her, most probably, results from a combination of pulsation related asymmetry and circumstellar grain scattering and its variation during a light cycle is not caused by changes in the circumstellar dust envelope, but by the changes in asymmetry in the star. (A.V. Raveendran, N. Kameswara Rao & M.N. Anandaram*)

Mira variable R Leporis

BVRI polarimetry of the carbon Mira variable R Lep obtained during 1984-87 shows large changes in the normalized wavelength dependence of polarization. The available data indicates that both the amount and position angle of polarization had components which secularly varied since their measurements in 1966. The average visual brightness of R Lep at the light curve maximum is ~ 6.7 mag; but, during 1959-60, it was fainter than 9.3 mag. The recovery from the maximum was very rapid and by the middle of 1962, the maximum had increased to ~ 7.5 mag. Most likely, the large value of polarization observed in 1966 (~ 2.8% in the V band) is directly related to the faintest light maximum of R Lep ever observed. The trend of the polarization curve suggests that it had a still higher value before 1966. The secular changes in the normalized wavelength dependence of polarization in R Lep indicates that at least at wavelengths longward of blue, circumstellar grain scattering is a major contributing factor to the observed polarization. For a net polarization to appear in integrated light, there should be an overall departure from spherical symmetry. The secularly varied component of polarization seen after 1966 is probably a result of an episodic asymmetric mass ejection sometime before 1962 and its subsequent dissipation in the circumstellar envelope. (A.V. Raveendran & N.K. Rao).

Rs CVn stars

UX Arietis

Differential BV photometry of UX Ari obtained during 1984-85, 1985-86, 1986-87 and 1987-88 observing seasons indicates that (B-V) is phase dependent with the system being reddest at the light maximum. The components of UX Ari are G5 V

and KO IV and the spectrum in the visible region is dominated by the G5V component. The cooler component is not a normal subgiant since we would expect it to be more luminous by about 1.5-2.0 mag in V. From the observed (B-V) of the system, the expected (B-V) of the cooler component at both the light maximum and minimum of 1986-87 season for a possible range of difference in V of both the components are derived. Analysis shows that the (B-V) variations seen in UX Ari is only a result of the variable fractional contributions by the hotter component G5 V to the total light at shorter wavelengths. It is found that at larger amplitudes of the photometric wave, the brightness at maximum increases and that at minimum decreases and both converge to $\Delta V \approx 1.0$ mag at very low amplitudes. It implies that the low wave amplitudes are essentially due to the greater homogeneity in the surface distribution of spots rather than due to low levels of spot activity. The variation in wave amplitude is found to be near sinusoidal with a period around 13-14 years. (S. Mohin & A.V. Raveendran).

Active chromosphere stars

High resolution Ca II K spectra of active stars were analysed to study the effect of rotation and binarity. It is found that both components of HD 155555 are very active and hence any interpretation of its light variability should be based on the combined effect of the activity of both components. A few of the very active stars, show very little variation in their emission strengths with respect to the photometric phases. (M.V. Mekkaden).

T Tau stars

Analysis of UBRI photometry of the isolated T Tau stars TW Hya and HDE 319139 gave very interesting results.. A periodicity of 2.15 days in the light variation of TW Hya was detected and also short time scale flaring. HDE 319139 has a photometric period of 2.23 days. Analysis of the photometry of A K Sco and FK Ser is in progress. (M. V. Mekkaden).

V718 Scorpii

V718 Sco (HD 145718) is an eclipsing binary system with an orbital period of 200 days. The primary component is of spectral type A2. The far-infrared IRAS data suggests that V718 Sco is surrounded by a dust enevelope. From the ratios of the fluxes, a dust temperature of about 140K is found. The system could be either a pre-main-sequence binary or an evolved Algol system that has experienced mass-loss or mass-transfer. (M. Parthasarathy).

Pulsating white dwarfs

Study of the oscillation of pulsating white dwarf stars provides a seismological probe of the interior structure and composition of these stars. These stellar remnant contain much information about the early universe and, through their cooling timescales, give an independent measure of the age of the galactic disk. It is possible to unlock the secrets of the white dwarf stars by only completely resolving the frequencies present in their light curves. In many cases, this is impossible with single-site data (the interruptions by daylight introduces gaps in the data which cause aliases in the power spectrum, making frequency identification and measurement virtually impossible). To overcome this problem an extended coverage program, an interacting global network of optical observers, was organised by Prof. R.E. Nather of the University of Texas. The observations of V471 Tau were made (eclipsing binary system consisting of a K dwarf and a hot DA white dwarf - a member of the Hyades cluster) on eight nights between 7-20 November 1988 using two star photometer. The hot DO white

dwarf variable PG 1159-035 was also observed on three nights in March 1989. The Fourier Transform (FT) of V471 Tau data resolved the 555 s pulsation into two closely spaced periodicities. The puzzling results of a single-site data, in which the pulsation was sometimes present and sometimes not, is readily explained as beating. The magnetic rotator model (based on the observed 555 s modulation in soft X-ray flux) does not explain the splitting of the 555 s period observed in the FT, nor can it explain the presence of additional regions of apparent variation in the power spectrum. The most natural explanation for these observed effects would be G-mode or R-mode pulsations, but the surface temperature of the white dwarf places it well above the ZZ Ceti instability strip. (E. Nather*, T.M.K. Marar*, J.C. Bhattacharyya, K.K. Ghosh).

General

Stellar rotation

Analysis of cluster data for effects of rotation on the colours and line indices of stars was continued. The analysis of data for Alpha Persei, Pleiades and Scorpio Centaurus association was completed. The colour indices were dereddened for interstellar extinction to derive rotation effects. All three clusters reinforce the conclusion that the effects of rotation in the intermediate band indices C_o and $(u-b)_o$ is considerable. The broad band $(U-B)_o$ is also found to be affected considerably by rotation.

Comparison with existing theoretical models indicate that for the middle B-type stars, the observed effects agree with predictions while for the early B-stars, the observed effects are much larger than what theory predicts.(R.Rajamohan & A.Mathew).

Oscillator strengths for Fe I lines

An extensive list of internally consistent oscillator strengths for Fe I lines has been prepared, that will serve as a valuable tool in the abundance analysis of Iron. Oscillator strengths existing in literature are compiled and critically reviewed. An attempt has been made to scale the oscillator strengths derived by different workers to that of Blackwell and his collaborators and prepare a single consistent set of oscillator strengths.

A $\log gf - \log \lambda - E_i - \log I$ relationship has been calibrated that can be used for calculating gf values for Fe I lines with no gf values available. We demonstrate that the standard errors of such a calibration can be considerably reduced by binning the data in 0.5 eV range in excitation potential. The systematic corrections to be applied to the oscillator strengths of Kurucz and Peytremann (1975), for lines belonging to different multiplets are tabulated. (S. Giridhar, A. Arellano Ferro*).

Stellar surface temperatures

That the surface temperatures of the hottest and most luminous stars on the extreme upper left of the H-R diagram are about 10^5 K was sought to be understood theoretically. It was shown that for objects radiating at the maximal Eddington luminosity, the surface temperature tends to a maximal limit of this order and this maximal temperature is very insensitive to the mass scaling as only the one-twelfth power. Similar considerations were applied to accreting neutron stars (giving temperatures of the order of two million degrees consistent with X-ray pulsars) and also neutron stars undergoing neutrino cooling (C.Sivaram).

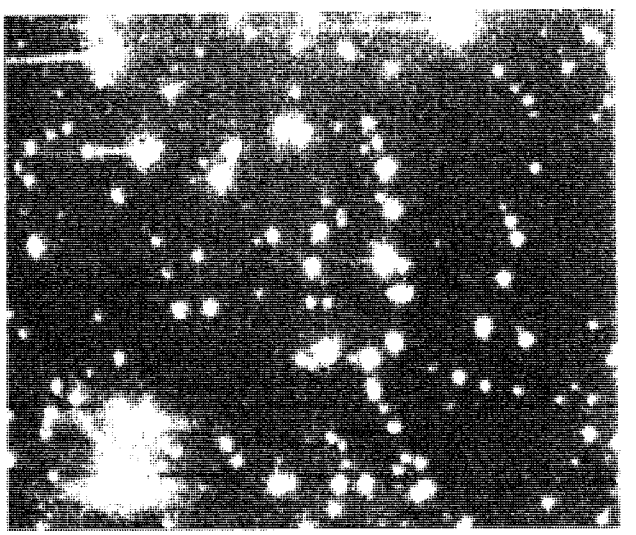


Fig.2. Cluster and nebulae NGC 2818 in red filter on 3 April 1989 obtained with the 2.34m VBT. (N K Rao)

Star clusters

Internal kinematics

Radial velocity and proper motion measurements of member stars in open clusters can be used to derive their distances if the internal velocity dispersions are isotropic. Proper motion data have been used to study the internal kinematics in ten open star clusters. The dependence of the intrinsic dispersion in proper motion on stellar mass and radial distance from the cluster centre have been studied. In most clusters no such dependence is observed. Velocity isotropy has been observed in all the clusters studied except NGC 2516 in which the radial and tangential components of the intrinsic proper motion dispersion are different in the outer regions of the cluster. (R. Sagar & H.C. Bhatt).

Cyg OB2 association

Several new red and reddened stars are detected in the most heavily reddened association Cyg OB2. About 47 IRAS sources are detected in Cyg OB2. Their flux distribution, and colours, suggest that they are young stellar objects embedded in dust envelopes or disks and are most likely members of the Cyg OB2 association. The large values of the flux ratio L_{IR}/L_{VIS} suggests that the central objects are obscured due to very large extinction. (M. Parthasarathy & S.K. Jain).

Open star clusters

A program to obtain deep CCD photometry in the B, V, R, I and U (when possible) bands of open clusters was started in Dec. 1988. The study aims at deriving the HR diagram of these clusters with

the hope of being able to reach the main sequence, for clusters of varying ages and galacto-centric distances. Using the latest stellar evolutionary isochrones, it will be possible to derive the age and metallicity of the clusters and besides, to study the variation in the Initial Mass Function with metallicity and with position in the Galaxy. The distribution of stellar mass within the clusters will also be studied. These factors provide important clues to the process of star formation in the Galaxy. Data were obtained for five fields in NGC 654 and eleven fields in NGC 2287 ; the data are being analysed (Ram Sagar & A.K. Pati).

The young open clusters as tracers of Galactic spiral features

Continuing the study of faint young open clusters as tracers of spiral features in our Galaxy, the age and distance of the hitherto not-well-studied faint cluster, Czernik 20, have been determined. This cluster is found to be young enough to be an indicator of a spiral feature, situated at a distance of about 4.27 kpc in the direction of Auriga constellation (G.S.D. Babu).

Globular clusters

The faint globular cluster NGC 6401 is located almost in the direction of the galactic center, and it lies in a region where a large amount of interstellar matter is present and for which E(B-V) = 0.8 and A(V) = 2.5 mag. It is proposed to obtain various cluster parameters, such as the age, distance modulus and the intervening interstellar extinction, using deep CCD photometry in UBVRI (G.S.D. Babu & B. Adur*).

Radiative transfer

Effects of expansion velocities and dust on curve of growth

Normally the curve of growth for spectral lines is constructed for a medium which is stationary. However, in practice, the atmospheres of stars are in radial motions and therefore, the velocities of expansion will change the nature of the curve of growth. We have computed curves of growth for an expanding medium in spherical symmetry. We have introduced variation of electron density and temperature, which is derived by the assumption that the source function changes as $1/r^2$ in a radiative equilibrium atmosphere.

We have taken the hydrogen Lyman alpha line because it is easy to calculate the optical depth without recourse to the statical equilibrium equations. Two kinds of curves of growth were derived :(i) equivalent width versus electron density and, (ii) equivalent width versus number of neutral hydrogen atoms. These curves were drawn for different velocities of expansion upto 50 mean thermal units of the gas. Constant velocity of expansion and velocity gradients were employed. We assumed scattering and/or thermal emission in the medium.

The above procedure has been repeated for a dusty medium. In this case we have investigated mainly how the equivalent widths of the lines change with respect to dust in scattering and also in a emitting medium, when the medium is in motion. (A. Peraiah & M.F. Ingalgi).

Aberration and advection in emitting media

Investigations have been made regarding the effects of aberration and advection on the medium which is moving with a near relativistic velocity. We have considered an emitting medium moving with velocities of the order $v/c \sim .01$. It is found that the changes are not more than 1 to 5 % in different cases (A. Peraiah & M.S. Rao).

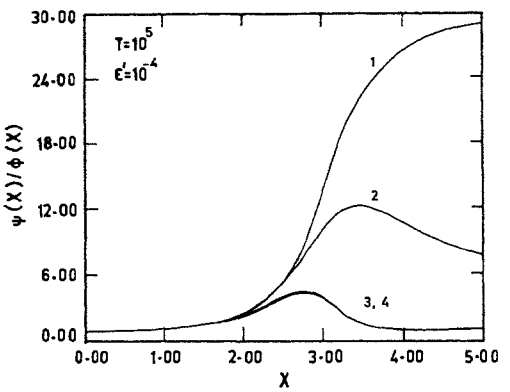


Fig.3

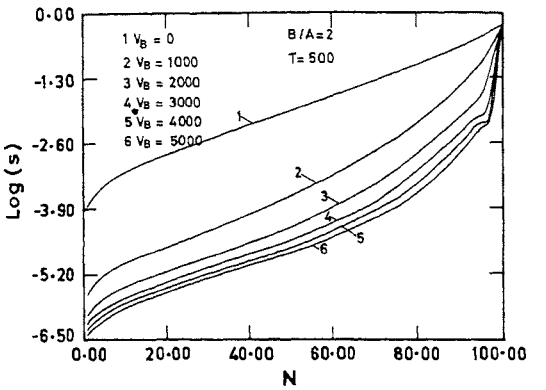


Fig.4

Fig.3 Ratio of the emergent emission profile to the abosrption profile for a self-emitting medium with total optical depth $\tau = 10^5$ and collisional de-excitation parameter $\varepsilon' = 10^{-4}$ is shown in the figure. The frequency x is measured in Doppler units. Symbols 1 and 2 denote the results for R_{II} redistribution with simulated emission parameter ρ = o and 2 respectively. Corresponding results for R_{III} redistribution are denoted by symbols 3 and 4. For resonance line scattering, R_{II} simulates nearly complete redistribution in the line core but becomes coherent in the wings R_{III} represents complete redistribution in the atom's frame and Doppler redistribution in the laboratory frame (K.E. Rangarajan, D.Mohan Rao, A. Peraiah)

Fig.4 Run of the source function across the medium divided into 100 shells, for the expansion velocities (in km s^{-1}) shown in the figure, in a spherically symmetric medium whose outer radius is twice the inner radius (B/A = 2). (A.Peraiah)

Time-dependent radiative transfer

We studied time-dependent transfer effects in a medium taking into account the time spent by the photon in the absorbed state. We considered three types of boundary conditions for the incident radiation on a scattering atmosphere: i) an isotropic pulse, ii) a pulsed radiation in a specified direction and iii) a constant input of radiation. The angular distribution of the time-dependent reflected and emergent intensities were computed for various collisional de-excitation values and also for different total optical depth of the medium. We found that the relaxation of the radiation field depends on the optical depth of the medium and also on the angle of emergence of the ray. When thermal sources are present in the medium, the emergent and reflected intensity distributions relax to their respective steady state values, and as the contribution from thermal sources increase, they reach the steady state value at a faster rate, irrespective of the direction of the ray.

Time dependent transfer is useful in laboratory physics and also in the studies of planetary atmospheres when the source of radiation is suddenly occulted or reinstated (D. Mohan Rao, K.E. Rangarajan & A. Peraiah).

The polarization of lines formed in spherical extended atmospheres was studied. Various line scattering mechanisms such as partial redistribution complete redistribution and coherent scattering were incorporated into the formalism of polarized radiative transfer equation. (K.N. Nagendra).

Spectral line formation with stimulated emission

When there are a number of absorbers of radiation

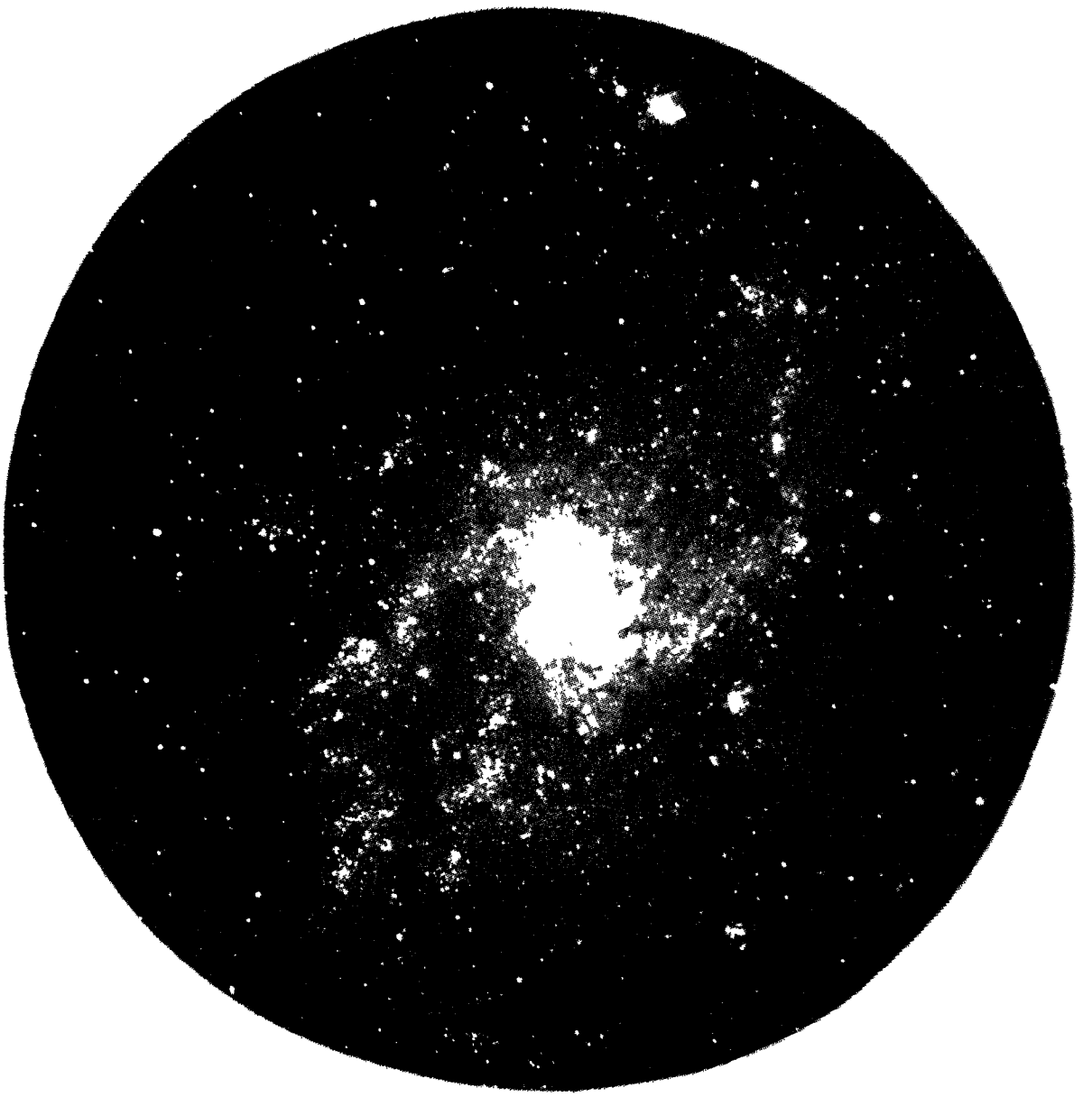
in an atmosphere, the profile of the absorption function need not be same as that of the emission function. The deviation of the absorption profile from that of the emission profile was investigated quantitatively. It was found that in the wings of the spectral line, the emission profile deviates significantly from that of the absorption profile and the deviation is more when the particles scatter the radiation in a coherent way compared to the non-coherent type of scattering. The stimulated emission of radiation also increases this deviation. These calculations are important for red transitions in hot stars and infra-red transitions in cool stars (K.E.Rangarajan, D.Mohan Rao & A. Peraiah).

Atomic absorption coefficients

A new method has been derived to calculate the atomic absorption coefficients in gases. Turbulent flows are shown to alter the absorption coefficients due to the presence of multiple time-scales in turbulent diffusion. The point that is noted here is that the atomic system responds to an electromagnetic field that acts at the instantaneous position of the atom. If the atom is in random motion, the above field is a random sum of several Fourier components. The total absorption of energy by the atom will thus be a combination of the absorptions appearing from all the Fourier components. Thus the spectral line actually follows the random motion of the atom. The absorption coefficient then has a non-standard form. In turbulent motion, random motion is due to both thermal effects and turbulent diffusion. The contribution of the turbulent diffusion part can be determined by a study of the spectral absorption coefficient (S.Chatterjee).

Volume of intersection of a cone with a sphere

Astrophysical observations of the scattered continuum light from comets, circumstellar envelopes, spherical reflection nebulae, planetary nebulae and similar astronomical objects are confined to a narrow cone of view (field of view) through a telescope with a finite aperture. The scattering phenomena are caused by the interstellar dust grains, gas, ions or electrons. The nature of the scattering agents is sought from the comparison of observations with calculated models on intensity, colours polarization, and spectra.The appropriate theoretical models should naturally require the consideration of volume elements of intersection between a cone and a sphere for the purpose of integrating the contributions of the scattered light along a given line of sight. The integration is required by the fact that the scattering angle and the number of scatterers vary with each volume element along the line of sight (G.A.Shah).



Photograph of M33, taken with the 2.34m VBT at prime focus. Exposure : 100 min. (K.K. Scaria and M.J. Rosario)

Interstellar Medium and Planetary Nebulae

Dust in planetary nebulae

In young compact planetary nebulae, the nebular dust optical depths can be quite significant. Scattering of light due to nebular dust can then cause intrinsic polarization, provided the geometrical distribution of the dust is not spherically symmetric. Polarization observations of the planetary nebula Cn 1-1 (distance ~ 450 pc) is caused in part by a sheet of interstellar dust at a distance ~ 250 pc and in part by dust intrinsic to Cn 1-1. The dust distribution is bipolar around the central star (H.C.Bhatt).

Central stars of planetary nebulae

A project to detect and estimate the visual magnitude of faint central stars of planetary nebulae was initiated. CCD observations of several planetary nebulae in the continuum light were made with a narrow band filter centered at λ 5101 (uncontaminated by nebular emission lines) (D.C.V.Mallik & A.K.Pati).

NGC 2440

The data on NGC 2440 obtained with the PRL Fabry Perot spectrometer were analysed. Scans were obtained at several positions of the inner elliptical disk of the nebula in [OIII] & [N II] lines. These lines show clear splitting, enabling unambiguous measurement of expansion velocities in all positions. The velocities are remarkably uniform over the inner elliptical disk varying less than 3 km s^{-1} from one position to another. A central expansion velocity of 13 km s^{-1} and 16 km s^{-1} were obtained in the [O III] 5007 & [N II] 6584 lines respectively (D.C.V. Mallik & S.K. Jain).

IUE observations of young-planetary nebulae

Hen 401, Hen 1013, Hen 1357, Hen 1428, Hen 1475, HD 149427, SAO 243756 are emission line objects. The far infrared (IRAS) flux distribution, and colours are similar to that of planetary nebulae. The circumstellar dust shell characteristics are also similar to that of planetary nebulae. The ultraviolet spectra of all the above mentioned objects were obtained with IUE Satellite. Analysis of the IUE spectra is in progress (M. Parthasarathy, S.R. Pottasch*, & J. Clavel*).

Bipolar proto-planetary nebulae

From an analysis of the IRAS data of Roberts 22, M1-92, M2-9, OH 231.8 + 4.2, M1-91, MWC-922, Hen 401, Mz-3, OH 19.2 - 1.0 and OH 26.5 + 0.6, it is found that the characteristics of the dust shells around these objects are similar to those observed in planetary nebulae. These ten objects may be described as transition objects evolving from the tip of AGB towards left in the HR diagram. The bipolar and disk geometry of the dust envelopes around them may be the result of the large angular momentum of the progenitor star; or the central objects may be evolved binary systems embedded in thick disks formed from severe mass loss (M. Parthasarthy).

Possible proto-planetary nebulae

From the IRAS data of high galactic latitude F supergiants, of few luminous F-G stars and of few peculiar (forbidden) emission line stars, Parthasarathy & Pottasch (1986, 1988, 1989), found that they have dust shells with characteristics similar to that observed in planetary nebulae.

The objects described here appear to have experienced severe mass loss in the recent past on their AGB stage of evolution. These stars are most likely post AGB stars or evolving from the tip of AGB towards the left in the H-R diagram and may be described as possible proto-planetary nebulae. From the IRAS data ten additional possible protoplanetary nebulae were found. From the IRAS data of HD 56126, -53 ° 5072, HD 168625 and -59° 6723 the luminosities, temperatures and masses of the dust shells are derived. HD 56126 (F5I), HD 168625 (B8Iae) and -59° 6723 (B8Iae)appear to be in an evolutionary stage (post-AGB) similar to that of HD 161796 and HR 4049 (M. Parthasarathy).

Galaxies, High Energy Astrophysics & Cosmology

Galaxies

Dynamics

The collision of a pair of disc-sphere galaxies has been studied using the impulse approximation. Various collision parameters like the impact parameter, the orientation of the disc galaxy with respect to the perturber's orbit and the relative velocity of the perturber were considered. During an encounter, the disc galaxy gains energy at the expense of the orbital energy of the perturber. A head-on collision with high relative velocity (>1000 Km s^{-1}) leaves the disc galaxy intact without causing much damage. It is shown that for small impact parameters and high relative velocities, a slightly inclined position of the disc galaxy produces maximum energy change. The energy exchange is observed to be asymmetric with respect to the direction of motion of the pertuber.

N-body simulations of interacting galaxies have been performed to study the dependence of tidal effects on the density ratio of the components. Numerical work shows that tidal effects increases with decreasing the eccentricity *e* of the perturber's orbit and is strongly dependent on *e*, provided the density ratio and the distance of closest approach are kept constant. (P.M.S.Namboodiri & R.K.Kochhar).

Stellar Populations in Galaxies

A study of the stellar populations in galaxies from integrated spectra was completed. The results of the study indicate that, in the early type galaxies, significant star formation has occurred as late as 5 to 8 giga years ago. In the case of NGC 5128, an early type galaxy with a dust lane which is also a powerful radio source, star formation is an on-going process. The technique of population synthesis, employed to determine the relative proportions of stars of different spectral type and luminosity classes, shows that the integrated light at wavelengths around 1 micron is not dominated by giant stars of late spectral type and that the contribution from late type stars on the main sequence is significant. The results also indicate that for galaxies showing on-going star formation, red metal-rich giant stars found in the Galactic bulge as well as evolved supergiant stars have to be included in the stellar libraries used for population synthesis. (A.K.Pati)

Emission line imaging of clusters of galaxies

A program to obtain narrow band image, centred on strong emission lines of the cores of clusters of galaxies at different redshift, has been started. The clusters selected have giant cD galaxies at the core, are bright in X-rays, and show fairly strong radio emission. The intra-cluster gas in the central regions of these clusters is thought to be cool on time scales shorter than the Hubble time, and, as a result large scale flows of gas towards the centre can occur. This flow could be as high as 100 solar masses per year and is expected to show strong emission lines as it cools below 10^4 K. The program aims at detecting this emission by imaging through interferences filters centred on the lines and on the neighbouring continuum. The data would show up the flows as well as the accompanying star formation activity which is expected to occur. Images were obtained for two clusters in the OIII 5007 A line on a trial basis and reductions are in progress. (J.Bagchi* & A.K.Pati)

Star Formation in nearby Galaxies

A program to map star formation in late-type galaxies, especially those showing evidence of large scale star formation with HII regions and multiple nuclei or hot spots, was begun. The observations are at present being done at the 1 metre telescope using the CCD system for imaging through an interference filter centred on the H_α line (Y.D.Mayya, T.P.Prabhu, A.K.Pati & Chanda Jog*).

Active nuclei of galaxies

A program to monitor the properties of galaxies with active nuclei (AGNs) was started as part of a broader international program to monitor such objects. The variability of the properties of the region emitting broad emission lines in these objects is an area of great current interest. Assuming the energy input to this region is via photoionisation, as the evidence suggests, the gas in this region will respond to variations in the ionising continuum flux, but with a delay due to light travel time effects. Hence, close temporal monitoring of both the emission lines and the continuum is essential to determine the energetics, geometry and velocity field of the emitting region. In the first instance, observations of the Seyfert 1 galaxy NGC 5548 have been taken up for the period Dec 88-Aug 89 as part of an international effort involving the IUE satellite as well as several observatories. Images have been obtained with the CCD system in the V band at the 1 metre telescope. (A.K.Pati & K.K.Ghosh).

Radio sources

The decameter wave radio telescope was used to measure the flux densities of 12 radio sources, identified with clusters of galaxies. The measured flux densities at 34.5 MHz are combined with other low frequency measurements to derive their radio spectra. It is found that the average spectral index in the frequency range 34.5 MHz to 408 MHz is -1.32, much steeper than the average of extra galactic sources (Ch.V.Sastry)

Quasars

Three different levels of description are available to describe the interaction of electromagnetic radiation with electrons in a fully ionized plasma. When the scattering of radiation occurs by excitation of a plasmon, the collective plasma oscillation of the electrons, it is called stimulated Raman Scattering. If it occurs by excitation of a heavily damped plasmon, it is called stimulated Compton scattering and if it is occurs by excitation of individual electrons, it is called Compton scattering. The scattering rates in each case differ significantly. The physics of these mechanisms is illustrated by taking a quasar as the source of intense radiation and the hot plasma surrounding it as the scattering medium. It is concluded that through Raman scattering the nonthermal radio radiation equilibrates with the intercloud medium at much higher temperatures than are achievable through Compton processes. (V.Krishan)

The occurrence of superluminal motion in extragalactic radio sources is believed to be quite common. Among others, the geometrical scattering of radio radiation can also cause superluminal expansion and or motion and halo formation. In this paper, the effectiveness of the stimulated Raman scattering in producing these features is investigated. The scattering medium is a plasma whose position, density and temperature decide the rate and angle of scattering. When radiation from a stationary and constant source gets scattered from a stationary plasma, a halo is formed around the source. However, the scattering of a rotating radiation beam does produce superluminal motion of the

virtual source. It is found that the plasma should have the characteristic of emission line regions and the intercloud medium in order to Raman scatter the radiation. Since the scattering is polarization dependent, it is possible to estimate the rotation of the electric vector along the direction of apparent motion of a radio source. (V.Krishan)

Quasar models

Detailed investigations of quasar models in Hoyle-Narlikar (HN) cosmology with a time varying gravitational 'constant' G, were carried out. The main conclusions are as follows :-

i. In HN cosmology, the epoch dependence of G leads to a systematic luminosity enhancement for quasars at earlier epochs.

ii. A quasar of redshift z, emitting at the Eddington luminosity, will be intrinsically brighter by a factor $(1 + z)$ than a nearby one.

iii. The increase in apparent magnitude is given by $\Delta m = 7.5 \log (1 + z)$. The resulting theoretical Hubble (m vs log z) plot shows a fair degree of agreement with the observational data.

iv. For hot, radiation dominated, super-massive star models, radiating as a black body, there is a systematic increase in temperature in the past, given by $T \alpha (1 + z)^{5/12}$, implying intrinsically bluer objects in the past

v. Preliminary, Newtonian calculations for Massive Black-Hole (MBH) models show that the central accretor mass has a strong time dependence and becomes vanishingly small at the time of birth of the quasar.

These models are being examined in the light of recent observational data. Also more rigorous calculations of MBH models, taking into account general relativistic effects, are being done. Alternative energy mechanisms for quasars and periodicity of quasar redshifts are being investigated. (P.K.Das)

Polarization observations of the double nuclei quasar 0957+561 A, B were made. These observations are being analysed to study the polarization states of the two components of this quasar. (J.C. Bhattacharyya, K.K. Scaria, A.R. Prasanna*)

High energy astrophysics

Pulsars / Supernovae

The detection of gamma ray lines from supernova SN 1987, characteristics of ^{56}Co decay and the exponential decay of the light curve, with a time scale similar to ^{56}Co decay half-life after about 120 days since the explosion suggest that the energy source is ^{56}Co radioactive decay. The unusual behaviour of the SN 1987A light curve during the first few months has been suggested as due to a central pulsar providing the energy. The energy transferred by the pulsar to the surrounding nebula will cause the supernova light curve to level off at some asymptotic value after the radioactive contribution has declined sufficiently. The observed luminosity therefore provides an upper limit of the central pulsar luminosity. Since the light curve has not shown any sign of levelling off even after more than 400 days, the luminosity of the central pulsar must be low, and that the pulsar must not be rotating rapidly. Using observational data, we derived quantitative lower limits on the rotation period of the central pulsar. We also showed that pulsars, born in type II supernovae are, in general, not likely to be fast pulsars. (H.C.Bhatt & B.Datta)

Rotation induced effect of line broadening will lead to a large difference in arrival times of two ends of a single monochromatic pulse from a fast pulsar, taking into account general relativistic ef-

fects of large spacetime curvature and large rotation. Thus there should in principle be a dispersion smearing in the receiver pass band. (R.C.Kapoor)

High density matter

The equation of state of high density neutron matter (densities 10^{14} gm cm^{-3}) is the most crucial input in constructing neutron star structure models. At these high densities, the extreme short-range component of the neutron-neutron interaction and relativistic effects will play important roles. A fully relativistic many-body description has been developed of high-density neutrons, in which forces deriving from the exchange of spin-2 mesons (corresponding to the extreme short-range part of the neutron-neutron force) have been included in a consistent manner. (B.Datta & V.Canuto*)

Supernovae neutrinos

The motion of neutrinos moving in a dense medium in the presence of large magnetic fields was considered especially in connection with supernova neutrinos. For the large magnetic fields expected inside a collapsing stellar core, even neutrinos with extremely small magnetic moments 10^{-20} μ_B, (μ_B is the Bohr magneton) could undergo spin flipping transitions. The neutrion oscillation parameters would also be significantly altered. The effects of charge screening in neutrino scattering cross-sections were also considered and constraints put on relevant neutrino parameters. (C.Sivaram)

Magnetic fields of astronomical objects

Empirical relations between the angular momenta of a wide range of celestial bodies as well as relations between masses and spins of hadrons were shown to have a fundamental basis. Magnetic moments of astronomical objects and elementary particles were also linked in this context. (C.Sivaram)

Cosmology

Early Universe

The quark-hadron phase transition in the early universe and some of its possible cosmological consequences, such as stable quark nuggets and possible candidate for dark matter and the effect on primordial nucleosynthesis were investigated. It was found that values for the abundances of light nuclei (H, D, ^{3}He and Li) agree with the predictions of the standard cosmological model as also with reported, observationally determined, abundance values. It was also find that these results are compatible with a 'flat' universe, so that primordial quark nuggets, if stable, are a distinct possibility for constituting the non-luminous matter in the universe (B.Datta, B.Sinha*, N.C.Rana* & S.Raha*)

Magnetic fields in the early universe

Role of magnetic fields in the early phases of the big bang were considered. The problem of the regeneration of the primordial magnetic field after the inflationary phase, was tackled in the context of spin-torsion interaction between spinning particles in the framework of the Einstein-Cartan theory. (C.Sivaram)

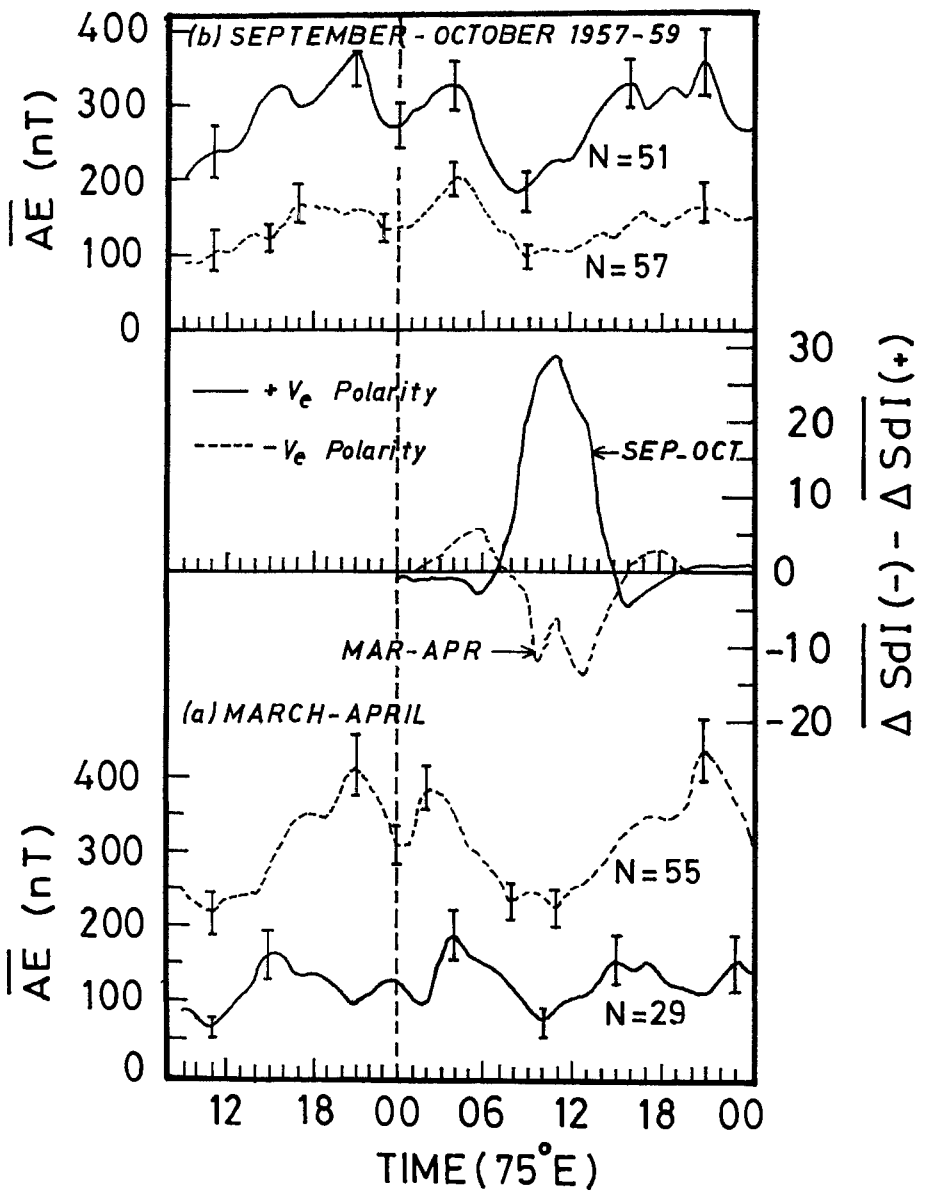
The dynamics of topological defects such as super strings and their higher dimensional analogues, the super d-branes, in the early universe were studied. It was shown that super d-branes cannot give rise to galactic type structures unlike strings. However they could initiate an early power law inflationary expansion. (C.Sivaram)

Some astrophysical and cosmological constraints on the fifth force were placed. Various theoretical frame works for additional long range weak force were examined. (C.Sivaram)

Quark-Gluon plasma

A reaction kinetics approach incorporating flows has been formulated to describe the hardonization process in quark-gluon plasmas. The change in density of any species is given by a continuity like equation.

The different species that appear in the equation are quarks, hadrons etc. Numerical solutions of this equation are being worked out. (B.Datta & S.Chatterjee)



Average temporal patterns of the auroral electrojet index (AE) on days with sunward (-ve polarity) and antisunward (+ve polarity interplanetary magnetic field (IMF) depicting the IMF polarity associated changes in the level of AE between the two equinoxes (top and bottom panels). The difference in the equatorial electrojet strength (and hence in the zonal electric field that drives it) between sunward and antisunward IMF polarity related modulation in the noon time equatorial electric field concomittant to that in the level of AE (J.H. Sastri)

Solar Terrestrial Physics

Ionosphere

Solar wind-magnetosphere-ionosphere coupling

The plausible modulation in the equatorial electric fields due to the sector structure of the interplanetary magnetic field (IMF) is assessed through a comparative study of the diurnal patterns of the electrojet strength on days on sunward and anti-sunward IMF, during vernal and autumnal equinoxes around the maxima of 19th (1957-59) and 21st (1979-81) solar cycles. The study revealed that, on average, the electrojet strength is reduced around noon (09-15LT) on sunward IMF days when compared to antisunward days in vernal equinox, and the pattern is reversed in autumnal equinox. This systematic change in the electrojet collaborates the trends found earlier in the behaviour of equatorial ionisation anomaly (which depends on electrojet strength), and strengthens the view that IMF polarity exerts discernible influence on the equatorial electric fields through its effect on the semiannual variation of geomagnetic activity. The average temporal profiles of auroral electrojet index (AE) showed not only the expected difference in the overall level of AE between sunward and antisunward IMF days, but also a preferential occurence of magnetospheric substorm activity 19-24 hours prior to local noon on sunward (antisunward) IMF days in vernal (autumnal) equinox. A substorm recovery phase is generally seen in the forenoon period more or less independent of IMF polarity in the two equinoxes. These characteristic features in AE are conspicuously absent during the autumnal equinox of 1979-81, when the IMF related changes the electrojet are not apparent. The results, which are the first ones of their kind, strongly suggest that the evident response of the day time equatorial electric fields to IMF polarity receives substantial contribution from westward electric field disturbances, caused by the ionospheric 'disturbance dynamo' mechanism, which prevails in the aftermath of magnetic storms typically with a delay of 13-24 hrs. (J.H. Sastri).

Radio wave scintillations

A study is made of the scintillation activity of 244 MHz beacon transmissions from the FLEETSAT satellite, recorded at Trivandrum, in relation to ionospheric structure deduced from Ionosonde data at Kodaikanal. The aim of the investigation is to ascertain the genesis of the apparent discrepancy in the average level of VHF scintillations during day time in the Indian and American equatorial regions, reported in the literature. It is found that VHF scintillations manifest themselves in two distinct forms during day time in the Indian sector. The first type are weak scintillations with peak amplitudes of 1-2 db, which preferentially occur under normal electrojet conditions and in association with q-type, of sporadic-E(Esq) irregularities. The second type, on the other hand, are impulsive and stronger scintillations with amplitudes >5 db, and occur under counter-electrojet conditions and in association with blanketing type sporadic-E (Esb) irregularities. This finding indicates that the reported longitudinal dependence of VHF scintillations stems from the differences in the occurrence patterns of Esq and Esb irregularities between the Indian and American sectors (P.V. Koparkar*, J.H. Sastri, R.G. Rastogi*).

Dynamics of F-region

Experimental characterisation and understanding of the plasma drifts of equatorial ionosphere F-region is very important because of the

role played by plasma drifts in many phenomena, in particular, the generation and sustenance of irregularities known as spread-F, which are a hindrance to radio astronomical observations and communications. Data from the HF Doppler radar are used to determine the diurnal pattern of vector plasma drifts as well as vertical plasma drifts near the dip equator in the Indian sector. The results showed that the pre-reversal enhancement in vertical plasma drifts (around sunset) is a maximum in equinox with a mean value of 40 m s^{-1}, which is greater by a factor of 4 than the minimum, occurring in summer. The diurnal pattern of vector plasma drifts revealed a strong day-night asymmetry in the zonal (east-west) component, with a westward drift of 50 m s^{-1} during day and a eastward drift reaching as high as 150 m s^{-1} during night. The meridional component, on the other hand, is more or less symmetric, with a northward drift typically of 100 m s^{-1} during day and southward drift of 70 m s^{-1} at night. Although the observed gross pattern of vector plasma drifts is in conformity with that expected from conventional thermospheric models, the results showed several consistent features, which cannot be accounted in terms of simple models. One such feature is the tendency for the southward plasma drift to reverse to northward just after midnight. This constitutes further evidence for the anamolous midnight temperature maximum in the equatorial thermosphere, the origin of which is yet to be established. (B. Jayachandran*, S.P. Namboodri*, N. Balan*, P.B. Rao* & J.H. Sastri).

Instrumentation

Computer Facility

For the Bangalore campus a powerful 32-bit super mini-computer MIGHTY FRAME II (MF II) which can support upto 64 concurrent users was acquired. This is manufactured by Convergent Technologies Inc, USA - who are well known as an O.E.M. (Original Equipment Manufacturers) Company- and marketed by UPTRON India Ltd. The main CPU works with a 68020 Motorola chip operating at 25 MHz and has a 128 Kb cache. To speed up the mathematical operations, a MC 68881 floating point processor is added to it. 8-Mb ECC RAM is present in the main memory. Two winchestor disk units with capacities 85 Mb and 280 Mb are also available. SCSI bus adapter working at 4 Mb/sec is in the I/O channel. 60-Mb capacity cartridge tape drive is also accommodated in the main cabinet itself. The CPU works at a 5 MIPS rating. MF II is one of the latest state-of-the-art computer systems.

CTIX, the operating system for the Mighty Frame series is derived from the industry standard UNIX system V. At present we have FORTRAN 77 and C compilers. One of the main attractions of this computer is its small physical dimensions : height 74 cm, width 29 cm, depth 66 cm and weight 64 kg. The main cabinet houses CPU, memory boards 3 disk drives giving over a giga byte of storage, and a cartridge tape drive. It occupies very little space and the power consumption is less than 3 KVA. The demand on air-conditioning requirements is also consequently less. The system has provision for memory and I/O expansion.

We have got four CT 220-type terminals, three personal computers (PCs) each with two floppy drives and one PC XT plus with a 20 Mb winchestor disc, a floppy drive and a colour chrome monitor, one Godrej printer (144 x 240 dpi) working upto a speed of 300 cps, all connected to the MF II computer. The printer has both parallel and serial ports and is also attached to the PC XT plus. In emulation mode it can work as EPSON MX 80, GRAFTRAX or ANADEX DP-9600 printers. File transfer utility through the PCs from the floppy diskettes to MF II and vice versa is available.

The capabilities of MF II are equivalent to that of a VAX 8600, both in CPU power and in the various disk and I/O operations to support the level of processing. However, the price of the MF II is about one seventh of that of a VAX 8600 (see Computer Age, February-March 1988, p.28).

The installation of MF II was completed in the first week of June and a training programme was given to all the users for a fortnight by UPTRON company. This was attended by IIA staff and a few research scholars from Bangalore University. Now the system is in regular usage for scientific purposes and there is a lot of demand for terminal and computer time. A spooler-type tape drive, augmentation of the memory to 16 Mb are all on the cards. (A.Peraiah, K.E.Rangarajan, D.Mohan Rao, B.A.Varghese, P.M.S.Namboodiri & S.Mohin).

CCD and image processing

CCD System

The CCD system set up at the 1 metre telescope was installed for regular use by observers and accounted for 50 to 60% of the observing time during Jan-March '89. The imaging mode at the f/13 cassegrain focus was first made available ; initial trials in early 1988, using a filter unit fabricated at Kavalur were done with the Fernie U, B,

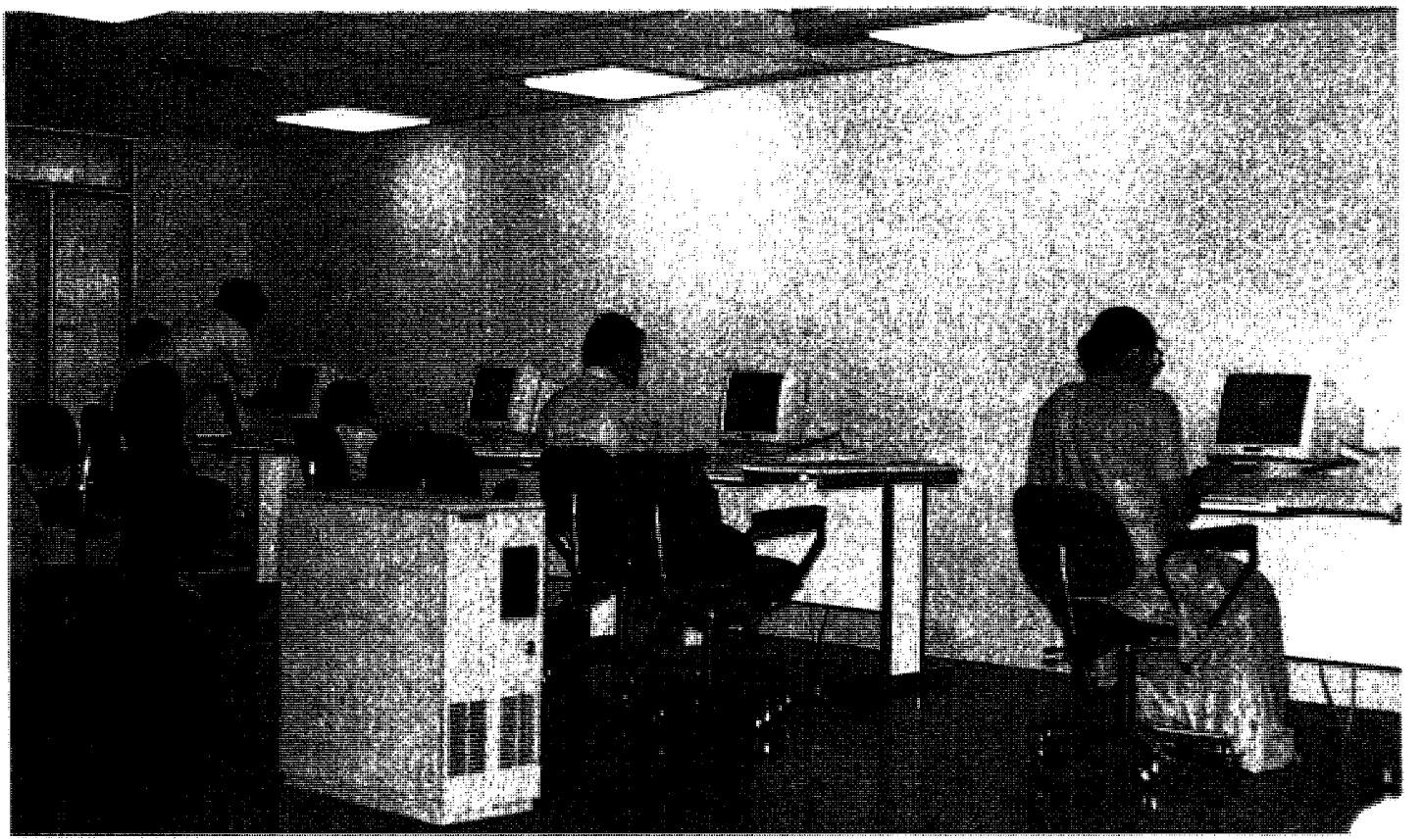


Fig. 1 Mighty Frame II Super mini-computer at the Bangalore Campus

V, R and I filters available at the institute. Observations of the open cluster M67 containing standard sequences enabled a calibration of the system to be done and it was found that good linear transformations to the standard Johnson U, B, V and Cousins R, I systems could be obtained (Ram Sagar and A.K.Pati, 1989). Subsequently, a new filter unit was developed to accommodate upto ten filters of 1 inch diameter or six filters of 2 inches diameter, using which the problems of flexure at large hour angles were greatly reduced. Several programs at the institute are now underway using this set up.

In Jan '89 the CCD system was also made available for spectroscopy, at the coude focus of the 1 metre telescope using the echelle spectrograph. The spectrograph was modified by the workshop staff at VBO to permit accurate adjustments ; the camera with focal length of 10 inches was modified to enable mounting of the CCD dewar and initial trials gave excellent spectra at reciprocal dispersion of around 7 A/mm. During the bright moon time in Jan-March '89, all the nights were allocated for CCD echelle spectroscopy. The same 10 inch camera when tried with the cassegrain spectrograph gave several problems of flexure ; it is hoped that a new housing for the camera, now being fabricated at the workshop at VBO, will solve these problems. (A.K.Pati)

Image data acquisition/processing system

A PC based image data acquisition/ processing system has been developed for acquiring data from a CCD camera. The software package for camera operation is menu driven and has the following broad category of features available at present :

1) system checkout
2) image data acquisition
3) image processing (to a limited extent)
4) image analysis
5) file operation
6) window operations etc.

The software has been developed using a combination of PASCAL, ASSEMBLER, MODULA-2 and CLIPPER routines with extensive calls to library routines provided under DT-IRIS.

The hardware is centred around an IBM - PC AT system with some special purpose cards for initiating commands for remove operation of the camera, acquire digitized data, display and process images.

The CCD camera comprising of P8603 GEC chip, a liquid nitrogen cooled dewar and the CCD controller have been imported from M/s. Astromed Ltd U.K.

The entire system has been undergoing field testing since Sept '88 and has been operational since JAN 89 at VBT, Kavalur.

In order to facilitate easy transportation of image data from PC to main frame system a magnetic tape drive system has been developed. (A.V.Ananth, R.Srinivasan, N.K.Rao, G.Srinivasulu, S.S.Chandramouli & V.Chinnappan).

The CCD in the scanning mode for imaging asteroids was successfully developed and tested at the prime focus of the 234 cm telescope. In this mode, the telescope is kept stationary and therefore the image of the sky moves across the CCD due to the Earth's rotation. The charges created in the CCD pixels by the image is shifted in synchronism with its movement across the CCD, read and stored in the PC. The scanning mode for imaging with CCD has been developed and all control commands are generated through a PC. The data can be subsequently transferred to tape for image processing and analysis.

The image scale at the prime focus of the 234 cm telescope is 27"/mm. Three pixels at a time were combined to achieve perfect synchronisation. This is equivalent to reducing the resolution form 0.6 arc second per pixel to 1.8 arc seconds per pixel. (J.C.Bhattacharyya, R.Srinivasan & R.Rajamohan)

Auxiliary instruments

A PC based spectrum scanner

A PC controlled spectrum scanner has been developed in the Electronics Laboratory of the Indian Institute of Astrophysics. The software which controls secondary storage media is implemented in Turbo-Pascal. The salient features of the controller include sequential or random scanning mode, and an online graphical dialogue facilitates, easy set-up of the operation. An automatic storage of the spectral data once in every ten scans, helps in recovering data, till the last tenth scan, in the case of power failure, during long exposures.

The two add-on cards developed to implement the scanner are as follows :

1. A gated-counter card with multiplexor
2. A translator card to drive the Stepper motor

These two cards are interfaced to the IBM PC, through a digital I/O card for 16 Bit In and 16 Bit Out sitting on XT/AT slot.

The scanner control and data acquisition software is written in Turbo-Pascal. The program is modular and is implemented through the following procedures.

1. Adjust channel routine
2. Gate-generation routine
3. Data Collection routine
4. Stepper motor control routine

5. Graphic display routine
6. Plot routine

The unit has been operational with the 40" Telescope at Kavalur, since August, 1988. (R. Srinivasan, R.Surenderanath and K.Jayakumar)

A new double pass monochromator

A double pass system spectrograph has been set up at the Bangalore campus with a view to acquire the Ca II K line profiles in the integrated sunlight with high photometric accuracy. The main aim is to procure these profiles with the minimum level of scattered light as possible and look for short term changes in them through the years of the forthcoming solar maximum. The optical set up uses the Czerny-Turner system in the double pass mode. The most attractive feature of this system is that the beams of the first pass and second pass are completely segregated from each other by orienting the optical components suitably. In addition, a system of baffles eliminates any cross talk between the first and second pass beams. Trial scans on NaI D_1 and Hβ line profiles on several occasions show that this instrument is a good near scatter free system. (K.R. Sivaraman, A.P.Jayarajan & R.Kariyappa)

Electronic circuit fabrication

To use the IBM PC effectively, I-O interface cards were designed, fabricated and checked. This card has 120 I-O lines, using 8255s, 6 timer counters using 8254s and an industrial co-processor. An analogue and digital I-O card is under design and fabrication. (V. Chinnapan)

Star and sky chopping polarimeter.

A fast star-and-sky chopping polarimeter (preliminary details reported last year) was completed, and put to regular use for observations. In this instrument, the program star and the neighbouring sky are observed alternately every 20 msec. This helps in reducing the noise due to scientillations as well as slow variations in sky transparency. The analyzer- a polaroid sheet - is rotated about the optical axis of the instrument in steps of 1.8", thereby requiring 200 steps to complete one full rotation. It is, however, possible to choose some other step size which can be specified through software. Signal at each step of the analyzer is recorded for 15 msec for each of the star as well as the sky channels. During observations the signal-to-noise ratio is built up by co-adding signal for a predetermined number of rotations of the analyzer.

A digital interface communicates between a UNICORN microcomputer and the polarimeter. Once the signal is recorded for the desired number of rotations of the analyzer, the raw counts in both the star and the sky channels are printed on the screen as a function of the stepper motor angle. This is a double cosine distribution if the star is polarized. The data is finally stored on a floppy diskette. (S.K. Jain & G.Srinivasulu)

Interferometery

Solid coherence interferometer

The solid coherence interferometer fabrication was completed. The polarisation effects introduced in the two arms due to the total internal reflection are being studied. A method for elimating the problem is being worked out.

For accurate testing of the right angle, base angle and phyramidal errors of these prisms, a method accurate to sub arc second has been developed during the course of the fabrications. This has been described in a paper entitled "Sub arc second testing of a right angle prism" (A.K.Saxena and L.Yeshwanth)

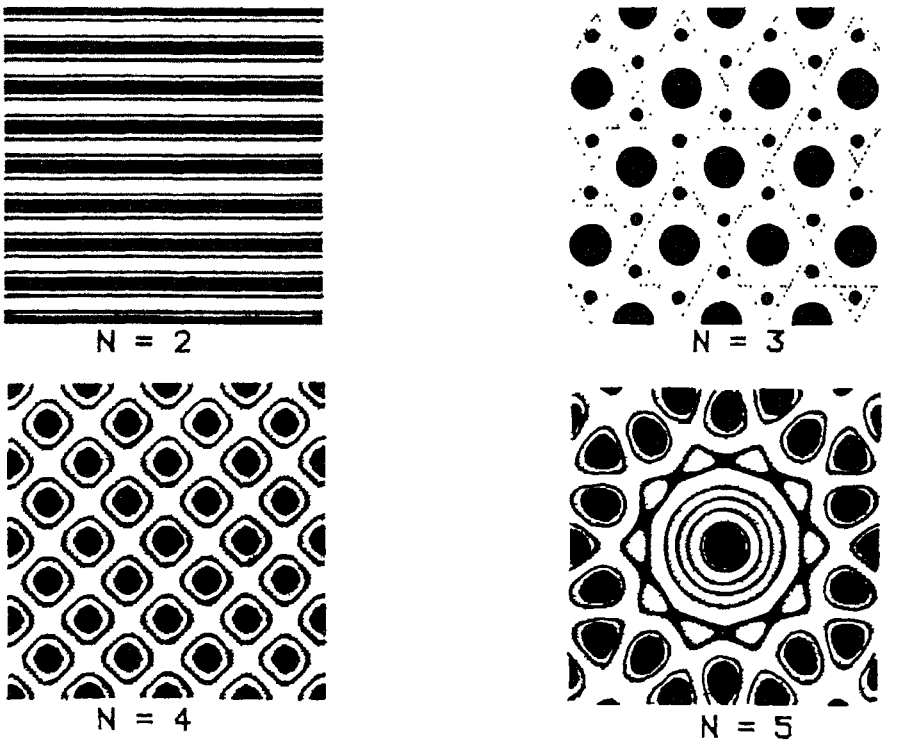


Fig.2 Intensity Distribution for different N values :(a) in absence of diffraction and phase randomness (b) diffraction present but no phase randomness (c) phase randomness present but no diffraction (d) diffraction and phase randomness present.

Wavefort sensing and evaluation

Interferometric method using two crossed Babinet Compensators for online evaluation of the wavefront (surface errors) in situations like active optics system is being developed. A paper demonstrating the method and its advantages has been accepted (A.K.Saxena & J.P.Lancelot)

Optical Interferometry

The temporal power spectrum of atmospherically induced path delay fluctuations between two points on the ground was estimated theoretically for a general orientation of the baseline vector with the direction of motion of the "eddies". For a single velocity of the eddies, the power spectrum is a function of baseline orientation as well as length. However if a spread in the velocities is assumed, then the temporal power spectrum becomes independent of the baseline. It turns out to be proportional to the spatial power spectrum of the fluctuations with the temporal frequency scaling as the product of the mean eddy velocity with the spatial frequency. For very low frequencies, the power is different for eddy motion along the baseline as compared to that for eddy motion perpendicular to the baseline. These results were applied to discuss the requirements of a path delay compensator that must be used in long baseline optical interferometers. (P.Venkatakrishnan)

Multiple telescope interferometry

Numerical study simulations of interference patterns for multiple telescope interferometry were made. Few such patterns are shown in Fig.2. It can be seen that the pattern has a centre of symmetry, located at the centre of the image. Referring to any point on the image by the polar coordinates $(r,\emptyset)$ the pattern repeats for $\emptyset + \emptyset_N$ where $\emptyset_N=2\pi/N$ for N even and $\emptyset_N=\pi/2N$ for N odd.(S. Chatterjee & K.N. Kutty).

Laboratory simulation of multiple aperture synthesis

In view of the growing importance of multiple aperture synthesis in optical astronomy, a laboratory simulation of the same was carried out. Fringes were obtained through the aperture mask of several holes arranged non-redundantly along a circle. To study the structure of the fringes with monospeckle, a laboratory set up consisting of an artificial star along with a telescope were simulated (S.K. Saha & A.P. Jayarajan).

Laboratory studies of atmospheric turbulance

Atmospherically induced phased fluctuations distort otherwise flat wavefronts from distant stars which reach the entrance pupil of a telescope with patches of random excretions in phases. Such phase distortions reduce the effective angular resolution of most telescopes to 1 second of arc, which is comparable to the diffraction limit of a telescope with an aperture of 10 cm or less. To study the effect of turbulence of the atmosphere, laboratory experiments were carried out and successfully obtained the photographs of speckles using different narrow band filters. Seeing was simulated by introducing various static dielectric cells of regular sizes etched in glass plate (S.K. Saha & A.P. Jayarajan).

Optics division

Casting of light weight mirror blanks (CLIMB)

The second casting run could not be successfully completed due to non-availability of uninterrupted power and certain mould defects. In order to overcome these difficulties, following arrangements and improvements for the furnace working have been done.

1. A provision of 37.5 KW Diesel Generator set for uninterrupted power supply during operation.

2. Electrical circuit modification to incorporate star and delta change over for better annealing control.

3. Four additional temperature sensing probes for better monitoring of temperature.

4. Better mould materials and mould making process is being explored and indigenous sources are being tried out.

5. Water blasting unit has been procured and its installation has been completed.

Preparation for the third casting is in progress. (A.K. Saxena, J.C. Bhattacharyya, J. P.A. Samson, R. Ismail Jabilullah and Narasimhappa).

VHRR - Passive cooler fabrication

A set of four sunshield panels for model ETM-1 are in final stages of the completion. Machining of the panel plates after the electroplating was incorporated for time saving and better results. A particle counter, an ultrasonic cleaner and a water filter pump has been received from ISRO for the above work and they are the new additions to the optical shop facilities at Bangalore this year. (A.K. Saxena, M.G. Mohan, S.Razack and J.P.A. Samson).

Other small optics

The 14.5" Cassegrain telescope optics for the Indian Astronomical Society of Calcutta was completed. In addition, the following precision optical components were fabricated for the Institute's use.

1. Dove prism
2. Cylinderical lens
3. 5" flat with two 10mm eliptical holes

CCD Camera guiding unit

A Lyot type depolarizer 15mm diameter is under fabrication. Necessary arrangement for accurate

testing of the optic axis of the crystal was incorporated in the Zygo interferometer. With the present arrangement the optic axis check within a few arc second is possible. (Optics Team).

Vacuum coating facility

The following aluminizing jobs were undertaken during this period.

1. 1m telescope primary mirror and other optics
2. 2.34m telescope cassegrain secondary mirror
3. 14.5" telescope optics (Indian Astronomical Society, Calcutta)
4. 50 small optical accessories including 30 ABAA mirrors
5. Regular evacuation of IR Photometer and CCD Dewars. (K. Ramankutty).

Telescopes

1 - Metre Zeiss reflector

Modifications were made in the drive electronics to improve the performance of the system. The power amplifier for the RA drive was perfected. Three cooling fans were introduced within the plug-in unit, for better heat dissipation of the amplifier unit.

Timing of the system was carried out to give optimum performance. A line-frequency monitor was added in the control cabinet, to indicate the drive frequency accurately. An on/off switch was introduced in the console for switching off the display during observations, if required. The Carl-Zeiss fuse holders were replaced with indigenous ones.

A key switch was introduced in the console for locking-up the system during maintenance phase and also to avoid unauthorised operations. Status-indicator has been incorporated outside the console room, to indicate the 'mains-on', the 'console-on' and the 'maintenance' or 'user' phase status.

During the observing season between October 1988 and March 1989, the control system failed on ten nights and the problems were rectified during the same nights (N.Sivaraj, S.Ramamoorthy, A.Ramachandran).

27" R.C. Telescope

A set of three similar systems are being fabricated. All the three mirrors are in the figuring stage. Parallely the secondary mirrors are also being worked. (A.K.Saxena and Optics Team).

A proposal to build a new medium sized (50 inches fast (f/1.5) telescope has ben submitted to the DST as an Indo-US collaborative project. This telescope is meant for dedicated search for near earth asteroids and planets beyond pluto with a CCD at the focal plane operating in the scan mode. The proposed telescope, unlike conventional Schmidts, will have multi-element correctors closer to the focal plane. The primary will be spherical. This design together with the operation in the scan mode , which dispense with the elaborate drive system, will lead to considerable reduction in costs. (J.C.Bhattacharyya, R.Rajamohan, A.K.Saxena, R.Srinivasan & R.Vasundhara)

76 cm Telescope

The modification required in the gear system in RA and DEC axes to mount the multiturn absolute encoders was carried out. Now the encoder values are within the range of multiturn encoders without data wrap around. (V.Chinnappan & N.Jayavel).

A solid state drive system for Telescopes

An all solid state coelostat drive system for three phase AC synchronous motors has been developed in the electronics laboratory of Indian Institute of Astrophysics. The novel feature of this drive

system includes a digital approach to sine wave synthesis and a digitally programmable frequency setting. The amplitude stability is obtained from a stable temperature compensated reference source and the frequency stability is derived from a crystal source.

The three phase sinusoidal waveform is obtained through the data stored in three EPROMs, driven by a programmable period generator. The digitally obtained sinusoidal output is boosted in power level using solid state Power Amplifiers (Type E M-1812 OOB of Iland Motor). The power amplifier outputs are coupled to the three phase synchronous motor through suitable coupling network.

The major building blocks of the system include:

A. Programmable period-generator
B. Three phase waveform generator
C. Power amplifier and coupling circuits

The system has been installed to drive the first stage motor of the coelostat system at the tunnel telescope at Kodaikanal and is operational since December, 1988. Initially during installation the monitoring of the solar image was carried out for 5 days, during different times of the day. The value of the frequency was adjusted during the day, so that the solar image remained steady in the E-W direction for more than 10 minutes. The value of the thumb wheel switch setting indicates that the same frequency is required during the same part of the day to keep the image steady in the E-W direction. For example, a setting of 47.19 HZ is needed at 10 Hour (IST) to keep the image steady in the E-W direction. While monitoring the solar image, any N-S drift is controlled by a guiding system which adjusts the second mirror, to keep the image steady in the N-S direction. (R.Srinivasan, Jagdev Singh & K.S.Ramamoorthy).

Radio group

The construction of the south array of the broad band 'T' is completed. This array consists of 64 log periodic dipoles usable in the frequency range 30-150 MHz. The dipoles are spaced 7.0 metres apart and the total length of the array is 0.45 km.

An acousto optic spectrograph with a bandwidth of 30 MHz is installed. The number of channels is 1760, giving a frequency resolution of about 30 KHz. The spectrograph is interfaced via an A/D converter and a memory bank to a VAX 11/730 computer. All its 1760 channels are scanned every 250 ms and the data are recorded either on the user disk or the computer or magentic tape.

A VLBI receiving system (using Rb oscillators) with a bandwidth of 50 KHz and a recording rate of 250 KHz is constructed and being tested (Ch.V.Sastry).

Ionospheric group

Fabry-Perot Spectrometer

Steady progress was made on the development of this experiment funded by ISRO, in line with the work plan drawn out. Vital components of the spectrometer such as the FP etalon, PMT housing and PMT were imported. The design of the spectrometer was frozen and fabrication of the mechanical units of the experiment was taken up (J.H.Sastri, A.K.Saxena, R.Sridharan, K.B.Ramesh & J.P. Lancelot).

HP Phase path (Doppler) sounder :

The HP Doppler sounder is equipped with a multi-aerial recording facility and regular observations are made with the augmented system at Kodaikanal. Software for the PC/XT based 16 channel digital data acquisition system (DAS), which was written earlier in assembler language had been recorded in a higher level language (Modula-2) for smooth maintenance. The new version of the software has been validated. DAS will be integrated with the doppler sounder at Kodaikanal in May 1989. (J.H.Sastri, A.V.Ananth & K.B.Ramesh).

National Facilities

2.34m V B T

Observing programs

CCD imaging in various narrow and wide filters at the prime focus of VBT were made. The CCD images of planetary nebulae (NGC 3242, NGC 6392, A 58 etc), star forming regions, galactic and globular star clusters (NGC 6401, NGC 1843, NGC 2818) and galaxies were obtained. Analysis of the data is in progress. (R. Surindranath, N.K. Rao, K.K. Ghosh, G.S.D. Babu, Ram Sagar, J. S. Nathan)

Scanning for asteroids

The CCD in the scanning mode for imaging asteroids was successfully developed and tested at the prime focus of the VBT. In this mode, the telescope is kept stationary and therefore the image of the sky moves across the CCD due to the earth's rotation. The charges created in the CCD pixels by the image is shifted in synchronism with its movement across the CCD and then read and stored in a PC. The scanning mode for imaging with a CCD has been developed and all control commands are generated through a PC. The data can be subsequently transferred to tape for image processing and analysis.

The image scale at the prime focus of the 2.34m. telescope is 27"/mm. Three pixels at a time were combined to achieve perfect synchronisation. This is equivalent to reducing the resolution from 0.6 arc seconds per pixels to 1.8 arc seconds per pixel. (J.C. Bhattacharyya, R. Srinivasan & R. Rajamohan)

Optics

The aluminized secondary mirror is awaiting installation in the telescope of the mirror cell and focusing arrangement.

The focusing arrangement was inspected and tested at M/s. Vani Machine Tools, Hyderabad for its axial movement. After incorporating minor changes, the residual uncertainty in the plane of the mirror due to focusing movement of the mirror alone is expected to be within 3-5". (A.K. Saxena & J.P.A. Samson)

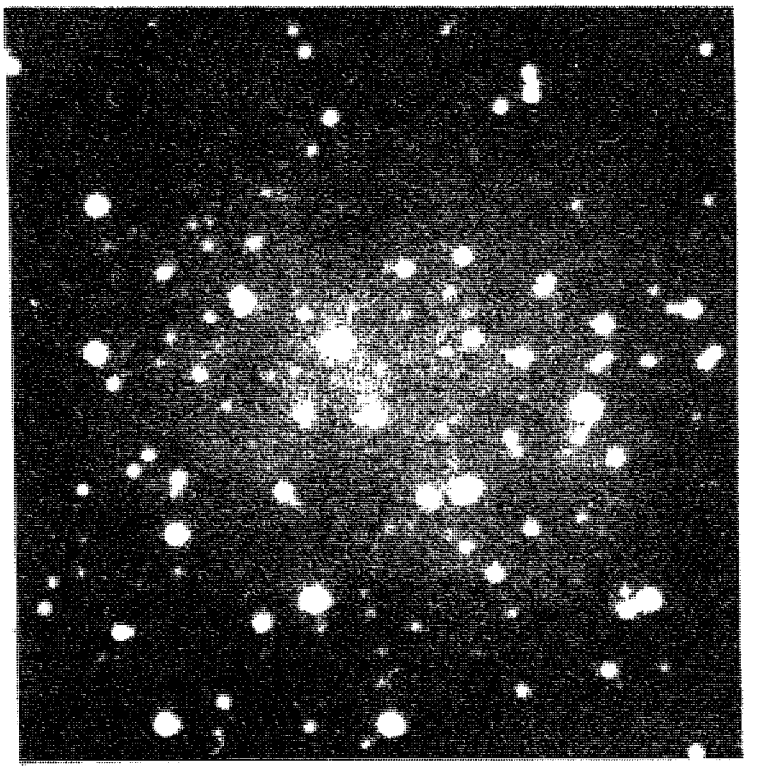
Remote guiding unit

Encouraging progress was achieved in the design and fabrication of a remote guiding camera for VBT. The proposed intensified CCD camera is intended for picking up the star field for guiding at either focus from the console. This camera preceded by a high gain microchannel plate works at the normal 50Hz television rate. An IBM compatible personal computer (PC) grabs and digitises the frames from the camera allowing image processing operations in real time. (V. Chinnappan, K.K. Scaria & N. Kamsewara Rao)

Operation

The 2.34m VBT was working very satisfactorily and several trial and regular observations were carried out using the liquid nitrogen cooled CCD at prime focus. Unguided exposures upto three minutes even near horizon gave steady images. During this year of operation problems which cropped up during regular use were sorted out after thorough investigation. Some of the problems encountered and the remedial action taken are described below:

It was noticed that image moved by upto a few arc second. This was traced to a defective incremental encoder in the RA axis, which used to behave unpredictably. This encoder was replaced by a new spare encoder. The up-down counter



CCD image taken with VBT in scanning mode with the drive off. Effective exposure time · 24 s

logic was picking noise occasionally even though this was not seen in previous years. Filtering of these digital noise and spikes at the up-down counter input solved the problem. A power amplifier which failed during operation of the telescope was replaced by a new one.

The control for focus motor is being finalised. The system will be installed in VBT in the near future.

In order to use the VAX 11/780 for instrument control and for pointing and error analysis, programs are being written. (R. Srinivasan, V. Chinnappan, M. Madhava Rao).

Mechanical engineering group

Modified guide wheel

12 sets of modified guide wheel assembly for the Vainu Bappu Telescope dome, fabricated and machined in IIA Mechanical Laboratory, is ready to be fitted on to the dome drive system.

Prime focus photometer

The prime focus photometer guiding unit has been modified to provide greater scope for selecting the guide star before the diaphram and after the diapharm.

Camera unit of CCD observation

A new camera unit which is suitable for CCd's with a provision to guide with a fiber scope has been completed for Vainu Bappu Telescope Prime Focus observation (F. Gabriel)

Position Angle Device

Position Angle Device for the Vainu Bappu Telescope Cassegrain focus was designed by Messrs Tekcons in consultation with IIA Scientists and Engineers.

Instrument cell and PDS

The instrumentation cell offers a facility for designing and constructing astronomical instruments through a centrally located team. Table 1 gives some of the main projects undertaken by this cell during 1988-89.

The PDS was used extensively for a variety of projects, the details of which are given in Table 2

Table 1

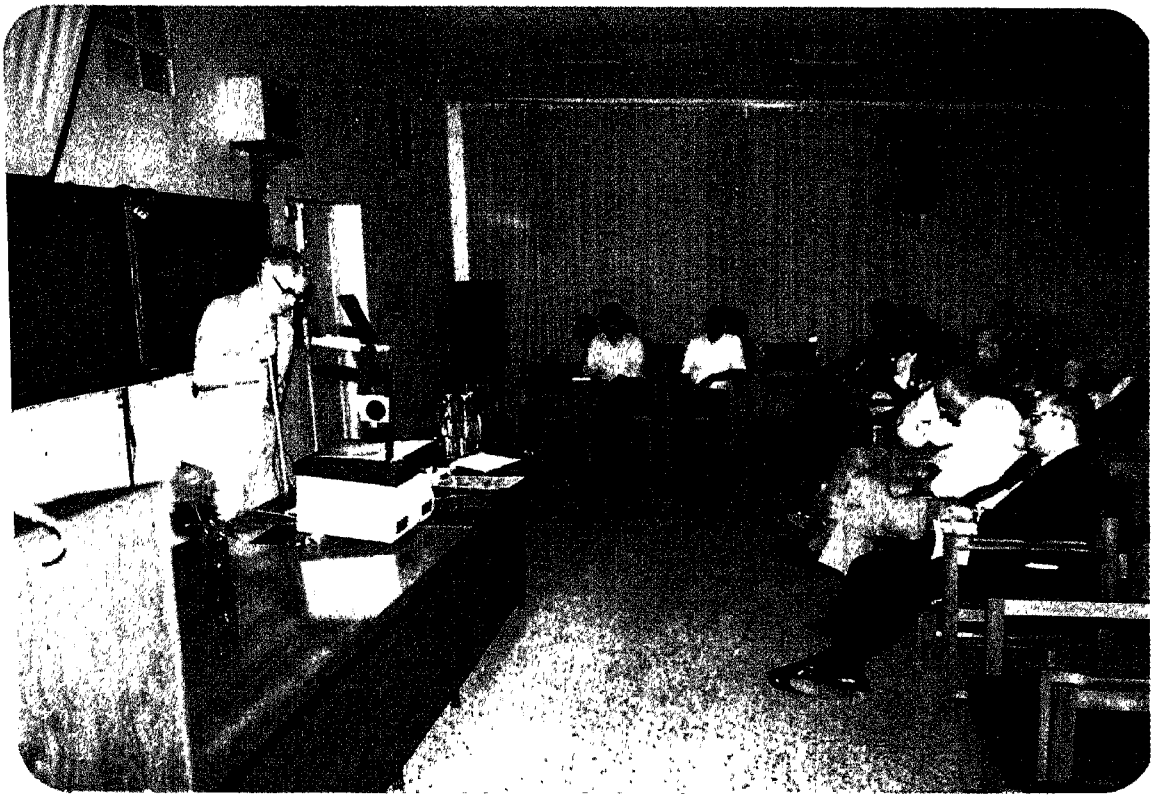
Jobs undertaken by the instrumentation cell during 1988-89

Sl.No.	Details of proposal	Status of work
1.	Design and constructionof Cass. focusing unit for VBT	Fabrication completed; installation under progress
2.	Double pass monochrometer for solar research	Alignment completed on 15 Nov.1988
3.	CCD mounting unit for the 30" Telescope at VBO	Design completed on 31st May 1989
4.	Design and fabrication of echelle spectrograph for the coronograph	Preliminary design under consideration
5.	Study of vibration problem, slow speed working of second mirror mount of Kodaikanal coelostat and modification of grating mount	A study of vibration problem made and a report prepared. Slow speed mechanism being rectified. Grating mount being designed for regd. ratio & accuracy.
6.	Duplication of prime focus photometer assembly for the 2.34m VBT	Fabrication completed
7.	Replacement of encoder with speed reducer and potentiometer kits at movable counterweight of VBT	Fabrication completed
8	Fabrication of solid state drive system for UP State Observatory	Work commenced
9.	Modification of coronograph mounting, tube	Design work started

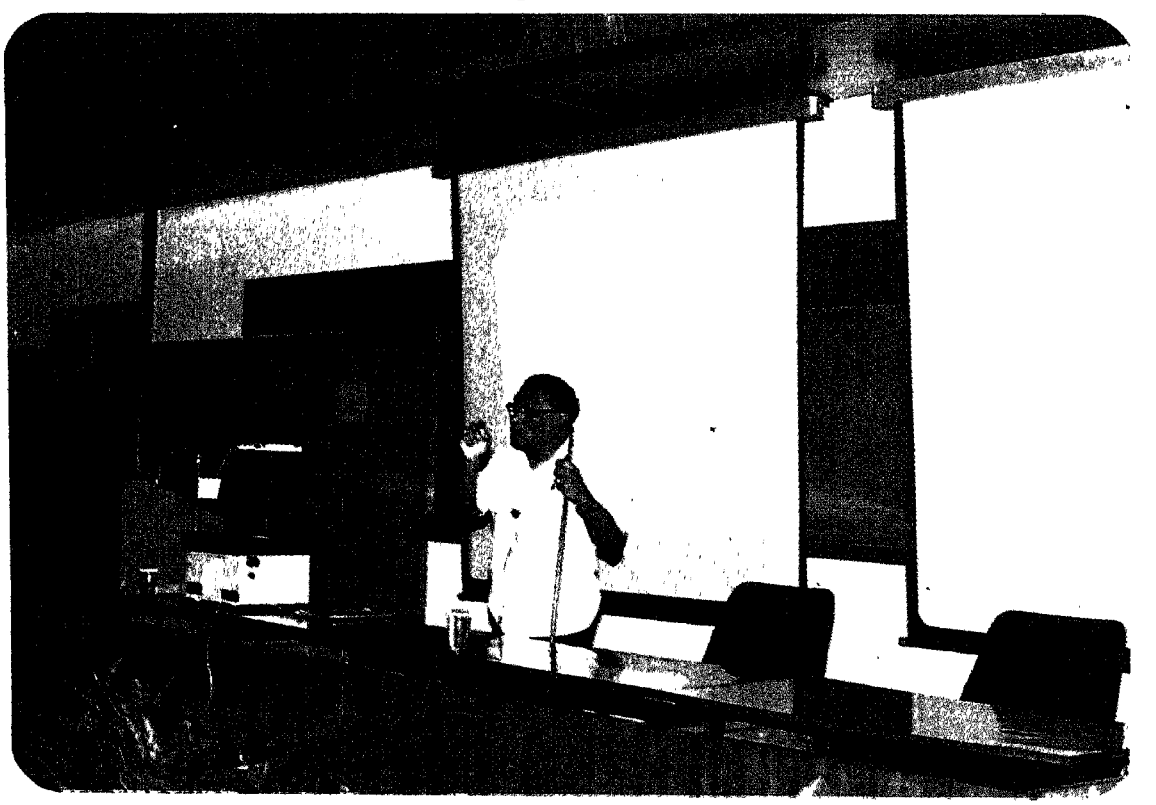
Table 2

Jobs done on the PDS during 1988-89

Sl.No.	Nature of project
1.	Intensity interferogram evaluation for optical testing
2.	Time sequence spectroscopy in the Ca^+ K-line of the solar chromosphere to study the dynamical properties of the arc second structures in the solar chromosphere
3.	Study of the solar cycle related variations in the emission from the Ca^+ K-line in the sun seen as a star
4.	Photometry of solar chromosphere to estimate the Ca+ K network brightness variations over a solar cycle
5.	Digitization of Kodaikanal Ca II K spectroheliogram for study of global magnetic oscillation of the Sun and of the time-variation of solar differential rotation
6.	Spectroscopy of Ca^+ K-line spectra obtained at Kodaikanal for the studies of sun to determine chromospheric rotation, differential rotation and variation of rotation with time
7.	Spectrophotometry of semi regular F type stars of high galactic latitude
8.	Spectrophotometry of long period classical cepheid variables
9.	Spectroscopy of the late G and K supergiants to study line asymmetries
10	Spectroscopy of hydrogen deficient stars
11	Spectroscopy of chemically peculiar stars to discover spectral line variability
12	Spectrophotometry of classical and recurrent novae : i) to study temporal spectral evolution and determine the physical conditions in the nova ejecta. ii) to study spectral variations during quiescence in an attempt to study the binary system
13.	Spectroscopy of supernovae during their outbursts to study the spectroscopic evolution and intrinsic difference between individual supernovae belonging to a given spectral class
14	Spectroscopy of member of young clusters and association for spectral classification
15	Spectroscopy of supernovae
16.	Spectroscopy of galaxies and standard stars for population synthesis



Professor A Hewish, F.R.S. delivering the CSIR distinguished lecture at the Institute



Professor C.N.R. Rao, F R.S delivering the third IIA bicentennial lecture

Growth of Astronomy

General

Observing conditions for optical astronomy at Leh

The sky and atmospheric conditions at Leh have been monitored since 1984 to determine its suitability as a site for a high altitude observatory. During the period 1987 May - November some atmospheric parameters were monitored such as relative humidity, and other parameters, giving qualitative indices such as photometric and spectroscopic hours and seeing conditions throughout the non-winter months. Extinction coefficients in U B V bands have been measured on 30 nights in 1987. The average values of extinction coefficients are $k_v = 0.18 \pm 0.05$, $k_b = 0.28 \pm 0.04$ and $k_u = 0.53 \pm 0.04$. These values agree well with those reported earlier for 1985-86, and appear to represent consistent conditions (J.C. Bhattacharyya & J. Singh)

The astronomy gallery for visitors

As the Institute is frequently visited by school children and the general public, a gallery is being developed at the Bangalore campus to popularise astronomy. The highlights of interest and activities pursued at Kavalur, Kodaikanal and Gauribidanur and some of the major findings are presented through various displays, showing celestial objects as well as the laboratories of the Institute. These deal with topics ranging from the sun and the solar system to the extragalactic systems.

The gallery has on display some original papers and photographs of John Evershed along with his correspondence with A.S. Eddington, R.H. Fowler and William Huggins. For instance, there is a letter from the Royal Society dated May 14, 1915 informing him of his election as Fellow and another one from King George the Fifth, dated June 2, 1923, upon conferment of the Companion of the Most Eminent Order of the Indian Empire.

The awards and recognitions received by the late Prof. M.K.V. Bappu have also been displayed. (R.C. Kapoor & A. Vagiswari)

National science day

The Institute took part in the science exhibition of the Department of Science & Technology during 6-18 Jan 1989 at Madurai to concur with the 76th Session of the Indian Science Congress. The exhibits and the video film shows on astronomy were a great attraction for the general public and school children (R.C. Kapoor)

On February 28, 1989, the Institute participated in the countrywide celebrations of the 'National Science Day' by observing an Open House Day for the general public.

An exhibition and video film shows on the activities and interests of the Institute were organized for the benefit of visitors, scientists and school children. (R.C. Kapoor & A. Vagiswari)

Awards/Honours

J.C. Bhattacharyya has been elected as the Vice President of the International Astronomical Union (IAU) Commission 9 'Instruments and Techniques'. He was also elected as a Fellow of the National Academy of Science, Allahabad and as a member of the Editorial Board of Astrophysics and Space Science.

C. Sivaram's paper entitled 'Super d-brane defects in the early universe' received honourable mention in the Gravity Research Foundation (Mass. U.S.) competition.

Several scientific staff members of the Institute became members of various commissions of the International Astronomical Union (IAU).

Visitors

1216 students of 17 Schools and 13 Colleges were shown around the Vainu Bappu observatory at Kavalur. Another 640 people from various Institutions were also shown around the observatory. All these persons were able to observe the night sky through the 6" telescope at VBO.

28 summer school students from Bangalore visited the Vainu Bappu Observatory at Kavalur.

Lectures/Colloquia by visiting scientists

R.E. Nather (Astronomy department, University of Texas, at Austin, USA)

Interacting collapsed objects (8.8.88)

P.R.K. Rao (BARC, Bombay):

Isotope shift studies and isotope separation by laser techniques (4.11.88).

R. Nithyananda (RRI, Bangalore)

Phase problems in Astronomy (9.11.88).

P.R.K. Rao (BARC, Bombay)

Lasers and spectroscopy (15.11.88)

S. Sudhakaran (Department of Physics, Sree Narayana College, Quilon) :

The problem of initial singularity (29.11.88).

A. Sharma (Department of Physics, King's College, London) :

Imaging photon detectors and their performance (23.12.88)

A.M. Soward (University of Newcastle, London)

Geodynamo theory (4.1.89)

S.M. Alladin (Astronomy department, Osmania University, Hyderabad) :

Galaxy interaction and consequent evolution (6.1.89)

K. Shivanandan (Naval Research Laboratory, Washington D.C. USA) :

Infrared observation of northern/southern dark clouds and optical/IR emissions from peculiar cometary nebulae (10.1.89)

D. ter Haar (University of Oxford, U.K.) :

My life as an astrophysicist - Astrophysics as the last bastion of the generalist (23.1.89)

-: Ball lightning (25.1.89)

-: Turbulence in fluids and plasmas (27.1.89)

M. Makita (Kwasan and Hida Observatories, Kyoto, Japan) :

Broad-band polarisation in Sunspots (9.2.89)

K.D. Abhyankar (Department of Astronomy, Osmania University, Hyderabad) :

Vedanga Jyotish (9.3.89)

R. Howard (National Scholar Observatory, Tucson, USA) :

The magnetic fields of solar active regions (10.3.89)

S. Kulkarni (California Institute of Technology, Pasadena, USA) :

Optical aperture synthesis (20.3.89)

P.A. Scheuer (Cavendish Lab. University of Cambridge, UK) :

Magnetic fields in radio galaxies (21.3.89)

Drs. J.E. Solheim, V. Bumba, Lynden Bell, R.Howard, E.E. Salpeter and T. Gehrels visited the Institute and the Vainu Bappu Observatory at Kavalur.

Ph. D. program

K.S. Balasubramaniam was awarded the Ph.D. degree for his thesis entitled

Stokes polarimetry and the measurement of vector magnetic fields in solar active regions.

G. Thejappa was awarded the Ph.D. degree for his thesis entitled

The Radio Bursts from the outer Corona.

A.K. Pati submitted his thesis entitled

A study of the stellar population in galaxies from integrated spectra.

R.T. Gangadhar, P.S. Joardar and Y. D. Mayya from the JAP programme are continuing their research work for the Ph.D. degree.

Annamma Matthew, K. Gangadharmurthy, M.F. Ingalgi and Prasannalakshmi are doing research work for the Ph.D. degree under the faculty improvement program of the U.G.C

G.C. Anupama, research scholar is continuing her research work for the Ph.D. degree.

Conferences/Lectures

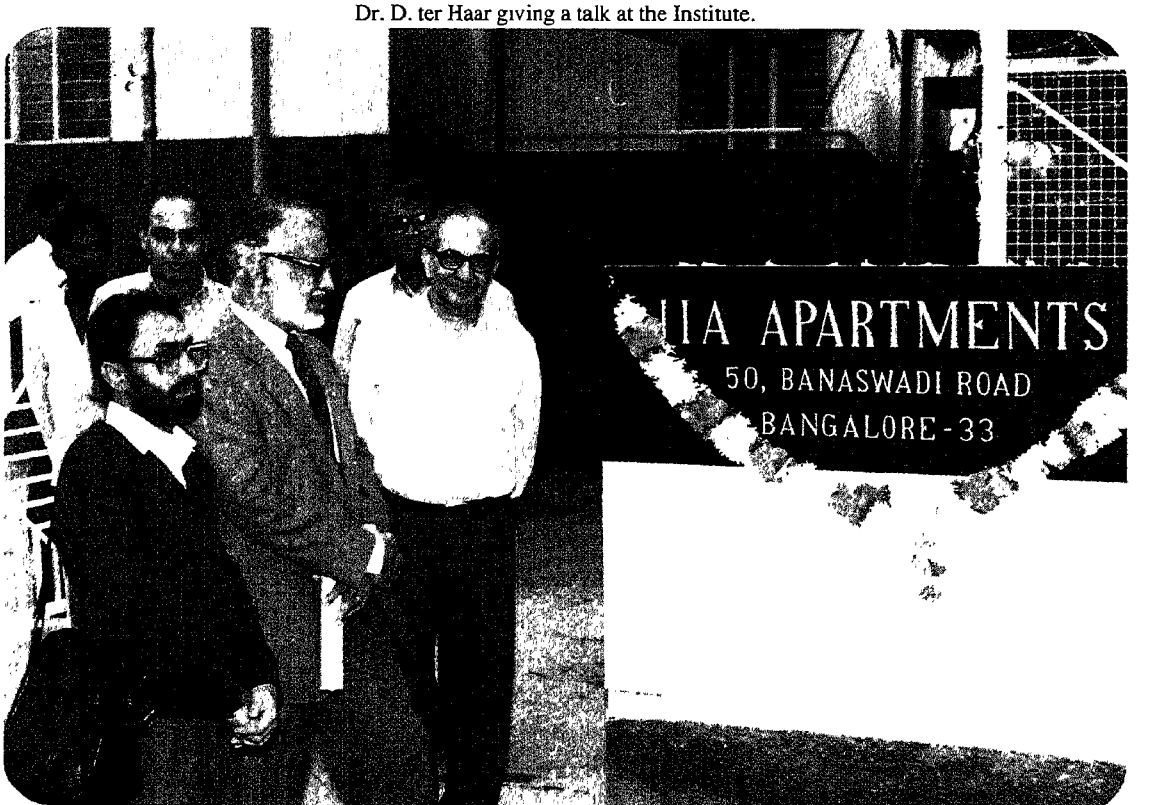
The third IIA bicentennial commemorative public lecture was delivered by Prof. C.N.R. Rao, Director, Indian Institute of Science, Bangalore, on *Super conductivity today* at Bangalore on January 30, 1989.

Prof. A. Hewish, FRS Cavendish laboratory Department of Physics, University of Cambridge, UK visited the Institute and delivered on January 9, 1989 the CSIR distinguished lecture entitled *Can we observe the origin of structure in the Universe?*

The Institute sponsored and took part in the organisation of the school and workshop on

Supernovae and stellar evolution, Goa, March 10-17, 1989.

Dr. D. ter Haar giving a talk at the Institute.

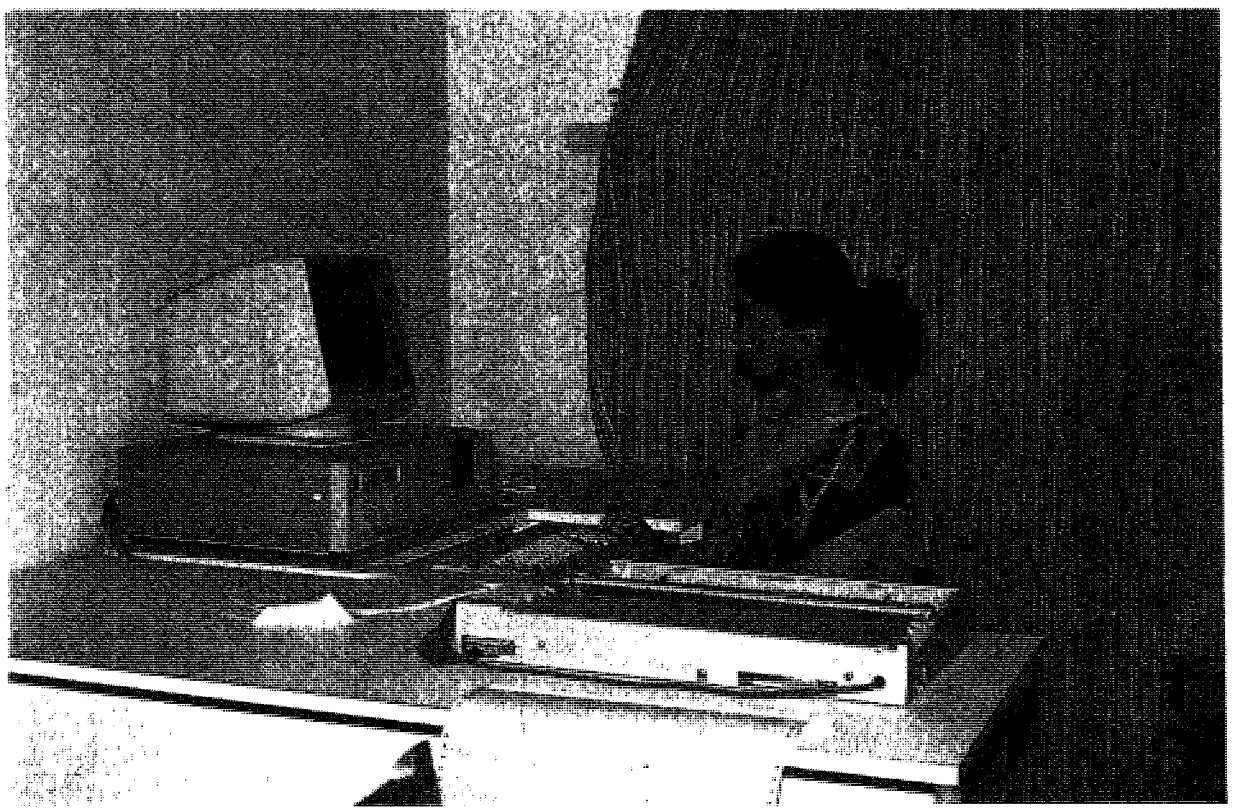


Professor M.G.K. Menon, Chairman of the Governing Council inaugurating the new residential complex

Library

The library subscribed to 142 journals with the addition of two new journals, Astronomy and Astrophysics Review & Journal of Pure and Applied Physics. It continued to receive some 65 publications on an exchange basis. An inter-library exchange with other astronomical libraries in the city helps it to display an additional 20 journals. During the year, 265 books were acquired for the library. The library extends a current awareness service through Recent Research in Astronomy & Astrophysics & the IIA preprint lists. Xerox copies of IAU Telegrams & IAU Circulars were mailed to 10 astronomical libraries.

Some additional books & journals were procured as second copies for the Kavalur & Kodaikanal libraries. The library has acquired a personal computer which is being used for library operations. Reference facilities are extended to outside research workers and scientists. Xerox copies of articles from the collection at the Institute were also supplied to other libraries.



The recently acquired personal computer

Staff List

(in March 1989)

Academic Staff

J. C. Bhattacharyya	Director
M. H. Gokhale	Professor
A. Peraiah	Professor
Ch. V. Sastry	Professor
G. A. Shah	Professor
K.R. Sivaraman	Professor
S. S. Hasan	Associate Professor
R. K. Kochhar	Associate Professor
V.Krishan	Associate Professor
N.K.Rao	Associate Professor
J.H.Sastri	Associate Professor
P.K.Das	Reader
B.Datta	Reader
R.C.Kapoor	Reader
D.C.V.Mallik	Reader
M.Parthasarathy	Reader
T.P. Prabhu	Reader
R.Rajamohan	Reader
P.K.Raju	Reader
R.Sagar	Reader
A.K.Saxena	Reader
K.K.Scaria	Reader
J.Singh	Reader
C.Sivaram	Reader
P.Venkatakrishnan	Reader
G.S.D.Babu	Fellow
S.P.Bagare	Fellow
H.C.Bhatt	Fellow
S.Chatterjee	Fellow
K.K.Ghosh	Fellow
S.K.Jain	Fellow
A.K.Pati	Fellow
A.V.Raveendran	Fellow
B.S.Shylaja	Fellow
K.R.Subramanian	Fellow
G.Thejappa	Fellow
P.S.M.Aleem	Research Associate
S.Giridhar	Research Associate
S.S.Gupta	Research Associate

R.Kariyappa	Research Associate
S.V.G.Mallik	Research Associate
D.N. Rao	Research Associate
S.Mohin	Research Associate
B.S.Nagabhushana	Research Associate
K.N.Nagendra	Research Associate
P.M.S.Namboodiri	Research Associate
R.S.Narayanan	Research Associate
K.B.Ramesh	Research Associate
K.E.Rangarajan	Research Associate
S.K.Saha	Research Associate
K.Sasidharan	Research Associate
K.Sundar Raman	Research Associate
R.Surendranath	Research Associate
J.P. Lancelot	Research Associate
R.Vasundhara	Research Associate

Technical staff

A.P.Jayarajan	Consultant
R.Srinivasan	Head, Electronics Labs. & Computer centre
A.V.Ananth	Senior Electronics Engineer
V.Chinnappan	Senior Computer Engineer
B.R.M. Rao	Senior Mechanical Engineer
N.Selvavinayagam	Civil Engineer
R.Sivashanmugam	Technical Officer
G.Srinivasulu	Computer Engineer
S.S.Chandramouli	Technical Associate
A.N.Ghouse	Technical Associate
A.T.A. Hameed	Technical Associate
H. N. Manjunath	Technical Associate
R.Muraleedharan Nair	Technical Associate
K.Narayanankutty	Engineer Associate
K.Ramankutty	Technical Associate
K.S.Ramamoorthy	Technical Associate
J.P.A.Samson	Technical Associate
K.G.Unnikrishnan Nair	Technical Associate
A.Vagiswari	Librarian

Visiting Scientist

S.K.Burman

Appendixes

Appendix A

Research publications

*Anandarao,B.G., * Banerjee,P.K., * Desai,J.N. Jain, S.K., Mallik,D.C.V., (1988) Mon. Not. R. Astr. Soc., **235**, 221. *Morphology of the bipolar planetary nebula NGC 2346 from emission line profile studies.*

Anupama,G.C., Prabhu,T.P. (1989) J.Astrophys. Astr,. **10**, 237. *The 1985 outburst of RS Ophiuchi: Spectroscopic results.*

*Arellano Ferro,A., Giridhar,S., * Chavez,M., * Parrao,L. (1989) Astr. Astrophy., **214**, 123. *A photometric study of F-type stars of high galactic latitude.*

Babu, G.S.D. (1988) J.Astrophys. Astr., (in press). *A study of faint young open clusters as tracers of spiral features in our Galaxy.* Paper 4: Czernik 20 (OCl 427).

Babu, G.S.D. (1988) Vistas in Astronomy, **31**, 527. *Detection of a branching-off feature from the Cygnus-Orion arm in the direction of Carina.*

Bagare,S.P., Nagabhushana,B.S., Aleem,P.S.M. (1989) Bull. Astron. Soc. India (in press). *Transient activity in the loop prominance system of a flare active region.*

Bhatt. H.C (1988) Kodaikanal Obs. Bull., **10**,33. Supernova 1987 A in L M C : Infrared observations.

Bhatt,H.C. (1989) Astr.Ap., **214**, 331. *Cn 1-1: a bipolar type I planetary nebula.*

Bhatt,H.C. (1989) Astr.Ap., **213**, 299. *Capture of field stars by molecular clouds.*

Bhatt,H.C. (1988) IAU Symp. 135 (in press). *Polarization due to dust scattering in the planetary nebula Cn 1-1.*

Bhatt,H.C. Datta,B. (1989) Mon. Not. Roy. Astr. Soc., **237**, 1033. *Supernova SN 1987A : Rotation rate of the central pulsar.*

Bhattacharyya, J.C. (1988) Science & Culture, **54**, 354. *Astrophysics and small observatories.*

Bhattacharyya,J.C. (1989) Indian Journ. of Pure & Applied Phy. (in press). *Optical telescopes in India.*

Bhattacharyya,J.C., Scaria,K.K., Singh,J., Babu,G.S.D., Muraleedharan Nair,R., Sivaraman,K.R. (1989) Bull. Astron. Soc. India (in press). *Atmospheric extinction measurements at Leh in near infrared bands.*

Chatterjee,S., *Gopal,E.S.R. (1988) J.Phys., **49**, 675. *Effect of capillary waves on the thickness of wetting layers*

Das,P.K. (1989) Astrophys. Space Sci., (in press) *Quasar models in the Hoyle-Narlikar cosmology*

Datta, B. (1988) Kodaikanal Obs. Bull., **10**, 107. *Equation of state of supernova matter.*

Datta,B., *Raha,S., *Sinha,B. (1988). Modern Phys. Lett. A 3, 1385. *On the neutrino emissivity of degenerate strange quark matter.*

Datta,B., *Raha,S., *Sinha,B. (1988) Nuclear Phys., A **490**, 733. *Photon and dimuon pairs in an expanding quark gluon plasma.*

*De Sabbata,V., Sivaram,C. (1989) Nuovo Cimento **101A**, 273. *Strong spin torsion interaction between spinning protons.*

*De Sabbata,V., Sivaram, C., (1988) Nuovo Cimento B (in press). *Neutrino emission from supernovae in presence of torsion.*

*De Sabbata,V., Sivaram,C., (1988)Nuovo Cimento, **102B**, 107. *Magnetic fields in the early universe.*

*De Sabbata,V., Sivaram,C. (1988) Nuovo Cimento **100A**, 919. *Strong gravity as the connecting link underlying universal relations between angular momentum of celestial bodies and spin of elementary particles.*

*Dwivedi,B.N., Raju,P.K. (1989) Adv. Space Res., **8**, 179. *Density diagnostics of solar emission lines from Nitrogen-like ions.*

Ghosh,K.K.(1989) Astrophys. Space Sci., (in press) *Activity in two Be stars: HR 7403 and HR 8762.*

Ghosh,K.K.(1989) Mon. Not. R. Astron. Soc., (in press). *Search for rapid V/R variability in* η *Cen.*

Ghosh,K.K. (1989) Publ. Astron. Soc. Pacific (in press). *Search for rapid spectral variability in* ψ *Aurigae*

Ghosh,K.K. *Apparao,K.M.V., *Tarafdar,S.P. (1989) Astrophys. J. (in press). *Observations of an* $H\alpha$ *outburst in the Be star HR 4123.*

Giridhar,S., *Arellano Ferro,A. (1989) J. Astrophys. Astr., **10**, 47. *An internally consistent set of oscillator strengths of Fe I lines.*

*Hagyard,M.J , Venkatakrishnan,P., *Smith,J.B. (1989) Astrophys. J.Suppl. Series (in press). *Non-potential magnetic fields and gamma ray flares.*

Hasan,S.S (1989) in AGU Monograph on "Physics of Magnetic Flux Ropes", eds. E.Priest & C.T.Russel (in press). *Dynamical effects and energy transport in photospheric flux tubes.*

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Jain,S.K., *Smyth,M.J. (1988) Bull. Astron. Soc. India, **16**, 192. *A rapid scan fourier transform infrared spectrometer.*

*Jayachandran,B., *Namboodri,S.P., Balan, N., *Rao,P.B., Sastri,J.H. (1989) Proc. IEE (London) (in press). *HF doppler radar observations of equatorial plasma drifts and spread - F.*

*Koparkar,P.V., Sastri,J.H., *Rastogi,R.G.(1989) Indian J. Radio Space Phys., (in press). *Daytime equatorial VHF radio wave scintillations and sporadic-E layer.*

Krishan,V. (1988) Kodaikanal Obs. Bull., **10**, 1. *Introduction to supernovae phenomenon.*

Krishan,V. (1988) Mon. Not. R. Astr. Soc., **234**, 79. *Scattering of quasar radiation in inter-cloud plasma*

Krishan,V. (1988) J.Astrophys. Astr., **9**, 231. *One more explanation of superluminal motion*

Krishan,V. Sastry,Ch.V.(1988) Solar Phys., **119**, 415, *Second national workshop on solar physics, Indian Institute of Astrophysics, Kodaikanal*

*Krishna Swamy, K.S., Shah,G.A. (1988), Mon. Not. R. Astr. Soc., **233**, 573. *Nature of dust grains in comets.*

*Makarov,V.I., Sivaraman,K.R. (1989) Solar Phys. **119**, 35-44, 1989. *Evolution of Latitude*

zonal structure of the large-scale magnetic field in solar cycles.

*Makarov,V.I., Sivaraman,K.R. (1989) Solar Phys., (in press). *New Results concerning the global solar cycle.*

*Makarov,V.I., Sivaraman,K.R. (1988) Solnechnye Dannye (in press). (in Russian) *On correlations of polar faculae and polar bright points in Ca II with sunspot activity on the sun.*

Mallik,D.C.V., *Peimbert,M. (1988) Rev. Mex. Astron. Astrof. **16**, 111. *Filling factor determinations and their effects on planetary nebula studies.*

Mekkaden,M.V., *Sinachopoulos,D. (1988) IBVS No. 3228. *Photometric variability of HD 81410 in 1988.*

*Mohan,V., Sagar,R. (1988) Bull. Astr. Soc. India, **16**, 159. *Field star contamination in open star cluster NGC 2301.*

Mohan Rao,D., Rangarajan,K.E., Peraiah,A. (1989) Astrophys.J., (in press). *Effect of the time spent by the photon in the absorbed state on the time-dependent transfer of radiation.*

Mohin S. ,Raveendran,A.V. (1989), J.Astrophys. Astr., (in press), *BV Photometry of UX Arietis.*

Nagendra, K.N. (1988) Astrophys. J., **335**, 269. *Resonance line polarization in spherical atmospheres.*

Nagendra,K.N. (1989) Astrophys. Space Sci., (in press). *Polarization of resonance lines formed in extended spherical atmospheres.*

Namboodiri,P.M.S., Kochhar,R.K. (1989) Astrophys. Space Sci., (in press). *Energy exchange during collision of a pair of disc sphere galaxies.*

*Pandey,A.K. *Bhatt,B.C., *Mahra,H.S., Sagar,R. (1989) Mon. Not. R. Astron. Soc., **236**, 263. *Integrated parameters of open star clusters.*

Parthasarathy,M. (1988) IAU colloquium No.106 (in press). *Possible proto-planetary nebulae.*

Parthasarathy,M. (1988) IAU, Highlights of Astronomy *(in press). The far-infrared (IRAS) excess in Roberts 22 and related objects.*

Parthasarathy,M. (1988) IAU colloquium No.107 (in press). *The dust shell around V718 Sco.*

Parthasarathy,M., Bhatt,H.C. (1988) IAU Colloquium No.106 (in press). *IRAS observations of symbiotic stars.*

Parthasarathy,M., Jain,S.K. (1988) IAU Symposium No.135 (in press). *Additional red and reddened stars in Cyg OB2 association.*

Pati,A.K. (1988) Ph. D. Thesis, Bangalore University. *A study of the stellar populations in galaxies from integrated spectra*

Peraiah,A. (1989) Kodaikanal Obs. Bull., (in press). *Effects of aberration and advection on partial frequency redistribution of photons in spectral line formation.*

Peraiah,A., Rao,M.S. (1989) Bull. Astron. Soc. India (in press). *Effects of aberration and advection in a partially scattering medium.*

Peraiah,A., Varghese,B.A. (1989) Solar Phys., (in press). *On the coronal lines λ 5303 and λ 6374.*

Prabhu,T.P. (1988) Kodaikanal Obs. Bull., **10**, 15. *SN 1987A: Light curves and inferences.*

Prasannalakshmi., Gokhale,M.H. (1988) Solar

Phys. **114**, 75. *Equilibrium of a thin isolated axisymmetric force free magnetic flux tube in a stratified atmosphere - I.*

*Raghu,M., *Subramanyam,S.V., Chatterjee,S. (1989) Solid State Communications, **69**, 949. *Pressure induced incommensurate to commensurate tranistion in $K_3 C_{48} 56$.*

Rajamohan,R., Paranjpye,A. (1989) Inf. Bull. Variable Stars., **3284**. *The spectrum variable HR 7817.*

Raju,P.K. (1989) Bull. Astr. Soc. India (In Press). *Emission line diagnostics for a coronal condensation*

Rangarajan,K.E., Mohan Rao,D., Peraiah,A. (1989) Astron. Astrophys., (in press). *Effects of emission profile on spectral line formation.*

Rao, N.K. (1988) Kodaikanal Obs Bull., **10**, 25. *Evolution of the optical spectrum of SN 1987A.*

Rao,N.K., Giridhar,S., *Ashoka,B.N. (1989) Proc. IAU Coll. 106 (in press). *Absorption spectrum of R Cr B during the light minimum.*

Raveendran,A.V., Rao, N.K.(1989), Astr. Astrophys., **215**, 63. *Long-term polarimetric behaviour of the carbon Mira R Leporis.*

Raveendran,A.V.(1989), Mon. Not. R. Astr. Soc., **238**, 945. *Dust envelopes around RV Tauri stars.*

Raveendran,A.V.,Rao.,N.K *Anandaraman, M.N. (1989) Mon. Not. R. Astr. Soc., (In press). *Polarimetric and photometric study of RV Tauri star AR Puppis*

Sagar,R., Bhatt,H.C. (1989) Mon. Not. R. Astr. Soc., **236**. 865. *Internal Kinematics of open star clusters.*

Sagar,R., Bhatt,H.C. (1989) Bull. Astr. Soc. India **17**, (in press) *Internal motions in the open star clusters NGC 654 and 6087.*

Sagar,R., Pati,A.K. (1989) Bull. Astr. Soc. India **17**, (in press). *Photometric performance of the CCD detector at the 102cm reflector at VBO.*

Saha,S.K., Jayarajan,A.P., Rangarajan,K.E., Chatterjee,S. (1988) Proc. of NOAO-ESO conference **29**, 661. *Simulation of multiple aperture synthesis.*

Sastry,Ch.V. (1989) Indian Journ. of Pure & Applied Phys. (in press). *The Gauribidanur radio observatory.*

Sastri,J.H. (1989) Planetary and Space Science (in press). *Response of equatorial electric fields to polarity of interplanetary magnetic field.*

Shah,G.A. (1988), SIAM Review, **30**, 310. *Volume of intersection of a cone with a Sphere.*

Shylaja,B.S. (1988) J.Astrophys.. Astr., **9**, 161. *Study of the WR members of the cluster NGC 6231*

Singh,J., Sivaraman,K.R., Rajamohan,R. (1988) Kodaikanal Obs. Bull., **8**, 33. *Observations of the corona at the eclipse of 1983 June 11, I: Temperature and rotation of the corona from 5303 Å and 6374 Å profiles.*

Sivaram,C. (1988) Amer. J. Phys., (in press). *Maximum stellar surface temperatures.*

Sivaram,C. (1988) Nuovo Cimento B (in press). *The fifth force as a manifestation of torsion.*

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Sivaram.C. (1988) Kodaikanal Obs Bull., **10**, 155. *Gravitational waves from collapsing stars.*

Sivaram,C., De Sabbata,V. (1989) Ann. Physik (in press). *Torsion, strong gravity and fundamental constants.*

Subramanian,K.R., Sastry,Ch.V. (1988) J.Astrophys. Astr. ,**9**, 225. *The low frequency radio spectrum of the continum emission from the undisturbed sun.*

Subramanian,K.R., Sastry,Ch.V.(1989) Bull. Astr. Soc. India, **16**, 183. *Decametric radio spectra of some galaxies in clusters.*

Thejappa.G. (1988) Kodaikanal Obs Bull.,**10**, 115. *Supernova shock.*

*Vaidya.D.B., Sivaraman.K.R. (1988) Proc. National Symp. on Comet Halley, Bangalore p.223. *Scattering properties of cometary grains.*

Vasundhara,R. (1989) J.Astrophys. Astr., **10**, 85. *Occultation by possible material in Saturn's outer magnetosphere.*

Venkatakrishnan, P., *Gary,G., (1989) Solar Phys. **120**, 235. *Offdisk center potential field calculations using vector magnetograms.*

Venkatakrishnan,P.,*Hagyard,M.J. *Hathway.D.H. (1989) Solar Phys., (in press). *Evaluation of shear in off-disk center active regions.*

Paper presentations at conferences/Technical reports/Newsletters

*Apparao,K.M.V., *Rengarajan,T.N., *Taraf-dar,S.P., Ghosh,K.K. (1989) Be Star Newsletter, No.**20**,9. *Simultaneous radio and Hα observations of Be stars.*

Bhatt,H.C., Datta,B.(1988) IIA Newsletter, **3**, 23. *Some characteristics of the central pulsar in SN 1987A.*

Bhattacharyya,J.C. (1988) CZ instruments Review **3,** *Discovery of outer rings of Saturn.*

Bhattacharyya,J.C. (1988) Proc. 13th meeting of the national symposium on instrumentation, Mysore (in press). *The present day techniques for optical astronomy.*

Bhattacharyya,J.C. (1988) IIA bicentennial workshop on Astronomical instrumentation: past, present and future. *Observation facilities in the Indian Institute of Astrophysics.*

Bhattacharyya,J.C. & Ghosh,K.K. (1989) IAU Circ. No.477., *27. Canis Majoris.*

Ghosh,K.K.(1989) 23 ESLAB Symp. (in press). *Changes in the optical spectra of Be stars due to the compact companions.*

Ghosh,K.K. Pukalenthi,S., Jayakumar,K. (1988) Be Star Newsletter, No.**18**, p.7. *Continuum level variability in the Be Star - η Cen.*

Krishan,V. (1988) IIA Newsletter, **3**, No,3., *Stimulated Raman scattering in quasar plasmas.*

Krishan,V. (1988) Newsletter of plasma science society of India. *Parametric instabilities in astrophysical plasmas*

Pati,A.K. (1988) Proc. of the workshop on CAMAC based instrumentation and data acquisition in research and industry, Indian physical society, Calcutta. *CAMAC applications at the Vainu Bappu Observatory.*

Rangarajan,K.E. (1988) IIA Newsletter **3** *A new computer system at the Bangalore campus.*

Saha,S.K., Jayarajan,A.P., Bhattacharyya,J.C. (1987) IIA Bicentennial workshop, Kodaikanal, Astronomical Instrumentation in India past, present and future. *Speckle camera for the prime focus of Vainu Bappu Telescope at Kavalur.*

Sastry,Ch.V. (1989) IIA Newsletter **4**, 1. *The decameter wave radio observatory at Gauribidanur.*

Sivaram,C. (1988) Gravity Research Foundation (Mass., U.S.) competition. *Super d-brane defects in the early universe.*

Sivaram,C. (1988) IX High energy physics Symp. Matscience, Madras. *Dynamics of super-d-branes in the early universe.*

Sivaram,C. (1988) Workshop on high energy physics and cosmology, ICTP, Trieste, Italy. *Some consequences of inflation with higher powers of the curvature scalar.*

Sivaram,C. (1988) Workshop on high energy physics and cosmology, ICTP, Trieste, Italy. *Cosmological constraints on the fifth force.*

Sivaraman,K.R. (1988) Science Focus PRL (in press) *Active and adaptive mirrors in Astronomy.*

Sivaraman,K.R. (1989) IIA Newsletter **4**. *A new double pass monochrometer for solar research at Bangalore.*

Talks/Lectures

J.C.Bhattacharyya: *The turbulent sun,* Institute of physics, Bhubaneswar, May 30, 1988.

-: *The observational optical astronomy,* Regional research laboratory, Bhubaneswar, May 30, 1988.

-:*Solar system studies,* Ramakrishna Vidyashala, Mysore, Nov.26, 1988.

-:*Observational facilities for optical astronomy,* National workshop on "Emerging trends in astronomy and astrophysics", Delhi, March 18-20, 1989.

B.Datta: *Physical processes at super high energies (The early universe),* Ninth high energy physics symposium, Indian Institute of Technology, Madras, December 14-19, 1988

-:*Pre-supernova evolution gravitational collapse and explosion,* school and workshop on "Stellar evolution and supernova", Goa, March 10-17, 1989.

-:*Cosmic separation of phases and primordial Nucleosynthesis.* Symposium on "The large scale structure and evolution of the universe", Radio Astronomy Centre, TIFR, Ootacamund, April 20 - 21, 1989.

M.H.Gokhale: *Structure of the sun and solar activity,* Summer School in Astronomy, I I Sc., Bangalore, May 1988.

-:*Helioseismology,* in Saha Institute of Nuclear physics, Calcutta, Feb 21, 1989.

S.S. Hasan: *Facilities for solar research in India,* Meeting organised by Delhi University on "Emerging trends in Astronomy and Astrophysics", Delhi, March 18-20, 1989.

V.Krishan: *New trends in astrophysical plasmas,* DST meeting on "Thrust areas in astronomy", Ahmedabad, November 17-18, 1988.

T.P.Prabhu: *Optical Spectroscopy of SN 1987A* School and Workshop on "Supernovae and stellar evolution", Panaji ,10-17 March 1989.

J.H.Sastri: Invited talk on *Large scale structure*

of solar corona-an interplanetary view, Physical Research Laboratory, Ahmedabad, December 1988.

– :Invited review talk on *Ionospheric waves*, Workshop on "Ionosphere-structure, composition and dynamics", Andhra University, Waltair, September 29-30 1988.

A.K.Saxena: *History of optical glass industries and optical technology in India*, in the workshop on "History of science in India", New Delhi, March 31 1989.

C.Sivaram: *String Models of Galaxy Formation*, at Instituto Nazionale di Fisica Nucleare, Bologna University, 29 April 1988.

– :*Final State of Evaporating Black Holes* at Department of Physics, Univ. of Ferrara, Italy, May 4, 1988.

– :*Problems of Modern Cosmology* (2 Lectures), Department of Physics, University of Ferrara, Italy, May 13, 1988.

– :*Neutrino Emission from Dense Gravitationally Collapsing Objects*, Department of Physics, University of Ferrara, Italy, May 20, 1988.

– : *Weak Interactions and Torsion Department of Physics, Institute of Nuclear Physics, Bologna University, Italy, May 20, 1988.*

– :*Possible Astrophysical Consequences of the Fifth Force*, Instituto Nazionale di Fisica Nucleare, Bologna, Italy, May 20, 1988.

– :*Physics of Stars and Galaxies* (2 lectures) At the Department of Physics, University of Ferrara, Italy, June 2-3, 1988.

– : *Astrophysical Constraints on the Fifth Force*, Department of Physics, University of Bologna, Italy, June 3, 1988.

– : *Theoretical framework for the Fifth Force*, Department of Physics, Univ of Pavia, Italy, June 9,1988.

– : *Possible Dipole Radiation from a Vector like Field Coupling to Baryon Charge*, Univ of Pavia, Italy, June 10, 1988.

– : *Unification of Weak and Gravitational Interactions*, Department of Physics, Univ of Bologna, Italy, June 12, 1988.

– : *Inflation with Higher Powers of Curvature and Unification of Interactions in the Early Universe*, International Centre for Theoretical Physics (ICTP), Trieste, Italy, July 14, 1988.

– :*Role of Higgs Fields in Inflation*, ICTP, Trieste, Italy, July 29, 1988.

– : *Some Cosmological Effects of the Fifth Force and Constraints from the Early Universe*, ICTP, Trieste, Italy, August 2,1988.

K.R.Sivaraman: *Active and adaptive optics for astronomy*, DST meeting on "Thrust areas in astronomy", Ahmedabad, Nov 17-18,1988.

– : *Solar constant monitoring and solar variability*, Second national workshop on "International geosphere biosphere programme-global changes" organised by INSA, Delhi, March 29-10, 1989.

Scientific meetings attended

XX General Assembly of the International Astronomical Union (IAU), Baltimore, USA, August 2-11, 1988. *K.S.Balasubramanyam, H.C.Bhatt, J.C.Bhattacharyya, M.H.Gokhale, S.K.Jain, N.Kameswara Rao, V.Krishan, M.Parthasarathy, A.K.Pati, R.Rajamohan, A.K.Saxena, K.K.Scaria, K.R.Sivaraman,*

A.Vagiswari.

International Astronomical Union Colloquium (IAU) No.112: Light pollution, radio interference and space debris the increasing environmental impacts on Astronomy, Washington, DC, USA, August 13-16, 1988. *J.C. Bhattacharyya.*

International Astronomical Union (IAU) Symposium No.135: Interstellar dust, California, USA., July 26-30, 1988. *H.C.Bhatt, S.K.Jain.*

International Astronomical Union (IAU) Colloquium No.106: Evolution of peculiar redgiant stars, Bloomington, USA, July 27-29, 1988. *N.Kameswara Rao, M.Parthasarathy.*

International Astronomical Union (IAU) Colloquium No.110: Library and information services in Astronomy, Washington, D.C, USA, July 28-30, 1988. *A.Vagiswari.*

International Astronomical Union (IAU) Colloquium No.104: Solar and Stellar flares, Stanford, USA., August 15-20, 1988. *V.Krishan*

International Astronomical Union (IAU) Colloquium No. 107 Algols, Victoria, B.E.Canada, August 15-19, 1988. *M.Parthasarathy.*

DST meeting on Brain Storming in Astronomy, PRL, Ahmedabad, November 16-18, 1988. *J.C.Bhattacharyya, N.Kameswara Rao, R.K.Kochhar, K.R.Sivaraman, V.Krishan, A.Peraiah.*

Raman Centenary Symposium on Waves and Symmentry, RRI, Bangalore, December 12-15, 1988. *J.C.Bhattacharyya, V.Krishan, A.K.Pati, T.P.Prabhu, Ch.V.Sastry, K.R.Subramanian, P Venkatakrishnan*

National Symposium for review and updating of national thrust areas in physical sciences, Santiniketan, Feb 23-25, 1989. *J.C.Bhattacharyya, M.H.Gokhale, N.Kameswara Rao, K.R.Sivaraman*

School and Workshop on supernovae and stellar evolution, Panaji, March 10-17, 1989. *G.C.Anupama, B.Datta, R.K.Kochhar, T.P.Prabhu, N.Kameswara Rao*

International Conference on Antarctica Studies, NPL, New Delhi, May 2-4, 1988. *J.C.Bhattacharyya.*

Silver Jubilee Seminar of the Andhra Pradesh academic of Sciences, Hyderabad, September 19-20, 1988. *J.C.Bhattacharyya, N.Kameswara Rao*

NATO Workshop on diffraction limited imaging, September 1988. *S.Chatterjee*

Emerging trends in astronomy and astrophysics, Delhi University, March 18-20, 1988. *J.C.Bhattacharyya, S.S.Hasan*

Fourth Chapman conference on Physics of Magnetic Flux Ropes, Bermuda, March 26-31, 1989. *S.S.Hasan*

High energy Astronomy Seminar, New Delhi, Feb 6-8, 1989, as part of the Festival of France in India. *R.C.Kapoor, R.K.Kochhar*

Seminar on operation and maintenance of Air-conditioning and Refrigeration plants, Bangalore, January 6-7, 1989. *B.R.Madhava Rao*

Workshop on CAMAC based instrumentation and data acquisition in research and industry, Indian Physical Society, Calcutta, November 15-18, 1988, *A.K.Pati*

54th annual meeting of the Indian academy of sciences, Calcutta, October 31, 1988.

A.K.Pati, P.Venkatakrishnan

XXVII COSPAR meeting at Espoo, Finland, July 18-29, 1988. *P.K.Raju*

NOAO-ESO conference on high resolution imaging by interferometry, Garching, F.R.G, March 15-18, 1988. *S.K.Saha*

NATO summer institute on Diffraction limited imaging with very large telescopes, Cargese, France, September 13-23, 1988. *S.K.Saha*

Workshop on History of Science in India, New Delhi, 31st March-2nd April, 1989. *A.K.Saxena, A.Vagiswari.*

Workshop on How to make the telescope, ASTEC, Udaipur, September 1988. *J.Singh.*

High spatial resolution solar observations: Results, techniques and prospects, National solar observatory, New Mexico, USA, August 22-26, 1988. *K.R.Sivaraman*

Symposium on sky wave OTH - B radar concepts and techniques, LRDE, Bangalore, October 11-12, 1988. *K.R.Subramanian*

Spring meeting of American Geophysical Union, Baltimore, USA, May 16-20, 1988. *P.Venkatakrishnan*

American astronomical society meeting, Kansas, USA, June 5-9, 1988. *P.Venkatakrishnan*

Max '91 Workshop No.1, Kansas, USA, June 10-11, 1988. *P.Venkatakrishnan*

Visits to scientific institutions

H.C.Bhatt visited the Queen Mary College, London, in August 1988.

S.Chatterjee visited CERGA, University of Nice, Saclay, and University of Ulm, in France during 1988.

B.Datta visited the Institute for space studies NASA, New York, USA in October 1988.

M.H.Gokhale visited the Saha Institute of nuclear physics Calcutta, and the Educational media research centre, Gujarat University, Ahmedabad in February 1989.

S.K.Jain visited the European Space Agency (ESA) and the Technology centre at Noordwijk, The Netherlands in July 1988.

N.Kameswara Rao visited the ESO, Chile, ESO, Munich, the Institute of astronomy, University of Mexico City, and the Department of astronomy, University of Texas at Austin, Texas, USA, during the period June-August 1988.

M.V.Mekkaden visited the ESO Chile during May-June. He also visited ESO, Garching. He returned after completion of study leave.

M.Parthasarathy visited the Department of astronomy, University of Texas at Austin, Texas, USA in August 1988. He also visited the Trieste astronomy observatory and the International centre for theoretical physics, Trieste, Italy during the period September-November 1988.

A.K.Pati visited the Astronomy department, University of Virginia, Charlottesville, USA, in August 1988.

K.B.Ramesh visited the Physical research laboratory (PRL) and the Airglow station of the PRL at Mt.Abu during Feb-Mar 1989.

Ram Sagar visited the TIFR, Bombay during October-November 1988. He also visited the U.P. State observatory, Nainital during Feb-March 1989.

S.K.Saha returned after the completion of a one year post-doctoral fellowship (CIES) from C.E.R.G.A. Caussols, France.

J.H.Sastri visited the Physical research laboratory, Ahmedabad in December 1988.

A.K.Saxena visited the Optical science centre, University of Arizona, USA, in August 1988 in connection with the scanner telescope project.

C.Sivaram visited several scientific institutions in Italy during April-August 1988.

K.R.Sivaraman visited the National solar observatory, New Mexico, in August 1988.

A.Vagiswari visited Caltech, the Astronomy library, and PCL Library, University of Texas, Austin, USA as a Fulbright scholar during June to November 1988.

Appendix B

Teaching of astronomy

The institute has continued its active participation in the Joint Astronomy Programme (JAP) with the department of physics, Indian Institute of Science (IISc), Bangalore. D.C.V.Mallik taught JAP students a course on stellar physics, and also gave several lectures on *stellar evolution*. H.C.Bhatt delivered several lectures on *interstellar matter*. V.Krishan gave a lecture on *Solar corona* at the summer school on astronomy and astrophysics organised by the department of physics, IISc in June 1988. S.S.Hasan delivered four seminar lectures on *Solar MHD* under the Joint Astronomy Programme. S.Giridhar gave four lectures to M.Sc. final, (Astrophysics) students of Ravishankar University, Raipur, on *Photometric Techniques, Photographic Spectrophotometry, Radial Velocity measurements, Period-Luminosity relation and distance determination for Classical Cepheids* in December 1988 at V.B.O., Kavalur, where these students came for a winter course on practical astronomy. A.K.Saxena gave a series of lectures during the course on *Modern trends on Optical Workshop and test evaluation* organised by the Engineering Staff College, India during 7-13 July, 1988 at Bangalore on *Advance Optical Fabrication Technology, Test methods for Large Optical Surface, Coating of Large Optical Surfaces*.

R.K.Kochhar wrote a course on astronomy as part of the Indira Gandhi National Open University's Foundation Course in Science and Technology. T.P.Prabhu guided two students of Birla Institute of Science and Technology (Pilani) on summer projects. J.C.Bhattacharyya collaborated with the Indira Gandhi National Open University, New Delhi, for an audio/visual programme on astronomy for inclusion in their syllabus.

Editing and publishing

The Journal of Astrophysics and Astronomy (JAA) and the Bulletin of the Astronomical Society of India (BASI), are being edited, as before in the IIA. JAA has entered its tenth volume. J.C.Bhattacharyya continued to be the chairman of its editorial board. T.P.Prabhu and R.K.Kochhar continue as associate editors of JAA and BASI respectively.

Kodaikanal Observatory Bulletins and IIA Technical reports continue to be published under the editorialship of Professor J.C.Bhattacharyya, with the assistance of A.Vagiswari and Christina Louis. Volumes 9-10 were published during this period.

The IIA newsletter entered its fourth year in January 1988. T.P.Prabhu and A.K.Pati edit the newsletter on behalf of the Director of the Institute.

The proceedings of the national workshop on *Supernova 1987A* (February 24-25, 1988, Bangalore), organized by the institute, were edited by N.Kameswara Rao and T.P.Prahu and were published as volume 10 of the Kodaikanal Observatory Bulletin.

The proceedings of the national symposium on *Comet Halley* (October 27-29, 1987, Bangalore), organised by the institute, were edited by K.R.Sivaraman and G.S.D.Babu and published as a separate volume.

Book reviews

H.C.Bhatt reviewed the book *Exploring the Southern Sky* by S.Laustsen, C.Madsen and R.M.West, (1987) Springer-Verlag for the Bull. Astr. Soc. India.

R.K.Kochhar reviewed the books *History of*

Oriental Astronomy (IAU Colloquium No.91) edited by G.Swarup et al., Cambridge Univ, press and *Kepler's physical Astronomy* by Bruce Stephenson, Springer-Verlag for the Bull. Astr. Soc.India.

V.Krishan reviewed *On Aesthetics in Science* edited by Judith Wechslev, Birkhauser Boston and *An agenda for the 21st century*, edited by Rushworth A.Kidder, MIT Press for the Journal of Indian Institute of Science 68, 429-432.

T.P.Prabhu reviewed *A Reference Catalogue and Atlas of Galactic Novae* by H.W. Duerbeck, D.Reidel, Dordrecht and Boston for the Bull.Astr.Soc.India.

P.Venkatakrishnan reviewed the books Cool stars, Stellar systems and the Sun (Lecture notes in physics 291), edited by J.C.Linsky and R.Stencel, Springer-Verlag and *Solar and Stellar physics* (Lecture notes in physics 292), edited by E.H. Schroter and M.Schüssler, Springer-Verlag for Bull. Astr.Soc.India.

Popular articles

J.C.Bhattacharyya

Supernova: an enigma of Nature Amrita Bazar Patrika, April 11, 1988, Calcutta (May 1988)

Astrophysics in India Encyclopaedia, The M.P.Birla Foundation, Calcutta (May 1988)

Mahaviswer Pranta, Desh, (Bengali), (1989 May).

Mahakasher tin durbodya Jyotiska, Desh, (Bengali) May 1988

Kompaman Surya, Jhan O Bigyan (Bengali), Sept 1989

Mahaviswe Praner Sambhavana, Kishore Gynan Bigyan (Bengali), Sept-Oct,1988.

Akasher Notun Jyotiska Rashi, Kishor Gyan Bigyan (Bengali), July 1988.

*Research Institutions in India - Indian Institute of Astrophysics*Invited article, Newsletter, American chapter of the Indian Physics Association, (Feb 89) (in press).

Do the stars influence human health? Invited article (Feb 89) (in press) St.John's Medical College Magazine, Bangalore.

Self relience in astronomical observations: examples of recent past. Jana Bigyan (Bengali), West Bengal Science Forum, Calcutta (Mar 89) (in press).

Indian Institute of Astrophysics entry in encyclopaedia (Gujarati), Gujarat Vishvakosh Trust, Ahmedabad (Apr 89) (in press).

S.K.Jain

Darkness at night Science Express, 17 May 1988

Mystery of the Siberian Crash Science Express, 5 July 1988

B.S.Shylaja

Future Space Missions Silver Jubilee Souvenir of Bangalore Science Forum, 1988

Double stars Science Express, 1988.

Doppler technique Kasturi (Kannada) 1989

Life of Richard Carrington Kasturi (Kannada) 1989

Radio/TV and Film programmes

S.P.Bagare gave radio talks in Kannada on

Ozone holes, planetary atmospheres and the sun. He also participated in the radio serial *Meet the scientist.*

J.C.Bhattacharyya collaborated with the Indira Gandhi National Open University, New Delhi, for an audio visual program on astronomy. He also participated in the Yuvavani radio serial *Meet the scientist.*

B.S.Shylaja gave a radio talk in Kannada on *What the star light tells us?*

Popular talks

G.S.D Babu gave a talk on the *Milky Way* at the National Science day at SHAR Centre.

S.P.Bagare gave a talk on *Astronomy* at the ANR College in Gudivada in April 1988.

J.C.Bhattacharyya gave the key note address at the annual meeting of the Orissa physics Society, Bhubaneswar, May 1988. He gave the valedictory address at the college day (Feb, 89) of Christ College, Bangalore and an inaugural address at the second All India Peoples Science Conference Calcutta, in March 1989. He also gave a talk on *Astronomical observing facilities in India today* at the Paschim Bangal Bigyan Mancha Calcutta in March 1989.

V.Krishan gave a talk on *Women worldwide in Astronomy:the Indian view* at the IAU 20th General Assembly, Baltimore, 1988.

R.Rajamohan gave a talk on *Project Kalki - A search for near earth asteroids and the tenth planet* at Bangalore Amateur Astronomers Association, VITM, Bangalore on 1.1.1989 and National College, Bangalore on 1.3.1989.

A.K.Saxena gave a talk on *Active optics systems for telescopes* at the ABAA meeting at Bangalore, on 6.11.88.

J.Singh spoke on the *Development of astronomy in India and observing the sun* at the ASTEC meeting at Udaipur, in September 1988.

Appendix C

Vainu Bappu Observatory

Sky condition at Kavalur April 1988 - March 1989

Year	Month	Spectroscopic hours	Photometric hours
1988	April	106.5	12.5
	May	92.5	9.5
	June	117.5	6.0
	July	27.0	1.5
	August	18.5	0
	September	39.0	8.0
	October	173.0	43.0
	November	145.5	74.0
	December	143.5	26.5
1989	January	131.0	34.5
	February	221.5	120.0
	March	231.0	101.0
	Total	1,446.5	436.5

Kodaikanal Observatory

Number of days of observations

Year	Month	Photoheliograms	Spectroheliograms		
			$H\alpha$	K-Flocculus	K-Prominences
1988	April	23	21	22	22
	May	19	18	16	10
	June	15	13	13	12
	July	12	10	9	8
	August	10	8	7	2
	September	13	10	8	7
	October	22	19	18	15
	November	17	14	11	9
	December	25	28	25	24
1989	January	25	23	22	18
	February	27	26	26	25
	March	29	28	28	26

Kodaikanal Observatory

Seeing conditions

Year	Month	Seeing (in arc sec)					Total no. of observation days
		5	4	3	2	1	
1988	April		2	12	9	-	23
	May		1	8	10	-	19
	June		2	9	4	-	15
	July		2	6	4	-	12
	August			5	5	-	10
	September			9	4	-	13
	October			15	7	-	22
	November			14	3	-	17
	December			16	9	-	25
1989	Jauary			10	15	-	25
	February			24	3	-	27
	March			23	6	-	29