INDIAN INSTITUTE OF ASTROPHYSICS

Annual Report 1989-90

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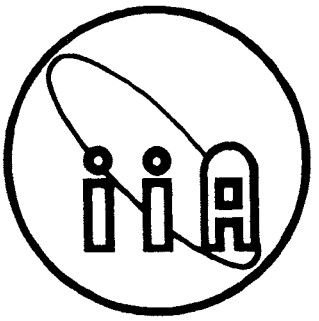

Annual Report 1989-90

Front Cover (inset) : Aerial view of IIA, Bangalore

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(for the triennial term 1988 June to 1991 June)

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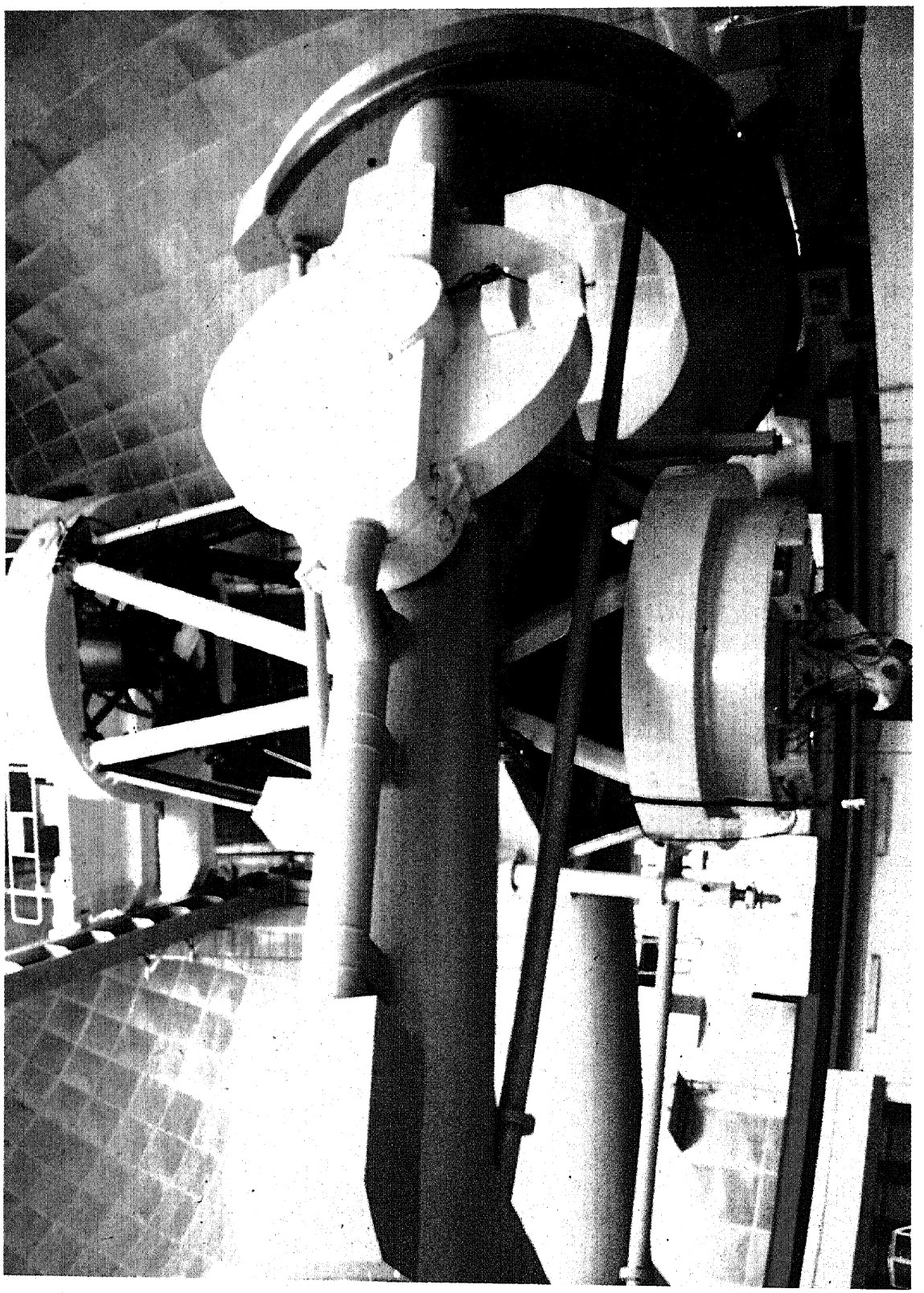


2.3 m VBT with the new Boller and Chivens Spectrograph, equipped with an Astromed CCD at the Cassegrain focus

The Year in Review

The present period in review, being the final year of the Seventh Plan, saw some hectic activities on the instrumentation front in order to complete some of the projected facilities within targeted dates. The major activity was the installation of the Cassegrain system on the Vainu Bappu Telescope, which was promptly equipped with a modified Boller and Chivens spectrograph, obtained earlier from the Anglo Australian Observatory. Along with this, the installation of another major facility of a remotely operated prime focus cage was also achieved; it is now possible to operate the prime focus CCD camera from the telescope console, and guide the telescope through the use of an intensifier-CCD guider system. More facilities for remote control and operation of the VBT are on the anvil, and expected to be installed before the next annual report is written. We are not very far from our dream of operating telescopes at Kavalur from a console in Bangalore.

The task of introduction of the VBT National Facility to the scientific community in the country was pursued with great enthusiasm. The VBT News Letters were circulated to more than 150 centres; two workshops gathering current and potential users of the facility were arranged. A special winter school was held under the auspices of the Institute, drawing post graduate students and degree college teachers from all over the country, to enable them to learn and understand the functioning and possibilities of frontline observational astronomy in India.

The other national facility run by the Institute for providing sophisticated instrumentation to astronomers was also kept busy by an increased volume of requests from scientific groups. The Uttar Pradesh State Observatory, Nainital requested a new driving system for the Sampurnanand Telescope, which has since been delivered; they have now requested another device developed in our laboratories, viz. a digital automatic star changing device for the same telescope. The entire instrumentation for the Antarctic Solar Observations was also completed by the Instrumentation Cell. A group from the National Physical Laboratory, New Delhi, was so impressed by the operation of the system during trials, that it requested our help in modifying their solar ultraviolet experiment, proposed to be conducted from Antarctica. A heliostat system was promptly designed and delivered before the team left in November 1989. A different group from the same laboratory has now come up with a request for the fabrication of yet another system with special features.

Research into various aspects of astronomy and astrophysics was continued with ever increasing enthusiasm and zeal. In solar physics, the perennial interest in understanding the granulation network resulted in several new ideas and information; these included a series of continuous observations, stretching over a few days, from Antartica of the supergranular structure - the first observation of its kind by any Indian team.

Activities of our solar system research group were rewarded when one of its discoveries was proved to be a hitherto unknown asteroid; the new minor planet has been named "Ramanujan" after the mathematical genius who had outshone many of his contemporaries and predecessors during his brief stay in the world. Incidentally, this is the first minor planet discovered by an Indian scientist; only a handful of other instances of similar discoveries from our country was by a British astronomer in the nineteenth century.

The availability of highly sensitive CCD detectors at the focal planes of our major telescopes has opened up the flood-gates of new

observational data. Objects which had earlier required a whole night's exposure can now be captured in a few minutes. Utilizing these capabilities, new investigations on several types of objects made spectacular progress. Symbiotic stars, B-emission stars, planetary nebulae and long period Cepheids are some of the objects which came under the intense gaze of our scientists. In some Be stars clear indications of mass loss through stellar winds, outbursts and phase transitions were obtained.

Supplementing all these, specially requested observations through satellites IUE and IRAS, revealed some of the enigmatic phenomena around astronomical objects. In a series of collaborative efforts, our scientists pooled their data with others in a bid to unlock some of nature's mysteries.

Some of our collaborative efforts went even further. While many of our young scientists spent nights at telescopes abroad, several foreign scientists came to spend their time with us, sharing their knowledge through discussions and supplementing their information with the help of our telescopes. This year we had collaborating scientists from USA, USSR, Italy and Mexico.

We could make substantial progress in our observing efforts in extra-galactic studies. Using new sensitive CCD detectors at the focal planes of both major telescopes, we could get useful observational information about star formation and giant HII regions in external galaxies. The X-ray emitting cluster of galaxies 2A 0335 + 096 has been mapped in detail in the VRI bands, using our telescopes.

Our efforts in theoretical astrophysics delved deeply into many areas. Dynamics of colliding galaxies, stellar population synthesis, anomalous absorption in quasar plasma, effects of dynamical friction on the motion of compact high redshift objects are some of the diverse topics studied. Pondering about the events in the early universe, our scientists have found connections between the energy dependent super string tension and fundamental physical constants. A study of the theory of strong gravity in five-dimensional Kaluza-Klein space-time was carried out in search of a physical significance of the cosmological constant; the questions concerning inflation and the formation of hierarchical structures were sought to be answered as a consequence of Weyl gravity in the early universe. Generation, modification and propagation of radiation in the interiors of stars and superdense compact bodies were other heavily investigated topics.

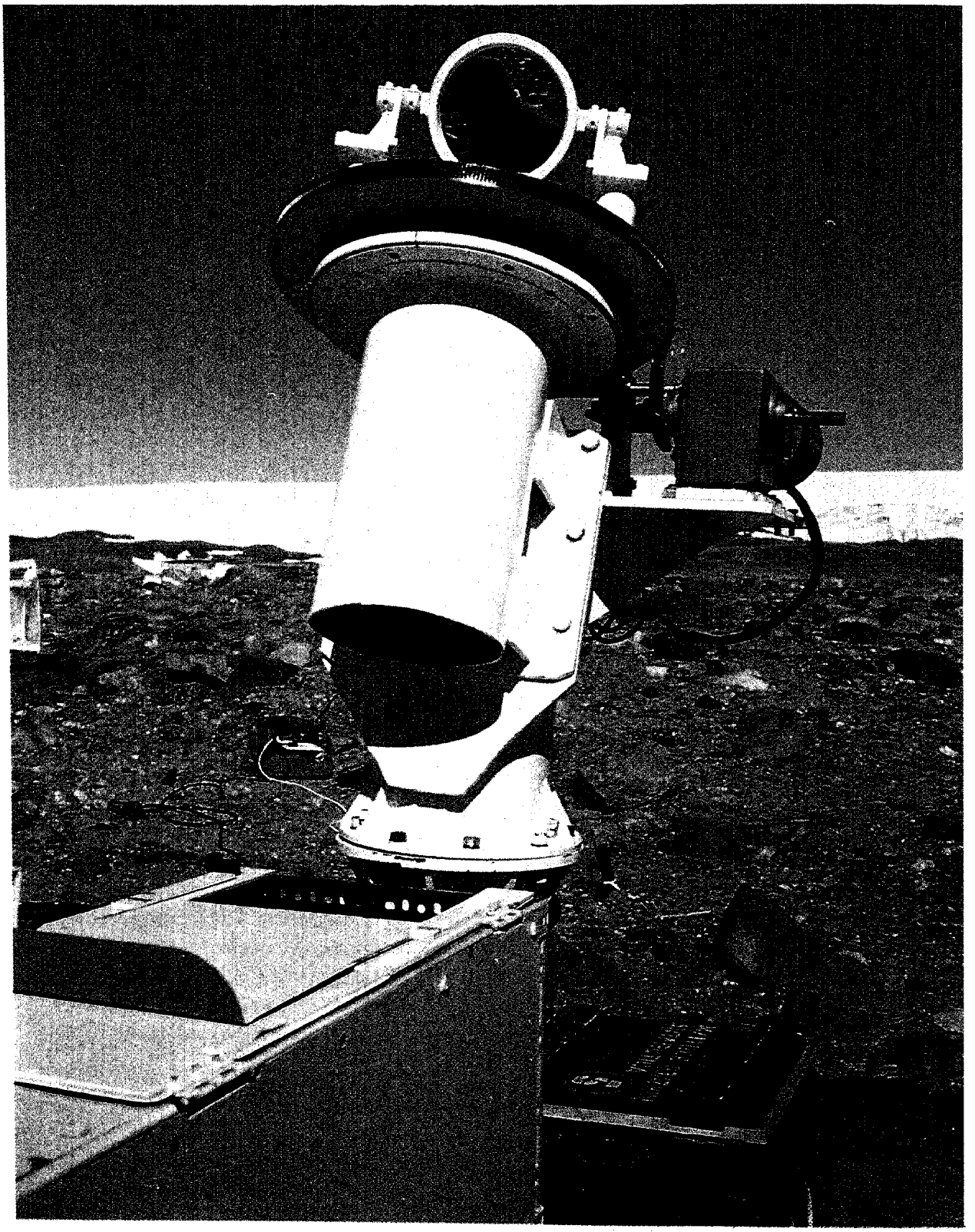
I shall desist from listing other highly interesting investigations in many fields of observational and theoretical astrophysics and observable manifestations in our immediate neighbourhood. More details are given in the body of the report; still more may be found in the extensive literature cited in the list of publications.

As in the previous year, this year too we had the privilege of hosting the CSIR distinguished scientist's lecture in Bangalore; the speaker was Prof. S.Chandrasekhar, the doyen of the world community of astrophysicists. Also, we had the privilege of hosting in Bangalore the IAU Symposium No.142 on Basic Plasma Processes on the Sun. Our scientists played a major role in the National Space Science Symposium in Nagpur in March 1990, and later in the same month, the Optical Society of India recognized the vital role played by the Institute in the development of an important part of optical science, by holding the XVIII Annual Symposium at our premises in Bangalore.

In all, the year represents an important era when plans for the development of astronomy and allied sciences in India started blossoming and bringing forth many promises for sustained future growth.

J.C. Bhattacharyya
Director

Research Highlights



Heliostat at Maitri, Antartica. (Jagdev Singh)

Solar Physics

Velocity fields

Supergranules

The study of evolution, decay and preferred location of formation of supergranulation cells is vital in understanding their dynamics. Supergranulation cells have dimensions of nearly 25000 km and lifetimes of around 20 hours. Therefore, to study the evolution of these cells one needs uninterrupted data of at least 2-3 days. Hence, it was planned to set up a telescope at the Indian station at Maitri, during the ninth Indian expedition to Antartica and obtain the images of the Sun continuously in the ionized calcium K line (3934Å) using a narrow band interference filter.

A team of three persons, two from the Indian Institute of Astrophysics (Jagdev Singh & G.S.D.Babu) and one from the Uttar Pradesh State Observatory (Wahabuddin) left for Maitri on November 30, 1989 with the ninth Indian Antartica Expedition. They successfully installed the telescope and obtained rare calcium K filtergrams on 7 days at intervals of 10 minutes. In all, 2500 photographs of the Sun were taken. On Feb. 12, 1990 a solar flare was recorded using pictures taken every 40 seconds. These filtergrams are being analysed to understand the evolution of supergranules. (Jagdev Singh, G.S.D.Babu, J.C. Bhattacharyya, K.R.Sivaraman & Wahabuddin*)

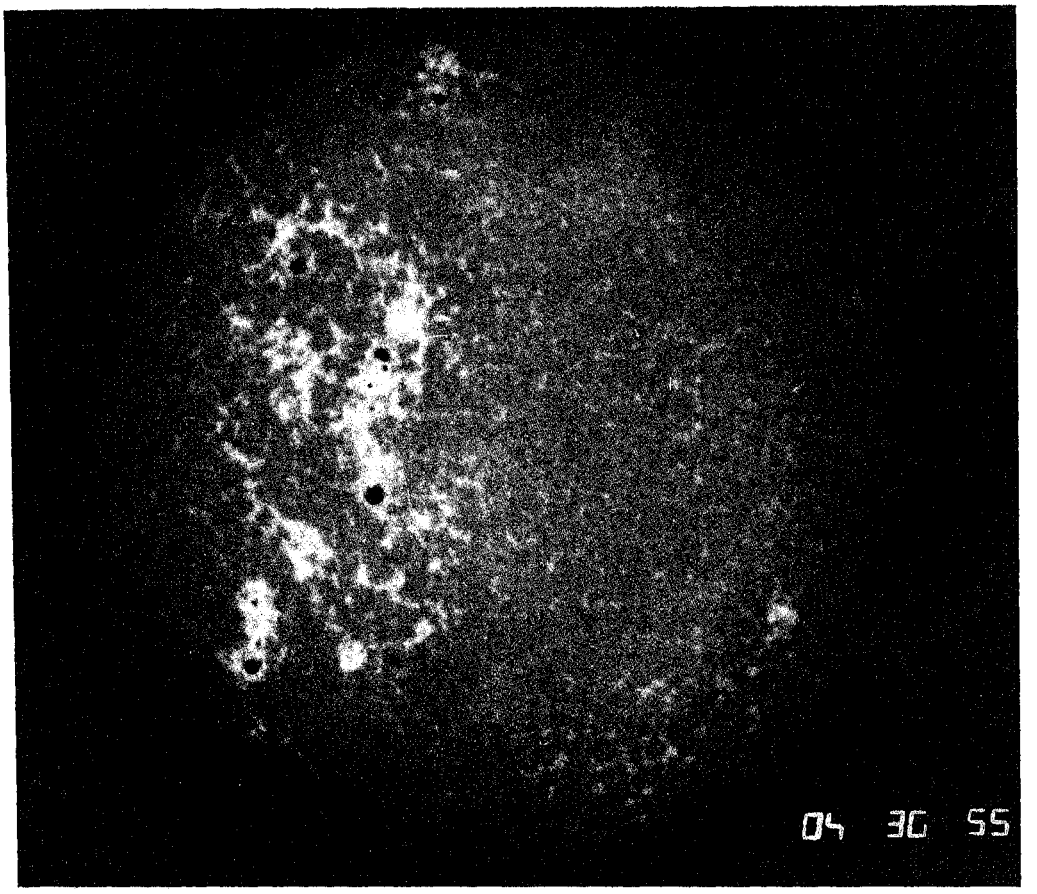
Solar telescope for Maitri, Antartica

It is not possible to use the available telescope or coelostat for observing the Sun 24 hours a day at Maitri, Antartica, where the Sun is visible continuously during December. Therefore, a heliostat system was built in the laboratories of the Institute. A 15 cm mirror, installed on a 2 m pillar, collects the sunlight and diverts it in the direction parallel to the rotation axis of the earth. The heliostat rotates (24 hours per rotation) by a synchronous motor through a worm wheel arrangement. A second flat mirror at the bottom of the heliostat tube makes the light beam horizontal and feeds an objective of 10 cm aperture and 300 cm focal length. The second mirror has a push pull arrangement to position and centre the image onto the camera. The converging beam from the objective passes through the calcium K 'Day star' filter with a pass band of 1.2Å centred around the K line and mounted on a Minolta X-700 camera. This camera has the additional facility to record automatically the epoch of every exposure on a corner of each frame of the filtergram.(Jagdev Singh, K.R.Sivaraman, J.C.Bhattacharyya & G.S.D.Babu)

Solar granulation

In a two dimensional incompressible fluid, the total energy as well as the total squared vorticity called enstrophy are conserved. It is found that the energy spectrum in two dimensional hydrodynamic turbulence cascades to smaller wavenumbers in the presence of viscous dissipation and therefore the energy is expected to accumulate at the longest wavelengths that the system allows. The enstrophy on the other hand cascades to shorter wavelengths and is continuously dissipated. This conclusion is reached by finding the inertial range of the tur-

* Names of coworkers from outside institutions



Calcium K picture of the Sun obtained from Maitri, Antartica on Jan. 11, 1990. (Jagdev Singh)

bulent spectrum. However, even in the absence of dissipation, one can show that the energy spectrum condenses to largest scales as a consequence of energy and enstrophy conservation during the cascade due to nonlinear effects. It is found that if the enstrophy vanishes, then the total energy remains constant even in the presence of dissipation. Thus, the system evolves to a state of minimum enstrophy with constant energy. (V.Krishan)

The observed two dimensional nature of the velocity fields in supergranulation permits us to make use of the characteristics of two dimensional hydrodynamic turbulence. Thus, it is proposed that supergranulation is produced from granulation by the selective decay process in which the energy tends to accumulate at the largest scales. This largest scale is determined from the ratio of energy to enstrophy and presumably determines the scale of the solar supergranulation. Inclusion of a magnetic field will lead to magnetohydrodynamic turbulence, which also permits the formation of organized structures. (V.Krishan)

While examining high quality filtergrams in Mg b, obtained using the Vacuum Tower Telescope at the Sacramento Peak Observatory, to study foot points of the chromospheric fine structure, the signature of a mesogranulation sized network was detected.

Mesogranulation is associated with convec-

tive cells in the solar photosphere, with a dimension of 5-10 Mm, which is between the well known photospheric granules and the supergranules. Mesogranules were first detected in 1981 and are seen mainly in data, reduced for Doppler velocity measurements.

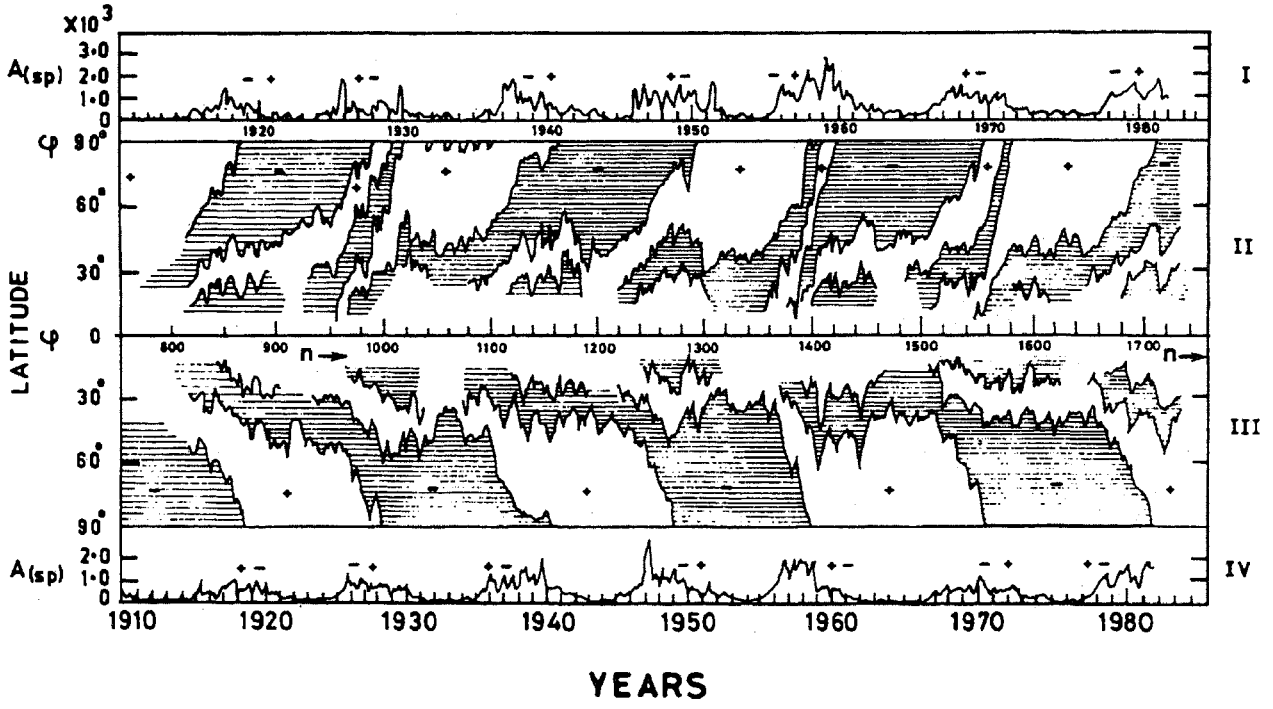
A further feature noticed in these data is the presence of 'exploding granules' within the mesogranulation network. Similar observations have been reported from studies based on the spacelab data. This aspect also serves as a confirmation of the detection of mesogranules in the direct filtergrams obtained from a ground based telescope. (S.P.Bagare & K.R.Sivaraman)

Sub arc second magnetic structures

After several runs since 1986 at the Solar Vaccum Telescope of the Sacramento Peak Observatory, it was possible to acquire good quality high spatial resolution observations as part of the programme for locating the foot points of the sub arc second magnetic structures in the quiet solar photosphere, with reference to the granulation. The acquired data consist of filtergrams through the universal birefringent filter (UBF), set sequentially in the core of the Mg b line (λ5172.698) and in four wavelength positions in the wings as well in the neighbouring continuum. In addition, using a beam splitter, a filtergram was obtained through a Ca^+ K line polarizing filter (with a pass band of 0.6Å) simultaneous to every exposure in the UBF of the same region on the Sun. The enlarged copies of the best frames in the form of transparencies of the Ca^+K and Mg b core filtergrams were coaligned and all the bright points (BPs) in the K filtergrams (those that occur in the interior of the network and on the boundaries) were identified. Following this, the Mg b core and continuum pictures were coaligned with the Mg b wing pictures that served as reliable intermediaries. The visual correlation done for nine frames covered a total of 1800 BPs. It was seen that 77.8% of the BPs are located in the dark intergranular lanes of the photospheric granulation, 14.4% on the very periphery of the bright granules and the rest on the granules themselves. With the one to one correspondence between BPs and the sub arc second magnetic points, that represent the thin flux tubes, the present observations lead to the result that the foot points of the sub arc second magnetic structures are rooted in the dark intergranular lanes in the photosphere. (K.R.Sivaraman, S.P.Bagare & L.November*)

Meridional motion

By extending the study of the poleward migration of filament bands, there is evidence for the dependence of the solar cycle on meridional motion at the solar surface. The motive force that causes the poleward migration of filaments is the meridional flow in the solar photosphere. From the filament band migration diagram (Makarov and Sivaraman, in Proc. IAU Symp. 138, p.281) for the years 1910 to 1982, it was seen that the filament bands start their poleward migration with small speeds ranging from 5 to 20 m s^{-1} synchronously with the rising phase of the solar cycle. These filament bands, moving rather slowly, experience a sudden acceleration around the peak of activity resulting in velocities as high as 40 m s^{-1} or more. On reaching the pole, they cause reversal of the polar fields. After the polar field reversal, during the years of solar minimum (1941-1945; 1960-1965; 1972-1976) the filament bands lie at low latitudes meandering with a quasi oscillatory motion of about 20 - 40 years. But they start their poleward drift synchronously with the increase in the



Boxes II and III show the migration trajectories of magnetic neutral lines (filament bands) derived from H-alpha synoptic charts in the northen and southern hemispheres for the periods 1910-1982. Boxes I and IV : The continuous curve represents the run of mean daily areas of sunspots [$A_{(sp)}$] expressed in millionth of the visible hemisphere and is used as the index of solar activity. Notice that during the years of solar minimum (1941-45, 1960-65,1972-76) the filament bands lie in the low latitude belt (20°–40°) without any sign of poleward movement and start poleward migration simultaneous with the onset of solar activity. The higher the activity, the higher are the speeds of the filament bands in their poleward migration. (K.R.Sivaraman)

solar activity. This provides evidence that the motive force driving the filament bands polewards is absent or is very weak during the solar minimum and starts operating with the commencement of the solar maximum. The aforementioned behaviour is seen unmistakably, cycle after cycle, in both hemispheres of the Sun. The meridional motion speeds, derived from the filament band motion, agree well with those derived from Doppler measurements. This establishes the dependence of the solar cycle on the flow in the photosphere. (K.R. Sivaraman)

Evershed effect in bipolar sunspots

Spectra in the non Zeeman line λ4912Å (Ni I) were obtained, at the solar tower telescope, over a number of spots, mainly of the bipolar type, and in a few cases over complex groups. In addition, spectra on several individual spots were also obtained to look for any relation between the onset of the Evershed flow and the magnetic field. (K.R.Sivaraman, K.Sunderaraman & P.S.M.Aleem).

The programme of monitoring the Ca II K line flux from the Sun as a star was continued with great vigour both at the Kodaikanal solar tower telescope as well as at Bangalore, with the double pass monochrometer. Analysis of the data is in progress. (K.R.Sivaraman, K. Sunderaraman, R.Kariyappa, A.P.Jayarajan & P.S.M. Aleem)

Chromosphere

Nonlinear development of the CO instability

This investigation is a sequel to the analysis on the linear stability of cool flux tubes in the solar chromosphere by Hasan and Kneer (1986, Astr. Astrophys. **158**, 288), in which it was demonstrated that flux tubes with CO and in radiative equilibrium are convectively unstable. The consequences of this instability have now been examined by solving the full nonlinear time dependent MHD (magnetohydrodynamic) equations in the thin flux tube approximation. Radiative energy transport in the flux tube was treated in the Eddington approximation, taking into account the contributions of H^- and CO to the opacity. The time evolution of the instability was followed. It was found that during the first few hundred seconds, large amplitude chaotic motions were generated. Subsequently, overstable oscillatory motions were set up, with a period of some 200 s. In the top layers of the tube, the amplitude of the velocity fluctuations was in the range of 4-5 km s^{-1}. The simulations, with a transmitting upper boundary, showed that the average energy flux in the oscillations is inadequate for chromospheric heating. However, the oscillations reveal interesting features, which are noteworthy in themselves. An important aspect of the calculations is that they provide a self-consistent model for physical conditions within chromospheric flux tubes. (S.S.Hasan & F.Kneer*)

Calcium network

In order to determine the contribution of the calcium network to the solar cycle variability, high resolution spectra in the ionized calcium K line, at all latitudes of the Sun, and integrated over the visible 180 degree longitude, are obtained daily. Spectra have been obtained on about 120 days. Digitization of these spectra commenced, using the PDS machine of the Institute. An optical layout was worked out to obtain the data faster and with good accuracy. (Jagdev Singh)

Corona

Coronal loops

The coronal loop plasma is represented by a superposition of the three lowest order (n=m=0,±1) Chandrashekhar-Kendall functions for the velocity and magnetic field. This system when perturbed linearly from its equilibrium state, exhibits sinusoidal oscillations. The period of these oscillations, a function of the amplitudes of the three components of velocity and magnetic field, can be expressed in terms of magnetic helicity and the ratio of toroidal to poloidal magnetic flux. This may provide a way of estimating magnetic helicity in oscillating coronal loops, which are observed frequently in coronographic movies. (V.Krishan)

Prominence - Corona transition region.

Diagnostic study.

Solar prominences are relatively cool material (electron temperature $T_e \sim 10^4$ K) embedded in the hot ($T_e \geq 10^6$ K) coronal plasma. This suggests the presence of a prominence-corona transition region (PCTR). The study of physical conditions within PCTRs is important for understanding important problems in solar physics, such as the existence, stability and disappearance of solar prominences. Within a PCTR, they are parameterised mainly by values of the elec-

tron density (N_e) and temperature (T_e). An elegant method to estimate the electron density and temperature involves the sensitivity of line intensities to variations in the electron density or temperature. This technique is independent of the detailed structure of the emission region. In this context, the extreme ultraviolet (EUV) spectrum (300 – 600 Å) of an eruptive prominence, observed from Skylab, was used to determine electron densities and temperatures within PCTRs. The electron densities were obtained from measurements of line intensity ratios. The electron temperature was determined by the value for which the emitting ion of an element has the maximum relative ion abundance. Amongst the numerous emission lines observed in an eruptive prominence, only a few could be reliably used for diagnostic studies. The following lines were considered: Ne V, Ne VI, Mg VII and Mg VIII. The value of the pressure (N_eT_e) across the PCTR can yield clues to the magnetic field structure. The results indicate that N_eT_e varies from 1.16×10^{15} K cm^{-3} at 2.5×10^5 K to 4.64×10^{14} K cm^{-3} at 8.0×10^5 K. For detailed modelling of PCTRs many more lines, with reliable intensities, are essential. (P.K. Raju & B.N.Dwivedi*)

Modelling coronal magnetic fields

A thesis proposal for studying the response of coronal magnetic fields to changes in photospheric boundary conditions has been submitted to Bangalore University. This study will model the vertical gradient of magnetic tension in terms of observable lateral gradients of the same parameter. It will also examine the special role of 3-D modelling for creating the special configurations that encourage the formation and disruption of active region filaments. (N.D.N. Prasad* & P.Venkatakrishnan)

Extreme ultraviolet (EUV) observations of the solar corona and transition region.

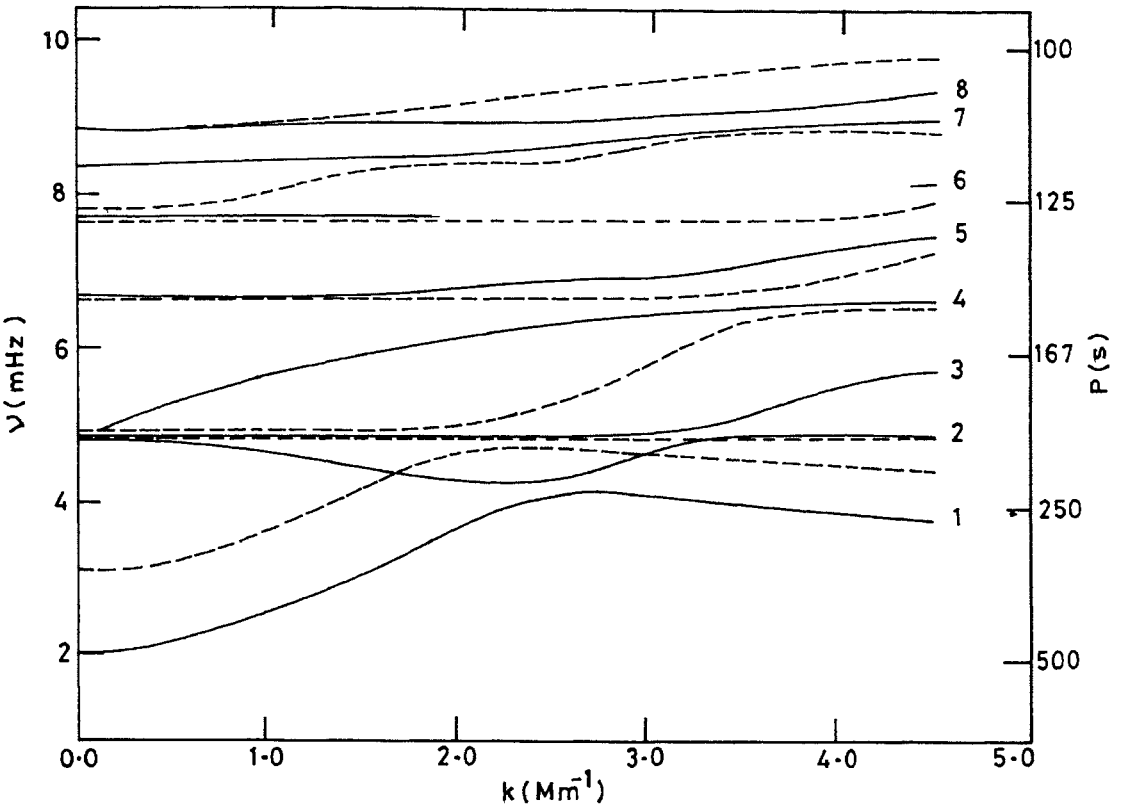
In collaboration with J.G.Timothy (Stanford University), M.C.E.Huber (ESTEC, Noordwijk) and G.Tondello (Padua University, Italy), a proposal to observe the solar corona and transition region in the EUV region at high spatial and temporal resolution was initiated. In this wavelength region a number of prominent lines (e.g. He I 584.3Å, O III 599.6Å, O V 629.7Å, Ca X 574.Å and Mg X 625Å) are available which span a range of temperatures from 10^4 to 10^6 K and provide important diagnostic means to study the solar chromosphere, transition region and the corona.The high resolution data will provide insight into the microscale dynamics of the Sun. It is also proposed to make simultaneous observations of the Sun in the He I 10830Å line.

A high resolution stigmatic EUV spectroheliometer is under development to be placed on a NASA Black Brant sounding rocket. The spectroheliometer utilizes a single toroidal diffraction grating in a near normal incidence Rowland circle and an imaging pulse counting multianode microchannel array (MAMA) detector. This will produce spatially resolved spectra of the chromosphere, transition region and the corona with an angular resolution of 0.4 arc sec or better, a spectral resolution of about 10^4 in the first order, and a temporal resolution ofthe order of seconds.The spectrometer will also be able to determine Doppler shifts to a resolution of at least 2 mÅ at wavelengths near 600 Å (or 1.0 km s^{-1}). (J.C.Bhattacharyya, S.K.Jain & A.K. Saxena)

Magnetic fields

Magnetoatmospheric oscillations in sunspots

This work is a further extension to the analy-



Diagnostic diagram for umbral oscillations showing the variation of frequency υ (in mHz) as a funtion of the horizontal wave number in a typical sunspot. The solid and dashed lines correspond to a vertical magnetic field of 2000G and 3000G respectively. The right scale denotes the periods and the numbers besides the curves denote the order or harmonics (with respect to B=2000G). (S.S.Hasan)

sis of wave modes in sunspots, in which the technique of Hasan and Sobouti (1987, M.N.R.A.S. **228**, 427) was applied in classifying the modes in a sunspot. However, owing to certain limitations in the numerical formalism, only a fairly small vertical extension of the umbral atmosphere could be treated in that investigation. For instance, the sharp temperature rise in the chromosphere and transition region and also in the convection zone could not be fully included. These difficulties have now been overcome, so that the wave modes in an atmosphere, extending from a depth of 2000 km below the photosphere to a height of 2000 km above it, could be examined. Approximating the sunspot as a thick flux tube of circular cross-section, the axisymmetric normal mode spectrum was determined and a diagnostic diagram generated for different magnetic field strengths. A noteworthy feature of the solutions is the presence of "avoided crossings", which demonstrate the coupling of modes with different physical characteristics. Eigenfunctions were determined, from which E_{kin} (the kinetic energy density in the oscillations) could be calculated. The earlier controversy on whether umbral oscillations in the 3-min range are photospheric or chromospheric resonances was resolved in this in-

vestigation by showing that the present theory predicts multiple modes in the aforementioned range (in agreement with observations). The properties of these modes are, however, different. For some of the modes, E_{kin} is high in the photosphere, indicating they are mainly confined to a photospheric cavity. But there are also modes for which E_{kin} can be large in the chromospheric layers or even distributed over a large height range. By decomposing the displacements into transverse and longitudinal parts, the "polarization" of a mode could be studied with height. Another important finding to emerge was an interpretation of the 5 min oscillations in sunspots. The present analysis indicated that these oscillations are in fact resonant modes of the sunspot itself and not the normal 5 min photospheric oscillations leaking into the spot from the ambient medium. (S.S.Hasan)

Spicules

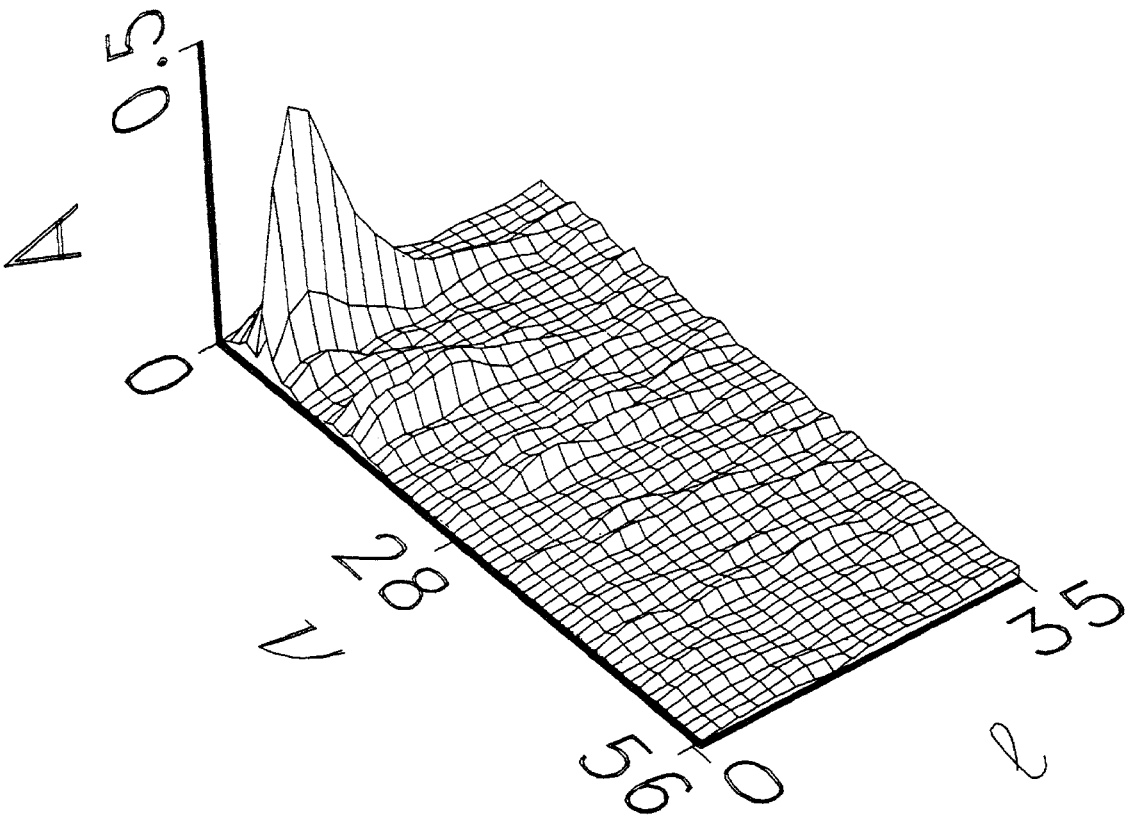
The formation of large structures in a nonlinear turbulent energetically open magnetohydynamic system was discussed using the concepts of self-organization processes. The presence of a magnetic field allows the existence of long-lived Alfvén waves, which can be easily excited by any external disturbance. The Alfvén waves generate a state of aligned velocity and magnetic fields, introducing large cross helicity in the system. In a compressible medium, the Alfvén waves are known to decay and the spectrum condensates towards lower frequencies and hence towards smaller parallel wavenumbers, giving rise to large anisotropy. This gives rise to long (in the parallel direction) and narrow (in the perpendicular direction) MHD structures which could be identified with spicules, since they are believed to be associated with the transport of energy by Alfvén waves. The aligned turbulence is further known to evolve to a state of dominant polarity with either $\mathbf{V.B}>0$ or $\mathbf{V.B}<0$ depending upon the initial conditions, where **V** and **B** denote velocity and magnetic field respectively. Thus anisotropy seems to be the crucial characteristic of turbulent media. (V.Krishan)

Magnetic shear and flares

The observed association of solar flares with sites of large magnetic shear on polarity inversion lines of active regions was earlier interpreted physically in terms of low magnetic tension. It was suggested that the latter caused inflation of the field and made it vulnerable to instabilities that modify the plasma density. This hypothesis has now been extended to estimate the excess energy available in highly sheared, tension free fields over that in force-free fields. It was shown that this energy is of the order of the energy released during the impulsive phase of a large solar flare, thereby providing support to the idea that instabilities can initiate a flare. The time scales of filament activation before flares was also used as an argument favouring an instability driven scenarios for flares. (P.Venkatakrishnan)

Solar magnetic oscillations

The study of long period global oscillations of the Sun, through a spherical harmonic Fourier analysis of sunspot data for the period 1874-1976, is in progress. This analysis has been further refined by: first, separating the data of the old and the new cycles during the overlap periods of the successive cycles and second by correcting for the undersampling of data in higher latitudes due to differential rotation. The



Spherical harmonic Fourier amplitude A of the odd degree axisymmetric modes in the 'nominal magnetic field' as a function of l and υ in units of = 1/105 y^{-1}. (M.H.Gokhale)

analysis of the odd degree axisymmetric modes upto l =37 and υ=55 (in units of 1/105 y^{-1}) was made.

By comparing the amplitudes and phases of the first (1/22 y^{-1}) and the third (3/22 y^{-1}) harmonics of the odd degree modes upto l =23, it was found that the power in the third harmonic may arise from a nonlinearity between the sunspot probability and the real magnetic field and not from any independent oscillation of the Sun. (M.H.Gokhale & J.Javaraiah)

It was found that the spectrum of the odd-degree axisymmetric modes can be fitted for l in the range 7-29, by the Chandrahsekhar's formula for steady state turbulence. (M.H. Gokhale, J.Javaraiah & K.N.Hiremath)

Magnetic field gradient near prominences

Using magnetograms and Hα spectroheligrams in the Solar Geophysical Data, the upper and the lower limits in the gradients of the large-scale field in the neighbourhood of prominence filaments within and outside active regions were determined. A comparison with gradients near neutral lines, without overlying filaments, showed that the derived limits represent necessary but not sufficient conditions for the existence of quiescent prominences.

Limits on the values of dB_r/ds for filaments inside and outside active regions are:

1. For filaments inside active regions.

Lower limit	Upper limit
$\approx 4 \times 10^{-5}$ G km^{-1}	$\gtrsim 18 \times 10^{-5}$ G km^{-1} (in 1981)

2. For filaments outside active regions.

Lower limit	Upper limit
$\approx 2 \times 10^{-5}$ G km^{-1}	$\gtrsim 9 \times 10^{-5}$ G km^{-1} (in 1981)
$< 1 \times 10^{-5}$ G km^{-1}	$\approx 6 \times 10^{-5}$ G km^{-1} (in 1984)

(B.S.Nagabhushana, M.H.Gokhale & J.Singh)

Miscellaneous

Solar radio emission

Characteristics of micro bursts observed at four frequencies in the range of 30 - 70 MHz, using the broadband array, were compared with normal type III bursts. The exciter duration and decay time constant were found to be correlated and to have values similar to those in normal type III bursts.

High time and frequency resolution studies of transient radio bursts from the Sun using an accousto-optic spectrograph are being carried out. (K.R.Subramanian)

Solar wind

It is well known that coronal streamers and coronal holes reflect the large-scale geometry of the solar corona and that the solar magnetic field plays a major role in the dynamics of the corona. Earlier semi-analytical calculations ignored the azimuthal motion of the solar wind plasma and hence showed a considerable acceleration of the solar wind.

This problem was simulated using detailed, rigorous numerical modelling, including rotation and latitudinal motions, to examine the effect of the field on the acceleration of the solar wind, not only along the equator, but also at other latitudes. A 2-D numerical model assuming azimuthal symmetry and an inviscid fluid with infinite conductivity was developed. The three components of the magnetic and velocity fields as well as the density were computed at each time-step until the system relaxed to a steady-state, as defined by the invariants along the equator. The simulation uses explicit finite differencing technique and a Runge-Kutta time scheme to integrate the MHD equations at each time-step. (C.T.Vanajakshi)

Boundary value problems in magnetohydrodynamics

In most time-dependent MHD problems, numerical simulation of the processes involves imposing artificial boundaries at the edges of the grid, defining the region of interest. But the time variation of the variables at these boundaries will depend upon the values of the variables on either side of the numerical grid, since, in reality, the medium is continuous across the boundary and physical processes propagate information through the (imaginary) numerical walls. Most problems are sensitive to the values of the variables at the boundaries and *ad hoc* methods to 'fix' these values according to approximate conditions for continuity of the variables or their derivatives (Dirichlet or Neumann conditions) can introduce minor perturbations, which will often cumulatively affect the outcome when the simulation is carried through many iterations or

time-steps.

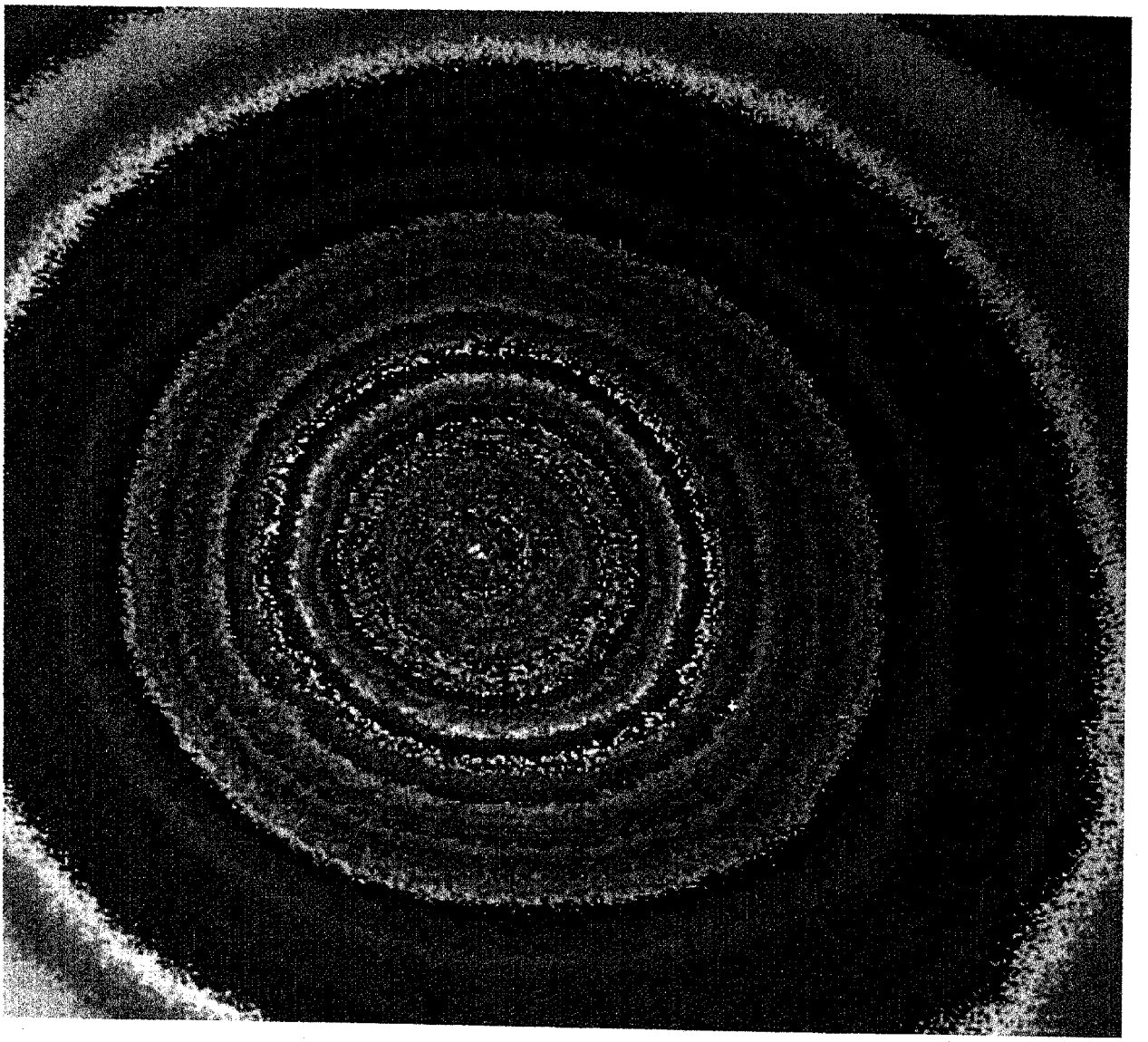
Specifically, when there are wavemodes propagating in and/or out of the region of interest, careful handling of the boundary conditions is essential because, otherwise, situations can occur where the wave energy gets artificially reflected at the numerical walls and introduces spurious effects.

There are two distinct types of cases in MHD simulations which need to be tackled using divergent approaches. The first type corresponds to cases where the waves propagate only out of the region of interest. In such cases, the application of a radiation boundary condition involves transforming the system of equations (through a similarity tranformation) such that the eigenvalues of the system correspond to distinct wave modes propagating in and out of the system and then selectively suppressing the incoming modes. This method, described by Vanajakshi et al. (1989, J.Comp.Phys. **84**, 343) is admissible when there are no actual incoming waves. In situations when there are wavemodes propagating into the region of interest from outside, this method will obviously not work since it suppresses all incoming modes. This is the second type of case.

In such a case the approach is to define realistic, time-dependent boundary conditions so that the time-variation of the relevant variables at the boundary can reflect the changing conditions in the medium, both inside and outside the numerical walls, at all times during the temporal evolution of the system. If U is the (column) vector of dependent variables, then the boundary conditions define $\frac{\partial U}{\partial t}$ at the boundaries. In such a case, the time variation of the variables at the boundaries will respond to the changing conditions in the interior of the numerical grid through the spatial differencing terms. This, in essence, allows the treatment of the problem as if there is a continuum of the medium despite the artificial boundaries. The method allows for quite complex boundary conditions such as the time variation of one variable in terms of the time variation of other variables at the boundary, involving simultaneous solution of all the relevant variables of the system at the boundaries. (C.T.Vanajakshi)

Solar neutrinos

The propagation and oscillations of neutrinos with magnetic moment inside the Sun was studied. If large magnetic fields (10^5 G) are present in the solar interior, the neutrino oscillation parameters could be significantly altered. The MSW effects are enhanced in the presence of a magnetic field for a large neutrino magnetic moment. The limits obtained earlier from supernova neutrinos are used to constrain MSW parameters in the light of recent Kamiokande solar neutrino detection. Nuclear scattering and screening effects were found to be small for solar neutrinos. The implications for the forthcoming gallium experiment were discussed. It was suggested that a neutrino magnetic moment along with presence of large magnetic fields in the solar interior would also drastically reduce the SNU count of the gallium experiment which should also show anticorrelation with solar activity. (C.Sivaram)



Equidensity contours of the nuclear region of Comet Austin, imaged on April 27, 1990 using a CCD system at the Cassegrain focus of the 1 m reflector at VBO, Kavalur. This 10 min exposure, through a Wratten 25 red filter, covers a region of 2' x 2' around its nucleus. As is evident from the equidistant contours, the tail of the Comet is towards the bottom right of the photograph. The large number of wiggles seen in the contours of the outer region show the large scale structure existing in the Comet's tail. (K.K.Scaria, A.Muniyandi & K.R.Sivaraman)

Solar System

Comets

Cometary physics

Comets exhibit basically two types of tails, a dust tail and an ionic tail. The dust tail generally appears as a broad, curved and featureless distribution of micron-sized particles made visible by scattered sunlight. In contrast, charge seems to be the only constant characteristic of ionic tails. As the name implies, ionic tails essentially consist of charged particles and therefore can interact with sunlight and the solar wind in a variety of different ways. A multitude of phenomena occur due to the very strong interaction of the solar wind and the tail plasma. The various manifestations of this interaction include disconnection events, the formation of condensations, kinks, helices, tail rays, arcade of loops and acceleration of ions down the tail.

During the recent appartition of Comet Halley in 1985-86, a transient ionic event in the form of a blob of H_2O^+ emission was recorded in the coma at 0^h UT on March 13, 1986. Strong hydrogen emission (Hα) associated with the blob was also observed. The velocity field in the blob was structured with relative velocities upto 35 km s^{-1}. The event was interpreted as arising due to the Comet crossing the sector boundary of the interplanetary magnetic field.

The space missions to Comet Halley reported an increase in the magnetic field strength from 12-15 gamma, characteristic of the interplanetary solar wind, to a peak field strength of 70-80 gamma within the environment of Comet Halley. The large magnetic field, if typical of the tail containing twisted magnetic fields, results in helical structures inclined at small angles to the tail boundary. (V.Krishan)

A new relation between the nuclear radius and the optical depth towards the nucleus of comet Halley was found on the basis of *in situ* measurements of variation of the effective area of the dust grains along the Giotto trajectory within the comet coma. These results show that the radial variation of area or the number density of the grains is steeper than what one would expect according to the inverse square law. The representative size distribution function of the grains based on *in situ* measurements by the Vega spacecraft mission were incorporated in the model. It was found that the optical depth (τ_n) towards the nucleus of Comet Halley varies from about 0.089 to 0.036 corresponding to the nuclear radius (R_n) in the range 8 to 16 km. The question is: Can there be a similar generic relation of the form $\tau_n=\alpha R_n^{-\beta}$ among comets? The constants α and β would depend on various factors such as heliocentric distance of the comet and the physics of the comet. (G.A.Shah)

The polarimetric observations of Comet Halley are being analysed to investigate the nature of the dust grains based on the wavelength dependence and the amount of linear polarization and its variation with time. Grains with refractive indices of $1.375\pm0.01-0.04\pm0.01i$ and power law type size distribution seem to be required. (M.R. Deshpande,* A.K.Sen*, U.C.Joshi*, A.V.Raveendran & N.Kameswara Rao)

Asteriods

The asteriod 1988 DQ1 discovered with the

45 cm Schmidt on February 17, 1988 was recovered close to its predicted position during the 1989 opposition on May 4,5,6 and 7. This asteroid was numbered 4130 and named "Ramanujan" after the Indian mathematical genius Srinivasa Ramanujan.

The sky survey with the 45 cm Schmidt to detect asteroids was continued. The software programmes used in this project for calculating orbital elements and for generating ephemerides of newly detected asteriods detected were developed by R.Vasundhara. (R.Rajmohan & J.C. Bhattacharyya)

Planets and Satellites

Planetary occultations

An international campaign carried out to observe the occultation of 28 Sgr on July 1989, and of SAO 187036 on Aug. 6-7, 1989 by Saturn's magnetosphere was well received. 25 groups from Australia, India, Japan, South Korea, New Zealand and South Africa participated in the campaign. Due to poor sky conditions, only seven groups could get some data around the predicated time. The data are being analysed. (R. Vasundhara)

Mutual phenomena of Jovian satellites

The mutual eclipse light curves of Jupiter's satellites were analysed. The observed light curves were fitted using Marquardt's technique. The model light curves were generated using satellite positions and velocities using the theory by J.Leiske (1980) and a detailed model which takes into account the limb darkening on the surface of the eclipsed satellite. Results of the eclipse event of Io by Ganymede on October 24, 1985 yield an impact parameter of 1710 km and limb-darkening constant of 0.71 for the surface of Io. (R.Vasundhara)

Surface composition of Io

The surface composition of Io is still an unsettled problem. Until recently, elemental sulphur was regarded as the main constituent on Io's surface, as it explains the blue edge of its reflectance spectra. Recently Hapke (1989) showed, from laboratory measurements, that poly sulphur oxide (PSO), sulphur dioxide (SO_2) and sulphur monoxide (S_20) provide an equally good fit. As the orbit of Io is inclined to the magnetic equator by 10° during its orbital motion its surface will be exposed to a changing magnetic environment. Hapke has shown that when exposed to dissociative environment, S_2O and PSO can be formed from SO_2. To look for changes in reflectance spectra with Io's magnetic longitude, 24 spectra of Io were obtained at various magnetic longitudes using the UAGS at the 102 cm telescope at VBO, during Nov. '89-March '90, with a 10Å resolution. Preliminary results indicate significant variation in reflectance spectra when Io crosses the 110° magnetic longitude of system III (1965). (R.Vasundhara)

Excess luminosity of Jupiter

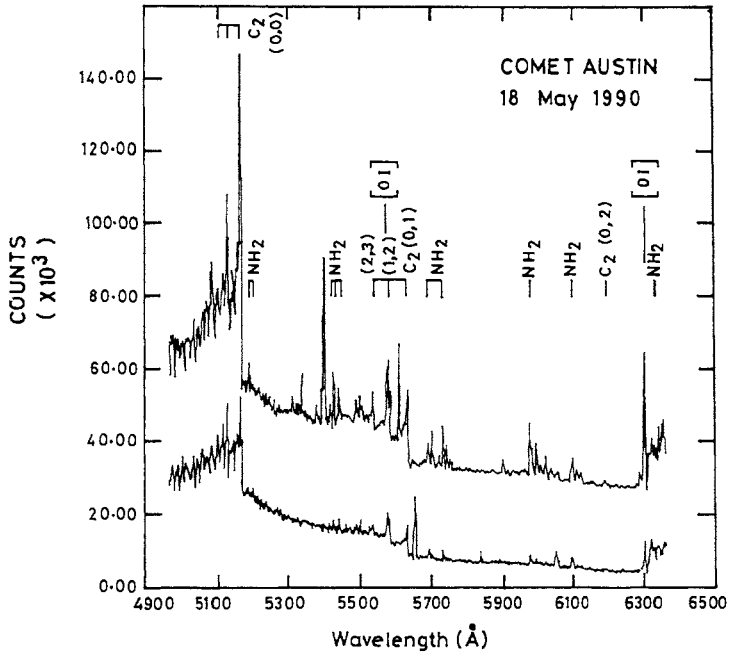
It has been known for some time (since voyager measurements) that Jupiter emits $\sim 10^{18}$ watts more radiation than it gets from the Sun. Many explanations have been proposed but there is no agreed solution. In this investigation the possibility of cold nuclear fusion between p–d nuclei in Jupiter's core, which roughly has a solid state density, was explored. It was shown that cold nuclear fusion would have made brown dwarfs much brighter than they appear if the same process takes place in their interiors. Fur-

thermore, when pressure effects are taken into account in cold fusion reaction rates, it appears that such processes (even if one accepts the laboratory claims on their observation) are too weak to account for Jupiter's excess luminosity. (C.Sivaram & V.De Sabbata*)

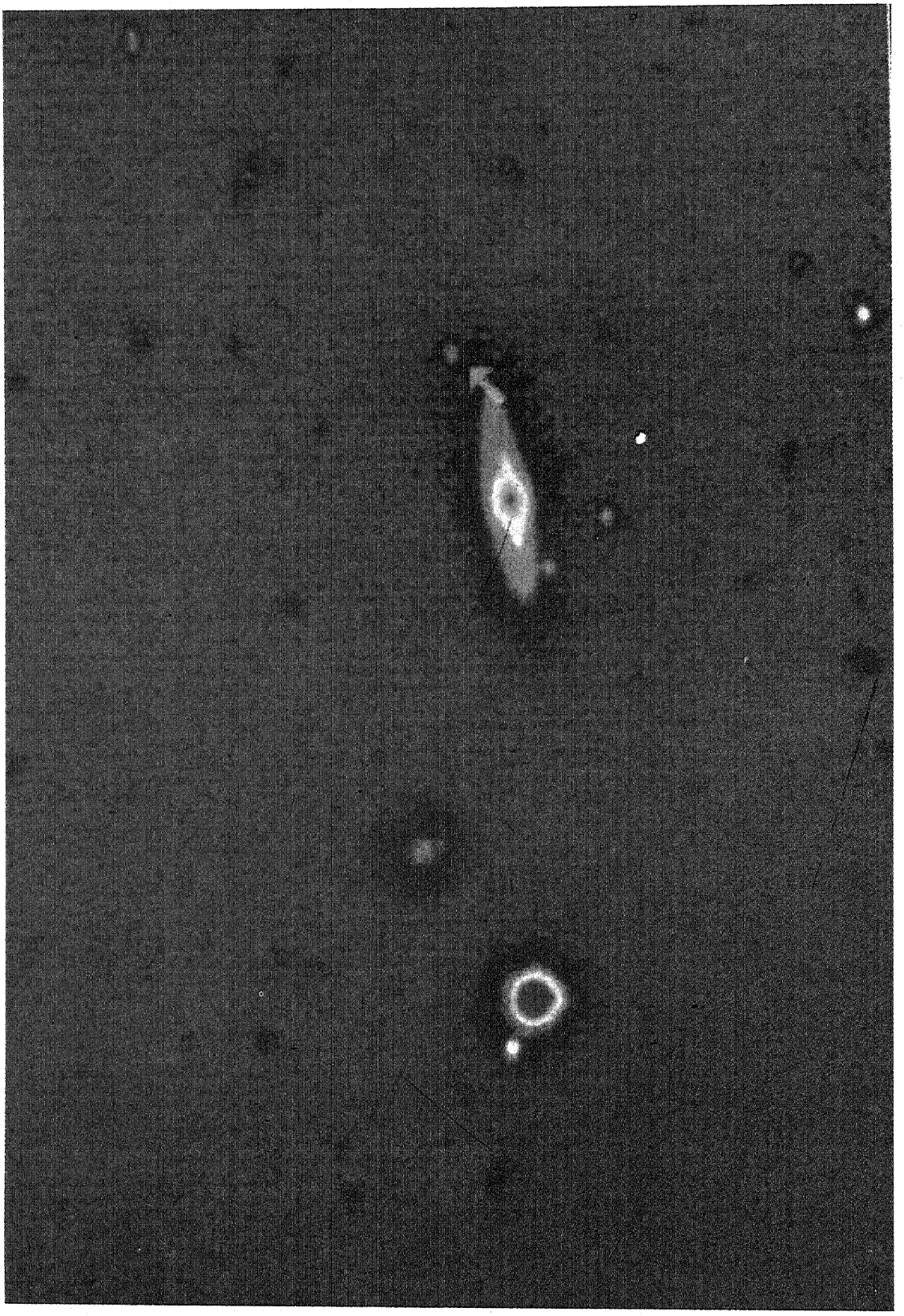
Star/Solar system formation

Formation of stars/solar systems depends critically on the conditions prevailing in the parent protostellar clouds (that collapse to form stars) during the early phase of the evolution. Since all these clouds have some degree of rotation as they start to collapse, centrifugal forces develop and increase (to conserve angular momentum) as the matter falls towards the centre. Eventually centrifugal forces exceed gravity and matter that accumulates at the centre is thrown out and forms a toroid or ring structure. This ring eventually fragments and forms a binary or a multiple stellar system. But unless some mechanism redistributes the angular momentum near the centre towards the outer regions of the cloud, this situation precludes the formation of a solar system — a central protosun with a protoplanetary accretion disk surrounding it. Turbulent viscosity is one of the mechanisms that can effect such redistribution.

A 2-D model of the gravitational collapse of a rotating, turbulent protostellar cloud was developed. Using this model the sensitivity of the final outcome (whether we get star systems or solar systems are formed) to initial conditions — initial rotation rate, initial density and velocity fluctuations, initial degree of turbulence — was studied. (C.T. Vanajakshi)



Spectrum of Comet Austin recorded with the Astromed CCD system on the Boller & Chivens spectrograph using the 2.3 m VBT on May 18, 1990. The top spectrum is that of the nucleus and the bottom one is offset 20 arcsec east. (K Jayakumar & K.K.Ghosh)



Supernova 1990G in the 15th magnitude edge-on spiral galaxy IC2735 (=UGC 6364). North is at the top and east is to the left. The 16th magnitude supernova is marked by an arrow. (T.P.Prabhu & A.Kembhavi*)

Stellar Physics

Novae and Supernovae

Novae in quiescence

Spectrophotometric monitoring of the recurrent novae RS Ophiuchi and T Coronae Borealis and the old nova GK Persei during their quiescent state was continued. The old nova HR Delphini and the recurrent nova T Pyxidis were added to the programme. The strengths of Balmer and He I lines in T CrB were found to vary with a possible correlation with the orbital period of 237 days. The accretion disc spectrum was distinguished from the spectrum of the secondary. (G.C.Anupama & T.P.Prabhu)

Novae in outburst

Nova Scuti 1989, which had an outburst in September 1989, was observed spectroscopically. The spectral evolution during the diffuse enhanced and Orion stages resembles that of a moderately slow nova like LW Serpentis (cf. T.P.Prabhu & G.C.Anupama 1987, J.Astrophys. Astr. **8**, 369). The nova was also observed polarimetrically in BVRI bands during October, 1989. (G.C.Anupama, T.P.Prabhu & S.K.Jain).

A single spectrum of nova Sagittarii 1990 was obtained in March 1990 when the nova had declined to about 14^m. The spectrum shows bright emission lines of hydrogen and helium. This is not typical of a classical nova. (T.P.Prabhu & G.C.Anupama)

Nova shells

The programme of narrow band imaging of shells around old novae was continued using the CCD camera at the 1 m reflector. Shells of novae GK Per and T Pyx were imaged in the light of Hα+[N II] and [O III], whereas the shell of T CrB was imaged only in Hα+[NII]. (G.C. Anupama & T.P.Prabhu)

Supernova 1989B in NGC 3627

Spectra of SN1989B in NGC 3627, obtained during February and March 1989 were reduced. The spectrum and its evolution bear a close resemblance to a normal Type Ia spectrum. The expansion velocity of the envelope decreased with time as observed in other supernovae. The observed velocities were slightly smaller than those of SN 1981D, and the decline slower than in SN 1986G. It appears that faster envelopes evolve slower spectroscopically. It was suggested that the interval between maximum light and the epoch at which S II 545.5, 546.0 nm lines disappear and Na I D, Fe II 492.4, 521.5 nm lines become prominent is a good measure of the rate of spectral evolution. (T.P.Prabhu & A.Krishnamurthi*)

Be Stars

Outbursts of Mu Centauri

In order to understand the mass loss mechanisms in Be Stars, regular monitoring of certain pole-on Be Stars was carried out. Recently two major outbursts of Mu Centauri during June 1989 and March-April 1990 were detected. Strong emission in Hα, Hβ and He I (5876 Å) lines was detected during the outburst phases. These lines were in pure absorption before the outbursts. It was also found that the absorption

depths of ionized photospheric lines increased during the outbursts. Detailed modelling is in progress. (K.K. Ghosh)

Phase transition of 27 CMa

It is well known that Be Stars change from the B to Be to Be-shell phase and vice-versa, but the cause of the transition is not known. Recent (April 1989 to April 1990) high resolution and high signal-to-noise ratio CCD spectra of the Be star, 27 CMa, which has undergone a transition from the Be to Be-shell phase, showed signatures of mass loss with an expanding shell (P Cygni profiles) before the transition. (K.K. Ghosh)

Be X-ray binaries

In order to understand the nature of the compact companions of Be X-ray binaries, an optical spectroscopic study (from October 1989) of nine such X-ray sources was carried out. An optical flare of the X-ray source, HDE 245770=A0535+26, was detected from the presence of C II emission and from the enhanced emission strength of the Hα line. (K.K. Ghosh)

Observations with a large optical interferometer

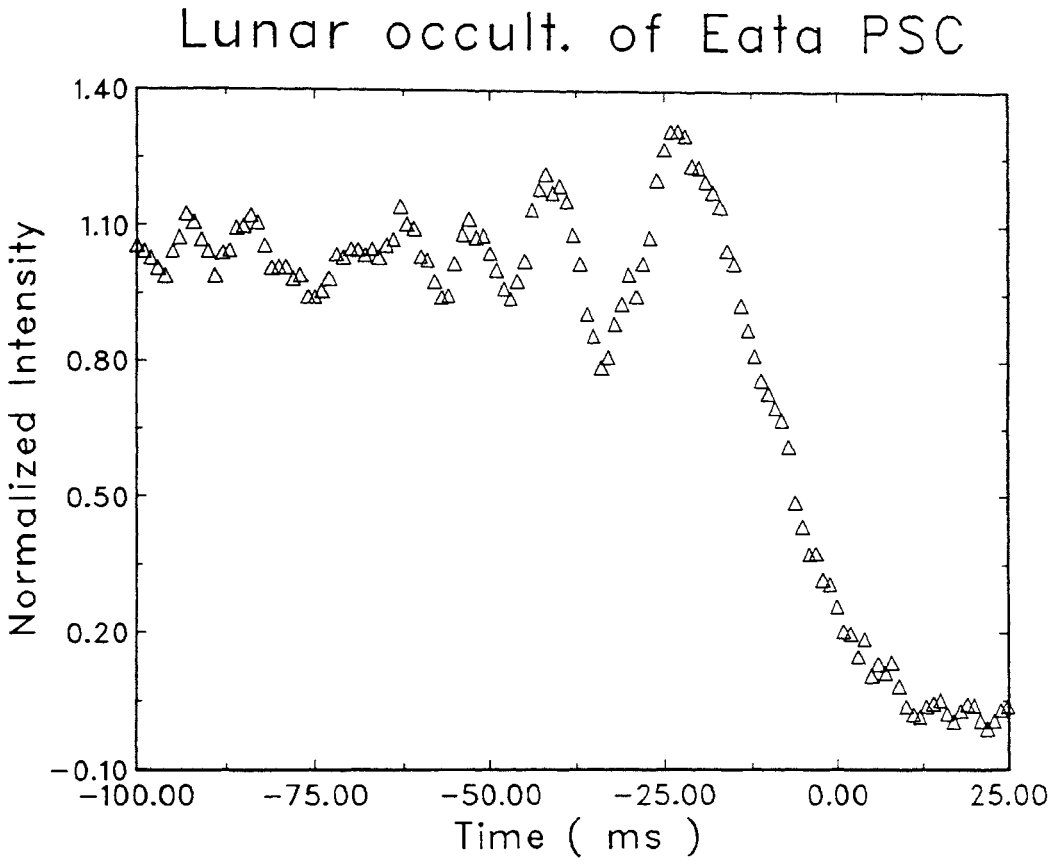
The angular size of the envelope of hydrogen gas in hot stars belonging to the Be class is too small either for direct detection by conventional telescopes or for speckle interferometry (a technique that restores the diffraction limited resolution, otherwise degraded or spoiled by the atmosphere). Recently, high resolution details of the hydrogen envelope of γ Cas (a Be star) were obtained using GI2T, an optical interferometer with a pair of 1.5 metre telescopes separated by 70 meters on a north south baseline at latitude 43° 45' N in France. About 300,000 exposures of γ Cas (with an exposure time of 0.02 s in order to freeze the effect of atmospheric turbulence) with a 1.5Å spectral resolution were obtained. The data clearly showed the envelope in rotation. (D. Mourard*, I. Bosc*, A. Labeyrie*, L. Koechlin* & S. Saha)

General

Close binaries

A preliminary analysis of the IUE high resolution ultraviolet spectra (1150Å to 1900Å) of a few low mass ratio algol systems was carried out to determine the carbon abundance. The primary components of low mass ratio algol systems S Cnc, HU Tau, S Equ and TV Cas are found to show nearly normal abundance of carbon. The absence of significant carbon deficiency in the photospheres of algol primaries suggests that a large fraction of the matter lost from the present secondaries at the time of Roche lobe overflow was lost from the system. The close binary systems V356 Sgr, RY Scuti and HD 72754 appear to be in an evolutionary stage similar to that of β Lyr and are expected to show CNO abundance anomalies.

From IRAS observations (12μm, 25μm, 60μm and 100μm) of βLyr, υSgr, HD 30353, SS 4300, RY Scuti and HD 62623, warm dust shells were detected. The presence of circumstellar dust around these evolved systems clearly suggest that they have experienced mass loss and that mass transfer is not conservative. (M.Parthasarathy)



The occultation trace of the star η Psc (m_v = 3.7, G7IIIa) recorded on 1.2 90 through a narrow band filter, centred on Hα. (J.C Bhattacharyya, R.Vasundhara, R Srinivasan, N Dinakaran & A.K.Venkataraman)

The orbital elements and the changes in the apsoidal motion of the early type highly eccentric spectroscopic binary HR 1952 are being estimated using a large number of spectra obtained with the 1 meter telescope at VBO along with older plate material available at other observatories. The analysis is nearly complete. (C.Lloyd*, C.D.Pike*, D.J. Stickland*, B.N. Ashoka & N.Kameswara Rao)

Ap and Am stars

Using the PC based photon counter, more than 30 Ap and Am stars were observed. Reduction and analysis of this data is in progress. (G.S.D. Babu)

Stellar rotation

The analysis of intermediate band indices show that for A-stars, rotation produces an average reddening of about $0^m.035 \pm 0^m.01$ per 100 km s^{-1} of $V \sin i$ in the C_0 index. For B-stars the slope is found to be about $0.04^m \pm 0.01$ in C_0 and $0.05^m \pm 0.01$ in $(u-b)_0$ per 100 m s^{-1} of $V \sin i$ These effects are also found to be considerable

for the broad band UBV indices and are consistent with theoretical predictions by Collins and Sonneborn. It is also found that these effects appear magnified especially in the U band if the observed indices are not corrected for interstellar reddening.

An attempt was also made to see if one can discriminate normal single stars from binary and peculiar stars after taking the effects of rotation into account. It was found that the residual spread in the observed colours does not in general allow such a discrimination except that the objects with large residual reddening are double line binaries and or emission lined objects. (R. Rajamohan & A.Mathew)

Lunar occultations

Lunar occultations of stars were recorded using a single channel photometer at the Cassegrain focus of the 0.75 m telescope at the VBO. The data were acquired using a PC based photon counting system developed in the Institute's electronics laboratory.

The occultation of the star η Psc (m_v = 3.7, G7IIIa) was recorded through a narrow band filter centred on Hα. The data will be analysed to estimate the projected separation between the components. (J.C. Bhattacharyya, R. Vasundhara, R. Srinivasan, N.Dinakaran & A.K.Venkataraman)

T Tauri stars

Broad band UBVRI and Strömgren photometry of a group of weak to moderate emission T Tauri stars was carried out. A few T Tauri stars showed periodic light variations due to rotational modulation of their surface inhomogeneities. A photometric analysis of the isolated T Tauri star, TW Hya obtained during April 1987 and May 1988, showed that the modulation of light is caused by short-lived, very active hot plage-like regions on the stellar surface. The steep increase in amplitudes of light curves towards shorter wavelengths is attributed to the rotational modulation of a hot, plage region. Using a theoretical spot model for the hot region, so as to reproduce the light variations in different wavelengths, the parameters of the hot spot were calculated. It was found that the nature of the light curve changes within a few weeks indicating that formation and disintegration of the hot plage-like regions is a fast process. Photometric analysis of the other group members (T Tauri stars) is in progress. (M.V. Mekkaden)

It is observed that a few Tauri stars show variable polarization, probably due to the changes in the configuration of the dust pattern around the star or by variable illumination of the circumstellar dust by a rotating spotted star. Near infrared observations showed that a few T Tauri stars have a large IR excess. (M.V. Mekkaden)

Active chromosphere stars

An analysis of high resolution CaII H and K and Hα spectra of active chromosphere stars showed that though, in general, there is a correlation between emission strengths and rotation periods, some stars exhibit abnormal behaviour. Photometric data of a few active stars, collected over a long period of time, were analysed to study the nature and evolution of dark spots on the stellar surface. (M.V. Mekkaden)

Cepheids

The long period (20.4 days) classical Cepheid RZ Vel is known to be a member of an OB association in Vela and a high metallicity is ascribed to it on the basis of earlier photometric work. An abundance analysis was carried out using high resolution CCD spectra. The results indicate near solar abundances for most of the elements in RZ Vel and hence the photometrically derived high metallicity is not valid. (S.Giridhar, A.A. Ferro* & A. Goswami)

The CCD spectra of G & K supergiants were obtained in the region of CaII near the IR triptet lines. Analysis of the CaII lines is in progress (S.V. Mallik)

Supergiants

OI (7774Å) line strengths

The equivalent width W_λ(OI 7774) of the OI feature at 7774Å was measured from high resolution coudé echelle spectra obtained with a CCD detector. These measurements are 20-30% smaller than the earlier measurements made by other investigators using lower resolution spectra. A new calibration of the M_V- W_λ (OI 7774) relation was derived using selected F-G supergiants in open clusters and OB associations as calibrators. The F-G giants and supergiants of known parallaxes were also included. The callibration was extended to the spectral range F0-G8 and luminosity class Ia-III and M_v range –10 to 2. The M_V-W_λ(OI 7774) relation appears to be nonlinear but the data points can be satisfactorily fitted by a second degree polynomial. The residuals about this fit show some dependence on stellar temperature. The introduction of the additional $(b-y)_0$ term modified the calibration relation for M_V which has a standard error of $\pm 0^m.9$. This calibration was used to derive values of M_V for peculiar stars 89 Her, HD 161796 and HR 4912 which are -5.2, -6.8 and –2.8 respectively. (A.A.Ferro*, S.Giridhar & A.Goswami)

Effect of Lyman radiation transfer in supergiants

At temperatures beyond 7000°K in chromospheres, the optical depth in the Lyman continuum is markedly reduced owing to the ionization of hydrogen. Furthermore at densities prevailing there, the thermalisation depth of Lyman α photons exceeds their optical depth, leading to their escape. Therefore, new Hα transfer calculations were performed in which the transfer equation in the Lyman continuum and allowing for the escape of Lyman α photons was solved. An iterative method was followed where the computed Lyman continuum radiation field was used to obtain improved estimates of the populations and optical depth distributions. This process was repeated until the solutions converged. Relaxing the assumption of detailed radiative balance in the Lyman continuum and in Lyman α photons resulted in a substantial decrease in ionization and a drastic overpopulation of level 1. These effects are more drastic at the surface than at the base of the line-forming region. The Hα profiles were calculated for a variety of optical depths, velocities at the surface and extents of the line-forming region. The Hα profiles are wider and deeper than in the case when there is detailed radiative balance. Although the profiles are only moderately affected, the calculations suggest a chromosphere with reduced ionization and a lower total hydrogen density. (S.V.Mallik, D.C.V. Mallik & D.Mohan Rao)

Non-thermal velocity fields

Earlier calculations revealed that in spite of including the Lyman continuum and the Lyman α transfer, the computed widths of the Hα line were smaller than those observed. This discrepancy has motivated an investigation into the role of various broadening processes in determining the width of the Hα line profile. Transfer calculations with only the thermal term yielded upper limits to the effect of opacity broadening. The maximum computed full width at half maximum (FWHM) lies in the range 4.8 - 6.7 Doppler units, depending upon the temperature structure chosen. Estimates of the non-thermal broadening parameter ξ_t were obtained by equating the maximum FWHM to the observed width and then quadratically removing the thermal term. The Hα line profiles were recalculated, incorporating both the thermal and the non-thermal velocity terms. A large number of numerical runs revealed that the widths can only be matched with ξ_t as large as 20-25 km s^{-1}. (S.V. Mallik)

Lithium rich G and K giants

The lithium rich G and K giants are a very small group of evolved stars. They are some 1% of the normal G and K giants. The cause for the over abundance of lithium is not understood. In order to further understand their evolutionary stage and study their CNO abundance anomalies, high resolution CCD spectra of a few of these stars were obtained with the echelle spectrograph at the 1 m telescope at Kavalur. Analysis of the spectra is in progress. It is planned to determine the carbon and nitrogen abundance and also the ^{12}C to ^{13}C isotope ratio. (M.Parthasarathy & K.K. Ghosh)

IRAS observations show that the star HD 68932 has a mild infrared excess. Polarimetric observations in BVRI were obtained to study the circumstellar shell. The star does not show any intrinsic polarization. The CCD spectrum obtained with the 1 m telescope shows a normal Hα profile consistant with an early K dwarf or a subgiant. It is a weak G band giant star. (A.V. Raveendran & N.Kameswara Rao)

The early R star HD 100764

From IRAS observations of early R stars (warm carbon stars) a detached cold dust shell was detected around the early R star HD 100764. In addition to the cold dust (140 K to 50 K) there is also warm dust (~1000 K) around HD 100764. The total shell mass is estimated to be of the order of 0.5 x 10^{-4} $M_{\odot}$. The presence of dust shell around the early R star HD 100764 suggests that it has experienced significant mass loss in the recent past. The luminosity of the star is too low (M=+0.4) to be on the asymptotic giant branch (AGB). The present dust shell around HD 100764 may be the result of mass loss experienced by the star during the helium core flash. (M.Parthasarathy)

Post AGB stars (or proto-planetary nebulae)

From an analysis of IRAS data Parthasarathy and Pottasch (Astr. Astrophys. 1986, **154**, L16; 1988, **192**, 182 and 1989, **225**, 521) detected several possible post AGB stars and proto-planetary nebulae. These objects are stellar in nature and have dust shells with characteristics similar to planetary nebulae. In order to understand the circumstellar dust characteristics about 30 ob-

jects of this type were observed with the 1 m telescope at Kavalur. Polarization observations were made in BVRI. Significant polarization was found in several of these objects. The polarization measurements of some of these objects show no significant wavelength dependence. Analysis of the data suggests that the dust grains in the circumstellar dust shells of these stars are relatively large. Detailed analysis of the observations is in progress. (M.Parthasarathy & S.K. Jain)

The post AGB stars and proto-planetary nebulae detected by Parthasarathy and Pottasch are most likely transition objects evolving from the tip of the AGB towards the left in the HR diagram. Detailed study of these objects will lead to an understanding of the AGB, post-AGB, evolution and also of the early stages of planetary nebulae. High resolution with high signal to noise ratio spectra of a few post-AGB stars were obtained with the Coudé Auxiliary Telescope (CAT) of the European Southern Observatory (ESO) at Chile to determine carbon, nitrogen and oxygen abundances. The abundance analysis will further shed light on the evolutionary stage of these objects and also enable a comparison of the abundance anomalies amongst these objects and AGB stars, post AGB stars and planetary nebulae. Analysis of the data is in progress. (M.Parthasarathy, S.R.Pottasch* & P.Garcia*)

RV Tauri star AR Pup

From BV photometry of the RV Tauri star AR Pup, obtained on 63 nights during 1986-87 and 1987-88 observing seasons, it was found that the (B-V) curve leads the V light curve in phase by 0.1 and also that the large variability seen in the V light curve is not reflected on the (B-V) variation. UBVRI polarimetry of the same object obtained on six nights during January - March, 1987 showed large variations, both in the polarization (~7 % in the U band and ~ 2 % in the I band) and its position angle (~40° in U and ~20° in I). The data clearly indicate that the large time-dependent variations in polarization, and its wave-length dependence, observed at earlier epochs, were not isolated events but were definitely cyclic and related to the light variation. The available data clearly indicate that polarization undergoes rapid changes after a light minimum, during the ascending branch of the light curve, a behaviour qualitatively similar to that seen in the Mira variable Omicron Cet, but on a much larger scale (14.5% against 3.5% in the U band). The time variation of the wavelength dependence of polarization seen in AR Pup is also found to agree qualitatively with that observed in Omicron Cet. (A.V. Raveendran, N.Kameswara Rao & M.N. Anandaram*)

R CrB stars

High resolution CCD spectroscopic observation during the 1988-89 light minimum of R Cr B, obtained with the 2.7 m telescope of the McDonald Observatory, were analysed. The previous result about the presence of cool regions was reconfirmed. The subtraction of the maximum and minimum spectra of the C_2 λ5635 (0,1) band clearly shows the enhanced C_2 strength and the structure indicates the presence of a region with temperature (T_e)~ 4000-5000 K. A preliminary model was presented in which the broad emission lines of HeI, CaII H&K and CII come from a permanent expanding hot (~10^4 K) upper chromosphere in addition to a cooler (T_e~5000 K) lower chromosphere with a mild expansion velocity (≤ 10 km s^{-1}). Very high resolution observations of NaI (D) and ScII lines

also indicate an emission component blue shifted by 10 m s^{-1}, which indicates the presence of a permanent chromosphere. In the proposed model, the light minima are caused by the presence of cool regions on the surface which quench the local heating of the chromosphere and thus cause a kind of molecular catastrophe (i.e., enhanced molecule formation resulting in further cooling) which finally results in formation of carbon grains. As soon as the grains are formed they get expelled by radiation pressure and cause the light minima. (S.Giridhar, N.Kameswara Rao & D.L. Lambert*)

R CrB and Hydrogen deficient carbon stars

With a view to study the elemental abundances of cool hydrogen deficient stars, high resolution (~0.3Å) spectroscopic observations in the spectral regions of 4200 - 4900 Å and 5500 - 6800 Å were obtained. Spectra of about 20 R CrB and hydrogen deficient carbon stars were obtained with the Cassegrain echelle spectrometer and the 4 m telescope of the Cerro Tololo Interamerican Observatory. Analysis of the data is in progress. Initially two stars (LR Sco and DY Cen) were studied in some detail.

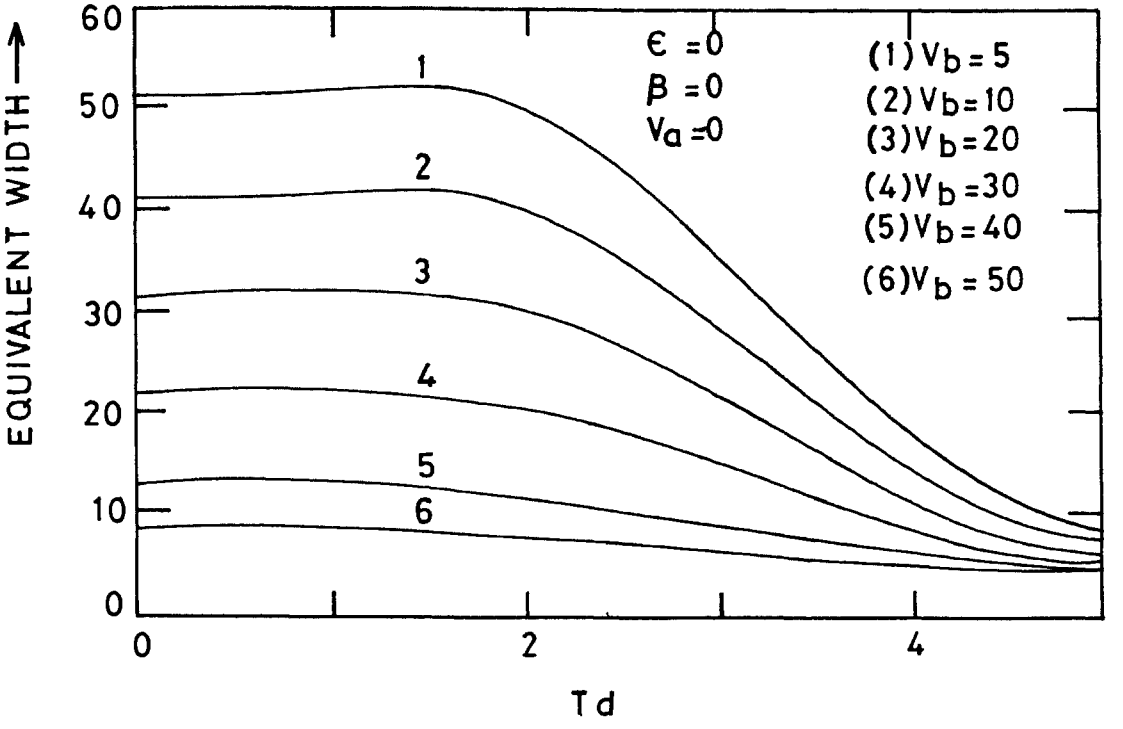
The star LR Sco, which was thought to be a R Cr B star by Stephenson and listed in Drilling and Hill's catalogue, is clearly not a R CrB star. The spectrum shows strong Hα lines and no CI lines and seems to be a normal F8 supergiant. However, the presence of infrared excess makes the star an interesting object worth further study.

The star DY Cen is a hot R CrB star with an effective temperature (T_{eff}) ~14000 K. Observations in the red region show the following characteristics: a strong absorption line spectrum dominated by lines of CII, NII and NeI; inverse P-Cygni type profiles to some CII and HeI lines and forbidden lines of [NII], [SII] and [OI]. The photospheric spectrum indicates a high abundance of C, N, He and Ne. The star also seems to possess an expanding chromosphere or stellar wind region. The forbidden lines indicate the presence of a low excitation nebula with electron temperature and density ~7500 K and 10^3 cm^{-3} respectively. The presence of low excitation nebulae may be a common property of the hotter R CrB stars.

To investigate general patterns in the abundance peculiarities in these R Cr B stars, several spectral orders containing spectral lines of Hα, LiI, NI and CI were reduced. It is hoped to do a kinematical study from radial velocities. (D.L.Lambert*, N.Kameswara Rao & S.Giridhar)

The UV spectrum of the WC 11 star CPD-56°8032 was analysed. The mass loss rates were estimated and the general properties of the WC 11 stars were discussed. Further high and low resolution ultraviolet spectra (IUE) of CPD-56°8032 were obtained. The CII λ2836 line clearly shows a P-Cygni profile. Analysis is in progress. (N.Kameswara Rao, S.Giridhar & K.Nandy*)

Observations of the CO (1-0) line at 2.6 mm were obtained for a few hydrogen deficient stars and nebulae, particularly the WC 11 stars He 2-113, V 348 Sgr and Abell 58 were observed with the Swedish ESO submillimeter telescope at La Silla. He 2-113 shows a very interesting behaviour and the other two sources have marginal detections. Further detailed observations both in CO (1-0) and (2-1) lines are planned (N.Kameswara Rao, L.Houziaux* & L.Nayman*)



Variation of equivalent widths with τ_d, the dust optical depth, in a medium with pure scattering. Note V_A is the initial velocity, V_B is the final velocity and the velocity is measured in mean thermal units. (A.Peraiah)

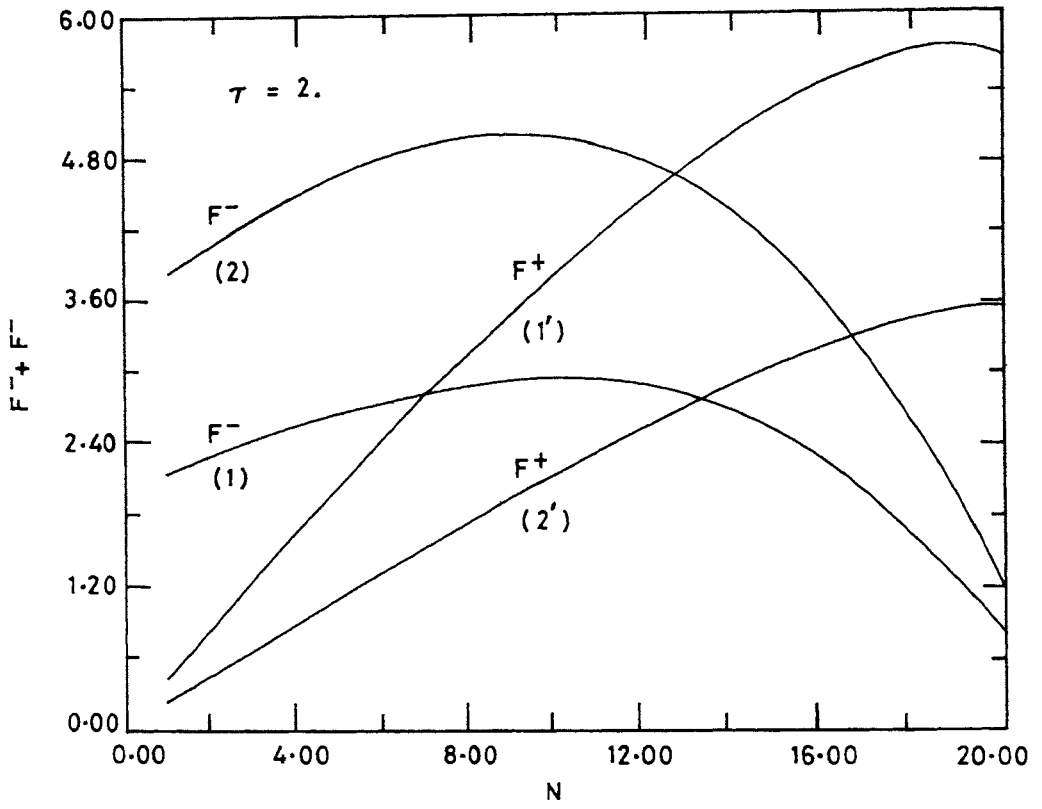
Star clusters

NGC 2236

The age and distance of the faint cluster NGC 2236 were determined. There is an indication of variable extinction across the field of this cluster with E(B-V) ranging from $0^m.89$ to $0^m.55$. The cluster stars show a range in their ages from 2.8×10^7 to 12.5×10^7 years. The distance of the cluster is 4.02 ± 0.23 kpc. This somewhat older cluster is located in the outer Perseus arm of the Milky Way. (G.S.D. Babu)

Stellar Rotation

The determination of the effects of rotation on colours and line indices of stars in various clusters, for which the data were available, was continued. There are 29 galactic clusters for which $V \sin i$ data (with a minimum of 10 stars in a cluster) are available. Data analysis was completed on the following: α-Persei, Pleiades, Scorpio-Centaurus association, Praescepe, Coma, Hyades, IC 2301, IC 2602, IC 4665, IC 4756, NGC 2422 and Cep OB 3 association. The reddening effect due to rotation on various col-



The forward and backward fluxes, F^- and F^+ respectively, as a function of N, the number of shells The curves 1 and 1' represent the solutions without the $\partial^2 I/\partial\lambda^2$ term, whereas the curves 2 and 2' correspond to solutions with this term. (A.Peraiah)

our indices was established. It was found that the observed effects for these cluster members, in the spectral type range BO-FO are in fairly good agreement with the predicted theoretical photometric effect by Collins and his co-workers. (R.Rajamohan & A.Mathew)

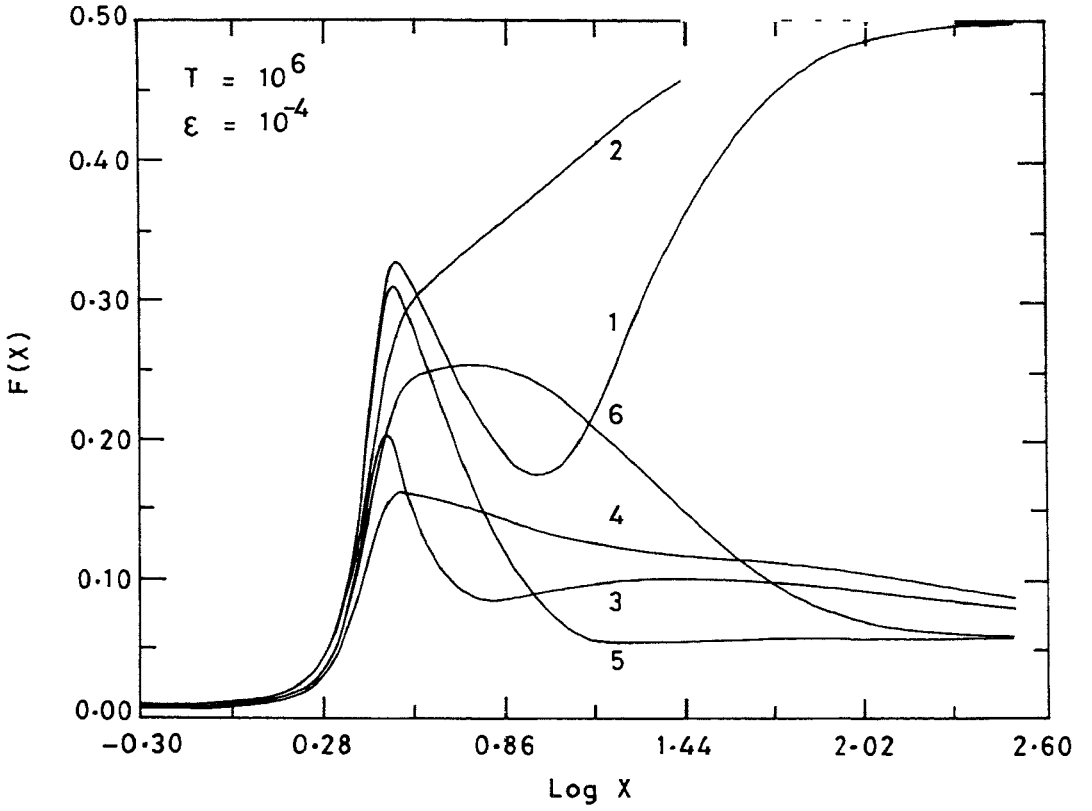
NGC 2818

The galactic cluster NGC 2818 which consists of the planetary nebula NGC 2818 was studied with the VBT using CCD images obtained in V, R, I filters. The distance modulus of $(m\text{-}M)_0$=12.9 was obtained from the turn off of the cluster. The age and the mass of the progenitor of the planetary nebula was estimated. An age of 5×10^8 years was estimated for the cluster. (R.Surendiranath, Ram Sagar, J.Nathan, N. Kameswara Rao & K.K.Ghosh)

Radiative transfer and Scattering

Radiative transfer effects of dust and expansion

The effects on line equivalent widths due to



Emergent flux is plotted for a spectral line having line centre optical depth $T = 10^6$ and collisional de-excitation parameter $\varepsilon = 10^{-4}$. Abscisa gives the frequency x measured from line centre in Doppler units in logarithmic scale. Odd numbers represent the results for partial redistribution in frequency and the even numbers denote the complete redistribution in frequency. 1, 2 denote the results without electron scattering and 3, 4 the results for non coherent electron scattering with $\beta_e = 10^{-5}$, where β_e is the ratio of electron scattering coefficient to line centre absorbtion coefficient. 5, 6 denote the results for coherent electron scattering with $\beta_e = 10^{-5}$. (K E.Rangarajan)

the presence of dust and the radial expansion of matter in spherical shells around stars were studied. A two level non-LTE atom approximation was employed, assuming that dust scattering is isotropic. Expanding shells were considered with and without velocity gradients. The equivalent widths change considerably depending upon the dust content, the velocity of expansion and the non-LTE parameters. These parameters have significant effects on the ratios of the emission peaks to the absorption depths in the P-Cygni type line profiles. As the dust optical depth increases, the equivalent widths in a medium moving with a velocity gradient are reduced while equivalent widths formed in a medium moving without a velocity gradient increase since the emission is considerably reduced.

The variation of the equivalent width in a

line as a function of the dust optical depth were calculated for various expansion velocities. These widths fall in a medium moving with a velocity gradient, when the dust optical depth increases beyond 2. This can be explained on the basis that dust scatters photons into the core of the lines so that the absorption is reduced and, therefore, the emission increases with the reduction of equivalent width. (A.Peraiah & M.F. Ingalgi)

Aberration and advection

The earlier work on aberration and advection was extended to the case of spherically symmetric media. The aberration and advection effects in a spherical medium, which scatters radiation isotropically and coherently, were considered. It was assumed that the spherical shell is moving radially with velocities 1000, 2000, 3000, 4000, 5000 km s^{-1} (v/c ~0.003-0.017, where v is the velocity of the gases and c is the velocity of light). The transfer equation was solved in the co-moving frame, and the effect of these high velocities on the radiation field in terms of $\bar{J}$, where $\bar{J}$ is the mean intensity, were studied. It was found that $\bar{J}$ changes from -4% to 2% at optical depth τ=1, B/A =2 (B and A are the outer to inner radii of the spherical shell) and to a maximum of 450% at τ =10 and B/A =2. It was noticed that in a spherical medium, unlike in a plane parallel one, the changes in $\bar{J}$ are not proportional to the optical depth τ. When the optical depth is increased to 50, the deviations in $\bar{J}$ vary between - 30% and 65%. When the geometrical thickness of the spherical shell is increased, the changes in $\bar{J}$ are not considerable. The amplification factor defined as $\bar{J}_{max}/100\beta$ shows a maximum at about τ =10 for B/A =2 and 5, although the maxima in the latter case are much smaller than those in the former case. The changes in mean intensities are large and depend on the geometrical and optical thicknesses of the spherical shell. (A.Peraiah)

Equation of transfer with Compton scattering

The solution of the transfer equation with Compton scattering in plane parallel layers and spherically symmetric shells was derived. Expanding the specific intensity term in a Taylor series and including the first three terms of the Taylor series, it was noticed that substantial differences exist between the solutions obtained when only the first two terms were included and those calculated using the first three terms. Another interesting feature is that incident radiation at the Compton wave length X=1 is scattered over several Compton wavelengths in a spherical medium with N=20 (N denotes the number of shells) and τ_{max}=5. (A. Peraiah & B.A.Varghese)

Effect of electron scattering on spectral line formation

The observed spectra of O,B stars and quasars show broad lines. The theoretical calculation of these lines taking electron scattering into account was started. Since electron scattering yields a large Doppler width, there is a need to extend the line calculations far from the line centre. Spline interpolation techniques were used to accurately determine the partial redistribution of photons by atoms in the far wings. It was found that the electron scattering broadens the spectral lines significantly. The calculations were performed with parametrized models to find out the effect of electron scattering and also to understand the underlying physical processes in line broadening. (K.E.Rangarajan, D.Mohan Rao & A.Peraiah)

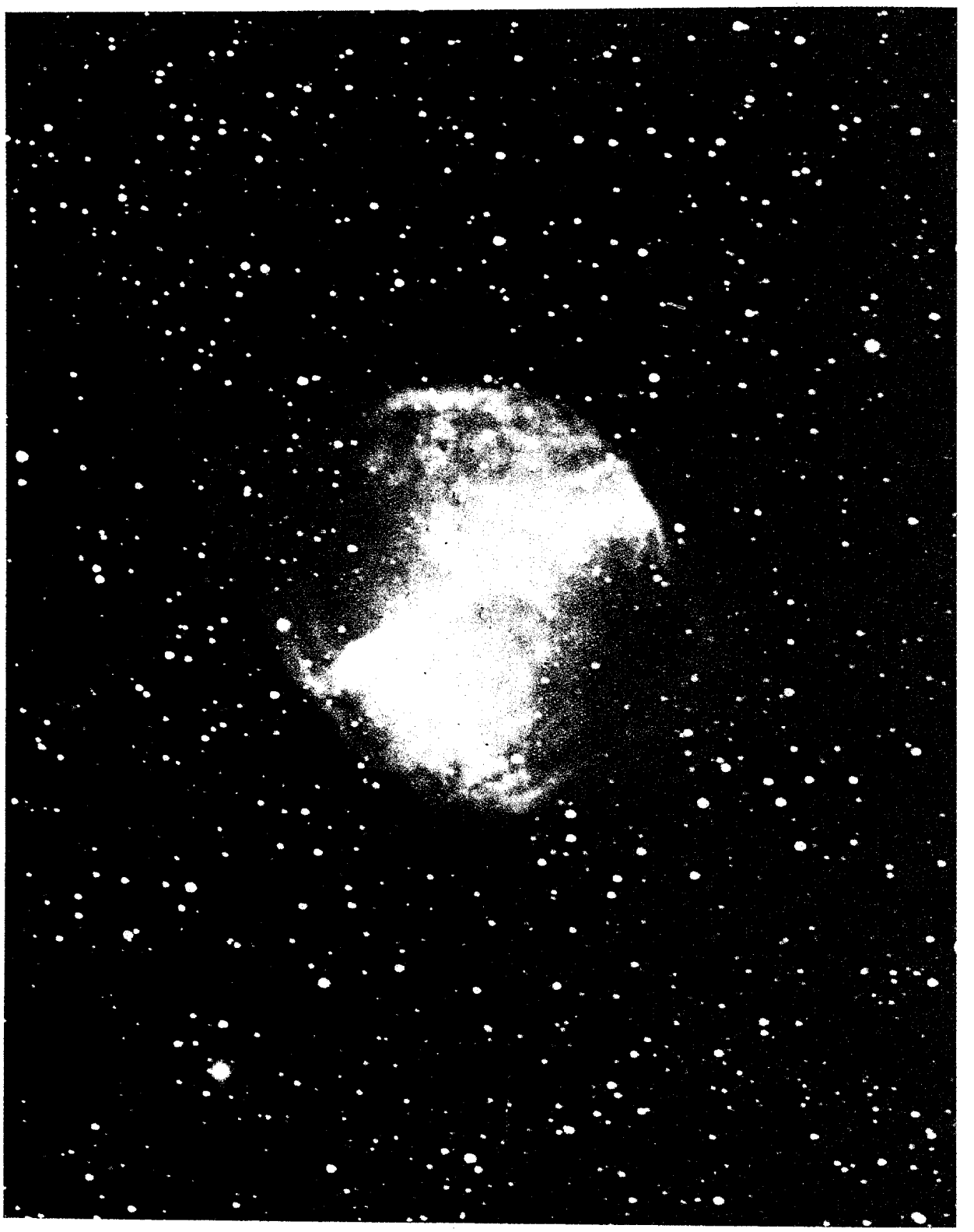
Time-dependent radiative transfer

The time-dependent transfer equation for a two-level atomic model, taking into account bound-bound and bound-free transitions, was derived. The form of the transfer equation is similar in both the cases. Hence the numerical scheme which was proposed earlier for solving the monochromatic time-dependent transfer equation can be easily extended to solve the problem of time-dependent line formation or the bound-free continuum. Since the recombination time is usually significant in most of astrophysical phenomena, the time-dependent bound-free continuum has a potential application. (D.Mohan Rao, K.E.Rangarajan & A.Peraiah)

Scattering

A study of asymptotic values of some scattering parameters, based on the Mie theory of scattering by a sphere was undertaken. The asymptotic values of the extinction, scattering and absorption efficiencies, albedo, asymmetry factor, efficiency of radiation pressure and back scattering efficiency for very large spherical particles can be calculated from the formulae based on geometrical optics and diffraction. However, their range of validity vis-a-vis Mie theory has rarely been discussed quantitatively in the literature. The Mie theory calculations were undertaken for a size-to-wavelength parameter x in the range $10^{-5} \leq x \leq 10^{5}$ and for a variety of indices of refraction, in order to delineate this aspect. (G.A.Shah)

The work on the scattering parameters for very large dielectric spheres from the viewpoint of geometrical optics and diffraction is in progress. (G.A. Shah)



Dumb-bell nebula M27, photographed with the 1 m telescope at Kavalur. (K.K.Scaria)

Interstellar Medium and Planetary Nebulae

Pulsars

Propeller spindown of pulsars in the interstellar medium

The standard rotating magnetic dipole model for pulsars predicts a spindown as rotational energy is lost. Spindown to periods upto 5 s can be achieved by this mechanism. Accretion of interstellar matter by pulsars was considered when the gas pressure at the light cylinder exceeds the pulsar radiation pressure. Infall of matter is arrested at the magnetopause and is flung away by centrifugal forces. This results in a loss of angular momentum of the neutron star and spindown to long periods ($\geq$100 s). A model was proposed for the recently discovered X-ray pulsar H0252+193, in the direction of the molecular cloud L1457, in which a neutron star, spun down by the propellar mechanism, was observed with a long period (~206 s) during its passage through the molecular cloud. (H.C.Bhatt)

Symbiotic stars and Planetary nebulae

Symbiotic stars

Symbiotic stars consist of two interacting components. One is a hot component which is a source of ionising ultraviolet radiation and the other is a cool giant star that loses matter through a stellar wind. The ultraviolet radiation from the hot component produces an HII region in the wind of the cool component. If the binary separation is large the HII region too can be quite large and it may be possible to resolve it. A programme of imaging symbiotic stars to detect and study extended emission nebulosities around them was started. Three symbiotics (RR Tel, H1-36 and R Aqr) were imaged with a CCD in the emission lines of [OIII], Hα, [NII] and [SII]. Ionisation stratification was found in the nebula around R Aqr. The [OIII] emission comes only from the core, while the low excitation lines dominate the outer parts. The other two symbiotics did not show any extended emission nebulae. (H.C.Bhatt, R.Sagar & R.Cannon*)

Planetary nebulae

Three new samples of planetary nebulae were studied to find the variation of the filling factor with the nebula size. Using the extensive compilation of forbidden-line electron densities by Stanghellini and Kaler (1989, Astrophys. J. **343**, 811) and the measured 5 GHz radio continuum fluxes it was possible to determine filling factors of more than a hundred planetary nebulae whose distances were estimated on the basis of the Cudworth scale. The filling factor showed a remarkable decrease with increasing size. A second sample of galactic bulge planetaries was analysed using the observations of Webster (1988, Astr. & Astrophys. **221**, 123). Since the electron density information was rather incomplete for this sample, filling factors for only a dozen planetary nebulae could be determined. The values are very small, of the order of 10^{-2} - 10^{-3}, showing that even for these nebulae, parameters governing their evolution are deeply affected by filling factor considerations.

Using the distance scale proposed by Mallik and Peimbert (1988, Rev.Mex.Astron. Astrof. **16**, 111) and the measured radio fluxes of an unambiguous sample of galactic centre planetar-

ies, the distance d_{GC} to the galactic centre was estimated to be 6.4 kpc. The current best estimate of d_{GC} is 7.8 kpc. This discrepancy is not surprising since the distance scale used was based on observations of the solar neighbourhood nebulae and may actually be indicative of a subtle population difference between galactic centre nebulae and those in the solar neighbourhood. (D.C.V. Mallik & M.Peimbert*)

Model nebulae

A numerical model to simulate the physical processes in a planetary nebula was developed. With a view to model low excitation nebulae, the spectra of M4 - 18, IC 2149, He 2-47, M1-14, and IC 4593 were obtained with a CCD spectrograph at the Kavalur 1 m telescope. (R.Surendiranath, N.Kameswara Rao & A.R.Hanumanthappa*).

Galaxies, High Energy Astrophysics & Cosmology

Galaxies

Star-forming regions in nearby galaxies

Observations of star-forming regions in external galaxies were continued with the 1 m and also with the 2.3 m VBT. The following galaxies were imaged in the Hα and R bands using different CCDs: NGC 278, 925, 1365, 1566, 2403, 2903, 2997, 4303, 4449, 4656, 5253, and 5713. In addition, some of these were observed in other bands of the BVRI system. A part of the data was reduced using a synthetic aperture photometric technique. Narrow band imaging of some of the galaxies (NGC 2903, 2997, 4303, 4656) was also attempted using a wide-slit spectroscopic technique in the wavelength range 4600-7600Å. (T.D.Mayya & T.P.Prabhu)

Initial mass function of extragalactic giant H II regions

The Balmer line fluxes from extragalactic giant H II regions can be used to infer the Lyman continuum flux of young star clusters embedded in them. These fluxes can be used to infer the O-type stars present in the cluster, whereas the B-band luminosities corrected for the contribution from the ionized gas yield an estimate of the B-type stars present. The ratio of these two quantities is thus an indicator of the initial mass function of the cluster ionizing the H II region for stars whose mass > $5M_{\odot}$. The method was tested on some H II regions using published spectrophotometric data. A comparison of the ratio of Lyman continuum fluxes to the B luminosities of the clusters as a function of metallicities of the H II regions suggests that metal-rich H II regions are deficient in high-mass stars. (Y.D.Mayya, T.P.Prabhu & F.H. Sahibov*)

Surface photometry

Images of the X-ray cluster of galaxies 2A 0335+096 were obtained in the VRI bands using the 2.3 m VBT and the Astromed CCD system of the Tata Institute of Fundamental Research, Bombay in January, 1990. The reductions are in progress. (K.P.Singh*, T.P.Prabhu, P.N.Bhat* & A.K.Kembhavi*)

Broadband images of many field galaxies were obtained with the VBT during January-March 1990, in the VRI bands, with the view of decomposing the luminosity profiles. The reductions are in progress. (A.K.Kembhavi*, T.P.Prabhu &P.N.Bhat*)

Shell type supernova remnant G 18.95 -1.1

This work is based on the analysis of VLA data available for the object G 18.95 - 1.1, a nonthermal galactic radio source, at frequencies 6 cm, 18 cm and 20 cm at the Radio Astronomy Centre, Ooty. It is expected that the analysis of this data would reveal some interesting central features from which information such as spectra and polarization can be derived. It was found that the map of G18.95-1.1 is consistent with the conventional shell-type morphology around a central object. (T.Velusamy,* V.R.Venugopal,* & A.Goswami)

Dynamics

Tidal disruption and merger are two important processes in the dynamical evolution of a

binary stellar system. Numerical simulations were performed to study the tidal effects of a massive perturber on a satellite galaxy. The model consists of a spherical satellite galaxy and a point mass perturber and assumes that the encounter is non-penetrating. A wide range of collision parameters like the density ratio and the eccentricity of the relative orbit were considered. A criterion for the disruption of the satellite galaxy was obtained in terms of the density ratio. Disruption occurs when $\rho_h/\rho_R<4$ where ρ_h is the mean density within a sphere of radius R_h (the half-mass radius) and ρ_R is the Roche density. In such cases, the ratio of the fractional change in the internal energy to the initial energy was greater than two and the mass loss exceeded 30-40%. Comparison of the numerical results with predictions of the impulse approximation (IA) showed that the IA estimates agreed within a factor of two with numerical results in the range $0.1<\Delta U/|U|<2$. (ΔU is the change in the internal energy and U is the initial energy of the satellite). The IA overestimates the energy transfer when $\Delta U<|U|<0.1$ due to the neglect of stellar motions and underestimates the same when $\Delta U/|U|>2$ due to the neglect of satellite loosening. The fractional change in the energy and angular momentum showed smooth variations in open orbit encounters and irregular variations in bound orbit encounters; this is due to the partial reversal of the tidal acceleration during a part of the orbit in the latter case. (P.M.S.Namboodiri & R.K.Kochhar)

The transfer of angular momentum to an initially non-rotating spherical galaxy, as it undergoes a collision with a point-mass perturber, was investigated by numerical simulations. The spherical galaxy acquires spin with direction parallel to that of the initial orbital angular momentum of the pair, provided there is no mass loss. In the case of mass loss, which is always anisotropic, the spin of the remnant bound system tilts towards the orbital plane. Thus an anomalous tilt of the spin can be taken as a signature of tidally affected elliptical galaxies. (P.M.S.Namboodiri & R.K.Kochhar)

The distribution of stars over the galactic disc, were calculated for a distribution $n(m) \propto m^{-x}$ for $m>m_0$ and $n(m) = 0$ otherwise, where $n(m)$ is the number density of stars with mass m and $x>1/2$. It is assumed that the system is close to thermodynamic equilibrium. The Poission equation was solved analytically and the gravitational potential was determined in terms of a confluent hypergeometric series. The mass distribution was computed for several functional forms of the stellar mass spectra. (S.Chatterjee)

Stellar population synthesis

Work in the area of stellar population synthesis was continued. The main emphasis was on building up a more complete library of standard stellar types. Metal weak and metal rich stars of known abundances were especially included in an observational programme to obtain CCD spectra in the wavelength region 3700–10000 Å, at dispersions which are also to be used for galaxies. (A.K.Pati)

Quasars

In addition to collisional damping, strong electromagnetic radiation suffers anomalous absorption in a plasma when the necessary and sufficient conditions of threshold intensity and conservation of energy and momentum are satisfied. The parameteric decay instability is excited when an electromagnetic wave decays into an

electron plasma wave and an ion-acoustic wave. Plasma heats up due to damping of these electrostatic modes. This instability was fully investigated in the following four limiting cases: (i) decay into an ion-sound wave, (ii) decay into a reactive quasi-ion mode, (iii) decay into a resistive quasi-ion mode and (iv) oscillating two stream instability. The intermediate parameter space, among these cases, depending upon the intensity of the electromagnetic radiation and plasma characteristics was also examined. It was found that a plasma can attain very high temperature through this process. The highest temperature for the emission line region of quasars was estimated. (V.Krishan).

A study was initiated to analyse the effects of dynamical friction on the motion of a compact high redshift object (quasar) ejected from the centre of a low redshift galaxy where the mass of the ejected object evolves with time in accordance with the theory of anomalous redshift quasars developed by Narlikar and Das within the framework of the conformal gravitation theory of Hoyle and Narlikar. (R.C.Kapoor & P.K.Das)

The quasar-galaxy pair 3C 232/NGC 3067

The phenomenon of visible connection between a low redshift galaxy and a high redshift quasar provides an important criterion for deciding the nature of quasar redshifts. Recently Carilli et al. (1989) reported an apparent bridge of matter connecting the low redshift spiral galaxy NGC 3067 to the much higher redshift quasar 3C 232. An explanation for this association is sought in terms of a model for the anomalous redshift quasars put forward by Narlikar and Das based on the Machian theory of gravitation by Hoyle and Narlikar. In this scenario the quasar is hypothesised to have been 'born' in and ejected from the nucleus of the associated parent galaxy. The quasar has an anomalous redshift component and the particle masses in it grow with time. It is shown that by a suitable choice of initial conditions the observed configuration of 3C 232 and NGC 3067 can be achieved. Further, the other observed features such as low redshift emission and absorption systems associated with the quasar and the severely disturbed state of the galaxy can be qualitatively accounted for in this scenario. (P.K.Das)

The effect of dynamical friction on the motion of a supermassive object ($M \sim 10^9 M_o$) ejected from the centre of a galaxy ($M \sim 10^{11} M_o$), studied earlier by Kapoor, was extended to the case when the mass of the ejected object is not constant, but evolves with time in accordance with the theory of anomalous redshift quasars developed by Narlikar and Das. (R.C.Kapoor & P.K.Das)

As a consequence of redshift, the proper period of a pulsar will be smaller than the observed one. The variation in redshift with radial position of the emitter along with rigid corotation of the magnetosphere, leads to an inconsistency among the observed periods at different frequencies. An estimate was made of the difference in the observed periods of emission from the surface of a rotating neutron star and from emitters located 10 m to 100 m above the surface. The discrepancies in periods of emitters on the surface and at a height of, say, 100 m above it, are found to be of the order of 0.1 milliseconds, for parameters specific to the Crab pulsar. The inclusion of rotational effects (frame drag and Doppler) improves these discrepancies by 3 nanoseconds. (R.C.Kapoor).

Quasars in a varying G cosmology

The effect of a variable gravitational 'constant' G on the properties of quasars was investigated. It was seen that the temporal variation of G leads to a systematic luminosity enhancement at earlier epochs, whereas the mass of the quasars increases with time. For hot, supermassive star models of quasars, G variation predicts higher temperatures and consequently bluer quasars in the past. Properties of massive black hole (MBH) models of quasars in this scenario were also investigated. More rigorous calculations for MBH models, taking into account general relativistic effects, are in progress. (P.K.Das & C.Sivaram)

High Energy Astrophysics

Neutron stars/Quark stars

Timing observations of glitches in the rotation rates of pulsar crusts and their time derivatives provide important clues to the interior structure of neutron stars. The most important information provided by the glitches and post-glitch relaxation is the fractional change of the spin-down rate. Current research suggests that this quantity depends on the fractional moment of inertia of the neutron star region involved in the glitch. All observations till now yield a value in the range 10^{-2} - 10^{-3} for this fraction, pointing to a component of the pulsar that carries less than a hundredth of the total moment of inertia. A detailed numerical survey of this fractional moment of inertia, corresponding to the presently available realistic equations of state of neutron star matter, was made along with a comparative study of the observational situation, with a view to obtain possible constraints on the equation of state models. (B.Datta)

Neutron star structure parameters were computed with the following new models of the equation of state: (a) one that incorporates short-range spin-2 interactions and the derivative form of the nuclear scalar interaction and (b) based on the chiral sigma model of nuclear matter. (B.Datta)

An estimate was made of the possible ohmic dissipation of the magnetic field in quark stars. It was found that the time scale of such dissipation is of the order of 10^{-8} seconds, thus implying that the surface magnetic field of all quark stars, if they exist, will be at most a billion gauss. (B.Datta & B.Sinha*)

The joint manifestation of two fundamental concepts of quantum physics was explored: (a) the Pauli exclusion principle and (b) vanishing of the mobility of particles at the band edge of a periodic lattice, in the presence of a magnetic field. It was shown that if the magnetic field H be such that $\mu_B H \geq E_B$ where E_B is the band width and μ_B is the Bohr magneton, a one dimensional chain of atoms becomes insulating even if it has one electron per atom. It was pointed out that this phenomenon can be found in neutron star atmospheres. (S.Chatterjee)

Combined hydrogen and helium burning reactions

An attempt was made to study the combined hydrogen and helium burning processes in high temperature and density conditions. The possible sites for these processes are believed to be the neutron star surfaces where the density ρ ranges from 10^4 to 10^7 g cm^{-3} and the temperature T ranges from 10^8 to 8×10^8 K. The screening effect which leads to an enhancement of nuclear reaction rates is taken into account whenever necessary. Finite amounts of ^{26}Al are found to be

produced at $T=2x10^8$ K and $\rho = 10^6$ g cm^{-3} due to these combined reactions. Thus, it is suggested that these processes may contribute to the galactic abundance of ^{26}Al, though on a very small scale. (A.Goswami, H.L.Duorah* & S.Ramadurai*)

Neutrinos

Stringent limits on the neutrino electric charge and magnetic moment were placed from various astrophysical considerations. (C.Sivaram)

The effects of a neutrino magnetic moment and neutrino oscillations in a primordial magnetic field in affecting big bang nucleosynthesis was analysed and constraints put on these parameters. It was shown that if neutrinos couple to torsion with the strength of weak interactions, then neutrino oscillations and a magnetic moment could be induced even for massless neutrinos. The consequences of this for the propagation of neutrinos in dense collapsing cores was considered. (C.Sivaram & V.De Sabbata*)

Pulsars

The production and emission of high energy particles from the submillisecond pulsar in SN 1987A was considered. The emission of high energy gamma rays from the pulsar surface and magnetosphere was also discussed. This enabled constraints on some of the current models of particle acceleration in pulsars to be put. Evolution of such pulsars and their contribution to the high energy cosmic ray background was also studied. (C.Sivaram)

Polarized gamma rays

It was suggested that the beta decay of various radioactive isotopes such as ^{56}Ni in supernovae should give rise to strongly right circularly polarized gamma rays from the annihilation of right helicity positrons of high energy. Intensity estimates were given for various superonovae and suggestions for observing such a flux from a space station were made. (C.Sivaram)

Gamma ray background from ^{26}Al radioactive decay

Explosive events in the galactic centre as well as in active galactic nuclei associated with supermassive stars could convert pre-existing magnesium into several solar masses of ^{26}Al. This should also happen in dense stellar clusters with a rapidly evolving stellar population. The decay of the isotope ^{26}Al by emission of radiation at 1.8 MeV should contribute to the intergalactic gamma ray background. This was estimated with a view to understanding its contribution to the 'step' in the MeV γ-ray background. (C.Sivaram)

Extragalactic cosmic rays

A mechanism for the injection of ultrahigh extragalactic cosmic rays involving dense stellar clusters in cores of active galactic nuclei was given which could account for the highest energy cosmic rays observed. (C.Sivaram & V.De Sabbata*)

Supernova SN 1987A

It was shown that the coincidence of photon and neutrino (antineutrino) arrival times to within a few hours from SN 1987A, enables useful and stringent constraints to be placed on many diverse questions regarding fundamental

properties of gravity. Among these are the validity of the weak equivalence principle for ultra-relativistic particles, infall of antiparticles, post-Newtonian parameters and non metric theories, and on possible C, P and CP nonconserving parameters of the gravitational field. Again tight constraints on possible long range very weak additional forces can be placed. (C.Sivaram)

Cosmology

Early universe

An energy dependent superstring tension in the early universe was shown to be connected to fundamental physical coupling constants. The role of Weyl gravity for sub-Planckian as well as for macroscopic domains was explored and the existence of a hierarchy of scales was considered. (C.Sivaram)

The consequences of an energy dependent torsion coupling constant for the evolution of the early universe was investigated. (C.Sivaram)

It was pointed out that massive spin-two fields could give rise to inflationary cosmological models in the early universe (C.Sivaram & V.De Sabbata*)

It was demonstrated that an energy dependent torsion coupling constant can make the spin contributions of matter sources large enough to cancel the cosmological constant term at all stages in the early universe from the Planck epoch in a modified Einstein Cartan theory (C.Sivaram & V.De Sabbata*)

A study of strong gravity theory was carried out in five dimensional Kaluza-Klein spacetime in connection with the cosmological constant. (C.Sivaram, S.Kumar* & S.Biswas*)

The detailed consequences of Weyl gravity for the early universe was explored especially in connection with inflation and the formation of hierarchical structures. (C.Sivaram)

The topological significance of six compactified dimensions in string theory was discussed and also the entropy of evaporating mini-black holes in the early universe in higher space dimensions. The consequences of black hole-string transitions in generating entropy in the early universe was studied. (C.Sivaram & V.De Sabbata*)

Gravimagnetic effects were considered in connection with the plasma damping of thermal gravitational waves in the early universe. (C.Sivaram)

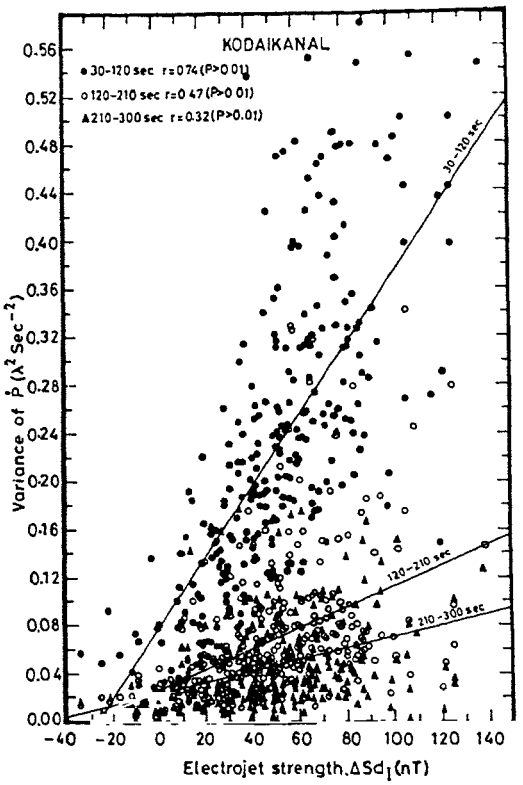
Solar - Terrestrial Physics

Ionosphere

Solar wind - magnetosphere - ionosphere interactions

A study was made of the response of the equatorial ionospheric electric field and plasma density to the magnetospheric storm of 31 Dec 1967 - 1 Jan 1968 which occurred in association with a steady and prominent southward IMF Bz for a prolonged period of time. The storm also displayed the unique characteristic of near - steady values of solar wind - magnetosphere dynamo power ($\in$) as well as the magnetospheric total power output (UT) for about a day interval when B_z assumed steady and high southward values. The storm thus provided a rare opportunity to investigate the response of the magnetosphere - ionosphere system to steady input - output conditions, and to address the unsettled question of the nature of the effect of steady and enhanced magnetospheric convection on the equatorial electric field. Analysis of data from the global networks of magnetometer/ionosonde stations revealed the presence of both transient and persistent perturbations in the equatorial electric field during the storm. The first transient disturbance occurred during the span when AE (auroral electrojet) levelled off but the ring current injection rate ($\dot{D}_{st}$) increased and its polarity was westward in the dayside (09-12 LT) sector. The persistent disturbance (of duration 7 hrs) prevailed in the recovery phase of the storm and was prominent enough so as to lead to not only counter electrojet (CEJ) conditions but also to a reversal of the equatorial ionization anomaly profile in the dayside sector. The characteristics of the evidenced electric field disturbances during the storm do not find a ready interpretation in terms of the physical mechanisms currently known to affect the equatorial electric field during periods of enhanced energy input to the magnetospheric system. The study thus brings into focus the need for the development of comprehensive theoretical models of the response of the equatorial electric field to electrodynamic changes in the magnetosphere and high latitude ionosphere. (J.H. Sastri & K.B.Ramesh)

Evaluation of the characteristics of the ionospheric storm that prevailed at equatorial latitudes in the wake of the severe ($|D_{st}|_{max}$=290nT) geomagnetic storm of October 28-29, 1961 strengthens the recent realisation that the equatorial thermosphere could yet undergo significant modifications during disturbed geomagnetic conditions and thus could play a prominent role in the storm-time behaviour of the equatorial ionosphere. The outstanding feature of this ionospheric storm is the anomalous behaviour of the F - region plasma density during the recovery phase of the geomagnetic storm, when a prolonged westward electric field disturbance prevailed in the Indian sector corresponding to daytime conditions. In association with the weakened electric field, $N_m F_2$ values near the dip equator were markedly reduced and the F - region experienced a substantial increase in height simultaneously indicative of strong heating effects. The equatorial anomaly in $N_m F_2$ was however not affected. In fact, the anomaly showed a strong and abnormal development early in the forenoon and maintained its depth throughout the day, although the absolute values of $N_m F_2$ at both the trough and crest latitudes of the anomaly were reduced. This behaviour of



Mass plot showing the dependence of the variance (σ^2) of the fluctuations in the time rate of change of phase path, $\dot{P}$ (or Doppler frequency shift Δf) of lower F-region reflections over Kodaikanal, on the ambient electrojet strength, ΔS_{dI}. The evidenced relationship suggests that the short-period (30-300 s) pulsations in $\dot{P}$ are due to phase path changes imposed on lower F-region reflections by the refractive index variation associated with the convective motions of plasma density irregularities (Type I and II) in the electrojet. Model calculations show that the electrojet irregularities $\left(\frac{\Delta n}{n} \sim 5 - 15\%, \text{thickness } 5 \text{ km}\right)$ can produce changes in phase path of the observed magnitude, even though they are located well below the reflection level. (J.H.Sastri, K.B.Ramesh & J.V.S.V.Rao)

the day time equatorial F - region does not conform to the conventional understanding, according to which the anomaly ought not to have developed or developed less due to a weakened electric field. The substantial reductions in N_mF_2 throughout the anomaly belt strongly suggest the prevalence of changes in neutral atmospheric composition i.e., increase in $n(N_2)/n(O)$ and $n(O_2)/n(O)$. The composition changes are, however, found to be spatially localised because the reductions in N_mF_2 were not evident at equatorial stations in the African sector. It should be emphasised that such composition changes, though not predicted by the current global thermospheric circulation models, were noticed very recently in satellite data. The origin and sources of the composition disturbances at equatorial latitudes is, however, obscure at the moment. Numerical solutions of the electron density continuity equation with model/ experimental inputs on winds, neutral atmosphere and electric fields are being obtained to validate the conclusions drawn from the data analysis (J.H.Sastri, R.R.Rao*, R.Sridharan* & R.Suhasini*)

Dynamics of the ionospheric F - region

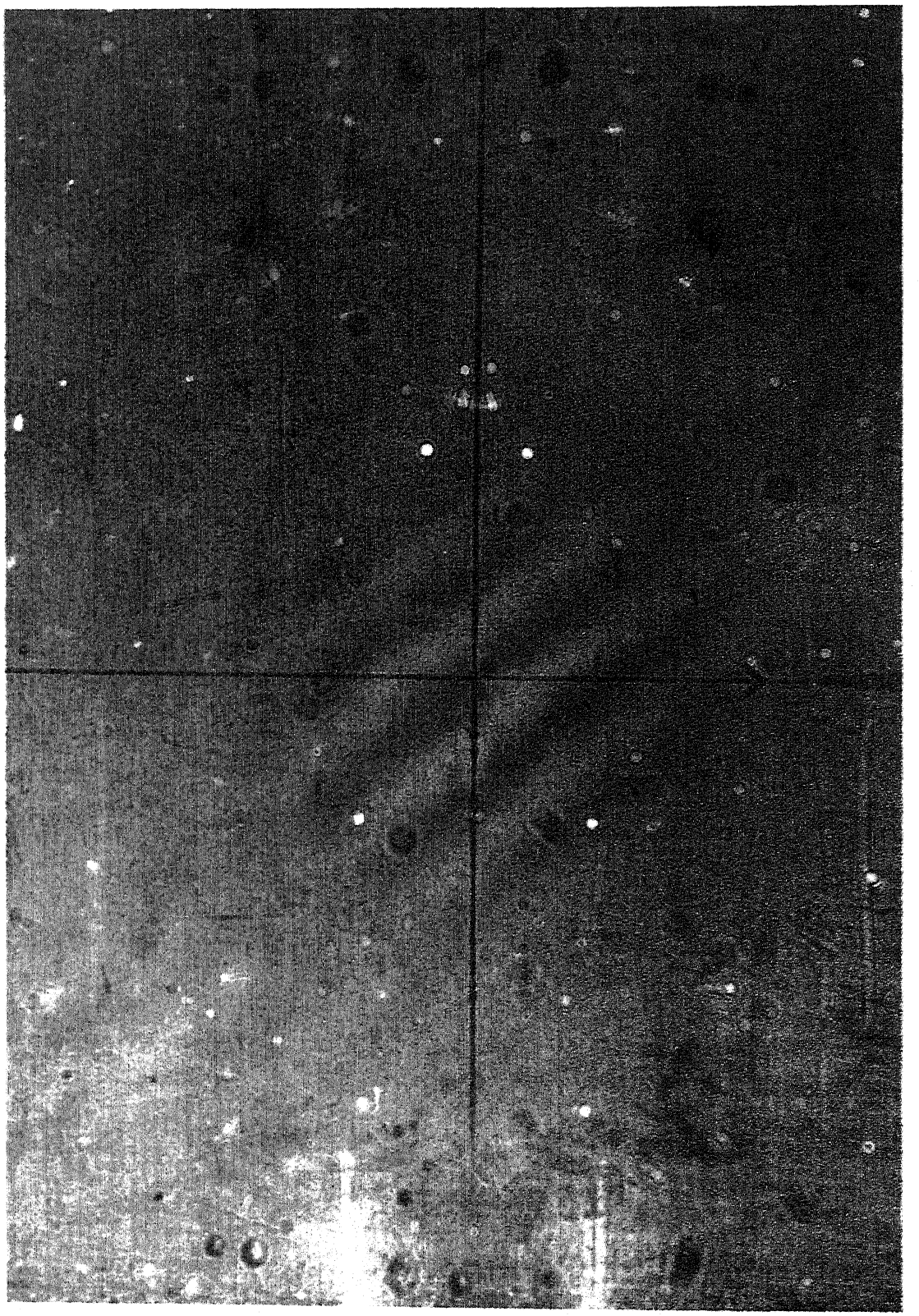
The occurence of quasi-sinusoidal variations in the time rate of change of the phase path $\dot{P}$ (or Doppler frequency shift Δf) with periodicities of 30-600 s, is a common and characteristic feature of the lower F-region (height of reflection 200 km) reflections at vertical incidence over Kodaikanal. The dependence of the lower period segment (30 - 300 s) of the Doppler frequency variations on the ambient electrojet strength and associated ionospheric conditions were studied to explore the genesis of the doppler pulsations. The variance of $\dot{P}$ (a quantitative measure of the wave activity in $\dot{P}$ in the period range 30-300 s, computed from $\dot{P}$ data synthesised through reverse FFT in the chosen frequency band of the FFT of original data) was

found to bear a systematic and significant linear relationship to the ambient electrojet strength. $\dot{P}$ fluctuations in the sub-band 30-120 s were found to be most sensitive to changes in the electrojet strength. The Doppler fluctuations in the band 30 – 300 s were consistently found to practically cease at times of the disappearance of E_{sq} (equatorial sporadic - E) on ionograms at Kodaikanal (signature of inhibition of the gradient drift plasma instability in the electrojet and the formation of the associated Type II irregularities). The short-period fluctuations in $\dot{P}$ were interpreted in terms of the phase path changes imposed on lower F - region reflections by the refractive index variations associated with the convective motions of plasma density irregularities (Type I and II) in the daytime electrojet. This interpretation was well supported by model calculations, which showed that for vertical soundings near the dip equator, the electrojet irregularities ($\Delta n/n$~5-10%), having a thickness of about 5 km, can produce appreciable changes in the phase path (ΔP) of F - region reflections, even though the irregularities are well below the reflection level. In fact, the model computed values of ΔP are in good agreement with the peak - to - peak amplitudes of the observed pulsations in the Kodaikanal $\dot{P}$ data. (J.H.Sastri, K.B. Ramesh & J.V.S.V.Rao)

Geomagnetic phenomena

The general mathematical analysis of the Kelvin-Helmholtz (K-H) instability of a three layered plasma system without restricting the magnetic and velocity field directions was applied to understand the wavy motions of the neutral sheet observed by IMP6 at about $20R_E$ tailward from the earth. In particular, it was found that when the y-component of the magnetic field, in each lobe was taken into consideration, the K-H instability can be excited only when the dawn-dusk flow has a value of around several hundred km s^{-1}, a factor of ten higher than that found by earlier authors, who assumed that the y-component of the magnetic field is zero. (C.Uberoi)

It was shown that in a plasma with an inhomogeneous magnetic field, with finite jump discontinuities in the field profile, the surface waves along the discontinuities, which are resonantly absorbed when the Alfvén frequency is not zero, will give rise to reconnection of field lines across the resonant layer if the Alfvén frequency becomes zero. This time-dependent reconnection, induced by the boundary perturbations, may explain the geomagnetic micro-pulsations associated with flux transfer events. (C.Uberoi)



White light fringe record obtained from the solid coherence interferometer in the laboratory using a spatially coherent point source. (A.K.Saxena)

Instrumentation

Computer facility

A laser printer and several desktop publishing software packages have been installed. A tape drive with 1600 bpi has been connected to the Mighty Frame II computer for data transfer purposes. (A.Peraiah, D.Mohan Rao & B.A. Varghese)

CCD System

Development of a controller for the GEC P8603 CCD Camera

The present CCD imaging system with the VBT, Kavalur makes use of a CCD dewar and a controller (from Astromed Ltd., UK). In order to provide a standby system for the existing controller and to meet the future requirements for the other telescopes at VBO, a CCD controller is being developed in the electronics laboratory.

As a first step, a high speed communication controller has been developed and tested. This improved board is located on the PC-AT expansion slot and combines the functions of the parallel I/O port (DIGIANA) and the parallel/serial converter electronics unit of the existing Astromed system. It provides advantages like elimination of I/O cabling and draws its power from the PC-AT power supply. A general purpose 16 bit parallel port has also been included in the new board for providing the interface to the digital magnetic tape system. A clock module and double correlated sampling module have also been developed and tested in the laboratory. The printed circuit boards for these modules are under fabrication. (R.Srinivasan, G.Srinivasulu, S.Muralishankar & Thulasidharan)

Remote guiding using an intensified CCD camera

This camera uses a scientific grade CCD chip from GEC (P8603) working in the frame transfer mode and giving a video signal at 50 Hz (TV rate). The CCD is preceded by a microchannel plate with a S-25 cathode and with a gain of about 10,000. This camera is able to show stars of magnitude 13.5 at VBT during dark nights.

To increase the faintness limit further, the image is captured by a frame grabber card (DT 2851 by Data Translation Inc.). Eight to ten frames are added after subtracting the background sky. This enhances the faintness limit. The resultant image is displayed on a TV monitor in the console room. The camera can be moved in the radial direction to search for guide stars in the field, through commands from the console. It is found convenient to guide the telescope remotely from the console room. An autoguider, based on this set up, is being taken up. A 16 bit digital to analogue converter card, which is required for this application, is being fabricated. The software is being written in the C language. (V. Chinappan & Faseehana)

Data acquisition/processing system

Photon pulse counting circuit

A high-speed pulse counting circuit has been designed for photon counting observations with the 75 cm telescope at the VBO. The unit built for IBM PCs satisfies the need for moderate time resolution (0.1 s to several minutes) counting applications.

The photon pulses are counted by a series of eight cascaded 4 bit binary counters. The first stage consists of a Schottky version (8291) of a presettable high speed binary counter, capable of counting upto 100 MHz. Successive stages use synchronous up/down counters 74LS193. The incoming pulses arrive via a terminated transmission line (50 ohm coaxial cable) from the PMT output.

Gate pulses are generated in the software to allow counting for the required integration times. The software in addition performs the following functions:

1) resets the counters,

2) performs the counting for integration time,

3) reads the low word (low 16 bits) by driving the word select pin low,

4) reads the high word (high 16 bits) by driving the word select pin high,

5) combines the two words to form a count at full length.

The integration times can be set interactively.

The I/O address for the card can be set on the board through a dip switch. An ECL to TTL translator (IC 10125) is also included so that the outputs of EMI PMTs can be handled. (R. Srinivasan & B.Nagaraja Naidu)

PC-AT based data acquisition system

The PC-AT based image data acquisition system for the VBT has been substantially modified and improved since it was originally installed in Jan '89. These modifications provide better CCD controller tests and window acquisition of images for focusing purposes.

An important addition to the system has been a magnetic tape drive system for data storage purposes. Originally only a RS-232C link was envisaged for data transfer purposes between a PC and the VAX-11/780 computer. In practice this arrangement was found inadequate, and hence a magnetic tape drive was provided.

The magnetic tape system sits on a multibus of a SBC-86/14 single board computer. In order to transfer files from the PC-AT to the tape, the data has to be first transferred to the single board computer system and then onto the tape by the programme resident on the single board computer. For this purpose a 16 bit parallel I/O and a foolproof handshaking algorithm were developed. The programme on the PC-AT has been developed in MODULA-2 and on the SBC 86/14 in machine code and fused into the Eprom. With this arrangement one image file transfer takes about a minute. (A.V.Ananth & G.Srinivasulu)

Installation of a PC-XT based data logger

A PC-XT based 16 channel data logger developed for the Solar-Terrestrial Research Labaratory, Kodaikanal has been installed and integrated with the HF radar system. Tests indicate satisfactory performance of the instrument. (A.V. Ananth, A.V.V. Kutty & J.H. Sastri)

Software modification on the Micro-PDP11 at Kodaikanal

Software modifications and some simple programmes have been developed for the Micro-PDP11 based sunspot area measuring system at Kodaikanal. The new programs are used to monitor the performance of the Calcomp digitizer. (A.V.Ananth)

System performance of the telescopes

One metre Zeiss reflector

The R.A. & DEC limits illuminating source fixtures have been modified to overcome the frequent failures of the unit by extending the holder length for better conduction of the photodiodes.

The performance of the new solid state drive system installed during August-1989 has been satisfactory with good accuracy in tracking.

The change over of the drive system from the Carl-Zeiss to the solid state drive was introduced at the control room, for smooth operation during maintenance or during system failure. A thermal overload relay has been connected to protect the system in case of any overload on the motor. The drive output is also connected through a limit switch relay, which cuts off the drive power when the telescope reaches the limit.

A new operating console has been installed at the 60 cm Schmidt telescope, to meet the requirements of observers. (N.Sivaraj & S. Ramamoorthy)

Display system for 1 m telescope

The present display system at the 1 m telescope at the VBO utilises synchro-transmitter and receiver pairs in a three speed gear arrangement. The information on position is transmitted from a torque transmitter to a torque receiver driving a display dial. These display dials often stick and the coordinate errors tend to increase with age.

An approach which can avoid mechanical changes to the existing design, is to retain the present synchro transmitters and to provide synchro to digital converters at the console end. Solid state Scott-T circuits have been designed to convert synchro signals to resolver format. Synchronising logic is applied to get the correct binary outputs from the three stage coarse-fine synchros of each axis. A PC compatible I/O interface card has been designed to read the binary outputs from the resolver to digital converters and also the sidereal time. The display programme, written in Turbo Pascal, computes various astronomical parameters. The display information is presented on seven segment LED displays at the console and coudé locations. (R.Srinivasan & B.Nagaraja Naidu)

75 cm telescope

The drive and display system have been working well during the year. The encoder zero error, which used to accumulate over time, has been corrected. In March 1990, the declination encoder failed and was replaced by another one. (V.Chinnappan)

Radio telescopes

The construction of the broadband array at Gauribidanur is progressing satisfactorily. About 200 log periodic dipole arrays were fabricated and tested. Out of these 128 are mounted in the east-west direction and 64 are mounted in the south direction. Cables are being laid to bring the signals to the central laboratory building.

In collaboration with the Raman Research Institute and the University of Mauritius a synthesis telescope for observations of the galactic center and the southern galactic plane is under construction. This telescope is located in the northern part of Mauritius.

The "T" array at Gauribidanur, operating at

34.5 MHz, is being used for solar and galactic recombination line observations. (Ch.V.Sastry)

Auxiliary instruments

Echelle spectrograph

The design of the echelle spectrograph for the 2.34 m VBT was completed. All manual controls in the initial design have been automated using stepper motors. The spectrograph is designed to be operated remotely from the telescope console room by a PC. (R.Rajamohan B.Madhava Rao & R.Srinivasan)

Solar vector magnetograph

The proposal for the construction of a solar vector magnetograph, to be employed at the solar tunnel telescope, Kodaikanal, has made considerable progress. The basic idea of the measurement is based on K.S. Balasubramaniam's doctoral work, where estimates of vector magnetic fields on the Sun were made by measuring the polarization in the wings of Zeeman sensitive lines. The present project, based on this analysis, is aimed at installing a practical measurement system at the solar tunnel telescope in order to determine the vector magnetic field.

The first step in this development is fabrication of the system, where variable modulation on the Stokes vectors can be obtained. The polarimetric scheme has been finalized; it consists of a rotating polaroid and employs other polarizing elements so that the light from the sensitive line wings will be modulated by this unit. These variations, extending over narrow rectangular sizes, will be sensed by a Peltier cooled CCD, and the resultant signals processed by a PC-AT system.

The fabrication of the mechanical mounting of the various optical components, comprising quarter wave plates, a polarizer and a filter is to begin shortly. The electronics for the rotation of the polarizer has been tested and the final fabrication will be undertaken soon.

The software for image acquisition from the asynchronous Peltier cooled CCD camera using a video frame grabber can be developed only after the availability of the necessary electronic hardware. However a preliminary version of the programme using spare cards from VBT are expected to be developed soon.

This programme will be used to capture, store and integrate pictures with orthogonal polarization at high rates to overcome the effects of atmospheric fluctuations.

The project also envisages a simple system, which will be able to display the magnitudes of different Stokes parameters and possibly the magnitude of the magnetic vector and its orientation. (J.C.Bhattacharyya, P. Venkatakrishnan, A.V.Ananth & R.S.Narayanan)

The solar tower at Kavalur

A 12 m tower has been erected at the Vainu Bappu Observatory, Kavalur. The inner tower houses a coelostat, a second mirror, a Grubb-Parson 20 cm objective and a third mirror. The f/90 beam forms a 17 cm image of the Sun in the laboratory to the south of the tower. The outer tower has been clad on the upper half, to minimize the vibration of the inner tower and the coelostat due to winds.

A solar limb monitor, using a pair of phototransistors as the sensors at opposite ends of the limb, has been set up at the focal plane, to measure the image motion in Right Ascension. The individual outputs of the sensors, their sum

and also their difference are amplified and then recorded on a two channel pen-chart recorder. The set up is being calibrated to measure image motion of the order of 1 to 10 arc seconds.

The central portion of the beam is deflected to a shutter-camera arrangement with which sequences of broad band filtergrams can be obtained on 35/70 mm film using Coleman automatic film magazines. A focal plane shutter has been designed and fabricated at Kavalur to give exposures approximately in the range of 1/100 to 1/1000 of a second. Trial sequences of the filtergrams have been obtained.

This is an ongoing project for standardizing the instrumentation and techniques of daytime seeing for site testing of the proposed National Solar Vacuum Telescope (NSVT) project. Continuous additions and improvements are being carried out at the solar tower facility. (K.R. Sivaraman & S.P.Bagare)

Fabry-Perot spectrometer

Development of this experiment for high-resolution spectroscopy of night airglow emissions, to investigate the dynamics of the equatorial thermosphere, is carried out at a place in line with the work plan drawn out. Procurement of the vital components for the spectrometer have been completed. Fabrication of the etalon chamber and the collecting tube, with side window facility, have been completed. Fabrication of the piston chamber unit and development of associated electronics is in progress. (J.H.Sastri, H.N. Ranganatha Rao, K.B.Ramesh, R.Sridharan, A.K.Saxena and J.P.Lancelot)

HF Doppler sounder

The HF Doppler (phase path) sounder at Kodaikanal, with a PC-XT based data acquisition system (DAS), enhances the sensitivity and temporal resolution of the ionospheric Doppler measurements. (J.H.Sastri, K.B.Ramesh & A.V.Ananth)

Optics division

68 cm RC primary mirrors

The figure of all three primaries were worked out and have reached the $\lambda/4$ stage. Further work on figuring is in progress. A hyperboloid secondary is in an advanced stage of figuring. (A.K.Saxena)

Casting of the light weight mirror blank

Casting of the second ribbed light weight mirror was completed successfully. Due to non-uniform shrinkages of the plate glass, a perfect blank could not be obtained. Preparations are currently on to cast a mirror blank using borosilicate glass and improved high alumina silica cores. (A.K.Saxena, J.C.Bhattacharyya, J.P.A. Samson, R.Ismail Jabilullah & Narasimhappa)

Wavefront sensing and evaluation

Using Fourier methods, the two Babinet compensator polarization interferometry is being modified to use it for online evaluation of wavefront errors in situations like an active optics system. Using monochromatic light, a 45 cm paraboloid was tested. A data reduction procedure for obtaining the wavefront error from interferometric intensity data was developed for this new method. This method is being extended for multiwavelength applications. (A.K.Saxena & J.P.Lancelot)

Solid coherence interferometer

A solid coherence interferometer is being used for laboratory experiments and for the exact evaluation of optical performance. It is planned to use this interferometer for atmospheric modulation transfer function measurements. (A.K.Saxena, L.Yeswanth & V.Robert)

Vacuum coating jobs

The following major aluminizing jobs were undertaken at the 1-m plant at Kavalur.

1. 75 cm telescope optics (primary & secondary),
2. 1 m telescope auxiliary optics,
3. 30 cm and 23 cm solar tower mirrors,
4. 15 cm and 20 cm mirrors (total of 15).
5. Antarctica expedition coeleostat mirrors.

Periodic aluminising of various small optics and manintenance of supporting jobs were carried out at the 30 cm plant at Bangalore. (K.Raman Kutty, J.P.A. Samson, M.G. Mohan, C.Jayaraman & P.Subramani)

VHRR passive coolers

Specular polishing of four sun shield panels (ETM-1) has been successfully completed. System integration is being carried out at the Indian Space Research Organisation (ISRO), Bangalore. Work on panels for the flight model will be taken up soon. (A.K.Saxena, J.P.A. Samson, M.G.Mohan & S.Razack)

LSSC project

Technical help was provided for assembling, adjusting the multi-mirror collimator and lens transfer optics of the Large Space Simulation Chamber (LSSC) of ISRO. (A.K.Saxena, R.Ismail Jabilullah & V.Gopinath)

1.2 m IR telescope

The mechanical system and optical alignment of the 1.2 m IR telescope (belonging to the Physical Research Laboratory, Ahmedabad) at Mt.Abu was brought to an optimum stage of performance. The optical quality of the mirrors needs to be further improved. (A.K.Saxena & J.P.A. Samson)

9th Antarctica Expedition

One 15 cm polar siderostat for NPL (the National Physical Laboratory), New Delhi for the 9th Antarctica Expedition was specially designed and fabricated at the Institute. The instrument fabricated, in only 10 days, weighs just 35 Kg. (J.P.A.Samson)

General

The project on "History of Optical Glass Industry and Optical Technology in India" was completed. A copy of the manuscript has been submitted to the Indian National Science Academy, New Delhi. (A.K.Saxena & A.Vagiswari)

Mechanical engineering group

A heliostat for the solar astronomy experiment at Antarctica was fabricated as per the design drawings prepared by the Instrumentation Cell.

Mechanical fabrication for the provision of prime focus observations using a CCD at the 30" telescope is ready at Kavalur. (B.R.Madhava Rao)

National Facilities

Computer software

VAX 11/780

The new version of the operating system (4.7) for the VAX along with special drivers for the COMTAL and TEKTRONIX graphics terminal were installed.

A new device driver for the CAMAC system, obtained from the Anglo-Australian Observatory, was also installed. Preliminary tests indicate satisfactory operation of the driver. The DR-11K driver was also modified for the new version of the operating system and is working satisfactorily.

Recent versions of STARLINK, STARMAN and AIPS packages have been installed. The Munich Image Data Analysis system (MIDAS), with a C compiler, was procured from the European Southern Observatory and will be installed soon. However in order to fully exploit the capabilities of the system, the image display routines need to be modified for the COMTAL device. (A.V. Ananth, K.N. Kutty & J.S. Nathan)

Reduction of spectroscopic data

The software package RESPECT was updated and many bugs removed. The algorithm for reduction of CCD spectra, developed by K.Horne (1986, Publ. Astr. Soc. Pacific, **98**, 619), was partially implemented. It is also now possible to display and examine results on the COMTAL monitor and also to perform minor operations on two-dimensional image data. Another new feature is a package for generating least squares and Gaussian fits to complex emission profiles. (T.P. Prabhu & G.C. Anupama).

Synthetic aperture photometry

Software was developed to carry out synthetic aperture photometry under the STARLINK environment using the COMTAL image processing system. Circular or rectangular apertures can be inputted from the keyboard or interactively on the image display monitor to extract the total number of counts in the apertures. These counts can then be converted to fluxes, magnitudes or to surface brightness units after subtracting the sky or any other background if necessary. The position and aperture of the background is also inputted interactively. (Y.D.Mayya)

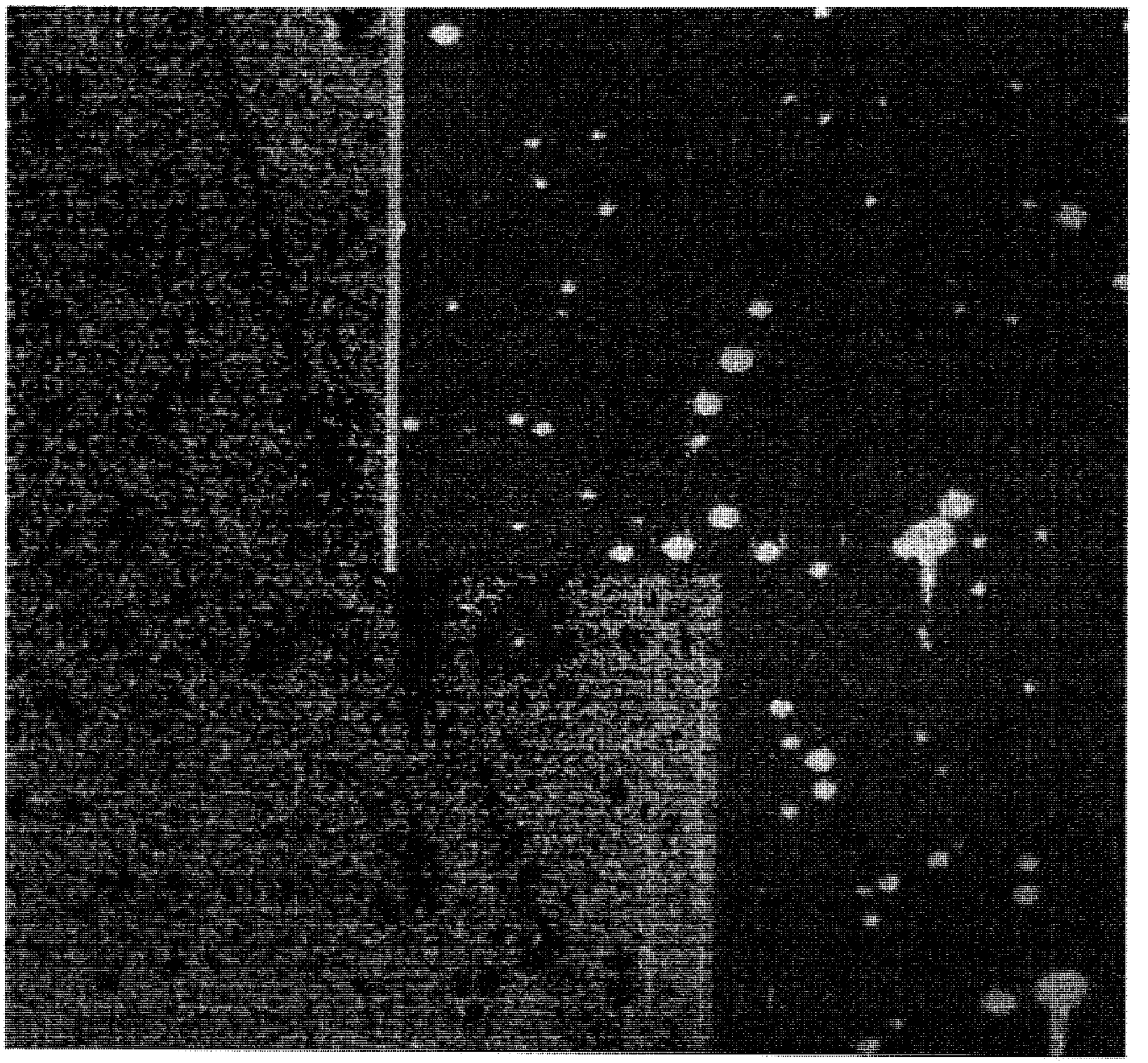
2.34 m Vainu Bappu telescope

Secondary mirror

The secondary mirror was installed during the first week of November 1989 and the final alignment was done during 7-9 November 1989. Visual observation of double and single stars at the Cassegrain focus indicate an image quality better than 1.5 arc sec. The full width at half maximum is expected to be 0.9 to 1.1 arc sec. (A.K. Saxena, J.P.A. Samson, R.Ismail Jabilullah & F.Gabriel)

Cassegrain panel

A Cassegrain panel was installed and is operational with the VBT since November 1989. During the initial phase (in 1985) of the installation, cables were laid and terminated at the centre piece elmex connectors. These cables carry communication signals, handset operation



The supernova remnant 1006 AD imaged with the CCD system at f/3.25 prime focus of the VBT on April 8, 1989. North is at the top and west is to the right. The picture is a composite of the narrow band Hα image at the left and the broad band red image at the right. The Hα image is contrast enhanced to bring out the faint supernova remnant extending from the northeast to the southwest. The images were acquired on the VBT using locally developed CCD data acquisition software and processed on the COMTAL system through software developed on the VAX 11/780 computer at VBO. (N.K.Rao, K.K.Ghosh, M.J.Rozario & R.Surendiranath)

command signals and AC and DC power utilities. In the second phase, the wiring was extended from the centre piece elmex connectors to the circular connectors at the Cassegrain panel.

The Cassegrain console provides emergency off and display off switches, AC and DC utilities and also two pairs of UHF connectors for the Cassegrain instruments. The panel incorporates a card cage with six slots for euro-size cards and houses the secondary mirror focus position display unit. All the movement commands for the telescope, dome, hydraulic platform and focus drum assembly can be controlled using handsets, which can be plugged into the Cassegrain panel. Baffle up/down movements and position angle clockwise and counter clockwise rotations are also initiated from the front panel switches.

For certain positions of the telescope, access to the Cassegrain panel can be inconvenient. To overcome this difficulty, a hand held display unit is provided for easy reading of such information as RA, DEC, HA, ST and UT. The display information available from the console room is read using a microprocessor (Intel 8085A) through three 8 bit ports. The BCD data is converted to ASCII form and is then transmitted serially to the Cassegrain console display unit using a RS-232C interface.

The secondary drum assembly is controlled by a handset for movements in the up and down directions, with a choice of two different speeds. The position information is available from a precision linear encoder of 20 micron accuracy and is presented to the display unit mounted on the Cassegrain panel. A remote reading is also provided in the console room to facilitate focus adjustment from that location. (R.Srinivasan, S.Murali Shankar & A.V.Ananth)

Servo-performance of VBT

The 2.34 m VBT functioned satisfactorily during the year without any need for servo retuning.

During this period, the motor brushes in the polar axis had worn out and were replaced. Declination motor brushes need to be changed. In order to reduce the flicker in the last digit in the hour angle display, the absolute encoders used for displaying counter weight position in hour angle and declination axes were replaced by 10 turn potentiometers. The counter weight positions are indicated in the console with digital panel meters. (R.Srinivasan, V.Chinnappan, & A.V.Ananth)

Design, fabrication and installation of focus motor drive system for the VBT

Design, fabrication and installation of a four quadrant DC drive system for the DC servo motor, used to drive the secondary mirror support system, was completed. The system utilises feedback control for speed and current loops. The servo motor has a speed range capability in excess of 20,000:1. Acceleration to 1000 RPM in 14 milli seconds is possible.

Two ranges of speeds are available for focus adjustment. The fast speed is used when instrument changes at VBT are made and the slow speed for focusing during observation. A movement of less than a 10 micron displacement of secondary mirror is possible. In the absence of movement commands, the secondary mirror is held in position by an electromagnetic brake.

When the focus movement switch is pressed, depending on the speed, a reference voltage is generated. A tachogenerator provided in the

same shaft of the motor generates voltage proportional to the speed. This voltage is fed back and compared with the reference voltage to generate an error voltage. In order to achieve a uniform speed, a current loop is also provided. When the motor draws current, a voltage signal proportional to the motor current is derived from the power amplifier. This voltage is compared with the error voltage generated by the speed loop. The output of the current loop is fed to the power amplifier, which drives the motor. A power amplifier of 1200 W, has been used as a linear amplifier with a gain of 20. Interlock logic is provided to switch off the motor at end limits. In order to reduce the current drawn by the motor, a gear box of 70:1 ratio has been introduced between the motor and the screw rod. Remote focusing from the console room is available. The unit has functioned well during the last six months. (V.Chinnappan, R.Srinivasan & B.R.Madhava Rao)

Dome automation

The multi I/O card, fabricated at the Institute laboratory, was used for dome automation. Absolute encoder data from hour angle and declination encoders are read by the multi I/O card located in a PC. A malfunctioning 16 bit dome encoder was replaced. The contact between the dome encoder friction wheel and the dome surface was improved. This system is expected to be commissioned shortly. (V.Chinnappan & Faseehana)

Mechanical mounting of the modified focus assembly

A modified focus assembly along with its components was designed and fabricated in the laboratories of the Institute. The mounting plate, of diameter 1.2 m, was used for the initial alignment and also for mounting the Boller and Chivens Spectrograph. An important design modification is the removal of the cover panels, which earlier enveloped the entire surface of the upper serrurier truss. The presence of these covers led to an increase in the temperature (by about 1°C) near the primary mirror. It has also considerably reduced the weight of the telescope tube and provided better ventilation for the tube, which houses the primary and secondary mirrors. Removal of the cover panel and addition of the modified focus assembly and the Cassegrain instrument mounting plate involved extensive rebalancing work. The entire focus movement is highly precise and is controlled from the console. (B.R.Madhava Rao)

New Cassegrain system

A handset has been provided to move and focus the telescope. Initially it was discovered that there was image motion and also that the image quality was not constant. This was due to the primary mirror supports not being active. The latter have now been readjusted.

A spacer has been introduced to separate the focal plane from the rear end of the primary mirror cell. This distance has been adjusted to lie in the range 500-700 mm.

Since the Cassegrain acquisition and guiding unit and the position angle device are not yet ready, the backend instruments are attached close to the rear end of the primary mirror cell, at a distance of 100-180 mm. (F.Gabriel, B.R. Madhava Rao, R.Srinivasan, V.Chinnappan, K. Ravi, A.K Saxena, J.P.A.Samson & N.K.Rao)

Backend instrumentation at the Cassegrain focus

Various backend instruments were tried and placed at the Cassegrain focus, such as the Boller and Chivens spectrogrph. The primary aim was to use the CCD with the spectrograph for direct recording of the spectrum. One of the main problems encountered was in bringing the focus of the camera to lie on the chip. The original B & C camera was not found suitable and instead another one was used. The first CCD spectrum with the VBT was obtained on December 5, 1989. However, owing to the aperture of the camera being smaller than the beam, there was light loss, resulting in a low efficiency of the spectrograph. The following methods were adopted in order to overcome this problem:

1) A reimaging unit consisting of a two matching Nikkor camera lens assembly has been used to transfer the focal plane from the original B & C Camera to the CCD chip.

2) Another Carl Zeiss Camera of aperture 120 mm and which has a 11-10 mm adjustable focus has been used, but the CCD Camera shutter is placed below the spectrographic slit. By this arrangement no light loss at the camera end occurs. However there remains another difficulty, namely the conversion of a f/13 beam to a f/18 beam, since the spectrograph was designed for the latter.

One method to overcome this difficulty and to make it more efficient, is to use a fibre optics cable to transfer the prime focus beam (f/3.25) to the Cassegrain focus and to use a small lens to achieve the f/3.25 to f/18 conversion. Initial experiments have already begun with a 100μ core fibre (~ 2.7 arc sec at prime focus) and a preliminary guiding unit has been made to acquire the field to place the star on the fibre and to guide it. More experimentation and further changes are currently underway.

The following other equipment was used at the Cassegrain focus: a speckle camera, photoelectric photometers and a polarimeter. (F. Gabriel, N.K.Rao, A.K.Saxena, P.Umesh Kamath & B.R.Madhava Rao)

Instrumentation 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 1989-90. 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 1989-90

Sl. No.	Details of proposal	Status of work
1.	Design and fabrication of the echelle spectrograph for a coronagraph.	Preliminary design under consideration.
2.	Fabrication of solid state drive system for the U.P. State Observatory.	Work has been completed except for the power amplifier assembly. Training programme started.
3.	Preparation of the engineering drawings for a coronagraph with modifications.	Design of drive system completed. Further work in progress.
4.	Design and manufacture of spur gears and worm gears for coelostat.	Design work completed. Manufacturing of 6 sets of worm and worm gear under progress.
5.	Design and fabrication of the structure of an 18" Gregorian telescope for use in a rocket pay load.	Engineering design in progress.
6.	Special type of plate holder for photography of Saturn's outer rings.	Item fabricated and being used.
7.	Fibre optics link between prime focus and the Boller and Chivens spectrograph of the VBT.	System designed and fabricated; needs further modification which is in progress.
8.	Heliostat to track the Sun for the National Physical Laboratory, New Delhi.	Initial discussion under progress.
9.	Design of stepper motor driven piston chamber unit for Fabry-Perot spectrometer	Mechanical drawings completed. Fabrication to be commenced.
10.	Display panel for telescope position at the Cassegrain focus	Designed, fabricated and mounted on the telescope.
11.	Design of echelle spectrograph for the VBT.	Concept design completed. Detailed engineering drawing under progress.

Table 2

Jobs done on the PDS during 1989-90

Sl. No.	Nature of the Project
1.	Spectra of peculiar stars
2.	Spectra of Be Stars.
3.	Spectra of galaxies and standard stars for population synthesis
4	Time sequence spectra of the CaII H line of the solar chromosphere.
5.	Spectra of classical and recurrent novae.
6.	Digitization of CaII spectroheliograms
7.	Wave front sensing and evaluation, rotation shearing interferometer, fringe analysis.
8	Variations in Evershed flow.
9	Spectra of supergiants and Cepheids.
10.	Study of Solar CaII K line profiles as a function of latitude.
11.	Analysis of satellite images.
15.	Analysis of Comet Austin images.
16.	Spectra of novae and supernovae.
17.	Interferograms analysis of the Orion Nebula.

Growth of Astronomy

General

Exhibitions and National Science Day

The Visitor's Gallery at the Bangalore campus is gradually being developed and is an attraction for both general visitors and students.

The Institute observed an Open House Day at the Bangalore campus on June 23, 1989 and on November 14, 1989 as part of the Nehru birth centenary celebrations, and on February 28, 1990 as part of the National Science Day celebrations on the occasion of the 62nd year of the discovery of the Raman Effect.

The Institute was a participant at the Science and Technology exhibition of the Department of Science and Technology, concurring with the 77th Indian Science Congress at Cochin during the period January 27 – February 17, 1990 where exhibits on the model of the 2.34 m telescope, the recent discovery of the asteroid Ramanujam and video shows of IIA films on the Institute and on the solar eclipse of February 16, 1980 attracted a large number of students and the general public.

The Institute collaborated with the Indian Space Research Organisation in organizing the 'Space and Man' Exhibition at New Delhi in November 1989 as a part of the Nehru Birth Centenary celebration. An exhibition was also organised on the theme: IIA's contribution to Studies of Jupiter, for the National Space Science symposium at Nagpur in March 1990. (R.C.Kapoor)

Visitors

A large number of students from various colleges and schools visited the VBO and were shown interesting astronomical objects through the small telescopes kept specially and maintained at the VBO for the popularization of astronomy.

Observing conditions at Leh

The monitoring of sky conditions at Leh during the non-winter months of 1988 continued. The observations stopped after November, 1988. The data on temperature, relative humidity, photometric and spectroscopic hours per night and extinction measurements in UBV bands for four years were analysed. In all 624 hours of photometric sky were available during 1987, 290 hours in 1988. Furthermore 913 spectroscopic hours were available in 1987 and 506 hours in 1988. The relative humidity varied between 20% to 90%. The change in relative humidity was about 5-20 % during the months of June-July and 20-40 % during rest of the months of observations. The extinction measurements in the UBV bands for the four years appear to represent consistent sky conditions.

In addition, standard stars were monitored on two nights in the JHKLM infrared bands, to determine the sky transparency in these bands. The extinction coefficients in J, H and K bands are $K_J = 0.05 \pm 0.01$, $K_H = 0.04 \pm 0.01$ and $K_K = 0.04 \pm 0.01$. Signals in the L and M bands were extremely weak, if at all present. Also, sky brightness was measured on 8 nights in the months of September and October 1988. The average values of sky brightness in magnitude per sq. arc sec in UBV bands were found to be 21.4, 22.3 and 21.4 respectively. The values of sky brightness appear to be marginally higher than at La Palma. (J.C.Bhattacharyya & Jagdev Singh)

Professor S. Chandrasekhar, Nobel laureate, delivering the CSIR distinguished lecture at the Institute.

Lectures/Colloquia by visiting scientists

P.J.McCarthy (Carnegie observatories, California, USA). *Radio galaxies in the early universe. (28.4.1989)*

Gary Fuller (Raman Research Institute). *Star formation and the structure of local molecular clouds. (16.5.1989)*

Paul Witta (Department of Physics and Astronomy, Georgia State University, Atlanta, Georgia, USA). *Continuum emission from active galactic nuclei. (1.8.1989)*

Tom Gehrels (Lunar and Planetary Laboratory, University of Arizona, USA). *Origin of Trojans and satellites of Jupiter. (20.9.1989)*

P.K.Pasricha (National Physical Laboratory, New Delhi). *Indian expedition to Antartica. (21.9.1989)*

C.J.Mayer (Royal Greenwich Observatory, U.K). *The Jacobus Kapteyn, Isaac Newton and William Herschel telescopes at La Palma. (13.10.1989)*

Leon Mestel (University of Sussex). *Magnetic braking. (8.12.1989)*

David Malin (Anglo - Australian Observatory, Australia). *The science of astronomical photography. (19.12.1989)*

D.L.Lambert (Department of Astronomy, University of Texas at Austin, USA). *Carbon stars with oxygen - rich circumstellar envelopes. (20.12.1989); Why do many S stars lack Technetium ? (21.12.1989); The chemical composition and origin of Lambda Bootis stars. (22.12.1989)*

A.Arellano Ferro (Institute of Astronomy, National University of Mexico). *F-G supergiants as distance indicators. (9.1.1990)*

J.G.Timothy (Centre for Space Science and Astronomy, Stanford University, USA). *MAMA detectors for ground based astronomy and space application. (15.1.1990)*

A.Wolfe (AT and T Bell labs, USA). *Hydromagnetic wave energy observed at low and high latitudes. (30.1.1990)*

V. De Sabbata (International Centre for Gravitation and Cosmology, Italy). *General relativity with torsion - some consequences. (20.2.1990); Torsion and Magnetism. (21.2.90)*

F.Sahibov (Institute of Astrophysics, Dushanbe, USSR). *Kinematics of spiral galaxies. (15.3.1990)*

Ph.D.Program

P.M.S.Namboodiri was awarded a Ph.D degree by Bangalore University for his thesis entitled *Studies in interacting galaxies.* A.K.Pati was awarded the Ph.D. degree for his thesis entitled *A study of the stellar populations in galaxies from integrated spectra.*

The following students are continuing their research work for the Ph.D degree : G.C. Anupama; R.T.Gangadhar and Y.D.Mayya from the Joint Astronomy Programmes; Annma Mathew, K.Gangadharmurthy, M.F.Ingalgi, Prasannalakshmi and T.D.Sridharan from the faculty improvement programme of the U.G.C.

Conferences/Lectures

The 4th IIA bicentennial commemorative public lecture was delivered by Professor Yash Pal, Chairman, UGC, on the topic entitled *Towards a planet assurance program*, at IIA Bangalore on January 31, 1990.

Professor J.C. Bhattacharyya delivering the keynote address at the XVIII Annual Symposium of the Optical Society of India held at IIA, Bangalore.

Professor S.Chandrasekhar, Nobel laureate, University of Chicago, USA visited the Institute on December 12, 1989 and delivered the CSIR distinguished lecture on *Newton's Principia.*

A national meeting organized by DST on *Astronomy facilities for the 8th plan* was hosted by IIA. The meeting took place in IIA, Bangalore on August 24-25, 1989. There were 66 participants representing various astronomical institutions and universities.

The first VBT workshop was held at VBO Kavalur on August 26, 1989. The theme of the workshop was *Low light level astronomy.* Several scientists and astronomers from various institutes and universities took part in the workshop.

The institute hosted the DST workshops on *National large telescope: Scientific requirements and requirements of site.* These workshops were held at IIA, Bangalore on October 19-21, 1989. About 50 scientists from various astronomical institutes and universities attended these meetings.

In the first week of December 1989, the Institute hosted in Bangalore the International Astronomical Union (IAU) Symposium No.142 on *Basic Plasma processes on the Sun.* More than one hundred and fifty scientists, including 80 scientists from abroad, representing various countries, attended the symposium. V.Krishan served as the chairperson of the scientific organising committe.

In the last week of December 1989, the Institute organised a winter school in Astronomy and Astrophysics for college teachers. It was held at IIA, VBO, Kavalur. About 35 college teachers including a few students participated in this winter school.

The Institute hosted the optical society of India's 18th Symposium on *Optical science and engineering.* The meeting was held on March 21-23, 1990 at IIA, Bangalore. About 200 scientists and engineers from various research organisations and universities attended the symposium. A.K.Saxena was the convener of this symposium.

The Institute participated in the organisation of an international workshop on *Binary stars and stellar atmospheres* which was held in August 1989 at the Department of Astronomy, Osmania University, Hyderabad.

Awards/Honours

J.C.Bhattacharyya was awarded the University Grants Coommission Hari–Om Ashram Trust award for physical sciences.

C.Sivaram's paper entitled *Constraints on the fundamental properties of gravity from SN 1987A* was awarded an honourable mention at the 1989 competition of the Gravity Research Foundation, USA competition.

J.H.Sastri was elected as a Fellow of the Indian Geophysical Union

A.K.Saxena continues to be an executive council member of the Optical Society of India.

Library

The library continued its activities of acquiring and processing astronomical literature. The present library collection includes:

Types of Documents	Total stock
Books	10678
Current periodicals	145
Bound volumes (journals)	16149
Standards, specifications & technical reports	390
Microfiche & magnetic tapes	575

The library aquired 274 books and 3 new journals during the year 1989-90. It continued to receive 65 observatory publications on an exchange basis. The stock of the library was supplemented through the inter-library-loan scheme and several books, journals and technical reports were borrowed from other libraries. The library also handled 75 requests from other libraries. During the year some 2500 pages were photocopied from its collection and supplied to other libraries and scientists. Scientific and technical information was disseminated through the IIA preprint list, through IIA technical report and through Recent Research in Astronomy and Astrophysics. The IIA preprint list is mailed to 175 institutions all over the world, the IIA technical report is circulated to 15 institutions and Recent Research in Astronomy & Astrophysics to 40 institutions in the country. The library brought out the Kodaikanal Observatory Bulletin (KOB)Vol.10 as a special issue covering the Proceedings of the National Workshop on Supernova 1987A. During 1988-89, 175 copies of the KOB and the Annual Report for the year 1988-89 were circulated to different institutions around the world.

The library acquired Unesco's CDS/ISIS software package for creating a data base of the library catalogue. The computer section of IIA also developed software for library circulation control and this will be implemented shortly. The library was used extensively by about 300 external research workers and scientists for reference work.

Software for circulation control

A software package for circulaion control and to generate various reports like daily acquisitions, issues, returns, reservations was designed, developed and tested. The system is to be installed shortly. Efforts are on to link this package with the "CDS/ISIS" package supplied by UNESCO. *(S.S.Chandramouli, A.Vagiswari & Christina Louis)*

Staff List

(as of March 1990)

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
N.Kameswara Rao	Associate Professor
R.K.Kochhar	Associate Professor
V.Krishan	Associate Professor
R.Rajamohan	Associate Professor
J.H.Sastri	Associate Professor
G.S.D.Babu	Reader
P.K.Das	Reader
B.Datta	Reader
S.K.Jain	Reader
R.C.Kapoor	Reader
D.C.V.Mallik	Reader
M.Parthasarathy	Reader
A.K.Pati	Reader
T.P.Prabhu	Reader
P.K.Raju	Reader
R.Sagar	Reader
K.K.Scaria	Reader
J.Singh	Reader
C.Sivaram	Reader
P.Venkatakrishnan	Reader
S.P.Bagare	Fellow
H.C.Bhatt	Fellow
S.Chatterjee	Fellow
K.K.Ghosh	Fellow
A.V.Raveendran	Fellow
S.Giridhar	Fellow
R.Vasundhara	Fellow
K.R.Subramanian	Fellow
G.Thejappa	Fellow
S.Mohin	Scientific Officer 'SC'

P.M.S.Namboodiri	Scientific Officer 'SC'
P.S.M.Aleem	Research Associate
S.S.Gupta	Research Associate
R.Kariyappa	Research Associate
S.V.G.Mallik	Research Associate
M.V.Mekkaden	Research Associate
D.M.Rao	Research Associate
B.S.Nagabhushana	Research Associate
K.N.Nagendra	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.Sundara Raman	Research Associate
R.Surendiranath	Research Associate
J.P.Lancelot	Research Associate
L.Yeswant	Research Associate
J.Javaraiah	Research Associate

Scientific/Technical staff

A.P.Jayarajan	Consultant
A.K.Saxena	Head, Optics Division
R.Srinivasan	Head, Electronics Labs. & Computer centres
A.V.Ananth	Principal Scientific Officer
V.Chinnappan	Senior Computer Engineer
B.R.Madhava Rao	Senior Mechanical Engineer
N.Selvavinayagam	Civil Engineer
R.Sivashanmugam	Technical Officer
G.Srinivasulu	Computer Engineer
S.S.Chandramouli	Technical Associate
A.M.Ghouse	Technical Associate
A.T.A.Hameed	Technical Associate
H.N.Manjunath	Technical Associate
R.Muraleedharan Nair	Technical Associate
K.Narayanan Kutty	Engineer Associate
K.Ramankutty	Technical Associate
K.S.Ramamoorthy	Technical Associate
J.P.A.Samson	Technical Associate
K.G.Unnikrishnan Nair	Technical Associate

K.Padmanabhan	Technical Associate
M.M.Abbas	Technical Associate
A.Charles	Technical Associate
A.Vagiswari	Librarian

Visiting Scientists

A.A.Ferro	Visiting Scientist (University of Mexico)
A.Goswami	Senior Research Fellow (CSIR)
F.H.Sahibov	Visiting Scientist (University of Dushanbe, USSR)
C.Uberoi	Visiting Professor (Indian Institute of Science)
C.T.Vanajakshi	Visiting Fellow

Research Scholars

G.C.Anupama	
Annamma Mathew	UGC Faculty Improvement Programme
Y.D.Mayya	Joint Astronomy Programme
K.T.Gangadhara	Joint Astronomy Programme

Appendices

Appendix A

Research Publications

Anupama, G.C. (1990) Bull.Astr.Soc.India (in press). *Fourier smoothing of digital photographic spectra.*

Anupama, G.C. (1990) in Proc. DST Workshop on National Large Telescope: Scientific requirements, Ed.M.Parthasarathy (in press). *Novae and Supernovae: Outburst and quiescence.*

Anupama, G.C. & Prabhu, T.P. (1990) in Proc. IAU Coll. 122 on Physics of Classical Novae, Ed.A.Cassatalla (in press). *Spectroscopic results on the recurrent Nova RS Ophiuchi.*

Anupama, G.C., Prabhu, T.P., Ashoka, B.N., Ghosh, K.K., Giridhar,S., Rao,N.K. & Jain, S.K., (1990) in Proc. XI ERAM on New windows to the Universe, Ed.F.Sanchez (in press). *Spectroscopic observations of SN 1987A between 190 and 385 days since outburst.*

*Apparao, K.M.V., *Rangarajan T.N., *Tarafdar, S.P. & Ghosh,K.K. (1990) Astr. Astrophys. **229**, 141. *Simultaneous radio and Hα observations of Be stars.*

Babu, G.S.D., Nathan, J.S., Rajamohan,R. & Sivaraman,K.R.(1989) Bull.Astr.Soc.India, **17**, 107. *Narrow-band photometry of Comet Halley in the emission bands and the continuum.*

*Bhat, P.N., *Kembhavi, A.K., *Patnaik, K., *Patnaik, A.R. & Prabhu, T.P. (1990) Indian J.Pure & Appl.Phys. (in press). *CCD Image data acquisition system for optical astronomy.*

* Names of coworkers from outside institutions

Bhatt.H.C. (1990) Astr.Astrophys. (in press). *Is the X-ray pulsar H0253+193 a neutron star spun down in a molecular cloud?.*

Bhattacharyya, J.C. in Proc. DST Workshop on Site for Large Telescopes, Ed. M.Parthasarathy (in press). *Possible good observatory sites in India.*

Chatterjee,S. (1989) Astrophys. Sp.Sci. **162**, 167. *Magnetic field induced metal -insulator transition in a one - dimensional chain: Application to neutron star atmospheres.*

Chatterjee, S. (1989) Optics Com. **74**, 149. *Probability of arrival of rays of light for propagation through random media: Connection with rotational Brownian motion.*

*Cook,J., *Bruckner,G.E. & Krishan,V. (1989) in The Solar Interior, University of Arizona Press, Eds. W.Livingstone et al. (in press). *Fine structure of the solar transition region, observations and interpretation.*

Das.P.K. (1990) in Proc. Int. Symp. on Supernovae and High Energy Astrophysics, Ed.S.De (in press). *Quasi-stellar objects in Hoyle-Narlikar Cosmology.*

*Debi Prasad, C.,*Chandrasekar, T.,*Desai, J.N.,*Ashok,N.M. & Krishan,V. (1989) J.Astrophys.Astr. **10**, 1. *Optical interferometric observations of a transient event of 1986 March 13 in the Coma of Comet Halley.*

*De Sabbata, V. & Sivaram,C. (1990) in Proc. XXI Int. Cosmic Ray Conf. Ed. R.Protheroe, Vol.10, (HE) p.51. *Neutrino magnetic moment induced by torsion: Consequences for supernova neutrinos.*

*De Sabbata,V. & Sivaram,C. (1990) in Proc. XXI Int. Cosmic Ray Conf.,Ed. R.Protheroe, Vol.4, (OG), p.31. *A mechanism for injection of ultrahigh energy extragalactic cosmic rays.*

Deshpande,A.A., *Shevgaonkar,R.K. & Sastry,Ch.V. (1989) J.I.E.T.E. **35**, 342. *The decametre radio telescope at Gauribidanur: Antenna arrays and control systems.*

Gangadhara, R.T. & Krishan,V. (1990) in Proc.IAU Symp. 142 on Basic Plasma Processes on the Sun, Eds. E.R.Priest & V. Krishan (in press). *Parametric heating of astrophysical plasmas.*

Giridhar, S.,Bhattacharyya, J.C. & Kutty, K.N. (1989) in Proc.Workshop on Image Processing in Astronomy, Eds.T.Veluswamy & V.R.Venugopal, p.47. *Image processing facilities at Vainu Bappu Observatory.*

Giridhar,S., Rao, N.K. & *Lambert,D.L. (1990) The Observatory (in press). *Is LR SCO a R CrB star?*

Ghosh, K.K. (1990) Astrophys.J. (in press). *Expanding shell and P Cygni profiles of 27 CMa.*

Ghosh,K.K. (1990) Astrophys. J. Suppl. Ser. (in press). *Rapid continuum level variability in Be stars earlier than B2.*

Ghosh, K.K. & Kuppuswamy,K. (1989) IAU Circ, No.4881. *27 Canis Majoris*

Ghosh, K.K.,Pukalenthi,S., Jayakumar,K., Kuppuswamy,K., Muniandi,A. & Sanjeevkumar,T. (1990) Astr. Astrophys. Suppl. Ser., **82**, 557. *Search for rapid spectral variability in Be stars: Alpha Columbae, P Carinae and Eta Centauri.*

Ghosh, K.K., Kuppuswamy, K., Ramchandran,A., Rajkumar, K., Ravi,K., & Dinakaran, N. (1989) IAU Circ. No.4806. *M Centauri*

Ghosh, K.K., Rao, N.K., Prabhu, T.P.,Mayya, Y.D.,Kuppuswamy & K.Muniandi,A. (1989) IAU Circ. No.4913. *HDE 245770.*

Gokhale, M.H. & Javaraiah,J. (1990) Mon.Not.R.Astr.Soc.**243**,241. *Sunspot activity as originating as interference of Sun's global MHD oscillations.*

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Lectures/Talks

J.C.Bhattacharyya

-: *Detection of faint astronomical sources,* Invited review at the 17th OSI symposium, CSIO, Chandigarh, April 26-28, 1989.

-: *Evolution of stellar spectra,* Invited lecture, National College, Bangalore Science Forum, July 1989.

-: *The measurement of sizes of celestial objects & the solar system: Our nearby universe,* National Remote Sensing Agency, Hyderabad, August 1989.

-: *Giant Indian optical telescope* presented at 8th Plan workshop, IIA, Bangalore, August 24-25, 1989.

-: *Large telescope* - Valedictory lecture, workshop on telescope making, VITM, organized by KRVP, Bangalore October 18, 1989.

-: *Frontiers of astronomies; Indian endeavours*, Keynote address, Prof.S.K.Mitra Centenary Function, Calcutta, October 24, 1989.

-: *Astrophysics in India today*, Physics Dept, Bangalore University, Jnana Bharathi, Bangalore, January 24, 1990.

-: *International Jupiter watch*, National Space Science Symposium 90, Nagpur, March 5-8, 1990.

-: Memoir on Dr.A.K.Das, INSA Memoirs, New Delhi (in press)

-: Keynote address - 18th OSI Symposium, March 26-29, 1990.

B.Datta

-: *Equation of state of neutron star matter*, Workshop on Neutron Stars, International Centre for Theoretical Physics, Trieste, Italy, September 11-29, 1989.

-: *Cosmic separation of phases and primordial nucleosynthesis*, International Symposium on Recent Advances in Physics, Bangladesh Atomic Energy Commission, Dhaka, Bangladesh, January 14-19, 1990.

-: *Astrophysics of high density matter*, Winter School on Quark-Gluon Plasma, Puri, December 6-16, 1989.

-; *End products of stellar evolution*, Winter School on Astrophysics, Vainu Bappu Observatory, Kavalur, December, 1989.

-: *Lithium abundance in the early universe*, Second VBT Workshop, Vainu Bappu Observatory, Kavalur, April 19-20, 1990.

K.K.Ghosh

-: *Spectroscopic studies of Be stars*, Sternwarte der Universität Bonn, F.R.G., March 7, 1990.

-: *Phase transitions and mass loss in Be stars*, Meudon Observatory, Paris, March 14, 1990.

M.H.Gokhale

-: *Spherical-harmonic-Fourier analysis of sunspot data*, Astronomical Institute, Zurich, May, 1989

S.S.Hasan

-: *Theoretical models for intense flux tubes*, Center for Astrophysics, Harvard University, U.S.A, April 7, 1989.

-: *The nature of oscillations in flux tubes*, Queen Mary College, London, U.K., April 21, 1989.

-: *What can we learn about sunspots from umbral oscillations?* University Observatory, Göttingen University, F.R.G., May 5, 1989.

-: *High energy processes in the solar atmosphere*, Institute of Physics, Bhubaneshwar, November 23, 1989.

N.Kameswara Rao

-: *CCD imaging with VBT*, Astronomical society of India meeting, Srinagar, June 1989.

V.Krishan

-: *Inverse cascade in hydrodynamic turbulence and its role in solar photosphere, structure, convection and magnetic fields*, Kiev, USSR, May 1989.

-: *Plasma processes in AGN*, Pulkova Observatory, Leningrad, May 1989.

-: *Solar granulation, Izmiran*, Moscow, May 1989.

-: *Nonthermal radiation from quasars*, Bresa Observatory, Milano, Italy, June 1989.

-: *Self-organization in turbulent media*, ICTP, Trieste, July 1989.

J.H.Sastri

-: *Equatorial anomaly*, Symposium on Current trends and future perspectives in Solar-Terrestrial Physics research, PRL, Ahmedabad, August 28-29, 1989.

-: *Geomagnetism and man*, Symposium on Geomagnetism and Aeronomy in the Nineties, IIG, Bombay, December 28-29, 1989.

-: *Solar wind - magnetosphere - ionosphere interactions*, STEP Workshop, Andhra University, Visakhapatnam, January 27-29, 1990.

-: *Spectroscopic studies of Io plasma torus*, National space Science Symposium, Nagpur, March 5-9, 1990.

A.K.Saxena

-: *Seeing measurements*, National Large Telescope and Site Survey Workshop, IID, October 19-21, 1989.

-: *Rotational shearing interferometer and seeing measurements*, RRI, Bangalore, January 2, 1990.

C.Sivaram

-: *Solar neutrinos: Old and new problems*, Instituto Nazionale di Fisica Nucleare, Bologna University, April 14, 1989.

-: *Current solutions to the solar neutrino problem*, Dept. of Physics, University of Ferrara, Italy, April 20, 1989.

-: *Black hole evaporation in higher dimensional space*, International School of Cosmology and Gravitation, Erice, Italy, May 4, 1989.

-: *Inflation with massive spin-two fields*, International School of Cosmology and Gravitation, Erice, Italy, May 11, 1989.

-: *Physics of stellar collapse*, Dept. of Physics, Univ. of Bologna, May 21, 1989.

-: *Some aspects of the fifth force*, Dept. of Physics, University of Konstanz, F.R.G, June 9, 1989.

-: *Torsion and the fifth force*, Dept. of Physics, University of Konstanz, F.R.G, June 10, 1989.

-: *Polarized gamma radiation from supernovae*, at Dept. of Physics, Univ. of Adelaide, Australia, June 10, 1990.

-: *^{26}Al radioactive decay and gamma ray background*, Dept. of Phys. University of Adelaide, Australia, January 10, 1990.

-: *Propagation of neutrinos with magnetic moment inside the Sun*, Dept. of Physics, University of Adelaide, Australia. January 15, 1990.

-: *Emission from sub-millisecond pulsar in SN 1987A*. Dept. of Physics, University of Adelaide, Australia. January 16, 1990.

-: *Neutrino magnetic moment induced by torsion: Consequences for supernova neutrinos*. Dept. of Physics, University of Adelaide, January 17,1990.

K.R.Sivaraman

-: *Solar activity and variability*, National Space Science Symposium, Nagpur, March 3-9, 1990.

-: *National solar vaccum telescope*, DST National meeting on Astronomy facilities for the 8th plan IIA, Bangalore, August 24-25, 1989.

C.T.Vanajakshi

-: *Effect of magnetic braking and ambipolar diffusion on the properties of Jupiter,* National Space Science Symposium, Nagpur, March 3-9, 1990.

-: *Human exploration of Mars,* National Space Science Symposium Nagpur, March 3-9, 1990.

Scientific meetings attended

Annual GONG meeting, Tucson, U.S.A., April 2-5, 1989. *S.S.Hasan*

'Evolution of the large scale universe', TIFR, Ooty, April 20-22, 1989. *J.C.Bhattacharyya, B.Datta, A.K.Pati, Ch.V.Sastry.*

International conference on Interferometry '89, Warsaw, Poland May 8-12, 1989. *J.P.Lancelot.*

IAU Symposium 138 on Solar Photosphere: Structure, convection and magnetic fields, Kiev, USSR, May 15-20, 1989. *M.H.Gokhale, S.S.Hasan, V.Krishan, K.R.Sivaraman.*

IAU Symposium 140 on Galactic and Intergalactic Magnetic fields, Heidelberg, F.R.G., June 19-23, 1989. *S.K.Jain.*

NATO-ASI Workshop on Quantum Fields in Curved Space Time, International School of Gravitation and Cosmology, Bologna, Italy, May 2-15, 1989. *C.Sivaram.*

Astronomical Society of India annual meeting, Srinagar, June 21-24, 1989. *J.C.Bhattacharyya, R.K.Kochhar, N.K.Rao, R.Srinivasan.*

IAU Colloquium 122 on Physics of Classical Novae, Madrid, Spain, June 27-30, 1989. *G.C.Anupama.*

XI European Regional Astronomy Meeting, Tenerife, Spain July 3-8, 1989. *G.C. Anupama.*

27th Course of the International School of Subnuclear Physics, Majorona Centre, Erice, Italy, July 1989. *C.Sivaram.*

6th Scientific Assembly of IAGA, Exeter, U.K., July 24-August 4, 1989. *J.H.Sastri.*

International Workshop on Binary stars and Stellar Atmospheres: Symposium organized in commemoration of Prof.K.D.Abhyankar's 60th birthday, Hyderabad, August 7-12, 1989. *J.C.Bhattacharyya, M.V.Mekkaden, M.Parthasarathy, A.Peraiah, R.Rajamohan, N.K.Rao.*

DST seminar on Thrust areas in Atmospheric Sciences, IITM, Pune, August 16-18, 1989. *J.H.Sastri*

DST National meeting on Astronomy facilities for the 8th plan, IIA, Bangalore, August 24-25,1989. *J.C.Bhattacharyya, M.Parthasarathy, A.K.Pati, N.K.Rao, A.K.Saxena, K.R.Sivaraman, P.Venkatakrishnan.*

1st VBT Workshop, IIA, VBO, Kavalur, August 26, 1989. Several staff members from IIA, Bangalore and Kavalur participated.

9th Conf. on Nuclear Emergencies and Environment, Majorana Centre, Erice, Italy, August 19-25, 1989. *C.Sivaram.*

Workshop on Particle Physics Phenomenology and Cosmology, ICTP, Trieste, August 1989. *C.Sivaram*

Symposium on Current Trends and Future Perspectives in STP research, PRL, Ahmedabad, August 28-29, 1989. *J.H.Sastri.*

IAU Colloquium No.117 on Dynamics of Prominences, Hvar, Yugoslavia, September 25-29, 1990. *B.S.Nagabhushana.*

DST Workshop on National Large Telescope. Scientific requirements and site survey, IIA, Bangalore, October 18-20, 1989. *G.C. Anupama, S.P.Bagare, J.C.Bhattacharyya, K.K.Ghosh, S.Giridhar, A.P.Jayarajan, M.V.Mekkaden, M.Parthasarathy, A.K. Pati, T.P.Prabhu, N.K.Rao, A.V.Raveendran, R.Sagar, A.K.Saxena, J.Singh, P.Venkatakrishnan, K.R.Sivaraman, Y.D. Mayya.*

55th Annual meeting of the Indian Academy of sciences, Bhopal, November 10-13, 1989. *J.C.Bhattacharyya, D.C.V.Mallik, T.P. Prabhu.*

IAU Symposium 142 on Basic Plasma Processes on the Sun, Bangalore, December 1-5, 1989. *P.S.M. Aleem, S.P. Bagare, J.C. Bhattacharyya, M.H. Gokhale, S.S. Gupta, S.S. Hasan, R.C. Kapoor, V. Krishan, R. Kariyappa, B.S. Nagabhushana, R. Rajamohan P.K. Raju, K.B. Ramesh, K.E. Rangarajan, D.M. Rao, S.K. Saha, K. Sasidharan, Ch.V. Sastry, J.H. Sastri, C. Sivaram, K.R. Sivaraman, K.R. Subramanian, R. Vasundhara, P.Venkatakrishnan, C.T.Vanajakshi.*

IAU Colloq.No. 124 on Paired and Interacting Galaxies, Alabama, USA, December 4-7, 1989. *R.K.Kochhar, P.M.S.Namboodiri.*

Workshop on Astronomical Instrumentation, IUCAA, Pune, December 10-13, 1989. *S.K.Jain, A.K.Saxena.*

Winter school, VBO, Kavalur, December 25-31, 1989. *J.C.Bhattacharyya, B.Datta, K.K. Ghosh, N.Kameswara Rao, D.C.V.Mallik, T.P.Prabhu.*

International Conference on Supernova and High Energy Astrophysics, Calcutta, December 27-30, 1989. *J.C.Bhattacharyya, C.Sivaram, R.K.Kochhar.*

Symposium on Geomagnetism and Aeronomy in the Nineties, IIG, Bombay, December 28-29, 1989. *J.H.Sastri*

59th Annual Session, National Academy of Sciences & National Symposium on Indian Geosphere and Biosphere Programme, Hyderabad, January 5-7, 1990. *J.C.Bhattacharayya.*

21st International Cosmic Ray Conference, Adelaide, Australia, January 6-20, 1990. *C.Sivaram.*

DST Workshop on AICPITS and STEP, Andhra University, Visakhapatnam, January 27-29, 1990. *J.H.Sastri.*

Course on Laser Systems and Applications, Hyderabad, February 6-12, 1990. *J.P.Lancelot, L.Yeswanth.*

2nd EXOSAT Database Workshop, Noordwijk, Netherlands, February 21-22, 1990, *K.K. Ghosh.*

National Space Science Symposium, Nagpur, March 5-9, 1990. *J.C.Bhattacharyya, K.B. Ramesh, H.N.Ranganatha Rao, J.H.Sastri, K.R.Sivaraman, R.Vasundhara.*

18th Optical society of India symposium: Optical Science and Engineering, IIA, Bangalore, March 21-23, 1990. *P.S.M.Aleem, J.C. Bhattacharyya, S.K.Jain, J.P Lancelot, M.V Mekkadean, P.K.Raju, R.Rajamohan, K.Raman Kutty, K.B.Ramesh, J.P.A.Samson, L.Yeswanth, G.A.Shah, A.K.Saxena, J.H.Sastri, K.R.Sivaraman, R.Srinivasan.*

Appendix B

Popular Talks

J.C.Bhattacharyya

-: *Excellence in Science,* Jagdish Bose National Science Talent Search, Calcutta, December 26-27, 1989.

-: Valedictory address, Kendriya Vidyalaya, Malleswaram, Bangalore, January 26, 1990.

-: Inaugural address, Southern Science Exhibition, Ananthapur, February 15, 1990.

B.Datta

-: The first three minutes, All India People's Science Congress, Bangalore, March 8-11, 1990.

K.K.Ghosh

-: *Astrophysics - where we stand,* All India Science Teachers Association, Krishnagiri (Tamil Nadu), January 28, 1990.

-: *Our Galaxy - the Milky Way,* Sacred Heart College, Tirupattur, October 27, 1989.

M.H.Gokhale

Sunspot Butterfly diagram, Nehru Planetarium, Bombay, May, 1989.

T.P.Prabhu

Neptune, Bangalore science forum, October 25, 1989.

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, Bangalore. H.C.Bhatt, S.Giridhar, A.K.Pati and P.Venkatakrishnan taught the JAP students during the academic year 1989-90.

T.P.Prabhu visited the Department of Physics and Astrophysics, University of Delhi, Delhi, during February 1990 and delivered lectures on *Astronomical spectroscopy, classical novae and data processing.*

B.Datta and D.C.V.Mallik gave several lectures on *Stellar evolution* and *Interstellar matter* respectively at the VBO winter school for college teachers which was held at IIA, Kavalur.

J.C.Bhattacharyya, M.H.Gokhale, R.K.Kochhar, D.C.V.Mallik, A.Peraiah, J.H.Sastri and K.R.Sivaraman participated in a meeting to formulate the syllabus for special papers in astrophysics at the M.Sc level in Bangalore University. Several scientists from the Institute will start teaching these courses from the academic year 1990.

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, at the IIA. JAA has entered its 11th volume. J.C.Bhattacharyya continues as the chairman of its editorial board. D.C.V.Mallik joined the editorial board. T.P.Prabhu and R.K.Kochhar continue as associate editors of JAA and BASI respectively. T.P.Prabhu joined the editorial board of BASI.

Kodaikanal Observatory Bulletins and IIA Technical reports are being published regularly, with the assistance of A.Vagiswari and Christina Louis. J.C.Bhattacharyya continues as editor.

The IIA newsletter entered its 5th year in January 1989. T.P.Prabhu and A.K.Pati continue to edit the newsletter on behalf of the Director of the Institute.

A newsletter entitled 'VBT news' was started to report the activities, information and developments related to the VBT (Vainu Bappu Telescope). The VBT news is edited by R.Rajamohan on behalf of the Director of the Institute.

V.Krishan jointly with E.R.Priest, is editing the proceedings of the IAU symposium 142 on *Basic plasma Processes on the Sun* which was held in December 1989.

P.Venkatakrishnan and V.Krishan prepared a booklet on *Solar Physics at IIA*, which gives an account of solar physics research work done at IIA during the past three decades.

A.K.Saxena and A.Vagiswari completed a write up on *History of optical glass industry and optical technology in India*. The manuscript has been submitted to INSA for publication.

The proceedings of the DST workshop on *National Large telescope scientific requirements and requirements of site* are being edited by M.Parthasarathy.

Book reviews

H.C.Bhatt reviewed the book *Interstellar Matters* by G.L.Verschuur (Springer-Verlag, 1989) for the Bull.Astr. Soc.India **17**, 151. 1989.

V.Krishan reviewed the books *Conceptions of space and time* by M.D.Akhudov (M.I.T.Press) and *Imagining tomorrow* by J.J.Cosn (MIT Press) for J. Indian Inst. Sci. **69**, 409 & 485 (1989).

Radio/TV/Film programmes

G.S.D.Babu and N.K.Rao wrote the script for the UGC TV-film, *Beyond Vision - the optical telescope*, produced by Ashok Mewada for the UGC. The film won the best edited film award.

J.C.Bhattacharyya collaborated with the Indira Gandhi National Open University, New Delhi on an audio/visual program on astronomy for inclusion in their syllabus.

M.H.Gokhale wrote the script and co-ordinated the production of the educational film *Kodaikanal Observatory* produced by the Educational Media Research Centre, Ahmedabad for a UGC TV programme.

T.P.Prabhu gave a talk on *Unravelling Neptune* on All India Radio Bangalore, January 12, 1990.

Appendix C

Vainu Bappu Observatory

Sky condition at Kavalur April 1989 - March 1990.

Year	Month	Spectroscopic hours	Photometric hours
1989	April	168.5	16.0
	May	86.0	0.0
	June	64.5	0.0
	July	19.5	0.0
	August	41.5	0.0
	September	34.0	3.0
	October	111.0	12.5
	November	137.0	40.5
	December	157.0	37.5
1990	January	304.0	90.0
	February	172.0	56.5
	March	176.5	63.0
	Total	1471.5	319.0

Kodaikanal Observatory

Solar tower observations and seeing conditions (in arc sec)

Year	Month	Total no. of days of observations	1 to 2	2	2 to 3	3	3 to 4	4	4 to 5	5	5 (poor)
1989	April	14	-	3	3	6	-	2	-	-	-
	May	9	-	-	-	2	1	6	-	-	-
	June	5	-	-	-	1	-	2	1	1	-
	July	7	-	-	1	1	-	5	-	-	-
	August	5	-	-	1	1	-	3	-	-	-
	September	7	-	-	-	4	-	2	-	1	-
	October	9	-	-	2	6	-	1	-	-	-
	November	13	-	1	1	9	1	1	-	-	-
	December	9	-	2	3	1	-	1	-	-	2
1990	January	14	-	-	2	4	5	1	1	1	-
	February	14	1	-	-	8	3	-	2	-	-
	March	17	-	2	4	6	1	3	1	-	-
	Total	123	1	8	17	49	11	27	5	3	2

Spectroheliograms/Photoheliograms

(No. of plates and seeing conditions)

Year	Months	Hα	KFL	KPR	PHGM	Seeing*				
						5	4	3	2	1
1989	April	28	27	23	28	-	2	19	7	-
	May	21	21	21	24	-	-	14	10	-
	June	12	11	09	16	-	-	9	7	-
	July	10	10	10	14	-	2	7	5	-
	August	14	16	14	19	-	-	12	6	1
	September	16	15	10	20	-	3	12	5	-
	October	17	15	11	21	-	4	12	5	-
	November	14	14	13	14	1	5	6	2	-
	December	22	21	10	23	-	6	13	4	-
1990	January	25	24	14	25	-	5	17	3	-
	February	25	25	-	25	-	7	14	4	-
	March	28	27	17	29	2	-	18	8	1
	Total	232	226	152	258	3	34	153	66	2

KFL = K - Flocculus

KPR = K - Prominences

PHGM = Photoheliograms

*(1 - v poor, 2 - poor, 3 - fair, 4 - good, 5 - excellent)