INDIAN INSTITUTE OF ASTROPHYSICS

Annual Report 1990-91

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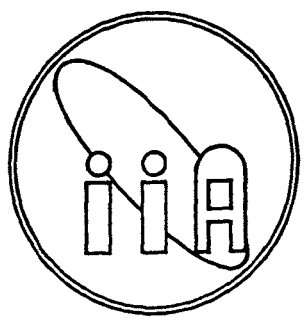

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Front Cover : Solar tower telescope at the Kodaikanal Observatory

Cover photo & design : Pankaj Shah

Edited by M. Parthasarathy, S.S. Hasan & R. Srinivasan

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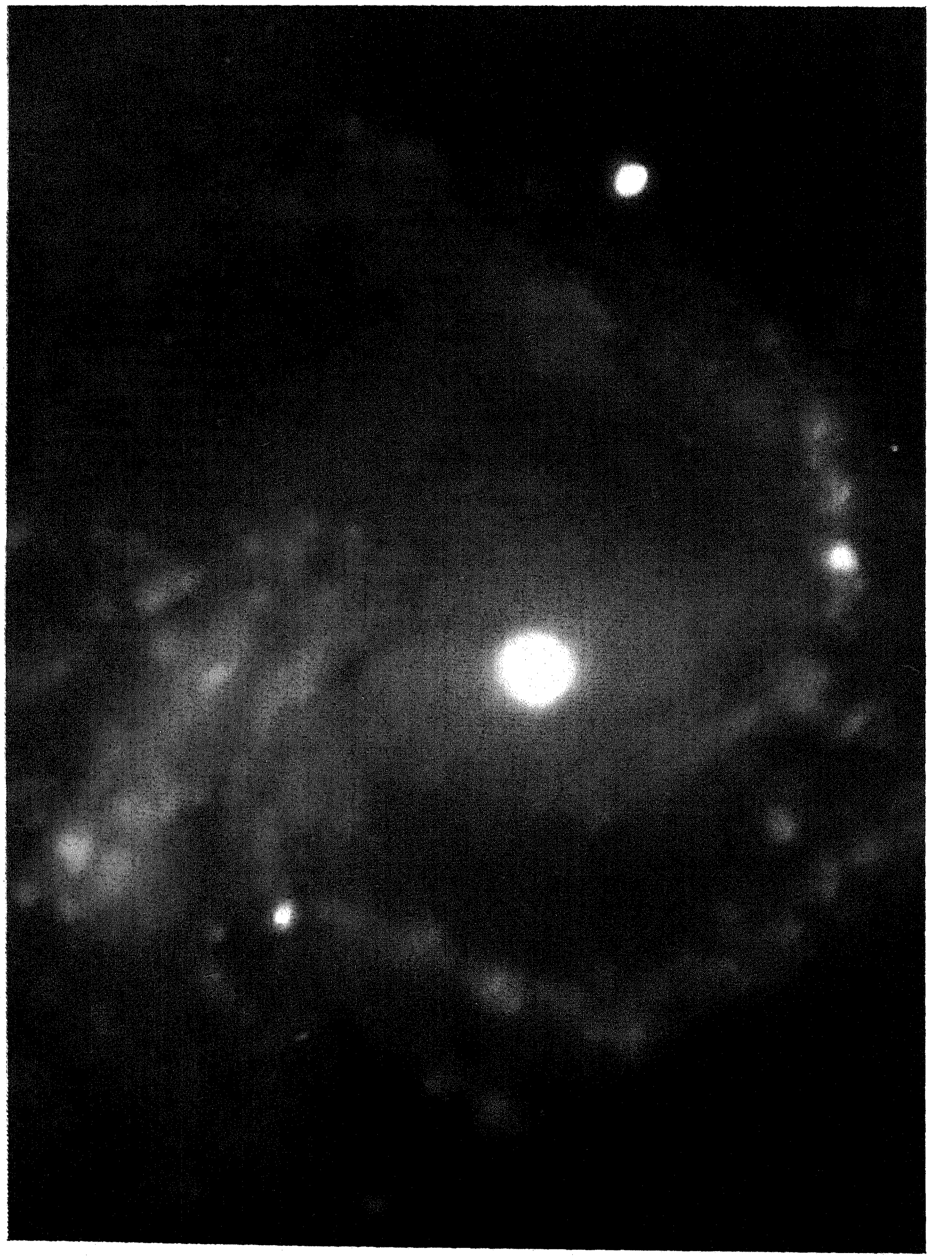


Picture of the spiral galaxy NGC 4303 constructed using the CCD images obtained with the Photometrics CCD system on the 1 m telescope. B and V broadband images and Hα narrowband image were added as blue, green and red images respectively. Individual images were pre-processed and the composite constructed on the COMTAL image processing unit at the VAX 11/780 installation of VBO. The field is 2 arcmin x 3 arcmin in size. North is at the top and east to the left. (Y. D. Mayya)

The Year in Review

The year under review witnessed substantial progress in all the areas of research activities pursed in the Institute. New and ambitious research programmes both observational and theoretical were planned and included as targets to be achieved during the Eighth Five Year Plan, in addition to the ongoing programmes. New observational programmes were initiated at the Vainu Bappu Telescope to utilise fully its capabilities. The Department of Science & Technology recognized the need to implement many of the recommendations that emerged at the National meetings on Astronomy organized by them in 1989. The Research Advisory Committee for Instrumentation held its second meeting on May 10 & 11, 1990 at IIA, Bangalore. Prof. B.V.Sreekantan and Dr. R. Hradayanath were present. Based on the scientific presentations made to the Committee and extended discussions following these, the Committee approved the research projects proposed by IIA for the coming years.

In the field of solar physics considerable progress was made both on the observational front as well as on the theoretical investigations. It was shown that the heating of the solar chromosphere takes place at the sites of the sub-arc structures (known as the bright points) in the interior of the network. Among other investigations are the determination of the mean lifetime of the supergranulation cells from a sample out of the continuous observations of the sun from the Maitri Station in Antarctica, detection of mesogranular cells; studies on the He I 10830 Å line parameter fluctuations; studies of flare related changes in magnetic shear and the continued observations of solar bursts at high temporal resolution using the Decameter array at Gauribidanur. Investigations in the field of theoretical solar physics included the spherical harmonic Fourier analysis of sunspot data that led to the inferences that the solar magnetic cycle is the outcome of a superposition of forced global oscillations and that the deep seated two additional components in the global oscillations (brought out in this analysis) are necessary to describe the surface magnetic fields at all latitudes on the sun; interpretation of the hierarchy of convective motions on the sun as a self organisation process in a turbulent medium; studies of the effect of a uniform vertical magnetic field on the modal structure of a stratified atmosphere as in the sun and the response of a dispersive characteristics of hydromagnetic surface waves along the boundary of moving compressible plasma in cylindrical geometry simulating the flux tubes on the sun. Studies on the particle acceleration mechanisms in solar flare were carried out from which the theoretical values of the hard X-ray intensity for different values of density and temperature were derived.

The activities of the solar system group was concentrated on the observational programme to acquire the light curves during

the mutual eclipse events of Jovian satellites. Fifteen eclipse events were observed successfully. These with the theoretical model developed, would yield the impact parameter and the scattering function for the light distribution across the surface of the eclipsed satellite. The polarimetric observations of comet Halley were used to derive the law of distribution and the nature of grains in the coma.

The research activities of the Solar Terrestrial Physics group dealt with the problems of the genesis of the short period Doppler frequency pulsations in the ionospheric F region and the response of the equatorial ionosphere due to the passage at the Earth of an interplanetary cloud.

In the area of star and stellar systems, spectroscopic analysis of novae, Be stars and supergiants was continued. Analysis of Hα line in the spectra of late type supergiants suggests mass outflow and the presence of non-thermal velocities. Equivalent widths of oxygen lines were used to derive the absolute magnitudes of F-G supergiants. Modelling of M-supergiant's atmospheres is in progress.

Chemical composition analysis of post AGB stars with A-F-G supergiant type spectra shows that the refractory elements such as Fe, Ca, Ti etc. are depleted but not CNO and S. The presence of circumstellar dust shells around these stars suggests the formation of cores of dust grains containing refractory elements, very close to these stars. The resulting dust driven mass loss may explain the observed abundance peculiarities. Analysis of (IUE) ultraviolet spectra of selected post AGB stars show evidence of stellar wind and mass loss. Spectroscopic analysis of few selected R Cr B stars show that they are metal poor and are enriched in the light s-process elements but not significantly in heavy s-process elements.

Analysis of polarimetric observations of carbon stars suggests that the circumstellar grain scattering is the main mechanism responsible for the continuum polarization of carbon stars.

CCD photometry of several galactic and globular clusters was carried out and their colour magnitude diagrams were compared with theoretical models.

Detailed analysis of radiative transfer incorporating the aberration and advection effects on line formation was carried out. The role of Compton scattering on line formation was studied and the spectral line broadening was calculated taking this into account. The reflection effect in close binaries was treated in three dimensional geometry. A solution of radiative transfer equation in three dimensions was developed.

From an analysis of IRAS data evidence for enhanced star formation in the cometary globules in Gum Nebula was found. CCD imaging of Herbig Ae/Be stars was carried out. Ionization structure of HII region was

investigated. New calculations of the hydrogen and helium ionization structure in H II regions were performed with the exciting stars spanning an effective temperature range of 40000 K to 60000 K. Study of low excitation planetary nebulae and bipolar planetary nebulae is in progress.

The work on extra-galactic research concentrated in deriving colour-magnitude diagram for a large sample of stars in the Fornax dwarf galaxy from BV electronographic observations. A comparison with galactic globular clusters as well as theoretical isochrones suggests [Fe/H] =-1.5 for the Fornax giant branch stars. The programme of CCD imaging of nearby galaxies in BVR and Hα to study the star-forming regions was continued. Theoretical modelling of the line formation in Seyfert galaxies was attempted. The X-ray spectra of three Seyfert galaxies and one quasar obtained with EXOSAT were analysed. Numerical experiments to study the transfer of angular momentum to an initially non-rotating spherical test galaxy as it undergoes a collision with a massive perturber were performed. A new model for clustering of galaxies based on the phenomenon of inverse cascade occurring in a turbulent medium was proposed and this was used to interpret the clustering of galaxies on all scales as a result of self organisation process occurring in such a medium.

The role of stimulated Raman scattering processes in the generation of the typical electromagnetic continuum of an active galactic nucleus and quasars was investigated. Possible ejection of quasars from nuclei of galaxies is being investigated. Also the study of the effect of dynamical friction on the motion of a supermassive object ejected from the centre of a galaxy was continued. A statistical analysis of the median angular separations between quasars and associated galaxies from the QSO catalogues was initiated.

A detailed numerical investigation was carried out of the oscillation properties of neutron stars using the realistic equations of state of high density matter. An estimate was made of the effect of light bending and redshift on the pulsar beam characteristics using a weak form of the Kerr metric, applicable to a slow rotating neutron star. An attempt was made to study how the process of explosive neutron capture is responsible for the synthesis beginning with ^{22}Ne. It was shown that when a spin dominated phase is considered in the very early universe, conditions for inflation can follow even for the anisotropic expansion. Several aspects and conditions in the early universe were investigated. The consequences of the quantum effects of torsion were studied and the consequences for the early universe were explored.

The work on the development of a variety of instruments like the solar vector magnetograph, extreme UV spectroheliometer, speckle camera system, solid rotational shear interferometer and a new 12 band photometer for stellar observations

made substantial progress. The F-P interferometer for the night air glow studies was fabricated and field tested. Besides, the electronic division implemented several replacements and modifications of auxiliary supporting systems to the various telescopes at Kavalur like the new display system and the star changing device for the 1-m reflector, software modifications for the CCD data acquisition system etc.

The optics division continued its support by fabricating many new optical surfaces for auxiliary instrumentation. Besides, development work in active optics for wavefront sensing and evaluation and the specular polishing of radiometer sunshield panels for the INSAT-II flight model progressed well. The mechanical workshops at Bangalore, Kavalur and Kodaikanal continued to provide the necessary support for the various projects.

The Institute operates a radio observatory in collaboration with the Raman Research Institute at Gauribidanur. Here a radio heliograph capable of mapping the Sun in the frequency range 150 - 30 MHz is under construction. An Acousto Optic Spectrograph is being used for high time and frequency resolution studies of solar radio bursts. A decametric VLBI system is being developed for high spatial resolution studies of solar and Jupitar radio bursts and some strong radio sources.

The Institute in collaboration with the Raman Research Institute and the University of Mauritius is constructing in Mauritius an aperture synthesis radio telescope to operate at 150 MHz mainly meant for the observations of the galactic center.

The VBT National Facility strengthened during this period functioned most satisfactorily. The demand on the observing time by proposals screened and recommended far exceeded the available time for allotment. Several programmes both on the prime focus (like imaging of galaxies) as well as at the Cassegrain focus using cooled CCD were carried out successfully during the observing season. Many software programmes for the reduction of spectroscopic data and image processing were expanded to meet the growing needs of the observers. The VBT was provided with an auto guiding system employing as intensifier CCD and the dome movement was automated. The services of the Instrumentation Cell was made use of by the astronomical community.

Many of the ongoing collaborative programmes were strengthened and fresh ones were commenced. Many scientists participated both in international and national conferences. Also there were many visitors from other institutions in India and abroad who spent varying amounts of time thus sharing and enriching the academic performance of the Institute.

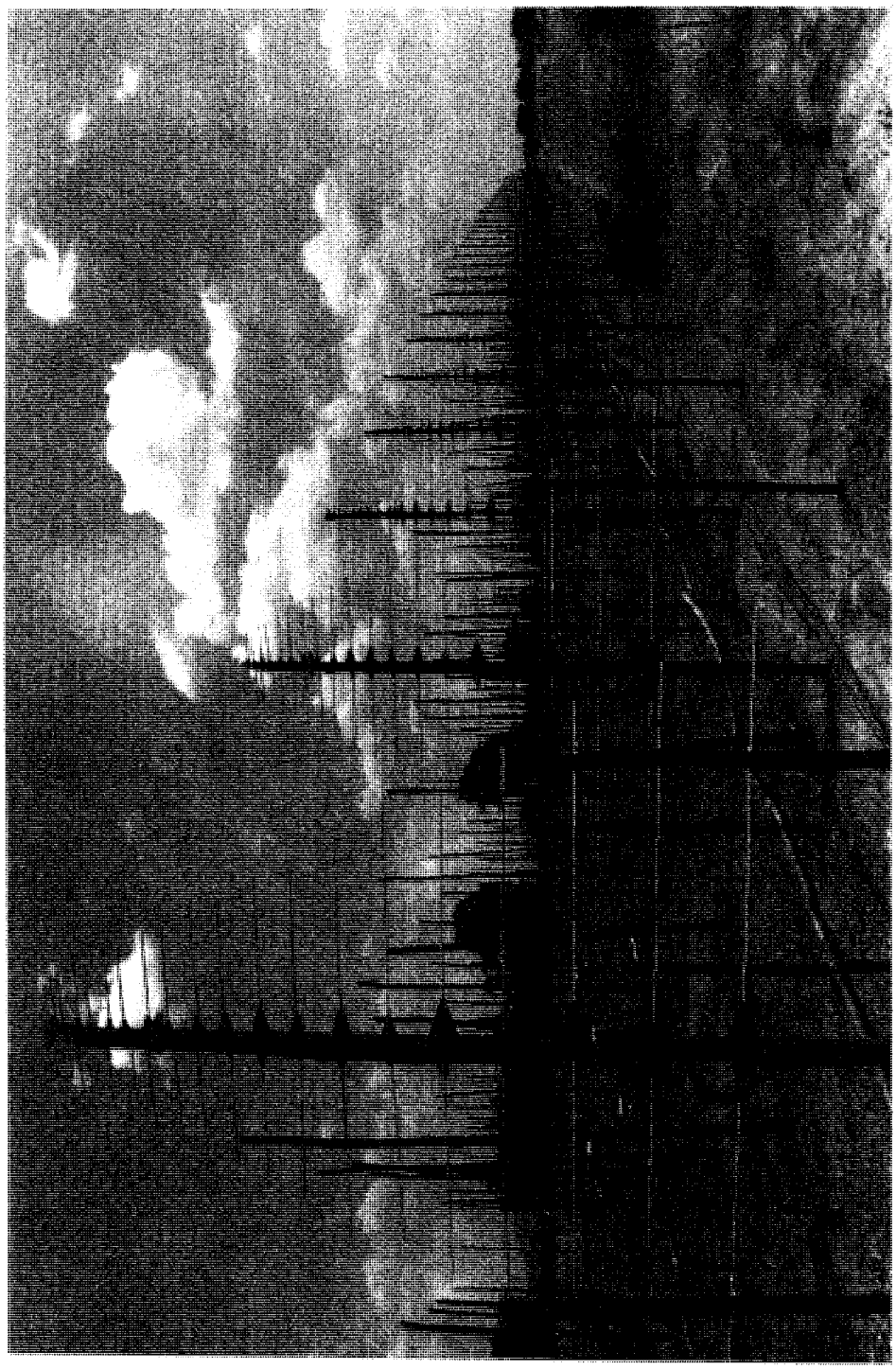
The Fifth IIA Bicentennial Commemorative lecture was delivered by Dr A.P.J.Kalam on the topic "Rocket Technology and its Streams".

The Department of Science & Technology besides providing the normal support for all the research activities of the Institute, recognised the need to create new National Facilities in Astronomy: The National Solar Vacuum Telescope and the National Large Optical Telescope. IIA would play a major role in the affairs of these two projects.

The year in review was prepared by Prof. K.R.Sivaraman Director (Acting) who retired on July 31st 1991.

Ch.V.Sastry
Director (Acting)

Research Highlights



The south array (log periodic diploes) of the solar radio telescope at Gauribidanur. (Ch. V. Sastry)

Solar Physics

Velocity fields

Solar granulation

Nonlinear interactions between small fluid elements in an energetically open system facilitate the formation of large coherent stable structures. This is known as self-organization. Solar granulation on all scales is interpreted to be the result of self-organization processes occurring in the turbulent medium of the solar atmosphere. This mechanism provides explanations for the intrinsic weakness of mesogranulation and the rare appearance of the giant cells in addition to the sizes and lifetimes of these structures. The entire energy spectrum for the smallest granules to the largest giant cells brings out the prevalence of Kolmogorov's $K^{-5/3}$ law. (V.Krishan)

Mesogranulation

The mesogranular cells detected in high quality Mg b filtergrams, obtained at the VTT (Vacuum Tower Telescope, Sacramento Park, U.S.A) are being examined. Morphological Studies and the size distribution of cells are being carried out. (S.P.Bagare & K.R.Sivaraman)

Supergranulation and lifetime of the calcium network

Filtergrams of the Sun in Ca K (3933 Å) were obtained with an interval of 10 min over a period of 3 days from Maitri, the Indian station at Antarctica. These are being analysed to determine the most probable lifetime of supergranular cells. Preliminary results indicate that the lifetime of these cells is about 20-23 hours. A detailed analysis will be done to detect a possible correlation between the lifetime and the size of the cell. It is also planned to digitize the filtergrams to study in greater detail the evolution and decay of these cells. (Jagdev Singh, G.S.D.Babu, K.R. Sivaraman & J.C.Bhattacharyya)

Evershed effect in bipolar sunspots

Fresh research material was obtained in the form of spectra in the non Zeeman Ni I line λ4912 Å for a large number of unipolar, bipolar and complex sunspot groups. In a few cases, spectra cover the same spot group for consecutive rotations and this provides information on changes in the Evershed flow during the evolution of a spot group. (K.R.Sivaraman, K.Sundararaman & P.S.M.Aleem)

Magnetic fields

Correlation between magnetic shear and magnetic tension in a solar active region

Magnetograms of NOAA AR 4474, obtained from the Marshall Space Flight Centre, were analysed for evaluating the magnetic shear (defined as the angular deviation of the observed field azimuth from that of the corresponding potential field) and

magnetic tension (defined as the angle between the transverse magnetic field and the gradient of the line of sight field) in four magnetograms. A typical correlation of about 50% was seen between both parameters. Although the two parameters are theoretically equivalent, the methods of estimating these are different which could explain the absence of 100% correlation. The observed correlation is however significant enough to allow the use of either parameter in the characterisation of vector magnetograms. (P. Venkatakrishnan, R.S. Narayanan & N.D.N. Prasad)

Global magnetic oscillations (data analysis)

Image-processed grey-level diagrams of the spherical-harmonic-Fourier (SHF) spectra of the odd and even degree modes in the Sun's magnetic field, as inferred from sunspot data, show power concentrations aligned with sets of curves suggesting dispersion relations for the modes constituting the field. However, comparison with the results from two simulated data sets shows that these alignments are statistical in nature, rather than physical. Thus, the power ridge along the narrow frequency band at about 1/21.4 ± 1/107 yr^{-1} and the low ridges along the odd multiples of this frequency strongly indicate that the solar magnetic cycle consists of global oscillations 'forced' at the frequency of about 1/21.4yr^{-1} by some forcing oscillation (e.g., as suggested by Dicke). The constancy of band widths at the odd multiples indicates that the band width of the forcing oscillation is much less than 1/107 yr^{-1}. (M.H. Gokhale, J.Javaraiah, K.Narayanan Kutty & B.A. Varghese)

From the r.m.s variations ($\Delta\delta_l$) of the relative phases (δ_l) in the odd degree modes of frequency 1/21.4 yr^{-1} in the inferred magnetic field, it was shown that modes l = 1 to 19 are stationary ($\Delta\delta_l \leq 15°$), and l = 21 to 27 are approximately stationary ($\Delta\delta_l \leq 30°$). The simulated data sets (with the same time epochs, but with random distribution of latitudes within the wings of the butterfly diagrams), cannot reproduce even the approximate constancy of phases for modes beyond l = 15. (M.H. Gokhale & J. Javaraiah)

The SHF modes l = 1 - 27 can be grouped in the following four distinct "geometrical eigenmodes", each characterised by its own phase and a power hump covering a specific range of l values:

$$B_1 = \left(\sum_{l=1}^{11} a_l \, P_l(\cos\theta)\right) \sin(\upsilon * t),$$

$$B_2 = \left(\sum_{l=7}^{17} a_l \, P_l(\cos\theta)\right) \cos(\upsilon * t),$$

$$B_3 = \left(\sum_{l=15}^{23} a_l \, P_l(\cos\theta)\right) \sin(\upsilon * t),$$

$$B_4 = \left(\sum_{l=21}^{25} a_l \, P_l(\cos\theta)\right) \cos(\upsilon * t),$$

where $\upsilon_0 = 1/21.4\ yr^{-1}$, θ is the heliographic colatitude, P_l are Legendre polynomials and a_l are the computed amplitudes.

The eigenmodes B_1 and B_2 are necessary and sufficient to produce the large scale structure of the butterfly diagrams. The eignmodes B_3, B_4, along with the modes $l \geq 29$, define the distribution within the butterfly "wings". The eigenmodes B_3 and B_4 cannot be reproduced by any simulated data set with random latitude distribution within the wings. Their presence cannot be detected by analysing the magnetogram data which spans only a little more than one magnetic cycle. However, without their inclusion in the field expression, one cannot predict, even qualitatively, the observed migrations of three or more neutral lines in the large scale photospheric field. Thus B_3 and B_4 represent the so far undetected real global oscillations in the deeper field responsible for producing sunspots. (M.H.Gokhale & J.Javaraiah)

Global magnetic oscillations (theory)

The eignfunction of the toroidal velocity in the torsional oscillation of a star, with zero order dipole field, was calculated using the WKB approximation. It was found that this profile does not agree with the profile of the torsional oscillations observed by Howard and Labonte (K.M. Hiremath & M.H. Gokhale)

Work is in progress for modelling the internal solar magnetic field that supports global Alfvén oscillations. For this an iterative algorithm was developed for determining the relative amplitudes of the Legendre components in an axisymmetric poloidal magnetic field, which will be radial at the star's surface and will give the same Alfvén travel time along all field lines. (K.M. Hiremath & M.H. Gokhale)

Effect of a magnetic field on the modes of a stratified atmosphere

The effect of a uniform vertical magnetic field on the modal structure of a stratified atmosphere was studied. General solutions of the wave equation for an isothermal medium were presented and their asymptotic behaviour was examined in the strong and weak field limits. In the latter case, an analytic expression for the dispersion relation could be derived, which demonstrates the effect of a weak magnetic field on the normal modes. It was found that for a weak field, the oscillation spectrum, to lowest order, consists of (a) p- and g- like modes (b) magnetic Lamb modes and (c) magnetic or slow modes. This approximation is valid as long as the frequencies of the individual modes are well separated and not too low. The frequency corrections for each of the modes due to coupling with the remaining modes were calculated. It was shown explicitly that when the frequencies of two different modes become close, strong mode coupling occurs and the waves acquire a mixed character. This can be seen clearly in the diagnostic diagrams,

through the phenomenon of "avoided crossings". Analytic expressions for the frequency corrections close to these crossings were obtained. Normal modes for the moderate to strong field case were also calculated and the various order solutions classified. (S.S. Hasan & J.Christensen - Dalsgaard*)

Pulse propagation in magnetised atmospheres

It is well known that a stratified atmosphere responds to a propagating pulse with a wake consisting of a few oscillations at the cutoff frequency for wave propagation. In a magnetised atmosphere there is more than one mode of wave propagation. It has conventionally been assumed that an impulse splits into the various modes and results in multiple fronts of propagation with corresponding wakes. A fresh look at this problem showed that indeed, there is only one pulse but the wake consists of oscillations with a fast mode cutoff but modulated at the frequency of the slow mode cutoff. (M. Dikpati & P.Venkatakrishnan)

3-D model of a force-free magnetic field

Three dimensional modelling of a force free magnetic field in the solar corona is essential to understand the various magnetic phenomena occuring in the solar corona. A programme, using T.Sakurai's iterative method, was written to compute a force free magnetic field of the form $\nabla \times \mathbf{B} = \alpha \mathbf{B}$, assuming a potential field in the photosphere as the boundary condition. In this method, the connectivity of the field line is conserved. Initially a potential field is assumed. On one side of the neutral line, α is specified. Later a known current is introduced into the field, due to which the field lines get distorted. The new field is calculated and again a new current is applied. This process is repeated till the field geometry does not change. The programme has been tested for a constant α force free field. It is proposed to extend this to a general force free field (N.D.N.Prasad & P.Venkatakrishnan)

Hydromagnetic surface waves

The conditions under which hydromagnetic interface waves can exist at a magnetic interface were deduced. Using these conditions, it was shown that a slow interface wave with a phase velocity of about 5 km s^{-1} and a fast interface wave with a phase velocity of 6.5 to 8 km s^{-1} can exist at the photospheric level. (K.Somasundaram*, S.Manthira Moorthi* & A.Satya Narayanan)

The dispersive characteristics of hydromagnetic surface waves along a plasma - plasma interface, when one of the fluids has a relative motion, was studied as a function of the compressibility factor, which is the ratio of the acoustic and Alfvén wave speeds in one of the media. Both slow and

* Names of coworkers from external institutions

fast magnetosonic surface waves for each symmetric modes can exist. The nature and existence of these modes depends on the values of the compressibility factor and the angle of wave propagation. (A.Satya Narayanan)

Magnetohydrodynamic surface waves carry energy whenever a discontinuity in the Alfvén speed is present. They are generally interpreted as Alfvén, fast and slow modes. It is well known that surface waves are two dimensional and, therefore, their propagation characteristics, in general, can be affected by the surface geometry. Since many discontinuous structures in the laboratory and in astrophysics, such as flux tubes in the Sun, are cylindrical rather than planar, it is more appropriate to study hydromagnetic surface waves along the boundary of a moving compressible cylindrical plasma column surrounded by a compressible stationary column. This is presently being attempted (A.Satya Narayanan)

Hydromagnetic surface waves along a plasma-plasma interface, when the upper fluid moves with a uniform velocity, were examined. The region of propagation of these waves is shifted above or below depending on whether the basic velocity (uniform) is positive or negative respectively. (A.Satya Narayanan)

Prominences

A two dimensional steady state dynamical model of the Kippenhahn-Schlüter type, for a prominence embedded in a magnetic arcade, is being developed. Thermodynamics and mechanical support are being treated self consistently. In order to explain the observed upward motions within the prominences, a diverging flow is introduced at the base of the arcade. Energy balance in the prominence is dictated by the relative magnitudes of the conduction and radiation loss terms. At high locations in the structure, the effect of thermal conduction is reduced due to the effect of field geometry. At the same time, the density declines, which tends to lower the effect of the radiation as well. If conduction effects dominate over radiation everywhere, the arcade will be filled with a hot stable plasma with a temperature of 10^6 K. If radiation dominates in some range of altitude, the plasma will cool down to form a prominence. Below the prominence, the field lines are short enough to prevent nonequilibrium, while above the prominence the density is low enough to do so.

So far, conditions have been worked out under which coronal equilibrium breaks down. The boundary conditions used in the model are based on observations. Once the prominence is formed, the downflow within the prominence is expected to suck new material from the sides. This could explain the source of prominence material. (B.S.Nagabhushana)

Chromosphere

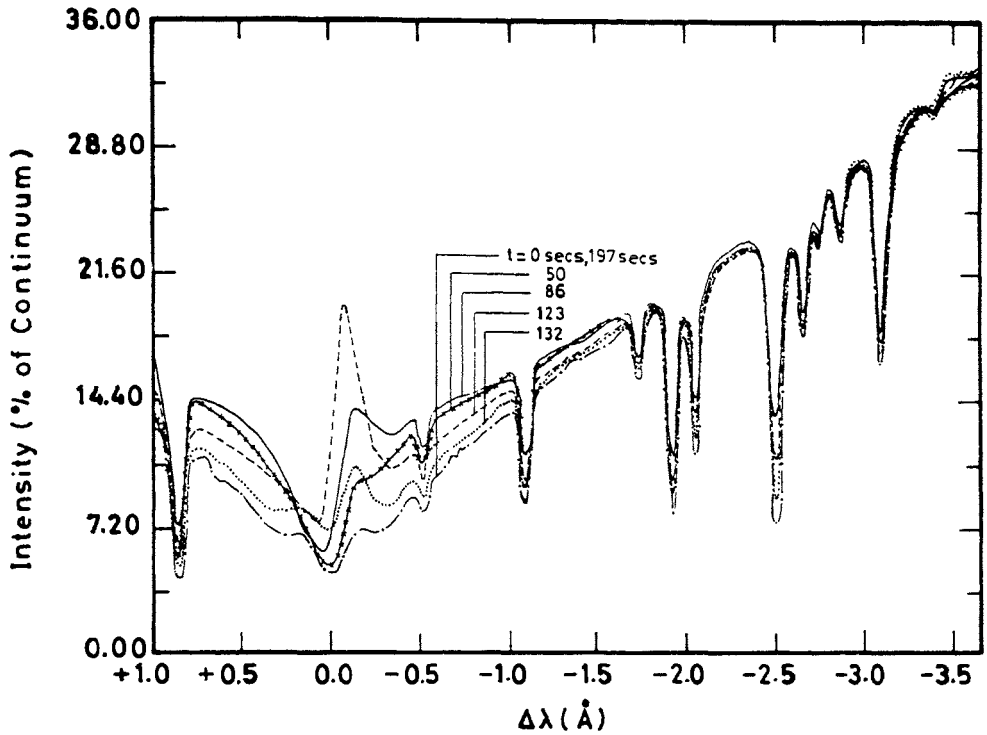
Bright points

Observations obtained under excellent seeing conditions, with the VTT, were used earlier to search for the foot points of sub arc second magnetic structures, with reference to the photospheric granulation in regions of the quiet Sun. This study was extended to areas in the vicinity of active regions. It was found that the number of bright points, with foot points in intergranular lanes in the photosphere, is less in active regions as compared to that of the nearby quiet region. Details of the trend in this variation from active to quiet regions are being worked out. (K.R.Sivaraman, S.P.Bagare & S.Koutchmy*)

Heating of the solar chromosphere

Analysis of a 35 min time sequence of spectra in the CaII H line, obtained at the VTT of a quiet region near disc centre, is nearing completion. These spectra are of high spatial, spectral and temporal resolution. The aim is to investigate small scale dynamical processes associated with arc sec structures (viz., the bright points) operative in the quiet solar chromosphere, leading to the heating of the lower chromosphere. The time separation between adjacent frames is 12 s and in all there are 177 spectrograms within the 35 min duration of the sequence. A total of 18 sample features (of which 16 are bright points and 2 lie on the network) along the slit were chosen and their line profiles were calibrated in terms of the neighbouring continuum for these 18 samples from the 177 spectrograms.

An examination of these line profiles provided a wealth of information on the onset and the progress of the dynamical processes operative in the chromosphere. The process begins as a brightening in the far wings of the H line and travels towards the higher levels of H_{2V} and H_{2R} simultaneously. When the brightening has reached the H_{2V} level, the line profile becomes highly asymmetric with an enhanced H_{2V} peak. This is accompanied by a redshift in H_3 which obscures the H_{2R} emission and keeps it far below the emission in H_{2V}. A little later, the H_{2V} emission fades and H_3 returns to its normal wavelength position. In many cases, the wing brightenings fade before the emission in the core (H_{2V} or H_{2R}) reaches its maximum brightness. The H_{2V} fades and merges with the background chromosphere. This constitutes one life cycle of the bright point and lasts for about 180 s, after which the whole cycle of events repeats at the same site of the bright point. This sequence of events can be interpreted as direct observational evidence for the upward propagation of non-thermal energy that heats the lower chromosphere by these pulses. A plot of the intensity of emission in H_{2V} versus time for the entire 35 min duration of the sequence and its power spectrum show that the bright points are associated with the 3 min chromospheric

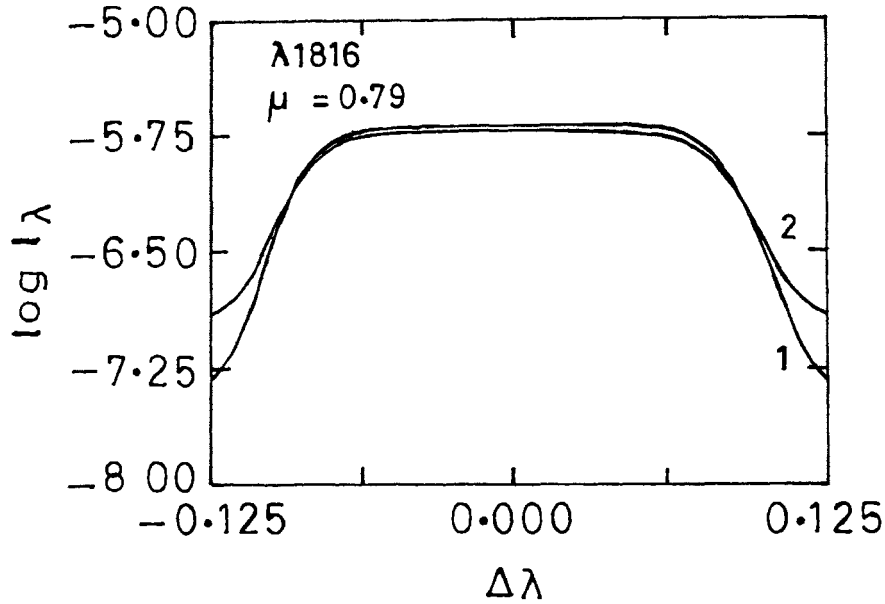


Time evolution of the H-line profile of a typical bright point out of a sample of 16 which were analysed. At t=0 the undisturbed profile shows the familiar symmetric shape. At t=50 s brightening starts in the far wings. At t=86 s the brightening in the far wings has simultaneously reached the H_{2V} and H_{2R} levels and has produced a highly asymmetric profile. At t=123 s a very intense single peaked emission has developed at H_{2V} and at t=132 s the wing and the H_{2V} emission start returning to the undisturbed condition. At t=86 s and t=123 s H_3 shows a large redward displacement $\Delta\lambda$=+0.055 Å & $\Delta\lambda$=+0.088 Å respectively. (R. Kariyappa & K.R. Sivaraman).

intensity oscillations, which were identified as long period waves that were responsible for heating the lower chromosphere. The present analysis shows that there are three different classes in the evolution of the bright points and the inference is that it is the magnetic field associated with the bright points that causes this difference.

It was noticed that the brightening in the bright points when traced down to the photospheric level, lie in the dark intergranular lanes. Thus, the bright points in the chromosphere have their foot points in the intergranular regions. In addition a phase coherence in the waves associated with the bright points located within a distance of 10-12 arc sec on the Sun was also noticed. This suggests a mesogranular cell structure at the chromospheric level.

In addition a 35 min long time sequence of spectra in Na I D_1 and D_2 lines (obtained simultaneously with the Ca II H spectra) were analysed. The intensity oscillations measured in the Na I lines show a



Specific intensity I as a function of Δλ, the wavelength difference from the line centre. Calculations were made with VAL model C for the Si II 1816 Å line in the solar chromosphere. The curves marked 1 and 2 indicate calculations without electron scattering and with non-coherent electron scattering respectively. (K.E. Rangarajan)

period of about 4 min, which lies intermediate between the photospheric (5 min) velocity and intensity oscillation and the chromospheric (3 min) intensity oscillations. There is evidence for the existence of the mesogranular cell structure at these levels as well. (R.Kariyappa & K.R.Sivaraman)

The effects of the electron scattering on Si II 1816 Å line in the solar chromosphere

In continuation of earlier work on the effect of electron scattering on spectral line formation, a specific application of this physical process on the line formation in the solar chromosphere was studied. The Vernazza Avrett Loeser (VAL) model was used for the electron density and temperature. The emission profile for the Si II 1816 Å line, which closely matches observations, was computed. This study is helpful in deriving microturbulent velocities more accurately. (K.E.Rangarajan)

Chromosphere-corona transition region

In order to understand physical conditions within the chromosphere-corona transition region (CCTR), reliable estimates of important physical parameters like electron densities (N_e) and electron temperatures (T_e) are essential. Several theoretical investigations in the past showed that the electron pressure (N_eT_e) within the CCTR tends to have a constant value. The sensitivity of emission line intensity ratios to variations

either in electron density (N_e) or electron temparature (T_e) provides a powerful tool to estimate these parameters. Assuming constant electron pressure, several emission line intensities for the lines of the ions Ne VI and Mg VI were computed as a function of electron temperature and electron density. These two ions are dominant emitters around $T_e = 5 \times 10^5$ K and are relevant to the central part of the CCTR. A comparison of the theoretical line intensity ratios for these ions with the available observed ratios would simultaneously yield N_e, T_e and relative elemental abundance of the two elements. In addition, the results would throw light on the reliabililty of the basic atomic data used and the validity of the results of the ionization equilibrium calculations, which constitute important inputs for the present investigation. The results are being analysed. As an extension to the above project, an attempt is being made to infer electron pressure within the prominence-corona interface (PCTR). The information on electron pressure within the PCTR is essential for studying its structure, its stability and the geometry of the magnetic field within it. (P.K.Raju & A.K. Gupta*)

Corona

Total solar eclipse of July 11, 1991

Considerable efforts and time were spent in the preparations for the forth-coming total solar eclipse on July 11, 1991. The two experiments planned by the solar astronomers of IIA are: (i) spectroscopy of the solar corona in the 5303 Å Fe XIV and 6374 Å Fe X lines using a multislit spectrograph, and (ii) imaging of the solar corona in five emission lines and in the electron-scattered continuum using narrow-band filters. The prime detector will be a Peltier-cooled CCD.

The coelostats, multislit spectrograph and accessories were fabricated in the Institute workshop. The optical flats were fabricated in the optical shop. The setting-up of the CCD system and allied software development is in progress. The stepper motor translators were fabricated in the electronics laboratory. (K.R.Sivaraman, Jagdev Singh & R.Srinivasan)

Coronal loops

A Vlasov-Maxwell description of the ubiquitous solar coronal structures was made. It was found that an equilibrium plasma configuration can exist with spatial gradients in density, temperature, current and drift speeds of the charged particles. In addition, a Vlasov description permits an investigation of kinetic processes like heating and radiation and does not require an equation of state to determine the variation of temperature and density of the constituent particles.(V.Krishan)

Solar and stellar coronae and the extremum entropy principle

A significant subset of systems in nature

(both terrestrial and extra-terrestrial) are observed to be capable of possessing extremely complicated behavior in their detailed dynamics. This behavior is associated with the presence of a large number of active modes, nonlinearities and uncertain initial conditions. Even the most sophisticated numerical treatments involve many approximations and simplifications, whose validity is often doubtful. The detailed numerical models produce a wealth of information, most of which is redundant in practical applications. In view of this, it would be useful to see whether there exist global principles, which at least allow certain "local invariants" (or averages over appropriate time scales) of a system to be calculated, without direct reference to the detailed underlying dynamics. Although the existence of such extremum principles is well established for steady states in linear systems with fixed boundary conditions, the situation is not clear in a nonlinear setting. For the earth-atmosphere climate system, Paltridge (1978, Quart. J.R. Metr. Soc. **101**, 475) demonstrated that the climate system is controlled by a simple extremum principle related to minimum entropy production rate. An attempt is being made to examine whether a similar principle can be applied to explaining the temperature structure of the transition region and solar corona. It is worth noting that apart from the possibility of having an alternative source of information regarding the mechanism of coronal heating, such a principle, if successful, might also yield clues as to the reasons for the changes in the coronal regimes, such as the Maunder minimum. (R. Tavakol* & S.S.Hasan)

Solar flares

Particle acceleration and X rays

An investigation into particle acceleration mechanisms in solar flares was begun. In this work, the role of induction electric fields associated with magnetic reconnection for particle acceleration was emphasised. The acceleration of a test particle motion under the influence of the explosive electromagnetic fields was examined by solving the equation of motion. Expressions for velocity, energy and pitch angle variations were used in terms of E and B fields to study the change in energy and pitch angle distribution of the particles. Using these energy and angular distributions, the hard X ray intensity for different values of density and temperature was computed. The nature of the computed X ray intensity is similar to that of the observed profile. A more detailed analysis of the above aspects is underway using numerical methods. (R.S.Narayanan)

Evaluation of magnetic shear in flaring regions

It is currently believed that the magnetic lines of force experience a shear in the energy buildup phase. If so, this could be used as a diagnostic in anticipating the

occurrence of flares. Measurement of coordinates of sunspots, within a group, along with the vector magnetic field measurements of the same region would uniquely and precisely give the amount of shear in the magnetic field lines. In the absence of vector field measurements, a first order evidence on the shearing of the lines of force can be derived from positions of sunspots and the Hα filaments and changes in their orientations. With this in view a programme was initiated at Kodaikanal to collect rapid sequence photoheligorams. The case study of a large number of flaring regions using the photoheliograms and Hα spectroheliograms show that flares occur following changes in the shear angle. The change in the shear angle seems to be the most significant diagnostic factor rather than the actual values of the shear.(K.R.Sivaraman, R.R. Rausaria & P.S.M. Aleem)

Flare related changes in magnetic shear and tension in a solar active region

Flares are predominantly caused by the relaxation of a stressed magnetic field to a less stressed configuration. Hence, there is now a great deal of interest in the search for flare related changes in the magnetic configuration of active regions. In the case of AR 4474, the Marshall Space Flight Centre obtained magnetograms, before and after the 2B/C6 flare event on April 28, 1984 at 20:17 UT. This is the first occasion where vector magnetograms are available before and after a flare and the search for flare related changes in shear and tension is underway. (P.Venkatakrishnan & R.S.Narayanan)

Miscellaneous

Solar radio emission

About 100 storms of type III solar radio bursts observed in the interplanetary medium (IP storms) identified in the ISEE-3 radio experiment were compared with decameter type III noise storm data obtained by the Meudon observatory, France. It was found that not all IP storms are correlated with decameter type III noise storms.

A broadband array and an acousto–optics spectrograph are being used for high time frequency resolution studies of solar radio bursts in the frequency range of 35 to 70 MHz.

A log periodic dipole array operating in the frequency range of 30 to 150 MHz is being constructed in collaboration with the Raman Research Institute for mapping the radio emission of the Sun at multifrequencies. (K.R.Subramanian)

He I 10830 Å line parameter fluctuations

The equivalent width, line depth, line width and Doppler shift of the He I 10830 Å line were extracted from two time series of spectra. Scatter plots of time-averaged line depth, line width and Doppler shifts, as well

as the root mean square temporal fluctuation of these quantities against the time-averaged equivalent width at a few hundred spatial locations were obtained. The statistical behaviour of these line parameters and their fluctuations was used to infer plausible reasons for the fluctuations. Examination of these results showed that the line parameter fluctuations could be caused by fluctuations in the UV radiation emitted in the transition region or the corona. (P.Venkatakrishnan, S.K.Jain, Jagdev Singh, F.Recely* & W.C.Livingston*)

Solar variability in the Ca II K line

The programme of monitoring the Ca II K line flux from the Sun as a star was continued systematically both at the solar tower telescope at Kodaikanal as well as with the double pass monochromator at Bangalore campus. (K. R. Sivaraman, K. Sundara Raman, R. Kariyappa, A.P. Jayarajan & P.S.M. Aleem)

Solar System

Comets

Comet P/Halley

The polarimetric observations obtained with the 1 m telescope in the various continuum filters (uncontaminated by emission lines) and the International Halley watch filters during 1985-86 were analysed, to study the properties of cometry dust particles. A power law type grain size distribution in the range of 0.001 - 20 , with refractive indices ranging from 1.387 - 0.032 i at 3650 Å to 1.374 - 0.052 i at 6840 Å are needed to explain the observations. (A.K.Sen, M.R.Deshpande, U.C.Joshi, N.K. Rao & A.V.Raveendran)

Asteroids

CCD photometry

CCD photometry of selected asteroids was carried out to study the possible cometary origin of the near earth asteroids and asteroids with unusual orbits. To distinguish the asteroids with possible cometary activity from those of the main belt, each object of interest was observed in two filters; one centred on the C_2 emission band at 5140 Å (90 Å bandpass) and the other centred on the nearby continuum at 4845 Å (65 Å bandpass)

During four observing nights in Feb. and March 1991, 12 asteroids and a comet were observed with the 1 m telescope at the Vainu Bappu Observatory (VBO). A few G-type standard stars were also observed.

The motion of each object from one frame to the other was checked for consistency with the expected change in pixel position. The magnitudes of each object in each filter were computed using aperture photometry programmes (adapted from the Starlink package), which are available on the VAX computer at the VBO. It was found that the magnitude difference in two filters for all the observed asteroids and the G-type standards peaks mostly near 0.5 and near 0.966 for the comet Aarseth Brewington. (R.Rajamohan & S.G.Bhargavi)

Planets

Imaging the outer rings of Saturn

An attempt was made to image the postulated outer ring system of Saturn at a distance of 12.5 saturn radii. A two hour long exposure of Saturn on May 31, 1990 was made with the 2.34 m telescope at the VBO. The central region was masked by a slightly out of focus seven minute image of Saturn taken immediately preceding the experiment. Guiding was done using an intensified CCD camera and the guide star was made to drift by the required amount to compensate for Saturn's motion. Correction for flexure of the telescope mount, estimated the previous night, was taken into account while guiding.

Faint image features could be brought

out using unsharp masking techniques. There is no suggestion of the expected ring at 12.5 Saturn radii down to the 17th magnitude. (R. Rajamohan & J.C. Bhattacharyya)

Mutual phenomena of Jovian satellites: observations

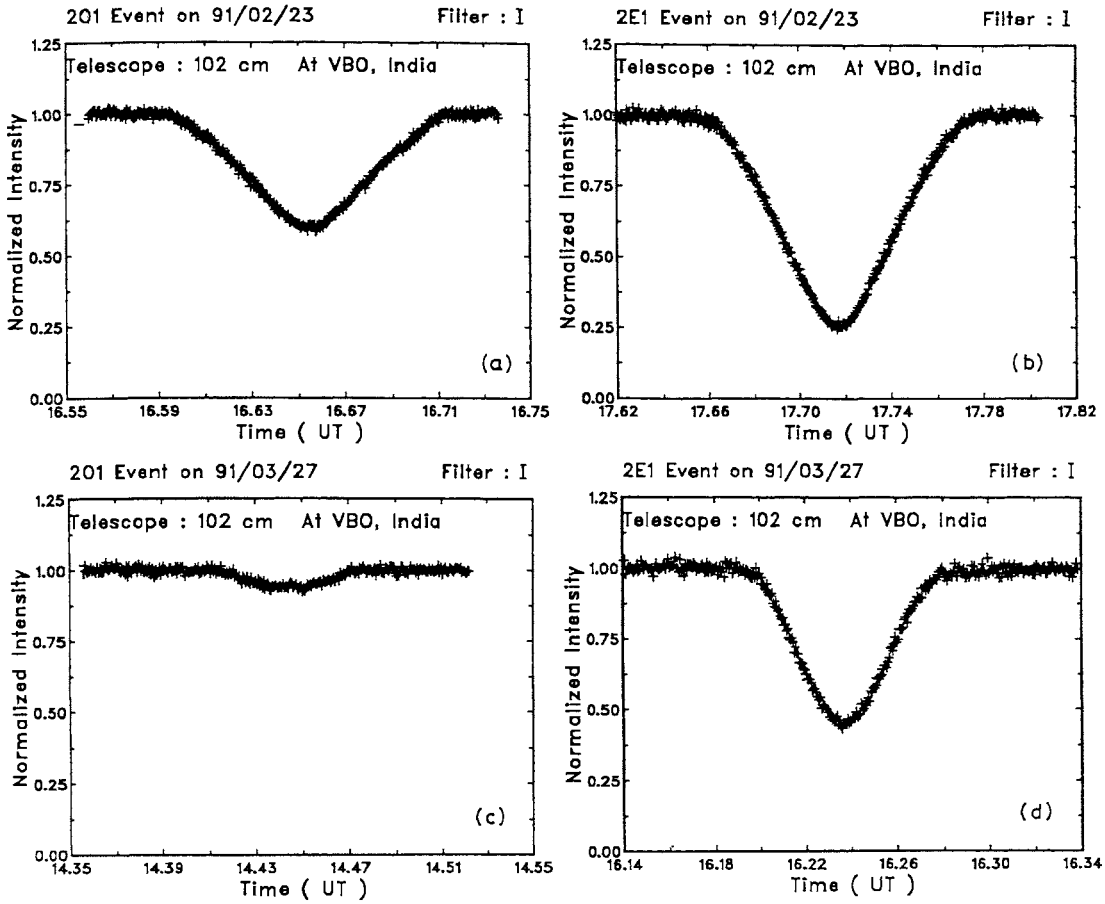
The present mutual eclipse season which commenced at the end of 1990 will continue till middle of 1991. An observational programme to record these events is being carried out at the VBO using the 75 cm, 1 m and 2.34 m telescopes. Most of the predicted events were attempted. Fifteen events were successfully observed.

The recording system consisted of a single channel photometer, a preamplifier and discriminator (PAD) unit and a PC based pulse counting unit running in occultation mode. The 32 kilobyte RAM buffer stores 16 kilo data points. Availability of a large buffer of this size was useful in getting a good time resolution. Integration times of 0.15-0.8 s were selected, depending on the duration of the events. Output from the PAD was taped and integrated for DC recording to facilitate real time monitoring. Standard filters along with suitable neutral density filters were used. The midtimes of the events and drop in magnitude would be determined from the light curves for comparison with theoretical predictions. The data will be fitted with theoretical light curves to derive the impact parameter and to study the scattering laws which determine the light distribution across the surface of the eclipsed or occulted satellite. (R. Vasundhara)

Mutual phenomena of Jovian satellites: theory

Twice during a Jovian year, the equatorial plane of the planet sweeps across the Sun and the inner solar system. During a few months around this time, the Galilean satellites frequently eclipse (occult) each other when any two of them are aligned with the Sun (Earth).

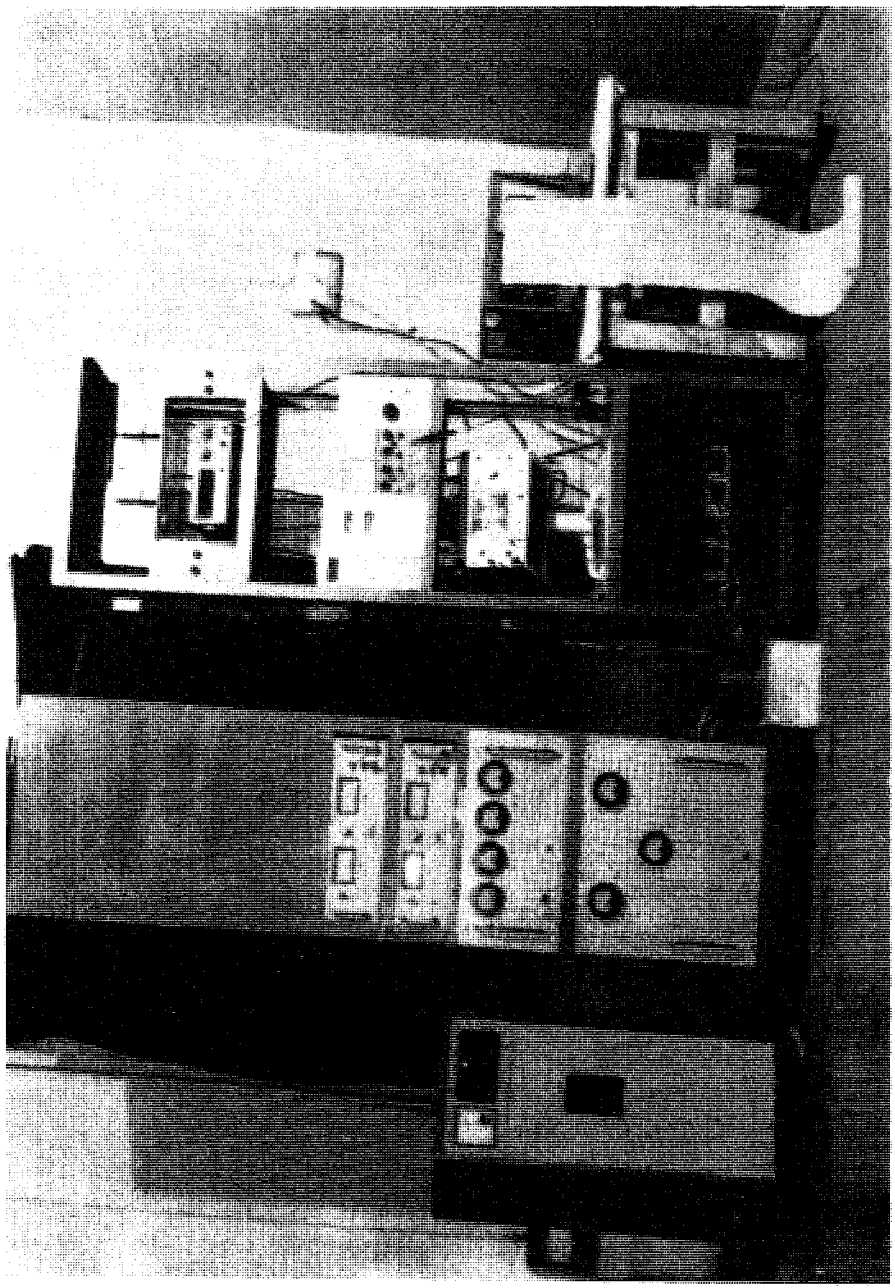
A model to generate the theoretical mutual event light curves for comparison with observations was modified to include the variation in intensity of scattered light over the surface of eclipsed satellite due to finite solar phase angle at the distance of Jupiter. It was first pointed out by Aksnes et al. (1986, Ap.J. **92**, 1436) that due to this phase effect, the time of light minimum does not actually correspond to the time of geometric closest approach of the eclipsed satellite to the shadow centre in case of eclipses and to the time of minimum projected distance between the two satellites in case of occultations. As the observed time is the time of light minimum, the required shift δx of the theoretical light curve was determined as a free parameter during the fitting process. In the absence of other sources like prominent surface features or non-perfect sky conditions which could lead to asymmetric light curves, δx would be a measure of the phase correction (Aksnes et al. 1986) with an accuracy as that of the midtime. The light



Light curves of occultation of Io by Europa (Fig. a and c) on 23 Feb. 1991 and 27 March 1991 respectively. The light variation during the eclipse of Io by Eurropa on the two days are shown in Fig. (b) and (d). The occultation light curves have been normalized to the combined light from both the satellites.

curves of 1E2 event on 24 Sept.,1985 and 3E1 event on 24 Oct., 1985 observed from the VBO and the published light curves of 1E2 on 14 Sept.,1985, 3E1 on 26 Sept.,1985 and 2E1 on 28 Oct.,1985 (Arlot et al.,1989) were fitted with theoretical light curves assuming various limb darkening laws. The best least squares fit was obtained using Lommel-Seeliger's law to describe the scattering over the surface of Io and Europa.

The present study indicates that the fitted impact parameter depends on the choice of the limb darkening law used in generating the theoretical light curve, the difference being around 100 km. The updated theory by J.Lieske is already capable of computing the positions of the satellites to this accuracy. To extract maximum information from mutual event data, it is therefore essential to use an appropriate model to describe the global reflectance characteristics of the eclipsed or occulted satellites. Heliocentric $\Delta\alpha\cos(\delta)$ and $\Delta\delta$ at mid times, derived from fitted impact parameters, were calculated. (R.Vasundhara)



H.F phase path (Doppler frequency) sounder at Kodaikanal observatory. (J.H. Sastri)

Solar Terrestrial Physics

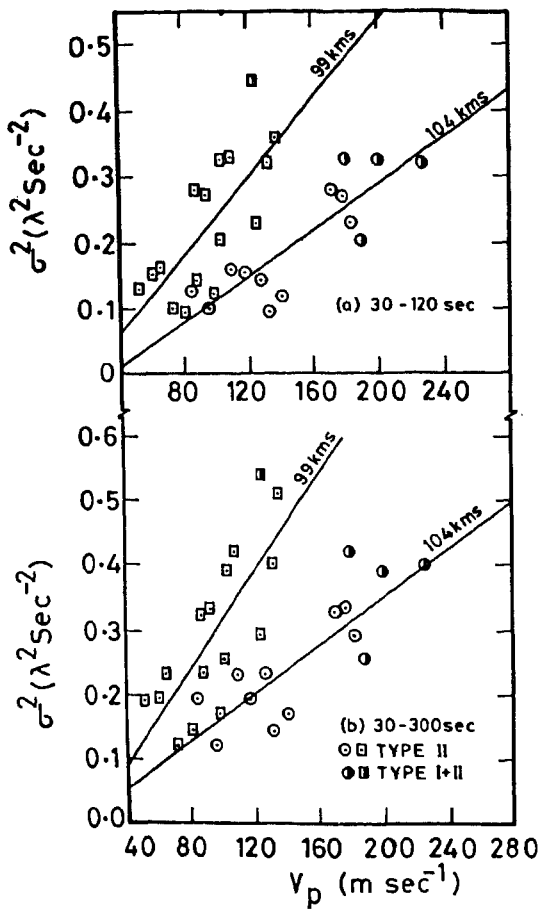
Ionosphere

Dynamics of the ionospheric F-region

Measurements of the phase path, P of the lower F-region reflections at normal incidence at Kodaikanal show the ubiquitious presence of 30-300 s quasi-sinusoidal variations in the time rate of change of the phase path, $\dot{P}$ (or Doppler frequency Δf) during day time. A study was made of the influence of irregularities in the equatorial electrojet (at E region altitudes) on the $\dot{P}$ fluctuations using simultaneous observations of the F-region phase path at Kodaikanal and of the equatorial electrojet with the VHF backscatter radar at Thumba, situated close to the axis of the electrojet in the Indian zone. It was found that the spectral content of the Doppler variations (quantified in terms of the variance, σ^2) bears a significant positive linear relationship to the horizontal phase velocity (V_p) of the 3 m size electrojet irregularities on a hourly basis. This result is in consonance with earlier findings of a significant linear dependence of σ^2 on the electrojet strength, and a practical cessation of the $\dot{P}$ fluctuations at the times of disappearance of Esq on ionograms (signature of a weakening or reversal of the normal electrojet electric field). The present work thus validates the interpretation that the turbulent state of the equatorial electrojet plasma at E region levels is the primary cause of the short-period (30-300 s) Doppler frequency pulsations of lower F-region echoes during daytime at electrojet locations. Because of their sensitivity to ambient electrojet conditions, the high-frequency component of F-region Doppler variations hold the promise of providing indirect information on the regime of the electrojet irregularities and their phase velocities, and hence on the equatorial electric field. Experimental data on the latter is one of the vital inputs needed for quantitative modelling of the low latitude/equatorial F-region (J.H. Sastri, K.B.Ramesh, V.V.Somayajulu* & J.V.S.V. Rao).

Solar wind - magnetosphere - ionosphere coupling

The response of the equatorial ionosphere to the passage at Earth of an interplanetary magnetic cloud during Jan. 13-15, 1967 was evaluated from an analysis of ionosonde and magnetometer data of selected stations in the Indian (75°)and Japanese (135°E) sectors. Magnetic clouds, which are currently considered as interplanetary signatures of solar coronal mas ejections (CMEs), are expected to cause significant perturbations in the near-Earth space environment because they possess a large southward directed IMF over a part of their typical 24 hrs transit time at Earth. The study, thus seeks, to explore a new facet of solar-terrestrial relationships wherein a logical and transparent cause-and-effect sequence prevails.



Dependence of the variance (σ^2) of the short-period (30-120 s, 30-300 s) fluctuations in the time rate of change of phase path, $\dot{P}$ of lower F-region reflections over Kodaikanal, on the horizontal phase velocities (V_p) of electrojet irregularities at 99 Km and 104 Km measured with the VHF coherent backsetter radar at Thumba. The nature of the Doppler power spectrum (type II/type I+II), from which V_P is estimated, is also indicated. The linear relationship between σ^2 and V_p confirms the interpretation that short-period $\dot{P}$ fluctuations are due to phase path changes imposed on lower F-region echoes by the refractive index variations associated with the convective motions of plasma density irregularities (type I & II) in the daytime equatorial electrojet at E region altitudes (J.H. Sastri, K.B. Ramesh, V.V. Somayajulu* & J.V.S.V. Rao).

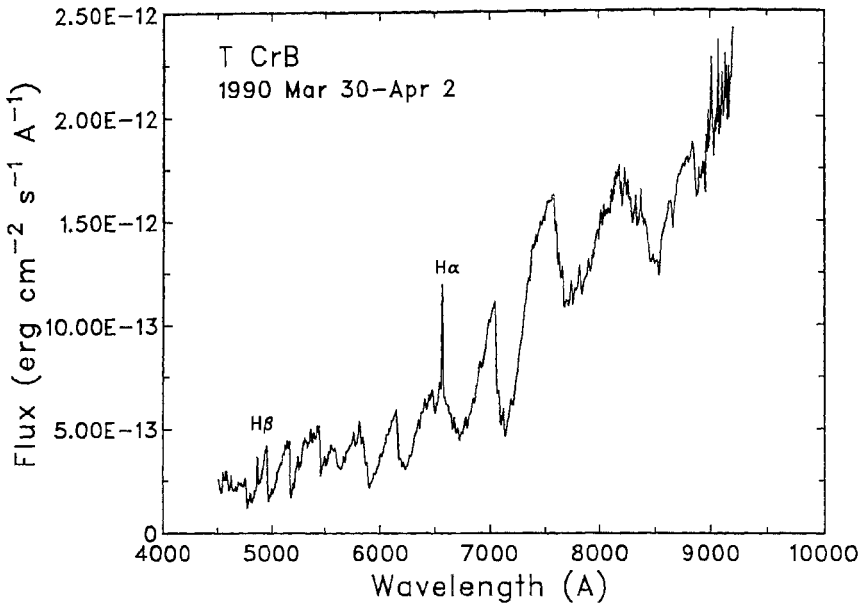
The passage of the cloud did result in a severe geomagnetic storm ($|D_{ST}|_{max}$, 176 nT) with distinct main and recovery phases. During the recovery phase of the storm on Jan. 14, 1967, the equatorial electrojet strength in the Indian sector was found to undergo a marked reduction practically throughout the day (leading to even counter-electrojet conditions at times), followed by a striking absence of the usual post-sunset rise in F-region height near the dip equator. Concurrently, the usual development of the equatorial anomaly in NmF2 (maximum plasma density in F-region) was not only inhibited but the profile also underwent a reversal from the normal at times. This unambiguous behaviour of the two major characteristics of the equatorial ionosphere indicates the setting up of a prominent and persistent electric field disturbance in the Indian sector with a delay of about 8 hr from the start of the geomagnetic storm induced by the cloud transit. The storm-time profiles of DNmF2 (deviations from quiet day averages) showed depressions or 'negative' effects in NmF2 at high latitudes and enhancements or 'positive' effects at mid-latitudes, while those of DhmF2 (height of maximum plasma density) revealed signatures of equatorward thermospheric winds both at high and midlatitudes on 14 Jan. In addition, a clear-cut anti-phase relationship between DNmF2 and DhmF2 was evident around the crest location of the equatorial anomaly in the Indian sector on 14 Jan., when the anomaly development was markedly affected.

Perturbations in the global thermospheric circulation set-up by storm-time energy inputs at high-latitudes is considered as primarily responsible for the delayed and long-lived electric field disturbance at equatorial latitudes through the 'distrubance dynamo' mechanism. Equatorward neutral winds which characterise such a perturbed circulation pattern are the cause of the 'negative' effects in NmF2 at high latitudes and 'positive' effects at mid latitudes. The confinement of the 'negative' effects in NmF2 to high latitudes reflects the restricted latitudinal spread of the distrubance in the neutral atmospheric composition (with enhanced N_2/O and O_2/O ratios, i.e., 'molecule enriched' air) in the winter hemisphere under storm-time conditions. The inhibition/reversal of the equatorial anomaly in association with the persistent electric field disturbance is due to the combined action of equatorward neutral winds and the reduced efficiency of the 'fountain' mechanism.

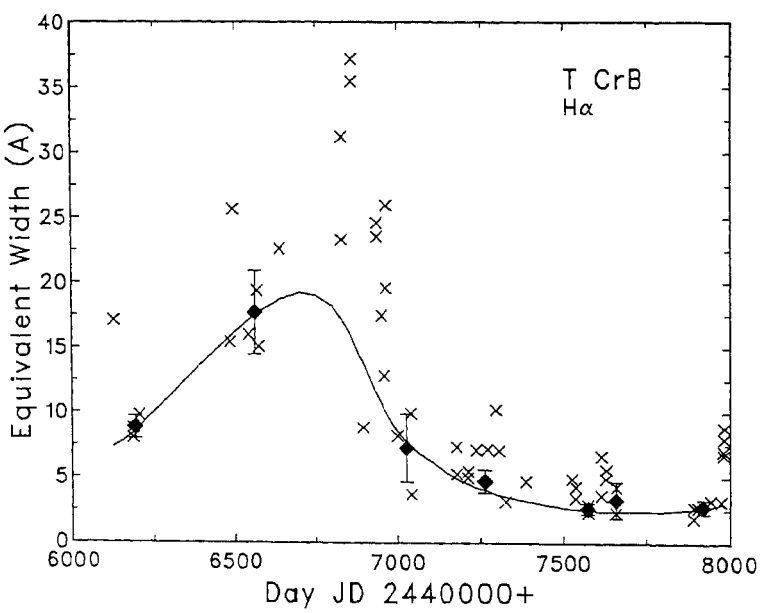
The observed response pattern of the sub-auroral ionosphere to the magnetic cloud passage and the attendant geomagnetic storm indicates a strong coupling of terrestrial ionospheric and interplanetary variabilities through magnetosphere-high latitude ionosphere interactions. The study also strengthens the view of the relevance and a major role of neutral atmospheric disturbances in the storm-time behaviour of the equatorial ionosphere, atleast for severe storms (J.H. Sastri & H.N. Ranganatha Rao)

Geomagnetic phenomena

In a recent paper Nakagawa and Nishida (1989) suggested that wavy motions of the neutral sheet can be generated by the Kelvin-Helmholtz instability if the dawn-dusk flow of only several tens of km s^{-1} is present. However, their mathematical analysis is based on the choice of particular magnetic field directions in the three regions consisting of north, south lobes and the neutral sheet. In an earlier paper, Uberoi (1986) discussed the Kelvin-Helmholtz instability of a similar structured plasma layer without any assumptions either on velocity field directions or on the magnetic field directions, thus pointing out the angle effect due to variation in magnetic field directions on the instability criterion. The relevance of these results to the problem of wavy motions of the neutral sheet were pointed out. In particular it was found that when the *y*-component of the magnetic field in each lobe is taken into consideration, the Kelvin-Helmboltz instability can be excited only when the dawn-dusk flow is of several hundreds of km s^{-1} a order of ten higher than that arrived in the analysis by Nakagawa and Nishida (1989). (C.Uberoi)



The spectrum of T Coronae Borealis obtained with the UAG Spectrograph and Photometrics CCD system at the Cassegrain focus of the 1 m telescope. (G.C. Anupama & T.P Prabhu)



The variation of equivalent width of Hα emission line in T Coronae Borealis during 1985 – 1990. The smooth line joins the mean minimum equivalent width (♦) in each orbital cycle. Superposed on this is the enhancement at orbital phases 0 and 0.5. (G.C Anupama & T.P. Prabhu)

Stellar Physics

Novae

Classical novae

The VBO spectra of Nova Scuti 1989, and also the ESO spectra made available by H.W.Duerbeck were analysed to study the spectral evolution of the nova in correlation with the outburst light curve. The spectra cover the diffuse enhanced and [O I] flash phases of the nova. Based on the observed emission line fluxes, the reddening and the distance to the nova and physical conditions in the envelope such as density and temperature were estimated. Spectra observed during oscillations in the light curve show that the variations are mostly in the continuum, and hence imply a change in photospheric radius.

CCD images of the shell of nova GK Persei, obtained in the lines of [N II] and [O III], were used to determine the expansion of the shell by comparison with data available in the literature. The shell is asymmetric, with the bulk of the emission arising in the southwest quadrant in the [N II] image. A difference in the distribution of [O III] and [N II] emission is present, indicating chemical inhomogeneites. The spectrum at quiescence was decomposed into spectra of K0-21V secondary and the hot accretion disc. The mass transfer rate was estimated to be $\sim 10^{-10}$ $M_\odot$ yr^{-1}. The He/H abundance in the accretion disc was estimated to be less than 0.24. Spectroscopic observations were continued during the current observing season using the 1 m and the 2.34 m (VBT) telescopes at the VBO (G.C.Anupama & T.P.Prabhu)

Recurrent novae

Spectra of RS Oph obtained during quiescence indicated that the secondary is a M1 giant. The quiescence spectrum was decomposed into the spectra of the cool secondary and the hot accretion disc. A mass transfer rate of $\sim 10^{-6}$ $M_\odot$ yr^{-1} was estimated. Spectra of the recurrent nova T CrB obtained during its quiescence phase (1985-1990) showed that the secondary is a M4 giant. The emission lines in the spectra were found to be variable in strength. The Hα flux showed a long term variation. Superposed over this was an orbital phase dependent variation with maxima around phases 0.0 and 0.5. The estimated mass transfer rate is $\sim 10^{-7}$ $M_\odot$ yr^{-1}

Based on the images of T Pyxidis in [N II] and [O III], obtained at ESO and made available by H.W. Duerbeck, a slow expansion at a rate of 0.2 arc sec yr^{-1} was detected in shells ejected during the 1920 and 1944 outbursts. The spectrum at quiescence, recorded from VBO using the 1 m reflector, is dominated by the accretion disc, and has a high degree of excitation. The mass transfer rate and helium abundance were estimated as $\sim 10^{-8}$ $M_\odot$ yr^{-1} and ≤ 0.24 respectively.

Spectroscopic observations of all the above mentioned recurrent novae were continued during the current observing season using the 1 m and the 2.34 m telescopes at the VBO. (G.C.Anupama & T.P.Prabhu)

Spectra of the recurrent nova V 3890 Sgr were recorded during its 1990 outburst using the 1 m reflector. The spectrum is dominated by broad emission lines due to hydrogen, helium and high excitation coronal lines. The spectrum resembles that of RS Oph during its coronal-line phase. (G.C.Anupama)

Be stars

Be stars are known to display spectra of B, Be and Be-shell phases and the cause of such peculiar behaviour is one of the major unsolved problem in this field. From the high resolution and high signal-to-noise ratio spectra of 17 Be stars, which were monitored for the last three years, it was found that certain Be stars (27 CMa, 48 Lib, etc.,) show inverse P-Cygni profiles in H_β and higher order Balmer lines and typical Be profiles in $H\alpha$. These results indicate that when the inner part of the envelope contracts the outer envelope expands. Probably the contraction of the inner part of the envelope will cause an instability on the surface of the star, which will lead to a shell phase of the star via a strong outburst. Analysis of the data is in progress. (K.K.Ghosh, G. Selvakumar & M.J. Rosario)

Gamma Cassiopeia

γ Cas is a well known Be X-ray binary, where the X-ray source shows transient pulsations of 6000 s. To study the nonradial pulsations of this binary system, γ Cas was observed on 12 nights using the echelle spectrograph at the coudé focus of the 1 m reflector at VBO. Surprisingly it was found that the Si II lines (6347 Å and 6371 Å) changed from emission to absorption on time scales of around 100 min. But no significant changes were noticed in H_β, $H\alpha$ and He I (5876 Å) lines on the time scales of 1 or 2 hr. This type of variation has not been observed so far in X-ray binary systems. (K.K. Ghosh)

Supergiants

The long period cepheid RZ Vel

The long period classical cepheid RZ Vel (HD 73502) with a period of 20.4 days is known to be a member of an association in Vela and a high metallicity is ascribed to it from photometric work. An abundance analysis was made using high resolution CCD spectra. On the whole, the elemental abundances of RZ Vel are very similar to other classical cepheids of the solar neighbourhood. (S.Giridhar, A.A.Ferro* & A.Goswami)

Hα in late type supergiant chromospheres

CCD spectra in the region of the Hα line obtained for 25 G and K supergiants clearly show that the Ha line is highly asymmetric, indicating mass outflows. The equivalent widths are in the range 1.3 - 1.8 Å and the full widths at half maximum lie in the range 75-100 km s^{-1} The blue shifts on an average correspond to about 10 km s^{-1}. Fresh calculations of radiative transfer in Hα were carried out in a spherically symmetric atmosphere, with outward-positive velocity and temperature gradients. A three level atom model with continuum was assumed and the statistical equilibrium equations for the levels were explicitly incorporated into the transfer calculations. The Hα line profiles were computed for a wide range of parameters in order to reproduce the observed features of the line. In particular, the role of various dynamical processes was demonstrated in conjunction with opacity in determining the Hα line widths. Reasonbly good theoretical fits with observed profiles yield Hα optical depths in the range 10-50, number densities in the range $2x10^8$ - 10^9 cm^{-3} and linear velocity gradients of some 20 km s^{-1}. Within this framework of the model, the calculations reinforce the idea that the non-thermal velocities have to be as large as 20-25 km s^{-1} to explain the large widths of the observed profiles. The rates of mass outflow were calculated to lie in the range 10^{-8} - 10^{-9} $M_\odot$ yr^{-1}. (S.G.V.Mallik)

High resolution CCD echelle spectra of several late type stars were observed in the region of NaI (5890 Å & 5896 Å), KI (7664 Å & 7699 Å) and Ca II (8498 Å, 8542 Å & 8660 Å) lines. Analysis of the spectra is in progress. (S.G.V.Mallik)

Strength of OI triplet at 7774Å

The strengths of OI triplet lines at 7771-7775 Å was measured for a select group of F-G stars showing semi-regular light variations using high resolution CCD spectra. Earlier M_V-W_λ (OI) - $(b-y)_o$ relation was calibrated using F-G supergiants belonging to open clusters and associations. This relation was applied to derive absolute magnitudes of certain UU Her stars and pseudo Cepheids. It was found that the absolute magnitudes derived from the above-mentioned relation are in good agreement with those derived using other means. (S. Giridhar, A.Goswami & A.A.Ferro*)

Modelling of cool star atmospheres

Modelling of the atmospheres of cool stars (M-supergiants) is in progress. The scope of this research was to obtain the physical parameters like gas pressure, electron pressure, density and temperature as a function of optical depth in the atmospheres of these stars and to calculate synthetic spectra. The curvature and extent of the atmospheres was taken into account. It is intended to deviate from the conventional assumption of LTE, because the densities are extremely low in the outer layers of giants or supergiants, which make

the collision rates very low, and the radiation field nonlocal. Currently, computations of absorption and scattering coefficients are being carried out. A knowledge of these parameters is indispensable because their values are required to solve the equation of hydrostatic equilibrium. Both, atomic and molecular species are being considered. Programmes were developed for computing gravity, election pressure, dissociation equilibria and radiation pressure gradient. (P. Singh & A. Peraiah)

Post AGB stars

High resolution spectra of a few post AGB stars were obtained with the ESO coude auxiliary telescope to derive metal and CNO abundances. Spectra of the post AGB star HD 56126 (F5I) were analysed. HD 56126 (F5I) is an IRAS source with detached cold dust shell with dust shell characteristics similar to the dust shells around planetary nebulae. From an analysis of high resolution high signal to noise ratio spectra using model atmospheres metal and CNO abundance have been determined. It is found that in HD 56126 [C/H] $\simeq$ −0.01, [N/H] $\simeq$+0.17, [O/H]= 0.02, [S/H] $\simeq$+0.01 and [Fe/H] $\leq$ −1.0. The C/N/O abundance ratios suggest that HD 56126 and related post AGB stars are evolved. From the high resolution spectra we derive the radial velocity HD 56126 to be +105.0±1.0 km s^{-1} which suggest that HD 56126 is a high velocity star belonging to the old disk. The abundance ratios [C/Fe], [N/Fe], [O/Fe] and [S/Fe] in HD 56126 and related post AGB stars are large and cannot be easily explained by nucleosynthesis and or mixing. The large ratios of [C/Fe], [N/Fe], [O/Fe] and [S/Fe] is due to the depletion of Fe but not of C, N, O, and S elements. The depletion of refractory elements and the lack of depletions in CNO and S in the atmosphere these post AGB stars is similar to that observed in the interstellar medium. Since most of the stars have circumstellar dust shell the depleted refractory elements appear to be locked up in dust grains. The results suggest that in the recent past the outer atmospheres of these stars expanded and cooled to the limit of the condensation temperature of refractory elements. Formation of cores of dust grains very close to the stars and the resulting dust driven mass loss may be able to explain the observed abundances peculiarites in these post AGB stars. (M. Parthasarathy, Pedro Garcia* & S.R. Pottasch*)

IUE (Ultraviolet) spectra of post AGB stars

IUE low resolution (6Å) ultraviolet (1250 Å to 3300 Å) spectra of post AGB stars Hen 401, Hen 1013, Hen 1428, HD 149427 (PC 11), Hen 1357 (SAO 244567) and Hen 475 were analysed. The most significant results are that the UV spectrum of Hen 1357 shows violet shifted strong P-Cygni type stellar wind profiles of CIV 1548.2 Å and 1550.8 Å resonance doublet and the NV resonance doublet at 1238.8 Å and 1242.8 Å. The violet shifts of

the violet edge of the stellar wind profiles of NV and CIV yield a terminal velocity of – 3000 km s^{-1}. The presence of a stellar wind clearly suggests that Hen 1357 is losing mass. The UV continuum energy distribution suggests that the spectral type is around B0. The 1990 Å to 3200 Å spectrum of Hen 1357 shows emission lines due to [C II] and [O II], which is a charateristic of very low excitation planetary nebulae. The far infrared IRAS flux distribution and colours suggests that the characterstics of the dust envelopes around Hen 1357 are similar to the dust envelope around planetary nebuale. Hen 1357 is most likely a very young compact planetary nebula.

Another significant result was the detection of a variation in the strengths of [O III] 1665.5 Å and [N IV] 1750 Å lines in the IUE ultraviolet spectra of HD149427 (PC11). The observed variation in the absolute fluxes of the above-mentioned emission lines suggests a change in the ionisation conditions in the envelope around HD 149427, or indicates that HD 149427 may be a planetary nebula in which the central star is a close binary. (M. Parthasarathy, S.R. Pottasch* J. Clavel*)

Polarisation observations of post AGB stars

Polarization observations in different wavelengths bands is also an important technique to study post AGB stars, as most of these objects have cold circumstellar dust shells, (Parthasarathy and Pottasch Astr. Astrophys. **154,** L16 1986; **192**, 182, 1989; **225**, 521, 1989) Polarization measurements in BVRI were made for 30 post AGB stars. Significant polarization in BVRI was detected from several of these stars. Analysis of the data is in progress. (M. Parthasarathy & S.K. Jain)

R CrB stars

High resolution CTIO echelle spectra of 10 R CrB stars with weak C_2 were obtained in July 1989. Preliminary abundance estimates of certain elements were made using the equivalent widths measurements of selected lines and Schönberner's model atmospheres for hydrogen deficient stars. The interesting outcome of this investigation was that four R CrB variables NSV 6708, UX Ant, V 3795 and VZ Sgr are metal poor and are highly enriched in the light s-process elements Y and Zr but are less enriched in the heavy s-process elements like Ba, La and Nd. These stars appear to be warm analogues of the remarkably cool R CrB star U Aqr. (S.Giridhar, A.Goswami, N.Kameswara Rao & D.L.Lambert*)

With a view to estimate the amount of cool gas and the mass loss rates, which might give clues to the evolutionary history of these objects, R CrB stars showing large infrared excesses were searched for CO (1-0) emission with the 15 m SEST from La Silla. V 605 Aql (A58), V 348 Sgr, UM Cen, DY Cen were observed. Only V 605 Aql

shows a signal at 2.6 σ level. Limits on the amount of cool gas present was worked out. (N.K.Rao, L.Houziaux*, L.A.Nyman*, K.Nandy*)

Intermediate resolution spectroscopic observations with the 2.3 m VBT using a B & C spectrograph were obtained for some R CrB stars, to study the variations in their chromospheric properties as well as their pulsations.

In order to examine the relationship with R CrB stars and their nebula properties, a few WC 11 stars were observed with the VBT. Several spectra of M4-18 were obtained to study the elemental abundances in the nebula surrounding this object. (N.K.Rao, R.Surendiranath & A.V. Raveendran)

Polarimetric observations of hydrogen deficient stars and WC 11 stars were obtained using the PRL polarimeter at the Cassegrain focus of the VBT along with a few carbon rich RV Tauri stars. (N.K.Rao, A.V. Raveendran)

Carbon stars

BVRI polarimetry

Multiband polarimetric observations of carbon stars belonging to different variability types - VX And, UV Aur, T Cae, Y CVn, U Hya, Y Hya, RY Mon, W Ori, Y Per, RT Pup and X Vel - were obtained with the 1 m telescope during the period 1984-87. An analysis shows that, in general, in carbon stars the polarization increases towards blue. Out of the 11 objects observed, the polarization was found to increase systematically towards red only in the semi-regular variable RT Pup. Though there is significant scatter, carbon stars, on an average, show a flatter wavelength dependence than the oxygen-rich objects. The rather weak wavelength dependence of polarization indicates that circumstellar grain scattering is the main mechanism responsible for the continuum polarization in carbon stars. The close resemblance in the normalized wavelength dependences, seen in the majority of the objects, indicates that the dust particles involved are of similar nature. (A.V. Raveendran)

Polarization models of circumstellar dust scattering

Many late-type variables exhibit polarization which often varies quasi-periodically. The two main mechanisms usually invoked to explain the intrinsic polarization in late-type stars are: Rayleigh scattering by molecules or atoms in an asymmetric photosphere, and scattering by molecules or dust grains in an extended asymmetric circumstellar envelope.

The polarization produced by dust grain scattering in circumstellar envelope was investigated using numerical modelling. It was assumed that firstly, the light emitted by the star is unpolarized, secondly, the grains are spherically symmetric, and

thirdly, the single scattering approximation holds good.

The computations indicates that: (i) dirty silicates provide a better approximation to the scattering dust grains than pure silicates in accounting for the polarimetric behaviour of oxygen-rich objects, (ii) the polarimetric behaviour of carbon stars is inconsistent with scattering by graphite grains, (iii) the radial pulsation of the star does not significantly change the net polarization produced by an envelope, (iv) the envelope geometry has very little effect on the normalized wavelength dependence, and (v) if the illuminating star has a non-uniform surface brightness distribution, circumstellar grain scattering produces not only significant changes in the normalized wavelength dependence of polarization, but also polarization changes across spectral features.(A.V.Raveendran)

Binary stars

The study of BD-1° 1004 (HR 1952), a highly eccentric early type double lines binary, was completed. New radial velocities obtained with the 1 m telescope were combined with archival material to determine orbital elements. An attempt was made to correct for line 'dragging' by the secondary spectrum. It was found that an earlier suggestion of apsidal regression is still possible. (N. Kameswara Rao, B. N. Ashoka*, C. Lloyd*, C.D. Pik* & D. J. Stickland*)

Speckle interferometric observations of binaries

In order to decode the diffraction limited information from short-exposure astrophotographs (which essentially freeze the motion of the turbulant atmosphere), several frames were obtained containing speckles of 17 binaries (separation < 1 arc sec) and of reference stars at the Cassegrain focus of the VBT. The camera, comprising a Barlow lens, a filter in the Hα region (FWHM 50 Å) and an intensified CCD was used to record these speckles. The detector was able to record speckles of stars of magnitude 6.7. Reference stars were chosen within 1 degree of the object. Specklograms of these reference stars were obtained by shifting alternately between the programme star and the reference star, during the observing run to equalise seeing distributions. A few reference stars were observed close to the programme stars (within isoplanetic patch 4 arc sec), to which the speckle holographic technique was applied. Development of an auto-correlation programme is underway to analyse the data. (S.K.Saha)

Be X-ray binaries

One of the challenging problems regarding X-ray binaries is to know the masses of the compact companions. An observationally derived parameter, the optical mass function, can be obtained from the orbital period and companion's projected orbital velocity. This parameter is a function of the masses of both components

and the inclination. From successive X-ray flares of the Be X-ray binary system one can compute the orbital period. But the detection of successive X-ray flares is difficult by X-ray satellites.

On the other hand, Ghosh, Apparao & Tarafdar showed that the detection of C II (6578 Å & 6583 Å) emission lines along with the enhancement of other emission lines (Hβ, Hα, He I and Fe II) can be used as a good indicator of X-ray flares in Be X-ray binary systems. From the regular monitoring programme (optical spectroscopy) of nine suspected Be X-ray binaries, recently two such flares were detected in 1H1249-637 and 1H0556+286 systems. (K.K. Ghosh)

T Tauri stars

Strömgren uvby and Cousins UBVRI photometry of the isolated T Tauri star V 4046 Sgr done during May and June 1988, August 1989 and July 1990 was analysed. It was found that the light variation of V 4046 Sgr has a periodicity of 2.44 days and the amplitude changes from season to season. A group of weak to moderate emission T Tauri stars was also monitored spectroscopically in the wavelength region of Hα to study surface activity. Analysis of the data is in progress.

Polarisation measurements of a few T Tauri stars were carried out. High linear polarisation was observed in P1394 and TW Hya. It was also observed that the time scale of polarisation variability in TW Hya is comparable to its rotation period. (M.V. Mekkaden)

Stellar rotation

Zero rotation main sequence

The calibration of colour and line indices taking the effects of rotation into account was completed. The zero rotation main sequence calibration was determined from an analysis of Hyades, Praesepe, Alpha Persei, Scorpio-Centaurus and Pleiades clusters. From the combined results, the zero age zero rotation main sequence was determined following a conventional cluster fitting procedure. (R.Rajamohan & A. Mathew)

Blue stragglers

The blue stragglers phenomenon in galactic clusters has had no convincing explanation so far. An analysis of these objects especially in relation to the effects of rotation in the colour-colour and colour-magnitude diagrams was taken up. Results for blue stragglers in the spectral type domain of A-stars indicates that their observed position in the H-R diagram can be completely accounted for in terms of the overall rotation effects on all member stars. (R.Rajamohan, A.Mathew & J.Pinto)

Star clusters

Cygnus OB2 association

From a study of IRAS observations in the region of Cyg OB2 association, 152 far infrared sources were detected. Of the 152 sources, 97 have fluxes in two or more IRAS bands. Of these 97 sources, 69 have positive spectral indices and steeply increasing flux towards longer wavelengths similar to that of young stellar objects (YSOs) embedded in thick dust shells. In addition, there are 23 sources that have IRAS flux in one long wavelength band and a low flux limit in a shorter wavelength band, which yields a positive spectral index. Sources with positive spectral indices (YSOs) appear to have no optical counterparts. The dust temperatures and far infrared luminosities were derived for all the 97 sources. Most of the sources with positive spectral indices and flux distributions similar to YSOs, have very cold (~40 K) dust shells. The far infrared luminosities range from a few 100 $L_\odot$ to a few times 10^3 or 10^4 $L_\odot$, which are expected luminosities of low mass (~1$M_\odot$) and massive premainsequence stars respectively. Some of the very luminous (~10^4 $L_\odot$) sources have massive cold dust shells and are likely to be younger than ultra compact H II regions. The luminosity function for the IRAS sources in the Cyg OB2 suggests that most of the sources with positive spectral indices similar to YSOs are most likely members of the Cyg OB2 association, and the extent of this association is of the order of 2° in diameter. These results suggest that star formation is still taking place in the Cyg OB2 association. (M. Parthasarathy, S. K. Jain & H. C. Bhatt)

Near-infrared photometry of young open star clusters

Young open star clusters (age<10^8 yr) are believed to have their birth places within gravitationally bound interstellar molecular clouds. It is believed that they are still embedded in dust and gas clouds. With time (~10^7 - 10^8 yr) this dust and gas is either used in star formation or blown away by radiation pressure of hot stars present in such systems. Consequently, in young open star clusters non-uniform extinction are generally present across the cluster region. To understand the possible cause of non-uniform extinction as well as to study the law of interstellar extinction in the direction of the clusters, JHK photometry of several stars in the region of NGC 654 and IC 1805 was made. Patchy distribution of interstellar matter seems to be responsible for the non-uniform extinction across the cluster faces. Near infrared and optical observations of these clusters indicate a normal interstellar extinction law in the direction of IC 1805 and an anomalous distribution of interstellar grains causing more extinction in U and B passbands compared to that obtained from the colour excesses E(V-J), E(V-H) and E(V-K) using a normal reddening law for the cluster NGC 654. (R.Sagar & Z.Y.Qian*)

Stability and structure of young open star clusters

Studies related to the stability and structure of galactic open clusters help in understanding the star formation processes in our galaxy. It was found that the differential extinction ΔE (B-V) in open clusters, which may be due to the presence of gas and dust, decreases systematically with the age of the cluster. Consequently one can infer that the average gas removal time must be about 10^8 yr. It was found that bound star clusters are formed in low-mass clouds ($M \leq 10^4 M_\odot$) while the unbound OB associations are formed in clouds having higher masses ($M > 10^5 M_\odot$) The present work also supports the existence of a corona around open clusters and the conclusion is that the coronal regions in open clusters are dynamically stable in the tidal forces of the galaxy. (A.K.Pandey*, H.S.Mahra* & R. Sagar)

OCl 493 (Czernix 25)

The age and distance of the faint cluster OCl 493 (Czernik 25) were determined. The interstellar extinction E(B-V) was found to be 0.58. The distance to the cluster is 5.6 kpc. The cluster stars show a range in their ages from 1.2×10^7 to 5.0×10^7 yr. This young cluster is located in the outer Perseus spiral feature of the Milky Way. (G.S.D. Babu)

CCD photometry of the distant southern globular cluster NGC 5824.

CCD observations of NGC 5824 were obtained for a sample of 285 stars reaching down to V = 20.5 mag. A well-defined blue horizontal branch was observed for the first time in the V, (B-V) CMD of NGC 5824. From the location of the horizontal branch in the CMD, the apparent distance modulus (V-M) was determined to be 18.0±0.2 mag. This yields a galactocentric distance of 25 kpc which, combined with recent radial velocity determination, enables the representative point of the cluster to be plotted in Lynden-Bell's velocity - distance diagram. Its location is consistent with a conventional value of the mass of our galaxy. (R.D. Cannon*, R.Sagar & M.R.S. Hawkins*)

Globular clusters

Further CCD observations of the faint globular cluster NGC 6401 were obtained in UBVRI with the 1-m and 2.34 m telescopes. Analysis of the data is in progress. (G.S.D.Babu & B. Adur*)

Distribution of stars, perpendicular to the plane of the galaxy

Rigorous analytical solutions were found for the Boltzmann-Poisson equation concerning the distribution of stars above the galactic plane. The number density of stars was considered to follow a behaviour $n(m,\theta) \sim \theta\,(m\text{-}m_0)\, m^{-x}$, where m is the mass of the star and $x>2$ is an arbitrary exponent. The velocity dispersion of the stars was assumed to have the form $\langle v^2(m)\rangle m^{-\theta}$, where the exponent θ is positive. It was shown that analytic expression could be found for

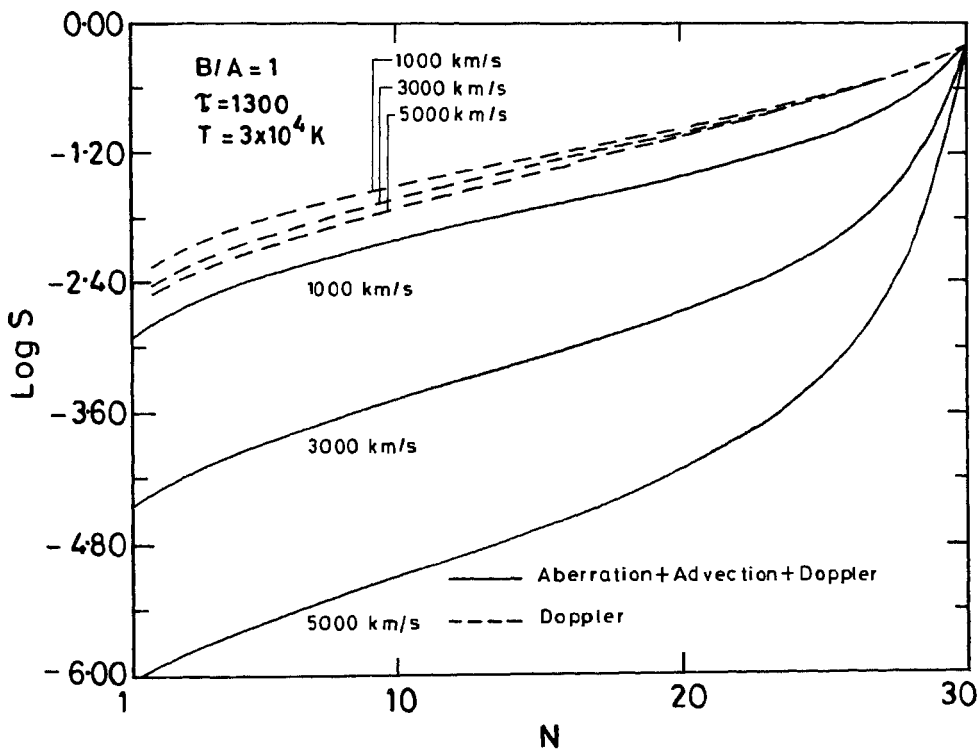
the gravitational field. The behaviour of the dispersion of the distance from the galactic disk for the stars of various masses was investigated. (S.Chatterjee)

Radiative transfer

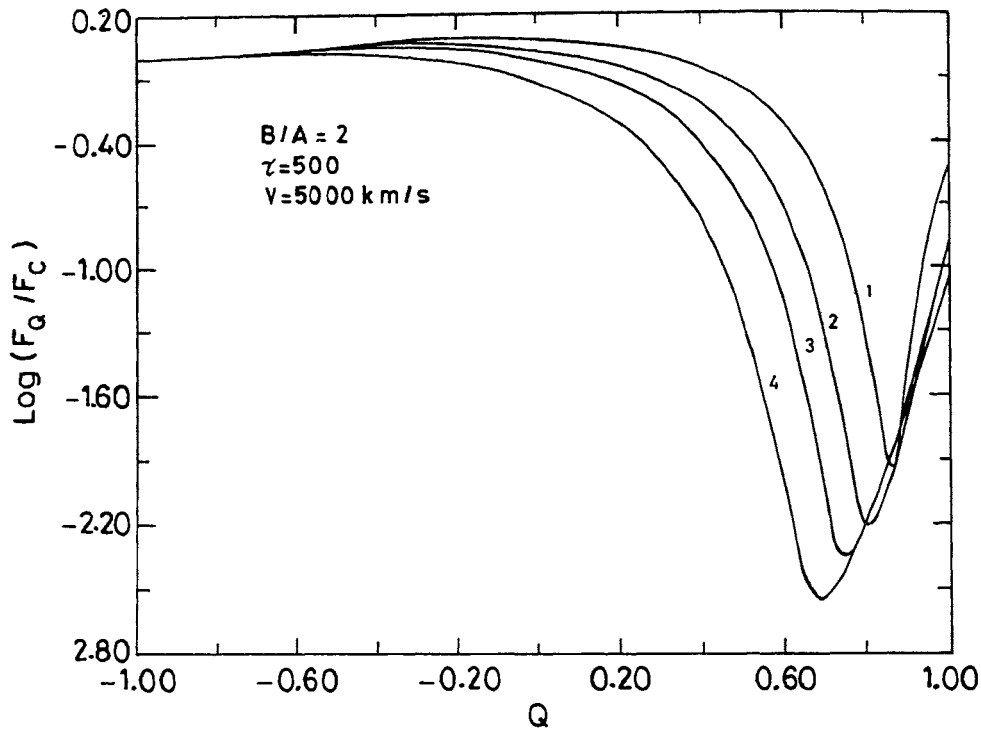
Aberration and advection on line formation

When aberration and advection are not considered in line transfer, the Doppler radial velocity gradients become operative in plane parallel geometry, while two more additional effects due to transverse velocity gradients and curvature become important in a spherically symmetrical medium. The effects due to these phenomena together with aberration and advection on the line source function with appropriate boundary conditions for a purely scattering medium were calculated.

Aberration and advection terms were introduced in the transfer equation in plane parallel approximation. The terms of aberration and advection together introduce more effects than those produced by the radial velocity gradient terms. In plane parallel layers, the interaction of the Doppler shifted radiation with that of the contin-



Log S is plotted against the shell numbers in plane parallel geometry. The broken curves represent the variation of the source function for Doppler velocity gradients and the continuous curves represent those which include Doppler gradients, aberration, and advection effects. (A.Peraiah)



Line profiles corresponding to the source function. The numbers on the curves correspond to the temperatures (1) 10^4 K (76 mtu), (2) 3 x 10^4 K (44 mtu), (3) (see text) 5 x 10^4 K (34 mtu) (4) 10^5 K (24 mtu) (A.Peraiah)

uum radiation is very effective in changing the line source function. The velocity field produces a Doppler shift and aberration of photons and gives rise to advection which describe "sweeping up" of radiation by the moving fluid. It is the combination of these effects that reduces the source function considerably.

Calculations were carried out in spherical geometry for several cases. Spherical symmetry introduces effects due to curvature and transverse velocity gradients which tend to reduce the line source function further. In addition, new terms, due to aberration and advection were introduced in the transfer equation. The combined effects of sphericity, Doppler velocity gradients, and aberration and advection again reduce the source function considerably. At the surface, the probability of escape increases in the spherical case and dominates the interception of continuum radiation by the Doppler shifted line. The velocity increases outwards and due to the effect of advection, the radiation is swept off by the moving matter. This further increases the probability of escape of photons. In the absence of any source to replenish the photons (no internal sources are given, as

one is dealing only with the scattering media) the source function is reduced considerably. Therefore, for a large velocity of V=5000 km s^{-1} and optical depth τ =1300 and B/A = 10, (where B and A are the outer and inner radii of the spherical shell) the source function is reduced dramatically as a result of the combination of the afore mentioned effects.

It was shown that the importance of the terms containing the velocity gradients is dependent on the temperature of the medium. As the gas velocity appears in the transfer equation in units of the mean thermal velocity, the velocity gradient terms will not dominate the effects in a sufficiently high temperature gas and the terms containing the aberration and advection will be more dominant in changing the radiation field in such a medium. To show that this is the case, isothermal media were selected with temperatures of 10^4 K, $3x10^4$ K, $5x10^4$ K and 10^5 K. At a higher temperature T (say around 10^5K) the aberration and advection terms are more important, than those with transverse velocity gradients.

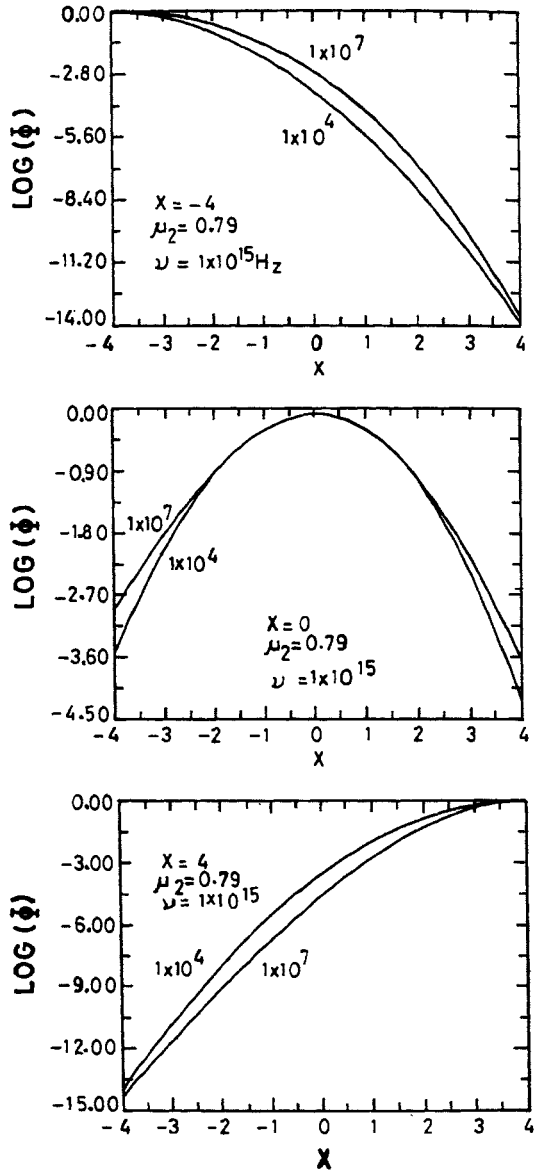
Velocities of expansion corresponding to V = 1000 km s^{-1} and 5000 km s^{-1} were considered and the corresponding integrated profiles were obtained. There are changes due to the bulk motion because the advection and aberration terms are unaffected by the temperature changes. As the temperature was increased, the value of the mtu (mean thermal units) increases and the number of mtu's for a given velocity reduces. From the table it is clear that for a hydrogen atmosphere the mtu's change from 76 to 24 when the temperature changes from 10^4 K to 10^5 K. Therefore, at a small number of mtu's the aberration and advection appears to be more effective. It was noticed that any further increase in temperature will not change the source functions considerably. Therefore, it appears that aberration and advection phenomena dominate even the strong effect of the Doppler velocity gradients. In spherical geometry when advection exists, the skewing of radiation is more effective. The curvature term is modified by the extra terms which contains the advection factors. The curvature changes the advection effects. Therefore, it is the combination of aberration, advection and curvature that dominate the well known strong effect of the Doppler velocity gradients in the treatment of line transfer (A.Peraiah)

Velocities measured in units of mean thermal velocities (A. Peraiah)

T (K)	Doppler velocity (km s^{-1})	Gas velocity (γ=0.003) (10^3 km s^{-1}) in mtu	Gas velocity (γ=0.17) ($5x10^3$ km s^{-1}) in mtu
10^4	13.13	76	381
$3x10^4$	22.17	44	220
$5x10^4$	29.36	34	170
10^5	41.5	24	120

Compton scattering on line formation

Electron scattering influences spectral lines through Compton broadening. The Spectral lines in the spectra of hot stars, AGN, Seyfert galaxies etc can be affected by Compton scattering. Electron scattering contributes not only to the opacity of high temperature stellar atmospheres, but also produces broadening and asymmetry in the spectral lines of such stars. The redistribution of photons in the line are due to Doppler motion of the electrons and the Compton effect in the scattering process. Münch investigated the broadening of spectral lines due to thermal motions and found this effect in Wolf-Rayet atmospheres. Chandrashekar examined the shifts due to Compton scattering, but neglected the Doppler shifts and used a Taylor series expansion (to the first term). This work was extended to the spherically symmetric geometry and by including the second derivative in the Taylor series. Dirac studied Compton scattering for the first time and found that thermal motions produced a non-Doppler blue shift whose frequencies would be larger than the red Compton shift. Therefore, it would be interesting to study how Compton scattering changes the energy of a high frequency photon. Edmonds derived the spectral redistribution function to the second approximation. However, he solved the equation of transfer in plane parallel approximation using the first approximation of the redistribution function. He found that the non-Doppler blue shift



The redistribution function for the normalized frequency X at X = -4, 0 and 4 Doppler units. (A.Peraiah & M. Srinivasa Rao)

due to the thermal motions was much larger than the Compton red shift for an optical depth of less than one which is appropriate in a Wolf-Rayet star. As the optical depth is

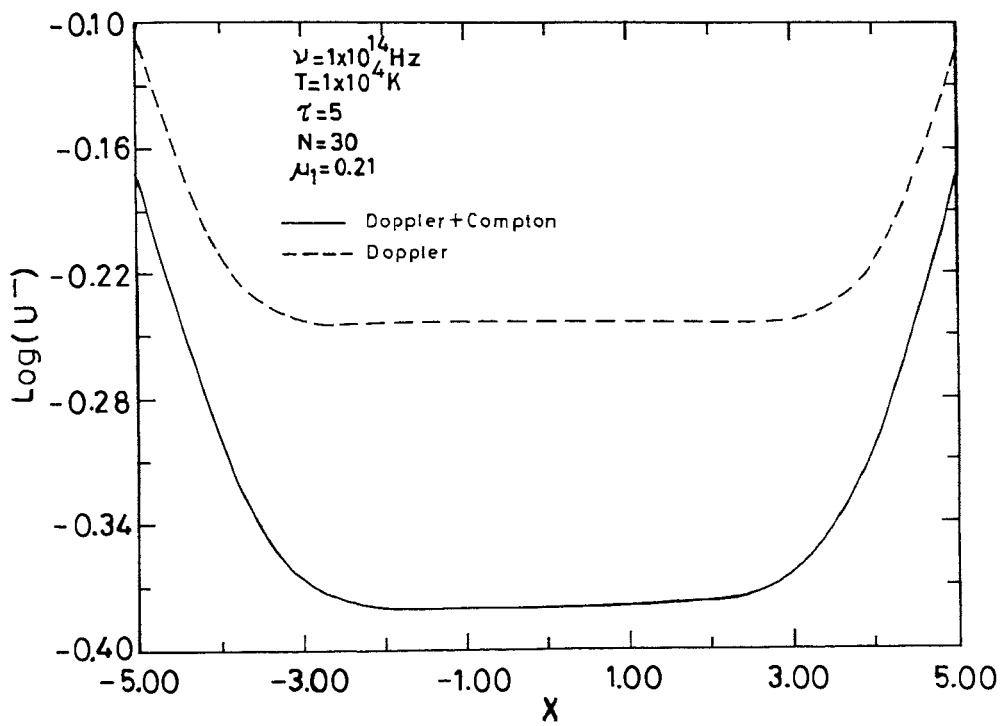
much less than what is to be found in other objects, the broadening due to Compton scattering was calculated by considering upto the second approximation. (A.Peraiah & M.Srinivasa Rao)

Three dimensional reflection effect

The reflection effect in close binaries was treated in three dimensional geometry. A solution of radiative transfer equation in three dimensions in a geometrically asymmetric media was developed. The study shows that observable differences were noted if one treats the transfer of radiation in the very extended layers of the distorted surface of components of close binaries. (A.Peraiah & M.Srinivasa Rao)

Scattering by a dielectric sphere

The asymmetry parameter of the scattering diagram and the efficiency of radiation pressure in scattering of electromagnetic radiation by a very large dielectric sphere was investigated. The present calculations were based on the theories of Geometrical Optics and Diffraction (GOD) suitable for sufficiently large spherical particles. Some calculations were done using Mie theory. The variation of the asymmetry parameters, $\langle\cos\theta\rangle$ and the efficiency of radiation pressure, Q_{pr}, with the index of refraction (m) in the range m=[1,5] were investigated. The imaginary part of the index of refraction is zero for a dielectric material. It appears that both $\langle\cos\theta\rangle$ and Q_{pr} would continue to show

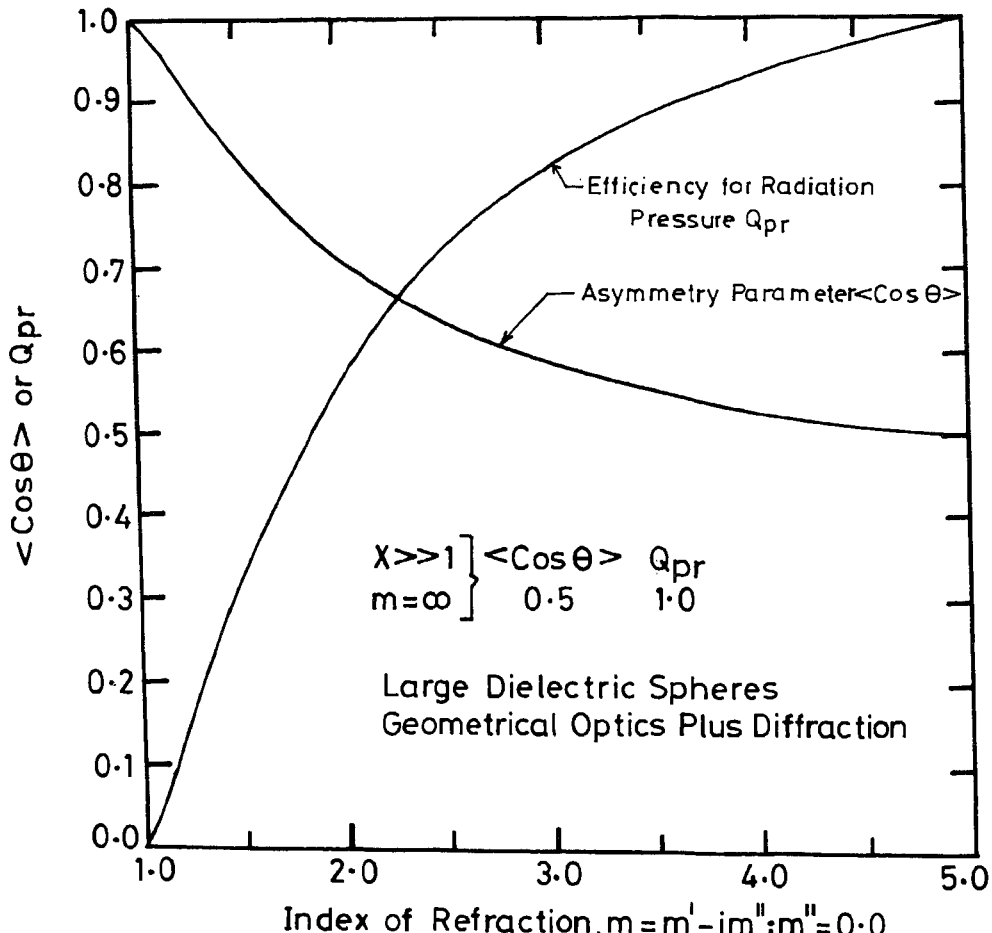


The specific intensity with Doppler and Compton broadening (A.Peraiah & M. Srinivasa Rao)

monotonic trends for $m>5$ also. However, the results of calculations for index of refraction in the range m=5(1) 50 revealed a new feature of shallow broad extremum (resonance) in the asymmetry parameter as well as in the radiation pressure. The extrema occur in the common interval defined by $11.201 \leq m \leq 11.23$. The minimum of the asymmetry parameter is given by $\langle\cos\theta\rangle_{min}$ = 0.476792 and the maximum of the radiation pressure is given by Q_{pr}=1.04642. (G.A. Shah)

Asymptotic values of some scattering parameters for Mie theory.

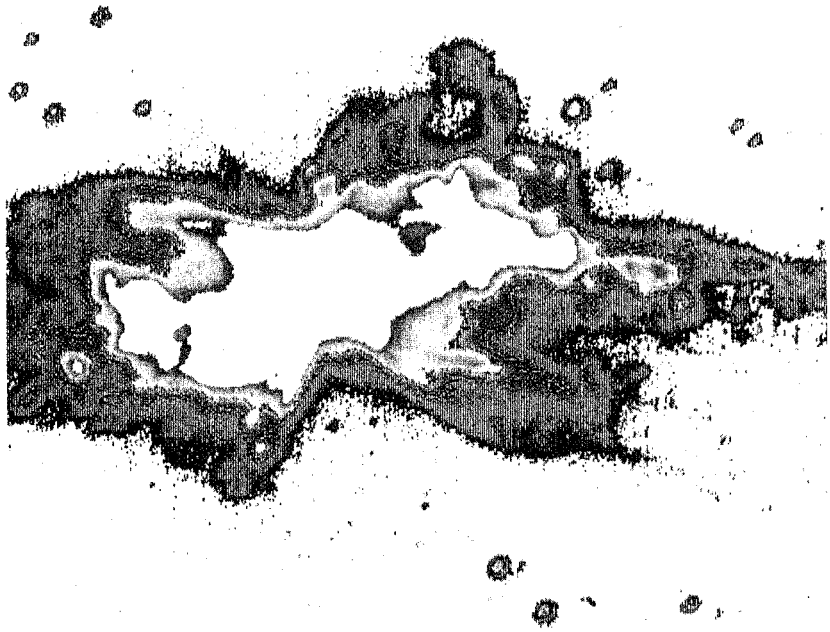
The scattering parameters such as extinction efficiency, albedo, asymmetry parameter, etc. were studied on the basis of the Mie theory of scattering of electromagnetic radiation by a sphere as well as the classical Geometrical Optics and Diffraction (GOD). The spheres are assumed to be composed of water or ice-like dielectric and absorbing materials relevant to atmos-



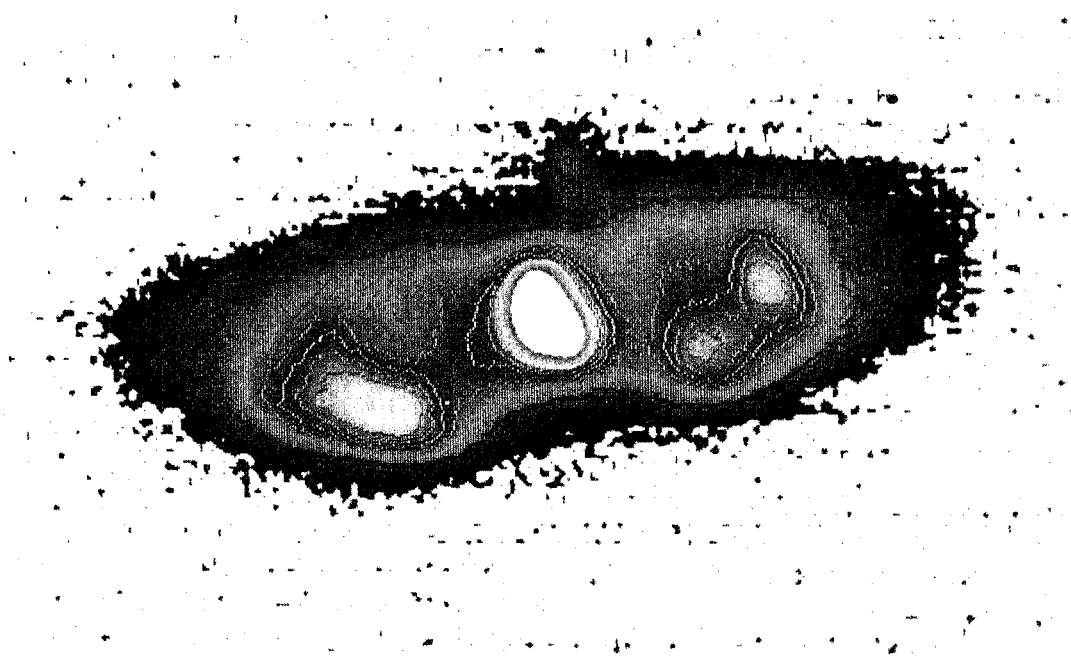
Asymmetry parameter (<*cos θ* >) and efficiency for radiation pressure (*Q pr*) versus index of refraction (*m*) of homogenous isotropic and smooth dielectric spheres. The range of *m* is [i.5]. (G.A.Shah)

pheric optics (terrestrial clouds), icy planets and satellites and interstellar grains. The indices of refraction, $m=m' - im''$, were chosen to be $m' = 1.33$ or 1.333, and $m'' = 0$, 0.0033, 0.033, 0.1, 0.33 or 3.3. The Mie theory calculations were carried out for a size-to-wavelength parameter x where, $x = 2\pi a/\lambda$, a is the radius of the sphere, and λ is the wavelength of the incident radiation in the range $10^{-5} \leq x \leq 10^{5}$ at selected intervals. The Mie theory calculations for very large values of x may become cumbersome, time consuming and expensive. As an alternative, it is possible to use the method of GOD for sufficiently large spherical particles ($x>>1$). The question is : how large should the value of x be ?

The minimum value (x_{min}) of the size -to-wavelength parameter was estimated for each scattering parameter so that the asymptotic value, obtained from the Mie theory calculations for $x \geq x_{min}$, agree with the corresponding result based on GOD provided accuracy is limited to three significant digits. It was concluded that one can use the short-cut method of GOD for scattering of electromagnetic radiation by sufficiently large spherical particles provided that $x \geq x_{min}$. (G.A.Shah)



NGC 6302



M 2-9

CCD images (Hα filter) of bipolar proto-planetary nebulae obtained with the 1 m telescope at VBO, Kavalur. (M.Parthasarathy & R.Sagar)

Interstellar Matter and Planetary Nebulae

Enhanced star formation in the cometary globules in Gum nebula

From an analysis of IRAS data, evidence for enhanced star formation in the cometary globules in Gum Nebula was found. 16 of the 29 globules were found to have IRAS sources within the globule heads. Their infrared flux densities increase with increasing wavelength, a characteristic of dust embedded young stellar objects. The IRAS source density for the cometary globules is found to be about 20 times the background which is around 0.7-20$L_{\odot}$. It was suggested that the radiation pressure due to the central stars ζ Pup and γ^2 Vel caused shock-induced collapse of the globule heads and the consequent star formation in the cometary globules. (H.C.Bhatt)

Polarization measurements of stars in the region of dark clouds.

As a part of a programme to map the magnetic field geometry in dark interstellar clouds and to study the properties of the cloud dust, polarization measurements of stars in the regions of the clouds L1457, L1621 and the Bok globule B227 were made. The field geometry is found to be roughly unidirectional for each cloud. The large degree of polarization observed for B227 would require a strong magnetic field (~100 μG) aligning the dust grains in the cloud. (H.C.Bhatt & S.K.Jain)

CCD imaging of Herbig Ae/Be stars

Herbig Ae/Be stars are pre-main sequence stars of intermediate mass, often surrounded by bright nebulosities. V, R and Hα CCD images of 15 of these objects were obtained. Magnitudes of the central exciting stars as well as integrated magnitudes for the nebulosities were derived. Large photometric variations (≥2 mag) were found for T Ori, RR Tau and LHα 25. Photometric variations are accompanied by colour variations such that stars that brighten up become bluer in colour. The radial gradients in surface brightness and colour for stars surrounded by nebulosities were derived. The radial surface brightness variations follow power laws that require radially falling off dust density distributions in the nebulae. Colours become bluer with increasing radial distance. In R Mon a feature at about 16 arc sec from the central star was detected. It is too bright to be explained in terms of scattering of central starlight by nebular dust and it was suggested that the feature may be a region of intrinsic line emission or an additional young stellar object buried in the nebular gas and dust. (H.C.Bhatt & R.Sagar)

Ionization structure of H II regions

New calculations of the hydrogen and helium ionizating structure in H II regions were performed with exciting stars spanning an effective temperature range 40000 K to 60000 K. An ambient atomic

hydrogen density of 10 cm^{-3} and helium abundance by number of 10^{-1} were used. For an effective temperature T_{eff} < 50000 K, the fluxes beyond the He I ionization limit are low and the He^+ zone always lies within the H^+ zone. At higher temperature the boundary of the He^+ zone approaches that of the H^+ zone but never goes beyond it. If the effects of helium recombinations of hydrogen ionization were neglected, as was done by most of the earlier workers, at temperatures T_{eff} > 55000 K a narrow zone of ionized helium appears at the edge where hydrogen is predominantly neutral. Physically, by ignoring the terms that couple hydrogen and helium ionizations, H ionization was artificially suppressed, at the same time the helium ionization was enhanced.

Recent observations of radio recombination lines in the H II region W3 revealed small regions where the He line intensities are as high as the H line intensities. Based on the above, anomalous ionization by a hard radiation field was ruled out. (D.C.V. Mallik, W.M.Goss* and P. Roelfsema*)

Planetary nebulae

The local statistics of planetary nebulae were determined on the basis of the new distance scale proposed by Mallik and Peimbert (1988, Rev. Mex.Astron.Astrof. **16**, 111). Since many of the planetary nebulae seemed to be optically thick to Lyc radiation, a new method was evolved to estimate their ages. The method makes use of model stellar fluxes and the evolutionary tracks of the central stars. The local density of planetary nebulae turned out to be 19±4 kpc^{-3} and their scale height was estimated as 153 pc. The birthrate of the nebulae based on these statistics is 1.5 x10^{-3} kpc^{-3} yr^{-1} which is within a factor of two of the recently determined white dwarf birthrate. (D.C.V.Mallik)

The recent work on the improved determinations of central star magnitudes and central star temperatures was reviewed. A reassessment of the central-star mass-distribution was made and the reasons for the preference of the "long" distance scale were presented. (D.C.V.Mallik)

Low excitation planetary nebulae

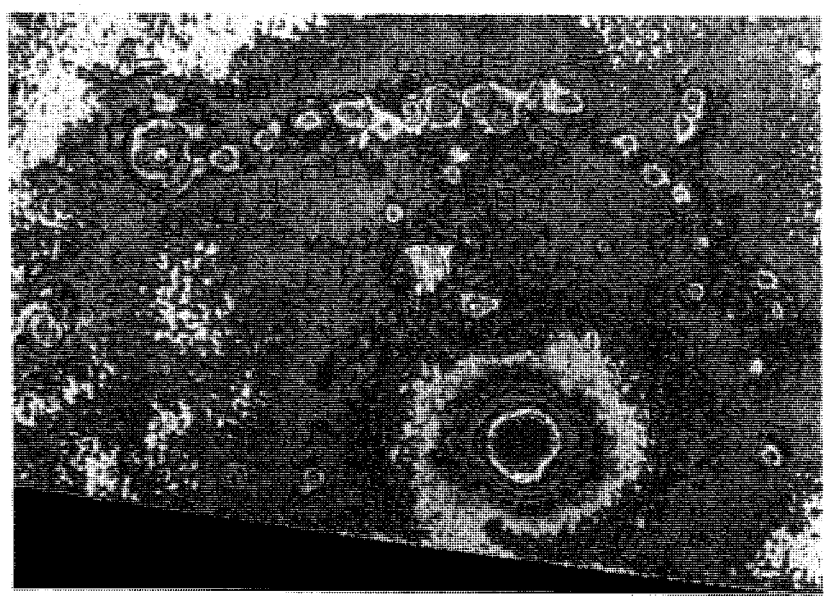
The evolutionary status of low excitation planetaries is not well understood. They may be proto-planetaries, or they may be older planetaries making another trip to the red giant branch. CCD spectra of M4-18 taken with the 1 m telescope at VBO in the wavelength range of 5600 Å to 10,000 Å are being analyzed with a newly developed photoionization code. The modelling work will combine observed data and the published IR data. A few such objects with WC 11 central stars were included in the programme.(R.Surendiranath, N.Kameswara Rao & A.R.Hanumanthappa*)

Bipolar proto-planetary nebulae

From an anlysis of the far infrared IRAS data of bipolar proto-planetary nebulae

(Parthasarathy, 1989, in IAU Highlights of Astronomy, **8**, 399) it was found that they have cold dust shells with characteristics similar to the dust shells around planetary nebulae. In addition to the cold dust these objects also have warm dust around them. In the optical region they show nebulosity which is bipolar in shape. The central stars are very faint and are obscured by dusty disks. CCD images of bipolar proto-planetary nebulae (HD 44179, Hen 401, IC 418, M2-9, Mz-3, NGC 6302, Roberts 22, and OH 231.8 + 4.2) were obtained in BVRI and Hα with the 1 m telescope at VBO, to study the flux distribution, colour gradients, bipolar structure and to detect the central stars. Analysis of the data is in progress. (M. Parthasarathy & R. Sagar)

Picture of the north-east arm of the spiral galaxy NGC 2997 constructed using the CCD images obtained with the Photometrics CCD system on the 1 m telescope. B and V broadband images and Hα narrowband image were added as blue, green and red images respectively. Individual images were pre-processed and the composite constructed. The field is 2 arcmin × 3 arcmin in size. North is at the top and east to the left.



Pseudo-colour representation of the same region observed in the Hα light. Circular apertures are superposed on the star-forming regions in order to extract fluxes. Rectangular apertures flanking them are selected for estimating the contribution due to the underlying population of the galaxy and foreground emission from sky. (Y.D. Mayya)

Galaxies, High Energy Astrophysics & Cosmology

Galaxies

The giant branch of the Fornax dwarf spheroidal galaxy

For population II objects, the structure of the giant branch down to and including the horizontal branch provides a useful measure of distance and metallicity. In spite of considerable observational efforts made during the last few years, no large-scale photometric study of the giant branch of the field stars of the Fornax dwarf galaxy has been made. A colour-magnitude diagram for a large sample of stars (~1300) in the Fornax dwarf galaxy was obtained from BV electronographic observations. These reach to the level of the horizontal branch, below V=21 mag. An analysis of structure in the giant branch indicates that the standard deviation of the intrinsic width of the giant branch is about 0.14 mag in (B-V) colour at a given luminosity, which yields a standard deviation of 0.3 in [Fe/H], if a spread in metallicity alone is responsible for the intrinsic width. Otherwise a combination of both variation in age from 3 to 17 billion years and a spread in metallicity equivalent to a standard deviation of 0.27 in [Fe/H] can account for the intrinsic width of the giant branch. A comparison with galactic globular clusters as well as theoretical isochrones suggests a mean value of [Fe/H] = -1.5±0.1 for the Fornax giant branch stars. (R.Sagar, M.R.S.Hawkins* & R.D.Cannon*)

Star-forming regions in nearby galaxies

The programme of imaging nearby galaxies in BVR and Hα bands using a CCD with 1 m telescope was continued. In addition some of the programme galaxies were imaged in Hβ, and [OIII] λ5007Å with the 2.34 m VBT. These observations are being used to obtain photometric fluxes of individual H II regions in the galaxies and then to determine extinction (using Hα/Hβ) and excitation (using [O III]/Hβ).

Software was developed to compute the theoretical model spectrum of a cluster of stars using the stellar evolutionary models of Maeder (1990, Astr.Astrophys. Suppl., **84**, 139) and stellar atmospheric models of Kurucz (1979: Astrophys. J. Suppl., **40**,1). A cluster in the model is defined by (i) age, (ii) metallicity (iii) total mass, and (iv) initial mass function (IMF) of the stars and is assumed to represent the ionizing as well as non-ionizing stars embedded inside giant H II complexes in external galaxies. Using the computed spectrum, the directly or indirectly observable quantities such as Lyman continuum photon luminosty and luminosities in BVR bands are computed.

The observed photometric parameters of H II regions will be compared with these models. (Y.D.Mayya & T.P.Prabhu)

Spectroscopy of galaxies

Spectra of the nuclear regions of few

Sersic-Pastoriza galaxies were obtained using the Boller & Chivens spectrograph and the Astromed CCD at the Cassegrain focus of the 2.34 m VBT with a view to modelling the H II regions as well as the underlying stellar population. In addition, the spectrum of the galaxy IC 2735 (m_{pg}=15.4) in which supernova 1990G had exploded, was obtained. The galaxy belongs to the cluster A 1228. The Na I D line and few absorption bands including the Mg I b were detected at a redshift of z = 0.037. This value is consistent with the published redshift of this galaxy, and also of IC 2738, another bright member of the cluster. (T.P.Prabhu & Y.D.Mayya)

Surface photometry of field galaxies

The programme of broadband CCD imaging of field galaxies was continued at the 2.34 m VBT. A few galaxies were imaged during April 1990 and Feb. 1991. The images would be used to determine the morphlogical and structural parameters of the galaxies. (A.K.Kembhavi*, T.P.Prabhu & P.N. Bhat*)

Broadband CCD photometry of X-ray selected active galactic nuclei

Three X-ray selected active galactic nuclei – MS 0941.7-2348, MS 1030.2-2757 and MS 1332.8-2935 were imaged using the Astromed CCD at the prime focus of the 2.34 m VBT. The images would be used to obtain the photometric parameters of these objects, and also to study the optical morphology, structure of the enviornment, and evolution. (K.P.Singh*, P.N.Bhat* & T.P. Prabhu)

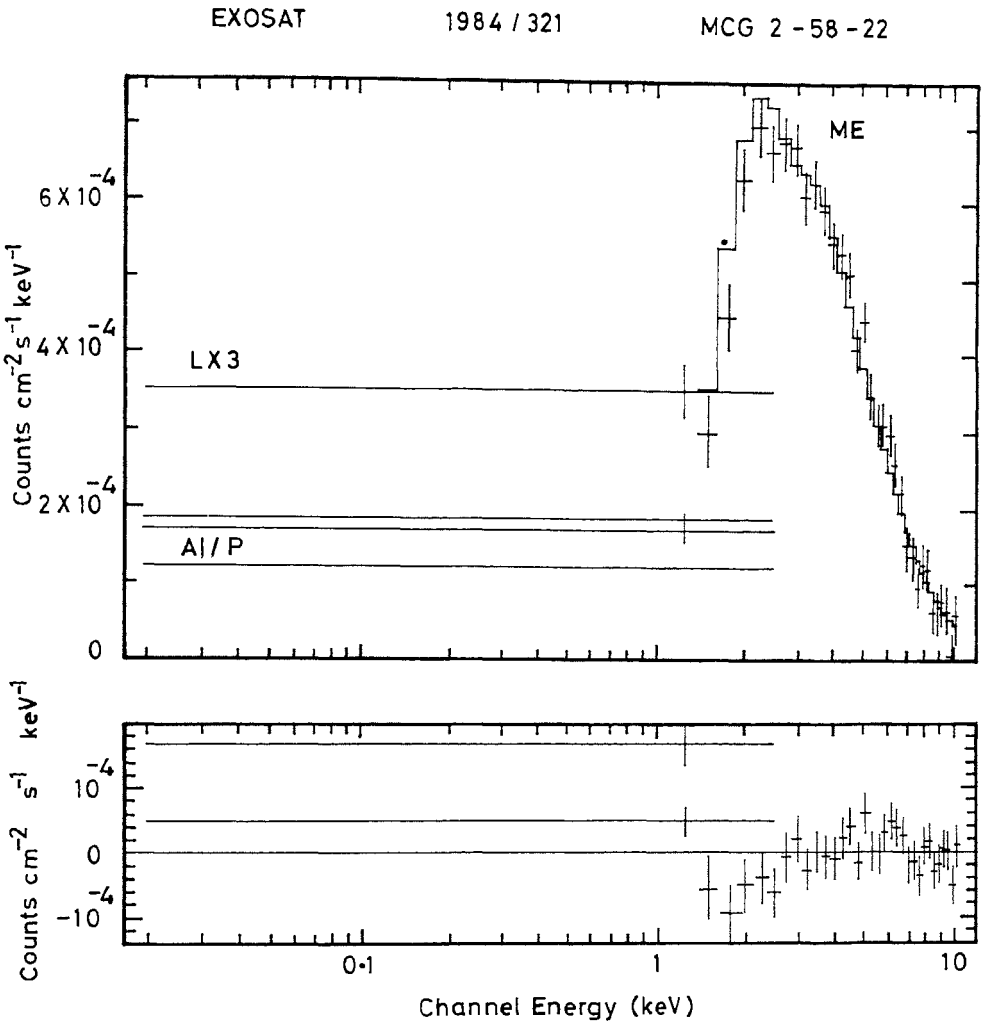
Line formation in Seyfert galaxies

The physical parameters in the extended narrow line region (ENLR) of Seyfert galaxies are highly uncertain. A project was started to compute the line stregths of hydrogen, nitrogen, oxygen, neon and sulphur to get an insight into the prevailing electron number densities, neutral gas densities, temperatures and velocities in active galactic nuclei (AGN). Models are being constructed to derive physical conditions in these objects. (A.Peraiah & P. Singh)

BL Lac objects

BL Lac objects are a subclass of active galactic nuclei. They are well known to be highly polarized objects in the optical and radio wavebands. Because of their polarization, characteristically strong and featureless continuum, and variable emission, these are considered to be pure non-thermal synchrotron sources residing in the nuclei of the host galaxies. Study of the wavelength and time-dependent polarization can yield extremely useful information about the emitting region such as the magnetic field geometry, electron velocity anisotropy and Faraday rotation etc.

Imaging polarimetric observations (0°, 60° and 120°) of four such XBLs in the V-band were made at the prime focus of the



Observed spectrum (+ symbol) of MCG 2-58-22 fitted with a simple power law and fixed absorption model (solid line). Lower panel of the figure shows the residual between the spectra and the model. (K.K.Ghosh & S.Soundarajaperumal)

VBT. Data analysis is in progress. (K.K. Ghosh, K.P. Singh* & P.N. Bhat*)

Active galactic nuclei (X-ray spectroscopy)

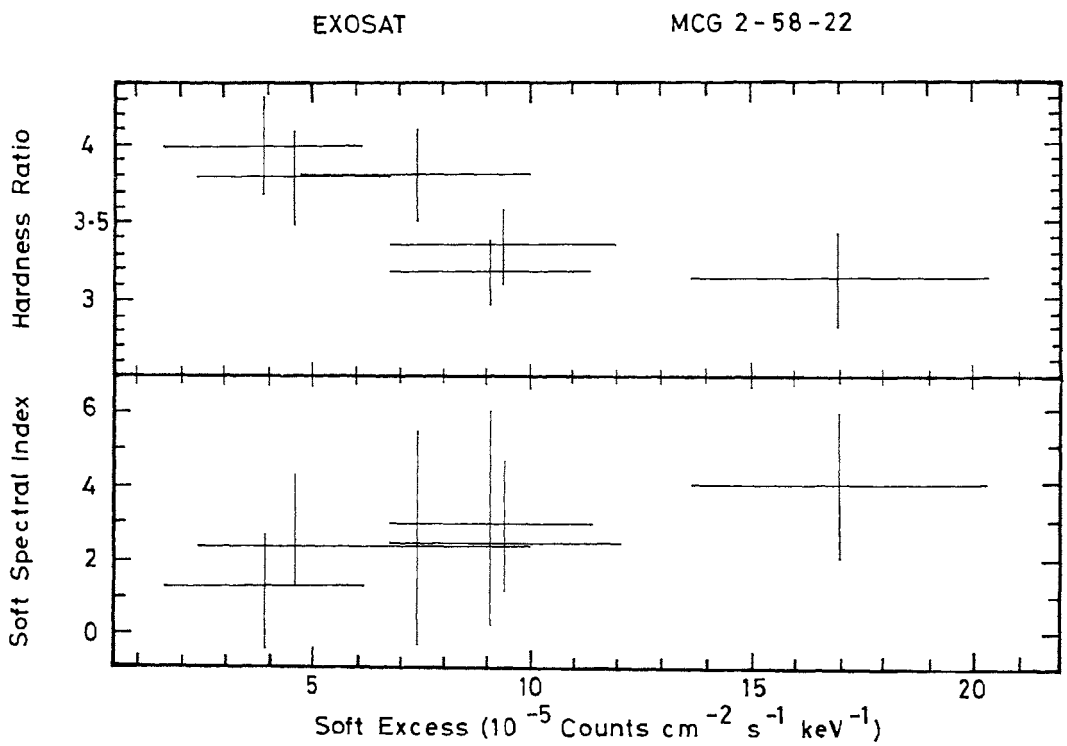
The X-ray (0.1–10 kev) spectra of three Seyfert galaxies NGC 3516, 3C 390.3 (also a Blazar) and MCG 2-58-22 and one quasar (PKS 1217 +023), obtained with EXOSAT, were analysed. Different models (power law + absorbing column density; power law + absorbing column density fixed with the galactic column density value of eqivalent hydrogen; two power laws; broken power-law with break energy fixed at 0.6 keV; thermal bremsstrahlung; Gaussian emission line and partial covering

model) were used to fit the X-ray spectra of the above mentioned AGN. Excess flux (below 2 keV) in NGC 3516 and MCG 2-58-22 was detected. Also an iron emission line around 6.0 keV in the X-ray spectra of NGC 3516, 3C 390.3 and MCG 2-58-22 was detected. On the basis of the line centre energies and the equivalent widths of the emission lines detected, it was suggested that the emission line is due to the red-shifted fluorescence of iron from an accretion disk around a collapsed object at the centre (supermassive black hole).

The soft excess detected in the X-ray spectra of Seyfert galaxies was correlated with the soft spectral index and anti-correlated with the hardness ratio (2-10 keV count rate / 0.1 - 2 keV count rate). The soft spectrum of the source becomes relatively steeper and the source becomes relatively softer when the soft excess is dominant. (K.K. Ghosh & S. Soundararajaperumal)

Dynamics

An important consequence of a tidal



Soft excess versus soft spectral index, obtained from two power law fits, (lower panel) and hardness ratio of the source (upper panel) (K.K.Ghosh & S.Soundarajaperumal)

encounter between galaxies is that energy from orbital motion is transferred to the internal energy of each galaxy. The angular momentum transfer takes place because of the presence of the gravitational quadrupole moment. The tidal forces stretch a spherical galaxy in the orbital plane and compress it in the perpendicular direction transforming the sphere into an ellipsoid The tidally affected galaxies, thus, acquire not only additional kinetic energy of random motion but angular momentum also. Numerical experiments were performed to study the transfer of angular momentum to an initially non-rotating spherical test galaxy as it undergoes a collision with a massive perturber. The test galaxy consists of a number of particles (250-1000) and the perturber is assumed to be a point mass. A variety of relative orbits and mass ratios were considered, while the distance of the pericentric distance of collision was kept constant. The encounters are mild and non-penetrating. It was noted that the spin acquired by the spherical galaxy increases as the mass ratio decreases. Further, a reduction in the eccentricity of the relative orbit increases the spin of the test galaxy. The acquired spin shows smooth variation with time in the case of open orbit encounters whereas in the case of closed orbit encounters the variation is irregular. A fraction of the initial mass of the spherical galaxy escapes carrying away a large fraction of the transferred angular momentum leaving the remnant bound system with very little spin. The tidally induced rotation of the remnant bound system is in the same sense, within statistical fluctuations, as that of the initial orbital angular momentum of the pair. (P.M.S.Namboodiri & R.K. Kochhar)

The stability of a satellite galaxy against disruption, when it encounters a point mass perturber was investigated by numerical simulations. The merging process dominates in the case of encounters of unequal mass systems. For systems widely differing in mass, the rate of disruption is chiefly determined by the density ratio of the two. A satellite galaxy suffers considerable disruption if its mean density is less than a critical density - the Roche density. The tidal effects show drastic decrease near the critical density in the case of encounters in which the initial relative orbit of the perturber is circular. (P.M.S. Namboodiri)

Clustering of galaxies

A new model for clustering of galaxies (and consequent formation of very large scale coherent structures) was suggested. This model involves the phenomenon of inverse cascade occuring in a turbulent medium. The clustering of galaxies on all scales is interpreted as a result of self organisation processes occurring in a turbulent medium. Comparision with cold dark matter and pancake models in the formation of hierarchical structures was explored. (V.Krishan & C.Sivaram)

Quasars

Stimulated Raman scattering

Stimulated Raman scattering processes appear to be able to produce the typical electromagnetic continuum of an active galactic nucleus. Seed photons beat through Raman forward-scattering to create Langmuir plasma waves which can quickly accelerate electrons to Lorentz factors of 10^3 to 10^4. These electrons radiate their energy through Raman back-scattering off magnetic fields engendered by magnetic modulational instabilities afflicting the Langmuir waves. The frequency of emission is proportional to the square root of the ambient density, and so γ rays can be produced in the highest density regions near the central engine, with X-rays through to IR photons produced at greater distances. Both the high luminosity and broken power-law continuum characteristic of AGN emerge from reasonable density distributions. The Bremsstrahlung emission in the UV is a by-product of this mechanism and could explain the 'blue bump'. Because the electrons are continuously accelerated in this picture, a steady-state distribution arises naturally and simple relation exists between the density of the relativistic particles which emit the radiation, and the ambient plasma density which is involved in the accelaration. (V.Krishan)

Coherent plasma processes

A coherent plasma process such as the parametric decay instability (PDI) was applied to a homogeneous and unmagnetized plasma. These instabilities cause anomalous absorption of strong electromagnetic radiation under specific conditions of energy and momentum conservation and thus cause anomalous heating of the plasma. The maximum plasma temperatures reached are functions of luminosity of the radio radiation and plasma parameters. It appears that these processes may be taking place in many astrophysical objects. Conditions in the sources 3C 273, 3C 48 and Crab Nebula were shown to be conducive to the excitation of PDI. These processes also contribute towards the absorption of 21-cm radiation. (V.Krishan)

Are quasars ejected from galactic nuclei?

While the cosmological interpretation of quasar redshifts is the most favoured one at present, an unbiased assessment of the observational evidence indicates that, at least for some quasars, a substantial part of the redshift is non-cosmological (anomalous/discordant). Arp (1987) had consistently argued that quasars are born in explosions in nearby galaxies. A theoretical alternative for this scenario was investigated. It was hypothesised that all quasars are born in and ejected from the nuclei of active galaxies. A mechanism for the excess redshift was sought in terms of the Variable Mass Hypothesis (VMH) arising from the Machian theory of gravitation of Hoyle and Narlikar (HN). In the VMH model

of the HN theory, the quasar redshift arises due to the variable particle masses in it. An analysis of the dynamics of the ejected quasar in quasar-galaxy associations shows that the VMH models can adequately interpret the angular separations and the phenomena of redshift bunching and alignments observed in such associations. It also shows how initial conditions can determine whether a quasar will form a bound system with the parent galaxy or will become a free (field) quasar.

The most direct and compelling evidence for the ejection hypothesis is the case where an apparent luminous connection is observed between objects with vastly dissimilar redshifts. The VMH model can provide an elegant interpretation for this phenomenon. This was demonstrated with the most recent example of NGC 3067/3C 232 pair, where an apparent bridge of matter is seen connecting the low redshift (z=0.005) spiral galaxy NGC 3067 to the high redshift (z=0.534) quasar 3C 232. It was shown how the observed spectroscopic features of 3C 232 and the disturbed state of the galaxy can be explained by the present model (P.K.Das)

Effect of dynamical friction on the motion of a supermassive object.

The previous work of Kapoor (1985) on the effects of dynamical friction on the motion of a supermassive object ($M \sim 10^9$ $M_\odot$) ejected from the centre of a galaxy ($M' \sim 10^{11}$ $M_\odot$) was extended to investigate the scenario where the mass of the ejected object evolves with time. Detailed calculations are in progress. (R.C.Kapoor & P.K. Das)

Statistical analysis of quasar-galaxy separations

A statistical analysis of the median angular separations between quasars and associated galaxies from the QSO catalogue of Hewitt and Burbidge (1987, 1989) was initiated and an interpretation sought in terms of the anomalous redshift quasar models developed by Narlikar and Das (1980). (P.K.Das & J.V.Narlikar*)

High energy astrophysics

Neutron stars

A theoretical determination of the maximum rotation rate that is allowed for a neutron star is important because it decides the maximum pulsar frequency that can be expected observationally. The instabilities that determine the maximum angular velocity of a rotating neutron star are directly influenced by the frequencies of oscillation. An understanding of the oscillation modes of neutron stars is, therefore, important. A detailed numerical investigation was carried out of the oscillation properties of neutron stars using the realistic equations of state of high density matter. (B.Datta & S.S.Hasan)

Pulsars

An estimate was made of the effect of light bending and redshift on the pulsar beam characteristics, using a weak form of the Kerr metric, applicable to a slow rotating neutron star. The calculations refer to the canonical narrow conical beam model of pulsar emission from a 1.4 $M_\odot$ neutron star with radius in the range 6-10 km and periods of 33 ms and 1.56 ms. It is found that the beam diverges by a factor of about 2 and suffers an intensity reduction by an order of magnitude, when emitted from close to the star's surface. This flattening of the pulse profile apprently is the strongest for the shortest of the neutron stars, becoming insignificant for emission points located beyond 20 km, for all the neutron star radii considered. For a given emission location, the divergence is comparatively greater in the Schwarzschild background than in the rotational case since, by virtue of the rotational terms in the metric, the aberration effect comes into play, which always tends to reverse the flattening effect of spacetime curvature by slightly squeezing the pulse in longitude. For instance, for a pulse emitted in the equatorial plane from beyond some 30 km, in the case of the 1.56 ms period, aberration is so strong that it overcomes the divergence effect. This will result in an apparent reduction of the duty cycle. Although the pulse must brighten up, a large redshift factor overcomes this to keep the pulse profile flattened. For larger periods, the squeezing is noticeably present at emission points greater than 500 km from the star's surface. For the same radial location, the squeezing is found to be less severe for emission at smaller inclination angles (R.C,Kapoor)

The effects of radiation from additional long range forces such as the "fifth force' on the emission of gravitational radiation from binary stellar systems were studied.It was shown that none of the conclusions regarding the binary pulsar are affected. However, for certain other systems such radiation could be important, enabling constraints on the parameters describing such forces to be put. Its effects on gravitational wave detectors were also analysed. (B.Bertotti* & C.Sivaram)

Black holes

The role of spin in black hole evaporation was studied. In connection with the quantization of black hole entropy, a modification of the third law of thermodynamics involving a minimal entropy for black holes was suggested. The connection between black holes, strings, membranes and wormholes was explored. The various physical processes entering in the evaporation of black holes were clarified. (C.Sivaram).

The synthesis of ^{26}Al in gamma-ray burst sources.

The widely accepted model of γ-ray bursts involves accretion of matter onto a neutron star surface. On reaching the neu-

tron star surface where the density ranges from 10^5 to 10^7 g cm $^{-3}$ and temperature from 10^8 to $8x10^8$ K, the accreting material ignites explosively and a thermonuclear flash is generated. Such thermonuclear flashes can be sites of synthesis of various chemical elements.

Under usual circumstances, hydrogen and helium burning occur in separate mass layers. On the other hand, if hydrogen burns at sufficiently high densities ($\rho=10^6$ g cm^{-3}) helium must eventually burn in the same mass layer. It was proposed that this combined hydrogen and helium burning reactions, starting with ^{12}C on the neutron star surface, can initiate new chains of reactions leading to the production of ^{26}Al. The temperature - density situations for the occurrence of these reactions of the abundances of ^{26}Al and ^{27}Al isotopes shows that a finite amount of ^{26}Al is produced at a temperature of $2x10^8$ K and $\rho=10^6$ g cm^{-3}. The amount of material procesed in the burst sources is very little compared to the amount of material processed in novae or supernove. Hence, for the enrichment of the general intestellar medium throughout the Galaxy, the contribution from γ-ray burst sources, seems negligible. But in the neighbourhood of burst sources, the average abundance of ^{26}Al will be substantially higher than in the interstellar medium Thus, rather than contributing to the overall amount of ^{26}Al, γ-ray bursts are likely to contribute to the inhomogeneity of ^{26}Al distribution in the interstellar medium. (A.Goswami)

Explosive neutron capture process

An attempt was made to study how the process of explosive neutron capture is responsible for the synthesis beginning with ^{22}Ne, its abundance distribution and how these results may be used for the interpretation of some isotopic anomalies observed in meteorites.

Norman & Schramm (1979 Ap.J. **228**, 881) derived estimates for the ranges of initial temperature, density, neutron/proton ratio and chemical composition at which an explosive neutron capture process can begin.

To overcome the Coulomb barrier between alpha particles and light to medium weight nuclei ($20 \leq A \leq 40$), a minimum temperature of approximately $7x10^8$ K is required. It was also found that, to prevent photodisintegration the temperature must not exceed $6x10^9$ K. Taking ^{22}Ne as the seed element, the neutron capture process was investigated at three different values of neutron binding energies (Q_n = 2.3, 2.7 & 3.0 Mev) as dictated by temperature (T=7–$9x10^8$K) and density ($\rho = 10^5$, 10^4,10^3 g cm^{-3}) range for a neutron processing from ^{22}Ne (α,n) ^{25}Mg, where a neutron density $n_n \geq 10^{17}$ cm^{-3} was found to be produced for timings of 0.1 - 30 s. The analysis and interpretation of the results are in progress. (A.Goswami)

Cosmology

Primordial nucleosynthesis

The idea that quarks and leptons are not fundamental particles, but composites (made up of preons) has been suggested in particle physics, in order to resolve the fermion generation puzzle and the fermion mass heirarchy. The relevance of the preonic model in the early universe was examined by looking into the question of whether a preon-to-quark phase transition could induce any local fluctuation in the very early universe, and thereby, influence the primordial nucleosynthesis. It was found that unless the energy scale associated with this transition is around (10-100) GeV, i.e. less than the top quark mass, the predictions of the standard model for primordial nucleosynthesis will remain unaltered. (B. Datta & B.Sinha*)

Early universe

It was shown that when a spin-dominated phase is considered in the very early universe, conditions for inflation can follow even for the anisotropic expansion. In the framework of the Einstein-Cartan theory coupled to a massless scalar field, one is naturally led to a power-law inflationary expansion without the need for massive or self-interacting scalar fields. (C.Sivaram & V. De Sabbata*)

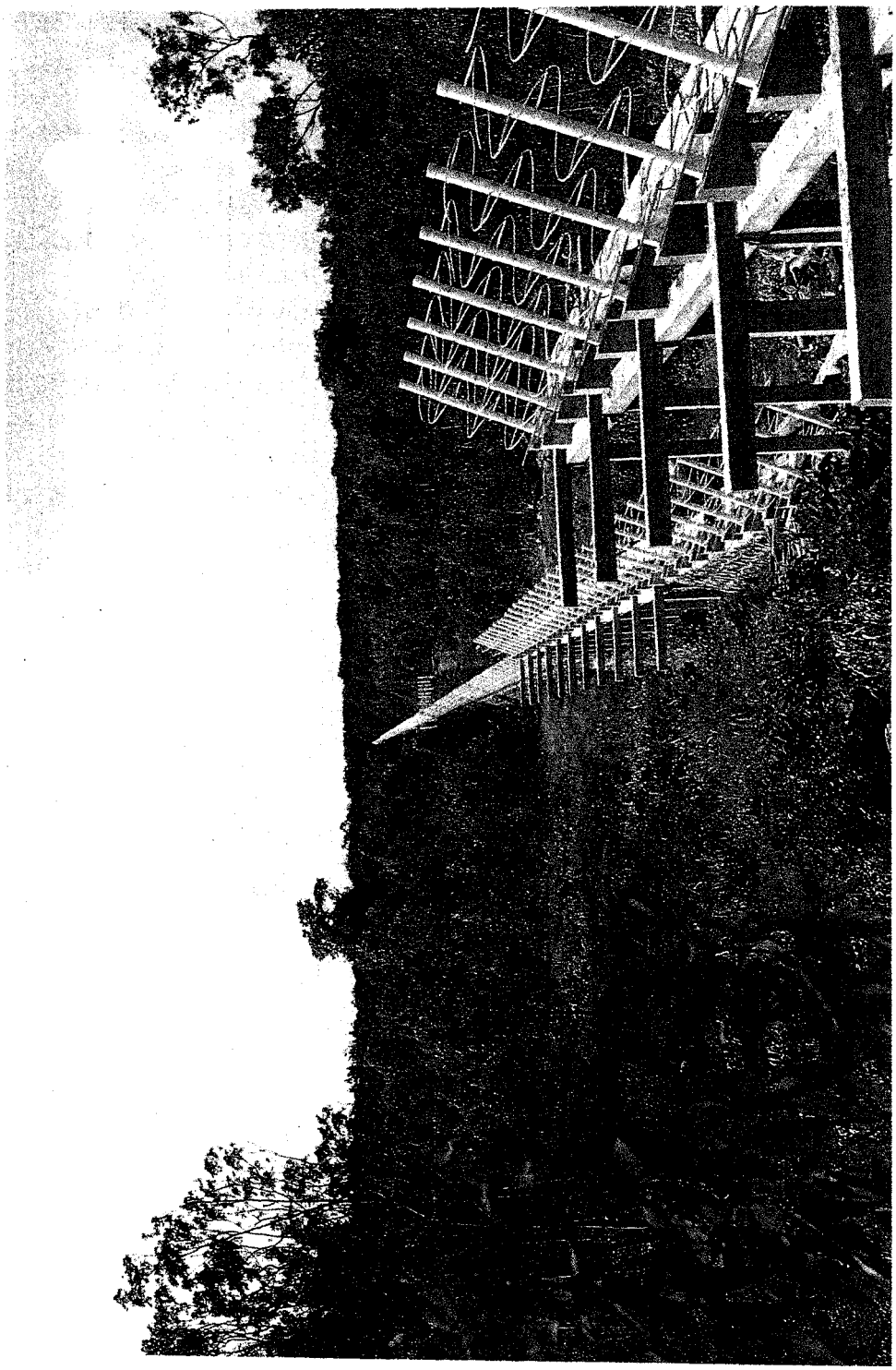
In the framework of the gauge theoretical formulation of the Einstein-Cartan theory, a wormhole instanton solution was found, which has a minimum (baby universe) radius of the Planck length. The basic difficulties with the wormhole approach to the explanation of the vanishing value of the cosmological constant in the present epoch was explored in some detail. An explicit calculation from the expression for the evolution of the scalar factor showed that the spin-spin interaction term in the very early universe can cancel the cosmological constant at that epoch. Generalized wormhole solutions with Yang-Mills field coupled to torsion were also found. (C.Sivaram & V.De Sabbata*)

The maximum accelaration at the Planck epoch was shown to be related to the maximum magnetic field and curvature as well as temperature in that era. Spin-torsion effects were also considered. The connection between the Hawking and Hagedorn temperature in the early universe in the string dominated phase was explored. (C.Sivaram & V.De Sabbata*)

The consequences of the quantum effects of torsion were studied. The role of torsion in making possible a consistent quantum formulation of general relativity with the curved space modification of the Heisenberg uncertainity relations was clarified. The consequences for the early universe were explored. The connection between torsion and string tension was explored. (C.Sivaram & V.De Stabbata*, H.Treder* & H.Brozeszkowski*)

Particle magnetic moments, in the framework of the Klein-Kaluza theory, were estimated. Its implication for a neutrino magnetic moment were studied. Possible consequences for solar neutrinos and cosmology were explored. (V.De Sabbata* & C.Sivaram)

The modifications in Maxwell electrodynamics in a space with torsion were considered. The resulting theory although still gauge invariant was shown to involve a cutoff parameter. Its consequences for cosmology were explored especially in connection with the generation of the primordial magnetic field. (V.De Sabbata* & C.Sivaram)



The East-West array of the Indo-Mauritius radio telescope.

Instrumentation

Solar instrumentation

Sunspot measurement

Measurements of 30 year Kodaikanal sunspot data were completed. An IBM-PC/AT based sunspot area measuring system was developed to serve as a standby to the existing PDP/11 system. A CALCOMP graphics tablet/digitizer was connected to the serial port of the PC so that the output from the digitizer could be transferred into the PC directly.

Programmes for data acquisition, data conversion to the VAX 11/780 computer format and for data analysis were developed in FORTRAN and Assembly languages (K.R.Sivaraman, S.S.Gupta, A.V. Ananth & R.Howard*)

Vector magnetograph

Significant progress was achieved in the construction of the solar vector magnetograph. A Peltier cooled CCD camera was procured and tested in the laboratory. The polarimeter package was designed and the assembly of the polarimeter and the fabrication of the mechanical components were completed in the Institute workshop. After laboratory tests and several iterations, a scheme for testing was finalised and set up in January 1991. This involved sending a collimated beam of monochromatic light (from a sodium vapour lamp) through a polariser with its transmission axis kept at a known angle to the vertical. The rotating half wave plate was kept at different angles to the vertical and the transmitted image was recorded by the camera and stored in a PC/AT. A least squares fit to the data provided the Stokes parameters. A similar procedure was followed for the case of circularly polarised light. In both cases the cross talk from Q into U or from V into Q and U was less than 10%. This is an acceptable level for measuring magnetic fields in solar active regions. This compares well with the MSFC vector magnetograph (at Huntsville, U.S.A.), employing crystal modulators and which has a similar level of cross talk between the various Stokes parameters.

A microprocessor based intelligent controller was fabricated for the stepper motor to drive the rotating half wave retarder independently, thereby reducing overheads on the PC. A special video frame grabber card DT 2861 was ordered (with 16 image buffers, each containing 512 x 512 pixel data) to enable rapid acquisition and recording of the Zeeman spectra in all the four Stoke's parameters. Meanwhile a DT 2851 card with two frame buffers was used in the trials. A hybrid computer programme (in Pascal and Assembly language) was written for controlling the overall functions of the magnetograph. This programme involving movement of the stepper motor through required number of steps, acquisition of the Stokes' spectra at the various positions of the half wave retarder and saving the images on the hard

disk of the PC was successfully tested in the laboratory. The magnetograph assembly was transported to Kodaikanal in March 1991 and field trials for ten days were conducted. The camera could not provide sufficient video output so as to clearly discriminate the various levels in the line profile. The on-chip integration facility will have to be built in for obtaining acceptable signal levels. Certain modifications to the camera mount and polarimeter calibration unit are also being implemented. (J.C.Bhattacharyya, P.Venkatakrishnan, A.V.Ananth, R.S. Narayanan, N.Jayavel & A.V.V.Kutty)

Solar tower at Kavalur

At the solar tower, the solar limb monitor which uses a pair of phototransistors as sensors, was calibrated for measuring image motions of the order of 1 to 10 arc seconds. Also, trials to obtain broad band filtergrams around 500 nm using a mechanical shutter and the Coleman automatic magazine on 35/70 mm films were completed. Regular observations started in Nov. 1990, to obtain continuous two-channel limb monitor records and intermittent filtergrams.

The filtergrams obtained show that good to excellent seeing conditions are common in Kavalur. However, consistent seeing-limited recording with the limb monitor will start as soon as the tracking efficiency of the coelostat is improved to meet the stringent demands of the experiment. While the observations are being continued on a regular basis, efforts are on to replace the coelostat and to minimize the wind shake of the tower. The electronic drive system is also being improved considerably.

Further, efforts are on to add a PC based acquisition and recording system for the limb monitor data and to programme the exposures for filtergrams using electronic shutters. The development plan also includes acquiring instrumentation for measuring the meteorological parameters needed to obtain a complete picture of solar seeing conditions at the site. (K.R. Sivaraman, S.P.Bagare, F.Gabriel & T.S.C. Devaraj)

Daytime sky conditions at Kavalur

Data on the sky definition and cloud coverage at Kavalur are being obtained continuously since May 1989. Simultaneous, but independent observations, were obtained by two observers for a major part of this period. The sky definition or transparency judged by the observers are ascertained by comparison with observations obtained at the solar tower, whenever possible. Analysis of the above data is in progress. (K.R.Sivaraman, S.P.Bagare & S.Pukalenthi)

Electronics division

New display system for the 1 m telescope

A new display system was fabricated and

a few satisfactory field trials were completed. The synchro transmitters on the telescope were retained. Solid-state electronics was utilised to convert the position information of the hour-angle and declination axes into digital form. The synchro excitation was altered to an unmodulated AC voltage of 90 V. With the existing gear ratios of 1:24:30 for hour-angle and 1:12:30 for DEC axes, a suitable synchronising logic was implemented in software, to achieve a resolution of 20 and 19 bits for the HA and DEC axis respectively. Initial trials indicate that an unambiguous display is possible without any jitter even in the least significant digits of the two axes.

The display system is modular and comprises of the following sub-systems: synchro to digital converters (SDC), data multiplexer, display multiplexer and an IBM compatible PC I/O interface.

Two of the resolver to digital converters failed in the initial trials and this problem was traced to latch-up under certain power supply sequencing conditions. A modified SDC was developed which includes a proper power-up sequence.

The display information covers RA, DEC, HA, ST, UT, zenith distance and air mass and is presented both on a PC monitor at the console and on seven segment displays at the coude room. (R.Srinivasan, B.Nagaraja Naidu & J.C.Bhattacharyya)

Star changing device for the 1 m telescope

A new star changing device based on control by a PC was installed at the 1 m telescope. The desired RA and DEC movement values are stored in units of arc seconds. The feedback from the telescope is incremental in nature with one pulse corresponding to 1 arc sec. Depending on the value of the displacement, two speeds of motion are selected from the programme. The slow and fast motions correspond to 10 arc min/min and 3 deg/min respectively. In order to select the fast motion, a displacement greater than 1900 arc sec is required to avoid any overshoot in position. The initial 100 and the final 200 steps are covered in slow motion to meet the required ramp-up and ramp-down conditions.

An interactive user-friendly menu driven programme is provided for telescope motion. The number of steps is programmable and a skip option provides a branching capability for pointing to different celestial objects in different regions of the sky. (R.Srinivasan, B.Nagaraja Naidu & J.C. Bhattacharyya)

A PC based vibration analyser

A vibration sensor was designed by introducing a mechanical coupling between the vibrating solid surface and a liquid layer. The liquid on picking up the mechanical vibration of the solid, creates

capillary ripples on the liquid surface. The tilt of the ripple is studied by reflecting a laser beam and is sensed by passing the reflected beam through an optical wedge and finally collecting it on a sensor. After conditioning, the signal is applied to the PC interface card. The vibration analysis is based on a programme for finding the discrete Fourier transform. A 64-point decimation - in time FFT algorithm is implemented. Based on this transform, a frequency spectrum is plotted. A dedicated instrument based on a microcontroller chip (Intel 8051) or a signal processing chip (TMS 32020) is planned. (S.Chatterjee, K.C.Thulasidharan & R.Srinivasan)

CCD image display card for personal computers

An image display interface card compatible, with an IBM PC, was designed for displaying CCD image data. This card has its own image memory and associated electronics for generating composite video signals for input to a TV monitor. The image memory is organised into 512 x 512 x 8 bits so as to display 512 x 512 CCD pixels with 256 gray levels for each pixel. The electronics of the card reads the image memory, one pixel at a time at 10 MHz, converts it into analogue form and mixes it with horizontal and vertical synchronization pulses, before feeding it to the TV monitor Software was written for the transfer of any stored file of CCD data into the display image buffer. (G.Srinivasulu & R.Srinivasan)

Indigenous design and fabrication of a CCD cryostat

CCDs need to be cooled to near liquid nitrogen temperatures to effectively eliminate dark currents, and require housing in a high vacuum environment to avoid frosting. In order to develop this technology, a joint programme was started between the Institute and the Indian Institute of Science, Bangalore.

A design for a CCD cryostat was made and critically reviewed. The printed circuit board, housing the CCD, and some parts of the first prototype of the cryostat are being fabricated at the electronic laboratory of the Institute. The vacuum sealed connectors will, however, be imported. Temperature monitoring and closed loop control of CCD temperature is being checked.

Fused quartz windows required for this instrument are being fabricated at the optical workshop of the Institute. Vacuum materials selection, mechanical fabrication, leak tests using mass spectrometers and vacuum tests are being done at the IISc. The first prototype is nearing completion and is expected to undergo vacuum tests shortly. The second version of the unit will have aluminium instead of the mild steel outer vessel in order to reduce the weight. (V.Chinnappan, R. Srinivasan, J.C. Bhattacharyya, Subash Jacob* & S. Kasthurirengan*)

Software modifications to the CCD data acquisition programme

Few additional features were incorporated into the CCD data acquisition system at the VBT. These relate mostly to the software control of the instruments like filter wheel movement, focus movement and display, and X and Y movements of the guide camera.

The programme relating to the 9 track magnetic tape on the PC had also to be modified due to the hardware problems in the SBC system controlling the drive. (A.V.Ananth, G.Srinivasulu & R.Srinivasan)

A parallel I/O Card for PC/AT

A parallel I/O card was designed for personal computers, which provides 64 input and 64 output lines. This card is useful for the PC/AT based image data acquisition system operating at the VBT. (A.V.V.Kutty & A.V.Ananth)

Optics division

Active optics, wavefront sensing and evaluation

Two crossed Babinet compensator polarization interferometry is being extended for multiple wavelength applications for online evaluation of the wavefront. A theoretical method was worked out to take into account the intensity integration for a particular bandwidth used during the measurement. It is planned to use this approach in active optics experimentation.

Work is in progress on the development of an active optics system for optimizing the optical quality of thin optical elements for future large telescope projects of the Institute. One 68 cm thin spherical mirror is being prepared for such experimentation. (A.K.Saxena, J.P.Lancelot & J.P.A. Samson)

Solid rotational shear (coherence) interferometer

Experiments were carried out in collaboration with the Raman Research Institute on the evaluation and optical performance of the solid rotational shear interferometer (RSI) fabricated in the optics laboratory of the Institute. Source sizes could accurately be determined from the interferometric data obtained in the laboratory using Fourier methods. It was demonstrated that this RSI can be used for high resolution astronomical imaging. A high degree of alignment accuracy and good seeing condition are imperative for recording of the interferogram. Initial results from VBT trials, showed that an order of magnitude improvement and stability is needed for the interferometer mounting and telescope adaptation. Necessary improvements are being made in the interferometer - telescope combination for future observations. (A.K.Saxena, N. Udyashankar*, K.R. Jayadev*, J.P.A. Samson, L. Yeswanth & K. Shanthi*)

VHRR passive cooler for INSAT-II

Specular polishing of the very high

resolution radiometer sunshield panels for the INSAT-II flight model is in progress. Earlier four sunshield panels of ETM-2 were successfully completed. (A.K.Saxena, J.P.A. Samson, S.Razack & M.G.Mohan)

LSSC project

Technical advice and help were provided for aligning and adjusting the multi-mirror and lens transfer optics of the large space simulation chamber (LSSC) of the Indian Space Research Organisation (ISRO). (A.K.Saxena, R.Ismail Jabibulla & V.Gopinath)

EUV spectroheliometer optics

The fabrication of an 45 cm Gregorian telescope optics for the spectroheliometer to be placed on a NASA Black Brant sounding rocket is under progress. The primary and the secondary mirrors require better than $\lambda/30$ rms surface accuracy. This will require extraordinary care during fabrication. Work on the fabrication of primary and secondary is in progress. (Optics team)

Optical flats for the solar eclipse

The fabrication of five 200 mm diameter flats for the coelostats for the solar eclipse expedition is under progress. (Optics team)

68 cm RC telescope

The fabrication of the two primaries and one hyperboloid secondary, out of the set of three have reached l/8 surface accuracy. (Optics team)

Vacuum coating jobs

The following major aluminizing jobs were undertaken at the 1.5 m vacuum coating plant at Kavalur: (i) 1.2 M telescopes optics of the Japal Rangapur Observatory, (ii) three 60 cm solar tower mirrors for IIA, Kodaikanal, (iii) two 30 cm coelostat mirrors for IIA, Kodaikanal, (iv) several smaller mirrors of the siderostat for the solar laboratory of IIA, Kodaikanal.

An interferometric beam splitter, a 22 cm flat mirror for the Mauritius project, a few partially reflected plates and several other small optics were coated using the 30 cm coating plant at Bangalore. (A.K. Saxena, K.Raman Kutty & aluminising team)

Mechanical engineering division

Solar coronograph at Kodaikanal

The earlier mount and drive for the solar coronograph needs to be modified and the tube to be stiffened. Detailed engineering drawings for the drive and mount were prepared. The work on stiffening of the tube is in progress. A unit for housing the lens and focusing adjustment was also provided. (B.R.Madhava Rao, P.K.Mahesh & P.U.Kamath)

Coelostats and drive systems

Six sets of worm gear of 1 mm module and ratio 200:1, with an accuracy class of DIN 9, were designed and fabricated. Three sets of the same are to be used for the 1991 solar eclipse project. The design for a 9:1 spur gear unit of 1.5mm module and accuracy class of DIN 9 is ready for fabrication.

The structures and drives for one single and two triple mirror coelostat were designed and fabricated for the 1991 solar eclipse. The coelostats have a drive system consisting of a stepper motor, running at approximately 60 rpm. The motor drives a 420.1 reduction gear head. The speed is further reduced by a 2:1 spur gear unit and a 200:1 worm gear unit.

The structure housing the first mirror (in the triple mirror coelostat) incorporates an altitude and azimuth adjustment. The second and third mirrors are mounted on top of a pipe structure. The triple mirror coelostat uses 20 cm and 15 cm plane mirrors, whereas the single mirror system employs a 25 cm plane mirror. (B.R.Madhava Rao, P.K.Mahesh, P.U. Kamath & A.Selvaraj).

Design of a vertical heliostat

A two mirror heliostat for tracking the Sun and for producing a vertical stationary beam was designed for the National Physical Laboratory (NPL), New Delhi. The structure incorporates an altitude and azimuth adjustment. The drive consists of a 1 rpm asynchronous motor driving a 5:1 spur gear unit and a 288:1 worm gear unit. (B.R. Madhava Rao, P.K.Mahesh & A.Selvaraj).

A two mirror heliostat, which will produce a horizontal stationary beam, was designed for the NPL. The primary mirror was placed above a stationary pillar. The mirror was mounted on a worm wheel, which forms part of the drive. The drive is a 1 rpm motor which drives a 5:1 spur gear unit and a worm gear unit of 288:1. The structure also incorporates an altitude and azimuth adjustment. The reflected beam from the primary mirror is inclined to the vertical and is made horizontal by a second mirror, kept at the bottom. (B.R.Madhava Rao, P.K.Mahesh & P.U. Kamath).

Aquisition and guiding unit for the Cassegrain focus at VBT

This unit carries out a precise linear movement of the mirror cell, which is kept at an angle of 45° to the light path from the secondary mirror. The mirror cell houses a 140 x 80 mm flat reflecting mirror with a hole for the programme star and a reflecting surface for selecting the guide star. A separate focusing arrangement for the microchannel CCD and zoom lens has been provided. The limit switch cuts off power supply to the motor when the mirror attains the desired position. (B.R.Madhava Rao, P.U.Kamath, K.Kanagaraj & F. Gabriel)

Fabrication and machining

The mechanical engineering division

also completed the design and fabrication of the modified drive system for the VBT dome encoder, and the VBT dome guide wheel assembly. It also carried out certain mechanical engineering works related to air glow experiments and undertook the modification of the IR photometer for the 1 m telescope at Kavalur. (B.R.Madhava Rao & K.Kanagaraj).

Design of echelle spectrograph

The design work for the echelle spectrograph, to be used at the Cassegrain focus of the VBT, was completed. The fabrication drawings for the main housing and the various sub-assemblies like collimater, echelle grating, cross dispersion grating and camera are ready. (B.R.Madhava Rao & P.K.Mahesh)

Auxiliary instruments

New 12 band photometer

A new twelve band photometer was designed and built at the Bangalore workshop. The photometer has 12 broad band filters which isolate the standard (Johnson) UBVRI bands of the visual region and JHKLM bands of the infrared region in the spectrum. In addition there are two narrow band filters (one with a bandwidth of 50 Å and the other with a bandwidth of 160 Å) for measuring Hα emission flux of the sources. The optical setup uses an interference filter to separate the IR and visual beams from the incoming radiation at the Cassegrain focus and to direct these beams to the respective photometers. This photometer is operational since Jan. 91 at the Cassegrain focus of the 1m telescope at VBO. The programmes include UBVRI, JHKLM and Hα photometry of Be stars and their variability. (K.K.Scaria, R.M.Nair & K.R.Sivaraman)

Extreme ultraviolet (EUV) spectroheliometer

Work on the design and development of the telescope, which forms an integral part of the EUV spectroheliometer payload, progressed satisfactorily. The curvatures of both the primary and the secondary mirrors were generated and the polishing work started. It is now clear that mounting of the primary mirror is the single most important job in designing the mechanical structure of the telescope. After evaluating several possible options, decisions were taken to mount the mirror in a cell with a suitable space grade encapsulating material. The details of the structure are being evaluated numerically, using a finite element method. (S.K.Jain, J.C.Bhattacharyya & A.K.Saxena)

Closure - phase imaging

Recent experiments (1986, Baldwin et al., Nature **320**, 595) with a three-hole aperture mask, using a large telescope, clearly established the potential of closure-phase technique in high resolution imaging. Implementation of this technique on three ground-based telescopes in the optical

domain would enable one to achieve very high resolution. Laboratory simulations of closure-phase technique were carried out to study the fringe pattern using aperture masks of different sizes arranged redundantly as well as non-redundantly. The fringe pattern was obtained through the aperture mask placed in front of a simulated telescope. (S.K.Saha & A.P.Jayarajan)

Fabry-Perot interferometer

Development of the pressure-scanned Fabry-Perot Interferometer (FPI) for high-resolution spectroscopy of OI 630 nm night airglow emissions was completed. The interferometer was installed at the Kavalur Observatory in Jan. 1991, after laboratory validation, with the He-Ne laser (632.8 nm). After field trials a regular observational programme will commence in April 1991. This project was undertaken with primary funding from ISRO/DOS under the RESPOND programme. (J.H.Sastri, H.N. Ranganath Rao, K.B.Ramesh & R.Srinivasan)

HF Doppler sounder

The HF Doppler (phase path) sounder at Kodaikanal is augmented with a second probing frequency at 4.0 MHz to extend the observational programme to the night time period (J.H.Sastri, K.B.Ramesh & J.V.S.V.Rao)

Speckle camera system

A new optical setup for use at the Cassegrain (f/13) focus of the VBT is being developed. The performance of the camera system was checked in the laboratory. Atmospheric seeing was simulated by introducing various static dielectric cells of various sizes etched in glass plate with hydrofluoric acid. An artificial star, a telescope with a focal ratio of f/3.25 and speckle camera system were developed to obtain these speckles. The speckle image was digitized by the PDS micro densitometer and processed using the COMTAL image processing system at the VBO. The results were compared with a computer simulation. The clipping method was used to enhance the grey levels. The clipped image is superposed on the histogram-equalized original image. (S.K. Saha, A.P. Jayarajan, J.C. Bhattacharyya, S. Chatterjee & K.Narayanan Kutty)

PC-486 system

A PC with an Intel 80486 chip was acquired. The CPU chip of the system contains a math co-processor and 8K cache memory, which accelerates the calculation of mathematical functions. The system has 4 MB RAM, 155 MB SCSI drive and a UNIX operating system. From benchmark tests, it was found that programmes which do not require large memory, run 30 to 40 times faster on this machine compared with the MF II computer at the computer centre of the Institute. On the other hand, programmes which require large memory and employ matrix manipulations are executed 7 to 9 times faster than the MF II computer. (D.Mohan Rao)

Radio astronomy

Broadband array for solar work at Gauribidanur

The existing "T" can be used at a frequency of 34.5 ± 0.5 MHz only. It was used for studies of extended H II regions, supernova remnants, extragalactic sources, background survey etc., in addition to solar observations. The construction of a broadband "T" telescope operating in the frequency range 30 to 120 MHz mainly for solar work is in progress. It consists of two arrays: The gain of eash LPD is ≈ 10 db and the effective area of the "T" ≈ 130 λ^2. The beam-widths range from 30 arc min. at 30 MHz to 7 arc min. at 120 MHz. The receiver is a 128 channel digital correlator. The radio maps of the sun with this instrument can be made by the end of this year. (Ch. V. Sastry & K.R.Subramanian)

Acousto optic spectrograph for solar burst studies

The AOS has a bandwidth of 30 MHz and 1760 channels. This is being used with 64 element biconical array and a VAX/730 computer for high time (200 ms) and frequency (30KHz) resolution studies of solar radio bursts. The instrument is in operation for about a year. (Ch. V. Sastry, K.R.Subramanian & E.Ebenezer)

VLBI system

A VLBI System for use at decametric wavelengths was developed and tested. The system is based on two Rb oscillators and has a bandwidth of 125 KHz. The data acquisition systems consists PC-XT's with 40 MB cartridge drives. The data is processed on a VAX 11/780 computer for which the necessary software was developed. This system will be used to study some strong sources and also for solar radio bursts. (Ch.V.Sastry & P.S. Ramkumar*)

Indo-Mauritius radio telescope

The construction of an aperture synthesis radio telescope operating at 150 MHz for observations of the galactic center and the southern galactic plane is in progress. This telescope is located on the island of Mauritius at a latitude of 20°S. It consists of a fixed array of 1024 helical antennas on a base line of 2 km in the East-West direction and 32 movable antennas on a rail track of length 1 km in the North-South direction. We plan to use a 1024 channel digital correlator for producing radio maps with a resolution of three arc minutes and a sensitivity of about 100 millijanskys. This telescope is expected to become operational around mid-1992. (Ch.V.Sastry & Raman Research Institute group)

National Facilities

VAX 11/780

MIDAS installation

Efforts were made to install the MIDAS (Munich Image Data Analysis System) package on the VAX 11/780 at Kavalur. Preliminary tests indicate satisfactory operation of the packages, except for the display related portions. The display routines, developed at the European Southern Observatory, support only a Gould/Deanza device. Presently, efforts are on to modify a set of routines called IDI (Image Display Interface) in order to display images on the COMTAL at the VBO. (A.V.Ananth & K.N.Kutty)

Reduction of spectroscopic data

The RESPECT software package was updated further to facilitate input from both the CCD systems available at the Institute, and also FITS format data in one and two dimensions. Some image arithmetic, extraction of specific rows and columns, and power spectral analysis of rows/columns for evaluation of the CCD are all available. A command to extract spectra using Horne's algorithm was optimized for data from the Universal Astronomical Grating Spectrograph. The command can also subtract sky exposed on either side of the star spectrum. The sky is smoothed over the continuum, but not at the location of lines. (T.P. Prabhu & G.C. Anupama)

Reduction software: detection of moving objects

Computer programmes for the detection of moving objects, developed originally at the Space Watch Project, Tucson for the Perkin Elmer 3241 system, are being implemented with necessary modifications on the VAX 11/780 computer at the VBO. In the scanning mode, the telescope is kept stationary and the charges from the CCD are shifted continuously at the rate by which the star image drifts across the CCD.

The CCD images from each region can be reduced essentially in two steps. The first step involves detecting the moving object and determining its pixel coordinates on the frame and in the second step determines the precise coordinates of the object and updates the expected positions for follow up.

The first step involves background subtraction, location of stellar images and the elimination of false detections like cosmic rays. Three scans of the same region are then aligned using one dimensional cross correlation techniques. After removing the stars which appear in the same relative position in all three scans, the candidates for moving objects are listed after checking for consistency in motion and brightness. The programmes for data handling and image display were developed so that images could be displayed on the Comtal device at the VBO. (R.Rajamohan & S.G. Bhargavi)

Speckle image processing

The scheme of iterative blind deconvolution technique of the two convolved functions was applied using a programme developed by P.Nisensson of the Center for Astrophysics, Harvard, U.S.A. Atmospheric phase errors introduce an unknown convolution into the imaging. This technique is appropriate for data having large phase errors with a small data sample. The speckle data obtained at the laboratory are being used as an input to decompose into the convolution of two images. Necessary software to run this programme at the VAX 11/780 was also developed. (S.K.Saha & K.Narayanan Kutty)

2.34 m Vainu Bappu telescope

Gain calibration of Astromed CCD system

The value of system gain, known alternatively as gain factor or transfer factor, was determined for the Astromed CCD system at two different settings of amplifier gain. The Astromed 'standard setting' of amplifier gain was 34. The system gain was determined by studying the photon noise, using the flat-fields in the I band obtained, during observations in January 1990 with the GEC 8603/B chip belonging to TIFR. The system gain was 0.95±0.01 counts per electron. As this gain is too high and reduces the dynamic range to a very low value especially for sky-background limited observations, the amplifier gain was reduced to the setting 9.2 during January 1991. Using the GEC 8603/A chip belonging to IIA, and using the flat-fields obtained at the laboratory, as also during the observations in February 1991, the system gain was determined to be 0.25±0.01 counts per electron. The readout noise in the latter chip is about 8 electrons. Hence the optimized system gain for both the read-out-noise-limited and sky-background-limited observations would be lower than the present by a factor of 2. (T.P. Prabhu & G.C. Anupama)

Performance of ICCD

Speckles were observed and recorded using the intensified CCD at the Cassegrain focus of the VBT. The frame grabber card (DT 2851) was used to acquire speckle images. It is found that the camera is able to record speckles in the frame time of 20 milli sec. Due to the limited number of buffers that can acquire data on line, it may not be an ideal instrument to record speckles. (V.Chinnappan, S.K.Saha & Faseehana)

Additional ICCD camera for guiding

One more ICCD camera was purchased during the year for slit guiding at the Boller & Chivens spectrograph mounted at the Cassegrain of focus of the VBT. Another camera was mounted at the Cassegrain offset unit for field guiding. The console

room display monitor can be conveniently used for guiding. (V.Chinnappan & N. Kameswara Rao)

Dome automation

The 2.34m VBT dome automation work was completed. It was found that the data sent by the dome encoder was noisy and unreliable. The data was transmitted by a 75 m cable which is not a twisted pair nor individually shielded. Differential line receivers were mounted in the console to receive the data from the encoders instead of single ended ones. This has improved the reliability of dome encoder data.

The encoder used is a 128 turn, 16 bit binary, having differential ouput drivers. The encoder is driven by a friction wheel. The wheel diameter is such that the friction wheel makes 128 rotation for one rotation of the dome so as to match the turns of the multiturn encoder.

A personal computer, mounted at the console, reads the dome encoder data and computes the equivalent azimuth of the dome. The dome centre and telescope centre do not coincide exactly which created some non-uniformity in positioning. The empirically corrected value is compared with the telescope value. A PC reads the 20 bit binary values of absolute encoders mounted in both axes of the telescope and computes the hour angle and declination (DEC). It reads the sidereal time and computes the right ascension (RA). Using latitude, azimuth and altitude are computed. All these parameters are displayed on the monitor.

The desired position in RA and DEC can be read from the file created by the pointing and modelling programme. This programme computes the correction required for refraction, telescope flexure, nutation and precession. The corrected coordinate is given as an input to this programme. The dome can start moving even before the telescope is positioned, thus saving time. The system is found to work satisfactorily. (V.Chinnappan & Faseehana)

Auto-guider based on an ICCD

In the remote guiding mode, the intensified CCD shows up to 13.5 magnitude stars at the Cassegrain focus of the VBT. Even though fainter stars are seen, it may not be possible to guide manually.

In the auto-guider mode the star position in the ICCD is used as the feedback signal to the servo loop to control the telescope automatically. The programme first acquires many frames (usually up to 10) from the ICCD. The image frame is multiplied by a constant. This increases the background noise also. It is then offset by another suitable constant. The brightest star in the field is selected and its position is indicated to the user. The difference in centroid in two successive intervals is resolved using two orthogonal coordinates. After suitable

scaling, this value is used to generate a number which can be given to a digital to analogue converter (DAC). The DAC output is used for control of the telescope and its value is superimposed on the existing tracking voltage. Certain application software was written and tested in simulated conditions. (V.Chinnappan & Faseehana)

Servo performance

The telescope drive system functioned well during this year. The servo parameters like amplifier gain, counter torque settings, tacho generator feedback and the motor current feedback remained fairly stable. (V.Chinnappan & R.Srinivasan)

Primary mirror realuminisation

The 2.34 m primary mirror was realuminised in June 1990 and aligned for the prime focus mode. Many changes in the telescope mechanical system were incorporated. These changes required readjustment of the Cassegrain optical system. (Optics team)

Additional instrumentation

The first version of the Cassegrain offset guiding system with a scale reduction and a field of view 4 arc min was installed. (F. Gabriel, A.K. Saxena, N.K. Rao, B.R. Madhava Rao & P.U. Kamath)

The B&C spectrograph was made operational at the Cassegrain focus of VBT. The experiments are being continued to link the prime focus image to the B&C spectrograph with optical fibers. The image acquisition part has to be optimised. (N.K. Rao, A.K. Saxena & F. Gabriel)

As a part of the programme to monitor the temperature, pressure and humidity during the night at VBT dome and the coudé floor, temperature probes were obtained. These are currently being checked and installed at the site. A PC to acquire data was also procured. (N.K. Rao, R. Srinivasan & V. Chinnappan)

Jobs done on the PDS

Sl.No.	Nature of the project
1.	Development of image processing techniques for improvement of signal to noise ratio using Fourier techniques.
2.	Scanning of the speckles of an aritificial star image to retrieve the error free information of the source.
3.	Scans of star trail frames around the north pole and around the 2.34 m telescope.
4.	Time sequence spectroscopy in the CaII K line of the solar chromosphere to study (i) the dynamical properties of the arc second structures in the solar chromosphere, (ii) temporal variations in the Na I D lines.
5.	i) Scans of granulation frames from observations at the National Solar

Observatory, at Sacramento Peak, U.S.A. to measure the contrasts of selected frames,

ii) Summer Students' 1991 project on measuring Zeeman splitting using observations made at the Solar Tower, Kodaikanal.

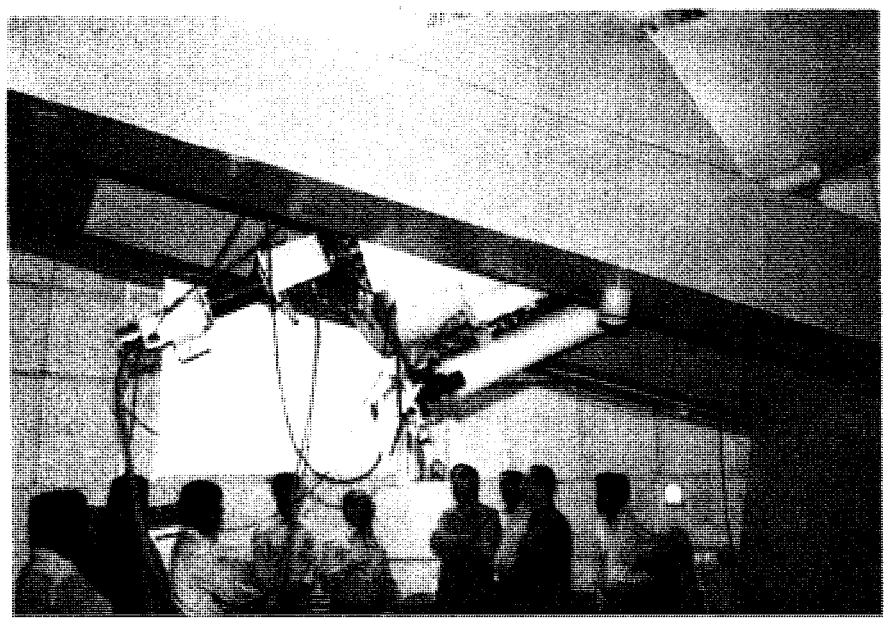
6. i) Digitization of Kodaikanal Ca II K spectroheligorams for study of global magnetic oscillation of the Sun and of the time variations in solar differential rotation,

ii) Spectroscopy of Ca II K line spectra obtained at Kodaikanal for studies of the Sun to determine chromospheric rotation, differentiall rotation and variation of rotation with time.

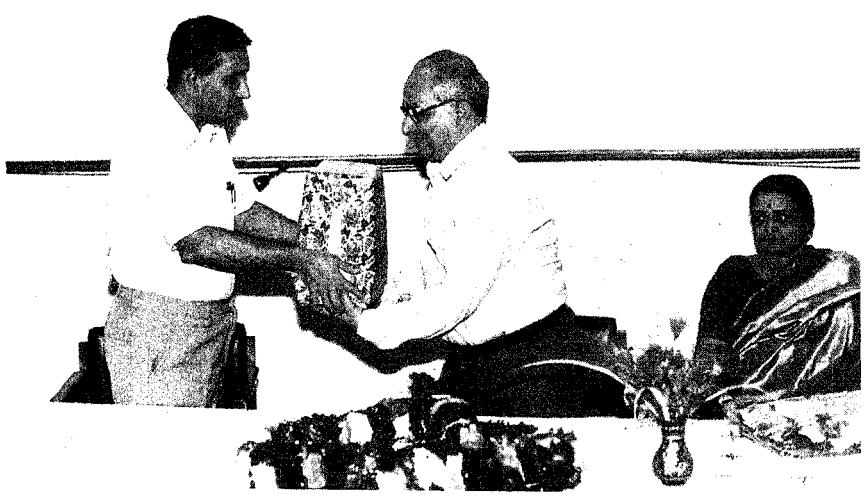
7. Spectroscopy of emission line stars.

8. Scanning of the Hα spectra obtained in a same of late G and K supergiants.

9. Spectroscopy of recurrent novae RS Ophiuchi and TCrB in quiescence in order to determine the long term variation of emission line fluxes and the spectral type of the secondary.



Visit of the Research Advisory Committee for Instrumentation to VBO, Kavalur on 10.5.1990.



On his retirement as Director Indian Institute of Astrophysics, Prof. J.C.Bhattacharyya being presented with a memento by Prof. K.R.Sivaraman.

Growth of Astronomy

Ph.D programme

G.C.Anupama submitted her Ph. D thesis entitled *Studies of Classical and Recurrent Novae* to Bangalore University.

R. Gangadharamurthy, K.M.Hiremath, M.F. Ingalgi, Y.D.Mayya and Prasannalakshmi are continuing their research for the Ph.D degree.

The following students have joined the Ph.D programme of the Institute: B. Eswar Reddy, N. Annapurni, D.Banerjee, G.Uma, S.K. Sengupta and M. Dikpati (CSIR-JRF,JAP).

Four physics teachers from Bangalore were enrolled as external candidates for the Ph.D degree. They are: A. Mathew, N.D.N. Prasad (M.S. Ramaiah College), T.D. Sreedharan (Mt. Carmel College), C. Chowdappa (Govt. P.U. College) and N.Sunder Rajan (Christ College).

Teaching of astrophysics and astronomy

The Institute gave full support to Bangalore University to introducing two special papers in Astrophysics at M.Sc (physics) level. This included help in framing the syllabus, providing expertise and facilities for students' practicals, arranging students' visits to the Institute's observatories, etc. J.C.Bhattacharyya, A.Peraiah, M.H.Gokhale (coordinator), J.H.Sastri, R.K.Kochhar, D.C.V.Mallik and A.V.Raveendran taught the students during the academic year 1990-91.

S.P.Bagare gave several lectures on *the applications of Spectroscopy to Astrophysics* in a UGC sponsored course on Molecular Spectroscopy, for college teachers, held at the University of Mysore during Nov. 1990. He also guided the M.Sc. (physics) students of the Bangalore University to conduct observational experiments in Solar Physics, as a part of their astrophysics course.

J.C.Bhattacharyya evaluated the thesis *'Fast Photometric study of some cataclysmic variables'* by Jyoti Singh, and conducted the viva for the award of Ph.D. degree at the Bombay University, Nov. 1990. He also gave a series of lectures on 'Astronomical techniques' to the M.Sc. (physics) students of Bangalore University, July-Aug. 1990.

H.C.Bhatt taught the course *AA 365 Galactic and Extragalactic Astronomy* in the Joint Astronomy Programme at the Indian Institute of Science, Bangalore.

K.K. Ghosh guided two M.Sc students of the American College, Madurai for their summer projects on *'Spectroscopy of Be stars'* during May-June 1990. Three B.Sc students of the Sacred Heart College, Tirupattur completed their B.Sc dissertations on Astrochemistry under his guidance during Jan.-March 1991.

D.C.V.Mallik taught part of the Astrophysics II special paper to the M.Sc. Final year students of Bangalore University, Aug. - Sep. 1991. He delivered a course on *Stellar Astronomy* to students of JAP, IISc during Jan. - April 1991.

M.Parthasarathy evaluated the Ph.D. thesis entitled "*Photometric study of two southern Algol type binaries*" by Moti Lal Vyas, Department of Astronomy, Osmania University and conducted the viva for the award of Ph.D. degree by the Osmania University. Moti Lal Vyas was awarded the Ph.D. degree.

M.Parthasarathy evaluated the Ph.D. thesis entitled '*Development of a stellar spot model and its application to* α^2 *CVn*' by Praveen Nagar, Department of Astronomy, Osmania University for the award of Ph.D. degree by Osmania University. Praveen Nagar was awarded the Ph.D. degree.

M.Parthasarathy was appointed as the external examinar, Department of Astronomy, Osmania University for M.Sc. (Final) Astronomy Practical paper IV '*Photometry and Binary stars*' for the examinations held in June 1989 and May 1990.

A.Peraiah gave thirty lectures on *Stellar Atmospheres* to the M.Sc. second year Physics students of Bangalore University.

T.P.Prabhu delivered two talks on *Optical Astronomy* at the IUCAA TIFR introductory summer school on Astronomy and Astrophysics, Pune, June 4-29, 1990.

J.H.Sastri gave a course on *Planetary Atmospheres* as a part of the syllabus for special papers in astrophysics for M.Sc. (physics) students of Bangalore University.

Institute sponsored meetings

The second VBT workshop was held at the VBO, Kavalur on April 19-20, 1991.

National Seminar on Plasma Sciences Technology, held at Calcutta (Jadavpur University) Dec 4-8, 1990.

The Indian Academy of Sciences First Kodai Workshop on "Optical Interferometry" held at Kodaikanal during August 10-17, 1990.

The DST's Working Group meeting on "Research in Geophysical Fluid Dynamics" chaired by Dr P.R. Pisharoty, during Sept 2-4, 1990.

The Institute participated in the Science & Technology Exhibition of the 78th Session of the Indian Science Congress, Indore.

Lectures/Colloquia by visiting scientists

The 5th IIA bicentennial commemorative public lecture was delivered at the Institute on 6th Feb. 1991 by Dr. A.P.J. Kalam, Director, Defence Research and Development Laboratory, Hyderabad. The title of his talk was *Rocket Technology and its Streams.*

T.N.Rengarajan (Tata Institute of Fundamental Research, Bombay). *Star formation in spiral galaxies: A global view.* (3.4.90)

A. Rai Choudhuri (Indian Institute of Science, Bangalore). *From the solar dynamo to sunspots: Questions & puzzles.* (24.4.90)

U.Y.Sharma (University of Connecticut, USA). *Gaussian electrodynamics.* (8.6.90)

R.R.Rausaria (Regional Engg. College, Srinagar). *Energetic electrons and their radiation signature in solar flares.* (14.6.90)

M.R.Deshpande (Physical Research

Laboratory, Ahmedabad). *Photometry and polarimetry of Markarian 421.* (14.6.90)

P. Wiita (Georgia State University, USA). *Rapid variability in optical and radio emission from AGN.* (13.7.90)

D. Raina (National Institute of Science, Technology and Development Studies, New Delhi). *Against colonial science.* (24.7.90)

D.L. Lambert (University of Texas at Austin, USA). *High resolution spectroscopy of interstellar CH, CH^+ and CN lines.* (27.7.90); *Do stars synthesize lithium?* (20.8.90); *The s-process in stars: The neutron density in the He-burning shell.* (21.8.90)

Chanda Jog (Indian Institute of Science, Bangalore). *A triggering mechanism for enhanced star formation in colliding galaxies.* (11.9.90).

I.P.Williams (Queen Mary College, London). *Inter-relations between asteroids and comets: observational tests.* (12.9.90); *Evolution of meteor streams.* (14.9.90)

Y.Sobouti (Shiraz University, Iran). *Symmetries of Liouville's Equation.* (1.10.90); *A Lagrangian formulation of non-equilibrium ensemble theories.* (4.10.90)

M. Valtonen (University of Turku, Finland). *Dark matter.* (18.10.90); *Black holes in the centres of galaxies.* (19.10.90)

N.Bhandari (Physical Research Laboratory, Ahmedabad). *Cometary impacts and stress on terrestrial life.* (15.11.90)

A. Chokshi (Princeton University, USA). IR imaging of high-z radio galaxies (10.12.90)

A.K.Mitra (Bhabha Atomic Research Centre, Bombay). *Ultra high energy gamma ray production in Cygnus X-3 and associated high energy processes.* (19.12.90)

P.K.Shukla (Ruhr University, Bochum, Germany). *Modulation of non-thermal Alfven waves.* (20.12.90)

I.W.Roxburgh (Queen Mary College, London, UK). *Angular momentum loss instabilities and mixing in stars.* (3.1.91).

M.R.Kundu (University of Maryland, USA). *Millimeter of interferometric observations of solar flares.* (10.1.91)

A.Ghosh (Indian Institute of Technology, Kanpur). *A model of inertial induction; some astrophysical and cosmological consequences.* (4.1.91)

A.G.Muslimov and A.I.Tsygan, (Ioffe Institute, Leningrad, USSR). *The electrodynamics of a neutron star in general relativity.* (16.1.91)

G.S.Murthy (Bhabha Atomic Research Centre, Bombay). *Ensemble concepts in physics and geophysics.* (20.2.91)

Yu.D.Zhugzhda (IZMIRAN, Moscow, USSR). *Waves in stratified atmospheres.* (19.2.91); *Space project CORONAS.* (25.2.91)

A. Kembhavi (IUCAA, Poona). *Quasar spectra: simplicity from complexity.* (22.2.91)

A.Z. Kazbegi, G.Z. Machabeli, G.I. Melikidze. (USSR) *Pulsar radiation processes.* (27.2.91).

Awards/Honours

G.S.D.Babu and Jagdev Singh were awarded certificates by the Government of India for participating as members of the summer team of the Ninth Indian Scientific Expedition to Antarctica in the year 1989-90. They also received Equator Crossing certificates from the Captain of the ship MV Thuleland. G.S.D.Babu was selected as a scientist member of the Core Group during the Ninth Indian Scientific Expedition to Antarctica.

N. Kameswara Rao received the Hari Om Ashram Prerit Vikram Sarabhai award for Space Sciences for 1989.

C.Sivaram received an honourable mention at the May 1990 competition of the Gravity Research Foundation, U.S. for his paper *Torsion, wormholes and the problem of the cosmological constant in the early universe*. He was also named co-director of the World Laboratory (Geneva) E-S international project to study the fundamental properties of gravity in relation to other basic interactions.

R. Sagar was awarded a research fellowship by the Alexander von Homboldt Foundation.

National Science Day

Continuing the tradition of the last few years, IIA, Bangalore organised an Open House Day on Feb. 28, 1991 as part of the National Science Day programme. More than 800 students along with their teachers from neighbouring schools, in addition to the general public, visited the Institute on this day. They were shown the visitors' gallery, which has various original historical instruments belonging to the Institute. In the optics laboratory the major attraction was a display of the imaging property of a concave mirror, besides the indigenously fabricated instruments. A live demonstration was organised for the first time of sunspots by projecting the Sun's image on a screen using a 3" telescope.

Two video films titled Beyond vision: a story of telescopes at VBO and the Physics of the Sun were shown in the concluding part of the visitors' programme. (G.S.D. Babu, S.P.Bagare & A.Vagiswari).

IIA and MAPCOST programme

Under a joint programme (between the IIA and MAPCOST, the Madhya Pradesh Council of Science and Technology) the IIA assisted MAPCOST to acquire one 8" reflector telescope and installed it at Pachmarhi inside the campus of the High Energy Gamma Ray Observatory of the Tata Institute of Fundamental Research. The telescope is equipped with a digital visual photometer and will be used by the MAPCOST scientists in collaboration with IIA for seeing and extinction measurements, and photometry of variable stars. (K.K.Scaria).

Library

During the year the Library added 401 books to its stock, bringing the total collection to 11067. The Library subscribed to 132 Journals and continued receiving 65 observatory publications.

The Library has an inter-library loan arrangement with other scientific libraries in the city. Scientific and technical information was disseminated through the IIA preprint list, IIA technical reports and through the Institute publication Recent Research in Astronomy and Astrophysics. A database of books using the CDS/ISIS software package is progressing. The Library compiled a catalogue of astronomy and astrophysics periodical holdings of all the important astronomy libraries in India.

The Library became a member of the international network 'Easynet' using the Indian computer gateway Videsh Sanchar Nigam, Bombay. Using Easynet it is possible to access a large number of databases all over the world. The Library is also making use of electronic mail to receive IAU telegrams from the Central Bureau of Astronomical Telegrams. The Library has also acquired access to SIMBAD (Set of Identifications Measurements and Bibliography for the Astronomical Data) of the Stellar Data centre at Strasbourgh and uses it regularly for scientists at the IIA and at other institutes.

A.Vagiswari, attended the Fourteenth meeting of the Astronomical Society of India, and the Workshop on Library and Information Services in Astronomy held at the Physical Research Laboratory, Ahmedabad. She also participated in a meeting at ISRO, Bangalore on Nov. 21, 1990, which was organised to promote inter-library co-operation and resource sharing among science libraries.

Christina Louis attended a 6 weeks' course on dbase III. H.N. Manjunath attended a short term course on CDS\ISIS during Jan.-Feb. 1991 conducted by INSDOC, New Delhi.

Staff List

(Academic and Technical as of March 1991)

Academic Staff:

J.C. Bhattacharyya	Director (upto 31.8.90)
K.R. Sivaraman	Director (Acting) (w.e.f. 1.9.90)
M.H. Gokhale	Professor
N. Kameswara Rao	Professor
A. Peraiah	Professor
J.H. Sastri	Professor
Ch. V. Sastry	Professor
G.A. Shah	Professor
B. Datta	Associate Professor
S.S. Hasan	Associate Professor
R.C. Kapoor	Associate Professor
R.K. Kochhar	Associate Professor
V. Krishan	Associate Professor
D.C.V. Mallik	Associate Professor
M. Parthasarathy	Associate Professor
T.P. Prabhu	Associate Professor
R. Rajamohan	Associate Professor
P. Venkatakrishnan	Associate Professor
G.S.D. Babu	Reader
S.P. Bagare	Reader
H.C. Bhatt	Reader
P.K. Das	Reader
K.K. Ghosh	Reader
S.K. Jain	Reader
A.K. Pati	Reader
P.K. Raju	Reader
R. Sagar	Reader
K.K. Scaria	Reader
J. Singh	Reader
C. Sivaram	Reader
S. Chatterjee	Fellow
S. Giridhar	Fellow
A.V. Raveendran	Fellow

K.R. Subramanian	Fellow
G. Thejappa	Fellow
R. Vasundhara	Fellow
S.S. Gupta	Scientific Officer 'SC'
J.P. Lancelot	Scientific Officer 'SC'
S. Mohin	Scientific Officer 'SC'
P.M.S. Namboodiri	Scientific Officer 'SC'
P.S.M. Aleem	Research Associate
S.S. Chandramouli	Research Associate
R. Kariyappa	Research Associate
D. Karunakaran	Research Associate
S.G.V. Mallik	Research Associate
M.V. Mekkaden	Research Associate
D. Mohan 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
L. Yeshwant	Research Associate
J. Javaraiah	Research Associate

Scientific/Technical Staff:

A.P. Jayarajan	Consultant (Optics Division)
A.K. Saxena	Head: Optics Division
R. Srinivasan	Sr Principal Scientific Officer
A.V. Ananth	Principal Scientific Officer
B.R. Madhava Rao	Principal Scientific Officer
A. Vagiswari	Librarian
V. Chinnappan	Sr Computer Engineer
N. Selvavinayagam	Civil Engineer
R. Sivashanmugam	Technical Officer
G. Srinivasulu	Engineer (Elec. & Comp. Sci.)

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

Emeritus Scientist:

J.C. Bhattacharyya	CSIR Emeritus Scientist

Visiting Scietists:

C. Uberoi	Visiting Professor (Indian Institute of Science)
R.R. Rausaria	Visiting Scientist (Regional Engg College, Srinagar)
C.T. Vanajakshi	Visiting Fellow
A. Satya Narayanan	Visiting Fellow
A. Goswami	Senior Research Fellow (CSIR)
S.K. Sen Gupta	Junior Research Fellow (CSIR)

Research Scholars:

N. Annapurni	Junior Research Fellow
G.C. Anupama	Senior Research Fellow
D. Banerjee	Junior Research Fellow
M. Dikpati	JAP Research Fellow (CSIR)
B. Eswar Reddy	Junior Research Fellow
R.T. Gangadhara	JAP Research Scholar
A. Mathew	Teacher - Fellow

Y.D. Mayya	JAP Research Fellow
H.N. Ranganatha Rao	Junior Research Fellow
G. Uma	Junior Research Fellow

Visiting Teachers: (External candidates for Ph.D degree)

C. Chowdappa	Govt. P.U. College
N.D.N. Prasad	M.S. Ramaiah College
T.D. Sreedharan	Mt Carmel College
N. Sundar Rajan	Christ College

Appendices

Appendix A

Research Publications

Babu,G.S.D. (1990) J.Astrophys. Astr. (in press). *Study of young clusters as tracers of spiral features in our Galaxy. Paper 5: NGC 2236 (OC1 501).*

*Banerjee, D.P.K., *Anandarao, B.G., Jain, S.K. & Mallik. D.C.V. (1990) Astr. Astrophys. **240**, 137. *Kinematic studies of five galactic planetary nebulae.*

*Bertotti,B. & Sivaram,C. (1991) Nuovo Cimento B (in press). *Radiation from the fifth force field.*

Bhatt,H.C.& Sagar,R.(1991) J. Astrophys. Astr. (in press). *Emission line CCD imaging of three southern symbiotic stars.*

Bhattacharyya, J.C., Scaria, K.K., Jagdev Singh, Babu,G.S.D., Nair,R.M. & Sivaraman, K.R. (1990) Bull. Astr. Soc. India. **18**,1. *Atmospheric extinction at Leh in near infrared bands.*

*Cannon,R.D., Sagar,R. & *Hawkins,M.R.S. (1990) Mon. Not. R. Astr. Soc. **243**, 151. *CCD photometry of the distant southern globular cluster NGC 5824.*

Chinnappan,V., Saha,S.K. & Faseehana (1991) Kodaikanal Obs. Bull. (special issue), Eds. A.K.Saxena & A.Vagiswari (in press). *Intensified CCD camera based remote guiding unit for VBT and observation of speckles with CCD.*

Das,P.K. (1991) Ap. J. (in press). *The quasar galaxy pair 3C 232/NGC 3067.*

*De Sabbata,V. & Sivaram,C. (1990) *Nuovo cimento **105B**, 1181 Particle magnetic moments in Kaluza-Klein strong gravity.*

*De Sabbata,V. & Sivaram,C. (1990) *Nuovo Cimento **105B**, 603 The neutrino magnetic moment in the early universe.*

*De Sabbata,V. & Sivaram,C. (1991) *Astrophys Sp. Sci. **176**, 141. Torsion and inflation.*

*De Sabbata,V. & Sivaram,C. (1991) Intern. Journ. Theoret. Phys. **30**, 123. *Torsion, wormholes and the problem of cosmological constant.*

*De Sabbata, V., Sivaram,C., *Borzeszkowski, H.V. & *Treder, H.J (1991) Ann.der Physik (in press). *Quantum general relativity, torsion and uncertainty relations.*

*De Sabbata,V., *Pronin,P.I. & Sivaram,C. (1991) Intern. Journ. Theoret. Phys. *Neutron interferometry in gravitational field with torsion (in press).*

*De Sabbata,V., Sivaram,C., & *Dingxiong Wang (1991) Ann.Der Physik (in press) *Can black hole entropy be quantized?.*

*De Sabbata,V., & Sivaram,C. (1991) Foundations of physics (in press) *Universality of charge arising from torsion.*

* Names of coworkers from external institutions

*De Sabbata,V., & Sivaram,C. (1991) Gen. Rel. (in press) *Maxwell electro-dynamics in space with torsion.*

*De Sabbata,V. & Sivaram,C. (1991) Nuovo Cimento (in press) *Gravimagnetic field, torsion and gravitational shielding-II.*

*De Sabbata,V. & Sivaram,C. (1991) in vol. II devoted to 85th Jubilee of D.D. Ivanenko, Ed. P.I.Pronin, World Scientific, Singapore (in press). *Torsion and quantum effects.*

*De Sabbata,V. & Sivaram,C. (1991) in Vol. devoted to 80th Jubilee of Ya.P. Terleski (in press). *Negative mass and torsion.*

*De Sabbata,V. & Sivaram,C. (1991) Ann der Physik (in press). *A Born-Infeld type of modification of general relativity with maximal curvature.*

*De Sabbata,V. & Sivaram,C. (1991) Ann.der Physik (in press). *Entropy and spin of black holes.*

*Foing,B.H., * Char, S., * Jankov, S., *Catala,C., Ghosh,K., * Vogt,S. & Zihe,G. (1991) Astr. Astrophys. (in press). *Active surface structure and first detection of optical flares on HR 1099 from the MUCICOS 89 campaign.*

Gangadhara,R.T.& Krishan,V.(1990) J. Astrophys. Astr. **11**,515. *Radio wave heating of astrophysical plasmas.*

Gangadhara,R.T.& Krishan,V.(1990) in Proc. of meeting on Variability of Active Galactic Nuclei, Eds. D.Miller & P.J.Witta (in press). *Parametric instability in 3C 273.*

Giridhar,S., Aruna Goswami., Rao,N.K. & *Lambert,D.L. (1990) in Proc. IAU Symp.145 *On Evolution of Stars: The Photospheric abundance connection, Eds. G.Michaud & A.Tutukov.The chemical composition of R Coronae Borealis stars.*

Giridhar, S., *Ferro, A.A. & Goswami, A. (1990) in Proc.IAU Symp.145 On Evolution of Stars: The photospheric abundance connection. Eds.G.Michaud & A.Tutukov. *Spectroscopic studies of F-G supergiants showing semi-regular light variation.*

Giridhar, S., *Ferro, A.A. & Goswami, A. (1991) J.Astrophys. Astr.**12**,27. *Abundance analysis of the long period southern Cepheid RZ Vel.*

Hasan,S.S. (1991) Ap. J., 366, 328. *Magnetoatmospheric Oscillations in Sunspot Umbrae.*

Hasan,S.S., 1990, in Fourth Regional Conference on Mathematical Physics, Eds. F.Ardalan & S. Rouhani, World Scientific Press (in press). *Oscillations in Magnetized Structures on the Sun.*

Hasan,S.S., 1991, in Mechanisms of Chromospheric and Coronal Heating, Eds. P.Ulmschneider E.Priest & R.Rosner, Heidelberg (in press). *Heating in Intense Flux Tubes.*

Jain,S.K.& Srinivasulu,G. (1991) Opt.Eng. (in press). *A star-and-sky chopping polarimeter : Design and performanace.*

Kapoor,R.C (1990) in Proc.IAU Coll.128 (in press). *Effect of light bending and redshift on the pulsar beaming : The case of shorter neutron stars.*

Kapoor,R.C.(1991) Ap.J.(in press). *The contribution of light bending and redshift to the pulse characteristics of pulsar in the case of shorter neutron stars.*

Kariyappa,R., Sivaraman,K.R.,& Anandaram, M.N. (1990) J.Vigyana Bharathi (in press). *Direct observational evidence for the heating of the solar chromosphere.*

Kochhar,R.K. (1990) in Proc. IAU Coll. No.124 on Paired and Interacting Galaxies, Eds: J.W.Sulentic, W.C.Keel & C.M.Telesco, NASA **3098**,315. *On a connection between supernova occurence and tidal interaction in early-type galaxies.*

Krishan,V. (1991) Mon. Not. R. Astr. Soc. (in press). *A model of solar granulation through inverse cascade.*

Krishan,V. & Sivaram,C. (1991) Mon. Not. R. Astr. Soc. (in press). *Clustering of galaxies by inverse cascade in turbulent medium.*

Krishan,V., Sreedharan,T.D. & *Mahajan, S.M. (1991) Mon. Not. R. Astr. Soc. (in press). *Vlasov-Maxwell equilibria of solar coronal loops.*

Krishan,V. & *Wiita ,P.J. (1990) Mon. Not. R. Astr. Soc.**246**, 597. *Coherent plasma processes and the continuum emission in active galactic nuclei.*

*Lambert,D.L., Rao,N.K. & Giridhar,S. (1990) J. Astrophys. Astr. **11**,475. *High resolution spectroscopy of R Coronae Borealis during the 1988-1989 minimum.*

Mallik,D.C.V. (1991) Proc. Astr. Soc. Australia (in press). *Planetary nebulae: Origin and evolution.*

Mallik,S.V., Mallik,D.C.V. & Mohan Rao, D. (1991) Astr. Astrophys. (in press) *Effect of Lyman radiation transfer on the formation of the Hα line in supergiant chromospheres.*

Mallik,S.V. (1990) Publ. Astr. Soc. Pacific **102**, 1148. *Role of nonthermal velocity fields in determining the Hα widths in supergiant chromospheres.*

Mekkaden,M.V., *Sinachopolous,D. (1991) Mitteilungen der Astronomische Gesellschat (in press). *Periodic activity in the T Tauri star V4046 Sgr.*

Namboodiri,P.M.S. & Kochhar,R.K. (1991) Mon. Not. R. Astr. Soc. (in press). *Spin angular momentum of tidally affected galaxies.*

Namboodiri,P.M.S. & Kochhar,R.K. (1990) Mon. Not. R. Astr. Soc. **243**,276. *Tidal change in the energy of a spherical galaxy.*

Namboodiri,P.M.S. & Kochhar,R.K. (1990) in Proc.IAU Coll.No.124: Paired and Interacting Galaxies, Eds J.W.Sulentic, W.C.Keel & C.M.Telesco) NASA CP **3098**,589. *Energy and angular momentum transfer in binary galaxies.*

Namboodiri,P.M.S. & Kochhar,R.K. (1991) in Proc. IAU Coll.132. on Instability chaos and predictability in celestial mechanics and stellar dynamics (in press), Ed. K.B. Bhatnagar. *Roche instability in binary stellar systems.*

*Pandey,A.K., *Mahra,H.S. & Sagar,R. (1990) Astr. J. **99**, 617. *The young open star clusters : Stability and structure.*

*Pandey,A.K., *Mahra,H.S. & Sagar,R. (1991) In Proc. 102nd Annual meeting of the Astronomical Society of Pacific (in press). *A study of the spatial variation of the mass functions in some young open clusters.*

Parthasarathy,M. (1991) Astr. Astrophys. (in press). *Detached cold dust shell around the early R star (warm carbon star) HD 100764.*

Parthasarathy,M. (1991) in Proc. IAU Symp. 145 Evolution of stars: The abundance connection, Eds.G.Michaud & A.Tutukov (in press). *Post AGB stars detected from IRAS data.*

Pati, A.K. (1990) In Proc DST Workshop on National Large Telescope: Scientific Requirements, Ed. M. Parthsarathy. *Stellar populations in galaxies p 37.*

Peraiah,A. (1991) Ap. J. (in press). *Effects of aberration and advection on line formation.*

Peraiah,A. (1991) Workshop on binary stars and stellar atmospheres, (in press). *Radiative transfer in fast moving fluids.*

Peraiah,A. (1991) Bull. Astr. Soc. India (in press). *Abhyankar-The scientist.*

Peraiah,A. & Srinivasa Rao,M. (1991) Mon. Not. R. Soc. (in press). *Compton broadening due to electron scattering.*

Peraiah,A. & Srinivasa Rao,M. (1991). Astr. Astrophys. (in press). *Reflection effect in close binaries.*

Raju,P.K. & *Dwivedi,B.N. (1989) Hvar Obs. Bull. **131**,87. *Diagnostic study of prominence-corona interface.*

Rangarajan,K.E. & Mohan Rao,D. (1990) in Proc. Heidelberg Conference on Mechanisms of chromospheric and coronal heating, Eds. P.Ulmschneider E.Priest & R.Rosner, Heidelberg, (in press). *The effects of electron scattering on Si II 181 line in the solar chromosphere.*

Rangarajan,K.E., Mohan Rao.D. & Peraiah, A. (1991) Mon. R. Astr. Soc. (in press). *The effects of non-coherent electron scattering on spectral line formation.*

Raveendran,A.V. (1991) Astr.Astrophys. (in press). *An investigation of polarization produced by circumstellar dust envelopes.*

Raveendran,A.V. (1991) Astr.Astrophys. (in

press) *BVRI polarimetry of carbon stars.*

Rao.N.K., Ashoka,B.N.,*Lloyd,C.,*Pike,C.D. & *Stickland. D.J. (1990) J. Astrophys. Astr. **11**,445. *The eccentric double-lined binary BD-1 1004.*

Rao, N.K., *Nyman, L.A., *Nandy, N.,*Houziaux, L. *International Colloquium on The infrared spectral region of stars Montpellier,* Ed. C. Jaschek (in press). *Search for CO (I→O) emission in R Cr B stars.*

*Richtler, T., Sagar,R.,*Vallenari, A. & *de Boer, K.S. (1991) in IAU Symp.148 The Magellanic clouds, Eds. R.Haynes & D.Milne (in press). *Effects of data incompleteness and metallicity on the mass functions of young LMC star clusters.*

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Lectures/Talks

J.C.Bhattacharyya

:- *Possible programmes with a 1 meter telescope,* IUCAA workshop, Calcutta, May 26, 1990.

:- *Astronomical seeing,* inaugural address and review at workshop on Current trends in optical interferometry, Kodaikanal, Aug. 10-17, 1990.

:- *Contemporary development of Science: Astrophysics,* Saha Institute of Nuclear Physics, Calcutta, Sept. 13, 1990.

:- *The role of astronomy teaching in science education,* inaugural address at the commencement of the astrophysics course, Dept of Physics, Bangalore, Sept. 24, 1990.

:- *Some trends in astronomical techniques,* inaugural address and invited talk at the Symp. on Modern Trends in Astronomy, PRL, Ahmedabad, Nov. 1, 1990.

:- *The present status of Hubble telescope,* 56th annual meeting of the Indian Academy of Sciences, Bhubaneswar, Nov. 1990.

S.P.Bagare

:- *Observational evidence for mesogranular cells in the solar atmosphere,* XIV ASI meeting, Ahmedabad, Jan. 29 - Feb. 1, 1991.

B.Datta

:- *Neutron star interior structure and rotation,* NATO Advanced Study Institute on Neutron Stars, Agea Palegia, Crete, Greece, Sept. 3-14, 1990.

:- *Neutron star: structure and dynamics,* Lecture Series at IUCAA Workshop on High Energy Astrophysics, Ahmedabad, Jan. 20-25, 1991.

:- *Equation of state of dense nucleon matter,* Institute of Physics, Bhubhaneshwar, Dec. 24, 1991.

R.T.Gangadhara

:- *Anomalous absorption of radio waves in quasars,* Georgia State University, Atlanta, U.S.A., May 15, 1990.

:- *Stimulated Raman versus stimulated Compton scattering in quasar plasmas,* National Seminar on Plasma Science, Jadavpur University, Calcutta, India, Dec. 4-8, 1990.

M.H.Gokhale

:- *Applications of mathematics in astronomy and astrophysics,* St. Xavier's College, Thirunelveli, Dec. 6-7.

:- *Third branch of helioseismology - a beginning,* XIV ASI meeting PRL, Ahmedabad, Jan. 29-Feb. 1, 1991.

S.S. Hasan

:- *MHD waves on the Sun,* National Seminar on Plasma Science, Calcutta, Dec. 4-8, 1990.

:- *Oscillations in sunspots,* Dept. of Astronomy, Osmania University, Hyderabad, Jan. 22, 1991.

:- *Dynamical effects and energy transport in intense flux tubes on the Sun,* Dept. of Astronomy, Osmania University, Hyderabad, Jan. 23, 1991.

Jagdev Singh

:- *Ca II network studies from Antarctica,* XIV ASI meeting PRL, Ahmedabad, Jan. 29-Feb. 1, 1991.

N.Kameswara Rao

:- *Atmospheric diagnostics of stellar evolution : Hydrogen deficient stars and other peculiar red giants,* Hari Om Ashram prerit Vikram Sarabhai award lectures at the Physical Research Laboratory, Ahmedabad, Aug. 9-10,1990

:- *High resolution spectroscopy of the hot R Cr B star DY Cen,* XIV ASI meeting PRL, Ahmedabad, Jan. 29-Feb. 1, 1991.

:- *Mid-ultraviolet analysis of helium stars, XIV ASI meeting PRL,* Ahmedabad, Jan. 29-Feb. 1, 1991.

R. Kochhar

:- *Science as a tool in colonial India,* Centre for Science Education and Communication, Delhi University, Delhi, March 22, 1991.

V. Krishan

:- *Formation of large scale structure in the universe by inverse cascade in a turbulent medium,* IAU Symp. 132, Delhi, Oct. 10-13,1990.

:- *Self-organization processes in astrophysics and what is common between solar granulation and clustering of galaxies,* National Seminar on Plasma Science, Calcutta, Dec. 4-8, 1990.

:- *Self-organization processes in astrophysics,* Vishwabharaty University, Shantiniketan, Dec. 9, 1990.

:- *Radiative processes in astrophysics,* Lecture Series at IUCAA Workshop on High Energy Astrophysics, Ahmedabad, Jan. 20-25, 1991.

D.C.V.Mallik

:- *Planetary neublae and stellar evolution,* 2nd VBT workshop, Kavalur, April 19-20, 1990.

P.M.S. Namboodiri

:- *N-body simulations of interacting galaxies, Mini-workshop on N-body Simula-*

tions in Stellar Dynamics, Osmania University, Hyderabad, Jan. 15-21, 1991.

M. Parthasarathy

:- *Post AGB stars,* Department of Astromony, Trieste Astronomical Observatory, Trieste, Italy, October, 1990.

:- *High galactic Latitude A-F supergiants,* Kapteyn Astronomical Institute, Groningen, The Netherlands, November, 1990.

T.P. Prabhu

:- *Recent developments in optical astronomy,* Regional Seminar on Recent Trends in physics, Bangalore University, Bangalore, Feb. 21, 1991.

R. Sagar

:- *Mass functions of young star clusters in LMC,* 2nd Annual Workshop of the ESO key programme on Coordinated Investigation of Selected Regions in the Magellanic clouds, Bonn, May 3, 1990.

:- *Interstellar extinction in young open clusters,* Astronomical observatories of Padua and Asiago, Italy Aug. 2, 1990.

:- *Distribution of stellar mass in open clusters,* The Astronomical Observatories of Padua and Asiago, Asiago, Italy, Aug. 3, 1990.

:- *Initial mass function and mass segregation in young open star clusters,* Observatoire de Geneve and Institut d'Astronomie de l'Universite de Lausanne, Switzerland, Aug. 14, 1990.

:- *Stellar mass distribution in young open clusters,* Lund observatory, Lund, Sweden, Aug. 23, 1990.

:- *Mass functions of young LMC star clusters,* Astronomical Institute, Munich University, Munich, Oct. 12, 1990.

:- *Mass functions of young LMC star clusters and the peculiar double star cluster NGC 2214,* Astronomical Institute, University of Bonn, Bonn, Nov. 30, 1990.

:- *The young LMC star cluster NGC 2214,* XIV ASI meeting, PRL, Ahmedabad, Jan. 31-Feb.1, 1991.

S.K.Saha

:- *Problems involved in speckle interferometry,* 2nd VBT Workshop, VBO, Kavalur, April 19-20, 1990.

:- *CERGA optical interferometers,* Workshop on Current Trends in Optical Interferometry, IIA; Kodaikanal, Aug. 10-17, 1990.

A.Satya Narayanan

:- *What is common between solar granulation and clustering of galaxies?,* National Seminar on Plasma Science, Calcutta, Dec. 4-8, 1990.

A.K.Saxena

:- *Large Optical mirror making technology and facility at Indian Institute of Astrophysics,* 15th Congress of International Commission for Optics, Garmisch, Par-

tenkirchen, Aug. 5-10, 1990.

:- *Optical technology at Indian Institute of Astrophysics,* Observatoire de Haute - Province, Limoges, France, Aug. 1990.

:- *Large optical telescope - Indian context,* 19th OST Symp., Lucknow, March 8-10, 1991.

P.Venkatakrishnan

:- *High angular resolution in astronomy,* Workshop on Current trends in Optical Interferometry, Aug. 10-17, 1991.

Scientific meetings attended

Second VBT workshop, Kavalur, April 19-20, 1990. *J.C.Bhattacharyya, D.C.V. Mallik, T.P. Prabhu, S.K.Saha.*

Debriefing meeting of the Dept. of Ocean Development on the IX Antarctica Expedition, New Delhi, May 1990. *G.S.D.Babu, J.C.Bhattacharyya, Jagdev Singh, K.R.Sivaraman.*

Second annual workshop of the ESO key programme, on Coordinated Investigation of Selected Regions in the Magellanic Clouds, Bonn, May 2-4, 1990. *R. Sagar.*

Meeting on Variability of Active Galactic Nuclei, Georgia, State University, Atlanta, U.S.A., May 2-4, 1990. *R.T.Gangadhara.*

All India seminar on Indian Astronomy and Jai Singh, B.M. Birla Planetarium, Jaipur, May 10, 1990. *G.S.D.Babu.*

Fourth regional conference on Mathematical Physics, Teheran, Iran, May 12-17, 1990. *S.S. Hasan.*

Heidelberg conference on Mechanisms of Chromospheric and Coronal Heating, Heidelberg, F.R.G., June 5-8, 1990. *S.S. Hasan, K.E. Rangarajan, K.R. Sivaraman.*

IAU Coll. 128 on Magnetospheric Structure and Emission Mechanism of Radio Pulsars, Lagow, Poland, June 17-23, 1990. *R.C.Kapoor.*

National symposium on Recent advances in Seismology and Applications, Gauribidanur July 16, 1990. *J.C. Bhattacharyya.*

Workshop on International Equatorial Electrojet Year, SPL/VSSC, Trivandrum, July 17-18, 1990. *J.H.Sastri.*

Fifth Asian-Pacific regional IAU, Sydney, Australia, July 16-20, 1990. *D.C.V.Mallik.*

Meeting of the Indian Academy of Sciences, Bangalore July 1990. *J.C. Bhattacharyya.*

XV Congress of the International Commission for Optics, Garmisch, Partenkirchen, F.R.G., Aug. 5-10, 1990. *A.K.Saxena.*

Workshop on Current Trends in Optical Interferometry, Kodaikanal, Aug. 10-17, 1990. *S.K.Saha, P.Venkatakrishnan, J.C.Bhattacharyya, M.H.Gokhale, R.S. Narayanan.*

IAU Symp. 145 on Evolution of Stars: The Photospheric Abundance Connection, Druzba, Bulgaria, Aug. 27-31, 1990. *S. Giridhar, M.Parthasarathy.*

Workshop on Galaxy Formation, Bombay, Sept. 3-7, 1990. *P.M.S.Namboodiri.*

NATO Advanced Study Institute on Neutron Star Interior Structure and Rotation, Agea Palegia, Crete, Greece, Sept. 3-14, 1990. *B.Datta*

IAU Symp. 132 on Instability Chaos and Predictability in Celestial Mechanics and Stellar Dynamics, Delhi, Oct. 10-13, 1990. *S.S.Hasan, R.K.Kochhar, V. Krishan, P.M.S.Namboodiri.*

S.K.Mitra centenary commemorative international symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, New Delhi, Oct. 23-26, 1990, *J.C.Bhattacharyya.*

International Symp. on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, Oct. 24-26, 1990. *H.N.Ranganatha Rao, J.H.Sastri.*

56th Annual Meeting of the Indian Academy of Sciences, Bhubaneswar, Nov. 8-11, 1990. *J.C.Bhattacharyya.*

National seminar on Plasma Science, Calcutta, Dec. 4-8, 1990. *R.T. Gangadhara, S.S.Hasan, V.Krishan, A.Satya Narayanan.*

First group monitoring workshop on Atmospheric Sciences, IITM, Pune, Dec. 17-19, 1990. J.H.Sastri.

Second Meeting of the EUV Spectroheliometer Project at Cockeysville and Stanford, USA., Jan. 18, 1991. *S.K.Jain.*

Workshop on High Energy Astrophysics, PRL, Ahmedabad, Jan. 20-25, 1991. *B.Datta, V.Krishan.*

Mini Workshop on N-body Simulations in Stellar Dynamics, Hyderabad, Jan. 16-21, 1991. *P.M.S.Namboodiri.*

First winter school on Indian MST Radar, Tirupati, Jan. 28 - Feb. 4, 1991. *K.B. Ramesh, H.N.Ranganatha Rao.*

XIV Annual meeting of the Astronomical Society of India, Ahmedabad, Jan. 29 - Feb. 1, 1991. *S.P.Bagare, Jagdev Singh, N.Kameswara Rao, M.H.Gokhale, R. Sagar.*

XIX OSI Symp., Lucknow, March 8-10, 1991. *A.K.Saxena.*

Visits to scientific institutions

S.S. Hasan visited the School for Mathematical Sciences at Queen Mary College, London for four weeks during June-July 1991 to carry out collaborative research work.

S.K. Jain visited Stanford University, U.S.A. in Jan. 1991 for discussions related to the EUV spectroheliometer project.

N. Kameswara Rao visited the Spectroscopic Division of BARC, Bombay in Jan. 1991 and IUCAA, Pune in Feb. 9-10, 1990.

M. Parthasarathy visited the Astronomy Department of the Trieste Observatory, Italy and the Kapteyn Institute at Groningen, The Netherlands for collaborative work during Sept.-Nov. 1990.

Ch.V.Sastry was a visiting professor at the University of Mauritius during the period Feb 1990 to July 1991.

A.K. Saxena visited Equipe d'optique del IRCOM, Faculté des Sciences, Limoges, France during Aug. 1990. In Germany he visited the Physikalisch-Technische Bundesanstall at Braunschweig and Berlin, the European Southern Observatory at Garching, and Schott Glaswerke at Mainz in connection with optical instrumentation programmes.

R. Sagar visited the Observatory of Bonn University, F.R.G. during October 1989 - Dec. 1990. During this period, he also made scientific trips to several other institutes in Europe.

C.Sivaram has been in Italy as a visiting professor at the International Centre for Gravitation and Cosmology since Sept. 1990. During Sept.1990 - March 1991 he visited several scientific institutes.

K.R. Subramaniam spent six weeks at the Meudon Observatory, France during April-May, 1990 as part of a collaborative research programme on solar observations and data reduction.

Appendix B

Popular talks

G.S.D. Babu

:- *IX Indian scientific expedition to Antartica - personal experiences of an astronomer,* Association of Bangalore Amateur Astronomers, May 6,1990; University extension lecture programme, Aligarh Muslim University, Aug. 4, 1990; inaugural address, Physical Sciences Association, St. Joseph's College, Bangalore, Sept. 20, 1991.

:- *Our beautiful universe,* S.P.G. High School, Nandyal, Oct. 11, 1990.

J.C. Bhattacharyya

:- *The role of astronomy teaching,* panel discussion on Avenue of Physics, Indian Physics Association, Bombay, Nov. 1990.

:- *New information about the solar system,* ISTRAC, Bangalore, Feb. 28, 1991.

:- *Some recent discoveries in the solar system,* IIT, Kanpur, Feb. 91

:- *Optical astronomy in India,* St. Joseph's College, Bangalore, March 1991.

S.S. Hasan

:- *The challenge of astronomy,* keynote address on the National Science Day, Lawrence school, Lovedale, Feb. 28, 1990.

Popular articles

G.S.D.Babu, *Mars at its brightest,* Deccan Herald, Nov. 22, 1990.

G.S.D.Babu, *Jantar Mantar magici strumenti a Delhi* (in Italian) l' astronomia 1990, No 99, p.31.

J.C.Bhattacharyya, *Measurement of distances in the Universe,* Desh (Bengali), Mar 1990.

J.C.Bhattacharyya, *What is more important in scientific research,* Jnan Bigyan (Bengali) Oct. 1990.

J.C.Bhattacharyya, *Map of the sky,* Kishore Jnan Bigyan, Dec. 1990.

J.C.Bhattacharyya, *The cosmic laboratory,* KJB, Oct. 90.

B.Datta & J.C.Bhattacharyya, *Hubble space telescope*, Desh (Bengali), Nov. 1990.

R.K.Kochhar (1991) J. Br. Astr. Assoc. *French astronomers in India during 17-19 centuries.*

R.K.Kochhar (1991) Vistas in Astr. **34**, 69 *Growth of modern astronomy in India 1651-1960.*

R.K.Kochhar (1991) Current Science **60**, 124. *Astronomy in British India : Science in the service of the State.*

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 IIA. JAA has entered its 12th volume. J.C.Bhattacharyya continues as the chairman of its editorial board. D.C.V.Mallik is appointed as the Associate Editor in place of T.P.Prabhu, who continues on the editorial board. R.K.Kochhar continues as the associate editor of BASI, and T.P.Prabhu continues to serve on its editorial board.

The IIA newsletter entered its 6th year in Jan. 1991. T.P.Prabhu and A.K.Pati continue to edit the newsletter on behalf of the Director of the Institute.

M. Parthasarathy edited the *Proceedings of the National large Telescope Workshop* held at the Indian Institute of Astrophysics, Bangalore, Oct. 19-21, 1989. The proceedings came out as a DST publication.

J.H.Sastri edited the *Proceedings of the DST workshop for I-STEP* held at Andhra University, Waltair during Jan. 28-29, 1990 as acting chairman of INSCOSTEP. The proceedings were published by INSA, New Delhi.

J.C.Bhattacharyya continues as a member of the editorial board of *Astrophysics and Space Science.* He is editing the book on Astronomy, written by the late J.N.Bhar, in addition to contributing a chapter. The book is being brought out by the Indian Science News Association.

Book reviews

H.C.Bhatt reviewed the book *Accuracy of element abundances from stellar atmospheres* ed. R.Wehrse, Springer-Verlag, 1990.

T.P.Prabhu reviewed the book *Classical Novae* edited by M.F.Bode & A.Evans (John Wiley, 1989).

Radio/TV programmes

The course work in audio/video in astronomy for the Indira Gandhi Nehru Open University, Delhi was continued.

G.S.D.Babu was interviewed in a 20-minute programme on Doordarshan Kendra (television centre) Bangalore about his experiences in Antarctica during the IX Indian Scientific expedition, Dec. 20, 1990.

S.P.Bagare gave three talks on Voyager at Neptune, Telescopes in Space and another popular science topic on All India Radio, June - July, 1990.

J.C.Bhattacharyya was interviewed by All India Radio, Bangalore about Research Projects in IIA, Apr 1990. He also gave a radio talk on Modern technology for better planetary research, Jan. 1991.

Appendix C

Vainu Bappu Observatory

Sky conditions at Kavalur, April 1990 - March 1991.

Year	Month	Spectroscopic hours	Photometric hours
1990	April	198	78
	May	55	6
	June	60	0
	July	28	4
	August	45	4
	September	15	2
	October	42	11
	November	115	29
	December	110	31
1991	January	174	44
	February	225	181
	March	208	95
	Total	1275	485

Kodaikanal Observatory

Solar Tower observations.

Year	Month	Total no. of days of Observation	Seeing conditions (in arc sec)							
			1 to 2	2 to 3	3	3 to 4	4	4 to 5	5	5 (Poor)
1990	April	19	2	6	5	1	3	-	1	1
	May	7	1	1	3	-	1	-	-	1
	June	6	-	1	2	-	-	1	-	2
	July	6	-	2	2	-	-	1	-	1
	August	7	-	-	1	-	-	-	2	4
	*September	7	1	-	5	1	-	-	-	-
	*October	9	-	1	4	-	3	-	1	-
	November	12	2	5	5	-	-	-	-	-
	December	13	1	-	8	2	-	-	-	2
1991	January	15	1	3	3	2	-	1	2	3
	February	23	2	5	7	1	-	3	2	3
	March	18	2	5	8	1	1	-	-	1
	Total	142	12	29	53	8	6	6	8	18

Remarks: *19th Sep to 2nd October, Mirror sent for Aluminising to Kavalur.

Spectroheliograms/Photoheliograms and seeing conditions (Kodaikanal observatory)

		No. of photographs in					Seeing*				
Year	Months	Hα	KFL	KPR	HPR	PHGM	5	4	3	2	1
1990	April	23	21	20	11	26	-	4	11	10	1
	May	11	10		8	12	-	1	7	3	1
	June	19	17		15	19	-	3	6	10	-
	July	13	11		9	16	-	4	9	3	-
	August	10	9		3	15	-	2	12	1	-
	September	17	19		11	22	-	1	15	6	-
	October	13	13		12	17	2	2	10	2	1
	November	15	15		15	16	-	6	9	1	-
	December	19	19		19	20	-	4	11	5	-
1991	January	25	24		23	26	-	3	14	9	-
	February	26	24		24	28	-	10	15	3	-
	March	30	30		30	31	-	9	20	2	-
	Total	221	212	20	180	248	2	49	139	55	3

KFL - K-Flocculus

KPR - K-Prominences

HPR - H-Prominences

PHGM - Photoheliograms

* (1 - V.Poor, 2 - Poor, 3 - Fair, 4 - Good, 5 - Excellent).