# Annual Report 1992-93
# Indian Institute of Astrophysics

# INDIAN INSTITUTE OF ASTROPHYSICS


## Annual Report
## 1992 - 93

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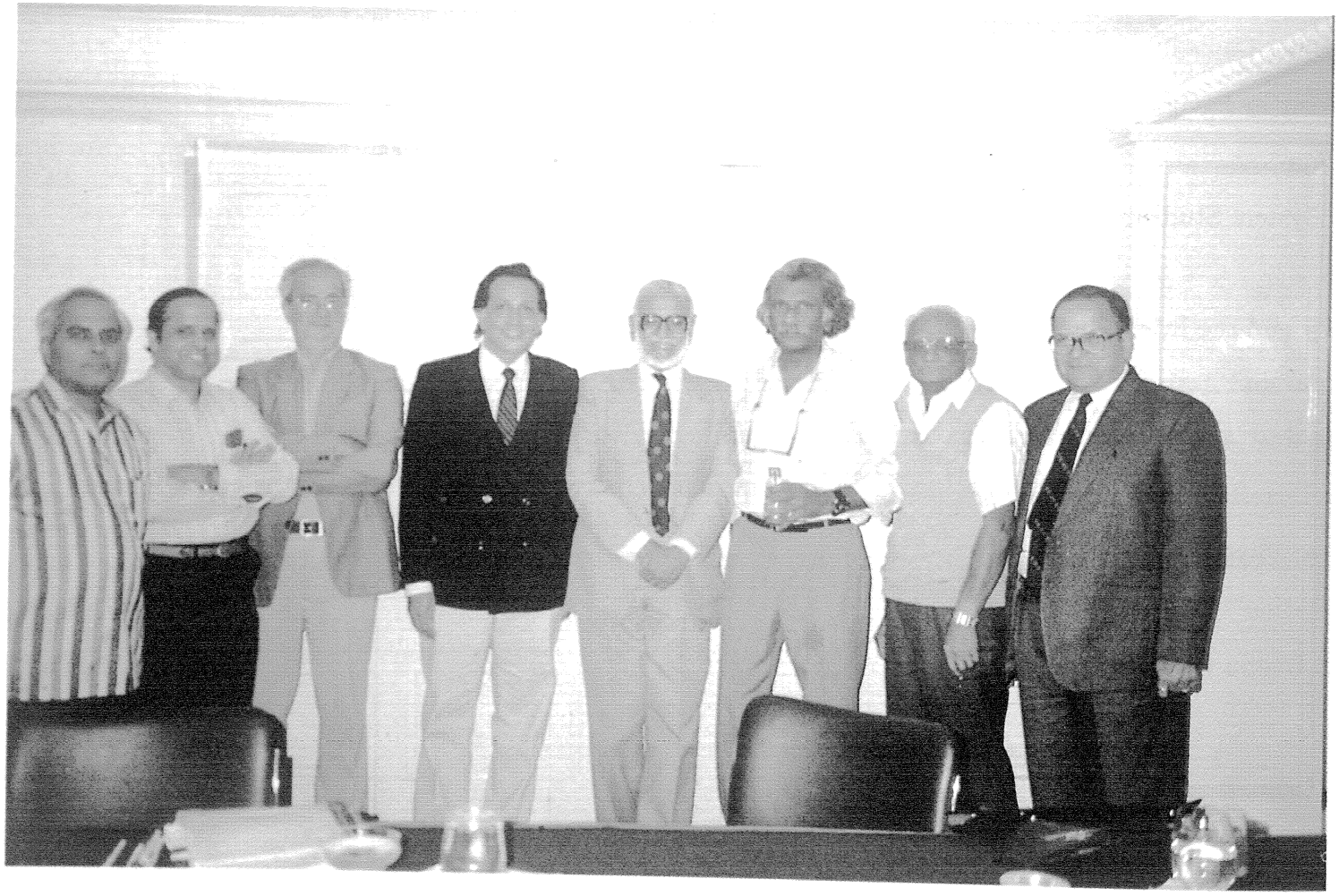
*The Previous Council*



# Governing Council

(for the triennium 1992 October – 1995 October)

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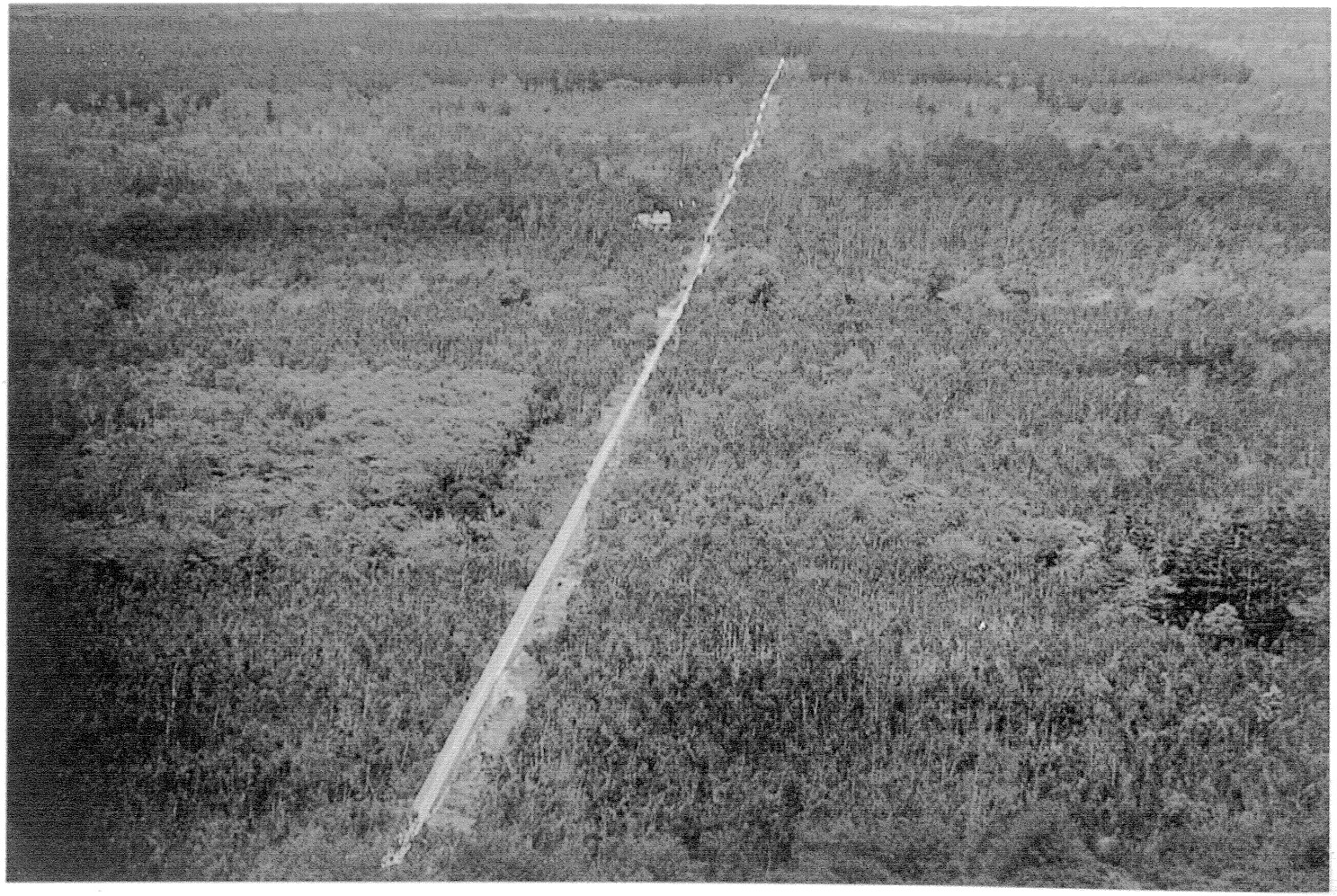
*Aerial view of the Mauritius Radio Telescope*



*Courtesy: Ch. V. Sastry*

# The Year in Review

The year 1992-93 was an eventful one. Much effort was directed to studies in astronomy, astrophysics and nuclear physics and important new results were obtained. Capabilities of the Vainu Bappu Telescope at VBO, Kavalur were enhanced and computing facilities at Bangalore were further augmented.

Preliminary discussions on the proposed National Large Optical Telescope were started.

The Governing Council of the Institute was reconstituted for a period of three years effective October 22, 1992. *Professor B.V.Sreekantan*, National Institute for Advanced Studies, Indian Institute of Science, Bangalore is the new Chairman of the Council.

The *Mauritius Radio Telescope*, a joint Indo-Mauritian venture, in which the Institute and Raman Research Institute are the participating Indian institutions, was inaugurated by the *Rt. Hon. Sir A. Jugnauth, Prime Minister of Mauritius* on November 4, 1992. The *Honorable Mr.P.R. Kumaramangalam*, Minister of State for Science and Technology, Ocean Development, Electronics and Parliamentary Affairs, Government of India, graced the occasion by his presence.

*Professor D.Balasubramanian*, Director, Centre for Cellular and Molecular Biology, Hyderabad delivered the Seventh IIA Bicentennial Commemorative Lecture on January 22, 1993.

The Institute signed Memoranda of Understanding for mutual collaborative research in astronomy and astrophysics with the Uttar Pradesh State Observatory, Naini Tal and Osmania University, Hyderabad.

A summary of the research activities appears below.

The 'shapes' and 'sizes' of the sunspot cycles were modelled in terms of interferences of global torsional MHD oscillations of the Sun. Two resonant modes of such oscillations, suggesting a crude dispersion relation, were identified. The recently suggested model of the 'steady' part of the Sun's internal magnetic field was substantially improved. The central singularity was eliminated and a much better isorotation was obtained with the helioseismologically determined rotation in the outer part of the Sun's radiative core. Data obtained during the first Indian astronomical expedition to Antarctica were analysed to derive properties of supergranulation. Analysis of the He I 10830 Å line showed that its width was correlated with its equivalent width. Since the line is assumed to be formed in the chromosphere through radiative excitation by high energy photons from the corona, this suggested that chromospheric dynamics and coronal heating were correlated. Improved Ephemerides were derived for Galilean satellites. Series of CCD photographs of the nucleus of the Comet Swift-Tuttle obtained at the prime focus of the 2.3 m VBT showed that the nucleus was rotating with a period of approximately 2.7 days.

Herbig Ae/Be stars were monitored polarimetrically to study the temporal changes in the structure of their dusty circumstellar discs. Time resolved spectroscopic observations of V 380 Ori and HD 76534 were obtained to investigate short-term variations of photospheric absorption lines of hydrogen and helium in the two stars. Be and B[e] stars were studied in detail. It was found that Be stars changed from Be to Be-shell type spectra via strong massloss. The infrared emission from B[e] stars indicated that part of their Balmer continuum was being converted into IR luminosity. The Institute participated in the international observing campaign, MUSICOS 92, and several spectra of the Herbig Ae star AB Aur and the Delta Scuti star $\theta^2$ Tau were obtained.

Spectral line variations of the hydrogen deficient star UW Cen were studied with the help of appropriate model atmospheres and the line synthesis technique. UW Cen shows a strong Li I feature indicating a logarithmic abundance of 4.6 for Li. Abundances of other

elements in UW Cen were also derived. The star V 854 Cen was observed at light minimum. The continuum radiation observed was identified as coming from a thick dusty disc obscuring the photosphere of the star. Broad forbidden emission lines seen in the spectrum were inferred to come from an extended region with nebular properties. Spectra of several other R Cr B type stars were obtained. UBVR polarimetric observations of V 854 Cen showed that the amount and position angle of its polarization changed significantly from epoch to epoch. Polarimetric observations of AR Pup showed a very interesting change in the position angle in U and B on two occasions.

An extensive study of the Ca II near infrared triplet lines in cool stars was started in 1991–92 and continued during 1992–93. Several metal poor stars were observed covering a wide range in [Fe/H] from −3.0 to +0.5. Analysis of the line strengths gave convincing evidence of the biparametric nature of their dependence on luminosity and metallicity.

Optical and infrared observations of LS II + 34° 26 were analysed. It was concluded that the star is a low mass post AGB B1.5 Ia - I abe supergiant with a detached cold circumstellar dust shell. Further observations of the post AGB star SAO 244567 revealed that this star has turned into a planetary nebula within the last twenty years.

Several novae were spectroscopically monitored during outburst and quiescence. Nova Puppis 1992, Nova Cygni 1992 and Nova Scorpii 1992 reached very high excitation during this period. The long term spectroscopic monitoring of the old nova GK Persei and the recurrent novae T Cr B and RS Oph was also continued.

A programme to detect optical counterparts of gamma ray bursters was started by searching with the 1 m and 2.3 m telescopes, negotiations are under way to make our observatory a part of a global network for multiwavelength observations of $\gamma$-ray bursts.

Polarimetric observations of several high galactic latitude molecular clouds were obtained. On the theoretical side numerical trajectories of protostars inside molecular clouds were computed to study their kinematic properties.

The effect of mass segregation on the mass function of young open clusters was studied. CCD photometry of several open clusters was carried out and the photometric data on NGC 2453, an open cluster in Puppis, was fully analysed. The results of this analysis showed that it is possible to reach up to V $\sim$ 20.0 with acceptable S/N ratio at the 1 m telescope with CCD detectors. The unevolved main sequence of NGC 2453 was clearly observed.

Radiatively driven winds in hot O and B stars were studied theoretically. A simultaneous solution of the equations of continuity, momentum conservation and radiative transfer was obtained in a pure hydrogen atmosphere that included the effects of Lyman, Balmer, Paschen and Brackett continua and the lines in these series up to 10 levels. Effects of the diffuse radiation field, backscattering, radial and transverse velocity gradients, aberration and advection were included for the first time in this type of calculation. A comparison of the results with observations in several stars show a good agreement.

Modulational instability of large-amplitude electromagnetic waves in an electron-positron plasma was studied. The effects such as relativistic mass variation of the plasma particles and the nonresonant, finite frequency electrostatic density perturbations were taken into account. The role of stimulated Raman and Compton scattering in the continuum emission of a quasar was explored. The nonthermal continuum of quasars, believed to be produced through the combined action of synchrotron and inverse Compton processes, could also be reproduced by a suitable combination of stimulated Compton scattering and stimulated Raman scattering processes. It has also been shown that the observed spectral breaks in the blue region could be due to the change of the emission process from stimulated Raman scattering to stimulated Compton scattering.

A new equation of state of nuclear matter was calculated based on the derivative scalar coupling model using improved values of the saturation density and binding energy. A finite temperature equation of state for nuclear matter was also derived based on this model.

Imaging of galaxies and quasars was carried out using the prime focus of the 2.3 m VBT and the Astromed CCD system. A dust shell

with $E(B-V) = 0.12$ was discovered in the elliptical galaxy NGC 3607 and H$\alpha$ emission from it was confirmed. Some Sersic-Pastoriza galaxies were also imaged for studying the nuclear star forming regions. Star formation in Giant Extragalactic H II regions (GEHR's) was investigated using optical photometry and evolutionary population synthesis models. GEHR's are inferred to contain hot massive stars and evolved red supergiants simultaneously implying more than one event of star formation in the last 10 Myr.

Deep imaging in BVRI has been carried out for several clusters of galaxies at different redshifts.

A Weyl type of action, scale free and quadratic in the curvature was suggested for strong gravity. The colour symmetry was built into the gauge group and incorporated in the small distance spacetime structure. The corresponding field equations have solutions which imply confinement. At the QCD scale, the scale invariance is broken inducing a Hilbert type term which describes the short distance behaviour.

It was shown that the dislocation defect induced by torsion in spacetime behaved like a string with tension. This gave rise to a defect angle and induced a spacetime curvature. From these considerations following the Sakharov idea of spacetime as an elastic continuum, a gravitation constant was arrived at, that occurs in the Einstein action, as the metrical elasticity of spacetime with the correct value, without introducing any arbitrary cutoff.

Studies of magnetosphere-ionosphere coupling using high-time resolution measurements of phase path P of ionospheric F region reflections at normal incidence at Kodaikanal, brought into focus the dominant role of electromagnetic (E x B) drift in the geomagnetic pulsation-related ionospheric Doppler velocity variations near the magnetic equator and provided first-order information on the causative electric fields. A synoptic picture of the thermospheric temperature over Kavalur was derived from measurements of the line profile of O ('D) night airglow emission with a pressure-scanned Fabry-Perot Interferometer.

Double beta decay of $^{128}Te$ was confirmed and the ratio of half-lives for double beta decay of $^{130}Te$ and $^{128}Te$ was determined as $^{130}Te_{1/2}/^{128}Te_{1/2} = (3.52 \pm 0.11) \times 10^{-4}$ by ion counting mass spectrometry of $Xe$ in ancient $Te$ ores. The $Xe$ measurements, combined with common $Pb$ dating, yield a $^{130}Te$ half-life of $(2.7 \pm 0.1) \times 10^{21}$ $yr$ and thus a $^{128}Te$ half-life of $(7.7 \pm 0.4) \times 10^{24}$ $yr$. These results give limits on the effective Majorana mass of the neutrino ($< 1.1 - 1.5$ $eV$) and right-handed currents ($| < \eta > | < 5.3 \times 10^{-8}$) comparable to the best obtained from direct neutrinoless double beta decay searches. They also imply new limits on nonstandard Majorons not constrained by measurements of the $Z^o$ decay width. This work was carried out in collaboration with the scientists of the Washington University, in St. Louis, Missouri, USA.

A 500 mm Cassegrain telescope optics was designed and fabricated for VSSC, Trivandrum. A final figure close to 1/10 wavelength of light was achieved. Specular polishing of a set of panels for the VHRR cooler of the satellite INSAT II A was completed. Another set of six panels was polished and supplied for the INSAT II B spececraft. Fabrication of the 18 inch f/15 EUV Gregorian telescope optics was completed. Final testing and evaluation of the primary and secondary mirrors in combination have been in progress. Fabrication of one unit of the telescope structure was completed and was delivered by the HAL Aerospace Division in the last week of January.

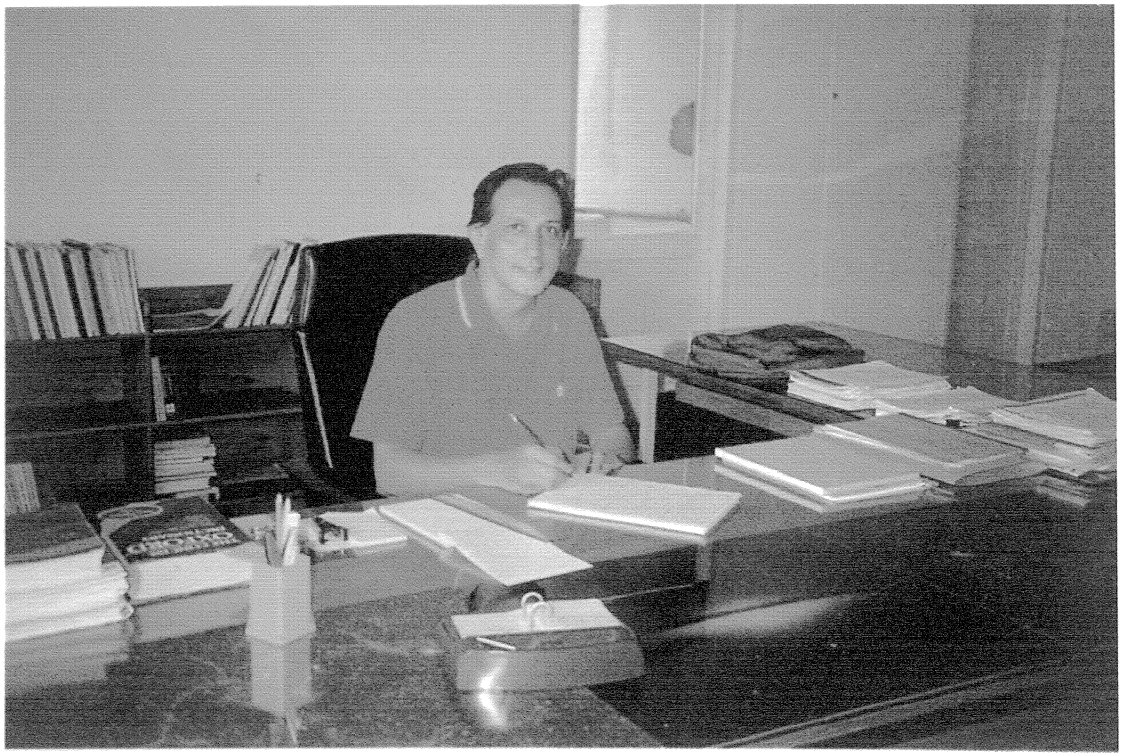
A liquid nitrogen cooled cryostat for CCD's was developed in collaboration with the Indian Institute of Science, Bangalore.

A liquid pool based vibration analyzer was developed. This instrument is capable of measuring vibrations in the low frequency range i.e. at less than 50 Hz where the conventional accelerometers fail. The performance of the instrument was tested by comparing the signal profiles obtained by it with those given by a B & K model 4370 accelerometer coupled to a charge amplifier B & K 2511 vibration meter when both were mounted on the same cantilever. For frequencies larger than 20 Hz the profiles matched while below 20 Hz the match was poor due to the insensitivity of the accelerometer. The instrument was used for studying the vibration spectrum of the VBT structure.

A 1024 channel correlator system for recording radio images of the Sun with the Gauribidanur Telescope has been under construction. A sixteen channel prototype was constructed. It has been working satisfactorily for both static and dynamic input signals.

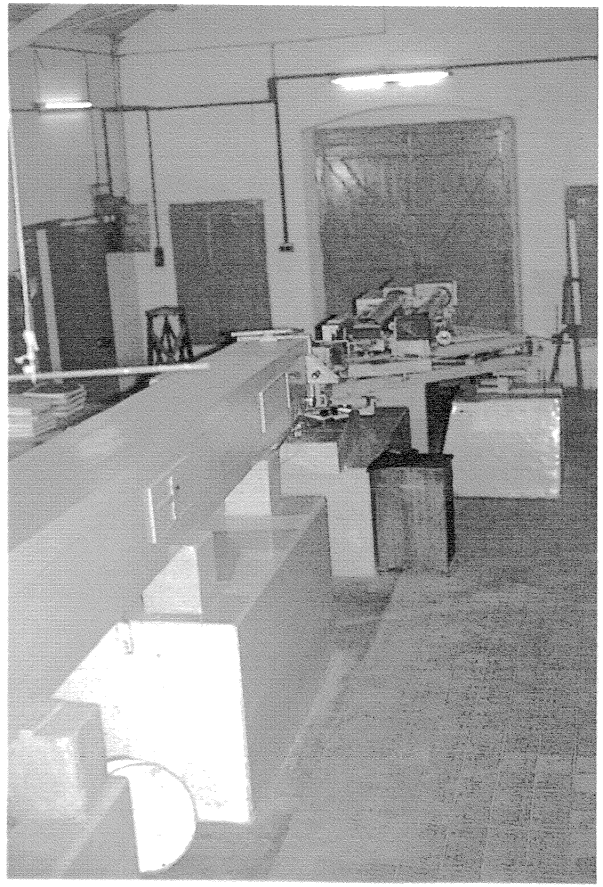
Upgradation of the grounds and facilities at Kodaikanal campus has been taken up, giving a new thrust to studies in solar astronomy and sun-earth interrelationship. Also a beginning has been made to start work in areas of physics with a view to enlarging the horizons of activity at IIA.

R. Cowsik
Director



*Astronomy and Astrophysics*

The siderostat at Kodaikanal for guiding the sunlight on to the spectroheliograph. (P.S.M. Aleem)



The spectroheliograph in operation since 1904 for taking pictures of the sun in H$\alpha$ and Ca II K. (P.S.M. Aleem)

## Modelling the 'steady' part of the sun's internal magnetic field

The earlier model of the 'steady' part of the magnetic field in the sun's outer radiative core and convective envelope has been improved by replacing the current-free assumption which led to a central singularity. The field there is now assumed to be in the form of Chandrasekhar's solution of diffusing poloidal field. This form gives a much better isorotation with the helio-seismologically observed internal rotation.

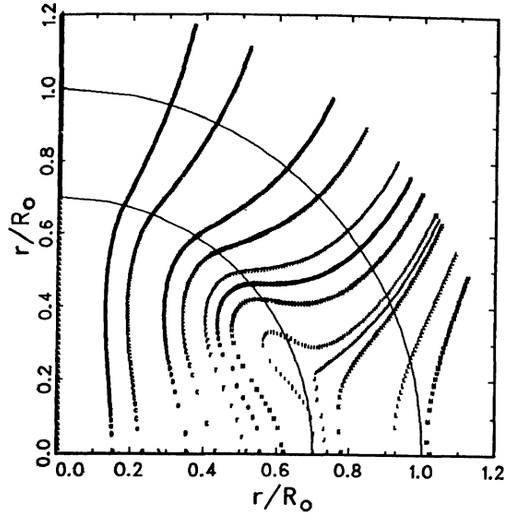



**Fig. 1.** The field lines of the 'steady' part of Sun's internal poloidal field in one quadrant of a meridian plane. The symbols A,B,C,...M represent magnetic flux values 0.0, 0.5102, 1.0204, 2.0408, 2.5510, 3.0612, 3.2653, 3.4694, 3.7074, 3.7551, 3.8163, 4.0816, 4.2857 in units of $\pi\ B_o\ R_\odot^2$.

It also gives a much simpler topology (Figure 1) and confirms the presence of a rotational shear near the base of the convective envelope that can provide very strong toroidal field there. (M.H. Gokhale, K.M. Hiremath)

## Modelling of the sunspot cycle

It was shown that sunspot activity is produced by superposition of the terms $l = 1, 3, ...13$ with frequencies $n = 1$ and 3 (in units of $\nu_* = 1/21.4\ y^{-1}$) in the Legendre-Fourier (LF) analysis of '$Q(\theta, t)$', the rate of emergence of toroidal magnetic flux per unit photospheric area as a function of colatitude '$\theta$' and instant '$t$', as determined from the sunspot data. However, exploiting the high mutual correlations between the amplitudes and phases of groups of terms, the 'shapes' and the 'sizes' of the sunspot cycles between 1879 and 1976 have been reproduced quite satisfactorily by superposing only the dominant terms $l = 3$ and 5 with $n = 1$ and 3 (see Figure 2).

Coherence and magnitudes of phase variations of LF terms suggest the presence of 'resonant' modes of global torsional (MHD) oscillations of the sun with $l = 1, 3, 5, 7; \nu = \nu_*$ and $l = 9, 11, 15, 17; \nu = 3\nu_*$ (wherefrom emerges a crude empirical 'dispersion relation').

The phase variations also indicate that the LF spectrum is maintained approximately steady by flow of energy from oscillations of frequency $\nu_*$ to those of $3\nu_*$ and $5\nu_*$, and the loss of energy through emergence of toroidal magnetic flux bundles that produce sunspot and non-sunspot activity at $5\nu_*$ and higher frequencies. These phase variations may be caused by variation of the Alfvén speed in the sun.

As a check the following correlations have been found :

(i) The 'size' of a sunspot cycle number '$i$' is correlated (a) approximately 90% to the total phase-change of the terms $l = 5; \nu = (1, 3, 5)\nu_*$ and (b) approximately 94% to the total phase-change of $l = 1, 3, 5, 7; n = 5\nu_*$ between the cycles $i - 1$ and $i$.

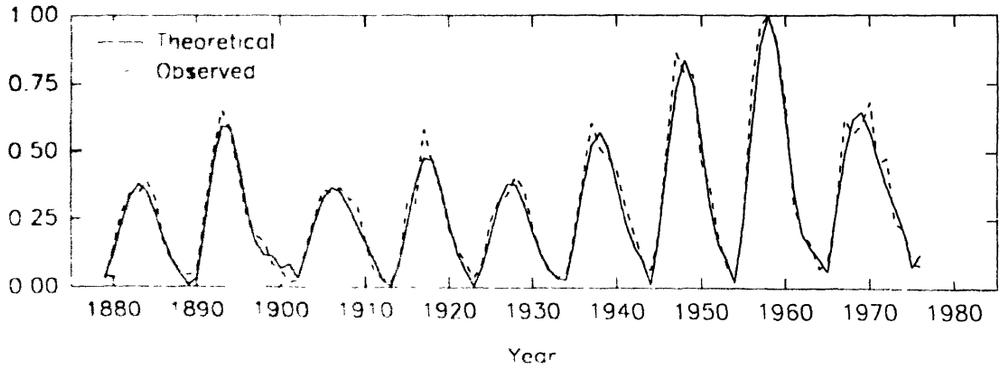
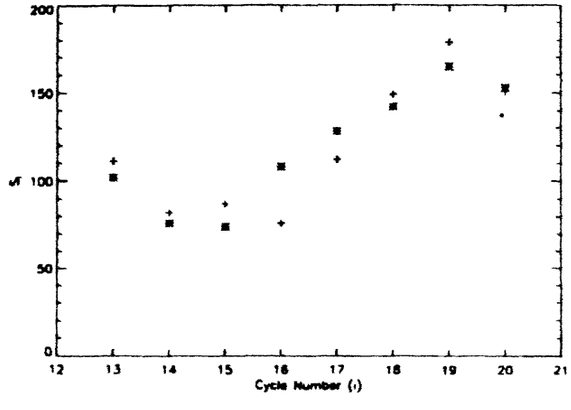



**Fig. 2**. The modelled and the observed variations of the annual measure of sunspot activity normalized to the value in 1958.



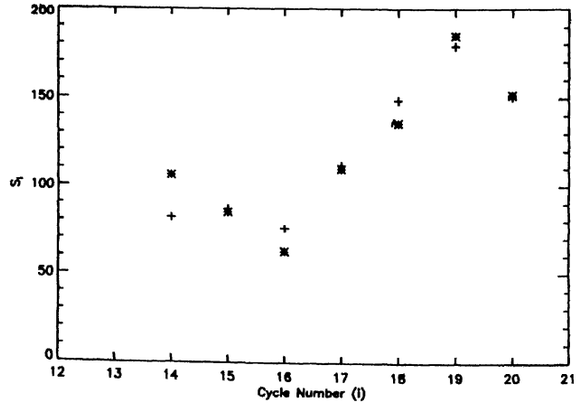




**Fig. 3** The observed (+) and the predicted (*) measures of total amount of sunspot activity during successive sunspot cycles. Predictions are based on correlations between : (a) $S_i$ and phase changes from '$i-1$' to '$i$' (b) '$S_i - S_{i-1}$ and phase changes from $i-2$ to $i-1$.

(ii) The *excess* of the size of cycle $i$ over that of $i-1$ is found to be correlated (90%) to the phase-shift of '$l = 11, n = 1$' between cycles '$i-2$' and '$i-1$'. These correlations may provide a physical basis for predicting the 'size' of a sunspot cycle (see Figures 3a & b).
(M.H. Gokhale, J. Javaraiah)

## Magnetic field effects on solar oscillations

In a previous study, the influence of a vertical magnetic field on the oscillations of a stratified isothermal atmosphere was studied. The effect of the magnetic field on the normal mode frequencies for the non-magnetized atmosphere was investigated. This analysis is now being extended to more general stratifications. The possibility of energy loss through the lower boundary through slow mode leakage is being incorporated. Further non-adiabatic effects such as radiative damping are also being examined. The importance of this study lies in understanding the fundamental nature of oscillations observed on the solar surface, and how they are modified by magnetic fields. (S.S. Hasan)

## Calcium II K line profiles

For evaluating the chromospheric variability in the sun (solar cycle related or any other) using the Ca II K line as an indicator, an essential prerequisite is the knowledge of the K line profile of the truly quiet sun. A standard disc averaged K line profile has been derived for the quiet sun from many profiles obtained during the years 1986 and 1987 when the sun was relatively quiet. Such a profile would serve as a standard of reference over which the enhancements in the K line emission can be measured. (K.R. Sivaraman, S.S. Gupta, R. Kariyappa)

The ongoing programme of monitoring the sun in the Ca II K line, started in 1968 at the Kodaikanal tower telescope and spectrograph, has provided a large amount of data of disc-averaged profiles. From these profiles the variability of the sun as a star as seen in the various K line parameters has been derived. Of particular interest is the 1 Å index which shows an increase of about 33% in 1990 from its minimum value attained in 1986-87 as against an increase of $\sim$ 27% during the last solar cycle. (K.R. Sivaraman, S.S. Gupta, R. Kariyappa, P.S.M. Aleem, K. Sundara Raman)

Concurrently, Ca II K line profiles have been obtained using the double pass monochromator at the Bangalore Campus. These data have been merged with the Kodaikanal data for estimating the solar variability in the K line band. (K.R. Sivaraman, R. Kariyappa)

## Results of analysis of obervations from Antarctica

The continuous sequence of calcium K line filtergrams for 106 hours spaced at an interval of about 10 minutes obtained at the permanent Indian station in Antarctica during December 1989 – March 1990 was analyzed. The most probable lifetime of the calcium K network is found to be about 22 hours. A study of the evolution of the individual cells shows a correlation between the lifetimes and the sizes. Lifetime is larger for the bigger cells. The cells of a given size associated with the remnant magnetic field regions live longer than those in the field-free region. It is concluded that magnetic field is playing an important role in the confinement of these cells. (Jagdev Singh, B.S. Nagabhushana)

## Chromosphere - corona transition region

Line intensity ratios of extreme ultraviolet (EUV) emission lines from Na VII and Al IX were considered for electron density and electron temperature determinations within the chromosphere - corona transition region (CCTR) and the corona. It was found that, under the assumption of constant electron pressure, the EUV emission lines from Na VII and Al IX could be used for simultaneous determination

of electron density and electron temperature within CCTR and the corona. The EUV emission lines from boron-like ions Na VII and Al IX have been observed in quiet and active regions of the solar atmosphere, coronal holes and off-limb regions of the sun. These lines have also been observed in the sunspot plumes. Emission lines from these two ions have not been previously considered for plasma diagnostics. Theoretical line intensities for these ions were computed using a model solar atmosphere and compared with the values as observed by the ATM (Apollo Telescope Mount) ultraviolet spectrometer. The observed intensities correspond to the quiet sun conditions near solar minimum. The analysis of Na VII and Al IX line intensities for the quiet sun conditions suggests the need for future observations at higher spectral resolutions to facilitate more detailed electron density and temperature diagnostics of CCTR and the corona. Observations at higher spectral resolutions will become available from the CDS and the SUMER instruments on SOHO (Solar Orbiting Heliospheric Observatory) which is scheduled for launch in 1995 by ESA/NASA. (P.K. Raju, *B.N. Dwivedi, *A.K. Gupta)

## Signatures of coronal heating in He I 10830

The He I 10830 Å line is formed in the chromosphere by radiative excitation by high energy photons emitted from the corona. The width of this line was seen to be correlated with the equivalent width. This was interpreted as the correlation of coronal heating with chromospheric dynamics. This is the first direct correlation of chromospheric dynamics with coronal heating and opens a totally new observational avenue for studying the problem of coronal heating.
(P. Venkatakrishnan)

## Time variability of He I 10830

The temporal variation of the equivalent width of $\lambda$10830 showed a marked difference from that of the line width. This was interpreted as evidence for ruling out coronal intensity fluctuations as the cause of the equivalent width fluctuations. The other possibility is the eruption of density inhomogeneties, like spicules, into the line forming region. (Jagdev Singh, S.K. Jain, P. Venkatakrishnan)

## Model for the relationship of granulation and supergranulation

A new mechanism has been proposed for producing the observed solar supergranulation from the photospheric granulation by dissipative decay of two-dimensional turbulence, which leads to concentration of the energy spectrum to the longest wavelengths. This concentration of convective eddies by selective dissipation to the scale with the maximum available spatial dimension and with a much longer time scale was verified by mode-mode coupling seen in computer simulations as well as in laboratory experiments. Theoretical predictions for these granulation scales and magnetic structures can be tested by high quality observations of the solar surface. (V. Krishan)

## Self-consistent models for solar flux tubes with multistream radiative transfer

This is a continuation of earlier work on developing comprehensive self-consistent models for magnetic field elements extending vertically in the photosphere of the sun. In the first phase of this work reported earlier, the equilibrium structure of intense flux tubes on the sun was calculated for a cylindrical flux tube, taking into account a refined treatment of radiative transfer and also convective energy transport. Flux tube models were constructed for a variety of parameters, such as the plasma beta (ratio of gas to magnetic pressure) and tube radius at the surface, and their effects were examined on the thermodynamic structure of the tube.

An interesting consequence of the above study, is the fact that it may be possible to indirectly estimate the depth in the convection zone to which flux tubes penetrate. It seems unrealistic to expect

that the tubes extend all the way down to the base of the convection zone, since this would imply field strengths of the order of several megagauss, which seems unlikely. Fresh calculations suggest that the energetics, particularly the efficiency of convection, may play an important role in determining the vertical extension of tubes.

In the next phase of the work, which is presently under investigation, nonlinear time-dependent simulations of flux tubes are being carried out, whose equilibrium structure has been determined as mentioned above. The aim of the project is to focus on the importance of dynamical effects in flux tubes and to examine the relevance of various energy transport mechanisms towards heating of the solar atmosphere. (S.S. Hasan)

## Solar rotation from sunspot measurements

Measurement of the daily positions and areas of sunspots from the Kodaikanal white light images was continued. (K.R. Sivaraman, S.S. Gupta, *R. Howard)

## Sunspot magnetic fields and the Wilson effect

The possible role of magnetic field strengths of the spot in the Wilson effect exhibited by some of the spot penumbrae, is being examined. A long series of high dispersion Zeeman spectra in the 6303 Å line and white light pictures, both obtained earlier at Kodaikanal, are being used for the study. Independent spots away from complex spot regions and suitable for the required measurements, are being selected. (S.P. Bagare, S.S. Gupta, P. Venkatakrishnan)

## Evershed effect in sunspots

Evershed flow observations in a non-Zeeman line $\lambda$4912 have been taken for nearly 150 unipolar and bipolar sunspots of different sizes. Line-of-sight components of the sunspot magnetic field were observed in $\lambda$6303 along with the velocity fields, especially in the case of bipolar spots, for determining the flow near the magnetic neutral line. (K. Sundara Raman, P.S.M. Aleem)

The time sequence spectra of 10 sunspots in the spectral region $\lambda$5890 – $\lambda$5910 were reduced to determine short time scale variations in Evershed flow. (K. Sundara Raman, M.H. Gokhale, K.M. Hiremath)

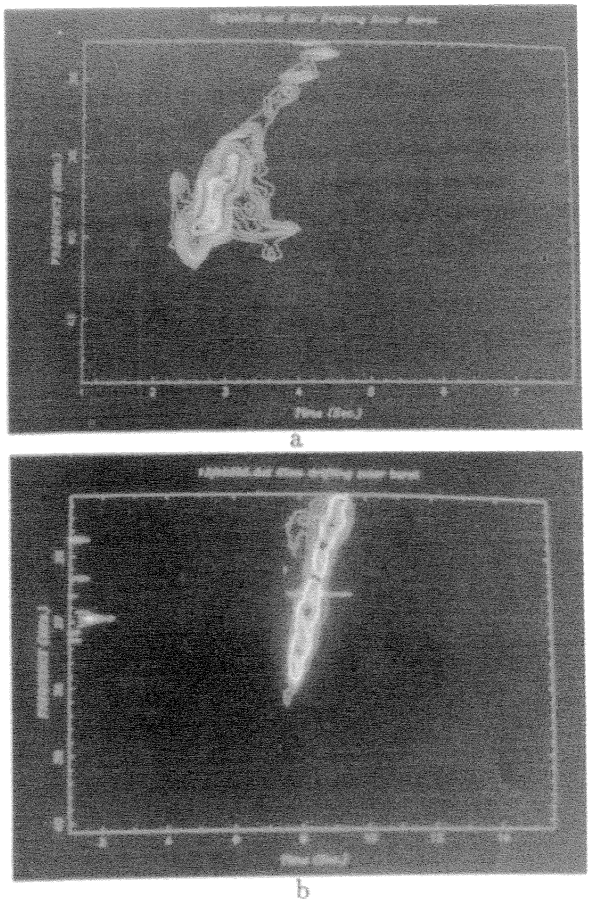
## Prominence evolution

It was shown that rotations of a plage and a spot play an important role on the evolution of prominences, one serving as the anchor and the other imparting the necessary shear. (R.R. Rausaria, S.S. Gupta, R. Selvendran, K. Sundara Raman, Jagdev Singh)

Equations have been set up to construct a quasi-two-dimensional MHD model for quiescent prominences incorporating non-adiabaticity, finite resistivity and the shear in the field. (B.S. Nagabhushana).

## Pre-flare changes in filament orientation

A number of papers have been written in the recent past reporting changes in the orientation of H$\alpha$ filaments prior to flare events. These orientation changes were thought of as representing changes in magnetic shear and statements were even made that large magnetic shear was not required for a flare onset. These erroneous notions were corrected in a letter to Solar Physics, where it was argued that the changes in filament orientation were more likely manifestations of flux redeployment. A comprehensive programme to study this phenomenon of filament reorientation involving polarimetry, spectroscopy and radio observations of such events is being planned. (P. Venkatakrishnan)



Slow drifting solar radio bursts observed using Broad Band array (Meridian transit instrument with a $7^{o}$ beam along EW direction at 65 MHz) and an acoustic optic spectrograph. The burst shown in (a) started at 06 13 52 UT while that in (b) started at 06 33 02 UT on February 13, 1990, during solar storm period. The drift rate of the bursts are 2.4 MHz/second and 1.125 MHz/second respectively. The intensity levels show progressively increasing radio flux from the outer contour to the inner. (E. Ebenezer, K.R. Subramanian, Ch.V. Sastry)

## Solar radio bursts

The data obtained from the broadband array and the acousto-optic spectrograph were analysed to study fine structures in solar radio bursts. Characteristics of slowly drifting bursts were investigated. The drift rate and the bandwidth suggest that these bursts are similar to Type I bursts. (K.R. Subramanian, E. Ebenezer, Ch.V. Sastry)

## Flares

The change in the orientation of a circular H$\alpha$ filament was found to trigger an instability giving rise to a double ribbon flare in a non-spot region. (K. Sundara Raman, S.S. Gupta, R. Selvendran)

The twisting of sunspot umbrae with a common penumbra was found to lead to fast changes (on the order of half a minute) in the filament orientation triggering the eruption of a 4B flare. (R.R. Rausaria, K. Sundara Raman, S.M. Aleem, Jagdev Singh)

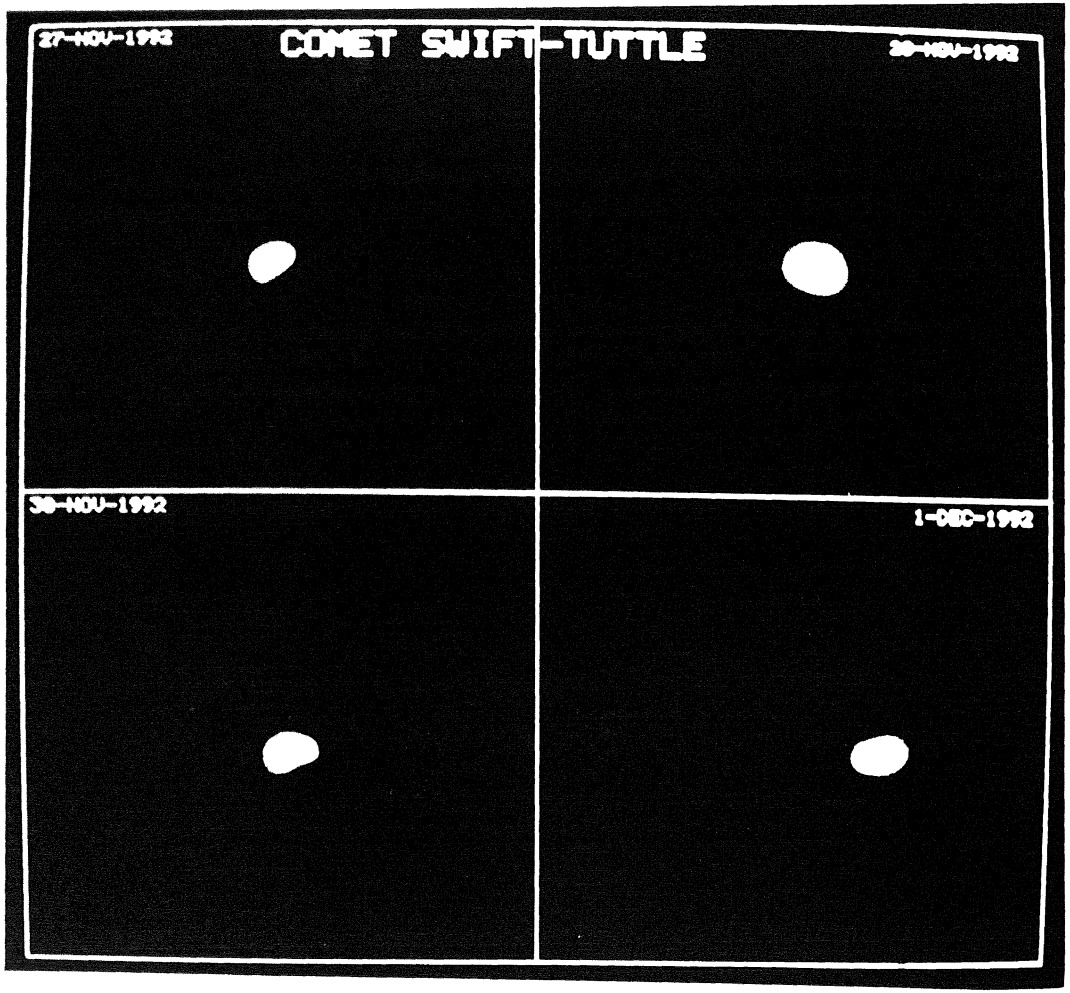
## Vector magnetograph project

Field trials of the polarimeter were continued at Kodaikanal. The polarimeter - spectrograph - CCD combination is now able to measure polarization correct to 0.6%. However, there is a small but correlated variation of the degree of polarization around the mean value with the total intensity, which is now being investigated. (P.Venkatakrishnan, A.V. Ananth, R.S. Narayanan)

## Bidimensional spectroscopy

A computer programme for bidimensional spectroscopy was written and spectroheliograms were composed from a series of spectra recorded by a CCD camera, while the solar image was made to drift

across the entrance slit of the solar tunnel spectrograph. This technique, when fully developed, can provide magnetograms and Doppler grams over a limited field of view. By acquiring images in one frame buffer and writing a portion of the 512 x 512 image to appropriate locations in the rest of the 15 available frame buffers, one is now able to store up to 240 spectra obtained in a continuous sequence. We have thus built 128 x 240 pixels 2-D pictures at particular wavelengths in the line profile. The same scheme is also useful for studying phenomena like sunspot oscillations or rapid spectral changes during solar flares. (P. Venkatakrishnan)




Rotation of the nucleus of Comet Swift-Tuttle.

# Solar System Studies

## Ephemerides of Galilean satellites

The relative astrometric positions of the Galilean satellites derived from mutual occultation light curves of 1985 and 1991 and published results of 1973 and 1979 mutual event seasons were combined with about ten thousand photographic positions during 1891-1990 to obtain improved ephemerides (I.32) for these satellites. This has been derived by obtaining the corrections to the mean motions, primary eccentricities, primary sine inclinations, mean longitudes, proper perijoves, proper nodes of the satellites, libration phase angle amplitude and the libration phase angle using Lieske's method (see Lieske, J.H. 1978, Astr. Astrophys. **65**, 83). In addition the longitudes of the satellites were analyzed to look for secular changes in their mean motions, which yield valuable clues to the evolution of the satellite system itself. The present investigation yields a value of $26.6 \times 10^{-11}\ yr^{-1}$ for the rate of change of Io's mean motion, suggesting that the tides raised by Jupiter are dominating. (R. Vasundhara, *J.-E. Arlot, *P. Descamps)

## Comet Swift-Tuttle

Series of CCD photographs of the nucleus of the comet Swift-Tuttle were taken at the prime-focus of VBT during November - December 1992. From these photographs it was found that the nucleus of this comet rotates with a period around 2.7 days. (N.K. Rao, K.K. Ghosh, K. Jayakumar, G. Selvakumar, M. Appakutty)

## Near-Earth asteroids

A programme for the search of near Earth asteroids has been envisaged in collaboration with the Department of Astronomy, Osmania University, Hyderabad using the 120 cm telescope of the Japal Rangapur Observatory (JRO). It is planned that initially six observing nights per month at JRO will be used for this purpose. A 1024 × 1024 pixel CCD from Photometrics Ltd, U.S.A., to be used in the time delay integration mode also, and two Sun work stations have been ordered for this project.

The CCD will be mounted at the prime focus of the telescope which has a unique Baker corrector system for a 3° × 3° corrected field for wide field imaging. One of the workstations will be used for image acquisition as well as for the near real time detection of moving objects. The second computer will be located in the Department of Astronomy, O.U. for regular analysis of all CCD data obtained with this telescope. The design of the CCD mount for the prime focus is under way. The elaborate software needed for the research for moving objects will take about a year to be ready for use. First observations with this large format CCD are expected to start by the beginning of 1994. (R. Rajamohan)

## Herbig Ae/Be stars

The pre-main sequence Herbig Ae/Be stars have been monitored polarimetrically. These objects show large values of polarization caused by scattering of starlight by circumstellar dust. Temporal changes in the structure of the dusty circumstellar discs are expected to produce changes in the polarimetric behaviour. About 40 of these stars have been observed at several epochs and variability has been recorded in a number of them. (S.K. Jain, H.C. Bhatt,*I.I. Romanyuk)

These stars show remarkable signs of activity – emission in the Mg II h and k lines, presence of the C IV resonance doublet at 1550 Å, emission in He I 5876 Å, Ca II T etc. The origin of this activity remains a mystery. Is it linked to phenomena occurring inside these stars like, for example, dynamo generated magnetic fields, or is it linked to an external agent like, for example, a boundary layer between an accretion disk and the stellar surface? Recent observations suggest that the activity in these stars may be of magnetic origin. In particular, rotational modulation has been observed in the lines formed in the wind of the Herbig Ae star AB Aur. By analogy with the solar wind, it has been suggested that the modulation may be due to corotation of azimuthal structures in the wind controlled by a surface magnetic field. So far there has been no clear indication that the source of modulation is near the stellar surface, since the lines for which the modulation is observed are supposed to form far out in the wind of AB Aur. Is it possible that some other type of variable phenomenon occurring in the wind itself is causing the modulation? To answer this question, an international observing campaign by the name Multi-site Spectroscopic Campaign or MUSICOS 92, was organised during 1992 December 7–14. Spectra of AB Aur were obtained. Detailed analysis of the spectra is in progress. (K.K. Ghosh, *C. Catala)

Time resolved spectroscopic observations of the two Herbig Ae/Be stars, V 380 Ori ($< V > = 11.2$) and HD 76534 ($< V > = 8.1$), were carried out on eleven nights at the Cassegrain foci of 102 cm and 234 cm telescopes of VBO, Kavalur, using the Universal Astronomical Grating Spectrograph and the Boller and Chivens spectrograph with CCD detectors. These observations were aimed at studying short term variations of photospheric absorption lines of H$\alpha$ and He I 6678 Å, within one night and from night to night. Also variations in the envelope emission lines H$\alpha$, Fe II, Si II, Ne I, He I etc. were searched for on time-scales of hours. On the basis of the observed characteristics of the variations of the two target stars, a model has been proposed involving a corotating and slowly expanding region surrounded by slowly rotating layers with higher expansion velocities. (K.K.Ghosh, K.V.K. Iyengar)

## T Tauri stars

In order to investigate the differences in behaviour of classical and weak-emission T Tauri stars, an observational programme involving spectroscopy, photometry and polarimetry was carried out. The programme stars consisted of the classical T Tauri stars TW Hya, HDE 319139 and the weak-emission T Tauri stars V 410 Tau, HD 288313, HD 283572 and FK Ser. Preliminary analysis of the H$\alpha$ spectra showed that the variation in the strengths of the H$\alpha$ emissions in weak-emission T Tauri stars are more or less periodic while in classical T Tauri stars strong and very rapid, non-periodic emissions are observed. In V 410 Tau, H$\alpha$ changes from emission to absorption within two days. The classical T Tauri stars that show strong H$\alpha$ emissions are assumed to have circumstellar material and active accretion disks. The very broad H$\alpha$ emissions observed in TW Hya and HDE 319139 suggest that the lines are formed in the circumstellar environment. These stars have active accretion disks and accretion occurs through the boundary layer.

The broad band polarimetric observations of the programme stars over a few rotation periods show that in some stars the polariza-

tion variability is periodic, the periods being the same as their rotation periods. Though variable polarization was observed in the remaining stars, periodicity was not detected. The near-simultaneous broad band photometry enabled us to detect the periodic nature of the light variations in some programme stars. (M.V. Mekkaden)

## Be stars

High-resolution spectroscopy of different lines of hydrogen, helium, magnesium, silicon and iron has been carried out for a large number of Be stars at VBO. From the preliminary results it is found that the Be stars change from Be to Be-shell type spectra via strong mass loss. Further there are clear indications of infall of matter on the surfaces of these stars before major outbursts. Recently $\gamma$ Cas (a bright Be star) was found to enter into the shell phase when the ratio of violet to red emission peaks (V/R) changed from a value greater than unity to one less than unity. Detailed studies are under way. (K.K.Ghosh, *K.C.Srinivasan, *R.Krishnamurthy, *K.R.Radhakrishnan, G.Selvakumar, M.J.Rosario, K.Kuppuswamy)

## B[e] stars

The observed infrared excess in B[e] stars was earlier interpreted as free-free and free-bound emission from a hot gaseous envelope around the B[e] star. It was then expected that this hot gas should also emit H$\alpha$ line radiation. Observations in the infrared and of H$\alpha$ showed that they are incompatible with each other, if it were assumed that they arise in the same ionized region; however, the two observations were made at different times. To make a more definitive assessment, simultaneous observations of infrared and H$\alpha$ line radiation were carried out in seven B[e] stars, viz., $\eta$ Tau (HR 1165), $\zeta$ Tau (HR 1910), $\kappa$ CMa (HR 2538), $\beta$ CMi (HR 2845), HR 3858, $\delta$ Cen (HR 4621) and HR 4123. The ratio of infrared and H$\alpha$ emission luminosities observed is much larger than the expected value of about 3 if both the infrared and H$\alpha$ emission were to arise from the ionized gas. These observations imply that either these radiations do not arise from the same hot gas or that additional processes are at work to produce the excess infrared radiation. (K.V.K. Iyengar, K.K. Ghosh, *K.M.V. Apparao, *S.P. Tarafdar, *R.P. Verma)

## Delta Scuti star $\theta^2$ Tau

The presence of a multitude of modes and periods for $\delta$ Scuti stars has been predicted by theory but these are rarely seen in photometric observations. The sensitivity of high-resolution spectroscopy to high-degree nonradial pulsations (NRPs) is yielding some answers. Both high-and low-degree variable modes of NRPs have been detected in $\delta$ Scuti stars, but the analysis of the variations was not always simple. Long term continuous spectroscopic observations would provide both the temporal and spatial resolution needed to identify both frequencies and modes of oscillations in $\delta$ Scuti stars. For this reason an international campaign, MUSICOS 92, was organised in 1992 December to observe a bright $\delta$ Scuti star, $\theta^2$ Tau. A large number of very good quality spectra of this star were obtained on 5 nights, during 1992 December 8–12 using the UAGS with CCD detectors at the Cassegrain focus of the 102 cm telescope at VBO. Preliminary results indicate at least two modes of oscillation are present in this star and most likely, many more modes could be identified leading to a possible application of stellar seismology.(K.K.Ghosh, *T.Kennelly, *G.Walker)

## Ap and Am stars

A comparison of the various physical parameters of the normal A stars with those obtained by using the peculiarity-free zones in the energy distribution curves of the Ap stars indicate that the peculiar A stars may be treated as normal stars as far as their effective temperatures, radii, bolometric corrections and the mass range are concerned. (G.S.D. Babu)

## RS CVn stars

### Infrared colours

IRAS 1D COADD data for 82 RS CVn systems were analysed to obtain their magnitudes at 12 and 25 $\mu$m . Their colours V−[12] and [12]−[25] were computed and their dependence examined. For 62 stars, the excess at 12 $\mu$m was derived using the information on the spectral types of their binary components and measured colours (B−V) and (R−I). It is found that RS CVn systems have genuine excess at 12 $\mu$m. However, no definite conclusions could be derived for the [12]−[25] excess. (K.V.K. Iyengar, *T.N. Rengarajan, *R.P. Verma)

### II Pegasi

The differential BV photometry of II Peg obtained on a total of 57 nights during 1986−1991 and H$\alpha$ spectroscopy of it obtained on 12 nights during 1990−1991 were analysed. The light curves are mostly asymmetrical in shape and rapid changes occur in the mean light level. The maximum light level was close to 7.35 mag during 1976−1983, but after a drop in 1985 it has shown a slight increase from 1986 onwards.

The behaviour of $\Delta V_{max}$ and $\Delta V_{min}$ in relation to the amplitude of light variation was analysed. At larger amplitudes the brightness at minimum decreases and the brightness at maximum increases, both converging to a particular value of $\Delta V$ at very low amplitudes. In terms of the starspot model this implies, qualitatively, either of the following scenarios: (i) At lower amplitudes, spots are evenly distributed in longitudes and are predominantly present at higher latitudes and hence are seen throughout the entire rotational period. (ii) At higher amplitudes, spots are more concentrated about some longitude and are predominantly located at lower latitudes and hence disappear from view during a fraction of the rotational period.

The behaviour of the phase of light minimum over the years was also investigated. II Peg shows both direct and retrograde migrations of the phase of light minimum. A total of six spot groups were identified during the period 1974−1991. On most occasions there were two prominent spot groups present. Observations of II Peg indicate a lifetime of two to seven years for a spot forming region.

The H$\alpha$ emission equivalent widths in II Peg indicate a modulation with the photometric phase in the sense that the emission equivalent width is more intense near the light curve minimum. The spectra of II Peg obtained on 1990 Nov. 22 show strong evidence of a flare. The present observations do indicate a strong relationship between spot activity as implied by the optical light curve, and chromospheric activity as implied by the H$\alpha$ emission equivalent width variation. (S. Mohin, A.V. Raveendran)

### V 711 Tauri

The differential BV photometry of V 711 Tau obtained on a total of 120 nights during the years 1984−1991 and H$\alpha$ spectroscopy of it obtained on 14 nights during the 1990−1991 observing season were analysed. The mean light level of the system during the period 1982−1991 was brighter by $\sim$ 0.05 mag compared to that during the period 1975−1982. Probably there was a corresponding change in the mean quiescent *uv* emission level also.

The behaviour of brightness at light maximum $\Delta V_{max}$ and at light minimum $\Delta V_{min}$ in relation to the amplitude of light variation has been analysed. At larger amplitudes $\Delta V_{min}$ decreases and $\Delta V_{max}$ increases; both converge to a particular value of $\Delta V$ at very low amplitudes as found in the case of II Peg.

In the case of V 711 Tau the spots are, most likely, confined predominantly to two different latitude belts as indicated by the grouping of the phases of light minima on two independent near-straight lines. The lifetime for a spot forming region is found to be more than 15 years.

Though the H$\alpha$ emission strengths are highly variable, V 711 Tau

does not show any modulation of the same with the orbital phase during the period of our observations. However, spectra obtained on one night (1991 February 6) show a sudden drop in equivalent width which occurs during the descending branch of the light curve. The present observations do not indicate a strong relationship between the spot activity implied by the light curve and chromospheric activity implied by the H$\alpha$ emission equivalent width.
(S. Mohin, A.V. Raveendran)

In 1992 December the photospheric surface of V 711 Tau was imaged as part of MUSICOS 92. The star is the brightest ($m_V$ = 5.7) of the active RS CVn binaries. The goal of this campaign was to obtain a nearly complete time coverage of photospheric line profile variations resulting from the rotation of the inhomogeneous stellar surface. A large number of spectra were obtained and these will be used to construct a Doppler image of the star. Detailed analysis of the data is under way. (K.K.Ghosh, *T.Wimon, *J. Neff)

## Hydrogen deficient stars

### Spectral line variation of UW Cen (1991-1992)

UW Cen was observed on 15/16 July 1991 when it was at light maximum and later in May 22/23 1992 when it was recovering after light minimum. The Na I D lines of the 1992 spectrum have very interesting profiles with strong violet shifted absorption components of possibly circumstellar origin. Both D1 and D2 lines have four components each. For the D1 line they correspond to velocities of $-154, -116, -2$ and $+24$ km s$^{-1}$. In case of D2 the components correspond to $-156, -122, -3$ and $+24$ kms$^{-1}$. However, the Na I D lines in the 1991 spectrum do not show such high velocity absorption components but the stellar lines are asymmetric in the blue side of line profiles. These changes are displayed in Figure 4. Further, the other absorption lines of intermediate strengths are stronger in the 1991 spectrum. A detailed quantitative investigation of the spectra at these two epochs was done using hydrogen deficient model atmospheres of Schönberner and the line synthesis technique. Atmospheric parameters (effective temperature, gravity and microturbulence) were determined using a set of Fe I and Fe II lines. The same effective temperature of 7750 K and log g of 0.5 have been obtained for both epochs. However, the microturbulence velocity was found to be 9.5 km s$^{-1}$ for the 1991 spectrum while for the 1992 spectrum it is 8.0 km s$^{-1}$. This difference in microturbulence can explain the observed strengthening of intermediate strength lines in the 1991 spectrum. The UW Cen spectrum shows a very strong Li I feature at 6707.8 Åat both epochs. This is only the fourth star after R CrB, SU Tau and RZ Nor to show a Li I feature. A log abundance of 4.6 for Li was derived which is far in excess of the solar value.

Atmospheric abundances of C, N, O, Mg, Al, Si, S, Sc, Ti, Cr, Mn, Fe, Ni, Y, La, Ce and Nd were also derived. (S. Giridhar, N. Kameswara Rao, *D.L. Lambert)

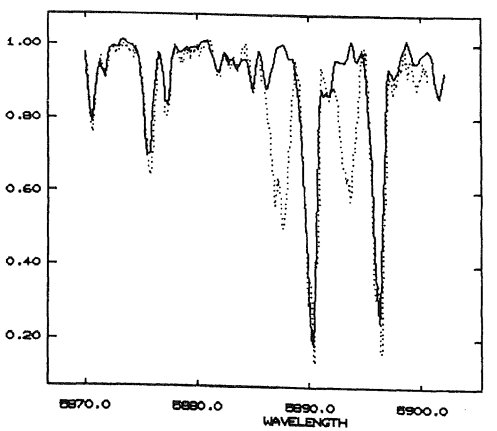



**Fig. 4.** Spectrum of R Cr B star UW Cen at light maximum (continuous line) and during light recovery (dashed line). Note the high velocity shifted absorption in components of Na I D lines indicating mass ejection during the minimum.

### V 854 Cen

The R Cr B star V 854 Cen was observed at minimum light (V $\sim$ 15.5) at high spectral resolution ($\Delta\lambda$ = 0.3A) from 5480 Å to 7070 Å. The spectra have been obtained using the CTIO 4 m telescope and the echelle spectrometer. The spectrum consists of three components: a continuum devoid of photospheric lines, a collection of sharp emission lines of Sc II, Ti II, Y II and Ba II and broad emission lines of [O I], [N II], [S II], H$\alpha$, Na I D, and $C_2$ Swan bands. A low resolution spectrum reveals additional lines of Ca II, [C I] and other species. The continuum is identified with a thick dusty disk obscuring the photosphere. The sharp emission lines are considered to be chromospheric lines. The broad lines with a full width of 400-500 km $s^{-1}$ come from an extended region with a temperature of about 7000 K but an electron density of 50 $cm^{-3}$ or less. It is suggested that V 854 Cen may be a bipolar nebula. (N.Kameswara Rao, *D.L.Lambert)

UBVR polarimetric observations of V 854 Cen were obtained with VBT during 1991 February – 1992 March. They include observations at both light maximum and during light minimum. Both the amount and position angle of polarization obtained during one light maximum differ significantly from that obtained during the other and the position angles are independent of wavelength. The wavelength dependence of polarization during the light minimum is much steeper than that during the light maximum and the corresponding position angles differ by $\sim$75°. During the decline phases the polarized flux is also attenuated by the same factor as the starlight implying that the cloud which obscures the photosphere causing the light fading obscures the scattering region also. This restricts the extent of the scattering region which contributes to the observed polarization at light maximum and early decline phases close to the photosphere. The polarization observed at light minimum, most likely, arises from scattering by dust particles distributed more extensively about the star. (N. Kameswara Rao, A.V.Raveendran)

Several unidentified broad emission features previously seen only in the spectrum of the nebulosity in the Red Rectangle have been observed in the spectrum of V 854 Cen taken in the deep minimum. These bands do correspond to some of the diffuse interstellar bands seen in absorption in the interstellar medium. The presence of the bands associated with an R Cr B star suggests that their carrier does not contain hydrogen atoms. Extended red emission seen from the Red Rectangle and probably associated with hydrogenated carbon grains is not present in the spectrum of V 854 Cen. (N. Kameswara Rao,*D.L. Lambert)

### V 482 Cyg

The R Cr B star V 482 Cyg is thought to be a member of a quadruple system by Gaustad et al. who derived an absolute magnitude $M_V$ = −2.8 for the star based on this membership. However, this membership critically depended on the assumption that the K5 III star V 482 Cyg B 6 arcsec away, is also physically associated with the R Cr B star V 482 Cyg A. To investigate this possibility we obtained high resolution spectra of both stars V 482 Cyg A and B with the CTIO 4 m telescope. The spectrum of B is that of a late K giant and shows a clear difference in the radial velocity of $\sim$ 35 km $s^{-1}$ with respect to star A. The strength and velocities of Na I D lines also indicate that the star A is much farther than star B. Thus it is shown that the low value of $M_V \sim -2.8$ is not proper. It is further estimated that $M_V \sim -5$ for the R Cr B star V 482 Cyg A. (N. Kameswara Rao, *D.L. Lambert)

### DY Cen

Spectroscopic analysis of the hot R Cr B star DY Cen was completed. The star shows a strong absorption line spectrum dominated by lines of C II, N II and Ne I. Some of the C II He I lines show inverse P-Cygni profiles and emission lines of [N II], [S II] and [O I] are detected. The spectrum also contains several diffuse interstellar bands that were used in estimating the E(B−V) of this star. The observed strengths of forbidden emission lines indicate the presence of a low-excitation nebula with an electron temperature of $\leq$ 10000 K and an

electron density of 450 $cm^{-3}$. Additional spectra of DY Cen have been obtained in 1992 with the CTIO 4 m telescope with higher resolution. There seems to be a variation in the line strengths of some of the elements. Detailed analysis is in progress. (N.Kameswara Rao, S. Giridhar, *D.L. Lambert)

### High resolution studies

Data analysis of a large sample of R Cr B stars, e.g., FH Sct, UW Cen, GU Sgr, SV Sge, UX Ant, XX Cam, SU Tau, V Cr A, MV Sgr, RY Sgr was done. The quantitative analysis to derive atmospheric parameters of these stars is in progress. (N.Kameswara Rao, S. Giridhar, G. Pandey, *D.L. Lambert)

### Polarimetry

Several polarimetric observations of hydrogen deficient stars as well as of RV Tauri stars were obtained with VBT. Particularly AR Pup showed a very interesting change in the position angle by almost 90° in U, B on two occasions in 1991 relative to its normal average behaviour in the earlier years. (A.V. Raveendran, N. Kameswara Rao)

## Ca T lines in cool stars

### Sensitivity to atmospheric parameters

Ca II triplet lines at λλ 8498, 8542 and 8662 have proved to be good diagnostics for studies of stellar populations in galaxies. The study of these lines, started in 1991, was further extended. High resolution CCD observations were obtained for another 22 stars at the 102 cm telescope with the Coudé echelle spectrograph. Several metal poor stars with metallicity [Fe/H] < −0.75 were observed and as a result, the [Fe/H] range covered earlier between −0.65 and +0.50 now extends from −3.0 to +0.5. The stellar atmospheric parameters log g, $T_{eff}$ and [Fe/H] have been updated for all the stars using the new [Fe/H] catalogue of Cayrel de Strobel et al. (1992, Astr. Astrophys. Suppl. 95, 273). Using this catalogue the behaviour of the Ca II triplet strengths has been reinvestigated.

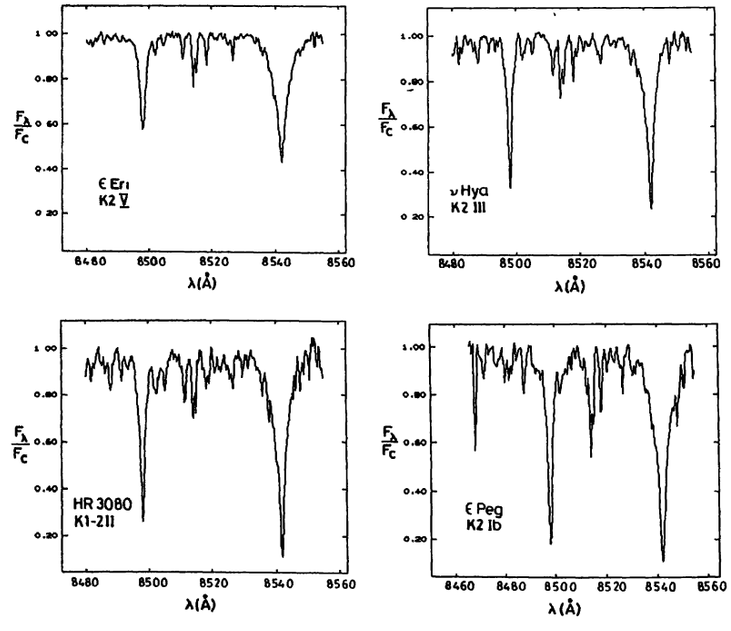



**Fig. 5.Coude echelle spectra of Ca T lines showing the variation with luminosity of the line strengths.**

The analysis gives a convincing evidence of the biparametric nature of the Ca II triplet strengths with a strong dependence on luminosity (Figure 5) and a milder dependence on metallicity. The relationship between the equivalent width and log g is much tighter in metal rich stars than in metal poor stars. Similarly, the correlation between EQW and [Fe/H] is much stronger for lower log g's. In both the cases, the relationship is nonlinear, contrary to what is shown by the previous studies. Very recently, Jorgenson et al. (1992, Astr. Astrophys. **254**, 258) have performed detailed non-LTE calculations to compute the Ca II triplet EQW's as a function of $T_{eff}$, log g and metallicity. We have made a detailed comparison of our observations with their theoretical results. The observed EQW's for stars with known log g, $T_{eff}$ and [Fe/H] match very well with the theoretical EQW's calculated for the corresponding values of the stellar parameters. Also, the theoretical EQW's exhibit a nonlinear dependence on luminosity and metallicity, very similar to what our observations suggest. (S.V. Mallik)

### Asymmetric profiles in superluminous supergiants

About 15 superluminous supergiants of luminosity type 0 or 0-Ia have been sampled from the Bright Star Catalogue and 'An Atlas of Spectra of the Cooler Stars' by Keenan and McNeil (1976). CCD spectra of 7 of them have been obtained in the Ca II triplet region with the Coudé echelle spectrograph at the 102 cm telescope at a resolution of 0.4 Å. The line profiles of $\lambda\lambda$ 8498, 8542 are seen to have a complicated structure quite different from those of supergiants Ib and Iab. The profiles are much wider and are often split into components with a central emission thus suggesting a complex velocity pattern. Analysis of the data is in progress. (S.V. Mallik)

## Post AGB stars

### LS II + 34° 26

LS II +34° 26 is an eleventh magnitude low gravity, high velocity and high galactic latitude B1.5 Ia - Iabe supergiant star. It is found to be an IRAS source with far IR colours, flux distribution, and dust shell parameters similar to those of planetary nebulae. Based on these observations it is concluded that LS II + 34° 26 is a low mass post AGB B1.5 Ia - Iabe supergiant with a detached cold circumstellar dust shell and not a young massive B star of Population I located at 17.8 kpc near the outer edge of the galaxy. It is the hottest post AGB supergiant discovered so far. With this detection the sequence of post AGB supergiants is found to extend from K to B type which indicates the evolutionary sequence of those objects from the tip of the AGB towards left in the H-R diagram. LS II + 34° 26 may be rapidly evolving towards hotter spectral types and into the region of planetary nebulae. (M. Parthasarathy)

### Hot post AGB stars

From an analysis of IRAS data several hot post AGB stars have been found. The IUE ultraviolet spectra have been obtained for several of these stars. Some of these hot post AGB stars appear to be rapidly evolving into the region of young low excitation PN. Further observations of SAO 244567 revealed that it has turned into a planetary nebula within the last 20 years. The 1970 optical spectrum shows that it was a B type post AGB star with H and He lines in absorption whereas the present spectrum shows H I, He II, [O III] and [N II] lines in emission very similar to the spectrum of a low excitation planetary nebula. (M. Parthasarathy)

## Unidentified IRAS sources

A search for the optical counterparts of 21 'unidentified' IRAS sources of a late type stellar nature was carried out using the POSS, ESO and SERC Sky Survey Prints. CCD photometric observations of these sources with optical counterparts were carried out using the 102 cm telescope at VBO, Kavalur. Spectroscopic observations in the range $\lambda\lambda$ 6000 – 10000 of three of the brighter sources from among these viz., IRAS 04184+2008, IRAS 07593 – 1452 and IRAS 12387 – 3717 were carried out using the VBT. Spectroscopic observations of a few late type spectral standards were also carried out to enable spectral classification of these stars. The spectroscopic data are under analysis at present. An examination of the spectra of IRAS 04184+2008 shows that Ca II $\lambda$ 8498 appears in absorption whereas the $\lambda$ 8542 and $\lambda$ 8662 appear in emission (indicating chromospheric activity), while in IRAS 12387 – 3717 all the three lines of the Ca II triplet appear in absorption. (K.V.K. Iyengar)

## Novae

Several novae were monitored spectroscopically during this year. Nova Puppis 1991, Nova Cygni 1992 and Nova Scorpii 1992 reached very high excitation during this period. Nova Sagittarii 1992 was also observed during the nebular phase. The long-term spectroscopic monitoring of the old nova GK Persei and the recurrent novae T Coronae Borealis and RS Ophiuchi was also continued.

The density in the shell of Nova Cygni 1992 decreased to $3 \times 10^5$ $cm^{-3}$ early in 1993 and the electron temperature increased to $10^5$ K. The Zanstra temperature of the ionizing source had reached $4 \times 10^5$ K by this time. The spectrum shows coronal emission lines due to [Fe VI] and [Fe VII] (Figure 6). The [Fe X] 6374 Å line could be identified blended with [O I] 6363 Å and continued to increase in strength. The [O III] 5007 Å line was the strongest line, three times stronger than H$\alpha$ indicating an overabundance of oxygen. The mass of the ejected shell is $\sim 3 \times 10^{-5}$ $M_\odot$. Lines due to He I, He II, and the CNO complex at 4640 Å are also strong. (*G.C.Anupama, T.P.Prabhu)

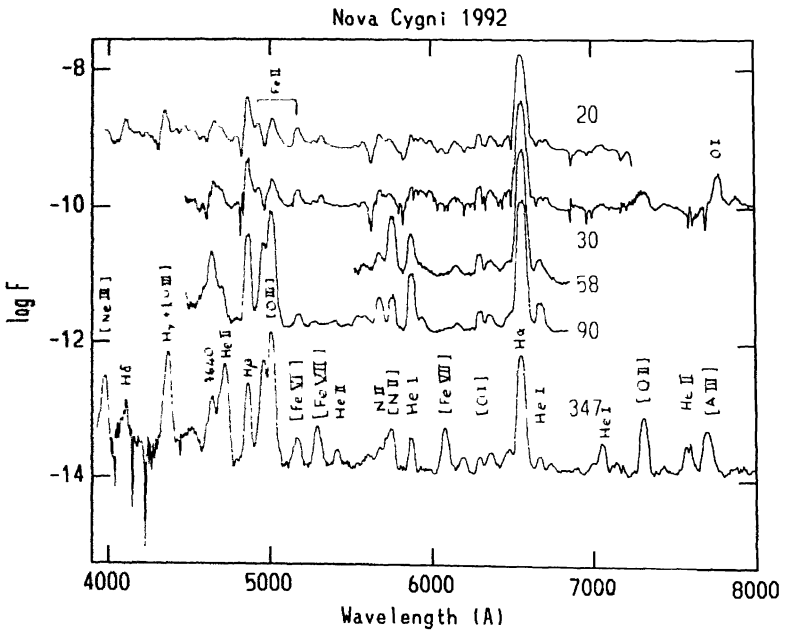



**Fig. 6.**Spectra of Nova Cygni 1992 obtained at 20, 30, 58, 90 and 347 days since outburst. The first and the last spectra were obtained using the 1-m reflector whereas the remaining ones are from the 2.3-m reflector. Ordinates are log $F_\lambda$ (erg $cm^{-2}$ $s^{-1}$ $Å^{-1}$) +constant where the values of constant are 2.0, 1.5, 1.0, 0.5 and 0.0 for the spectra in chronological order.

## Rapid Search for the optical counterpart of GRB 930131

On January 31, 1993 at 18:57:11.71 UT, the BATSE detectors on the Compton Gamma Ray Observatory detected a gamma-ray burst which had the highest peak flux of any burst ever detected by BATSE. The BATSE and COMPTEL instrument teams notified observers throughout the world the preliminary position of this burst for epoch 2000.00 (RA.: $12^h\ 19^m.2$, DEC.:$-8.7°$) to enable them to follow immediately the above detection with observations around the specified location to search for fading counterparts expected of gamma-ray burst sources immediately after the burst. CCD photometric observations around this preliminary position were carried out on 1993 February 2, in the BVRI bands using the 102 cm telescope and in R and H$\alpha$ bands using VBT at Kavalur covering an area of $\Delta$ RA $\times$ $\Delta$ Dec = 3 $\times$2 arcmin$^2$ and 4 $\times$ 6 arcmin$^2$ from UT $22^h\ 27^m$ to $23^h\ 30^m$ and $23^h\ 05^m$ to $24^h\ 10^m$, respectively. However, a more accurate position for the burst source became available a few days later which happened to lie outside the region covered by our observations. These observations did not result in the identification of the counterpart of the gamma-ray burst source. (K.V.K. Iyengar, T.P. Prabhu)

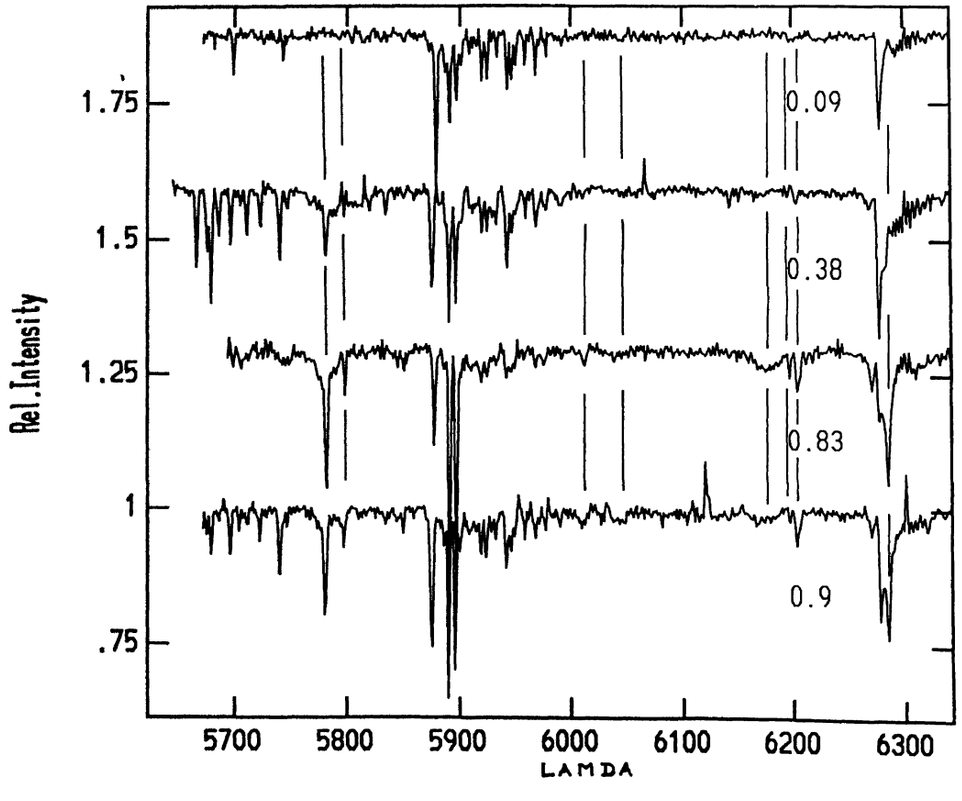



**Fig. 7.** Variation of the strengths of diffuse interstellar bands with E(B-V). (N.K. Rao)

# Galaxy and the Interstellar Medium

## Interstellar clouds

### High galactic - latitude molecular clouds

Magnetic fields play an important role in the evolution of interstellar clouds. Polarization measurements of stars in the regions of the clouds can be used to map the geometry of the magnetic fields. As part of a programme to map the geometry of the magnetic fields in the molecular clouds at high galactic latitudes, polarimetric observations of the clouds MBM 23 and MBM 36 have been made. Earlier, polarization maps were made of two other high latitude clouds MBM 12 and L 121. Analysis of the data for MBM 23 and MBM 36 is in progress. (H.C. Bhatt, S.K. Jain)

### Protostars in molecular clouds

Protostars begin their life as compact subcondensations within molecular clouds. They are acted upon by the gravitational force due to the cloud mass and the viscous drag force as they move relative to the cloud gas. Starting with a mass spectrum for the protostars and a velocity distribution, the trajectories of the protostars in the clouds have been followed numerically and the evolution of their kinematic properties have been studied. It is found that higher mass protostars spiral in toward the cloud centre. This produces mass segregation as is observed in several young open clusters in the Galaxy. (Uma Gorti, H.C. Bhatt, * I.P. Williams)

### Diffuse interstellar bands

Spectra of several stars (including some WC 11 stars) have been obtained with the Boller and Chivens spectrograph on VBT to study the diffuse bands. (N.K. Rao, H.C. Bhatt, A.V. Raveendran)

## Star clusters

### Effect of mass segregation

The effect of mass segregation on mass function of young open clusters has been studied and it is found that the slope of the mass function is steeper in the outer part of the open clusters. Since derived dynamical relaxation time is always larger than the age of the cluster, it is inferred that the observed mass segregation might have taken place at the time of the formation of these clusters. (R. Sagar, *A.K. Pandey, *H.S. Mahra)

### King 10

CCD photometry of the open cluster King 10 was carried out in the UBVRI photometric passbands down to $V \sim 19.5$ *mag*. The reddening for the cluster region was found to be variable. A distance of 3.2 *kpc* was estimated for the cluster, while age of the cluster was determined to be less than 50 *Myr*. (R. Sagar, *V.Mohan, *A.K.Pandey, *D.C.Paliwal, *H.S.Mahra)

### NGC 2287

This large cluster has been observed in several fields over the past three years. In the present year some fields overlapping earlier ones were observed in order to permit calibration of the data. The observational strategy has been to utilise data even from non-photometric nights, with a view to improving signal-to-noise by multiple observations and to use overlaps with fields observed during photometric nights, to do the calibration. There is now extensive data on this cluster and reductions are in progress. (A.K. Pati, R. Sagar)

### NGC 2453

A detailed photometric study of the open cluster NGC 2453 in Puppis is in progress. The core region of the cluster was observed in V and I bands using the Photometrics CCD system at the Cassegrain focus of the 102 cm telescope of VBO. Each image frame covers a field of 2'.3 x 3'.4 of the sky.

The data were initially processed using the STARLINK package and the magnitude estimation of stars was done using DAOPHOT. A well populated main sequence down to $V \geq 20.0$ is seen clearly (Figure 8). This is the first time the unevolved main sequence of the cluster has been observed. After applying appropriate extinction and colour corrections a true distance modulus of $12^m.9 \pm 0^m.25$ corresponding to a cluster distance of 3.80 $\pm$ 0.47 *kpc* has been obtained. Since the distance estimate to the cluster puts it at nearly the same distance as the PN NGC 2452 (the PN is located at about 7.' away from the cluster core), it is natural to ask if the nebula and the cluster are associated.(D.C.V. Mallik, R.Sagar, A.K. Pati)

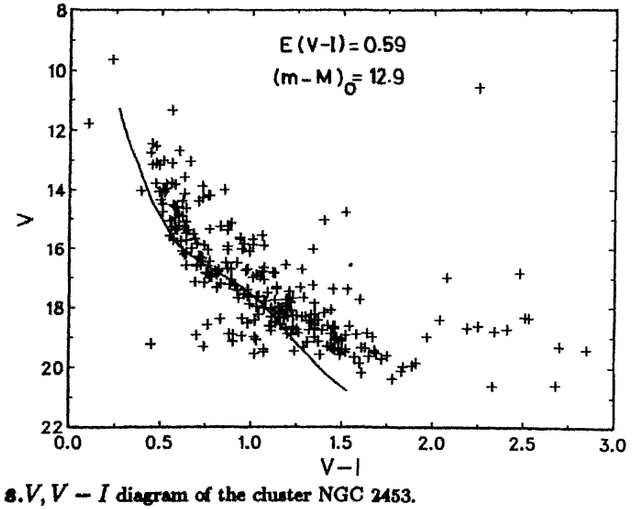



**Fig. 8.** $V, V - I$ diagram of the cluster NGC 2453.

## Planetary nebulae

### WC11 type nebulae

a) Photoionization modelling

In an effort to improve modelling calculations by use of model atmosphere fluxes instead of blackbody fluxes for the central star a collaborative work with Dr. Wolf-Rainer Hamann (Institut für Theoretische Physik und Sternwarte der Universität Kiel) was initiated. Model atmosphere fluxes for M 4-18 using his computer code which features NLTE and mass loss were computed. The central star in this WC11 type nebula is hydrogen deficient and also exhibits, mass loss via stellar wind.

b) CO observations

CO observations for M 4-18 were carried out using the 10 m millimetre wave telescope at Raman Research Institute, Bangalore. After a preliminary reduction, it was realised that the integration time required to obtain a good S/N ratio would be very large (~15 hrs) with the 10 m dish.

c) UV observations with the IUE satellite

New UV observations of M 4-18 obtained with the IUE satellite were analysed and the modelling for M 4-18 was redone.

d) Spectroscopy

Spectroscopic observations of WC11 type PNe with the B&C spectrograph at VBT in the wavelength range of 4000 – 10000 Å were continued.

e) Polycyclic aromatic hydrocarbons (PAH)

It has been known for some time now that WC11 type PNe show emission features at 3.38, 7.7, 8.7 and 11.3 $\mu$m attributed to the presence of PAHs. Preliminary exploratory work to understand PAH physics, particularly to improve the dust modelling by way of inclusion of PAHs along with dust, was carried out. The following are the

broad general ideas that emerged out of this exercise: (i) Inclusion of PAHs in nebular models is obviously of considerable importance; there is, as yet, no "standard model" for doing this and it is still being worked out. (ii) A description of PAH absorption cross section, PAH excitation following absorption and the PAH emissivity are required. Further research along these lines is being pursued. (R.Surendiranath)

### Search for [Fe X] line at 6374Å

It is now known that several planetary nebulae show extended x-ray emission. An observational search program to spectroscopically detect the [Fe X] line at 6374 Å from nebulae that show such emission was started. A preliminary estimate of the flux expected in this line for a $T_{plasma}$ of $1.6 \times 10^6$K (NGC 6543) comes out as $\sim 9 \times 10^{-8}$ ergs $cm^{-2}s^{-1}$. The search is being continued in a systematic manner using the B&C spectrograph coupled with a CCD detector at the 230 cm telescope. (R. Surendiranath)

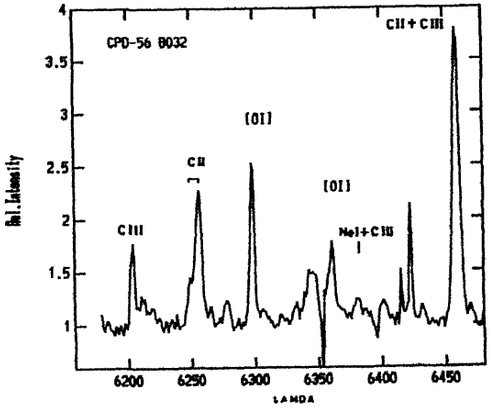
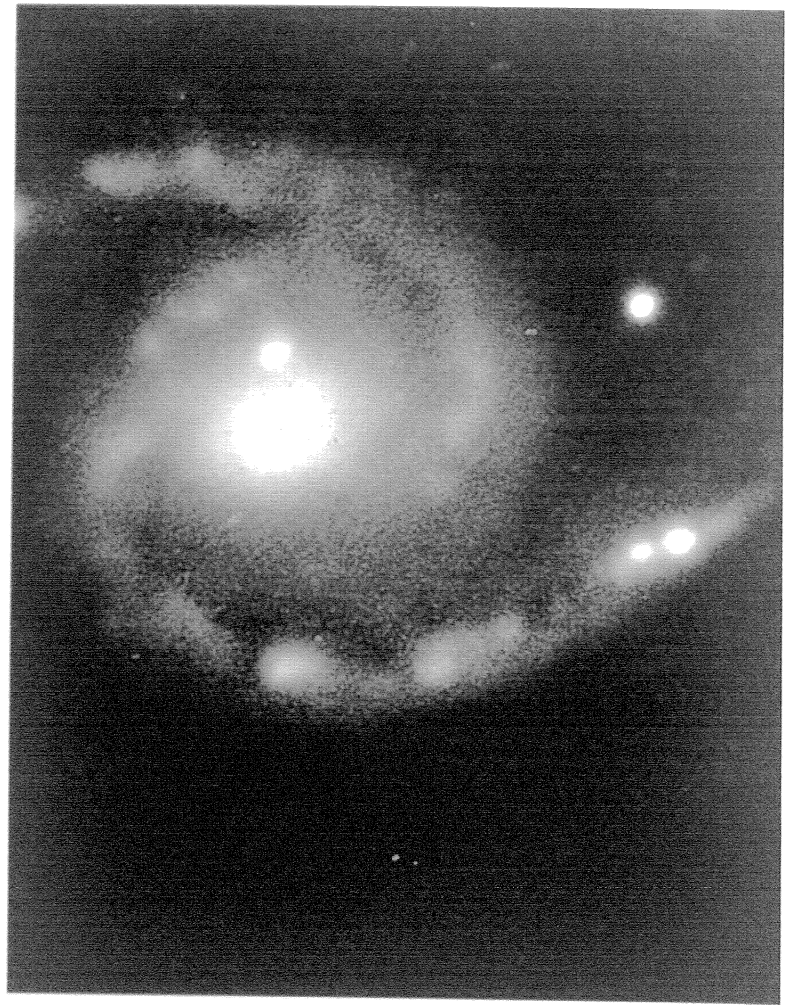



**Fig. 9.Spectrum of CPD −56°8032 obtained at VBT with the Boller and Chivens spectrograph. (N.K. Rao)**



A composite BV H$\alpha$ picture of the spiral galaxy NGC 1566. The picture is constructed using CCD images obtained at the Cassegrain focus of the 102 cm reflector at VBO. (Y.D. Mayya)

# Galaxies and Active Galactic Nuclei

## Dynamics

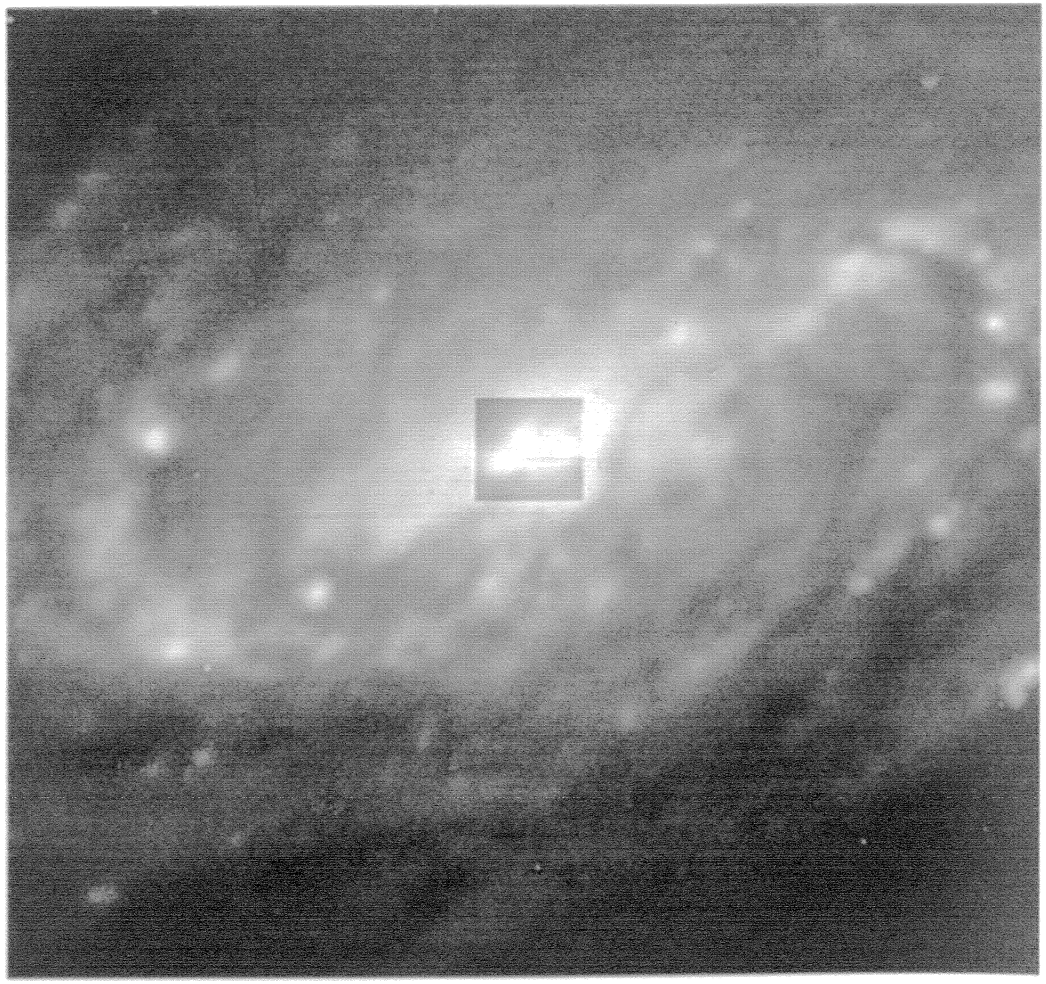
The tidal influence of a massive galaxy on a non-rotating spherical companion was studied using numerical simulations. The main parameters crucial to a tidal encounter are the velocity of the encounter, the mass ratio of the two galaxies and the pericentric distance. The simulation used a wide variety of initial values for the mass ratio and the velocity of collision while the pericentric distance p was kept constant at $p \equiv 3R$ where $R$ is the initial radius of the spherical galaxy. The massive perturber was allowed to move on hyperbolic, parabolic, elliptic and circular orbits. The collisions produced significant rearrangement in energy and mass of the spherical galaxy. The half-mass radius $R_h$ of the remnant of a collision remained almost the same as that of the initial system with which the simulations were started. The collision resulted in a contracted core and an expanded halo. The expansion produced in the outer parts - tidal distension - was seen to be maximum when the galaxies had undergone collision on a parabolic orbit. The surface density profiles of the survivors of collision closely followed an $r^{1/4}$ law up to $r = 4\ R_h$. The profiles showed evidence for a tendency to develop bulges in the outer parts when the masses of the stellar systems are comparable. (P.M.S.Namboodiri, R.K.Kochhar)

The head-on collision of two identical spherical galaxies is investigated for several values of the velocity of collision. The spherical galaxies are modelled as two N-body systems each containing more than a thousand particles. The initial separation between the galaxies is large enough to make the tidal force negligible at that position. The collision velocity is taken from the range $0 \leq V/V_e \leq 3.6$ ($V$ is the velocity of collision and $V_e$ the escape velocity at maximum separation). It is shown that when $V/V_e < 1.6$ the collision resulted in a merger. The galaxies showed increased velocity dispersion and overall expansion. (P.M.S.Namboodiri)

Tidal effects of disruption and merger of a massive perturber-quasar on a galaxy cluster have been studied by computer simulations. The model consists of a spherical N-body galaxy and a joint-mass perturber. A wide range of initial conditions, viz., the mass-ratio, the virial coefficient $q$ of the N-body system, the pericentric distance and the eccentricity of the relative orbits, have been considered. It is shown that the collisions resulted in a merger when the relative orbit is parabolic and the value of the virial coefficient $q < 0.5$. The merged product showed properties of cD galaxies. (P.M.S. Namboodiri,*J.Anosova)

## CCD imaging of galaxies

Several programmes are under way which involve CCD imaging of galaxies and quasars using the prime focus VBT and the Astromed CCD system. The system has been calibrated in BVRI bands during the current year. The programme on imaging elliptical galaxies selected on the basis of their radio and x-ray properties yielded significant results. A dust shell with $E(B-V) = 0.12$ has been discovered in the galaxy NGC 3607 and H$\alpha$ emission from this elliptical is confirmed. Estimated masses of neutral and ionized hydrogen in the galaxy are $4 \times 10^7$ and $6 \times 10^4\ M_\odot$, respectively. Recent star-formation is proposed to be the most likely cause of H$\alpha$ emission. The gas is probably acquired from a neighbour. Some Sersic-Pastoriza galaxies were also imaged during the year with a view to studying the properties of nuclear star-forming regions and the large-scale structure of the galaxies. BVR photometry of a few X-ray selected quasars was also carried out. (T.P.Prabhu,*K.P.Singh, *G.C.Anupama,*A.K.Kembhavi, * P.N.Bhat)



A composite BV H$\alpha$ picture of the spiral galaxy NGC 2903 constructed from CCD images obtained at the 102 cm reflector at VBO. (Y.D. Mayya)

## Star formation in giant extragalactic H II regions

Star formation properties in giant extragalactic H II regions (GEHRs) are investigated using optical photometry and evolutionary population synthesis models. The photometric data were obtained using the telescopes at VBO for the last 3 seasons. Population synthesis models developed over the last two years were improved upon to include the effects of red supergiants. Updating of these models with newer stellar evolutionary calculations and atmospheric data is under way. The main results of the analysis are as follows.

We find it necessary to have differential extinction between embedded cluster stars and the surrounding nebulosity in GEHRs, with about 50% of the cluster photons escaping the nebula unattenuated. GEHRs are found to contain hot massive stars and evolved red supergiants simultaneously, implying more than one event of star formation in the last 10 Myr. We have identified some regions on our images which may be examples of young and old regions spatially separated by 40-100 pc. Extended duration of star formation in GEHRs may be a result of a trigger from the earlier star formation event. (Y.D.Mayya, T.P.Prabhu)

## Population synthesis of galaxies

Observations during 1992-93 were directed towards obtaining spectra in the region $\lambda\lambda$ 3700 – 6000 for population synthesis standard stars and galaxies, for which spectra in the red and near infrared region had been acquired in 1991-92. This is a continuing programme aimed at deriving the distribution of stars in the HR diagram of galaxies from integrated spectra. Spectra were obtained using UAGS with the Thomson CCD detector at the 102 cm telescope of VBO. (A.K.Pati)

## Photometry of clusters of galaxies

A new long-term programme was started on photometry of clusters utilising observations with VBT. The aim of the programme is to obtain deep photometry in BVRI passbands, in order to derive the overall cluster luminosity functions, luminosity functions by galaxy type, and spatial gradients in the colours of the galaxies within the cluster (if any). Such studies have an important bearing on the formation and evolution of galaxies, especially in the cluster environment. It is essential to study the above properties as a function of redshift; the aim in the first phase of the programme has been to reach a redshift range of 0.3 to 0.5. Images were obtained of two to three fields in three clusters and a single field in two clusters going up to a redshift 0.17, during 1993 January – March. This first set of data is being reduced. (A.K.Pati, T.P. Prabhu)

## Alternatives to dark matter

In recent years several alternative explanations, different from the conventional dark matter hypothesis, have been proposed for the flat rotation curves of spiral galaxies. The more recent ones invoke magnetic fields and gravo-inductive force fields to account for constant rotation velocities at large distances from galactic cores. A critical study of these alternate explanations was carried out. It is found that these are inconsistent and cannot account for the flat rotation curves. Specifically, couplings of these force fields to matter are found to be far smaller than what is required. (C. Sivaram)

## Optical variability in radio-quiet QSOs

A new programme was started using VBT to search for intra-night optical variability in radio-quiet QSOs. Five QSOs were chosen which are radio-quiet but optically bright and luminous. The limited data obtained so far show mild indications of microvariability for some of the sources, but in no case has the reality of the fluctuations been

clearly established. Additional observations of these and other QSOs could provide a powerful means of discriminating between various theoretical mechanisms proposed for the origin of optical microvariability in active galactic nuclei. Further observations are planned. (R. Sagar, *Gopal-Krishna, *P. J. Wiita)

## Monitoring of blazars

This programme using primarily the VBT for observations, was started in 1992-93. Blazars are a class of AGN exhibiting, often, violent variability on short time scales in addition to variability on longer time scales. The variability in different wavelength domains and the correlation between these is poorly understood. The programme aims at monitoring the optical variability over the time scales of days, weeks, months and year to year for a fair sample of these objects. Such data are essential, together with those obtained in other wavelength domains, to validate or rule out models of blazars. (A.K. Pati, K.K. Ghosh)

## NGC 3783

The nucleus of the Seyfert galaxy NGC 3783 was monitored spectroscopically and photometrically as a part of the campaign due to International AGN Watch consortium. All observations were carried out with the 102 cm Zeiss reflector. Spectra were recorded with the UAGS at a dispersion of 5.5 Å per pixel in the range 3900-7000Å. The Photometrics CCD system was used both for spectroscopy and imaging. The pooled data showed considerable variability of the optical continuum and H$\beta$ with the light curves resembling the ultraviolet light curve, whereas the near-infrared light curve appeared independent. There is no evidence for significant delay between the optical and ultraviolet continuum variations. The H$\beta$ emission, however, varies with a time delay of 8 days. (T.P.Prabhu, Y.D.Mayya, A.Subramaniam, K.K.Ghosh, R. Sagar, *G.C.Anupama, A.K.Pati)

## X-ray emission from AGN and modelling

X-rays from AGN are supposed to be produced in or near the physical region where the bulk of the energy from these objects is released. Thus the study of the x-ray emission in AGN provides a direct probe of the internal machine. Low-energy (LE) and medium-energy (ME) (0.1-10 keV) spectra of thirteen AGN observed by EXOSAT were analyzed and different emission models were fitted to explain these. Of these PKS 2128-158 stands out as the *most luminous* object in the Universe. We also report the first detection of iron K line emission in six AGN. A brief account of the results obtained follow. (K.K. Ghosh, S. Soundararajaperumal)

(a) *PKS 2126-158*

The X-ray ($0.1-10\ keV$) spectrum of the luminous ($z = 3.27$), radio-loud quasar, PKS 2126-158 can be well explained by a power-law and fixed absorption (fixed with Galactic $N_H$) model. The parameters of this model suggest that this quasar is a flat spectrum source with no soft excess or low energy absorption . From the derived X-ray ($0.1-10\ keV$) luminosity ($7.8 \times 10^{14}\ L_\odot$) we found that PKS 2126-158 is more luminous than IRAS 10214+4724 (luminosity in $6-36\ \mu m$ band is $4 \times 10^{14}\ L_\odot$) which was previously known as the most luminous object in the Universe.

(b) *3C 382*

X-ray observations of this broad line radio galaxy were carried out with EXOSAT on many occasions (more than 20 epochs) between 1983 and 1985. In 1985 a major outburst in the X-ray band was found in this galaxy. Both the LE and ME count rates displayed dramatic variations (maximum to minimum variations were $\sim$ 120% and 110% in the LE and ME bands, respectively) during the outburst. Also, LE and ME light curves contain a prominent dip about halfway through. Although the variability of the LE and ME count rates was correlated, the ME spectral slope was roughly constant ($\sim 1.7 + 0.1$) and the LE spectral slope varied in correlation with the LE count rate. Variable soft excess emission detected in this galaxy is best fitted with the broken power-law model which suggest a variable soft

component below 0.6 *keV* and a nonvariable hard component between 0.6 and 10 *keV*. A highly significant (> 99.9%) emission line with measured equivalent width between 100 and 1100 *eV* was detected around 6 *keV* which may be due to fluorescence of cold iron around the central continuum source.

(c) *MCG-2-58-22*

Variable soft excesses have been detected on time scales of 2 - 3 days, and no variations of the hard X-ray flux were found during EXOSAT observations of this source. A two power-law and fixed absorption (fixed with galactic $N_H$) model provides a better fit to the soft excesses. Variations in the LE count rate are correlated with the variations of the soft spectral index and anticorrelated with the hardness ratio of the source. Also it has been found that the hard spectral slope remained almost unchanged during the observations, and the variations of the ME count rates were independent of the variations of the hardness ratio of the source. All these results indicate that the soft and hard X-rays have different origins. A highly significant (> 99.9%) emission line around 6 *keV* was detected in this source, which may be due to the fluorescence of cold iron from an centrally illuminated accretion disk seen face-on.

(d) *ESO 012-G21*

From the first X-ray spectrum of this galaxy we have detected the presence of a soft excess emission in this source. This soft excess fits well with the broken power-law model. No low energy absorption was found in this Seyfert galaxy. Thermal bremsstrahlung model also gives good fit to the data. The plasma temperature obtained from this model is $\sim 4.6 \pm 1.9$ *keV*.

(e) *Mkn 352*

From the comparison of the fluxes measured with Einstein and EXOSAT, it appears that the luminosity did not vary significantly between 1980 January and 1983 November. No intrinsic low energy absorption was found in this source. We have detected the presence of soft excess emission in this Seyfert galaxy. Broken power-law model fits well with the soft excess. Thermal bremsstrahlung model also fits well with the spectra of this galaxy.

(f) *Mkn 374*

The X-ray luminosity did not vary significantly between Einstein (1979 April) and EXOSAT (1984 November) observations. A weak soft excess in the EXOSAT spectrum was detected for the first time in this Seyfert galaxy and it fits well with the broken power-law model. No low energy absorption was found.

(g) *Mkn 766*

Soft excess and an iron emission line around 6 *keV* was detected, for the first time, in the X-ray spectra of this Seyfert galaxy. The detected soft excess displayed weak variability on time scale of hours and is correlated with the LE and ME fluxes. The soft excess emission was stronger when the galaxy was brighter. LE and ME fluxes also varied in concert.

(h) *Mkn 279*

The X-ray fluxes in the soft and hard X-ray bands displayed no marked variations on a time scale of years or months. The soft excess values, detected from the spectral fits to the EXOSAT data remained almost unchanged between 1983/320 and 1984/028. This soft excess is best explained by the broken power-law model.

(i) *Mkn 464*

The EXOSAT spectral results reveal the presence of a soft excess, in this Seyfert galaxy, which can be well fitted by the broken power-law model. An iron fluorescence emission line around 6.4 *keV* was also detected in this source.

(j) *Mkn 290*

From the comparison of the X-ray fluxes obtained with Einstein and EXOSAT we find that there is no significant variation between 1979/210 and 1985/055. For the first time we detected a soft excess and an iron emission line in this Seyfert galaxy.

(k) *ESO 140-G43*

This is a flat spectrum source with a weak low-energy absorption. No

soft excess is present, but an emission line around 6 $keV$ was detected in this source for the first time. Probably ESO 140-G43 also has a weak soft excess, which was hidden by its $N_H \sim 10^{21}\ cm^{-2}$ absorber. Thus we suggest that soft excesses are a common feature of Seyfert galaxies and the detection of soft excess depends on the low-energy absorption in the line of sight to the source.

(l) *NGC 3783*

This Seyfert galaxy was observed with EXOSAT on three epochs between 1983 and 1985. No low energy absorption, intrinsic to the source, was found in this galaxy and the spectral index of the power-law fit did not vary during the observations. Strong flux variations of NGC 3783 have been found on the time scales of six months. The soft excess emission was maximum when the source was the brightest. A highly significant emission line around 6 $keV$ was detected for the first time.

(m) *PHL 909*

A weak soft excess was detected in this radio-quiet quasar. Two power-law and broken power-law models fitted well with the LE+ME spectra. Fit parameters to the EXOSAT ME data show a steep spectral index for this quasar typical of radio-quiet quasars. A highly significant (> 99.9%) emission line around 6 $keV$ with measured equivalent width between 300 and 1000 $keV$ was detected.

## Radiative transfer

### Winds in O and B stars

The problem of radiatively driven winds in hot O and B stars was investigated. An isothermal pure hydrogen atmosphere was considered for the purpose.

For a complete description of the problem the equations of continuity and momentum conservation along with the equation of radiative transfer were written down. The Saha ionization equilibrium equation was used.

The equations were discretised and a non-LTE two level atom approximation was used to calculate the radiation flux in the lines. Lyman, Balmer, Paschen and Brackett continua and the lines in these series up to ten levels were taken. The effects of diffuse radiation field, back scattering, radial velocity gradients, transverse velocity gradients, aberration and advection were included in the calculation of the radiation pressure in the line for the first time. Radiation due to electron scattering was included although the continuum radiation was neglected as this did not seem to affect the total amount of radiation required to produce the necessary momentum to push the gas. The equations were solved simultaneously to obtain terminal velocities and other physical parameters of the winds.

The results of these calculations were applied to several stars whose masses, radii, surface temperatures and mass loss rates are known so that terminal velocities and densities in the winds could be derived. As an example, the case of HD 24534 (X Per) is displayed in Figures 10(a)–(f). The data for this star are : $T_{eff} = 30{,}200$ K, $M = 3.2 \times 10^{34}$ gm, $R_o = 3.71 \times 10^{11}$cm, $V_\infty = 3150$ km s$^{-1}$, $\dot{M} = 1.38 \times 10^{-5}$ $M_\odot$ yr$^{-1}$. The radial variations of the electron density, the non-LTE parameter $\epsilon$, the total radial optical depth $\tau$, the force terms, the wind velocity V and the mass density $\rho$ are shown. It is seen (Figure 10e) that the observed terminal velocity for this star is reached at $R/R_o = 9$. In each segment the abscissa depicts the radial distance in the wind in terms of the stellar radius $R_o$.

The table below shows for several stars a comparison of the observed terminal velocities $V_\infty$ with the results obtained here and the results from the theory developed by Pauldrach et al. (1986, Astr. Astrophys.164,86). (A. Peraiah, B.A. Varghese)

| | Star name | $V_\infty(\frac{PPK}{CAK})$ (km s$^{-1}$) | $V_\infty$(km s$^{-1}$) (this work) | $V_\infty$(Obs) (km s$^{-1}$) |
|---|---|---|---|---|
| HD | 30614 | 860 | 2158 | 2450 |
| | 46150 | 2330 | 3325 | 3400 |
| | 48099 | 2690 | 3284 | 3300 |
| | 57061 | 800 | 2806 | 2500 |
| | 152234 | 770 | 2374 | 2650 |
| | 152249 | 1560 | 2357 | 2600 |
| | 157857 | 1650 | 3186 | 3250 |
| | 164794 | 2400 | 3419 | 3650 |
| | 167263 | 1770 | 2315 | 2450 |
| | 175876 | 2190 | 2893 | 2800 |

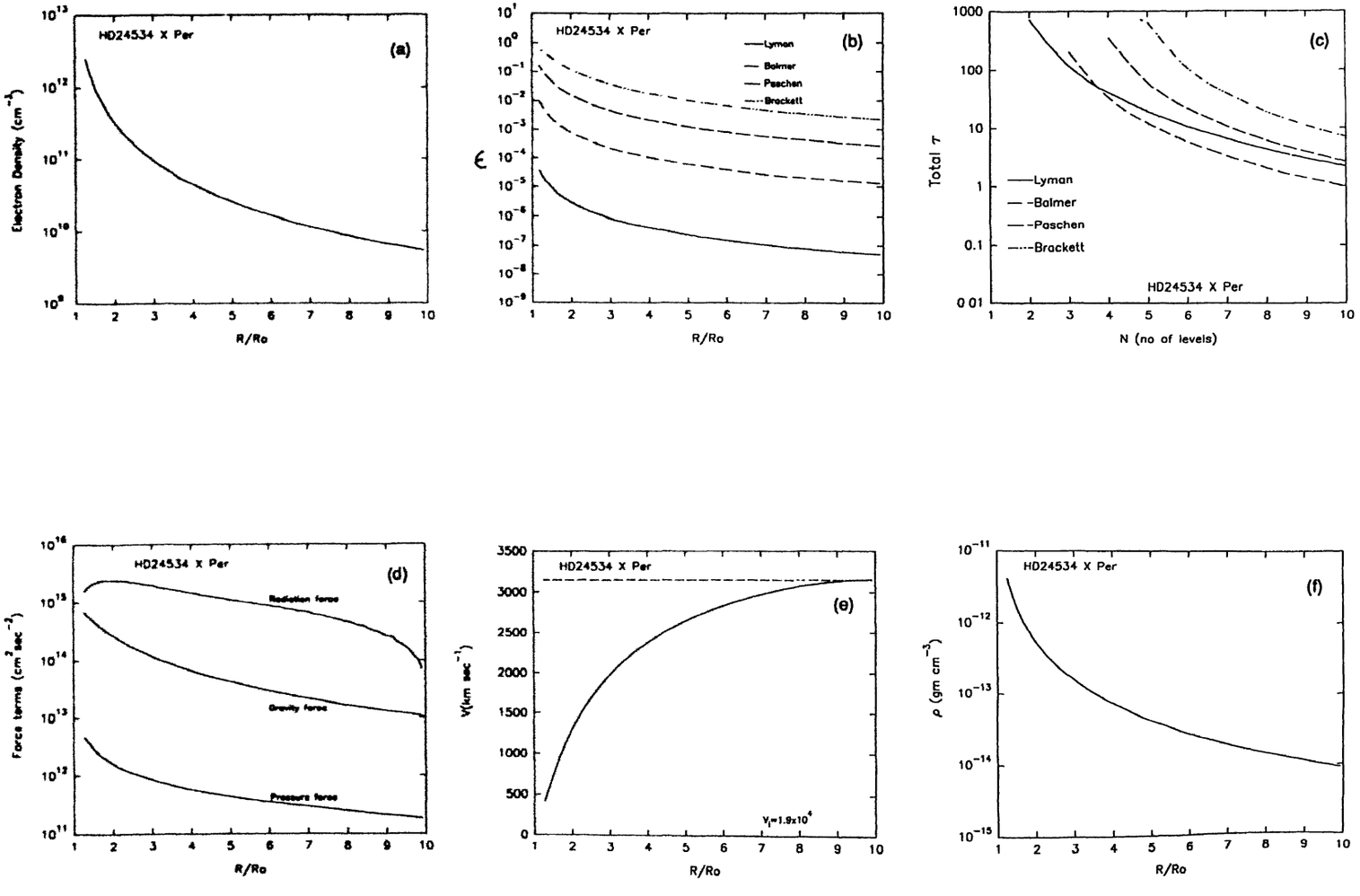



**Fig. 10** (A. Peraiah and B.A. Verghese)

### Polarized line transfer with collisional redistribution

Observation of linear polarization warrants a detailed study of resonance line polarization formed with partial redistribution. To this end, a theoretical study was done of depolarizing collisions on resonance line polarization in the absence of magnetic fields. It was found that the depolarizing collisions have a drastic effect on the polarization in the line core. The polarization rate at the line centre decreases like a monotonic function of $1-d$, where $d$ specifies the fraction of scattering events which are perturbed by depolarizing collisions (Figure 11). The authors also looked for the validity in polarization calculations of replacing the redistribution $R_{III}$ by complete redistribution. For all the models used (isothermal or semi-infinite atmospheres with depth independent parameters), it was found that the approximation allowed recovery of the polarization at line centre and in the wings. In the intermediate frequency domain between the line core and wings (around 2 Doppler widths from the line centre), it led to significant underestimation of the polarization when $\gamma$, the coherence parameter is smaller than 0.9. $\gamma$ is the ratio of the atoms that emit coherently to all atoms in the excited state. These results hold when depolarizing collisions are taken into account. (D. Mohan Rao, K.E. Rangarajan).

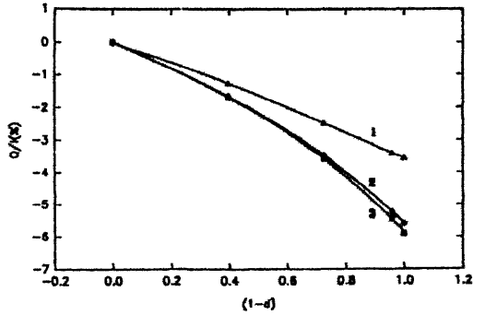



**Fig. 11.** The percentage of polarization at the line centre Q/I is plotted against $(1-d)$ for various models. $d$ gives the probability that the elastic collisions which destroy alignment occur followed by a deexcitation of the atoms. Depolarising collisions are included in all the models here. Curve 1 is for $T = 10^2$, $\epsilon = 10^{-4}$ (effectively thin medium). Curve 2 is for semi-infinite atmosphere with $\epsilon = 10^{-4}$. Curve 3 is the same as curve 2 but for $\epsilon = 10^{-6}$. T is the total optical depth and $\epsilon$ is the probability that a photon is destroyed by collisional deexcitation.

### Polarization of molecular bands in Earth's atmosphere

A transfer code was developed for computing the polarization of radiation from planetary atmospheres. The code may be used to obtain the linear polarization for monochromatic radiation field and also for line profiles and molecular bands. The authors calculate the reflected and the transmitted radiation from a planetary atmosphere when the sun's radiation falls on it at any polar and azimuthal angle. The atmospheric $O_2$ and $H_2O$ bands have been studied using this code. (K.E. Rangarajan, D. Mohan Rao, *K.D. Abhyankar)

## Plasma physics

### The modulation of radiation in an electron-positron plasma

The modulational instability of a large-amplitude electromagnetic wave propagating in an electron-positron plasma was studied. The effects such as relativistic mass variation of the plasma particles and the non-resonant, finite frequency electrostatic density perturbations, caused by the large-amplitude radiation field, were taken into account. The radiation from many strong sources such as AGN and pulsars, has been observed to vary over a host of time scales. It is possible that extremely rapid variations in the nonthermal continuum of AGN as well as in the nonthermal radio radiation from pulsars can be accounted for by the modulational instabilities to which radiation may be subjected during its propagation out of the emission region. (R.T. Gangadhara, V. Krishan, *P.K. Shukla)

### Polarization changes through stimulated Raman scattering

Change of polarization of electromagnetic radiation due to its propagation in a magnetized plasma (Faraday rotation) and due to electron scattering is well known. The change in the polarization due to the coherent scattering of the electromagnetic wave off the electron plasma wave (stimulated Raman scattering (SRS)) was investigated. It was found that some of the observed polarization properties of the pulsar and quasar radio radiation, not accountable by Faraday rotation and electron scattering could be explained by SRS. (V. Krishan, R.T. Gangadhara)

### Continuum radiation due to collective plasma process in quasars

The possible role of stimulated Raman and Compton scattering in the continuum emission of a quasar has been explored. There are three ways in which an electromagnetic wave can undergo scattering in a plasma: (i) when the scattering of radiation occurs by a single electron, it is called Compton Scattering; (ii) if it occurs by a longitudinal electron plasma mode, it is called stimulated Raman scattering (SRS); and (iii) if it occurs by a highly damped electron plasma mode, it is called stimulated Compton scattering (SCS). The nonthermal continuum of quasars is believed to be produced through the combined action of synchrotron and inverse Compton processes, which are essentially single particle processes. As an example, it is shown here that the complete spectrum of 3C 273 may be reproduced by a suitable combination of stimulated Compton scattering and stimulated Raman scattering processes. It has also been shown that the observed spectral breaks in the blue region could be due to the change of emission process from stimulated Raman scattering to stimulated Compton scattering. The differential contributions of these stimulated scattering processes for different values of the plasma parameters have been calculated. (R.T. Gangadhara, V. Krishan)

### Characteristics of Synchrotron-Cerenkov radiation

A diagrammatic technique has been worked out in the framework of nonequilibrium statistical mechanics as developed by Prigogine and co-workers to tackle the problem of radiation emission from a relativistic plasma in an ambient plasma embedding an axial-wiggler magnetic field. The theory is exact in that the diagrams contributing towards the self-consistent-field approximation have been summed up exactly and one obtains a time-dependent response. The kinetic regime has been obtained by eliminating the memory by taking an asymptotic limit in time. Explicit calculations have been effected to obtain functions like the Cerenkov angle and the refractive index as well as the power emitted by the system. It has been shown that the radiation emitted has very peculiar polarization features.
(K. Sasidharan, V. Krishan, *R. Pratap)

### Electrostatic oscillations in the presence of grain charge perturbations in dusty plasma

The linear properties of low-frequency oscillations in an unmagnetized dusty plasma have been studied accounting for the time dependent variation of the grain charge. It has been found that the latter gave rise to a novel purely damped mode, in addition to causing a collisionless damping of the existing normal modes. An interesting electrostatic instability was found in the presence of an equilibrium drift of the dust particles. The relevance of these investigations to laboratory and space plasmas is under discussion.
(V. Krishan,*R.K. Varma, *P.K. Shukla)

### Accretion discs

Astronomical objects like x-ray sources and active galactic nuclei are powered by accretion disc around strongly gravitating bodies. Since the matter in the disc is in plasma state, it is necessary to take into account the combined influence of the gravitational as well as the electromagnetic forces. Using the kinetic theory approach to

study the dynamics of accretion disc plasma, the spatial profiles of disc parameters like number density, temperature, drift speed and magnetic field were obtained. The kinetic approach provides a basis for investigating the micro instabilities responsible for the heating, acceleration and radiation of plasma.
(P. Bhaskaran, V. Krishan)

## Fluid mechanics

An exact solution of the nonlinear, time dependent stream function for quasi two-dimensional hydrodynamic flows with dissipation has been obtained. It has been shown that in the limit $n \rightarrow 0$, this solution is identical with the solution of the self-organised state of a quasi two-dimensional flow. The expression for the temperature corresponding to the three-dimensional variation equation has been derived. This expression coincides with the temperature obtained by Hasegawa (1985, Adv. Phys., 34,1) for the two-dimensional case.
(A. Satya Narayanan)

## Compact objects

### Neutron stars

An investigation of the evolution of neutron star magnetic fields has been initiated. The idea that the magnetic fields of neutron stars must decay with age, due to Ohmic dissipation of currents that maintain these magnetic fields, was suggested by Ostriker and Gunn more than two decades ago. Since then, it has remained a focus of research interest because the various theoretical and observational considerations have not led to any consensus (except that observations have shown that some field decay does seem to take place). The Ohmic decay of the magnetic field initially confined to the surface layers of the neutron star crust has been considered by some authors in recent years. However, it is not at all clear if such an initial condition is a realistic assumption. It is possible that the decay of the magnetic field is caused by the expulsion of magnetic flux from the superconducting interior of neutron stars. For such initial conditions the authors have studied the field decay, taking into account the various details of the crustal properties.
(B. Datta, *D. Bhattacharya)

### Equation of state of dense matter

An equation of state of nuclear matter was calculated based on the derivative scalar coupling model proposed by Zimanyi and Moszkowski, using improved values of the saturation density and binding energy. Comparison of the prediction of the model for the energy per nucleon has been made with available estimates from heavy-ion collision data and with the theoretical requirement for a prompt type II supernova bounce. A finite temperature equation of state for nuclear matter based on this model has also been derived. (B. Datta, *P.K. Sahu)

In place of the purely derivative coupling of the scalar field to the baryons and vector meson, a variant where the interaction is both Yukawa point type and derivative type (for coupling to baryon and to omega and rho meson fields) was suggested by Glendenning, Weber and Moszkowski (1992, Phys. Rev. C, 45,844). This improves the agreement with the compression modulus and the effective nucleon mass at saturation density. This model has been extended to incorporate the interactions due to spin 2 meson exchange, which plays a role at higher densities. Application to neutron star structure of this equation of state is carried out. (B. Datta, *V. Canuto, *G. Kalman)

### Pulsars

A study is in progress to estimate the contribution of spacetime curvature and aberration to a pulsar beam as observed at infinity. A squeeze in the beam has been noted which is nontrivial at high emission altitude. This is being studied for the oblique dipole case for

various pulsar periods, emission altitudes and impact angles. (R.C. Kapoor, *C.S. Shukre)

### Radiative effects of additional force fields

If additional force fields like the 'fifth-force-field' existed in nature, their radiative effects are bound to compete with gravitational radiation from cosmic sources. In relation to the experimental constraints, possible situations have been discussed in which these effects dominate the prevailing energy loss (e.g. in close binary systems). The consequences of such additional radiation losses for stellar collapse and supernovae have been considered and constraints placed on the couplings of such forces to matter. It is to be noted that although such forces may cancel each other in static laboratory experiments of the Cavendish (torsion-balance) type, their radiative effects in astrophysical systems *add* up. This may provide a signature for such force. (C. Sivaram, *B. Bertotti)

## Astroparticle physics–the Early Universe

### QCD, confinement and strong gravity

A Weyl type of action which is scale free and quadratic in the curvature is suggested for strong gravity. This improves the renormalisability of the earlier approaches. The colour symmetry is inbuilt in the gauge group and incorporated in the small distance spacetime structure. The corresponding field equations have solutions which imply confinement. At the QCD scale, the scale invariance is broken inducing a Hilbert type term which describes the short distance behaviour. This approach may provide a strong gravity basis for QCD. The hydrodynamics of the quark gluon state in the above strong gravity approach is analysed and consequences for the early Universe studied. (C. Sivaram,*Abdus Salam)

### Curvature from spin

It is shown that the dislocation defect induced by torsion in spacetime behaves like a string with tension. This gives rise to a defect angle and induces a spacetime curvature. The space with torsion and curvature is then equivalent to an elastic continuum which has undergone plastic deformations. Following the Sakharov idea of describing spacetime as an elastic continuum, we arrive at a value for the gravitational constant, as well as the Einstein action. This correct value of the induced gravitational constant is obtained without introducing any arbitrary cutoff. In this picture it quantitatively describes the metrical elasticity of spacetime. (C. Sivaram, *V.de Sabbata)

### Consequences of a time-temperature uncertainty principle

Linking torsion in general relativity to defects in spacetime topology, we have a minimal unit of time as well as a general relativistic time-temperature uncertainty relation. This eliminates the divergence in self energy integrals and it is also possible to understand black hole evaporation as a process of quantum diffusion leading directly to a Hawking like formula. (C. Sivaram, *V. de Sabbata)

### Anyons and Torsion

In analogy to electromagnetic anyons as charge-magnetic flux composites, the gravitational anyon as a mass-spin (energy-spin) composite is considered. It is shown that the torsion interaction has many features in common with the Chern-Simons term, which supports the possibility of a gravitational anyon arising from torsion without introduction of the Chern-Simons term. (C. Sivaram, *V. de Sabbata)

### Origin of ultra-high energy cosmic rays

Cosmic rays with energy exceeding $10^{20}$ eV have been observed. The origin of such Ultra-High Energy (UHE) cosmic rays remains a mystery. The known astrophysical acceleration mechanisms such as ac-

celeration in supernova shocks, Fermi acceleration mechanism etc., can explain the existence of lower energy particles, but they are inadequate for accelerating particles to energies $\sim 10^{20}$ eV and above. Cosmic rays above a certain high energy may have a more *fundamental* origin in the sense that they may not have been accelerated at all; instead these particles may simply be the decay products of some sufficiently massive particles surviving from an early cosmological epoch. A specific physical realization of this idea of *non-acceleration* origin of the UHE cosmic rays has also been given in terms of a model that involves collapsing cosmological topological defects, in particular, cosmic strings. Topological defects (TD) such as magnetic monopoles, cosmic strings, domain walls etc. could be formed in certain symmetry-breaking phase transitions in the early Universe. Because of their topological stability the TDs formed in the early Universe can survive till the recent epochs. However, some fraction of these TDs could be mechanically unstable; for example, closed loops of cosmic strings can collapse, monopoles and antimonopoles can annihilate one another and so on. When TDs are physically destroyed due to collapse or annhiliation, the energy contained in the TDs would be released in the form of massive quanta (" X " particles) of the various fields (gauge bosons, Higgs bosons, heavy fermions) that constitute the TDs. The decay products of these massive X particles finally end up mainly as nucleons, gamma rays, and neutrinos with energies up to $\sim m_x$, the mass of the X particles. For TDs formed at the grand unification (GUT) energy scale, $m_x$ can be as large as $\sim 10^{25}$ eV. This, therefore, can be a natural mechanism of production of extremely energetic particles up to an energy $\sim 10^{25}$ eV *without any acceleration mechanism.* (P.Bhattacharjee,*F. Aharonian, *C.T. Hill, *D.N. Schramm)

The expected spectra of protons, gamma rays and neutrinos resulting from collapse or annhiliation of TDs have been worked out. The model predicts a definite spectrum shape for cosmic rays above $5 \times 10^{19}$ eV which will be testable in some of the proposed large-area detectors to be built by various experimental groups in the world. The UHE neutrinos predicted in this model may also be detectable in a detector such as the DUMAND in the Pacific Ocean. One important prediction of this new theory is that cosmic rays at energies above $\sim 10^{20}$ eV should be highly rich in gamma rays– the ratio of photon-to-proton at these energies can exceed 10. These predictions also provide search strategies for possible signatures of Grand Unification and/or Planck-scale physics in the UHE cosmic ray spectrum.
(P. Bhattacharjee)

### Relics from quark-hadron phase transition

A dynamical study, based on the Chromoelectric Flux Tube model of confinement, has been carried out to look into the question of survivability of "quark-nuggets" that could be formed during a possible first-order quark-hadron phase transition in the early Universe. It has been shown that quark nuggets with initial baryon numbers of $\sim 10^{44}$ or higher can be stable against baryon evaporation from their surfaces. These quark nuggets can, therefore, be a good candidate for the baryonic dark matter in the Universe.
(P. Bhattacharjee, *J. Alam, *B. Sinha, *S. Rahe)

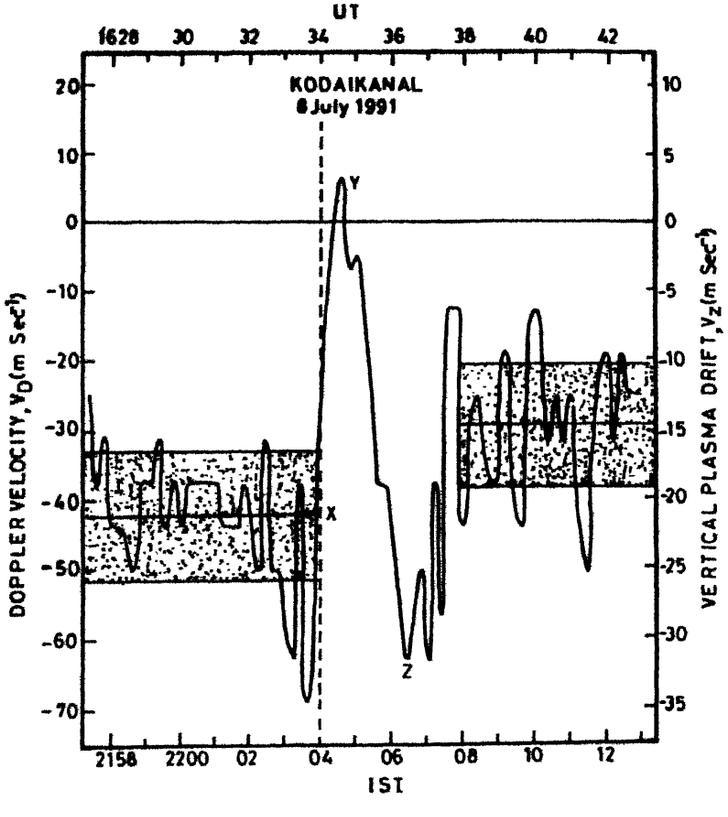



**Fig. 12.**Time variation of Doppler $V_D$ (vertical drift, Vz = $V_D/2$) of F-region plasma over Kodaikanal around the time of the geomagnetic sudden commencement (sc) on July 8, 1991. With the onset of the preliminary impulse (PI) of sc* at Fredericksburg at 1634 UT (vertical dotted line), the ambient downward plasma drift (Vz) over Kodaikanal abruptly ceased and even reversed to upward for $\approx$ 1 minute, followed by enhanced downward drift for $\approx$ 2 minutes. The transient perturbation in $V_D$ (Vz) indicated the prevalence of an eastward electric field of $\approx$ 0.95 mV/m (corresponding to the segment marked XY on $V_D$ curve) during the PI of sc* and a westward electric field of $\approx$ 1.35 mV/m (corresponding to the segment marked YZ on $V_D$ curve) during the main impulse (MD). The observation is the first and direct experimental evidence of vertical plasma motions due to the sc-associated electric fields in the nightside dip equatorial ionosphere. (J.H. Sastri)

## Magnetosphere-ionosphere coupling

High time resolution measurements of the phase path P of ionospheric F region reflections at normal incidence at Kodaikanal (dip 3.5° N) revealed quasi-periodic variations in the Doppler velocity $V_D$ (time rate of change of phase path) of large amplitude (peak-to-peak 18 - 66 $ms^{-1}$) over the period 1730-1845 IST on 1991 March 24 (Ap = 161; $\Sigma$ kp = 54), concurrent with ground level geomagnetic micropulsations of $P_{sc}$ 5 type. The spectral content of the pulsations in $V_D$ at Kodaikanal as well as in H-field at Trivandrum (dip 0.6° S) and Alibag (dip 24.5° N) is found to be confined to the period band 6.4 - 10.7 min. Though such quasi-periodic variations in $V_D$ are not uncommon at locations near the dip equator during daytime and dusk period, the variance of the fluctuations in $V_D$ in the period range 6.4 - 10.7 min is higher on March 24 by a factor of 4.3 compared to the average for 19 other days in the same month when geomagnetic pulsations were absent in the specific local time interval. The observations demonstrate that on March 24 the Doppler velocity of F-region reflections at Kodaikanal is influenced around sunset by MHD waves, the magnetic effects of which are detected on the ground as $P_{sc}$ 5 micropulsations. The evidenced Doppler velocity oscillations are due to fluctuations in vertical plasma drift induced by the zonal component of time-varying electric fields (peak-to-peak amplitude 0.25 – 1.3 mv/m) associated with the ULF geomagnetic pulsation activity. The study brought into focus the dominant role of electromagnetic (**ExB**) drift in the geomagnetic pulsation - related ionospheric Doppler velocity variations near the magnetic equator and provided, for the first time, first-order information on the causative electric fields. Multi-frequency Doppler velocity measurements are needed to assess the mode of propagation of HM waves responsible for the evidenced pulsation electric fields in the equatorial region. (J.H.Sastri, K.B.Ramesh, *D.R.K.Rao, J.V.S.V.Rao)

High time resolution data from the HF Doppler radar at Kodaikanal are also used to evaluate the nature of the perturbations in the vertical drift of the F-region plasma associated with the geomagnetic sudden commencements (sc) on 1991 July 8 and 1992 January 1. Both the events which occurred in a narrow time window, 1630 - 1700 UT (2200 - 2230 IST) were of sc* type at middle and high latitude stations in the afternoon sector. The sc of January 1 is characterized by a double-step main impulse (MI) in the ground level H-field at Kodaikanal in the night hemisphere (the structure of the sc on July 8 could not be ascertained from normal run magnetograms due to its large amplitude and very small rise time). It is found that the usual downward motion of F-region plasma during the pre midnight hours at Kodaikanal abruptly ceased (and even reversed to upward in one event) for about 1 minute coincident with the preliminary impulse (PI) of the sc*, and was immediately enhanced in association with the MI of the sc*. This pattern which is consistently seen in both the events implies that an eastward electric field prevails near the nightside dip equator at the time of the first impulse of double-step MI there and PI of sc* at high latitudes. Our Doppler velocity observations constitute the first experimental evidence of vertical plasma motions due to the sc* associated electric fields in the nighttime dip equatorial ionosphere. They confirm the theoretical prediction that the dusk-to-dawn electric field imposed on the polar ionosphere with the onset of PI of sc* can instantaneously penetrate to the dip equator on the nightside as on the dayside. (J.H.Sastri, J.V.S.V.Rao, K.B.Ramesh)

A case study is made of the local time (LT) dependence of substorm-related electric field disturbances in the nighttime low latitude equatorial ionosphere using ionosonde data of stations in the African, Indian and Japanese sectors. Comparison of the polarity pattern of the electric field disturbances in the different LT sectors with theoretical predictions showed only partial agreement. A major discrepancy is found around the expansive phase of the substorm activity when eastward electric fields prevailed in the predawn LT sector,

instead of the westward fields consistently predicted by the various convection models. The observed eastward field thus seems to result not from the penetration of primary convection electric fields associated with changes in polar cap potential ($\theta_{pc}$) and high latitude field-aligned currents (FAC). It is suggested that this may be due to the penetration or mapping of secondary polarization electric fields produced either at the edges of auroral westward electrojet by the gradients of conductivity, electric fields and currents or in the inner magnetosphere by unsteady convection. Detailed theoretical studies are needed to verify the proposed explanation. (J.H.Sastri, K.B.Ramesh, H.N.Ranganath Rao)

## Structure and dynamics of the equatorial upper atmosphere

A synoptic picture of the thermospheric temperature (Tn) over Kavalur is derived, for the first time, from measurements of the line profile of O('D) night airglow emission with a pressure-scanned Fabry-Perot Interferometer (FPI) during 1992 March - April. The observations correspond to quiet to moderate geomagnetic activity conditions at an epoch of moderate solar activity (mean F10.7 $\approx$ 165). The neutral temperatures determined from the data obtained by FPI are found to be consistently higher than the MSIS - 86 model values. A notable feature of the nocturnal variation of the temperature over Kavalur is the occurrence of an enhancement around midnight that is accompanied by a decrease in F-region height over Ahmedabad, a higher latitude station around the crest region of the equatorial ionization anomaly in the same longitude zone. This relationship is seen in a case study as well as in the average patterns of the concerned parameters. The temperature enhancement is interpreted as the signature of the equatorial midnight temperature maximum (MTM) and the associated descent of F-region over Ahmedabad as the effect of poleward neutral winds set up by the MTM. The highly variable nature of the characteristics of the MTM (shape, amplitude and time of occurrence) is considered as partly responsible for the observed day-to-day variability of the nightly average (2130-0430 IST) temperatures. The commissioning of the FPI station at Kavalur has opened up the possibility of attempting studies in depth of the coupled equatorial ionosphere-thermosphere system by coordinating the FPI observations at Kavalur with those at Mt. Abu (PRL) and also with other ionospheric diagnostics (ionosonde, HF Doppler radar,etc) available with us and other groups in the country. (J.H.Sastri, H.N.Ranganath Rao)

Simultaneous HF Doppler radar and ionosonde observations are used to assess the relative importance of height, vertical drift velocity and electron density gradient of the post sunset bottomside equatorial F-region for the generation of F-region irregularities (equatorial spread-F, ESF). The study conducted for the periods January-March 1984 and 1985 showed that the height of the F-layer, determined by the time history of the prereversal enhancement of the drift velocity, is the deciding factor for the onset of ESF. Maximum growth rate of linear collisional Rayleigh-Taylor instability (RTI) is found to occur at the time of peak height rather than at the time of peak velocity indicating that the layer should attain a threshold height for the onset of ESF. With the decline in solar activity from 1984 (mean F10.7 = 120) to 1985 (mean F10.7 = 70), the threshold height fell from 450 km to about 350 km due to the decrease in ion-neutral collision frequency. The effect of the decrease in the threshold height is reflected in the large decrease in the intensity as well as duration of ESF. (J.H.Sastri, *B.Jayachandran, *N.Balan, *P.B.Rao, J.H.Sastri, *G.J.Bailey)

A long term programme of observations with the HF Doppler radar was initiated in 1991 February at Kodaikanal (dip 3.5° N) for comprehensive studies of ionospheric dynamics. Analysis of the first 15-months of observations (1991 February - 1992 April) is made to derive the morphology of $V_z$ for high solar activity conditions (mean F10.7 $\approx$ 207 units). The seasonal and geomagnetic activity effects in the postsunset enhancement of $V_z$ at Kodaikanal are found to be distinctly different from those at Jicamarca (76.87° W, dip 2° N) for similar solar activity conditions. A new feature observed is the season-dependent nature of the day-to-day variability of the post sunset enhancement in $V_z$ which is highest in summer and lowest in winter. (J.H.Sastri, K.B.Ramesh, J.V.S.V.Rao)

*Physics*

# Nuclear Physics

## Neutrino mass limits from double beta decay experiments

Double beta decay of $^{128}Te$ has been confirmed and the ratio of half-lives for double beta decay of $^{130}Te$ and $^{128}Te$ has been determined as $^{130}Te_{1/2}/^{128}Te_{1/2} = (3.52 \pm 0.11) \times 10^{-4}$ by ion counting mass spectrometry of $Xe$ in ancient $Te$ ores. The $Xe$ measurements, combined with common $Pb$ dating, yield a $^{130}Te$ half-life of $(2.7 \pm 0.1) \times 10^{21}\ Yr$ and thus a $^{128}Te$ half-life of $(7.7 \pm 0.4) \times 10^{24}\ Yr$. These results give limits on the effective Majorana mass of the neutrino ($< 1.1 - 1.5\ eV$) and right-handed currents ($| < \eta > | < 5.3 \times 10^{-8}$) comparable to the best obtained from direct neutrinoless double beta decay searches. They also imply new limits on nonstandard Majorons not constrained by measurements of the $Z^o$ decay width.

Keeping in mind the importance of double beta decay studies as probes of the physics beyond the $TeV$ scale, a region inaccessible as yet to the present day accelerators, we plan to take up a new experiment in this area. This experiment envisages probing the double beta decay of $^{82}Se$ into $^{82}Kr$, using the techniques of noble gas mass spectrometry on a large number of Precambrian selenium minerals. It is expected that the experiment is sensitive, at present, to lifetimes in the range of $10^{25} - 10^{26}$ years. As a consequence of the small $\beta\beta$-$Q$ values, $T_o = 0.136$ MeV, the lifetime for the $\beta\beta 2\nu$ mode is expected to be longer than 10 years, and thus the experimental observation of a finite decay rate with a shorter lifetime would constitute a definite signature of the contributions of other modes such as $\beta\beta 0\nu$ and $\beta\beta O\nu$. The existence of the neighbouring isotope $^{82}Se$, which double beta decays into $^{82}Kr$ with a half-life of $1.3 \times 10^{20}$ years provides an in situ calibration, in a manner analogous to the case of $^{128}Te$ and $^{130}Te$, whose double beta decay has been established with accuracy recently. The procedure that would be adopted in the present experiment will be based on the experience gained in the study of the tellurium system and envisages making improvements in sample handling, data acquisition, and analysis. (R.Cowsik, *T.Bernotawicz, *J.Brannon, *R.Brazzle, *C.Hohenberg, *F.Podosek)

# Gravitation

## Improved experimental facility

The underground chamber at Gauribidanur has been made thoroughly water-proof and the torsion balance of improved sensitivity will be installed inside it by December 1993. The torsion fibre has been changed from a circular cross-section to a rectangular one which reduces the torsion constant by a factor of about ten. A high-vacuum chamber will now enclose the ultrahigh-vacuum chamber housing the balance and the experimental pit will be hermetically sealed. These improvements will tend to enhance the signal and reduce the noise driven by variations of temperature and pressure. We expect to be able to test Einstein's principle of equivalence with a sensitivity of $\sim 10^{-13}$ within a year. (R.Cowsik, *N.Krishnan, *S.N.Tandon, *C.S.Unnikrishnan)

# *Instrumentation, Optics and Computing facilities*

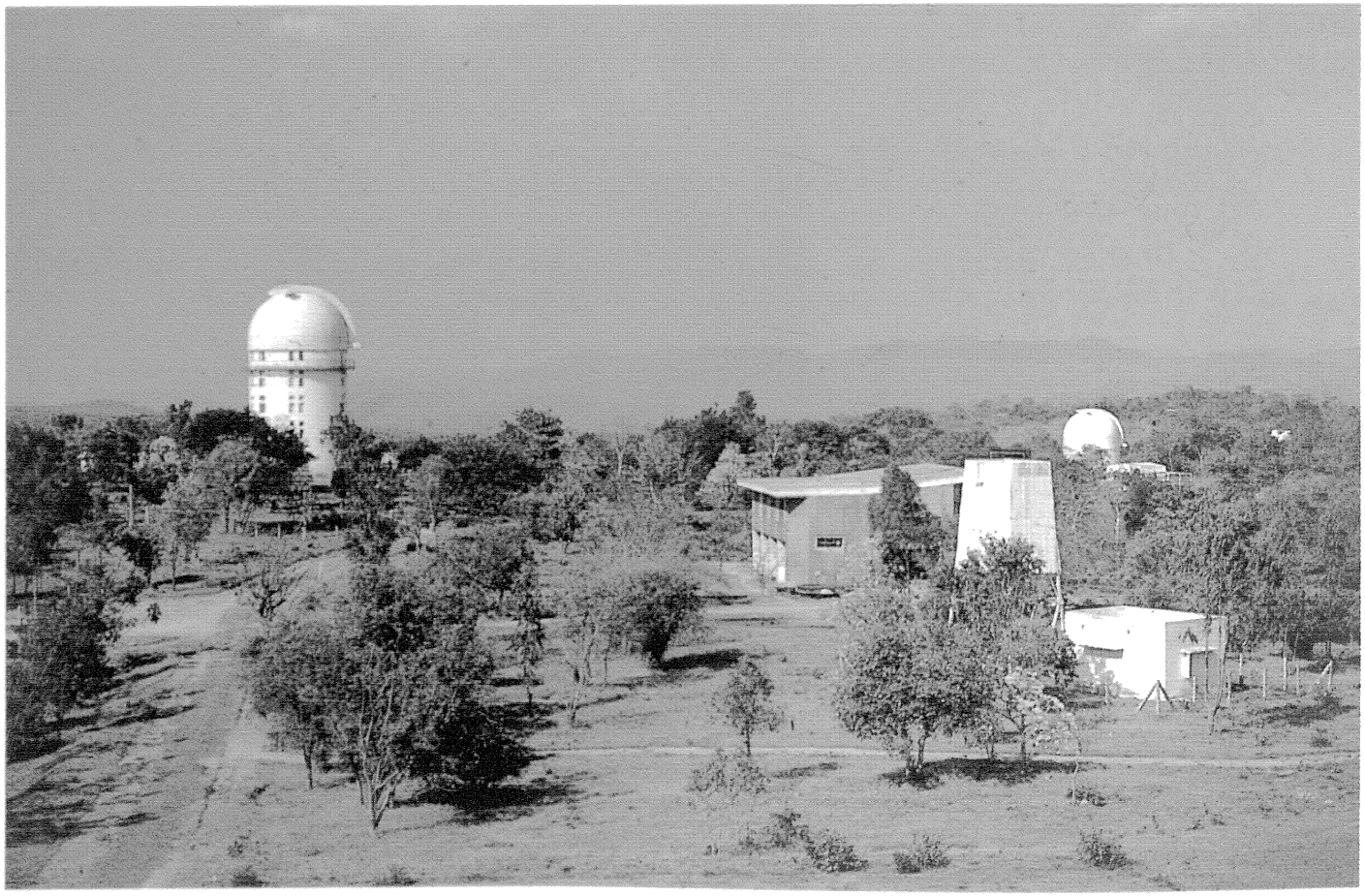


*Photo : M. Ramani*

# Vainu Bappu Observatory

## Vainu Bappu Telescope

### Aluminization and alignment

The mirrors of the 2.34 m Vainu Bappu Telescope were realuminized and the telescope was aligned in 1992 September. The existence of a shift of the secondary mirror with respect to the primary mirror noticed earlier, was confirmed. To quantify the shift and to locate the source of this error, various mechanical and optical tests were carried out by F. Gabriel and J.P.A. Samson. It was inferred that the Serrurier truss flexure caused a shift of the secondary mirror in extreme positions of the telescope tube. The system was later realigned for its optimum performance. (A.K. Saxena, Photonics and Mechanical Teams)

### Cassegrain acquisition and guiding unit

Schematic designs of the *Cassegrain Acquisition & Guiding Unit* for the VBT (*90CAGU*) were completed. The design pertains mainly to the optical configuration at this stage, and laboratory trials have to be done before the optical configuration is finalised and the mechanical design of the structure would then follow. Some of the optical and mechanical components (mounts and stages) have been acquired while for the others procurement action has been taken. A laboratory is being set up for the experimentation; an optical table is being acquired for this purpose. In the meantime, some testing of the control of precision translation stages to be used in the instrument has been done. (A.K. Pati)

### New CCD detector

The programmes under way at the VBT require a larger format CCD than the current one of 384×576 pixels; the CCD currently in use has served for several years. A study of the suitability of various large format CCDs for the purpose was conducted and a proposal was made for acquiring it. A thinned, back-illuminated, anti-reflection coated Tektronix CCD was finally chosen; even though CCDs operating in the MPP mode have low dark current noise at operating temperatures achievable by thermoelectric coolers, the CCD being acquired will be liquid nitrogen cooled. A detailed look at the signal-to-noise of detection of faint stars with the VBT for different configurations of CCD and cooling led to the choice. The chosen device has the highest quantum efficiency available (about 80 % at 7000 Å) and a star of $m_v$=22 is expected to be detected with a signal-to-noise of 11 per pixel over the sky background in an exposure of 30 minutes.
(A.K. Pati)

### Reliability improvement of electronics

In order to improve the general operating reliability of various units at VBT, several major steps were initiated :

1. The power supplies (5 volts & 24 volts) needed for the prime and cassegrain foci which were spread over 4 racks earlier, have been relocated into a single rack and rewired. Two level regulation has been implemented to suppress the noise and improve regulation.

2. The power and signal cables have been segregated and relaid.

3. The Stepper motor controllers have been thoroughly tested for their rated torque performance.

4. A new 17 bit absolute encoder has been installed at the DEC, and line driver/receiver pair have been provided for error-free performance.

5. A new 70 metre cable has been added for connecting the CCD controller to the data acquisition computer in the console room, for enhancing the reliability of data acquisition. A new double correlated sampling card has been installed for the TIFR Astromed controller. This change brought about software compatibility between all the controllers. In order to operate the CCD camera at high humidity levels a provision for flushing dry air on the CCD window is available both at prime and cassegrain. (M.Muraleedharan Nair, K.S. Ramamoorthy, K. Ravi, A.S. Babu, G.Srinivasulu, R. Srinivasan)

### Astromed CCD data

Output format of the Astromed CCD data is being continuously upgraded by the technical group to incorporate more and more of user requirements. The final images stored are, however, not portable to other machines. Software is being upgraded continuously to incorporate these changes and input the data into STARLINK and RESPECT packages available at the VAX 11/780 installation at VBO. Users who require the data in FITS format can subsequently convert it through STARLINK or RESPECT utilities. (T.P. Prabhu)

### Strain gauges for balancing telescopes

It was decided to test with a strain gauge instead of a load cell the balancing of telescopes. Due to imbalance, the torque required to rotate a telescope axis in one direction is different from the torque required to drive in another direction. This idea was utilised in this method of balancing of telescopes. Tests were carried out on the R.A. axis of VBT by mounting etched foil strain guages supplied by M/s Integrated Process Automation Ltd., Bangalore. The idea proved feasible and a good sensitivity for the method was also established. It is now proposed to develop a more sensitive electronic circuit with some additional features based on the experience obtained from the tests already conducted. During the next phase of the work, it is proposed to develop a closed loop control system for the 75 cm telescope using the strain gauges mounted on the axis of the telescope as sensors of dynamic forces on the structure. (P.K. Mahesh, B.R. Madhava Rao)

### Focussing drive system for the VBT

The requirement of having a totally backlash free system of focussing for the secondary mirror system as well as the prime focus unit of VBT has led to the design of a system using a linear motor.

A linear motor produces linear translation of the unit to which it is connected. It incorporates a permanent magnet which can hold the moving load rigidly in the 'power off' position. A linear encoder attached to the unit gives the position readout or the same can be done with a LVDT and a digital readout.

The moving portion of the linear motor can be connected to a bracket located at the centre of the moving unit, at a suitable location behind the unit so that there is only minimal light obstruction. The non-moving portion of the motor can be connected to a bracket attached to the stationary outer drum.

Since there is no mechanical coupling in the system involving gears, screws, rods or nuts the backlash in the system is zero. This is the major advantage of this system over the conventional ones.

Since the stroke required for the VBT secondary unit is 12 mm (the stroke required for the prime focus unit is lesser) it is felt that no guiding through guide rods is required.

A company manufacturing linear motors of the capacity required has been located and feasibility studies of the same are on. (P.K. Mahesh, B.R. Madhava Rao)

## 102 cm telescope

Schematic design of the optical configuration of the *Holographic Grating Spectrograph* for the 1m telescope at VBO (*40HGS*) was also done. Some components for trials of the configuration in the laboratory have

been ordered. The same laboratory being set up for the 90 CAGU will be used for this purpose.

The *CCD detector at the 1 m telescope* which has been operating for about five years, developed problems of vacuum retention. The liquid nitrogen dewar was tested and the leaks were sealed using facilities available with ISRO. Proposals were made for upgrading the CCD system at this telescope, but this could not be taken up due to paucity of funds. (A.K. Pati)

## Modifications to the 75-cm telescope drive/display electronics

A console similar to the one in VBT has been installed. For reliable performance the L & T operational switches have been replaced by Hall-effect switches. While the RA tracking frequency is derived from a crystal oscillator, the set, guide and fine guide speeds are generated by individual timer circuits (555 ICs). The sidereal clock is built into the console.

The microcontroller 8052 AH has been replaced by a PC for coordinate display. A data multiplexer card has been incorporated to read the encoder data, UT and ST. The RA, DEC, HA, Zenith Distance, Air mass, UT and ST information are displayed on the PC monitor. A provision is made in the console for the guide field display. (B.Nagaraja Naidu, K. Ravi, R. Srinivasan)

## Vacuum coating plant and aluminizing

The 2.8 m coating plant was maintained and used for realuminising the 2.3 m VBT primary mirror.

The VBT secondary mirror, LIDAR telescope optics, EUV telescope optics and the 1.02 m telescope's 25 cm guide telescope optics were aluminized at the 1.5 m coating plant.

With the procurement of a new Leybold digital ionization gauge, all the other vacuum gauges are being calibrated. The 30 cm coating plant at Bangalore has been upgraded with the installation of a digital thickness monitoring unit. This plant was extensively used for aluminising various small optics. (A.K. Saxena, K. Ramankutty, J.P.A. Samson and aluminising team)

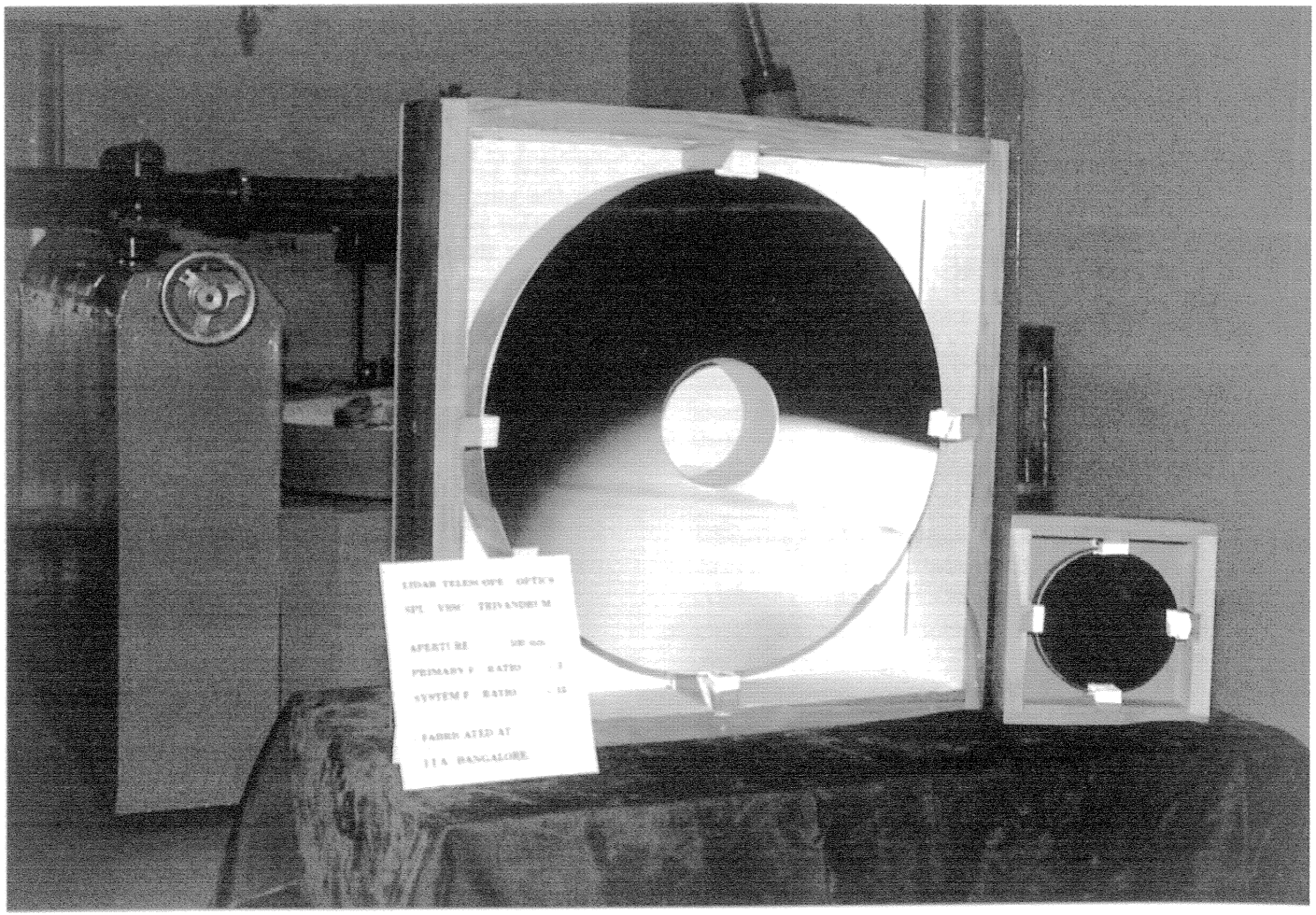


Photo : M. Ramani

***LIDAR Telescope Optics***

# Optics

## Wavefront sensing and evaluation for active optics experimentation

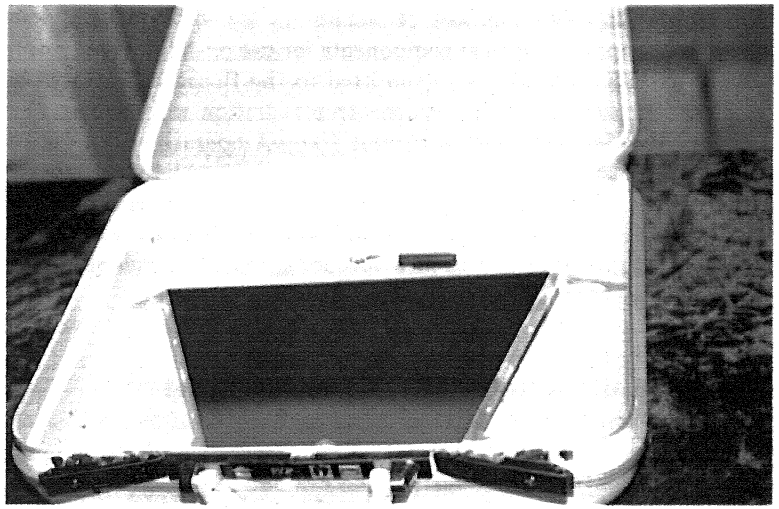
In continuation of earlier reports, the interferometric records were obtained and data analysis work is in progress. The grinding of the 27″ thin mirror is in progress. The configuration of the active support system which will be used for the laboratory setup is being designed. (A.K. Saxena, J.P. Lancelot, J.P.A. Samson)

## LIDAR telescope optics

A 500 mm Cassegrain telescope optics has been designed and fabricated for VSSC, Trivandrum. The complete optics was ready in 1992 November as per the MOU and it was handed over to VSSC 1993 January 22. A final figure close to 1/10 wavelength of light was achieved. (A.K. Saxena, J.P. Lancelot, V. Gopinath, D.V. Janakiraman)

## VHRR passive cooler for INSAT - II (ISRO)

Specular polishing of a set of panels for the VHRR Cooler of the satellite INSAT II A was completed during the year. The satellite was lauched in July 1992. USER'S committee headed by experts from IMD has concluded and certified the excellent performance of the passive coolers. Another set of six panels were polished and supplied for the INSAT II B spacecraft. The Satellite is scheduled for launch in 1993 September. (A.K. Saxena, M.G. Mohan, J.P.A. Samson, S. Razack)



VHRR sun shield panels for INSAT II B.

## Fabrication of Schlieren windows for NAL

Two Schlieren windows (14 x 39 x 215 mm) having a surface accuracy of $\lambda/4$ on both surfaces required reshaping of the edges and chamfering for the wind tunnel experiments of NAL. High optical quality and the odd shape of the windows made the job more difficult. A special type of fixture was fabricated and used with the milling machine for the above work. This was a very specialized job which required special care. It was completed satisfactorily to the accuracies specified by NAL, Bangalore. (A.K. Saxena, J.P.A. Samson, S. Razack, R. Ismail)

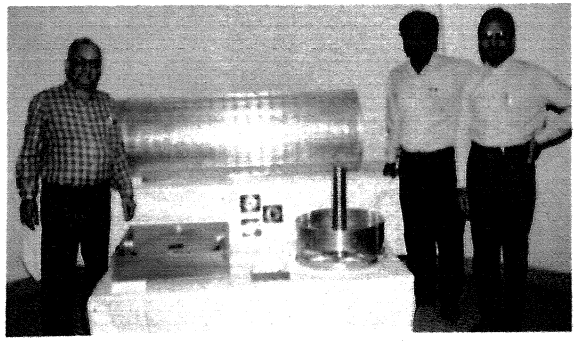
## Technology development for synchrotron radiation beam line optics

A proposal on "Development of technology for vacuum ultraviolet optics and supply of optical components for use on XUV synchrotron source INDUS - 1" has been submitted to the Board of Research on Nuclear Sciences. The XUV synchrotron radiation will have an electron energy 450 MeV, with a current 100 mA operating at a critical wavelength of 61 Å. This source will be used for solid state physics experiments. The beam line optics requires sophisticated technology and very specialized fabrication techniques. Import of these components is not possible and such a technology is not available in the country elsewhere. (R. Cowsik, A.K. Saxena)

## Extreme ultraviolet (EUV) spectrometer

The fabrication of the 18 inch f/15 EUV Gregorian telescope optics has been completed. Final testing and evaluation of the primary and secondary mirrors in combination are in progress. Integrated test of optics along with the structure is being planned. (A.K.Saxena, J.P.Lancelot, V.Gopinath, R.Ismail)

The fabrication of one unit of the telescope structure was completed and its delivery was taken from HAL Aerospace Division in the last week of January. The work will be completed by the end of April. (S.K.Jain, A.K.Saxena, J.C.Bhattacharyya)



## Interferometry

### High resolution imaging using a rotational shear interferometer

In continuation of the earlier reports, the rotational shear interferometer fabricated in house, has been extensively used for high angular imaging observations during 1992-93. Observations were carried out at VBO, Kavalur with the 2.34 m VBT and the 1.02 m telescope at the Cassegrain focus. Successful interferograms were recorded on $\alpha$ Bootis and other bright objects using a 60 nm filter. These records are being used for calibrating the instrument and developing a data analysis procedure. During these observations, the data acquisition system has been upgraded with a EEV asynchronous ICCD camera and a SONY VCR 8 mm format model having a SNR of 45 db for acquisition. The observations were repeated with the 1.02 m telescope, UPSO, Nainital, during 1993 February. This has assisted in evaluating the true instrument performance and the limiting magnitudes which can be achieved. Preliminary data analysis has been done on the data obtained from these sessions. The fringe signal clearly shows that the peak is not well defined and the SNR is poor. Efforts are on to improve the SNR and an on-line tilt mirror is being incorporated in the system. Rigorous data analysis with appropriate algorithms is being worked out. (A.K.Saxena, N.Udayshankar*, R.Jayadev*, M.Selvamani*, J.P.A. Samson)

### Temporal Wiener spectrum of path delay fluctuations in an interferometer

Earlier work by Fried had predicted nonzero d.c. power for atmospherically induced path delay fluctuations when the turbulent eddies move perpendicular to the baseline of the interferometer. This unphysical result was corrected using a proper analysis of the situation. The new results show a vanishing d.c. power irrespective of the orientation of the baseline w.r.t. the direction of the eddy flow. (P.Venkatakrishnan)

### Speckle interferometer

Significant progress has been made by setting up the optical components and aligning the speckle camera for the prime focus of 2.34 m Vainu Bappu Telescope, Kavalur in the makeshift laboratory. An f/3.25 beam was generated. The optical alignment of the speckle camera was optimized and designed for guiding the field stars, as well as to focus the magnified image ($\sim$ f/130) of the object. A prototype adapter for these optical mounts is being made in our mechanical workshop to test the performance. It is to be noted here that the same camera could be used at the Cassegrain focus of the said telescope as well, where the beam would slow down to $\sim$ f/520. This would ensure the photon centroiding of each speckle. Due to the high magnification of the image, the camera would be highly sensitive to the thermal expansion of the metal. The optical alignment may get distorted due to the nocturnal temperature variations during the observations at VBO, Kavalur. Therefore, a high quality iron alloy viz. Invar is ideally suited. Efforts are on to obtain this alloy. Alternate arrangements can be made to procure special quality stainless steel viz. 304L or 410 to fabricate this camera. A prototype mount for the microscope objective and the focal plane flat (which contains the aperture $\sim$ 35 $\mu$) has been made and is being tested. This mount is very crucial to maintain the optical axis between the aforementioned aperture and the microscopic objective. Special care is being taken to avoid tilt and microfluctuations by grinding the facets of the mounts and house to maintain the surface accuracy to a few microns. Efforts have been made for blackening those mounts and house at NAL. In order to bring down the total weight of the instrument the light weight material made of carbon composite developed by NAL is also being considered for covering the house and to make the attachments. This would ensure the reduction of the possibility of any flexure at the rear end of the instrument. (S.K.Saha)

### Image processing

The technique of speckle interferometery recovers the diffraction limited spatial Fourier spectrum and images of the object intensity distribution from a series of short exposure images. The Fourier modulus or the Autocorrelation (A.C) of the object can be measured by this technique, while the Fourier phase can be reconstructed by the Knox-Thomson (K-T) method, Speckle Masking (Bispectrum) technique and Blind Iterative Deconvolution (BID) technique. In this respect, we have developed the necessary softwares for the 2-D Autocorrelation technique for analysing the data of speckle interferograms obtained earlier at VBT, using a speckle recording system comprising a Barlow lens, a narrow band filter in H$\alpha$ wavelength (FWHM $\Delta\lambda$–50Å), and intensified CCD. Associated software for 2-D convolution, 2-D power spectrum, averaging of several frames etc was developed. These programmes were tested with known simulated convolved functions used as input and the Fourier modulus of the object was successfully retrieved. The close binaries viz. HR 5747, HR 5138 were also resolved. Owing to the limited number of samples of speckle interferograms, it was not possible to reduce the contamination. A large number of data samples are required to enhance the signal to noise ratio.

In order to reconstruct the Fourier phase of the object, the technique of Blind Iterative Deconvolution was applied using a programme developed by P.Nisenson of the Center for Astrophysics, Harvard, USA. In this technique, the iterative loop is repeated enforcing image-domain and Fourier domain constraints until two images are found that produce the input image when convolved together. The image domain constraints of non-negativity is generally used to iterative algorithms associated with optical processing to find effective supports of the object and/or PSF from a speckle interferogram. Here, we have used a Wiener filter to estimate one function from an initial guess of the PSF. The uniqueness and convergence properties of the deconvolution algorithm are uncertain for the evaluation of the reconstructed images if one uses the BID method directly. In this respect, we use the autocorrelation technique to detect the Fourier

modulus of the object. If the correct estimate of this result is fed as an input support radius of the object, the reconstruction can be completed satisfactorily after several iterations.

We have deconvolved a computer generated speckle image using the aforementioned algorithm. The residual noise in the deconvolved results is less than 5% the computer simulation of speckle image obtained on imaging through atmospheric turbulence. The speckle images of two close binary stars HR 5138, HR 5747 were also used to retrieve the phases of the objects. The position angle and separation were seen to be consistent with results of the autocorrelation technique. (S.K.Saha, P.Venkatakrishnan)

### Fabry-Perot Interferometer (FPI)

Regular observations of the line profile of [OI] 630 nm nightglow emission were made at Kavalur using the pressure-scanned Fabry-Perot Interferometer (FPI). A total of 650 individual profiles covering 49 nights over the period November 1992 through March 1993 have been obtained for studies on the structure and dynamics of the equatorial thermosphere. The project was funded by ISRO/DOS under the RESPOND programme. (H.N. Ranganath Rao, J.H. Sastri)

# Instrumentation

## Status of indigeneously developed CCD cryostat

A liquid nitrogen cooled cryostat for CCDs has been developed in collaboration with the Indian Institute of Science. This has a capacity to hold 1 litre of liquid nitrogen. Some of the features available in the instrument are:

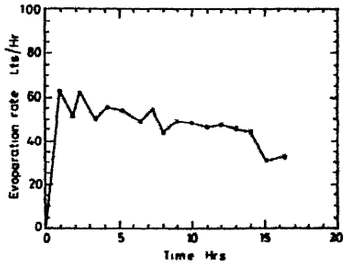
1. A getter pump in addition to the charcoal pump for prolonging the vacuum holding.

2. Electrical connections (terminated in a circular connector) compatible to the existing Astromed CCD controller.

A commerical EEV P8603 CCD chip has been mounted in the Dewar using the antistatic work table, in the newly established clean room facility of the Electronics Laboratory. The tests conducted so far indicate that the CCD temperature can be brought down to 143°K and no significant deviation from the set value has been observed. Figures 13–16 illustrate the CCD temperature and evaporation rate of the liquid nitrogen for the normal mode and the inverted mode respectively. The cryostat has undergone preliminary field trials. It has been observed that the vacuum is held for more than 8 weeks. (G.Srinivasulu, V.Chinnappan, R.Srinivasan, *S.Jacob, *S.Kasthurirangan, *R.Karunanithi)

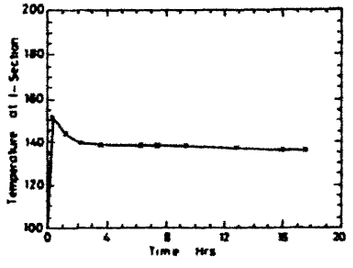
## Asteroid project

A study of detector requirements for use at the *1.2 m telescope of the Japal-Rangapur Observatory* was done and steps taken to acquire such a system. This will be a CCD detector similar to the one to be set up at VBT, and will be used to carry out research under the collaborative arrangement with the Osmania University. The first usage of the system will be for the asteroid search project. The system will have a facility for both 'stare mode' as well as 'time delay integration mode' of operation. (A.K. Pati)



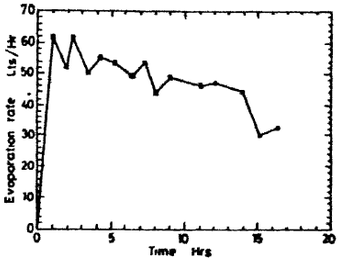

Normal mode operation

Fig 13



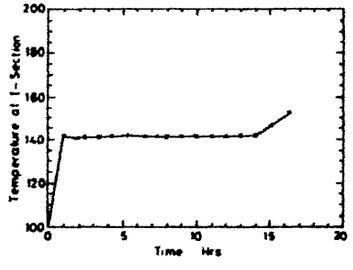

Normal mode operation

Fig 14




Inverted mode operation

Fig 15




Inverted mode operation

Fig 16

## Software modifications for the solar vector magnetograph

The vector magnetograph instrument has been operational at the Solar Tower Telescope, Kodaikanal since January 1992. In the initial form the image acquisition and the analysis programs were seperate and this was found to be inconvenient. A new command driven package has been developed in FORTRAN and ASSEMBLY languages on the PC/AT. The highlights of the package are:

1. Image acquisition

2. File/buffer handling

3. Quick look image analysis features like row-cut, column-cut, etc. (A.V.Ananth, P.Venkatakrishnan, R.S.Narayanan, J.C.Bhattacharyya)

### HF Doppler radar

The HF Doppler radar at Kodaikanal was effectively operated to develop an extensive and good quality database on the vertical drift of F-region plasma during the evening-nighttime period. Continuous observations were made on 202 nights over the period April 1992 – March 1993 including the campaign periods of International programes STEP and IEEY. (J.V.S.V. Rao, K.B. Ramesh, J.H. Sastri)

### Software modification for the CCD image data acquisition system at VBT

The image data software has been modified to: 1. improve the quality of data. 2. provide additional header fields in the image for subsequent use in image analysis. 3. improve the reliability of operation of various auxilliary instruments like filterwheel, guide focus and guide scan movements. (A.V.Ananth, G.Srinivasulu, R.Srinivasan)

### PC/AT based polarimeter

The fast star-sky chopping polarimeter data acquisition package has been written for PC/AT. The required hardware interface has been developed in the electronics laboratory. The software is command driven and user friendly. There are 13 commands, seven related to data acquisition and instrument control and the remaining for handling data. Presently the package is undergoing field trials and will be available to users shortly for observations. (G.Srinivasulu, S.K.Jain)

### Imaging polarimetry with a CCD camera

With a view to improving the efficiency of polarimetric observations of extended objects, a prototype imaging polarimeter was built. The instrument uses a polaroid sheet as the analyzer which is rotated manually in steps of 45 degrees and a CCD camera as the detector. Five filters, each 50 mm x 50 mm in size, can be mounted in a wheel which is thumb-driven and carries engraved identification of the filter band. The instrument was tested successfully by observing a number of standards (both polarized and unpolarized), one spiral galaxy and several assorted objects at the 1.02 m telescope on 30 March 1993. (S.K.Jain, T.P.Prabhu)

## Vibration analyser and its calibration

The vibration analyser, Kampana has been designed to measure vibrations in the low frequency range, at less than 50 Hz where conventional accelerometers fail. A schematic diagram is shown in Figure 17. The optical wedge converts the fluctuations of the wander of the laser beam to fluctuations in intensity.

The analyser was calibrated in the Vibration Analysis laboratory, Department of Mechanical Engineering, Indian Institute of Science. To test its performance, a comparison was made with the signal profile given by a B&K model 4370 accelerometer, coupled to a charge amplifier B&K 2511 vibration meter, with both Kampana and the accelerometer mounted on the same cantilever as shown in Figure 17. The profiles are seen to match for frequencies larger than 20 Hz (see Figures 18 and 19). Below 20 Hz the fit is poor due to the insensitivity of the accelerometers in the regime. The response of Kampana is seen to be orders of magnitude higher than that of an accelerometer without a charge amplifier. This is illustrated in Figure 20 in which the upper signal is due to Kampana while the lower one is due to the charge amplifier, the lower channel being kept in a scale ten times more than the upper one.

The instrument was used for studying the vibration spectrum of the VBT structure. (S. Chatterjee, K.C. Thulasidharan, R. Srinivasan, *U. Srinivasa, *Syed Karemulla)

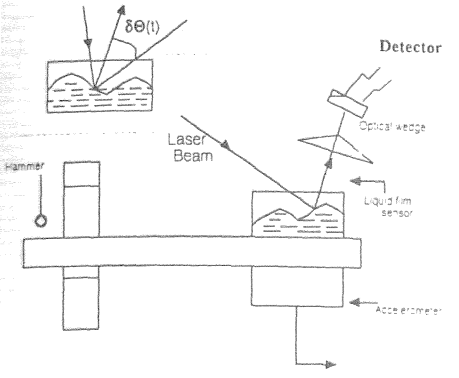



**Fig. 17** Schematic diagram of the liquid pool vibration analyser Kampana.

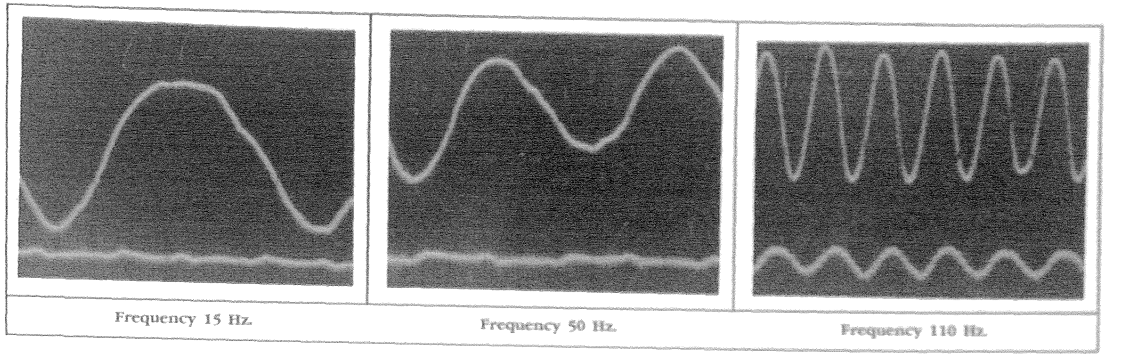



Fig 20

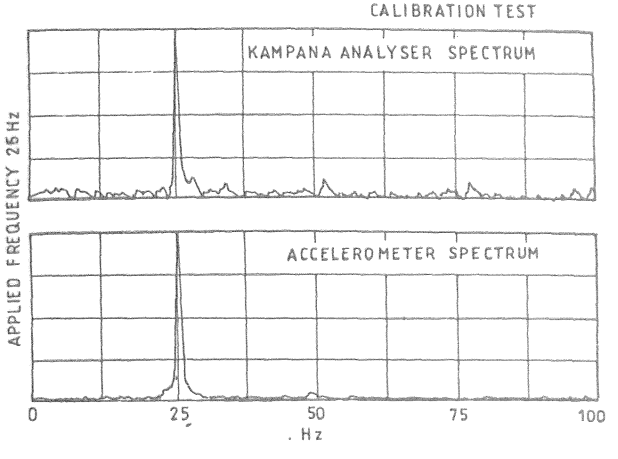



Fig 18

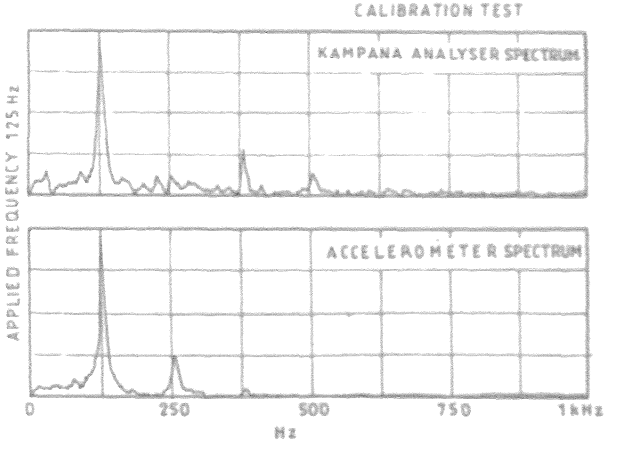



Fig 19

## A Single board controller for EEV CCDs

A single board high-density double sided PCB has been developed incorporating the camera controller for EEV CCDs. The controller includes clock and bias generation circuit, thermal and shutter control electronics, double correlated sampler and PC interface circuits. A full frame readout takes about 8 seconds. Using laboratory set-up images have been obtained. Efforts are on to minimise the readout noise to about 6 electrons from the present 100 electrons level obtained in our initial trials. (S. Murali Shankar, R. Srinivasan)

## India-Mauritius radiotelescope

The India-Mauritius radiotelescope constructed in collaboration with the Raman Research Institute and the University of Mauritius was inaugurated on November 4, 1992.

Observations on some strong southern point sources are in progress with the purpose of testing various sub-systems of the telescope and for calibration. Some preliminary maps of extended southern sources including a few of the Galactic centre region will be ready within the next few months. (Ch.V. Sastry)

## Gauribidanur-radioheliograph

We have constructed a log periodic array operating in the frequency range of 30 to 150 MHz for mapping the radio emission of the sun. The East West arm of this radio heliograph is completed and the signals from the eight groups were brought to the receiver building using open wire transmission lines. The phase stability of these lines was checked by observing strong radio sources using the longest baselines and found to be less than 10 degrees at all frequencies. A switching system was constructed to correlate the 8 East West baseline signals using analog receivers. Observations of strong radio sources were carried out to determine the phase and amplitude corrections for getting the expected beam pattern. (K.R. Subramanian, Ch.V. Sastry, R. Ramesh)

### Digital correlator system

A prototype sixteen channel digital correlator system was built and tested and is functioning satisfactorily. A 64 channel digital correlator is being constructed to correlate 8 East West group outputs with 4 south group outputs. This system is expected to become operational shortly. (M.S. Sundararajan, Ch.V. Sastry, K.R. Subramanian)

## Mechanical works

The coelostats designed and fabricated for 1991 total solar eclipse had slight oscillation and drift. This problem needed to be eliminated in order that these could be used for longer observations. A set of antibacklash spur gears and pinion having one module, with 123 and 60 teeth respectively was designed. Orders have been placed to get the machine through one of the gear manufacturers.

*The Gear box for the 17 bit absolute encoder* is a precision mechanical interface between the telescope drive shaft and the 17 bit absolute encoders. The speed increase of 1:16 obtained by the gears and pinions are fed to the 17 bit absolute encoders. By suitable electronic interactions it is proposed to obtain the absolute position accuracy of the order of 20 bits.

*The filter wheel assembly for the polarimeter of 1 metre telescope* can accomodate 2″ size UBVRI filter with options to have rotating polaroid sheet for polarimetry.

*Mechanical mount for 17 bit absolute encoder* was designed, fabricated and put into operation. This is useful when the 20 bit absolute encoder is not operative. (B.R. Madhava Rao)

# Computing Facilities

## Bangalore centre

Intel 860 computer work station with 420 MB hard disk and a terminal has been installed and available to users from May 1992. Some of the features available in this system are: 1. a vectoriser for vectorising the normal FORTRAN programme to improve the programme execution speeds and 2. the power fail restart facility.

The Sun 4/280 computer became operational from April 1992. This system is used for image data reduction for data acquired from various instruments available at different field stations.

The IRAF V2.10 obtained from NOAO, USA is the major package for astronomical image data reduction on the Sun system.

The super Mongo graphic package and the open cluster database 'BDA' are also available. A thin ethernet link has been established between various computers enabling the user to transfer programmes and data across various machines. (J.S. Nathan, A.V. Ananth)

## Kavalur centre

The VAX 11/780 system at Kavalur continues to be used for astronomical data reduction as well as for converting data from various telescopes, available in different data formats into FITS format to enable data portability. (K.N. Kutty, A.V. Ananth)

## New systems for CCD control and data acquisition

A study was made of the computer systems which would be appropriate for control and data acquisition of the CCD systems for both the VBT as well as JRO. The criteria leading to a choice of systems were: availability of interfaces for fast acquisition of frames from the CCD, sufficient CPU power for 'quick-look ' processing of the data during the observing run, system compatibility for running standard astronomical packages (eg. IRAF), archival compatibility with systems at other institutions. For the VBT, an additional criterion was the need to upgrade the computing facilities (the existing VAX is getting expensive to maintain and is, besides, slow for processing large format images). For JRO, the asteroid project requires very high CPU power for near real-time detection of moving objects in scans of the sky. One SUN SPARC station 10, four SUN SPARC station LC s and one DEC Alpha workstation are being acquired for the control, data acquisition as well as reduction/processing of the CCD data. (A.K. Pati)

*A view of Tso Morari*

*Courtesy: A.K. Pati*

# National Facilities

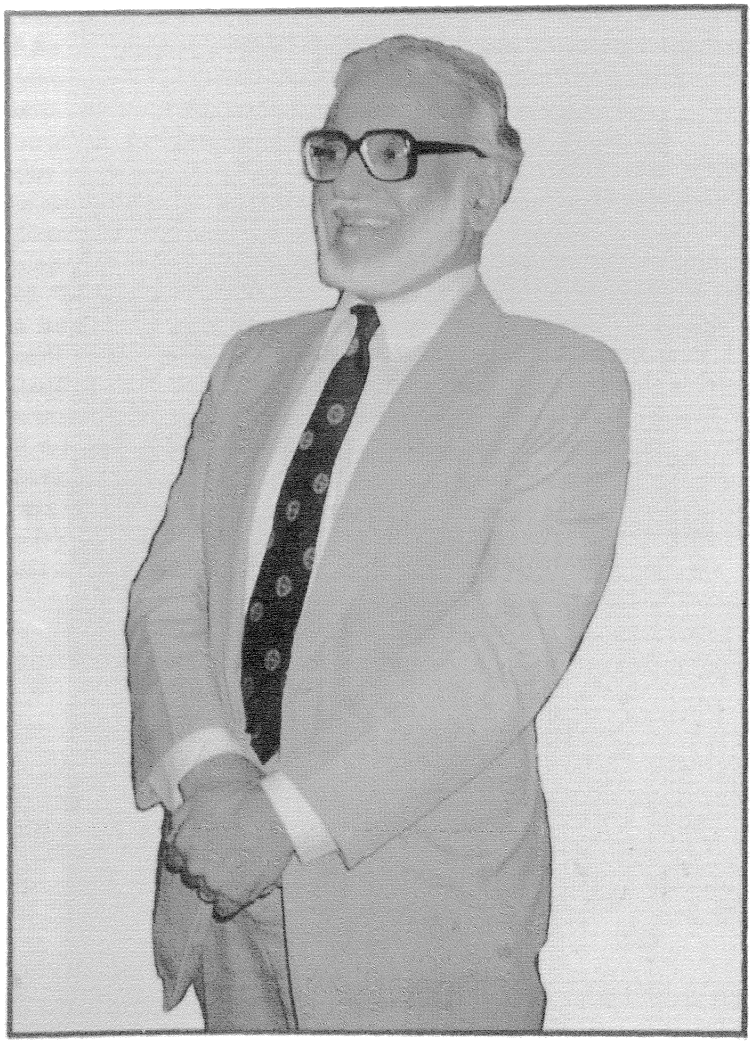
## Vainu Bappu Telescope

During the earlier part of the year the Vainu Bappu Telescope was realuminized and aligned. The electronic controls were improved upon to obtain greater reliability of operation. Mechanical balancing was tested with the use of strain gauges. During late November and December 1992 the telescope was thoroughly tested by technical and scientific teams. Regular observations started soon after. During the first quarter of 1993 (January - March) the telescope was over-subscribed by a factor of three. Thirty one scientific proposals were allotted observing time. The telescope operated in the prime mode on forty five nights and in the Cassegrain mode thirty eight nights. Two groups from outside India, one from the USA and the other from Korea used the telescope for a total run of nine nights. At the prime focus CCD imaging was done using broad band and narrow band filters. In the Cassegrain mode spectroscopy was done on sixteen nights using the Boller and Chivens spectrograph. Two groups from PRL observed on a total of fifteen nights, eleven of which were used for polarimetry and four for Fabry-Perot spectrometry. The two-star photometer of ISRO was used on four nights and the rotational shear interferometer of RRI on another three nights.

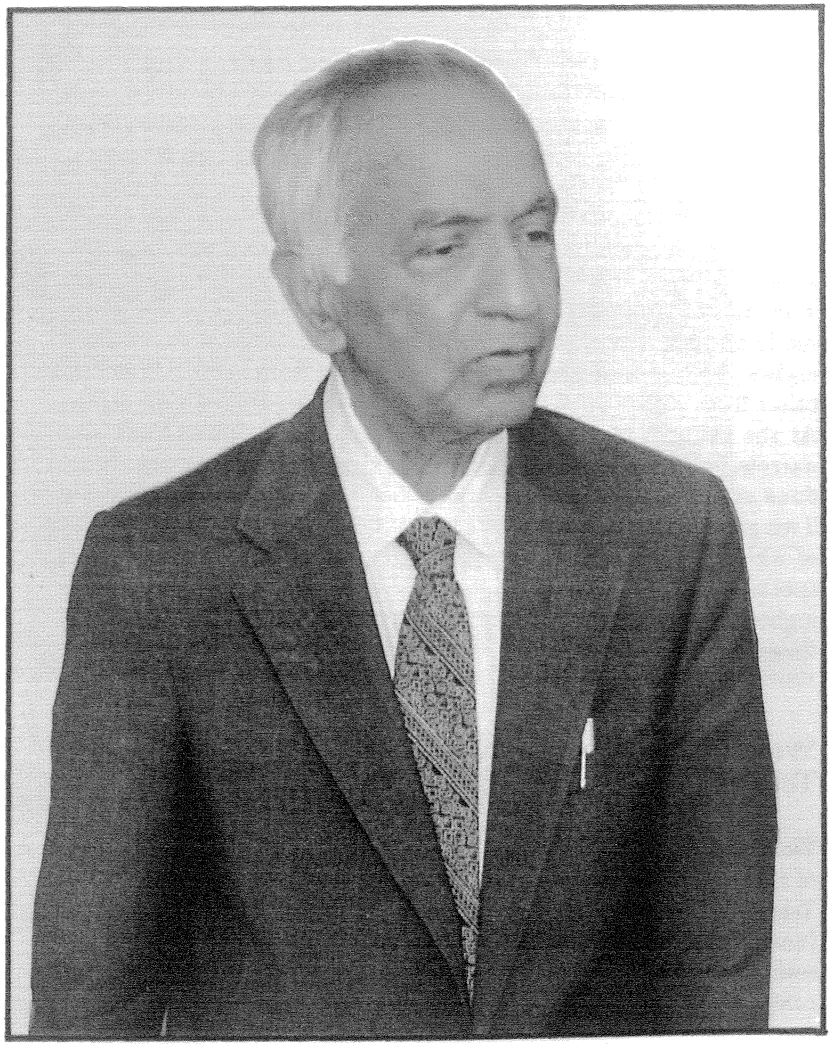
## Working group for National Large Optical Telescope

Work towards the selection of possible sites was continued as part of the activity of the Working Group for the National Large Optical Telescope . Apart from the region around Dalhousie and Devasthal (near Naini Tal), which may yield 150 to 180 clear nights in a year, some locations at altitudes over 4000 metres (above sea level) were considered. These locations were identified from contour maps and by considering the topographical information as well as general meteorological information for the regions. The locations are all chosen to lie on the leeward side of the Greater Himalayan ranges, and are all in eastern Himachal Pradesh (Spiti region) and Ladakh. The rationale dictating such a choice are as follows: the prevailing winds are from the west and south-west and the Greater Himalayas act as a barrier to low clouds. These regions have no 'monsoon' and are on the edge of a high altitude plateau extending into Tibet. The most promising of these locations lies east of a lake named Tso Morari (size roughly 25 km in the N-S direction and 6 km in the E-W), at an altitude of about 4500 metres at approximately 32° 52' N latitude and 78° 26' E longitude. The high ranges are approximately 20 to 30 km west of the lake and most of the turbulence at low levels generated by these ranges, in the prevailing winds from the west, is expected to dissipate over this distance. Further, the presence of a large body of water of uniform temperature would serve to make the wind flow laminar in nature. To the east of the lake, the topography is gently contoured, providing reasonably flat sites of the order of one to two square kilometres at altitudes from 500 metres to 1200 metres above the level of the lake. Being a high, cold desert, the humidity in the area is also expected to be low. (A.K. Pati)

# *The Honorary Fellows of the Institute*



*Prof. M.G.K. Menon*



*Prof. S. Chandrasekhar*

# Miscellaneous

## Honorary Fellowships

The Institute conferred its first Honorary Fellowship on Professor M.G.K.Menon, FRS. Professor Menon was the Chairman of the IIA Council for more than two decades and played a pivotal role in shaping the Institute since its inception.

The second Honorary Fellowship was conferred on Professor Subrahmanyan Chandrasekhar, Nobel Laureate, of the University of Chicago, USA.

## Awards

K.R. Sivaraman, Professor Emeritus was awarded a citation by National Aeronautics and Space Administration, USA, in appreciation for his outstanding contribution to the successful completion of *The International Halley Watch*.

C. Sivaram received an honourable mention at the 1992 competition of Gravity Research Foundation for his essay "A Born - Infeld type of modification of general relativity and its consequences for black hole physics".

S.S. Hasan was appointed an Associate of the Harvard College Observatory for a further period of one year from August. He also recieved an award from the National Science Foundation USA to carry out research on *Radiative transfer on intense flux tubes.*

R. Kariyappa was given an award for best thesis presentation at the XV ASI Meeting in Bombay 1993 March 2–6.

## Distinguished visitors

Professor Subrahmanyan Chandrasekhar visited IIA on January 11, 1993. He had informal meetings with the graduate students of IIA and other institutions. He also met the scientists. In the afternoon Professor Chandrasekhar gave a colloquium on *Nonradial oscillations of stars as a problem in the scattering of gravitational waves.*

The *Executive Committee of the International Astronomical Union* (IAU) met in Bangalore at the Raman Research Institute in September 1992. Members of the EC visited IIA, Bangalore and the Vainu Bappu Observatory, Kavalur, September 12, 1992. Professor A.A. Boyarchuk, President IAU, gave a talk on *Symbiotic stars and the Russian space project SPECTR UV.* Professor L. Woltjer, President-Elect IAU, also gave a talk titled *Future large telescopes.*

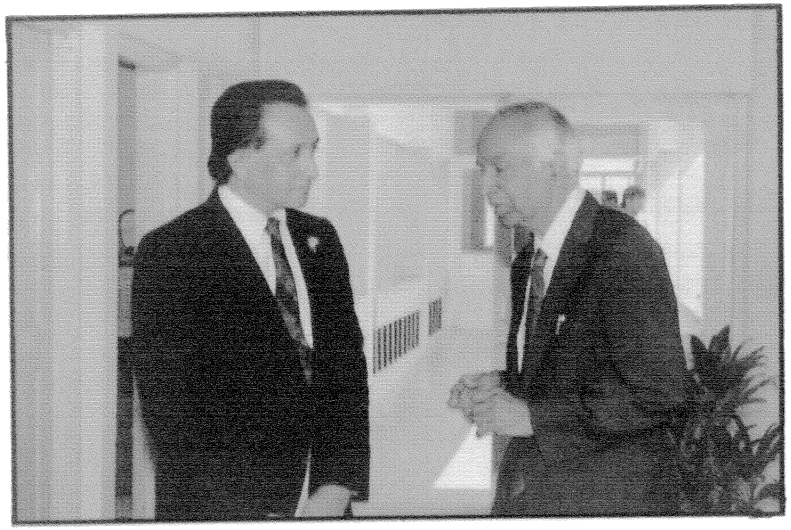
Other distinguished visitors include Dr Russell Cannon, Director, Anglo-Australian Observatory, Dr Alain Omont, Director, Institut d'Astrophysique, Paris and Professor David Lambert, Isabel McCutcheon Harte Centennial Professor of Astronomy, University of Texas, USA. Professor Cannon and Professor Lambert also visited VBO, Kavalur and spoke to the participants of the Winter School on Astronomy.

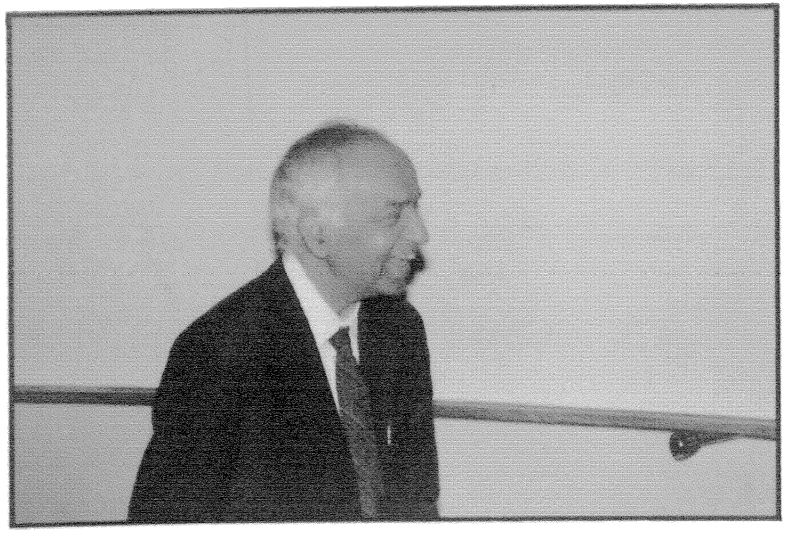
## Doctoral dissertations

R. Kariyappa was awarded the Ph D degree of Bangalore University for the thesis titled *Study of inhomogeneities in the solar atmosphere*

Y.D. Mayya submitted his Ph D thesis to the Indian Institute of Science and R. Vasundhara here to Bangalore University.

# *Visit of Professor S. Chandrasekhar*





*Photos: M. Ramani*

## Meetings at IIA

The Institute hosted a Neighbourhood Astronomy Meeting *Jan Oort and the Universe* on March 31, 1993. It was attended by astronomers and physicists of the Bangalore area and a large number of students. The speakers touched upon various aspects of Jan Oort's work and their impact on the astronomy of the twentieth century.

A Winter School on Astronomy was organized at VBO, Kavalur during 1992 December 22–31. Twenty six M.Sc. and Engineering students from various colleges, universities and IIT's were participants. Speakers included staff members of IIA and Professors R. Cannon and D.L. Lambert. A wide variety of topics ranging from *Rings around planets* to *Nature and distribution of dark matter* was covered. The participants were given short training in observational aspects of astronomy also.

## Exhibitions

An astronomy exhibition was organized at Panaji, Goa during 1993 January 3–8 to coincide with the 80th Indian Science Congress at Panaji. This was part of the exhibition sponsored by the Department of Science and Technology, Government of India, New Delhi. The exhibits highlighted the Institute's work in observational and theoretical areas, the Mauritius Radio Telescope project and the 234 cm Vainu Bappu Telescope. Sunspot viewing was arranged with a 3″ refractor. A large number of scientists, students and public in general visited the IIA stall.

The Institute celebrated the National Science Day by participating in an exhibition organized at the Jawaharlal Nehru Planetarium, Bangalore during 1993 February 28–March 2. (R.C. Kapoor, Prabhjot Singh)

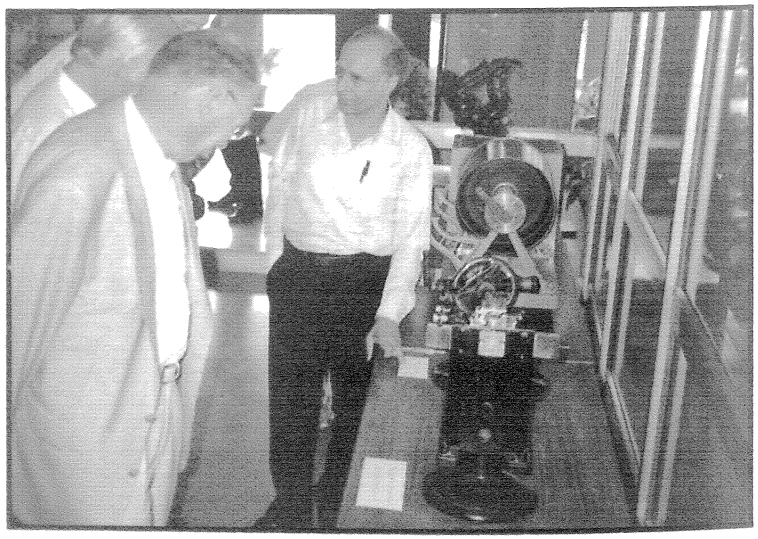
## Bicentennial Commemorative Public Lecture

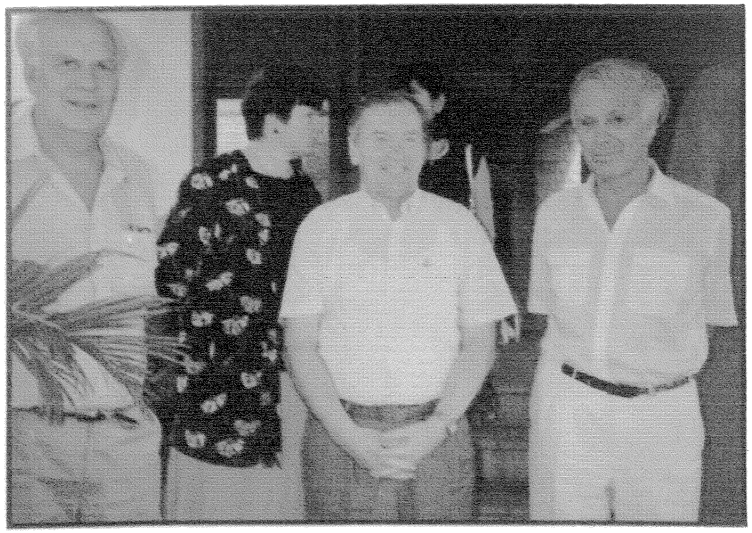
The seventh IIA bicentennial lecture on 'Studies of Cataract and Transparency of the lens' was delivered on 22 January 1993 by Prof. D. Balasubrahmanian, Director, Centre for Cellular and Molecular Biology, Hyderabad.

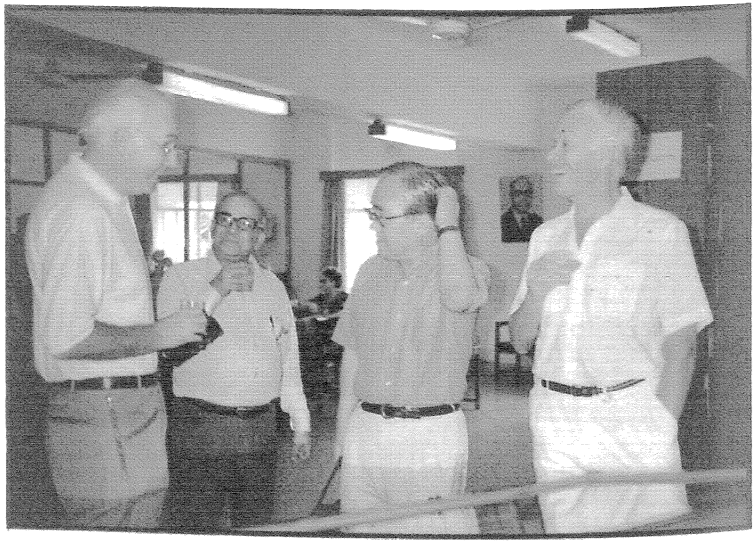
The bicentennial commemorative lecture series was instituted in 1987.

*Photo: K.T. Rajan*

# *Visit of the Executive Committee of the IAU*







*Photos: M. Ramani*

## Colloquia by visiting scientists

Mean tidal fields in clusters of galaxies
*Monica Valluri, JAP, IISc, Bangalore*, 1992 April 7

The emission spectrum of $TiCe^+$ in the yellow-green region
*K. S. Chandrasekhar, University of Victoria, British Columbia, Canada*, 1992 May 5

Role of the state in science and technology development
Krishna Kumar, Institute of social and economic change, Bangalore, 1992 May 28

Recent trends in digital signal processors
*S. Ganesan, Oakland University, Michigan, USA*, 1992 June 11

Faint galaxies and gravitational lensing by clusters
*R. Guhathakurta, Institute for Advanced Study, Princeton, USA*, 1992 June 19

Myth and reality about psychology
*Jitendra Mohan, Punjab University, Chandigarh*, 1992 June 30

Solar-terrestrial energy program (STEP)
*Juan G. Roederer, Geophysical Institute, University of Alaska, USA*, 1992 July 16

Yohkoh satellite — Studies of the sun
*C. D. Pike, Rutherford Appleton Labs, UK*, 1992 July 21

Superfluidity and superconductivity in neutron stars
*G. Srinivasan, RRI, Bangalore*, 1992 August 11

Strong interactions of photons
*R. M. Godbole, Dept of Physics, University of Bombay*, 1992 September 10

Outstanding problems in planetary science
*T. Gehrels, University of Arizona, Tucson, Arizona, USA*, 1992 September 15

Symbiotic stars and Russian space project 'Spectr UV'
*A. A. Boyarchuk, Astronomical Council, USSR Academy of Sciences, Moscow, Russia*, 1992 September 21

Future large telescopes
*L. Woltjer, Observatoire de Haute Provence, France*, 1992 September 21

High resolution astronomical imaging using rotational shear interferometry
*J. K. Rajagopal, RRI, Bangalore*, 1992 October 13

Deep infrared survey of the southern sky
*Alain Omont, Institut d'Astrophysique, Paris, France*, 1992 October 21

Homeopathy: a modern medical science
*B. D. Patel, Former Principal, Homeopathy College, Bangalore*, 1992 December 17

On the origin of Li, Be and B in the early galaxy
*D. L. Lambert, Univ. Texas, USA*, 1922 December 21

Isotopic fractionation of carbon monoxide in diffuse interstellar clouds
*D. L. Lambert, Univ. Texas, USA*, 1922 December 22

Ages and abundances of globular clusters
*R. D. Cannon, AAO, Australia*, 1922 December 24

Nonradial oscillations of stars as a problem in the scattering of gravitational waves
*S. Chandrasekhar, University of Chicago, USA*, 1922 January 11

Galactic distribution functions
*W. Saslaw, Univ. Virginia, USA*, 1993 January 6

Recent results in helio- and asteroseismology
*J. Christensen-Dalsgaard, Institute of Astronomy, Univ. Aarhus, Denmark*, 1993 January 12

High angular resolution observations of the Sun
*F. Kneer, Göttingen Observatory, Germany*, 1993 January 19

Non linear $\Sigma$ models and cosmology
*S. V. Cheron, Moscow State Univ., Russia*, 1993 January 29

A model for beta decay strength and application to astrophysics
*K. Kar, Saha Institute of Nuclear Physics, Calcutta,*
1993 February 12

Multiplicity corrected mass function of stars in the solar neighbourhood
*Sarbani Basu, TIFR, Bombay,* 1993 February 12

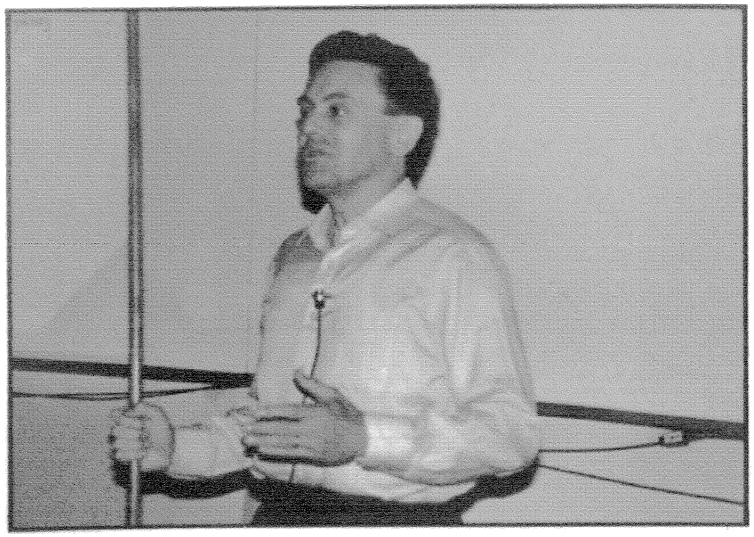
Generation of spatial structures in star-forming systems
*V. I. Korchagyn, Rostok Univ., Russia,* 1993 February 22

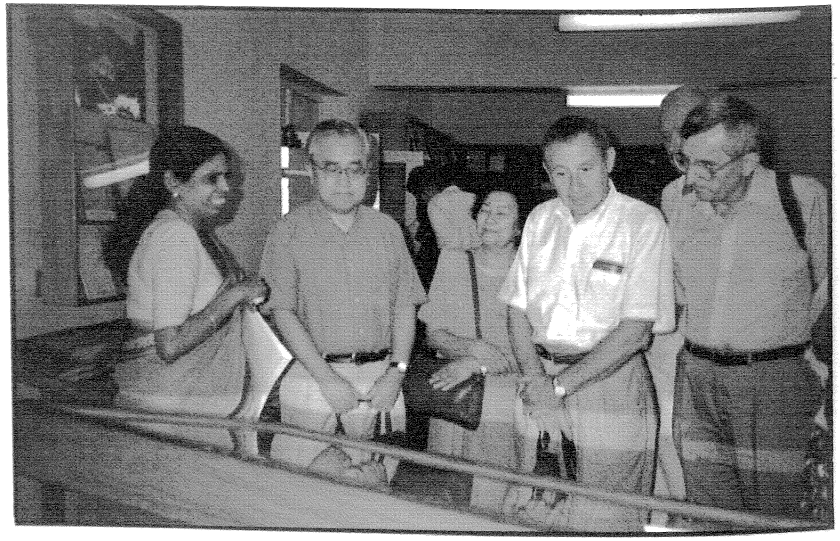
Accretion by magnetic stars: theory and observation
*Pranab Ghosh, TIFR, Bombay,* 1993 February 23

Pulsating characteristics of peculiar dwarf cepheids
*C. Kim, Chonbuk National Univ., Korea,* 1993 February 26

Strong Newtonian interactions of the three- and N-body systems
*J. Anosova, PRL, Ahmedabad,* 1993 March 10

Quark-gluon Plasma
*Jan-e Alam, Variable Energy Cyclotron Centre, Calcutta,*
1993 March 30





*Photos: M. Ramani*

# Library

The library was actively involved in the computerization of the card catalogue during 1992-93. 9200 books were entered using the CDS/ISIS software. The circulation has been automated using a package developed by the Computer Section of IIA and is working effectively. The library acquired 300 books during the year. 5 new journals were added, 2 journals and second copies of 5 other journals were discontinued making the total number subscribed 140. 343 volumes of journals and reports were bound during the year. 76 SIMBAD searches using the Stellar database and 23 on-line searches from Science Citation Index, INSPEC database were made using the Easynet. The library organised a special display of historical materials for members of the IAU Executive Committee. The library undertook the publication of Kodaikanal Observatory Bulletins Vol.12.

A. Vagiswari, Librarian attended the 15th meeting of the Astronomical Society of India, hosted by BARC Bombay 1993 March 2-5. She presented a paper on Common Communication Format. The draft copy of the Directory of Astronomers was given to the ASI Executive Committee for its comments. Christina Louis and H.N. Manjunath attended the DRTC seminar 1992 July 7-9 and presented a paper titled "IIA Library Automation : Case study".

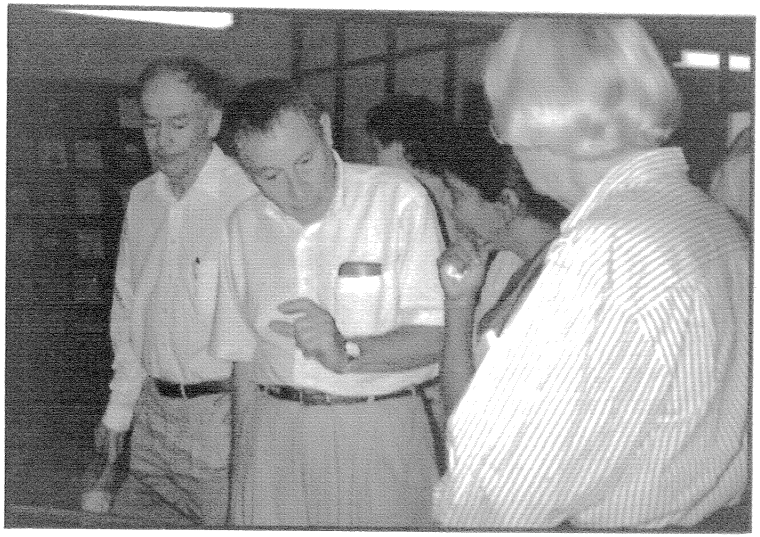
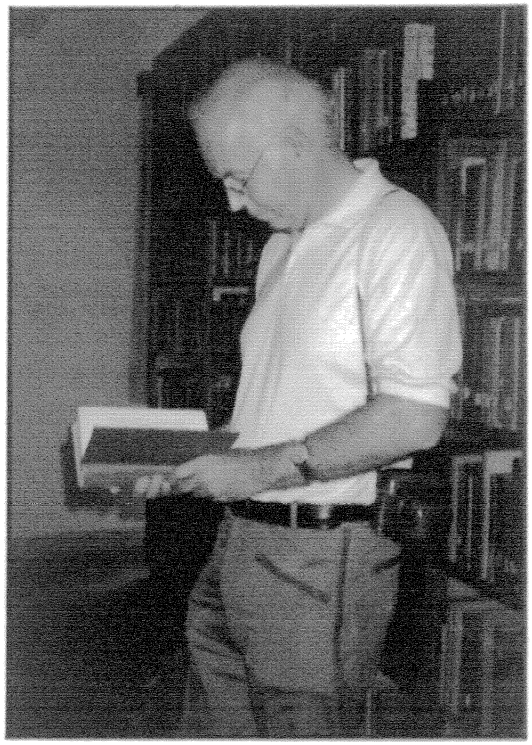


*Photo : M. Ramani*



# Personnel

The academic and technical staff during the period 1992 April – 1993 March include the following :

**Director**: Ramanath Cowsik

**Senior Professor** : A. Peraiah, Ch. V. Sastry, C. V. Vishveshwara

**Professor** : M. H. Gokhale, N. Kameswara Rao, R. K. Kochhar, V. Krishan, J. H. Sastri

**Associate Professor** : B. Datta, S. S. Hasan, R. C. Kapoor, D. C. V. Mallik, M. Parthasarathy, T. P. Prabhu, R. Rajamohan, Ram Sagar, C. Sivaram, P. Venkatakrishnan

**Reader** : G. S. D. Babu, S. P. Bagare, H. C. Bhatt, P. K. Das, K. K. Ghosh, S. K. Jain, A. K. Pati, P. K. Raju, A. V. Raveendran, J. Singh

**Fellow** : P. Bhattacharjee, S. Chatterjee, S. Giridhar, D. Mohan Rao, S. G. V. Mallik, K. N. Nagendra, K. E. Rangarajan, S. K. Saha, A. Satya Narayanan, K. R. Subramanian, R. Surendiranath, G. Thejappa, R. Vasundhara

**Research Associate** : P. S. M. Aleem, S. S. Chandramouli, J. Javaraiah, R. Kariyappa, D. Karunakaran, M. V. Mekkaden, B. S. Nagabhushana, R. S. Narayanan, K. Sasidharan, K. Sundara Raman, B. A. Varghese, L. Yeshwant

**Senior Principal Scientific Officer** : R. Srinivasan (Dean)

**Head, Photonics Division** : A. K. Saxena

**Principal Scientific Officer** : A. V. Ananth, B. R. Madhava Rao, K. K. Scaria*

* deceased 29 August 1992

**Scientific Officer 'SD'** : M. S. Sundara Rajan, G. Srinivasulu

**Scientific Officer 'SC'** : S. S. Gupta, J. P. Lancelot, S. Mohin, P. M. S. Namboodiri, K. B. Ramesh

**Senior Computer Enginer** : V. Chinnappan

**Senior Civil Engineer** : N. Selvavinayagam

**Librarian** : A. Vagiswari

**Asst. Librarian 'A'** : C. Louis

**Technical Officer** : R. Muraleedharan Nair, K. Ramankutty, R. Sivashanmugam, K. G. Unnikrishnan Nair

**Technical Associate** : M. Md. Abbas, A. M. Batcha, A. M. Ghouse, A. T. A. Hameed, H. N. Manjunath, S. Muthukrishnan, J. S. Nathan, K. Padmanabhan, K. S. Ramamoorthy, J. P. A. Samson, K. S. Subramanian

**Engineer Associate** : Fasccehana Saleem, K. Narayankutty

**Documentation Associate** : Sandra Rajiva

**Emeritus Professor** : J. C. Bhattacharyya, K. R. Sivaraman

**Emeritus Scientist (CSIR)** : K. V. K. Iyengar

**Post Doctoral Fellow (CSIR)** : P. Bhaskaran

**Graduate Students** : Angom Dilip Kumar Singh, S. Annapurni, S. G. Bhargavi, D. Banerjee, S. Banerjee, Charu Ratnam, M. Dikpati (CSIR), B. Eswar Reddy, R. T. Gangadhara, Gauri D Kamat, V. Krishnakumar, Y. D. Mayya, G. Pandey,

R.D. Prabhu, R. Ramesh, H.N. Ranganath Rao, S.K. Sengupta (CSIR), T. Sivarani, S. Banerjee, Swara Ravindranath, A.V. Thampan, G. Uma

**Visiting Teachers** (external candidates for Ph.D. Degree):
C. Chowdappa, N.D.N. Prasad, T.D. Sreedharan, N. Sundara Rajan

**G.S.D. Babu** assumed charge as Director, Jawaharlal Nehru Planetarium, Bangalore 1992 October 1. He is on deputation from IIA. **P. Bhattacharjee** was appointed Fellow 1992 November 11. **Ramanath Cowsik** assumed charge as Director, IIA 1992 July 15. **A. Satya Narayanan** was appointed Fellow 1993 March 3. **K.K. Scaria**, Principal Scientific Officer, died after a long illness 1992 August 29. He had joined the erstwhile Kodaikanal Observatory in 1961. **G. Thejappa** has been on leave during the year. **C.V. Vishveshwara** joined the Institute as Senior professor 1992 December 1.

## Involvement in the scientific community

**Ramanath Cowsik** is the convener of the International Conference on Non-accelerator Particle Physics (ICNAPP 94) to be held in IIA 1994, January 2–9. **B. Datta** is serving as a member of the organising committee of the International conference on Astrophysics and Cosmology to be held in Calcutta 1993 December. Datta is also a member of both the Local and the National Organizing Committees of ICNAPP 94. He is currently a member of the Academic Programme Committee of the Indian Association for General Relativity and Gravitation. **S.S. Hasan** is a principal investigator on the Indo-US project *Structure, Dynamics and Heating of the Solar Atmosphere*. This three-year long project has been recommended for funding and support by the Indian Government. He is also a member of the *Magnetic effects* team of GONG (Global Oscillation Network Group). **V. Krishan** has been appointed a member of the Scientific Organizing Committee of IAU Commission 49 for the triennium 1992-95. She has been serving as the secretary of the Plasma Science Society of India for the period 1991-93. She also served on the SOC of the Annual Meeting of the Plasma Science Society held in Bombay 1992 November 3–7. **D.C.V. Mallik** served on the Scientific Organizing Committee of IAU Symposium 155 on Planetary Nebulae. He has also been nominated a member of the Working Group on Planetary Nebulae of IAU Commission 34. **N.K. Rao** served on the Scientific Organizing Committee of the 6th Asia-Pacific Regional IAU Meeting to be held in Pune 1993 August. He continued to serve as a member of the Science Advisory Committee of IUCAA, and attended the SAC Meeting in 1992 December. **J.H. Sastri** has served as Member-Scretary, Indian National Committee for SCOSTEP of INSA, New Delhi. He is also the co-convener of the Symposium 2.3 on "Equatorial Ionosphere – thermosphere Coupling and Dynamics (EITCD)" scheduled to be held at the 7th Scientific Assembly of IAGA, 1993 August 8 – 20, Buenos Aires, Argentina. **A.K. Saxena** continues to be a member of the Working Group of NLOT and NSVT. **Jagdev Singh** has been nominated as the Indian representative on the Permanent Working Group on Solar, Terrestrial and Astrophysical Research of the Scientific Committee on Antarctica Research (SCAR). Singh has also been appointed a member of the Working Group on Eclipses of the IAU. **K.R. Sivaraman** was nominated the Chairman of the Scientific Programme Committee of the Visvesvaraya Industrial and Technological Museum, Bangalore in 1993 January for a three year term. He continued as a member of the Programme Advisory Committee of the DST, New Delhi. He is also serving as the Chairman, LOC of ICNAPP 94. **P. Venkatakrishnan** was placed on a pool of reviewers of NASA proposals for the year 1992-93.

## Visitors

A. Peerally, University of Mauritius, Mauritius
1992 June 4–7

R. Guhathakurta, Institute for Advanced Study, Princeton University, USA
1992 June 19

C. D. Pike, Rutherford Appleton Laboratory, Chilton, UK
1992 July 17–22

T. Gehrels, University of Arizona, Tucson, Arizona, USA
1992 September 13–16

Alain Omont, Institut d'Astrophysique, Paris, France
1992 October 21

D. L. Lambert, University of Texas, Austin, USA
1922 December 10–30

R. D. Cannon, Anglo-Australian Observatory, Epping, Australia
1922 December 23–27

P.K. Shukla, Ruhr University, Bochum, Germany
1992 December 23–27

M. Pick, Observatoire de Paris, Section de Meudon, France
1993 January 14–18

W. Saslaw, University of Virginia, Charlottesville, Virginia, USA
1993 January 6

S. Chandrasekhar, University of Chicago, Chicago, Illinois, USA
1992 January 11–12

J. Christensen-Dalsgaard, Institute of Astronomy, Univ. Aarhus, Denmark
1993 January 12

F. Kneer, Göttingen Observatory, Germany
1993 January 19

S. V. Cheron, Moscow State University, Russia
1993 January 29

V. Kotsagyn, Rostok University, Russia
1993 February 20–26

Y. Matogawa, Institute of Space & Astronautical Science, University of Tokyo, Japan
1993 March 11

# APPENDIXES

## Appendix A

### Publications

### In Journals


*Aharonian, F. A., Bhattacharjee, P., *Schramm, D.N. (1992) *Phys. Rev.*, D 46, 4188–4192.
Photon/proton ratio as a diagnostic tool for topological defects as the sources of extremely high energy cosmic rays.

*Anupama, G.C., *Kembhavi, A.K., Prabhu, T.P., *Singh, K.P., *Bhat, P.N. (1993) *Astr. Astrophys. Suppl.*, in press.
BVRI photometry of the dipper asterism region of M 67.

*Anupama, G.C., Prabhu, T.P. (1993) *Mon. Not. R. astr. Soc.*, **263**, 335–342.
The nebular remnant and quiescent spectrum of nova GK Persei.

*Bernotawicz, T., *Brannon, J., *Brazzle, R., Cowsik, R., *Hohenberg, C., *Podosek, F. (1992) *Phys. Rev. Lett.*, 69, 2341–2343.
Neutrino mass limits from a precise determination of double beta decay rates of $^{128}Te$ and $^{130}Te$.

*Bernotawicz, T., *Brannon, J., *Brazzle, R., Cowsik, R., *Hohenberg, C., *Podosek, F. (1993) *Phys. Rev.*, C 47, 806–825.
Precise determination of relative and absolute double beta decay rates of $^{128}Te$ and $^{130}Te$.

Bhatt, H.C. (1993) *Mon. Not. R. astr. Soc.*, 262, 812–816.
Enhanced star formation in the cometary globules in the Gum Nebula.

Bhatt, H.C., Jain, S.K. (1993) *Astr. Astrophys.*, in press.
Polarisation maps for dark clouds B 227 and L 121.

Bhatt, H.C., Sagar, R. (1992) *Bull. astr. Soc. India*, 20, 271–277.
A possible scenario for the formation of the composite Large Magellanic Cloud star cluster NGC 2214.

*Bhat, P.N., *Singh, K.P., Prabhu, T.P., *Kembhavi, A.K. (1992) *J. Astrophys. Astr.*, 13, 293–305.
VRI photometry of M 67 for CCD standardization at 2.3m VBT.

Bhattacharjee, P., *Alam, J.,*Sinha, B., *Raha,S.(1993)*Phys. Rev.*, D, in press.
Survivability of cosmological quark nuggets in the chromoelectric flux-tube fission model of baryon evaporation.

Bhattacharjee, P., *Hill, C.T., *Schramm, D.N. (1992) *Phys. Rev. Lett.*, 69, 567–570.
Grand unified theories, topological defects and ultra high-energy cosmic rays.

Bhattacharyya, J.C., Rajan, K.T. (1992) *Bull. astr. Soc. India*, 20, 319–343.
Vainu Bappu Telescope.

*Bünte, M., Hasan, S.S., Kalkofen, W. (1993) *Astr. Astrophys.*, 273, 287–292.
On the interchange instability of solar magnetic flux tubes II. The influence of energy transport effects.

*Chakrabarty, S., Datta, B., *Sinha, B. (1992) *Modern Phys. Lett.*, A 7, 2377–2381.
A cosmological lower limit for quark compositeness energy scale.

Chinnappan, V. (1992) *Bull. astr. Soc. India*, **20**, 345–351.
The design and installation of the secondary mirror control for 2.34 m Vainu Bappu Telescope.

Chinnappan, V. (1993) *Kodaikanal Obs. Bull.*, **12**, 1–14.
Telescope drive requirements and design of a microcontroller based drive and display system.

Chinnappan, V., Faseehana, S. (1992) *Bull. astr. Soc. India*, **20**, 353–361.
Automation of dome rotation at 2.34 m Vainu Bappu Telescope.

*Choudhuri, A.R., Dikpati, M., Banerjee, D. (1993) *Astrophys. J.*, in press.
Energy transport to the solar corona by magnetic kink waves.

Datta, B., *Alpar, M.A. (1993) *Astr. Astrophys.*, **275**, 210–212.
Implications of the crustal moment of inertia for neutron star equations of state.

*de Sabbata, V., Sivaram, C. (1992) *Foundations of Phys. Letters.*, **5**, 579–585.
Curvature from spin.

*de Sabbata, V., Sivaram, C. (1992) *Foundations of Phys. Letters.*, **5**, 183–190.
Consequences of a time-temperature uncertainty principle.

*de Sabbata, V., Sivaram, C. (1992) *Nuovo Cimento.*, **107 B**, 1201–1206.
Anyons and Torsion.

*Deshpande, D.D., Naidu, B.N. (1992) *Ind. J. Tech.*, **30**, 615–619.
H-bonding studies in sterically hindered alcohols.

Gangadhara, R.T., Krishan, V. (1992) *Ind. J. Phys.*, **66 B**, in press.
Continuum radiation due to collective plasma process in quasars.

Gangadhara, R.T., Krishan, V., *Shukla, P.K. (1993) *Mon. Not. R. astr. Soc.*, **262**, 151–163.
Modulation of radiation in an electron-positron plasma.

Ghosh, K.K., Soundararajaperumal, S. (1992) *Astrophys. J.*, **389**, 179–187.
EXOSAT observations of the broad line radio galaxy 3C 382.

Ghosh, K.K., Soundararajaperumal, S. (1992) *Astr. Astrophys.*, **265**, 413–416.
First X-ray spectrum of the most luminous quasar PKS 2126-158.

Ghosh, K.K., Soundararajaperumal, S. (1992) *Astrophys. J.*, **398**, 501–506.
X-ray observations of the Seyfert 1 galaxy MCG 2-58-22.

Ghosh, K.K., Soundararajaperumal, S. (1992) *Mon. Not. R. astr. Soc.*, **259**, 175–190.
X-ray spectra of eight Seyfert galaxies.

Ghosh, K.K., Soundararajaperumal, S. (1992) *Publ. astr. Soc. Pacific*, **104**, 258–262.
X-ray continuum with an iron emission line from the radio-quiet quasar PHL 909.

Ghosh, K.K., Soundararajaperumal, S., Kalai Selvi, M., Sivarani, T. (1992) *Astr. Astrophys.*, **255**, 119–123.
X-ray spectrum of NGC 3783 : detection of soft excess and an emission line.

Giridhar, S., Rao, N.K., *Lambert, D.L. (1992) *J. Astrophys. Astr.*, **13**, 307–318.
High resolution spectroscopy of the semiregular variable LR Sco.

Gokhale, M.H., Hiremath, K.M. (1992) *Astrophys. J.*, **407**, 359–366.
A model of the "steady" and "fluctuating" parts of Sun's internal magnetic field.

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## Attendance in Conferences, Workshops and other Scientific Meetings

IAU Colloquium 137: Inside the Stars
Vienna, Austria
1992 April 13-18 M.H.Gokhale

Workshop on Observational Cosmology
TIFR, Bombay
1992 April 14-18 T.P.Prabhu, S.Sengupta

International Workshop on Luminous High Latitude Stars
Cambridge, Massachusetts, USA
1992 May 28-30 M.Parthasarathy

1992 International Conference on Plasma Physics
Innsbruck, Austria
1992 June 29-July 3 V.Krishan

Fourth Symposium on Double Layers and
other Nonlinear Potential Structures in Plasmas
Innsbruck, Austria
1992 July 6-7 V.Krishan

IAU Colloquium 138: Peculiar Versus
Normal Phenomena in A-type and Related Stars
Trieste, Italy
1992 July 6-10 G.S.D.Babu, M.Parthasarathy

XIX IAU School for Young Astronomers
Beijing, China P R
1992 July 19–August 8 G.S.D. Babu, Prabhjot Singh

IAU Symposium 155: Planetary Nebulae
Innsbruck, Austria
1992 July 13-17 D.C.V.Mallik, M.Parthasarathy, R.Surendiranath

Meeting on STEP in Third World
Columbia, Maryland, USA
1992 August 21-22 J.H.Sastri

Symposium on 1992 STEP/5th COSPAR Colloquium
Laurel, Maryland, USA
1992 August 24-28 J.H.Sastri

IAU Colloquium 141: The Magnetic Field and Velocity Field of Solar Active Regions
Beijing, China
1992 September 6-12 J.Singh

IEEY Workshop
NGRI, Hyderabad
1992 September 29 J.H.Sastri

M N Saha Centenary Meeting
Calcutta
1992 October 29-31 J.C. Bhattacharyya

Annual Meeting of the Plasma Science Society of India
Bombay
1992 November 3-7 M.H.Gokhale, V.Krishan

Symposium on Mathematical Methods and Applications
Department of Mathematics, IIT, Madras
1992 December 22 A.Satya Narayanan

X DAE High-Energy Physics Symposium
TIFR, Bombay
1992 December 26-31 R.Cowsik, P.Bhattacharjee

Dedication Ceremony of IUCAA
IUCAA, Pune
1992 December 29-31 R. Cowsik, T.P. Prabhu, N.K. Rao

BCSPIN Winter School on Particle Physics and Cosmology
Puri, Orissa
1993 January 2-18 P.Bhattacharjee

Workshop on Helioseismology
PRL, Ahmedabad
1993 January 3-8 M.H.Gokhale, S.S. Hasan, K.M. Hiremath
V. Krishan, A. Satya Narayanan, D. Banerjee

II International Conference on Physics and Astrophysics of Quark Gluon Plasma
Calcutta
1993 January 19-23 P. Bhattacharjee, B. Datta

XIII Moriond workshop on Perspectives in Neutrionos, Atomic Physics and Gravitation
Villars sur Ollon, Switzerland
1993 January 30–February 6 R.Cowsik

Miniworkshop on the results of the SROSS-C Mission
Bangalore
1993 March 1 J.H. Sastri

XV Meeting of the Astronomical Society of India
BARC, Bombay
1993 March 2-5 G.S.D. Babu, R. Sagar, S.K. Jain,
R.T. Gangadhara, B. Eswar Reddy, Y.D. Mayya, D. Banerjee
Annapurni S., Uma Gorti, R.D. Prabhu, H.C. Bhatt,
S.P. Bagare, N. Kameswara Rao, M.Srinivasa Rao,
R. Surendiranath, K.V.K. Iyengar, R. Srinivasan,
V. Chinnappan, B.R. Madhava Rao, S. Pukalenthi,
K. Kuppuswamy, K.K. Ghosh, A. Vagiswari,
T.P. Prabhu, V.Krishan, R.Kariyappa

Miniworkshop on Techniques for Astronomical High Resolution Optical and IR Spectroscopy
Gurushikhar Infrared Observatory, Mt. Abu
1993 March 22-26 N. Kameswara Rao

Meeting on Futuristic Perspectives in Aeronomy and Atmospheric Science in India
PRL, Ahmedabad
1993 March 23-24 J.H. Sastri

## Colloquia and Invited talks at Conferences, Workshops and Seminars

Bhatt, H.C.
Jan Oort and comets
Neighbourhood Astronomy Meeting, IIA, Bangalore
1993 March 31

Bhattacharjee, P.
On the survivability of cosmological quark nuggets
Second International Conference on Physics and Astrophysics of Quark Gluon Plasma, Calcutta
1993 January 19–23

Bhattacharyya, J.C.

Asutosh Roy Memorial Lecture
Indian Association for the Cultivation of Science, Calcutta
1993 March 1

Cowsik, R.

Neutrino properties derived from Astrophysics
INSA Seminar on Current Status and Future Perspectives of High Energy Physics in India, VEC Centre, Calcutta
1992 August
Uttar Pradesh State Observatory, Naini Tal
1992 November
Dark matter in the Universe
CCMB, Hyderbad
1992 December

The importance of atomic experiments in NAPP
IX National Conference on Atomic and Molecular Physics, BARC, Bombay
1992 December 14–18

Experimental study of scattering of neutrinos by single crystals
A precise determination of relative and asbolute double-beta decay rates of $^{128}$Te and $^{130}$Te
X DAE Symposium on High Energy Physics (dedicated to the memory of P.K.Malhotra)
TIFR, Bombay
1992 December 26–31

Experimental studies of gravitation and feebler forces
IUCAA Dedication seminar, Pune
1992 December 28–30

The principles of multiwire proportional counters, drift chambers and their applications in particle physics
Raman Research Institute, Bangalore
1993 January 21

Experimental studies of gravitation and feebler forces at Gauribidanur
XIII Moriond workshop on 'Perspectives in neutrionos, atomic physics and gravitation', Villars sur Ollon, Switzerland
1993 January 30–February 6

The double beta decay of tellurium nuclides
IUCAA, Pune
1993 February 22
Raman Research Institute, Bangalore
1993 February 25

Double beta decay of tellurium nuclides. Experimental studies of gravitation and feebler forces
University of California, Santa Barbara
1993 March

Perspectives on dark matter
University of California, Irvine
1993 March

Datta, B.

High density matter in the chiral sigma model
Institute of Mathematical Sciences, Madras
1992 December 23

Radial pulsation of quark stars
Second International Conference on Physics and Astrophysics of Quark-Gluon Plasma, Calcutta
1993 January 19–23

Ghosh, K.K.

Astronomy with Vainu Bappu Telescope
XV ASI Meeting, Bombay
1993 March

Gokhale, M.H.
Primordial and oscillating components of sun's poloidal magnetic field
Astron. Institut, ETH, Zurich
1992 April 24

Mysteries of sun's magnetic field
Institute of Mathematical Sciences, Madras
1992 July 22

Steady part of sun's internal magnetic field
TIFR, Bombay
1992 September 15

Kochhar, R.K.
History and geography of Vedic people
Kosambi Memorial Lecture, New Delhi
1992 October

Akbar's interaction with Jesuit men of science and its impact
Indian Council for Historical Research, New Delhi
1992 October

Secondary tools of empire: Jesuit men of science in India
Xavier Centre of Historical Research, Goa
1992 November

Krishan, V.
What is common between solar granulation and the large-scale structure of the Universe
Ruhr University, Bochum, Germany
1992 July

Structure formation in a turbulent medium
Max Planck Institut für Aeronomie
1992 July 24

The phenomenal diversity of astrophysical plasmas and fluids
Investiture function of Dr Vikram Sarabhai Award
PRL, Ahmedabad
1992 August 10–12

What is common between solar granulation and the large-scale structure of the Universe
IPR, Gandhinagar
1992 August 13

Mallik, D.C.V.
Planetary nebulae
Raman Research Institute, Bangalore
1993 February 11

Oort and interstellar clouds
Neighbourhood Astronomy Meeting, IIA, Bangalore
1993 March 31

Parthasarthy, M.
Post-AGB stars detected from IRAS data
Space Telescope Science Institute, Baltimore, USA
1993 June

Chemical composition of post-AGB stars
Kapteyn Astronomical Institute, Groningen, The Netherlands
1993 July

Prabhu, T.P..
Redshift determinations of distant galaxies
Workshop on Observational Cosmology, TIFR, Bombay
1992 April 14–18

Superclusters
Neighbourhood Astronomy Meeting, IIA, Bangalore
1993 March 31

Rao, N.K.
Galactic astronomy with VBT
XV ASI Meeting, Bombay
1993 March 2–6

High resolution spectroscopy
Miniworkshop on High Resolution Astronomical Spectroscopy
Mt Abu
1993 March 21–26

Sagar, R.
Star clusters in the Magellanic Clouds
Raman Research Instiute, Bangalore
1992 July 23

Sastri, J.H.
Thermosphere-ionosphere coupling in the equatorial region
Space Physics Laboratory, VSSC, Trivandrum
1993 March 10

Plasma irregularities in the equatorial ionosphere
PRL, Ahmedabad
1993 March 23–24

Sivaram, C.
Astrophysical constraints on the electromagnetic field coupling to torsion in general relativity
International Conference on Gravitation and Cosmoloy, Cordoba, Argentina
1992 July 2

A critical discussion of the alternatives to dark matter
UERJ, Brazil
1992 July 9

Some consequences of the vacuum energy in general relativity
UERJ, Brazil
1992 July 22

Strong gravity approach to QCD
CBPF, Rio de Janiero, Brazil
1992 July 30

Dark matter–A matter of particle physics or gravity?
CBPF, Rio de Janiero, Brazil
1992 August 3

Sivaraman, K.R.
Recent results on solar chromospheric heating
TIFR, Bombay

Surendiranath, R.
A photoionization model for the PN M4–18
ESO, Münich
1992 July 20

Vishveshwara, C.V.
The cosmic picture book
IUCAA, Pune
1993 March 29

## Lectures

Babu, G.S.D.
Structure of our Galaxy
IAU School for Young Astronomers Beijing, China P R
1992 July 19–August 8

Bhatt, H.C.
Interstellar medium
Winter School on Astronomy, VBO, Kavalur
1992 December 22–23

Bhattachayya, J.C.
Fundamentals of observational astronomy
PG Diploma students
Birla Planetarium, Calcutta
1993 March

Distances in the Universe
VBO, Kavalur
1992 August 10

Cowsik, R.
Invisible universe
Winter school on Astronomy, VBO, Kavalur
1992 December 22–31

Datta, B.
White dwarfs and neutron stars
Second Inter-University Adv. Graduate School on Relativistic Astrophysics and Cosmology
North Bengal University
1992 October 14–November 4

Neutron Stars
Minischool on Pulsars
IUCAA, Pune
1993 February 15–20

Hasan, S.S.
Recent advances in solar physics
Department of Physics, Aligarh University, Aligarh
1993 January

Developments in the theory of magnetic fields and new results in helioseismology
Centre for Advanced Study in Astronomy, Osmania University, Hyderabad
1993 February

Krishan, V.
Astrophysical magnetohydrodynamics
Second Inter-University Adv. Graduate School on Relativistic Astrophysics and Cosmology
North Bengal University
1992 October 14–November 4

Magnetohydrodynamics and kinetic plasma processes
Osmania University, Hyderabad
1993 March

Mallik, D.C.V.
Stellar structure and evolution
Winter school on Astronomy, VBO, Kavalur
1992 December 22–31

Interstellar medium and our Galaxy
IUCAA Regional School on Introductory Astronomy
University of Kerala, Trivandrum
1993 March 10–15

Pati, A.K.
Galaxies
Winter School on Astronomy, VBO, Kavalur
1992 December 22–31

Mohin, S.
Broadband photometry
Minischool on Photometry with Small Telescopes
IUCAA, Pune
1993 January 4–18

Prabhu, T.P.
Active Galactic Nuclei : Emission lines – theory and applications
SERC School on Active Galaxies and Quasars
IUCAA, Pune
1992 November 22–December 11

Ram Sagar
Stellar photometry
Winter School on Astronomy
VBO, Kavalur
1992 December 22–31

Raveendran, A.V.
Broadband photometry
Minischool on Photometry with Small Telescopes
IUCAA, Pune
1993 January 4–18

Vishveshwara, C.V.
Black holes
Cosmology
IUCAA Regional School on Introductory Astronomy
University of Kerala, Trivandrum
1993 March 10–15

Spacetime symmetries
IUCAA, Pune
1993 March 30–31

## Paper presentations at Meetings

Bhattacharjee, P.
Possible signatures of GUT and/or Planck scale physics in the ultra-high energy cosmic ray spectrum survivability of quark nuggets
X DAE Symposium on High Energy Physics
TIFR, Bombay
1992 December 26–31

Gangadhara, R.T.
Polarization changes through stimulated Raman scattering
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Ghosh, K.K., Selvakumar, G., Kuppuswamy, K., Pukalenthi, S., Srinivasan, K.C., Krishnamurthy, R.
High resolution specftroscopy of $\gamma$ Cas
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Ghosh, K.K., Iyengar, K.V.K.
Time resolved spectroscopy of two Herbig Ae/Be stars V 380 Ori and HD 76534
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Iyengar, K.V.K.
Optical identification and BVRI photometry of a few unidentified IRAS sources of a late type stellar nature
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Das,*B., Ghosh, *S. K., Rengarajan, *T.N., Verma, *R.P., Iyengar, K. V. K., Tandon, *S.N.
Balloon-borne far infrared mapping of galactic star forming regions
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Krishan, V.
Polarization changes through stimulated Raman scattering
1992 International Conference on Plasma Physics
Innsbruck, Austria
1992 June 29–July 3

*Rengarajan, T.N. *Verma, R.P., Iyengar, K.V.K.
Infrared colours of RS CVn binaries
XV ASI Meeting
BARC, Bombay
1993 March 2–6

Sastri, J.H.
Local time dependence of substorm related electric field disturbances in the nocturnal low latitude/equatorial ionosphere
Vertical plasma drifts of night time F region near dip equator
1992 STEP Symp./5th COSPAR Coll.
Johns Hopkins University, USA
1992 August 24–28yy

## Visits to scientific institutions

**G.S.D. Babu** visited Beijing Astronomical Observatory and its stations at Xing Long, Shahe and Miyun. **R. Cowsik** visited the Center for Particle Astrophysics, University of California, Berkeley as Regents Lecturer during March 6–31. During this period he visited Irvine and Santa Barbara Campuses of UC and worked on collaborative research programmes. **M.H. Gokhale** visited TIFR, Bombay 1992 April 1–6, Max-Planck Institute for Astrophysics, Garching 1992 April 18-22, Institute of Astronomy, ETH, Zurich 1992 April 23-25. He also visited the Institute of Mathematical Sciences, Madras 1992 July 21-23 and Gujarat University, Ahmedabad 1992 September 29. **S.S.Gupta** visited the National Solar Observatory, Tucson, Arizona 1992 September 29-November 1 in connection with the IIA-NSO collaborative programme on Analysis of Kodaikanal and Mt.Wilson photoheliograms of the Sun. **S.S. Hasan** visited the Harvard-Smithsonian Centre for Astrophysics, Cambridge, Massachussetts, USA during 1992 November. He also visited Aligarh University in 1993 January and Centre for Advanced Study in Astronomy, Osmania University in 1993 February. **K.V.K.Iyengar** visited the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts during 1992 September-October on an appointment as a 'Short term visitor'. **N.Kameswara Rao** visited Cerro Tololo Inter American Observatory, Chile to conduct observations 1992 May 21-23 and also visited Astronomy Department, University of Texas at Austin for three weeks during 1992 May-June. **V.Krishan** visited the Ruhr University, Bochum, Germany 1992 July 8-August 7. She visited Max-Planck Institute for Aeronomy 1992 July 23-25. She also visited the Institute for Plasma Research, Gandhinagar in 1992 August. **D.C.V.Mallik** visited the Stellar Data Centre, Strasbourg Observatory, France 1992 July 20-22. He also visited Trivandrum Observatory 1993 March 15. **A.K.Pati** visited the Department of Astronomy, Osmania University, Hyderabad and the Japal-Rangapur Observatories to assess and delineate the requirements, both instrumental and infrastructural, for carrying out collaborative programmes between IIA and Osmania University. **M. Parthasarathy** visited the Kapteyn Astronomical Institute, Groningen, The Netherlands in 1992 June. **Ram Sagar** visited the U.P. State Observatory, Naini Tal for two weeks during 1992 November. **J.H.Sastri** visited CNET/CRPE, Saint-Maur, Paris 1992 August 31-September 4 and also the Space Physics Laboratory, VSSC, Trivandrum 1993 March 8-11. **R.Surendiranath** visited ESO, Munich 1992 July 19-20. **C.Sivaram** was a visiting professor at the Universities of Bologna and Ferrara, Italy 1992 April–May and the Universities of Rio de Janiero and Sao Paulo, Brazil during 1992 June–August. **K.R. Sivaraman** visited the National Solar Observatory, Tucson, Arizona in 1992 October–November. During this period he observed at the Vacuum Telescope at KPNO. He also visited several colleges in Tamil Nadu and delivered lectures. **R.Vasundhara** visited the Buereau des Longitudes, Paris during 1992 September-November for collaborative work with Prof.J.-E.Arlot on the ephemerides of Galilean satellites.

# Appendix B

## Teaching

Members of the academic staff continued their help with the teaching programmes at the Indian Institute of Science (JAP) and the Bangalore University. Ram Sagar, M. Parthasarathy and R.K. Kochhar taught respectively Observational techniques, Stellar astronomy and Galactic and extragalactic astronomy in JAP. V. Krishan and D.C.V. Mallik served on the Management Committee of JAP. At Bangalore University M.H. Gokhale, T.P. Prabhu, A.V. Raveendran, J.H. Sastri and D.C. V. Mallik taught parts of the Astrophysics Special Papers in the second year of M.Sc. M.H. Gokhale continued to coordinate this programme. Two M.Sc students from National College, Trichy did their projects on the Sun at Kodaikanal under the guidance of S.S. Gupta. Two B.Sc. students of Sacred Heart College, Thirupattur did dissertation work on Astrochemistry working at VBO, Kavalur under the guidance of K.K. Ghosh. Three M.Sc. students of American College, Madurai worked on Summer Projects on Be stars in 1992 May–June also under the guidance of K.K. Ghosh.

## Editing and Publishing

D.C.V. Mallik continued to serve as the Associate Editor of the Journal of Astrophysics and Astronomy (JAA) and Ram Sagar as the Associate Editor of the Bulletin of the Astronomical Society of India (BASI). N.K. Rao served on the Editorial Board of JAA and T.P. Prabhu on that of BASI. J.H. Sastri served on the Editorial Board of the Indian Journal of Radio and Space Physics. The IIA Newsletter completed its seventh year in 1992. T.P. Prabhu and A.K. Pati continued to edit it on behalf of the Director, IIA.

## Popular articles

Babu, G.S.D.
Total eclipse of the moon
Deccan Herald, 1992 December 7

Bhattacharyya, J.C.
Land surveys beyond the Earth
Science Reporter, in press

No room on Earth
Kishore Vigyan, 1992 October

Theory of thermal ionization
Kishore Vigyan, 1992 November

M N Saha and stellar spectra
Jnan O Vigyan, 1992 October

Hubble space telescope
Jnan O Vigyan, 1992 October

## Book Reviews

Bhatt, H.C.
Astrophysics : stars and galaxies
K.D. Abhyankar
1993, Bull. ASI, **20**, 481

**Radio/TV**

Babu, G.S.D.
Telescopes
AIR Bangalore
1993 May 12

Tracking interplanetary objects
AIR Bangalore
1993 May 14

Bagare, S.P.
Popular astronomy and science topics
AIR Bangalore
1992 May–July

S.P. Bagare gave four talks and an interview on popular astronomy and topics in science broadcast by AIR, Bangalore 1992 May–July.

**Popular Talks**

Babu G.S.D.
The Milky Way – our home galaxy
VIT Museum, Bangalore
1992 June 2
Bangalore Science Forum, Bangalore
1992 July 3
The Army School, Bangalore
1992 August 28

Nebulae and stars
VSM English school, Bangalore
1993 February 17

St Joseph's college, Bangalore
1993 March 18

IX Indian scientific expedition to Antarctica – Experiences of an astronomer
Rotary club, Koramangala, Bangalore
1992 April 24
The 19th Int. school for Young Astronomers, Beijing, China
1992 July 29
The Army School, Bangalore
1992 August 28
JN Planetarium, Bangalore
1992 December 1
BMS College for Women, Bangalore
1993 February 13
St Joseph's College, Bangalore
1993 March 18

Bagare, S.P.
Observations of the sun from space
Jyoti Nivas College, Bangalore
1993 Jan 28

Vishveshwara, C.V.
Matter and magic
Bangalore Science forum

K.R. Sivaraman was the principal speaker at the annual gathering of amateur astronomers organised by the Department of Science and Technology, Tamil Nadu Government, Madras. He was also the principal speaker at Hosur on the occasion of the inauguration of a telescope there.

## Appendix C

### Kodaikanal Observatory

**Spectroheliograms/Photoheliograms** (No. of Plates and Seeing conditions)

| Year | Month | Hα | KFL | HαPR | PHGM | Seeing* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5 | 4 | 3 | 2 | 1 |
| 1992 | April | 27 | 25 | 25 | 28 | — | — | 25 | 3 | — |
| | May | 22 | 20 | 21 | 24 | — | 2 | 17 | 4 | 1 |
| | June | 8 | 8 | 8 | 10 | — | — | 9 | 1 | — |
| | July | 3 | 3 | 3 | 4 | — | — | 3 | 1 | — |
| | August | 10 | 10 | 9 | 12 | — | — | 7 | 5 | — |
| | September | 8 | 7 | 7 | 15 | — | — | 9 | 6 | — |
| | October | 7 | 7 | 7 | 11 | 1 | 2 | 7 | 1 | — |
| | November | 8 | 8 | 8 | 8 | — | 1 | 6 | 1 | — |
| | December | 18 | 17 | 16 | 19 | — | 5 | 10 | 4 | — |
| 1993 | January | 18 | 18 | 18 | 20 | — | — | 13 | 7 | — |
| | February | 19 | 23 | 19 | 26 | — | 5 | 17 | 4 | — |
| | March | 25 | 26 | 22 | 29 | — | 4 | 21 | 1 | — |
| | Total | 173 | 172 | 163 | 206 | 1 | 19 | 144 | 38 | 1 |

KFL = K-Flocculus HαPR = Hα-Prominences PHGM = Photoheliograms
* (1 — Very poor, 2 — Poor, 3 — Fair, 4 — Good, 5 — Excellent)

## Vainu Bappu Observatory

### Sky condition at Kavalur

| Year | Month | Spectroscopic hours | Photometric hours |
|---|---|---|---|
| 1992 | March | 277.0 | 137.5 |
| | April | 198.0 | 77 |
| | May | 84.0 | 5 |
| | June | 31.0 | 0 |
| | July | 15.0 | 0 |
| | August | 24.5 | 0 |
| | September | 27.5 | 0 |
| | October | 74.0 | 11 |
| | November | 59.5 | 7 |
| | December | 150.0 | 25 |
| 1993 | January | 217.0 | 52 |
| | February | 205.0 | 109 |
| | March | 197.0 | 80 |
| | Total | 1569.0 | 503.5 |