INDIAN INSTITUTE OF ASTROPHYSICS

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INDIAN INSTITUTE OF ASTROPHYSICS

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Annual Report

The Institute records its profound grief and sense of shock at the sad and violent demise of the Prime Minister, Mrs Indira Gandhi. She was a patron of science and deeply committed to the development of science and technology in India. Indian science will always recall with gratitude the impetus it received under Mrs Gandhi's leadership.

Contents

Summary

The sun: The Ca II K-line parameters for the sun viewed as a star (i.e. in integrated light) have been found to be sensitive to the strength of the individual solar maximum. He I 10830 A line data and solar white light flux show that the sun is a variable star with flux increasing during the maximum phase. The solar rotation rate as determined from a statistical analysis of the Kodaikanal calcium plage area data 1951-81 varies over time scales ranging from 11 year cycle down to about two years.

The 1983 solar corona turned out to be typical of the intermediate phase of the solar cycle. A value of 5302±0.01A was obtained from eclipse observations for the wavelength of the green emission line.

There does not appear to be any appreciable contribution to the decametric radio emission from active regions. Microwave observations of the sun (at 2 and 6 cm wavelengths) have led to a two-component solar flare model.

A method has been evolved to estimate the ambient magnetic field of the corona overlying mildly active regions. It is shown that the generation of superthermal electron beams in the vicinity of the shock front is very essential to explain type II solar radio bursts, whereas ion-sound turbulence can satisfactorily explain the generation of type I radio bursts. The steady state structure of a solar coronal loop has been studied, and fast time variability in the hard x-ray emission from solar flares examined.

It has been shown that the magnetic flux tubes producing sunspot activity originate in long-lived structures. Nonlinear resonance of a slender magnetic flux tube with external pressure fluctuations is not quenched by a lateral exchange of heat. Nonlinear time-dependent

MHD euqations in thin flux tube approximation have been numerically solved.

Solar system: A two-component model has been suggested for a possible ring system around Saturn at 12.5 planet radii in which micron-sized dust grains lie in the equatorial plane of the planet, and ionic and molecular belts stretch above and below the equatorial plane.

Molecular emission fluxes in CN, CH and C_2 bands have been computed for comet Crommelin. Comet Austin and Shoemaker have been observed. Io-controlled IPS sources are spatially distributed with frequency; and Io-A and Io-B lie on opposite sides of Jupiter. A theory to explain the shadow bursts in the Jovian decametric emission in terms of an interaction S^- and L^- bursts has been suggested.

The stars: VLA observations of hydrogen deficient stars at 2 and 6 cm have helped placed upper limits on mass loss from them. IRAS observations of R Cr B and other stars indicate the presence of a cool dust component, in addition to the presence of hot dust.

Appreciable changes occur in the light curves of RS CVn stars even on a time scale as short as a few orbital periods. Also, the hemisphere of a RS CVn star presented to the observer at light minimum is cooler than that seen at the light maximum.

Five students of Joint Astronomy Program participanted in the study of energy distribution of southern chemically peculiar stars.

It has been shown that brown dwarfs (objects that were not massive enough to become stars) would chiefly radiate in the infrared with an effective temperature of 1500 K, and a luminosity of 10^{-8} - $10^{-6} L_{\odot}$.

Interstellar medium: Low frequency recombination lines C 574 and C575 have been detected in the direction of Cas A. It has been shown that the abundances of NH and OH radicals may be used as a diagnostic probe to detect interstellar shocked regions.

Radiative transfer: Simultaneous solution of radiative transfer equation and the statistical equilibirum equation with eight levels of the hydrogen atom has been taken up. Majority of the observed profiles in P-Cygny type atmospheres have been found to be mostly due to velocity gradients rather than spatial distribution of ions. A study of neutrino transfer in collapsed objects has been taken up. Radiative transfer calculations of the H-alpha line in the comoving frame are being done. Two PhD theses, one on time-dependent radiative transfer and the other on the effects of redistribution functions on the formation of spectral lines, have been written.

The Galaxy: Photoelectric and photographic photometry of 32 young southern open clusters done at Kavalur and Siding Spring (Australia) have shown that four of the clusters are located in the outer Perseus arm at a distance of about 5 kpc.

A study of enrichment pattern of C, O and Fe suggests that stars more massive than about 30 M_0 do not effectively participate in nucleo-synthesis. A study of a sample of 22 Cepheids with well determined atmospheric abundances shows that the most conspicuous irregularity in metallicity is exhibited by stars that are born in the local arm or in the interarm region.

Galaxies: Spatial photometric scanning and spectroscopy of a sample of galaxies in the Virgo and Fornax clusters were undertaken for doing population synthesis.

A study of the dynamical evolution of aniostropic spheroidal cluster of mass points constrained to have anistropic velocity distribution (a problem earlier considered by Chandrasekhar & Elbert) has shown that with a negative total energy, the system execute finite amplitude oscillations in size and between prolate and oblate shapes. It has been shown to be unlikely that the missing mass in galactic halos is dominated by massive neutrinos.

High energy astrophysics: Gauribidanur observations of pulsars 1919+21 and 0950+08 indicate that the radiation from nearby pulsars may suffer much less multiple and strong scattering in the interstellar medium than has generally been assumed.

Two essays, that received 'honourable menion' at the 1984 Gravity Research Foundation essay competition, discuss (i) the relativistic effects of rotation on the structure and emission of the millisecond pulsar 1937+214; and (ii) thermal gravitational radiation from hot neutron stars and white dwarfs.

Low resolution spectra of SN 1983n (NGC 5236) and SN 1984 (NGC 4419) show that SN 1983n is an extremely peculiar supernova of typeI whereas SN 1984 is a typical type I supernova.

It has been shown that a class of core-envelope high redshift configurations in general relativity can serve as plausible models for the high redshift QSOs and in general provide a natural explanation for the observed upper bound of QSO redshifts.

Solar-terrestrial relationship: The response of the equatorial F-region to sector boundary crossings has been interpreted in terms of perturbations of the equatorial east-west electric field in the post-sunset hours. A study is underway on the origin of the radio star fade-out phenomenon at equatorial latitudes.

Instrumentation and techniques: An image dissector scanner (IDS) has been obtained from the Anglo-Australian Observatory. An improved dc electrometer amplifier has been developed. AC flicker type polarimeter has been calibrated against laboratory standards. A microprocessor-based slow scan CCD camera controller has been developed. A Carl-Zeiss microdensitometer has been automated using the TDC 316 computer. The automated spectrum scanner has been duplicated to function as a standby unit.

Optics of the 24 inch Schmidt telescope has been made ready. The Pyrex secondary of the 0.75 m telescope has been replaced by a Zerodur secondary. The 48 inch primary and the Cassegrain secondary of the PRL telescope are in the process of figuring.

A theoretical study of semiautomated figuring process has been taken up.

2.34 m telescope project: The erection of the mechanical mount of the 2.34 m telescope in the dome was completed and commissioning trials were started. The computer centre was set up at Kavalur, and VAX 11/780 system installed. COMTAL image processing system, CAMAC interface hardware, and two packages Astronomical Image Processing System and Starlink were acquired.

History of Astronomy: Documentary evidence shows that the Madras Observatory, the precursor of the Institute and Kodaikanal Observatory was set up in 1786 (and not 1792 as generally believed) as a private observatory. It was taken over by the East India Company in 1789. The observatory builing was constructed in 1792. Observations made in 1786 exist in manuscript form.

Film on the 1980 solar eclipse: A 16 mm colour film of 33 minutes duration has been made on the Institute's expedition to Jawalagare for the total Jwalagere for the total solar eclipse of 1980 February 16.

The sun

Sun as a star: The ongoing program at the Kodaikanal solar tower telescope of monitoring the Ca II K-line from the integrated sun light which commenced in 1969 has brought out several interesting facts about the sun viewed as a star. Results of analysis of earlier data had suggested that the addition of two years of data (1982-1984) which represents the descending phase and the solar minimum would add significantly to the interpretation of the results. The analysis of these additional data was completed during the present year and the nine parameters that characterize the K-line profile have been evaluated. The most striking features found by Sivaraman, Singh, Bagare & Gupta are (i) the pattern of variation of the 1 A index which represents the equivalent width of emission centred around the wavelength of K_3 absorption; (ii) enhancement in the intensities of K_3 and K_2; and (iii) the width of the K_2 emission profile at the half intensity point. The 1 A index was enhanced by 20% during the sunspot maximum of 1969-70, whereas the enhancement was 30% during the solar maximum of 1979-80. Similarly, the enhancement in the K_3 intensity was 30% and 50%; and in the K_2 intensity 35% and 50% for the two solar maxima. Thus the K-line parameters besides reflecting the solar cycle variations are found to be sensitive to the strength of the individual solar maximum.

1980 Solar eclipse: The analysis of the broadband photographs of the corona obtained at the eclipse of 1983 June 11 at Indonesia has been completed by Sivaraman, Singh & Kariyappa. The brightness of the corona along the equatorial and polar directions has been derived. The isophotes of the corona were derived from the photographs, and the coronal brightness along the equatorial and polar directions has been computed.

These values show that this corona is a typical one belonging to the intermediate phase of the solar cycle.

Singh has taken part in the analysis of the data obtained from multislit experiments by Livingston & John Harvey (NSO) at the eclipses of 1980 and 1983. The results confirm the earlier findings that solar corona is remarkably quiet in terms of small scale random velocities and corotates with the photosphere. The width of 5303A [Fe XIV] line yields a temperature of about 1.7×10^6 K for the solar corona. The mean value 5302.78±0.01 A derived from the 1983 eclipse data may be the most reliable value for the wavelength of the green line as it is based on measurements of scattered light on the solar corona.

Solar rotation: Singh & Prabhu have computed Fourier components of daily calcium plage area data for the period 1951-1981 which includes the solar cycles 19 and 20. They have used the total plage area over the entire visible hemisphere of the sun, as also the data grouped into different latitude bins (10-15°N, 15-20°N, 10-15°S, and 15-20°S) to compute the rotation period of the sun in the corresponding regions. The analysis indicates that rotation period at a fixed latitude changes with time the variation being of the order of 10% from the mean value of 27 d (synodic). A power spectral analysis of the derived rotation rate as a function of time indicates that the rotation rate in each latitude belt varies over time scales ranging from the 11 year cycle of solar activity down to about two years. Variations in adjacent latitude belts are in phase indicating that the length scales of perturbations are larger than 10° in width. It is interesting to note that the rotation rates in northern and southern belts are not correlated, which fact would relieve some of the constraints imposed by angular momentum conservation on the theoretical models.

He I 10830 A line: Singh, during his visit to National Solar Observatory at Tucson, USA has compared the data obtained from the active cavity radiometer irradiance monitor (ACRIM) experiment on the solar maximum mission with the equivalent width of 10830 A line obtained at KPNO. Singh, W.C. Livingston (NSO) & O.R.White find that variations in white light flux and He I equivalent width are correlated, indicating that sun is a variable star with white light flux increasing during the maximum phase. The variation is of the order of 0.1%.

Singh & F.Recely (NOAA) have obtained the time sequence spectra of 10830 A line with the vacuum tower telescope of KPNO. These data will be used for the studies of spicule evolution by Venkatakrishnan, Singh, Jain & Recely.

Radio sun from Gauribidanur: The decameter wave radio telescope at Gauribidanur was used to map the continuum radio emission from the sun during quiet periods. The data obtained during the period 1983 August 6 - 30 (when the sun was exceptionally quiet) were analysed. On these days the position of the centroid of the radio emission agreed quite closely with the centre of the optical sun indicating that there is no detectable contribution to the decametric radio emission from active regions. But the observed peak brightness temperature varied from 200,000 to 800,000 K. These variations are not correlated with those at centimetric and decametric wavelengths. The observed minimum brightness temperature cannot be explained on the basis of the usually accepted density models and an isothermal corona of a million degrees.

Radio sun from VLA: Shevgaonkar with M.R.Kundu (University of Maryland) were involved in microwave observations of the sun from VLA. From

dual frequency observations at 2 and 6 cm, they have suggested a two component solar flare model. Taking the dc electric field model for flares, they have estimated the electric field in the flaring region from the time difference between the flare peaks at the two wavelengths. From the pre-flare active region studies they have provided evidence for the emergence of the magnetic flux which ultimately triggers the flare.

Coronal magnetic fields: Gopalswamy, Thejappa & Sastry have evolved a method to estimate the ambient magnetic field of the corona overlying mildly active regions. Since most of the radio bursts excepting noise storms are flare associated, the physical parameters deduced from such radio data correspond to the corona above active regions conductive for flares. The type I radio emission is not flare associated and therefore will correspond to mild active regions which do not lead to flares. Assuming that the chains are generated by mild shock waves, they estimated the coronal magnetic field using the Rankine-Hugoniot jump conditions. The density jump across the shock was related to the drift rate of the type I chains. These two parameters were put in the Rankine-Hugoniot relations to get the Alfven velocity of the ambient corona and hence the magnetic field. Assuming various density models for the corona, they have obtained the dependence of the magnetic field on the radial distance from the photosphere.

Radio bursts of type II: Thejappa continued the theoretical investigation of solar type II radio bursts in collaboration with Krasnosel'skikh, Kruchina and Volokitin of Space Research Institute, Moscow. Their work emphasizes that the generation of superthermal electron beams in the vicinity of the shock front is very essential to explain various characteristics of type II solar radio bursts. It is shown that the electrons are accelerated to very high energies by the low frequency turbulence generated by the reflected ions from the shock front.

They also show that the brightness temperature of the radio emission is equal to the effective temperature of Langmuir waves ($T_b = T_{eff}$ 10 K). The proposed model also explains well the finite bandwidth and polarization of the type II emission. The fine features like herringbone structure are easily explained.

Thejappa, Sastry & Gopalswamy have started an investigation of the most frequent phenomena in the solar radio emission at decametric wavelengths. They have found many interesting features like drift pair chains, drift pairs with very large drift rates, and drift pair clusters etc. They find that the drift rate decreases as frequency increases.

Gopalswamy & Thejappa derived the dispersion relation for ion sound waves generatged in a perpendicular shock and obtained the energy density of ion-sound turbulence using quasilinear theory. The result is compared with the lower hybrid turbulence generated under similar conditions. They also show that ion sound turbulence can satisfactorily explain the generation of type I radio bursts in the solar corona.

Coronal loops: Krishan has discussed the steady state pressure structure of a solar coronal loop using the theory of magnetohydrodynamical turbulence in cylindrical geometry. The steady state is represented by the superposition of two Chandrasekhar-Kendall functions. This representation in principle delineate the three dimensional temperature structure of the coronal loop. Krishan has restricted herself to a two-dimensional modelling since only this structure submits itself to the scrutiny of the available observations. The radial as well as the axial variations of the pressure in a constant density loop are calculated. These variations are found the conform to the

observed features of cool core and hot sheath of the loops as well as to the location of the temperature maximum at the apex of the loop. It is found that these features are not present uniformly all along either the length of the loop or across the radius. Possible oscillatory nature of these pressure variations and the associated time periods have been estimated.

Solar flare x-rays: Krishan & Kundu have discussed the fast time variability in the hard x-ray emission from solar flares. Spikes with time variations of the order of a milliseconds are seen superimposed on the slowly varying x-ray emission. In the nonthermal model of x-ray emission, the time variability results from electron acceleration and electron beam propagation effects. In the thermal model, the temporal fluctuations may result from an increase of emission measure during primary energy release phase of the solar flare and a decrease of emission measure due to convective and conductive cooling of the plasma. Krishan & Kundu propose a quantitative treatment of the proposal based on disruptions in plasmas. The millisecond rise time corresponds to the impulsive heating of the plasma. This phase leads to a steepening of the current profile and conditions for the excitation of $m = 1$ tearing mode are established. The fast fall time of the x-ray spike then represents a quick cooling of the plasma due to accelerating growth rate of the $m = 1$ tearing mode. The estimated characteristic time durations of a x-ray spike are found to be in good agreement with the observed ones.

Krishan has indicated a clue to the preflare configuration of a magnetic loop based on Taylor's selective decay hypothesis. The numerical investigations of an MHD turbulent plasma indicate that a high energy and nearly force free state of plasma decays to a minimum energy state with a release of energy via magnetic reconnection processes.

Flux tubes: Gokhale pointed out that the currently used system of equations for equilibrium of an isolated, thin, untwisted magnetic flux tube in a stratified atmosphere is based on an implicit assumption that the magnetic flux distribution within the tube is similar at all points along the tube axis. When this assumption is explicitly stated, the system of equations becomes mathematically 'closed' and it is neither possible nor necessary to solve it as usual with an additional and adhoc assumption about the difference of density or temperature inside and outside the tube. Replacing the similarity assumption by a less stringent assumption Gokhale showed that the equilibrium configuration will depend up the amount of magnetic flux within the tube. This tube has important implications for models of solar magnetic flux tubes, especially those meant for estimating the depths reached by the tubes.

By subtracting from the observed longitudes of sunspot groups the amount of the differential rotation undergone by the associated plasma elements from the beginning of a solar cycle, Gokhale has concluded that the magnetic flux tubes producing sunspot activity originate in long-lived structures which execute axisymmetric as well as nonaxisymmetric oscillations inside the sun. He has pointed out that such oscillations might be playing an important role in the basic mechanism of solar activity as pointed out in a phenomenological model proposed by him earlier.

Gokhale & Nagabhushana have shown that the correlation between the monthly sums of the maximum areas of sunspot groups and the monthly sums of the areas of filaments (prominences seen on the disc) are much higher than the correlation between the yearly sums. They find that the correlation between the two sums is maximum when the sums

of prominence areas are assigned a one-month lag with respect to the sums of sunspot areas. These results confirm the relation, suggested earlier by Gokhale & Sivaraman, between the magnetic flux appearing as sunspot groups and that disappearing as a consequence of prominences. This also indicates that the magnetic flux takes about a month's time to diffuse from the locations of sunspot to the locations of prominences.

Venkatakrishnan numerically studied the nonlinear response of a slender magnetic flux tube to external pressure fluctuations and obtained large amplitude resonant oscillations of gas within the tube. The resonance was seen not to be quenched when lateral exchange of heat was considered. The heat exchange merely introduced a phase difference between the external pressure fluctuations and the internal velocity oscillations.

Plage heating: Venkatakrishnan & Gupta have started a program of measuring the CN 3883 and $Ca^{+}K$ 3933 intensities over plages with a view to comparing the relative configurations of the iso-intensity contours. This comparison would provide clues to the mechanism of plage heating.

Vector magnetic fields: Balasubramaniam (Joint Astronomy Program), Venkatakrishnan & Bhattacharyya have simulated the polarization produced by the three mirror system in the Kodaikanal solar tower for various declinations and hour angles of the sun. This simulation was undertaken to estimate the most favourable epochs for measuring vector magnetic fields. The other aims of this simulation are to judge the sensitivity and capability of the telescope to measure weak magnetic fields without introducing on-line polarization compensation, as also to design the necessary on-line compensation to increase the sensitivity.

Stability of the solar chromosphere: Hasan & F.Kneer (Kiepenheuer Institut, Freiburg) have examined the stability of the solar atmosphere assuming an initial state which is in radiative equilibrium. Owing to the presence of carbon monoxide in the atmosphere, there exists a narrow region near the temperature minimum where the temperature gradient may be steep enough to drive a convective instability. They use the thin flux tube equations to make a linear stability analysis. Radiative effects are included in a simplified manner by using Newton's law of cooling using a Planck mean opacity. Initial states of constant β are considered. In the adiabatic case it is found that the atmosphere is monotonically unstable for $\beta > \beta_c$ with $\beta = 5$. Inclusion of radiative exchange between the flux tube and the ambient medium leads to the generation of overstable oscillations with periods of a few hundred seconds. They also studied phase relationships between various variables and discussed some of the observational implications of our study.

Hasan & Kneer, generalizing the above analysis, have solved the nonlinear time-dependent MHD equations in the thin flux tube approximation. Radiative effects are included by solving the equations of radiative transfer in the LTE approximation. The investigation is in progress.

Theoretical V and I profiles: Hasan, Ribes & Rees have constructed theoretical V and I profiles using results generated from numerical calculations of the convective collapse of flux tubes on the sun. They solve the equations of radiative transfer in LTE numerically using the code developed by D.Rees.

Chromosphere-corona transition: Raju has undertaken diagnostic studies, based on emission-line intensity ratios, of the chromosphere-corona transition region and the corona.

Coronal structure: Raju & Sivaraman are setting up of a self-consistent model for the coronal structure, based on ultraviolet line fluxes, over an active region.

[Fe X] Coronal lines: A theoretical investigation in being carried out by Raju & Singh to understand the mode of excitation of [Fe X] coronal emission line, as observed during the solar eclipse of 1980. In this study electron density profile, as derived from brightness and polarization measurements of the solar corona during eclipse of 1980, is being used to calculate [Fe X] emission line intensity.

The solar system

Rings around Saturn: Bhattacharyya & Vasundhara have suggested a two component model for a possible ring system at about 12.5 planet radii from the planet to explain the shapes of the immersion and emersion profiles obtained during the occultation of the star SAO 158913 by Saturn's magnetosphere on 1984 March 24 (immersion) and 1984 March 25 (emersion). According to this model the four sharp dips observed symmetrically on either side of the planet may be due to micron-sized dust grains confined close to the equatorial plane of the planet. The extended wings associated with the sharp features may be due to extended ionic and molecular belts stretching far above and below the equatorial plane of the planet Saturn. From the optical depth measurements column density of the ring and albedo have been estimated.

Planetary occultation: Vasundhara, Rosario & Santhanam monitored the star SAO 158763 on 1984 May 12 (immersion) and 1984 May 13 (emersion) as it passed behind Saturn's magnetosphere at about 19R. The immersion light curve showed variations which are similar to the variations observed by H.S.Mahra's group at Nainital. Vasundhara & Bhattacharyya are analysing these data.

Comets: The Kavalur scanner observations of comet Cromelin on 1984 March 2 & 3 obtained by Sivaraman, Babu & Shylaja at the Cassegrain focus of the 1 m reflector have been reduced. The scans over a wavelength range of 4100 A - 5800 A. The molecular emissions fluxes in the bands of CN (4214 A), CH (4280 A), C_2 (4737 A), C_2 (5165 A) and C_2 (5635 A) have been computed and the total number of molecules integrated along the line of sight has also been derived. The ratio of fluxes in the bands of CN, C_2 (4337 A), and C_2 (5635 A) with respect to that in C_2 (5165 A) has been found to be 0.0115, 0.424, and 0.624 respectively.

Sivaraman, Shylaja & Babu continued the observations of comets. Comet Austin (1984i) and comet Shoemaker (1984s) were observed. Comet Levy Rudenko (1984t) could not be observed because of unfavourable weather condition.

Interplanetary scintillations: Hanumath Sastri, in collaboration with A.Boischot of the Observatoire de Meudon, has studied the interplanetary scintillations (IPS) of Jupiter decametric radio sources from the dynamic spectra obtained at Nancay during 1978 and 1979. Analysis done till now shows that (i) for a given solar wind direction, the sense of frequency drift of IPS is opposite for Io-A and Io-B sources; and (ii) for a given Jovian source, the sign of frequency drift changes at opposition and conjunction. These results clearly indicate that emission from the Io controlled sources is spatially distributed and could occure along field lines (as assumed in previous theories) and that Io controlled A and B sources are on opposite sides of Jupiter. It was also found that the frequency drift characteristics of IPS of the non-Io sources are very much similar to those of the Io controlled sources. The implications of this new result for the theory of the Jovian DAM are being assessed.

Sastri & Ramesh are continuing the program of synoptic observations of [S II] optical emissions from the Jovian inner magnetosphere, using the image tube spectrograph of the 1 m telescope at Kavalur.

Asteroids: It was shown that the mass-angular-momentum relation for asteroids (from the available data for 250 asteroids) would tend to favour the fragmentation hypothesis rather than the accretion hypothesis. This follows from the stability conditions for rotating bodies on the verge of fragmentation.

Again, considerations of the basic physics involved in the structure of the asteroid (assumed to be balanced by shear and gravitational forces) were used by Sivaram to obtain theoretical relationships for the radius, period and mass of typical asteroids. The values calculated correspond well with those observed.

Jovian decametric emission: Gopalswamy has proposed a theory to explain the shadow bursts in the Jovian decametric emission. The shadow events occur when S- and L-bursts interact. The S-bursts are due to the gyro-synchrotron emission of energetic electrons. The L-bursts are due to a different bunch of energetic electrons with a loss-cone distribution. When the S-electrons invade the region of L-emission, the loss-cone of the L-electrons is momentarily filled, thus cutting off the free energy source for L-emission. Once the S-electrons leave the L-emission region, the loss-cone is reestablished, and hence the L-emission is regained. For the duration of interaction, the shadow or 'absorption' appears on the dynamic spectrum. A modulation hypothesis is used to explain the two types of shadows - the single streaks at high frequencies and tilted-v patterns at low frequencies. The theory also clarifies that the S-electrons are injected into the Jovian magnetosphere from the planet rather than from the Io satellite.

Gopalswamy & Nagabhushana have commenced work on the Kelvin-Helmholtz instabilities and the results will be used to explain various features in the cometary tails.

The stars

Hydrogen deficient stars: Kameswara Rao & V.R.Venugopal (TIFR) have analysed the observations of the hydrogen deficient binary υ Sgr taken optically, and with Astronomical Netherland Satellite (ANS) and VLA. The absolute magnitude M_{υ} has been estimated as - 4.8 ± 1.0 from the distribution of the interstellar reddening, polarization and interstellar lines of the surrounding stars. From the ANS observations obtained at the time of secondary eclipse it appears that the hotter secondary is surrounded by a disc with colours of a B8-B9 star. The λ 1550 C IV absorption line arising in the stellar wind does not show any change in strength during the secondary minimum. The upper limit to the mass rate from the high temperature wind is estiamted $\simeq 5 \times 10^{7}\ M_{\odot}\ yr^{-1}$.

The VLA observations obtained at 2 and 6 cm for six hydrogen deficient stars R CrB, HD 160641, BD -9° 4395, V348 Sgr, MV Sgr, υ Sgr have been analysed by Rao, in collaboration with V.R.Venugopal & A.R.Patnaik of TIFR. The upper limits to the mass loss have been estimated for some of them from the observed upper limits to the radio flux densities.

R CrB stars: The IRAS observations of R CrB type stars obtained by Rao in collaboration with K.Nandy and A.McLachlan of Royal Observatory, Edinburgh as guest observer are being analysed. The observations, along with observations taken from the catalogue of IRAS point sources, of R CrB, SU Tau and V 348 Sgr indicate the existence of a cool dust

component of temperature ≈ 30 K in R CrB and SU Tau and ≈ 100 K in V 348 Sgr, apart from the hot dust. This cool dust shell is a remnant of the stage when these stars were red giants for the first time. It appears they are near the red giant stage for a second time. The comparison of the properties of V 348 Sgr and R CrB indicates the occurrence of evolution proceeding from left to right in the HR diagram after planetary nebular ejections. Although R CrB was observed by IRAS during a visual light minimum no significant IR flux increase is apparent.

Rao, Ashoka & Surendiranath have continued to obtain spectra of R CrB and few other hydrogen deficient stars with the 0.75 m and 1 m telescopes at Kavalur with a view to studying the pulsation properties of these stars from radial velocity variations.

Along with the program of obtaining scanner energy distributions of R CrB type stars, polarimetric observations of hydrogen deficient stars and late type carbon stars have been started with the 40-inch telescope by Rao & Raveendran in collaboration with M.R.Deshpande (PRL). In this study they found that AR Pup, a carbon RV Tauri star, showed drastic variations in the wavelength dependence of the amount of polarization as well as the position angle, even though the visual magnitude was roughly the same. The hydrogen deficient binary with H-alpha emission, HD 30353, shows variability in few days of polarization and position angle at H-alpha, independent of the continuum. Rao & Surendiranath are studying the behaviour of the broad helium lines seen at the time of visual light minimum in R CrB.

Irregular variable V 348 Sgr: The radio observations along with Bracket gamma observations obtained with Anglo-Australian Observatory telescope have been studied by Rao & Nandy to study the reddening and dust

distribution around the hydrogen deficient irregular variable V 348 Sgr. These observations indicate large value of reddening E (B-V) = 1.4 as earlier estimated from the Balmer decrement, whereas the star shows only E (B-V) = 0.4 to 0.6. The infrared observations, both ground based and with IRAS, show that there are two dust components present. The hot dust represented by a 600 K black body longward of 3.5 μ m and another cool dust with temperature of 100 K black body. The dust extends to about 6 arcsec radius from the star. There is a temperature gradient across this region with hot dust (T_d = 1130 K) closer to the star within 2.3 arcsec. This dust is not the cause of the nebular extinction. The cool dust surrounds the nebula and probably is responsible for the high extinction in the nebula and is the result of first red giant phase. The dust and gas are probably distributed such that the star is not reddened and only the nebula shows the reddening.

Beta Cephei type variable V Cen: The spectroscopic observations obtained of the single line spectroscopic binary and β Cephei type variable V Cen with the 0.5 m and 1 m telescopes during 1983-1984 have been analysed by Ashoka, Surendiranath & Kameswara Rao. From the radial velocity measurements fresh orbital elements have been determined by combining these observations with observations obtained eighty years earlier. In addition to the orbital period, β Cephei type variability with 0.1690156 day periodicity seems to be present in these observations separated by eighty years. It was indicated from observations by Rajamohan that apart from these two types of variations emission episodes with possible mass ejections occur causing anomalous line shifts, and that one such episode occurred during 1968-1972.

RS CVn star DM UMa: Mohin, Raveendran, & Mekkaden photometrically observed BD+61°1211 = DM UMa - one of the most active members of the RS CVn group, during 1980, 1981 and 1982 observing seasons. The data indicated that the amplitude of light variation has monotonously decreased since the 1979 discovery of its light variability. For a conclusive analysis they have combined their data with the 1981-1984 data of D.S.Hall (Vanderbilt University) and his associates, and drawn the following conclusions on the evolution of starspot regions on DM UMa.

From the photometry available for the years 1979-1984, it is seen that the light curves exhibit subtle changes from season to season. Appreciable changes occur in the light curves even on a time scale as short as a few orbital periods. The amplitude of the photometric wave in the visual band decreased from 0.32 mag in 1979 to about 0.12 mag in 1982 and started increasing then onwards. It is found that the light curves obtained during 1979-1980 show sharp decline and slow increase, whereas those obtained during 1983-1984 show sharp increase and slow decline. The light curves obtained during the intervening period 1981-1982 show two maxima and minima.

The (B-V) colour depends on the visual magnitude of the star, in the sense that as the star becomes faint it becomes redder. In terms of the spot model, it means that the hemisphere presented to the observer at light minimum is cooler than that seen at the light maximum. Assuming that the interstellar reddening is negligible, the mean (B-V) = 1.065 ± 0.002, obtained at Kavalur indicates a spectral type of K1 III or K2 IV for the visible component of DM UMa.

The data yielded a mean photometric period of 7.478 ± 0.010 days, which agrees well with the known spectroscopic orbital period.

RS CVn binaries: Raveendran & Mohin continued their photometric program on late type emission binaries using the 0.34 m telescope. Special attention was given to V 711 Tau, UX Ari, II Peg, and DM UMa the only four RS CVn systems so far known that show H-alpha as a pure emission feature above the continuum consistently at all times.

Colours of early type stars: Rajamohan & Ghosh have taken up a statistical study to determine the effects of rotation on colours and line intensities of early type main sequence stars. This study is also expected to yield methods of separating the effects on colours due to binary companion from that of rotation effects.

Infrared sources: Prabhu & K.V.K.Iyengar (TIFR) have obtained spectrograms of 13 infrared sources from EIC-1 catalogue. All these sources are found to be stars of spectral type M 4.5 - M 6.5 III. One source, EIC 258, was found to be variable, and may also have significant infrared excess.

Nova Vulpeculae 1984: Pati & Prabhu have recorded the near-infrared spectrum of Nova Vulpeculae 1984 with the Cassegrain image tube spectrograph at the 1 m telescope. Shylaja obtained its spectrophotometric scans during the early decline phases. The nova's spectral evolution is consistent with its being a slow nova.

Recurrent nova RS Ophiuchi: Anupama & Prabhu have obtained several spectrograms of the recurrent nova RS Ophiuchi during the late decline after the recent outburst. The spectra cover the range 4800 - 8900 A, spanning H_β and P_{11}. Anupama, Prabhu & Giridhar have also obtained photoelectric scans of the spectrum in the range 4000-8000 A. Numerous Balmer and Paschen lines, as also several coronal lines have been identified in the spectra. Further analysis is in progress.

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Dwarf nova EX HYa: Shylaja completed the analysis of the photometric observations of the dwarf nova EX Hya obtained earlier. The 67 min modulation of the light curve is confirmed and the colour variation with phase suggests a hot source for this modulation.

Wolf-Rayet binaries: Shylaja continued the spectrophotometric observations of WR binaries CQ Cep, HD 50896, and HD 76536. The monochromatic light curves of CQ Cep at various wavelengths have been obtained. The solutions yield results similar to previous broadband light curves. The emission flux variations of He II, He I, N III, N IV and C IV lines with orbital phase are quite striking. All the emission lines except NV 4603 A show enhancement of flux at minima and this indicates that the line forming region is in the common envelope, surrounding both the stars.

Peculiar stars: Shylaja & Babu continued the studies of energy distributions of southern chemically peculiar stars. Five students from the Joint Astronomy Program participated in this study, as part of their course work. They observed one Am star each and obtained the effective temperatures by fitting the observed energy distributions with theoretical models.

Be stars: Ghosh has started spectrophotometric and spectroscopic studies of Be and Bep stars to understand the different physical processes taking place in those stars.

Peculiar stars at medium dispersion: A program of observing peculiar stars at medium dispersion has been started by Rajamohan. The following are the scientific goals for the next decade.

i) To find if the so called non-magnetic sequence of peculiar stars of the upper main sequence has subsurface magnetic fields which cause rotational braking.

(ii) To search for long term variations amongst magnetic variables to find if any solar cycle type variability exists.

(iii) To find more short term variables.

Wilson-Bappu effect: The existence of a tight linear correlation between stellar absolute magnitude M_V and Mg II K line emission width log W has been confirmed by Parthasarathy. Efforts to determine accurate calibration are being continued. Correlations between Mg II K line widths and fluxes and other stellar parameters are being studied.

Epsilon Aurigae: Parthasarathy continued the analysis of the recent eclipse of ε Aur. The eclipse starts slightly earlier in the UV compared to the visual light curve. The Cepheid-like pulsation with a period of 100-130 days complicates the analysis of the eclipse light curves. No additional reddening at 2200 A is observed during the eclipse. The 2200 A dip within and outside the eclipse is consistent with E(B-V) = 0.35. This result suggests that the dusty disc must be made of particles much larger than those present in the interstellar dust. $1^m.0$ to $1^m.8$ pre-eclipse brightening at 1500 A does not significantly show up a longer wavelength. The brightening at mid-eclipse and similar brightening at other phases are too large to be attributed only to the variability of the F0 Ia component. The discontinuties noted in the light curve suggest gaps, or holes in the disc-shaped secondary. Anal ysis of the IRAS data of ε Aur shows excess flux in the far-infrared. The eclipse depths at 12μ , 25μ , and 60μ are significantly less. The colour temperature of the disc is found to be 550 K. A gaseous envelope more extended than the dusty disc appears to explain the shell spectrum. The shell spectrum started developing much before the beginning of the photometric eclipse. The part of the shell which follows the orbital motion rotates faster than the preceding one.

The rotational velocity of the shell lines with respect to the primary at ingress phase is about + 16 km s^{-1}. The H and K lines of Ca II show slightly different behaviour relative to other metallic and also hydrogen lines. This may be due to the blending of shell and circumstellar H and K lines with the photospheric line. The general behaviour of H-alpha is very similar to that observed by Wright & Kushwaha during the 1955 eclipse.

λ Boo stars: These are early A dwarfs with very weak metallic lines for their colours and hydrogen line spectral types. The nature and evolutionary status of λ Boo star is not clear; though light element abundance may provide a clue to their relation to normal A, Am and Ap stars. Analysis of the high resolution spectra by Parthasarathy suggests that λ Boo stars are not deficient in carbon; carbon may be normal or in excess with respect to other heavier elements.

Algol systems: Primary components of Algol systems are late B and early A dwarf stars. Analysis of the IUE high resolution SWP spectra of a few Algol primaries by Parthasarathy suggests that they are deficient in carbon and may be slightly overabundant in nitrogen.

Analaysis of the IUE high resolution spectra of 28 Tau and α Car was undertaken.

Stellar diameters: Padmavathy (ISRO) & Vasundhara estimated the diameter of the stars SAO 077911, SAO146598 and SAO 098250 by analysing the fast light curves of these stars while being occulted by the moon. The computer program using cross-correlation technique to match the theoretical and observed light curve, developed by Bhattacharyya, Gokhale & Namboodri was used for this analysis.

Brown dwarfs: The various physical parameters characterizing celestial objects having a mass several times that of Jupiter but still not massive enough to trigger thermonuclear reactions have been obtained by Sivaram from theoretical considerations. These objects dubbed brown

dwarfs are between 0.01-0.08 $M_{\odot}$, and cool down by radiating energy stored up as heat in the initial gravitational contraction. Sivaram calculated that these objects would chiefly radiate in the infrared with an effective temperature of 1500 K and a luminosity of 10^{-8}-$10^{-6} L_{\odot}$. There is some recent observational support for the existence of such cool substellar objects. The observational consequences of the presence of such objects as binary companions to normal stellar objects like red giants was also explored.

The theoretical basis for the mass-angular momentum empirical relations for stellar bodies was explored and the origin of Wesson's empirical constant was thus explained.

In collaboration with B.C.Chandrasekhara of Central College, Bangalore , Namboodri investigated the influence of variable permeability on convection. They considered both free and forced convection about inclined surfaces in porous media.

Interstellar medium

H II regions: Observations on the galactic H II regions using the decametre radio telescope in continuum absorption are being continued by Sastry. The giant H II region complex W 51 is being observed again with a modified receiver system with improved sensitivity. Very significant nonthermal emission from the eastern region of the nebula is detected. Analysis of the observations made on several other H II regions like the Scutum ring etc is in progress. Low frequency recombination lines C574α and C575α have been detected in the direction of Cas A.

Electromagnetic scattering: Shah has completed a new representation to the Guttler's theory of electromagnetic scattering by a stratified

core-mantle sphere. The theoretical expressions for the multipole expansion coefficients for the electric and magnetic modes corresponding to such a comprehensive sphere have been cast in the forms amenable to fast and accurate calculations with the aid of modern computers. These coefficients are useful for evaluation of radiation scattering parameters such as extinction, scattering and absorption cross sections, scattering phase functions, albedo etc., which occur especially in the problems of interstellar grains. The development of a general purpose comuter code based on the present results is in progress.

Synthesis of long chain molecules: Certain experimental studies related to the collisional processes in interplanetary and interstellar medium were carried out by Ghosh at Calcutta University and the results were analyzed in collaboration with Narayanan Kutty using VAX 11/780. From the above studies it was found that the abundances of NH and OH radicals may be ussed as a diagnostic probe to detect interstellar shocked regions. Also it was found that the bases of nucleic acids (RNA & DNA) may be formed in interstellar and meteorite medium and these results may be important to understand the problem of the origin of life.

Gravitational instability: Theoretical studies by Ghosh on the dynamics of the interstellar magnetic clouds give the condition of the critical mass for contraction, i.e. for gravitational instability.

Radiative transfer

Peraiah and his associates have been working on the calculation of the ratios of line strengths in quasars and solar prominences. They have obtained a simultaneous solution of radiative transfer equation and the statistical equilibrium equation with eight levels of the hydrogen atom. In the case of quasars the line ratios of hydrogen Ly_α to H_β were found to be varying between 3 to 100, depending upon

the density and geometrical extension. In the case of prominences the line ratios of intensities of Balmer and Pashen lines for n = 11 to 18 were found to be between 3.2 to 3.5. They employed an optically thin medium and a plane parallel approximation. These calculated ratios appear to agree with the observed ratios.

P-Cygni type profiles in a medium which is moving radially outward with a velocity gradient have been computed. The effects of velocity gradients on the shape of these lines have been thoroughly studied. The effects of spatial distribution of ionic concentration in the medium are taken into account in a few cases. Majority of the observed profiles in P-Cygni type atmospheres are found to be mostly due to velocity gradients rather than the spatial distribution of ions. A new method of calculating lines formed in expanding stellar atmospheres has been developed. Now this is being employed to calculate the radiation field of the spectral lines in the comoving frame of expanding, dust filled, extended medium.

Peraiah and his associates are studying the neutrino transfer in collapsed objects. Here the equation of hydrostatic equilibrium, conservation of mass are solved simultaneously with the equation of transfer for neutrinos. The chemical potentials for several compositions have been evaluated. The whole system of equations is linearized as this is a highly nonlinear system of equations.

The new technique of solving the equation of transfer has been conveniently employed in the processes of Comptonization. This is being applied to the objects where x-ray emission is observed.

Nagendra & Peraiah have studied the effects of scattering on line formation with Zeeman effect. Mohan Rao has completed his PhD thesis on time-dependent radiative transfer problems. He has examined several

approaches to obtain a stable and accurate solution to the time-dependent radiative transfer problems. He is applying these solutions to radiation problem in stellar atmospheres. Rangarajan has completed his PhD thesis on the effects of redistribution functions on the formation of spectral lines. He considered several redistribution functions including R_V, and has now extended the work to include velocities.

Sushma Mallik has continued with the radiative transfer calculations of the Hα line in the comoving frame. Since Hα was earlier seen to be formed in a region with velocity linearly increasing outward, the density distribution of the model region is assumed to be of the form $n(r) \alpha\ r^{-3}$. The Hα line source functions have been obtained for a range of optical depths (10-1000) and velocities upto six Doppler widths assuming different thickness for the line forming region (one tenth to three times the stellar radius). These have then been transformed into the Hα line profiles in the observer's frame. The equivalent widths and the line core displacements of these profiles have been compared with those of the observed. The best fits yielded optical depths in the range of 25-500 and velocities on the order of 1 to 3 Doppler widths. Assuming a microturbulent velocity of 15 km s^{-1} and an excitation temperature of 6000 K in the expanding chromospheres of the late supergiants, the mass loss rates for a steady flow turn out to be in the range of 2×10^{-5} - 2×10^{-7} $M_\odot$ yr^{-1}.

The strength of the emission component lying to the red of the Hα absorption profile is found to be very sensitive to the extent of the line forming region. A good fit with the observations is obtained only if the extent is chosen to be of the order of the stellar radius.

Na D and KI λλ7665, 7699 observations have been obtained by Sushma Mallik for 12 stars using the Coude echelle spectrograph at the 1 m telescope with the 10 inch camera and the Varo image tube. Reduction of the data is in progress. Asymmetries to those of the Hα line are detected. She is engaged in analyzing the data using similar radiative transfer calculations.

The Galaxy

Young open clusters: The study of hitherto not-well-studied faint young open clusters is being continued by Babu. Using the modified objective grating spectroscopic techniques, a total of 32 open clusters have been examined, out of which six could be categorized as young clusters. In addition, six more were selected by visually inspecting the sky survey charts of the southern regions. To avoid complications due to the effects of interstellar extinction in the Galactic centre direction, the study has been restricted to the anticentre direction only (l=160° to 280°). Photoelectric and photographic photometry of 11 of the above mentioned clusters was done using the telescopes at the Mt Stromlo and Siding Spring Observatories. Preliminary analysis of this data shows that four of these clusters are located in the outer Perseus arm at a distance of about 5 kpc. The farthest cluster seen among these, is at a distance of 6.9 kpc in the direction of l=265°. The cluster excess E(B-V) is between 0.40 and 0.75 mag in l=165° to 220° to distance of about 5 kpc.

Chemical evolution: In continuation of their collaborative study of the chemical evolution of the solar neighbourhood, Mallik & Mallik studied the enrichment pattern of the primary synthesis elements C, O and Fe. The theoretically computed yields are rather high and Mallik & Mallik suggest that to match the observed abundances

stars more massive than about 30 $M_{\odot}$ do not effectively participate in nucleosynthesis. They also find that almost 50% of the galactic carbon originates in progenitors of planetary nebulae and if massive stars produced carbon at the predicted efficiency, carbon would be overproduced in the Galaxy. The overproduction problem is even more severe with iron since type I supernovae are copious producers of this element. They have considered the currently popular carbon deflagration models of these events and show that at the observed SN I rate these models produce three times the observed galactic iron plus the entire galactic carbon and moderate amounts of galactic oxygen. The role of massive stars in galactic nucleosynthesis has become rather unclear. They also show that if stars more massive than 30 $M_{\odot}$ evolve to total collapse the helium-to-heavy element enrichment ratio is greatly enhanced.

Cepheid birthsites: Giridhar has derived birthsites for a sample of 22 Cepheids with well determined atmospheric abundances in an attempt to study the chemical inhomogeneities in the local interstellar medium. She finds that the most conspicuous irregularity in metallicity is exhibited by stars that are born in the local arm or in the interarm region. She has proposed a scenario to explain these local variations in terms of supernova-induced star formation in interstellar gas which is enriched by density-wave induced massive stars but has not been well mixed.

Galaxies

Integrated spectroscopy: Observations were made by Pati with the 1 m reflector telescope and the Cassegrain photometer, scanner and image tube spectrograph with a view to obtaining spectral line widths and colour indices of galaxies and standard stars for doing population synthesis. For some of the of the objects, spatial photometric scanning was also attempted, to obtain luminosity profiles.

Photometric scanning involved placing the aperture at 25 to 30 different positions along the major axis of the galaxies and obtaining counts in the U, B, V, R and I bands. The sky needed to be monitored after every two positions on the object. On two partially photometric nights, partial scanning (about 8 to 10 positions) could be accomplished for the galaxies NGC 3368 and 3623. During further observing runs, photometric skies were not available to complete observations of these objects. This work would be continued.

Spectroscopy for some of the galaxies was attempted using the Cassegrain image tube spectrograph with the 6" Schmidt camera and the 400 l/mm (λ 8452 A blaze in first order) grating in the first order. The spectral range was 6200 - 8600 A. A usable spectrum of NGC 5236 was obtained on one partially clear night. Three usable spectra were also obtained of NGC 1316 in the Fornax cluster. Till now, several field galaxies and galaxies in the Virgo and Fornax clusters have been observed using this instrumental set up. Spectra in the blue region will be attempted for these objects. Some objects at higher redshifts were attempted but no spectra could be obtained since light losses in the telescope and spectrograph are very high.

Scanner observations in the region 588 to 7800 A with a resolution 10 A were made for the galaxies NGC 4472 and 4621 and for standard stars.

The sky was not very good during these observations and the quality of the data is very marginal.

Tails and bridges: Interacting galaxies show peculiar features like bridges, counterarms and tails of various sizes and shapes. Namboodri & Kochhar investigated, by numerical experiments, the formation of bridges and tails in interacting galaxies. He used restricted-three-body approach

and studied the structure of a test galaxy for various values of the mass-ratio. It has been found that bridges and tails are formed when the mass-ratio is close to unity. Bridges are short-lived whereas tails last longer than bridges but it takes time to build up well developed tails.

Galaxy dynamics: Som Sunder & Kochhar have reconsidered a problem earlier examined by Chandrasekhar & Elbert. They study using tensor virial equations dynamical evolution of a homogenous isotropic spheroidal cluster of mass points constrained to have an isotropic velocity distribution. They show that if the total energy is negative the system executes finite amplitude oscillations in size and between prolate and oblate shapes. The results remain qualitatively the same if the spheroid is heterogeneous.

Missing mass: Sivaram, Datta & Ghosh (TIFR) have shown that several inconsistencies (such as the constraints of phase space, density distributions of degenerate and partially degenerate configurations, etc) would tend to rule out the idea that the missing mass in galactic halos is dominated by massive neutrinos or other light neutral fermions such as gravitinos or photinos.

In further extension of this work, Sivaram has shown that the flat rotation curves of large spiral galaxies can be produced only by missing mass in the form of an isothermal distribution of light fermions but such a halo of thermal neutrinos would dissipate on timescales substantially shorter than typical galaxy ages. Several difficulties with the idea of neutrino-initiated galaxy formation were pointed out.

The empirical angular momentum-mass relation for spiral galaxies was sought to be understood by Sivaram as a consequence of the intial conditions during their condensation from primeval inhomogeneities.

High energy astrophysics

Pulsars: Pulsars PSR 1919+21 and PSR 0950+08 were observed by Sastry at Gauribidanur at 34.5 MHz using the decametre wave radio telescope. The average energy per pulse for PSR 1919+21 is 2550 ± 400 x 10^{-29} J m^{-2} Hz^{-1} and that for PSR 0950+08 is 460 ± 115 x10^{-29} J m^{-2} Hz^{-1}. The amount of interstellar scattering in the direction of these pulsars was also estimated. The characteristic width of the scattering impulse response of the interstellar medium in the case of PSR 1919+21 is 67 ± 22 ms and that for 0950+08 is 14.5 ± 4 ms. These values indicate that the radiation from nearby pulsars may suffer much less multiple and strong scattering in the interstellar medium than has been generally assumed.

Pulsar pulse profiles: The implications of large spacetime curvature and large rotation rate on the pulse profile of fast pulsars have been studied in detail by Datta & Kapoor. The calculations suggest a larger brightness temperature than inferred observationally for all pulsars irrespective of their rotation rates.

Fast pulsars: Datta, Kapoor & A.Ray (TIFR) have discussed the relativistic effects of rotation on the structure and surface emission of the millisecond pulsar 1937+214 using an axially perturbed interior spherical metric. In such a system, rotation, manifesting itself through the dragging of inertial frames, can lead to a few observationally interesting effects.

The essay has won 'honourable mention' at the 1984 Gravity Research Foundation essay competition.

Hot neutron stars: Thermal gravitational radiation from hot neutron stars and white dwarfs was estimated by Sivaram. It was shown that in inflationary cosmological models with a GUTS phase transition there would be practically no remnant of a thermal gravitational radiation background unlike in the usual big bang models where such a remnant

with a temperature $\simeq$ 1 K is to be expected. Ways of detecting such a thermal gravitational radiation background were discussed as this provides additional important information about the earliest hottest phases of the universe. This essay won an 'honourable mention' at the 1984 Gravity Research Foundation essay competition.

Supernovae in NGC 5236, and 4419: Prabhu has obtained low-resolution spectra of SN 1983n in NGC 5236 and SN 1984 in NGC 4419. The spectrum of SN 1983n is extremely peculiar type I with the characteristic dip at 6150 A missing and helium lines showing strong P-Cygni profiles. SN 1984 in NGC 4419 is a typical type I supernova.

Active galactic nuclei: Krishan has proposed that the region containing fast particles, electrostatic and electromagnetic fields, around active galactic nuclei is responsible for generating electromagnetic emissions from x-rays to radio waves. The electrons are accelerated by Langmuir turbulence originating through the process of Raman forward scattering. The radiation mechanism is stimulated Raman backward scattering over spatially periodic magnetic field. The spatially periodic magnetic field results from magnetic modulational instability of the Langmuir waves. This model accounts well for the large luminosities observed in active galactic nuclei from x-rays to radio waves and in addition relates physically the emission regions and different wavelengths.

Inflanationary universe: The implications of the inflationary universe model concerning the most general upper bounds that can be set on the age of the universe have been examined by Datta & P.S.Joshi (TIFR).

Missing mass: It was shown that neutrinos or other light fermions with masses < 50 eV which are required from phase space considerations to provide the galactic missing mass would be in conflict with the known ages of Friedmann models unless a cosmological constant was involved. Observational limits on such a cosmological term would then provide a more stringent upper limit on the total masses of the light neutral particles.

Some further aspects of the astrophysical consequences of neutron-antineutron oscillations were considered.

Relativisitic star clusters: Das has completed the calculations of velocity distribution functions for a class of core-envelope type high redshift configurations in general relativity. He has further worked out the constraints, imposed by the dual requirements of positivity of the distribution function and pulsational stability on the equations of state and consequently on the maximum obtainable redshifts of these configurations. He has shown that these configurations can serve as plausible models for the high redshift QSOs and, in particular, provide a natural explanation for the observed upper bound of QSO redshifts.

Conformal gravity QSO models: Das in collaboration with Narlikar (TIFR) had earlier constructed models for QSOs based on the Machian theory of conformal gravity of Hoyle & Narlikar. He has made theoretical calculations of luminosity evolution of these models by considering various continuum radiation mechanisms, such as synchrotron, bremsstrahlung and inverse Compton processes. However, comparison of the theoretical predictions with observational data from the recent QSO catalogues did not yield unambigious results. Hence he is undertaking a more detailed calculations of the radiation mechanisms by taking into account higher order terms arising due to the mass-varying property of Hoyle-Narlikar theory.

Hubble plot for quasars: Das has been doing a χ^2 minimum statistical analysis of the angular diameter redshift data of the 3CR QSOs in order to test the hypothesis that a major portion of the redshifts of the high redshift quasars is of gravitational (or in general noncosmological) origin.

Solar-terrestrial relationship

Ionospheric F-region: Hanumath Sastri explored the influence of the polarity of the interplanetary magnetic field (IMF) on the characteristics of the terrestrial ionospheric F-region near dip equator, through a steady of h'F data of Kodaikanal (dip 3.5°N) with reference to the solar wind sector boundary crossings near earth in a superposed epoch analysis. He obtained evidence which shows that the h'F values at 2000 hrs LT undergo a reduction one or two days after sector boundary crossing. The amplitude of the reduction in h'F which is noticed with both (+,-) and (-, +) sector boundaries is higher in equinoxes than in solstices. He interprets this response of the equatorial F-region to sector boundary crossings in terms of perturbations of the equatorial east-west electric field in the post-sunset hours, due to the well known enhancement in geomagnetic activity in the wake of sector boundary passage. The finding constitutes further circumstantial evidence for the electrodynamic coupling of the equatorial and high latitude ionospheric dynamo regions during disturbed geomagnetic conditions.

Sastri studied the patchy or discontinuous occurrence of equatorial spread-F irregularities using Kodaikanal ionogram data. He finds that during years of high sunspot activity, the patchy occurrence of spread-F depends on season. While spread-F occurrence is usually continuous on nights during the June solstice, it is frequently discontinous on nights of the equainoctial months. This seasonal pattern which is similar to the one recently noticed in VHF scintillation activity, is not evident during years of low sunspot activity.

Sastri in collaboration with R.Raghava Rao, G.D.Vyas (PRL), M.N.Rao & M.S.Rao (Andhra University, Waltair) studied the changes in in the latitudinal structure of the F-region electron density at fixed altitudes in the Indian equatorial region in relation to the occurrence of spread-F in ionograms. The investigation, which is based on the (N-h)

profile data of Ahmedabad, Waltair and Kodaikanal showed that on nights with post-sunset onset of spread-F, the ratio of the electron density in the altitude region 270-300 km between Ahmedabad and Waltair consistently undergoes a sudden enhancement starting at 1700 hrs LT by a factor of 8 to 30 (at 1900 hrs LT) from the near constant value of 2 during the daytime. No such enhancement of the density ratio occurs on nights without spread-F irregularities. The enhancement of the electron density ratio prior to the onset of spread-F is interpreted as an intensification of the northern crest of the equatorial ionization anomaly, with the ionization in the bottomside F-region as far north as 9° from the dip equator participating in the crest intensification process. The results of the study suggest a significant role of the ionization anomaly in the post-sunset generation of spread-F irregularities.

Sastri & Ramesh in collaboration with Ch.V.Sastry and his group are studying the origin of the radio star 'fade-out' phenomenon at equatorial latitudes, using the data obtained with the Gauribidanur decameter wave radio telescope of 6 sources (3C 144, 3C 218, 3C 274, 3C 348, 3C 405 and 3C 461) during 1981-83. Analysis so far made shows that (a) the 'fade-out' at Gauribidanur is essentially a night time event and exhibits, by and large, a preference to occur in the early evening hours, and (b) on the aggregate, the loss of data due to fade-outs occurs 5-15 per cent of the observing time. Further study of 'fade-outs' in relation to the ionogram data of Kodaikanal is in progress to infer the irregularity regime and/or conditions in the terrestrial ionosphere responsible for the 'fade-outs'.

The HF phase path sounder at Kodaikanal was regularly used by Ramesh, Rao & Sastri to obtain data on the phase path variations of ionospheric reflections at normal incidence, under a variety of equatorial electroject conditions. Analysis of the data is in progress.

Saha, Rao & Sastri obtained data of the temporal variations of the Zenith intensities of night airglow emissions [OI 630 nm, 557.7 nm and OH (7,2)] at Kodaikanal on a number of nights during the period of this report. Analysis of the data is in progress.

Instrumentation and techniques

Image dissector scanner (IDS): It was learnt that the Anglo-Australian observatory was interested in finding a new home for their image dissector scanner. Negotiations were made for the purchase of this equipment at a cost of US 14,000 plus freight, insurance, and installation charges. Chinnappan & Prabhu visited AAO in 1984 July for training in maintenance and use of the equipment. Various clearances from the Government agencies were obtained for its import. The instrument will be installed at the Coude focus of the 1 m Kavalur telescope.

Electrometer amplifier: Raveendran & Mohin have constructed a dc electrometer amplifier which is suitable for use with small telescopes and chart recorders. It has got a wide range of gain settings and a built-in calibration unit. It was tested at the telescope and the performance was highly satisfactory.

Polarimeter: AC flicker type polarimeter developed by Jain was calibrated in the laboratory. Using a variable light source, a calibration plate and an uncooled photomultiplier tube, degree of polarization equal to 0.4% could be easily detected at a light level corresponding to approximately tenth magnitude as seen through the 1 m telescope. With a cooled photomultiplier tube and a photon counting unit a sensitivity level of 0.1% is expected to be achieved.

Automated data acquisition: Ananth undertook a program for one-dimensional scanning of spectrum plates, and digitization and data acquisition on the TDC 316 computer.

A program for FITS FORMAT translation into TDC 316 FORMAT was also taken up. Though the program was developed in 1983, its correctness could be confirmed only recently. The present program can handle data, on tape from 32 bit machines, and on machines using other word lengths.

Spectrum scanner: The spectrum scanner unit which was developed by Santhanam had been duplicated to be a standby unit and some software changes had been made to suit the astronomers' need.

CCD camera: A microprocessor based slow scan CCD camera controller, for astronomical imaging purpose using CCD 222 and 202 has been developed. Preparations to couple this system and CCD camera subsystems to VAX 11/780 are underway.

Maximum entropy method: Shevgaonkar has been developing the maximum entropy method (MEM) for improving the radio images obtained from synthesis telescopes. He has formulated the method for polarized emission and tested with the simulated examples. The method has been applied to a new problem of phase refinement of the unstable aperture synthesis data. The method has also been extended for the low frequency imaging.

48 inch PRL telescope optics: The 48 inch primary mirror and the Cassegrain secondary of the PRL telescope are in the process of figuring.

24 inch Schmidt telescope: The Schmidt telescope optics was made ready for the observations of comet Halley, using an already made sphere of 600 mm (f/2.29).

As proposed in the last report the Pyrex secondary of the 0.75 m telescope was replaced by a Zerodur secondary, resulting in a great improvement in the quality of the image.

The 50 inch grinding machine was modified and improved for its working for figuring work and arrangements for the automated figuring process are being incorporated.

Fabrication of a mounting fixture for the 50 inch Hindle sphere required for secondary testing has been completed.

The theoretical study of semiautomated figuring process has been taken up. Wear profile of a small tool in its most general form of working has been worked out. The computer program for computing this wear profile has been finalized and will be used for computing wear profile for different tools required in the automated working of figuring process.

Encoder plates: Optical encoder plates of 8 bit were designed and fabricated using photo-resistive etching methods. Using these plates, IR LED 55C as source and L14C x 54 planar silicon phototransistor as detector a prototype incremental and absolute encoder is being developed. Incremental encoder is ready. Work for the absolute encoder is in progress.

Coating plants: The 1.5 m and the 12 inch vacuum coating plants have been in constant use for aluminizing of the optics of the Institute and a few other research organizations.

Training program: As a part of training program, Messrs J.D.Patel & A.C.Dighe of Space Applications Centre, Ahmedabad underwent a month's training on fabrication and testing of aspheric surfaces in 1984 November.

234 cm telescope project

The erection of the mechanical mount of te 2.34 m telescope in the dome was completed. Electrification and commissioning trials have been started.

The Hindle sphere is in the final stages of figuring. Cassegrain secondary mirror has been polished and is ready for figuring. Figuring of Coude third mirror has started. Necessary fixtures for the edging of optical elements were fabricated, and are being used for edging of the Wynne corrector elements.

VAX 11/780 system: The VAX computer system and peripherals as well as the COMTAL image processing system arrived at Kavalur during 1984 April-May. The computer centre was set up and the system has been in use since 1984 September. The graphics system and the CAMAC interface hardware for instruments to be used with the telescope arrived in 1985 February-March. Two packages, Astronomical Image Processing System and Starlink, were acquired.

A set of general purpose subroutines containing 162 user oriented Fortran subprograms has been added to the VAX system library. The PLXY software enables the matrix printer (Printronics 300) to be used in the plot mode. The RGL software enables the graphic terminal VT 125 to be used in graphic mode. These softwares have been installed and are accessible to the users. Special routines have been developed to be able to convert the data or programs stored on the tape in various formats e.g. EBCDIC to ASCII or vice versa.

Motor controls: All auxilliary motor controls such as mirror flap, Baffle tube, Coude mirror 3, right ascension counter weight, declination counter weight 1,2,3 and instrumentation motor controls (25 in number) and display of their positions were undertaken by Santhanam. This system is based on microprocessors and all necessary electronic circuits with PCB such as electronic decoding cards, contact sense inputs card, line driver, line receiver, stepper motor power driver card, relay driver cards, encoder driver cards, multiplexer cards, CPU cards for slave processors, and multibus compatible interface cards for master processor were developed and fabricated and are in final implementation stage at Kavalur. Details of wiring and cable routings were finalized by Srinivasan & Santhanam.

Plate holder: 93 inch prime focus plate holder assembly has been got ready by Scaria. This unit is provided with all facilities required for direct photography at prime focus. It was tested at the Casssegrain focus of 40 inch telescope and was found to be very satisfactory in

all respects.

A camera was made by Scaria in the Institute workshops for use in the electronics laboratory to make printed circuit boards of sizes upto 18 inch in length and 14 inch in width. The camera has provisions for colour separation and hence is useful for making double sided circuit boards.

History of astronomy

Kochhar has produced evidence to show that the Madras Observatory - the precursor of the Indian Institute of Astrophysics through the Kodaikanal Observatory - was set up in 1786 by William Petrie as a private observatory and taken over by the East India Company in 1789 and Michael Topping appointed the Astronomer (as the director was then called). Observations made in 1786 are on record in manuscript form. The year 1792 which is usually quoted as the year of the founding of the observatory is merely the year when the observatory building was constructed.

Bhattacharyya & Vagiswari prepared a comprehensive report on the astronomical activities in India during the twentieth century for the Indian National Science Academy.

Collaborative programs

Leh project: A high altitude astronomical observatory was set up at Leh in Ladhak region for ascertaining the suitability for a future high altitude infrared observatory. The old 20 inch Bhavnagar telescope was modified and installed in a temporary enclosure and sky extinction observations were started.

Indian Halley Observation Program: Under the sponsorship of ADCOS, DOS, DST & UGC this program has been drawn up. K.R.Sivaraman was chosen as Chairman of this coordinated observing program, in which eight institutions participate. Additional funds for this project are granted by ADCOS, DOS, DST & UGC.

A workshop, organized by the IHOP at the Institute on 1984 July 19 & 20, was attended by scientists from other observatories and organizations besides those who are participating in the IHOP. The Institute scientists took active part in the workshop and presented scientific papers.

Visiting scientists

The scientists who visited the Institute and gave talks include Drs V.I.Makarov (Main Astronomical Observatory of the Academy of the USSR); A.I.Tsygan (A.F.Ioffe Physical Technical Institute, Leningrad); G.S. Bisnovaty-Kogan (Space Research Institute, Moscow); S.R.Pottasch (Kapteyn Laboratories, Groningen); D.Gough (Institute of Astronomy, Cambridge); Leventhal (Bell Labs); J.McKim Malville (University of Colorado); S.Wang (Beiging Observatory); C.Madsen (ESO); K.Shivanandan (Naval Research Laboratory, Washington, DC); V.Trimble (University of Marlyland); Don Loomis (Custom Optics, Tucson, Arizona); a Soviet delegation consisting of nine scientists of various disciplines; S.M. Alladin (Osmania University); P.N.Ghosh (Calcutta University); M.R. Deshpande and P.Velu (Physicl Research Laboratory); K.P.Sinha, P.L.Sachdeva and R.Rajaraman (Indian Institute of Science); T.M.K.Marar (ISRO Satellite Centre); R.Nityananda, A.A.Deshpande and K.R.Anantharamaiah (Raman Research Institute); B.Venkatachallappa (Bangalore University).

Scientific meetings

IIA co-sponsored a summer school on astronomy and astrophysics along with ISRO, TIFR-RAC AND RRI at the Indian Institute of Science, Bangalore. J.C.Bhattacharyya, B.Datta, D.C.V.Mallik, A.K.Pati & T.P.Prabhu gave lectures and Datta Mallik & Prabhu guided students in their projects.

J.C.Bhattacharyya, Ch.V.Sastry, R.K.Kochhar & P.Venkatakrishnan attended the Third Asian-Pacific regional meeting of the IAU at Kyoto,

1984 September 30 - October 5. Sastry visited Tokyo Astronomical Observatory, under INSA-Japan Society for Promotion of Science, Venkatakrishnan visited Okayama Astrophysical Observatory, Tokyo Astronomical Observatory, and University of Tokyo. Kochhar visited the University of Tokyo, Meguro-ko.

N.Kameswara Rao atended the Fourth European IUE conference at Rome 1984 May 15 - 19. Rao spent a few weeks at Vatican Observatory, and Royal Observatory, Edinburgh. He visited University of Kiel in connection with the organization of IAU colloquium No.87 on 'Hydrogen deficient stars and related objects', and attended a workshop on 'White Dwarfs' held at Kiel during that time.

Hasan who was on study leve at Kiepenheur Institut, Freiburgh, attended the Fourth European meeting on 'Solar Physics' at Noordwijkerhout, Holland, 1984 October 1-3.

R.K.Shevgaonkar attend the 164th meeting of the American Astronomical Society at Batlimore, 1984 June, and NRAO workshop on 'Low frequency radio astronomy' at Green Bank 1984 November.

J.Singh visited Kitt Peak National Observatory, Tucson and Sacramento Peak Solar Observatory, 1984 October - 1984 January. K.R.Sivaraman and Singh attended the Giovanelli commeorative colloquium on 'Current controversies in solar magnetic fields' at Tucson, 1985 January. Sivaraman attended the meeting of the International Halley Watch at Pasadena 1985 January.

The Tenth meeting of the Astronomical Society of India at BARC, Bombay 1984 November 26-29 was attended by J.C.Bhattacharyya, Ch.V.Sastry, K.R.Sivaraman, M.H.Gokhale, R.K.Kochhar, A.K.Saxena, N.Gopalswamy, S.P. Bagare, V.Chinnappan & G.Thejappa. M.H.Gokhale, R.K.Kochhar, N.Gopalswamy, G.Thejappa attended the Third Indo-USSR workshop on 'Plasma astrophysics' at Chandigarh 1984 December 9-15. D.C.V.Mallik visited Physical Research

Laboratory, Ahmedabad and gave three talks on planetary nebulae, stellar evolution and the chemical evolution of the Galaxy. P.K.Raju attended the Fifth national workshop on 'Atomic and molecular physics' at TIFR, Bombay 1984 December 17-21. J.H.Sastri attended the 25th COSPAR meeting at Graz, Austria 1984 June 25-July 7. After attending, he visited Observatoire de Meudon, Paris. The Indian Academy of Sciences workshop on 'Supernovae, their Progenitors, and remnants' was attended by R.K.Kochhar, D.C.V.Mallik, V.Krishan, P.K.Das, R.C.Kapoor, T.P.Prabhu, B.Datta & C.Sivaram.

The meeting on giant metrewave radio telescope (GMRT) held at Raman Research Institute, Bangalore 1984 November was attended by J.H.Sastri, G.Thejappa, & N.Gopalswamy.

J.H.Sastri attended the First workshop of IMAP results at Bangalore 1984 November 14-16.

C.Sivaram and B.Data attended diamond jubilee Bose Symposium at the Indian Institute of Science, Bangalore 1984 November 19 - December Datta attended international conference on 'Nuclear physics', at BARC, Bombay 1984 December.

J.C.Bhattacharyya inaugurated the national symposium on 'Thin film science & technology' at Indian Institute of Science, Bangalore 1985 January.

J.C.Bhattacharyya, T.P.Prabhu, A.K.Pati & P.Venkatakrishnan attended the golden jubilee meeting of the Indian Academy of Sciences, Bangalore 1985 February 6-8.

G.S.D.Babu was at Mt Stromlo and Siding Spring Observatories, Australia 1985 January - February to obtain photometric data on several southern open clusters.

Popularization of astronomy

Telescope for schools: A 3 inch refractor and a 6 inch Newtonian telescope were designed for use in schools and amateur astronomical work. The detailed design of the 3 inch telescope was supplied to CSIO, Chandigarh for fabrication of a prototype as per the requirements of ADCOS. Four prototype telescopes were made by CSIO. The prototype has been found satisfactory for its optical quality and mechanical performance.

Film on the 1980 eclipse: The Institute has made a movie (16 mm, colour, 33 min) about the Institute expeditions to Jawalgere and Hosur for observations of the total solar eclipse of 1980 February 16. The film was made by Kapoor on Dr Bappu's suggestion. The commentary, on a separate tape has been provided by Bhattacharyya.

Lectures given outside the Institute

G.S.D.Babu (1984 Sep) The structure of our Galaxy, St Joseph's College, Bangalore

J.C.Bhattacharyya (1984 Apr) Astronomical activities at the Indian Institute of Astrophysics, Astronomical Council of USSR, Moscow.

J.C.Bhattacharyya (1984 July) Minor bodies in the solar system, Science Forum, Bangalore.

J.C.Bhattacharyya (1984 Sep) Milky way galaxy, Poorna Prajna Education Society, Bangalore.

J.C.Bhattacharyya, (1984 Nov) Professor M.N.Saha, International Symp. on Theoretical Physics, Bangalore.

J.C.Bhattacharyya (1985 Jan) The role of science fairs and museums in education - Inaugural address, Southern India Science Fair, Bangalore.

J.C.Bhattacharyya (1985 Feb) Outer rings of Saturn, Symp. on Applications of Mathematics to Science & Technology, Calcutta.

J.C.Bhattacharyya (1985 Mar) Some topics on present day solar research, UGC Instructional conference on ion physics, Aligarh.

N.Gopalswamy (1984 May) Solar system, Thiruvalluvar Government Arts College, Salem.

N.Gopalswamy (1984 Sep) Role of plasma physics in astrophysics, American College, Madurai.

D.C.V.Mallik (1984) Planetary nebulae and stellar evolution,

. Position of central stars on the HR diagram

. Planetary nebulae and chemical evolution of our Galaxy

Physical Research Laboratory, Ahmedabad.

A.K.Saxena (1984 Dec) Optical telescopes, Visveswaraiah Industrial and Technological Museum, Bangalore.

B.S.Shylaja (1984) Birth and death of stars, Vijnana Parishath, Bangalore.

J.Singh (1985 Jan) Mode of excitation in the solar corona,

. Variation in solar rotation rate,

Kitt Peak National Observatory, Tucson.

C.Sivaram (1985 Jan) The end of the universe, Bangalore Amateur Astronomers' Association.

Radio talks:

G.S.D.Babu (1984) Asteroids

B.S.Shylaja (1984 Oct) Outer planets

Binary stars

Exploding stars

Artificial satellites (all in Kannada)

Awards

T.P.Prabhu won the 1984 young scientist award of the Karnataka Association for Advancement of Science.

V.Krishan was awarded the associate membership of the International Centre for Theoretical Physics, Trieste. P.Venkatakrishnan was made a young associate of the Indian Academy of Sciences.

B.Datta was awarded the Indian National Science Academy Golden Jubilee Biren Roy Trust Fellowship 1984.

Library

Library acquired 400 books and continued subscription to 124 journals. Four new journals were added to the list during the course of the year. Some journals from Raman Research Institute and Tata Institute of Fundamental Research Centre libraries were displayed in the Institute library. Approximately 60 documents from other libraries were procured for the staff. In return library supplied 1777 xerox pages and 200 pages of hard copies from microfiche to other libraries and scientists. Printing of Kodaikanal Observatory Bulletins Vol.4 was done in the Institute using the Swift printing machine.

Compilation and distribution of Recent Research in Astronomy and Astrophysics and IIA preprint list continued.

The library continued its efforts towards collection of historical records pertaining to Indian astronomy. Copies of letters written by Naegamvala to Christi and a monograph of transit of Venus by Raghunathachary written in three languages were acquired.

Hours of observation and seeing condition at Kavalur

Month	Hours of spectroscopic work	Hours of possible photometry	No. of nights when spectroscopic work 9 hrs or greater was done	No. of nights with average seeing 1".5 or better than 1".5
1984 April	145.0	18.5	6	2
May	191.5	40.0	12	2
June	59.5	6.0	1	-
July	21.0	-	-	-
August	129.0	6.0	7	2
September	83.0	7.0	1	2
October	95.0	17.5	4	2
November	88.0	8.0	5	4
December	186.5	100.0	16	12
1985 January	181.0	26.0	8	5
February	233.0	64.5	16	5
March	248.5	110.0	16	1
	1661.0	403.5	92	37

Observing conditions at Kodaikanal (Solar tower)

Month & year	Total no. of days of observations	Seeing (in secs. of arc)						
		2 to 3	3	3 to 4	4	4 to 5	5	>5(poor)
1984								
April	16	-	3	3	8	1	-	1
May	20	-	4	6	7	3	-	-
June	3	-	-	-	-	-	1	2
July	7	-	-	1	4	1	-	1
August	10	-	2	-	5	1	1	1
September	12	-	5	2	4	-	-	1
October	12	-	5	2	3	1	-	1
November	13	-	-	1	7	1	-	4
December	23	-	4	5	5	4	3	2
1985								
January	20	1	8	4	5	1	1	-
February	15	-	1	2	4	-	2	6
March	20	1	3	6	5	3	-	2
	171	2	35	32	57	16	8	21

Spectroscopy lab

Observations	Total no. of days of observations	Total number of plates obtained
Photoheliogram	225	225
Hα	211	404
K-fl	214	274
K-Pr	187	197

List of academic & technical staff

J.C.Bhattacharyya, D.Phil.	Director
Ch.V.Sastry, Ph.D.	Professor
K.R.Sivaraman, Ph.D.	"
M.H.Gokhale, Ph.D.	Associate Professor
J.Hanumath Sastri, Ph.D.	" "
A.Peraiah, D.Phil.	" "
G.A.Shah, Ph.D.	" "
P.K.Das, Ph.D.	Reader
S.S.Hasan, Ph.D.	"
N.Kameswara Rao, Ph.D.	"
R.C.Kapoor, Ph.D.	"
R.K.Kochhar, Ph.D.	"
V.Krishan, Ph.D.	"
D.C.V.Mallik, Ph.D.	"
R.Rajamohan, Ph.D.	"
P.K.Raju, Ph.D.	"
A.K.Saxena, Ph.D.	"
K.C.Abdur Raheem, B.Sc.	Fellow
G.S.D.Babu, M.Sc.	"
S.P.Bagare, Ph.D.	"
V.Chinnappan, B.E.	"
B.Datta, Ph.D.	"
K.K.Ghosh, Ph.D.	"
N.Gopalswamy, Ph.D.	"
S.K.Jain, Ph.D.	"
A.K.Pati, M.Sc.	"
T.P.Prabhu, Ph.D.	"
P.Santhanam, M.Sc.	"
B.S.Shylaja, M.Sc.	"
K.K.Scaria, Ph.D.	"
J.Singh, Ph.D.	"
C.Sivaram, Ph.D.	"
P.Venkatakrishnan, Ph.D.	"
S.Mohin, M.Sc.	Research Associate
P.M.S.Namboodri, M.Sc.	" "
A.V.Raveendran, M.Sc.	" "
K.R.Subramaniam, M.Sc.	" "
Sunetra Giridhar, Ph.D.	" "

R.Surendiranath, M.Sc.	Research Associate	
G.Thejappa, M.Sc.	" "	
R.Vasundhara, M.Sc.	" "	
M.Parthasarathy, Ph.D.	Visiting Scientist	
Sushma Vasu Mallik, Ph.D.	Post Doctoral Fellow	
C.G.Anupama Rao, M.Sc.	Research Scholar	
K.S.Balasubramaniam, M.Sc.	" "	(Joint Astronomy Program)
D.Mohan Rao, M.Sc.	" "	
K.N.Nagendra, M.Sc.	" "	
Parthasarathy Joarder, M.Sc.	" "	(Joint Astronomy Program)
K.E.Rangarajan, M.Sc.	" "	
G.Som Sunder, M.Sc.	" "	
J.Vijapurkar, M.Sc.	" "	

Technical staff

A.P.Jayarajan, M.A.	Consultant
S.C.Tapde, B.Sc (Hons)	Project Manager, 234 cm telescope project
R.Srinivasan, Ph.D.	Principal Scientific Officer (Electronics)
A.V.Ananth, M.Tech.	Sr Electronics Engineer
T.S.Raghu, M.E.	" " "
B.R.Madhava Rao, B.E.	Sr Mechanical Engineer
R.K.Shevgaonkar, M.Tech.	Electronics Engineer
N.Selvavinayagam, B.E.	Civil Engineer
Abdul Hameed	Technical Associate
R.Muraleedharan Nair, B.Sc.	" "
K.Raman Kutty	" "
K.G.Unnikrishnan Nair, B.Sc.	" "
A.Vagiswari, M.A.	Librarian
Parag Seal, Ph.D.	CSIR Scientists Pool Officer

Council meetings

The Governing Council of the Institute had two meetings during the year one at Bangalore and another at New Delhi.

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(Asterisk denotes authors not from the Institute)

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