INDIAN INSTITUTE OF ASTROPHYSICS

Annual Report

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INDIAN INSTITUTE OF ASTROPHYSICS

ANNUAL REPORT FOR THE YEAR APRIL 1, 1982 TO MARCH 31, 1983

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All members of the Institute deeply mourn the untimely passing away of its Director, Dr.M.K.V.Bappu, on August 19, 1982 at Munich, West Germany due to complications following a coronal by-pass surgery. Dr.Bappu, who took over as Director of the erstwhile Astrophysical Observatory, Kodaikanal in early 1960 is responsible for extending its activities and mainly through his efforts the Observatory became an autonomous Institute in 1971. He is the main architect for the creation of the astronomical research facilities of a very high standard in the country. The members place on record their indebtedness for his leadership in steering the course of development of the organisation in its formative stage and winning an international status for the Institute.

SOLAR PHYSICS

The programme to examine the luminosity variation of the sun as a star in the K line of ionised calcium commenced in 1969 by Bappu and Sivaraman using the solar tower telescope at Kodaikanal has now covered the span of more than one complete solar cycle. Sivaraman and Jagdev Singh have completed the analysis of these spectra and have evolved ten parameters which would characterise the mean K line profile and enable the study of the temporal changes in the profile over the time scale in view. The main findings are:

1. The K_3 absorption brightens up by almost 40% with the the increase in plage coverage;
2. The emission line width at half power point increase in phase with solar activity showing the increased weighted contribution from the plages and their influence on the width of the K line profile in the integrated light from the sun. This would provide a valuable clue in inferring the nature of the magnetic structures in other sun like stars whose K line profiles have been determined.
3. There is clear evidence to indicate the oscillation of the temperature minimum region in the solar atmosphere and that the phenomenon is related to the solar cycle.

Bagare and Gupta have collected Ca II K profiles over many plages using the Kodaikanal tower telescope to establish a relation between the profile and the plage characteristics.

Sivaraman in collaboration with Makarov of the Pulkova Observatory, Leningrad, have extended their analysis of the poleward migration of the large scale active regions on the solar surface back in time reaching upto 1904, (for which magnetograms do not exist) and established the epochs of sign reversals of the polar fields of the sun during this period. They used the Kodaikanal H-alpha spectroheliograms for this period of seven cycles as the basic material.. They find that the migration of filament bands takes place in the form of two or sometimes three waves, reaching the pole one after the other. The amplitude of these waves is directly related to the magnitude of the activity in the respective cycles. The drift velocity of the filament bands ranges from 5 to 29 metres per second and shows a similar dependence with solar activity. The results explain the single pole configuration at times exhibited by the sun which has been detected by recent magnetograms and hence provide information of the existence of such features in the period prior to the magnetograms.

Considerable efforts and time have been spent towards the preparation for observing the total solar eclipse of June 11, 1983 at Indonesia with a totality lasting 5 minutes. The experiments planned were:

1. Determination of the two dimensional distribution of the coronal temperatures with equatorial regions of the corona using the [Fe XIV] 5303Å and [Fe X] 6374Å emission lines and the velocities of these ions. The experiment planned to use a multislit spectrograph and obtain spectra simultaneously in these two lines.
2. The second experiment is aimed to detect the neutral hydrogen emission from the corona. Such emission was discovered by the Institute team during the eclipse of March 7, 1970 at Mexico and this has been continued during the subsequent eclipses by the French, American and Soviet teams. The emission has been interpreted as due to the existence of cool columns of gas within the hot coronal surroundings. The present experiment is designed to quantitatively estimate the amount of neutral hydrogen responsible for this emission.
3. Determination of temperatures in the polar regions of the sun using the [Fe X] 6374Å emission line.

4. Broad band photography of the sun to study the brightness distribution in the corona.

All these experiments have since been successfully completed.

A photo electric scanning arrangement was made and added to the observing facility at the Kodaikanal Solar Tower Telescope. Synoptic observations of the sun were continued at Kodaikanal.

Scaria used unsharp marking techniques to bring out fine features in the photographs of Solar Corona taken on February 16, 1980. The results indicate the fine details of coronal streamers and loops.

Sastry utilising Gauribidanur Decameter Wave Radio Telescope* carried out observations on the slowly varying component of the solar radio emission. The maps of radio emission thus obtained are being compared with K coronometer data of Mauna Loa Solar Observatory, Hawaii. Preliminary results indicate that the centroids of decameter radio emission coincide with the positions of coronal streamers.

High sensitivity observations on the fine structures of noise storm radiation are being made with a sixteen channel receiver. The time and frequency resolutions are 100 milliseconds and 50 KHz respectively. Some cases of fine structures of slow drifting spike bursts have been detected on the records.

Gopal Swamy has undertaken the task of interpretation of these spikes through various linear and non linear plasma processes that can take place in the solar corona. In his analysis he considers the corona as an extensive hot plasma permeated by complex magnetic fields. The sudden reductions observed in the decametric continuum has been interpreted as the absoprtion of radiation temporarily by a 'screen' of ion-sound turbulence generated by a collisionless shock wave. The effect of the surface waves on the plasma processes responsible for radio bursts is also being investigated.

Gokhale continued working on the rotational acceleration or deceleration of sunspot groups during their life time. It was found that the inclusion of sunspot groups beyond 80° from the central meridian

* The Gauribidanur Radio Telescope is operated jointly by the Indian Institute of Astrophysics and Raman Research Institute.

introduced inequalities in the samples of spot groups used for averaging the 'initial' and 'final' values of the rotational velocity. When he eliminated this source of error from his earlier analysis of the data, he found that spot groups in any given interval of maximum areas often show statistically significant differences of either sign between the initial and the final values of the rotational velocity. The comparison with the 'mean' values of the rotation velocity indicates a 'trend' that the rotation of sunspot groups accelerated during the earlier part of their life and decelerated in the later phase.

Gokhale and Hiremath confirmed that the rotation of small spot groups is significantly less differential than that of the large spot groups. They also confirmed that the differential rotation of the spot groups varies with the phase of the solar cycle. However, to obtain more detailed information than what was obtained by earlier authors, it was found that the method of analysis will have to be much more detailed. With a view to detect the effects of the 22 year torsional oscillations of the sun on the rotation of sunspot groups, Gokhale has started an analysis of 'abnormally fast rotating' and 'abnormally slow rotating' sunspot groups during the earlier solar cycle.

Raju concentrated on the emission processes from the chromosphere-corona transition region. His method consists of computation of line intensity ratios for model distribution of electron density and temperature. Assuming a schematic model for an extensive cold region (electron temperature around 10^5 K) within the corona, he is computing H-alpha emission line intensity in an attempt to explain the presence of H-alpha emission line on coronal spectrograms taken during total solar eclipses.

Venkatakrishnan continued his studies of convective instability of slender flux tubes in solar active regions. The non linear development of effective instability in a polytropic atmosphere was taken as a model for calculations. For the adiabatic case it was seen that the time development of the instability depended on the boundary conditions. For "closed-closed" boundary conditions an initial minor up flow developed into a large one accompanied by field intensification. An initial small down-flow developed into a large down flow without any field intensifications. For "closed-open" boundary conditions the flow developed into strong down flow irrespective of initial direction of perturbing flow. In either case an initial magnetic field had a stabilising influence on the instability.

For the case with heat transfer, it was seen that for a given value of radiative diffusivity, there existed a critical radius of the tube such that tubes with radii greater that the critical value underwent oscillations. Smaller tubes tended to be completely dispensed at focal points. To reconcile observed downflows with the reported calculations, one must assume very fine structure for the observed magnetic elements, the observed flow then being interrupted in terms of a velocity-brightness correlation in the manner suggested by Spruit.

Vinod Krishan and Sivaram have computed a generalised version of the linear acceleration mechanism for emission of radiation from plasma. The results indicate that such processes facilitated harmonic generation and includes the effects due to relaxation of the dipole-approximation. The results are applied to the solar radio burst of types III and IIIb.

PHYSICS OF THE SOLAR SYSTEM

Sivaraman, Babu and Shylaja obtained the spectrum of the Comet Churyumov-Gerasimenko with the Cassegrain spectrograph on one night and spectrum scans on two nights when the Comet was at a distance of 1.5 a.u from the sun in December 1982/January 1983. The spectra show weak emission from CN and C_2 from the coma. There is no trace of H_2O^+ bands in the optical range.

Preparations for observing Comet Halley are in progress. It is planned to obtain spectra of the coma with dispersions around 10Å/mm to derive the velocities of ejection of the neutral molecules within the coma, and the total gaseous output. In addition, observations on the tail and near nucleus studies are planned with a 24-inch schmidt camera.

In continuation of her earlier work on acceleration of ions in the comet tail, Vinod Krishan sought to explain the kinky structure of the tail of the comet Ikeya Seki (1965) by invoking the presence of helical magnetic fields. The tail aligned current sheath which gains in radial thickness at the site of anomalous resistivity and gives rise to an azimuthal component of the magnetic field with a magnitude comparable to that of the axial magnetic field. The resulting local magnetic field configuration is favourable to the formation of helical features by one or more of the knows mechanisms. This model accounts naturally for the fact that the helical structures are seen far from the comet head.

Utilising the records obtained earlier Vasundhara and Bhattacharyya showed that the fine features of the ε ring of Uranus shows a twisted structure like that of the newly discovered 'F' ring of Saturn. Several other peculiarities of this ring structure are being investigated.

Sastry using the Gauribidanur radio array has obtained observations on the decametric radio bursts from Jupiter. The time and frequency structure of these bursts are studied together with the long term correlations between solar activity and the radio emission from electrostatic discharges on Saturn. This program was taken up as a collaborative venture between Dr.F.Biraud of Observatorie de Paris, Meudon.

Attempts to obtain a good occultation record by the asteroids were continued. Five teams of scientists at different locations in the country have been organised for searching possible occultation events. Bhattacharyya continued to guide these units by supply of required information for all such events.

STELLAR ASTROPHYSICS

Further observational work on Wolf Rayet stars were continued with the 102 cm telescope by Rajamohan. The profile of the H-alpha line in γ_2 Velorum from 22Å/mm IIIa-F plates for selected phases were obtained. These profiles indicate that there are no large changes associated with phase. It is found that a fairly stationary narrow emission component superposed over a broad flat topped profile. However, there seems to be a periodic change in the intensities of the violet and red wings. Whereas the violet shifted Helium I 3888Å line indicates considerable strengthening at zero phase and splitting at quarter phase, there are no associated changes in the region of H-alpha.

The profile of the H-alpha line in HD 47129 as a function of phase has been obtained. The preliminary results indicate very dramatic periodic changes. This massive binary star is not an eclipsing binary; however, the emission components in the H-alpha region indicate that the extended regions associated with the binary components undergo eclipses.

The studies of faint galactic clusters was continued by Babu; objective grating spectra of thirteen more clusters have been obtained with the 102 cm telescope at Kavalur. Two of them have been found belonging to young cluster category. Photometric work on one of the clusters has been completed while observations on three more are in

progress. All these clusters are in the anticenter direction of the galaxy and generally located around the constellation of Monoceros. The distances and ages of these young clusters are being estimated by constructing accurate colour-magnitude diagrams using these results.

Babu and Shylaja undertook a program of comparing the diameters of Ap and Am stars with those of normal A stars of the Main Sequence. It is found that although the brighter Ap stars have a little larger radii they are not different from those of the slightly evolved normal A stars. The Am stars have radii which appear to be same as those of the cooler A stars.

The studies of globular clusters were continued by Scaria. Changes in U-B/R-I colours in integrated light were measured in Omega Centauri system. It is found that the nature of changes in the radial direction is such that there should be an increase in the concentration of AGB stars towards the centre. Scanner observations from 3200Å to 5000Å were made in several locations in the clusters. Also photographs of the clusters were obtained in U, B, V, R and I bands for photographic photometry of individual stars.

Sivaraman and Shylaja have commenced a study of the Ca II K line emission widths in giants in relation to their age. A preliminary examination of the data shows that the K line emission width increases with age of giants. Using the analogy from the integrated solar K line behaviour they find enough evidence to infer that the changes are in the nature of the magnetic structures in giants as they evolve.

Shylaja obtained spectra of Nova Muscae (1983) during Feb 1983. The spectrum showed various emission lines of HI, HeI, FeII, NII and NIII. The Balmer decrement value agrees with the case of high optical thickness and high density. It is inferred that the Nova was in 'Orion' phase at the time of observations.

Giridhar determined atmospheric abundances of selected cepheids to study the large-scale chemical inhomogeneties across the galactic disc. High dispersion spectra of Cepheids WZSgr, XSgr, SGem, TMon and SVMon were obtained using the 102 cm reflector of Kavalur Observatory. The atmospheric abundances were determined by theoretically synthesizing the selected portions of the stellar spectrum and comparing with the observed spectra. In order to compute the theoretical spectrum, the

formal solution to the equation of radiative transfer was numerically evaluated with the assumption of LTE, plane parallel geometry and hydrostatic equilibrium. The atmospheric abundances of iron-peak elements Fe, Cr, Ti, Ca and heavier s-process elements Y, Ba, La, Ce, Sm were obtained by synthesising selected portions in wavelength range 4330Å - 4650Å. The derived radial abundance gradient for iron $d[Fe/H]/dr_{gc}$ = 0.056 ± 0.08 for the region of galactic disc between 6.7 and 10.9 kpc from the galactic centre. This value agrees with the photometric estimates but is smaller than the one derived by Luck (1982). The derived abundances of the elements do not show any significant correlation with atomic number. Also the abundance ratio [S/Fe] does not show any correlation with [Fe/H]. This lack of correlation for disc population stars shows the inadequacy of simple models of galactic chemical evolution and favours the infall models.

Kameswara Rao, Ashok and Surendranath have continued the observations of the enigmatic binary ε Aur. covering the recent eclipse. This system which shows a total eclipse once in 27.1 years is being studied both spectroscopically with a dispersion around 44 A/mm in blue and also in the H-alpha region. The emission structure at H-alpha seems to follow the same pattern as in the last eclipse which occured in 1955. The energy distribution for the wavelength range 3200-7780Å has been determined by the computer controlled scanner on the 102 cm telescope; the main point of interest in these studies is the wavelength dependance of the extinction at the primary minimum; these observations are being compared with our IUE Satellite observations which had been obtained both at partial and total phases. There are enhancement of emissions in Fe-II and Fe-I multiplets in UV along with the Mg II lines.

Kameswara Rao and Rajamohan have completed the study of the spectrum and wide band colours of the Ap star embedded in the reflection nebulae VdB 102. The extinction properties show that the ratio of total to selective absorption is 4.3 implying that dust particles around the star have a mean size greater than that attributed to normal interstellar medium. They have estimated the effective temperature around 13000 K and a value of log g = 3.6 ± 0.2.

Kameswara Rao in collaboration with D.P.Gilra of Kapteyn Astronomical Laboratory, Groningen has studied the UV variability of HD 62001, the central star of the missing nebula VV 1-7. This study has been accomplished with the help of the Ultra Violet spectra obtained

by International Ultra Violet Explorer Satellite. It has been concluded from both UV data and UBV photometry with 102 cm telescope that the UV variability seen in the ANS (Astronomical Netherlands Satellite) is a result of a blue field star sitting on the edge of the diaphram getting in and out of the field because of jitter of the ANS telescope. However HD 62001 still shows optical light variations which suggests a binary nature.

Kameswara Rao, Ashok and Surendranath have continued the studies of RCrB stars and other hydrogen deficient stars from their spectra in the blue region to obtain the radial velocities systematically at regular intervals. Their energy distribution in the entire visible spectral band was also under investigation.

Kameswara Rao and Mekkaden undertook a study to detect the presence and variability of the Ca II emission in α Car (Canopus). Coudé Spectra at 4Å/mm dispersion have been obtained with the 102 cm telescope at Kavalur; the aim is to check any periodicity in the variations of K line of ionised Calcium.

Further spectroscopic observations of the peculiar G supergiant HR 8752 were continued by Ashok and Kameswara Rao.

Prabhu in collaboration with scientists of Tata Institute of Fundamental Research, Bombay, commenced a programme for observations of suspected variables from the Equatorial Infrared Catalogue. The programme involves obtaining spectral types of these stars together with their photometric magnitudes in the UBVRIJHKL bands.

Mallik continued his theoretical estimates of the birthrate of planetary nebulae. The estimate was derived on the assumption that stars with main-sequence masses in the interval 0.98 $M_\odot$-Mu eventually become planetary nebulae and the present death rate of these stars should therefore equal the planetary nebulae birth rate. The upper mass limit M_u was varied from 2 - 8 $M_\odot$.

Several initial mass functions and various choices of the star formation rate were used for the calculations. While the observed birth rate using the empirical mass-radius relationship was found to be in agreement with the theeoretical estimates, the previous estimated birth rates from observations of planetary nebulae were considerably higher and could not be reconciled to the present values. The total

number of planetary nebulae in the galaxy was also determined from the data on local planetaries derived above and the galactic centre planetary nebulae density derived by Isaacman (1981); these are in excellent agreement with other estimates.

Mallik also studied various distance scales and statistics based on recent Ultraviolet and Infrared Observations of planetary nebulae. The empirical mass-radius relations was used to compile a new list of local planetaries. A correlation between the ratio of IR flux to Lyα flux and the r.m.s. electron density was established, which gave indications that many observed planetaries are probably optically thick. Recent determination of the effective temperatures of stars and their new locations on the HR diagram were described. Chemical abundance studies were discussed with special reference to carbon abundances.

Peraiah and Srinivasa Rao studied reflection effects in close binary systems, taking the transfer of radiation in the irradiated surface as a primary cause for the reflection of radiation. They have considered two types of calculations i.e. radiation incident from a point source and that from an extended source. They have calculated the distribution of radiation in the atmosphere and also the variation of radiation along the limb of the reflecting atmosphere. Using a scattering medium to enable evaluate radiation field easily, they have estimated the radiation both in the continuum and in the lines. Effect of a plane parallel approximation on the continuum and line radiation have also been studied.

Large differences in the radiation field as well as in the limb darkening are found to exist between plane parallel and spherically symmetric cases. The irradiations from a point source and an extended source give different kinds of radiation fields. In case of a point source it is found that maximum radiation is emitted from the intermediate points of the atmosphere; the kind of change is a function of the type of density variation employed. Some of these effects are not found when the point source of irradiation is replaced by an extended source. The law of darkening becomes the law of brightening depending upon how the electron-density is varied in the atmosphere. In the case of spectral lines, the irradiation from the secondary component has considerable effect. The lines received large amounts of flux from the irradiation, so that all points in the lines are affected.

Peraiah and Nagendra studied the scattering aspects of magnetic polarisation in white dwarfs. The effect of magnetic field on the atomic absorption coefficient is considerable; the scattering process complicates the transfer of radiations.

Peraiah and Nagendra also studied the effect of radiation driven winds on profiles of spectral lines by solving the equation of energy, momentum, mass and that of radiative transfer simultaneously. Latest techniques in iterative process are being used in these computations.

Peraiah, Rangarajan and Mohan Rao continued the study of the effects of various partial frequency redistribution on the formation of spectral lines in expanding stellar atmospheres. They studied the properties of symmetry or lack of symmetry of these functions in a static medium, and how these functions change the emission profile both in a static and in an expanding medium.

GALAXIES

Prabhu and Kochhar continued the study of large scale parameters of external galaxies that had produced supernovae. It is seen that elliptical galaxies which have produced supernovae are bluer and more metal-rich compared to those which have not produced. These observations support the idea that the supernovae have experienced a recent phase of formation and that type I supernovae results from the intermediate age stars.

Prabhu and Kochhar studied the axial ratios of ellipticals with extended radio structure. The results appear that intrinsically rounder galaxies are more efficient in forming extended radio sources, while the emission is contained within the galaxy in flatter ellipticals.

By using Gauribidanur low frequency radio telescope Sastry obtained a radio map of diffuse halo in the Coma cluster of galaxies. The size of the halo is found to be 54 arc minutes by 30 arc minutes and the integrated flux is 60 Jy. An extended source in the south of Coma A has also been detected. The measured flux is about 15 Jy and the spectral index in the frequency range 408 to 34.5 MHz is found to be -1.0 It is suggested that this source also belongs to Coma cluster. A radio survey of the galactic plane has been carried out at Gauribidanur. The limits of the survey are 0-10 hrs in RA and 74^{o} to 45^{o} in declination.

A map of the galactic centre region within the limits 17 to 18.5 hrs in R.A. and 35^{o} to 5^{o} in declination has already been made. Spectra of many interesting emissions and absorption features detected at this map are being determined.

INTERSTELLAR MEDIUM

Shah has completed a study of the phase retardation caused by the interstellar grains in the form of cylinders composed of pure (index of refraction, m = 1.33 - i0.0) and dirty (m = 1.33 - i0.05) dielectric grains. If the medium of interstellar grains has birefringent property, one would expect a component of circular polarisation in the observed star light. It is essential, however, that in the source itself there should be a component of linear polarisation, this model is based on rigorous electromagnetic scattering theory of infinite cylinder shows some interesting features. The predicted circular polarisation of the interstellar origin is more pronounced in the near and far infrared wavenegth regions. The orientation of the grains plays an important role in producing the interstellar circular polarisation. It is found that phase retardation for a given angle of incidence reduces monotonically as the size to wavelength parameter $2\pi a/\lambda$ increases. For pure grains similar trends are also shown as for the case of dirty grains but the phase retardations are considerably reduced. A change of sign in the circular polarisation in the middle of optical window is predicted; such an effect was previously expected in scattering by dielectric grains. The present result shows that the change of sign may not occur at all unless the alignment of the grains is favourable.

A radio map of the H-II region Rossette nebulae in continuum absorption has been made at Gauribidanur Low Frequency Telescope by Sastry. These observations are combined with those at high radio frequencies where the nebulae is optically thin, to derive electronic temperature distribution across the nebula. It is found that the electronic temperatures in the south eastern parts of the nebulae are around 5000^{o}-6000^{o}K and increase upto 8500^{o}K in the north-eastern regions. This effect is being interpreted in terms of the presence of more dust in the south-eastern region which changes the spectrum of the ionising radiation.

Prabhu in collaboration with K.P.Singh of Tata Institute of Fundamental Research, Bombay, has commenced a programme for optical identification of newly discovered X-ray sources. The source in the field of G.189+1 has been identified with an M-type star of magnitude V=14.4.

The processes of Stimulated Raman Scattering (SRS) and Stimulated Compton Scattering (SCS) were investigated by Vinod Krishan in order to provide a possible emission mechanism for the extra galactic X-rays and radio sources. The system proposed is a relativistic plasma beam propagating transverse to a static periodic magnetic field. The role of the incident pump radiation e.g. the microwave background, has been replaced by the static spatially periodic magnetic field. It is shown that by varying the spatial periodicity of the magnetic field, one could generate X-rays to radio waves by a single mechanism of SRS and/or SCS.

Modifications of synchrotron radiation spectrum in the presence of helical magnetic field was investigated by Vinod Krishan. It is shown that a proper choice of the spatial frequency of the magnetic field, can yield large amounts of power over a wide region of the electromagnetic spectrum. The peak in the radiation spectrum shifts towards higher frequencies as the spatial period of the magnetic helix is reduced. The mechanism has been applied to the case of Crab Nebula Pulsar NP 0532 and interesting preliminary results obtained.

Sivaram and Vinod Krishan investigated the phenomenon of neutron-anti-neutron oscillations which has been recently proposed as a novel consequence of grand unified theories. The sensitivity of the oscillations to the existence of magnetic field and the presence of a large neutron population in the nucleo-synthetic era of the big-bang provides a lower limit on the strength of any ordered primordial magnetic field. This would supplement recent attempts to fix upper limits on the primordial field by considerations such as neutrino oscillations and helium production.

The question of diffused X-ray model was studied by Sivaram. The problem with the existing models necessitate requirement of very hot intergalactic gas which conflicts with the temperature values estimated from primordial deuterium abundance. X-ray from galactic cluster halos alsohas problems in the energetics of heating the gas. Drawing an analogy with the decay of massive neutrinos and the ultraviolet luminosity of galactic clusters (implying neutrino lifetime and masses consistent within theoretical

limits), it was suggested that the additional particles predicted by super gravity theories (which attempt unification of all four fundamental interactions) such as photinos and gravitinos could partly account for the missing mass in these clusters. The decay of these particles would give rise to photons in the KeV X-ray range, thus partially ameliorating the energetics problem in producing these X-rays.

Sivaram has also estimated an upper limit on the temperature of currently evaporating blackholes in an expanding Robertson-Walker universe. It is seen that this temperature is coincident with the Hagedorn temperature obtained in bootstrap models of particle physics.

Sivaram has also studied that beta decay of various unstable isotopes produced in supernova explosions leads to production of highly polarised positrons which on annihilation with the ambient electrons will produce strongly right circularly polarised annihilation MeV gamma radiation accompanied by polarised X-ray bremsstrahlung. Observations over an extended period by a gamma ray Space Telescope has been suggested.

In another investigation Sivaram has estimated the sequences of magnetic fields for the positron annihilation. Most of the annihilation of the low energy positrons take place via triplet photon annihilation of positronium. A magnetic field can however mix the triplet and singlet states and it is found that only for greater than a few thousand gauss two photon annihilation is possible. The relative strengths of the line and continuum gamma radiation can provide a diagnostic for the magnetic field in the emitting region.

Sivaram's paper on "Origin of the gravitational constant and its behaviour at very high energies" was awarded 'Honourable Mention" at the International Paper Competition held by the Gravity Research Foundation, Mass. USA.

The paper deals with the connection between spontaneously broken symmetry and gravitation, i.e. in analogy with the unification of other interactions, gravity can also be realised from a broken symmetry and this enables a possible extension of Einstein's general relativity to deal with interactions at very high energies and a definite prediction to be made as to how the gravitational constant would behave at such high energies, since it is known that the coupling constants of the other interactions become energy dependent in various unified gauge theories. Application of this model to situations such as the very early universe and the terminal stages of gravitational collapse are discussed.

Sivaram has pointed out that the gross parameters characterising the universe such as overall size and mass can be arrived at from micro-physical considerations involving the fundamental interactions of elementry particle physics. Interesting relations for the Hubble radius and closure density are obtained in terms of the coupling constants underlying these interactions.

Sivaram has pointed out that the distortion in the 3K spectrum of the black body background cosmic radiation has led to suggestions that a part or even all the radiation was generated by pregalactic supermassive stars.

Das has investigated the plausibility of different theoretical models for red shift QSOs. While considering a star cluster scenerio for these models it is seen that the velocity distribution function for all these models become negative over a part of the phase space. This negativity is essentially a surface phenomenon and can be avoided by suitably altering the equation of state near the surface. This has been explicitly demonstrated by considering a thin surface layer of matter obeying a polytropic equation of state. Red shifts and other physical parameters for these composite models have been calculated. It is further seen that the requirements of positivity of distribution function and pulsational stability put an upper limit ($Z \lesssim 2.5$) on the central red shift values that can be obtained from these models. This could be a possible reason for the observed paucity of QSOs with $Z \gtrsim 3.5$ assuming that the contribution of cosmological red shift is not more than ~ 0.5.

Das and Sivaram further developed QSO models based on conformal gravitation Theory of Hoyle and Narlikar. Recent observations of Arp on QSO-galaxy associations provide further support for these models. At present continuum radiation for these models are being investigated. It has been shown that for Synchrotron and Inverse Compton processes the absolute luminosity L of a QSO with red shift Z_Q will increase as $(1 + Z_Q)^2$ whereas for bremsstrahlung $L \propto (1+Z_Q)$. The resulting m - z relations have been obtained. The results have been applied for QSO-galaxy associations data from Hewitt-Burbidge (1980) catalogue.

The implication of Arp's observations has been considered by Kapoor in other aspects. Quasars seen in association with lower red shift galaxies are interpreted as bodies ejected from the centre of the associated galaxy. Kapoor points out that in most cases the magnetoid, spinar or massive object will collapse to become a blackhole and become

invisible by the time it emerges out of the galaxy. He has offered an explanation for quasars observed in association with respective nearby galaxies in terms of accreting supermassive blackholes ejected from the centres of the former. If the black hole is supermassive, the model can explain the gross features of the quasars such as luminosity, spectrum, metal abundances and can cause perturbations in the galaxy as observed.

Datta has endeavoured to develop a realistic model for gravitational collapse and supernova theory. Final values of the entropy and lepton number at the terminal stage of the stellar collapse process determine the energy of the shock wave that is generated at the end of the collapse and that is believed to be a viable mechanism for explaining the energetics of observed supernova explosions. The entropy generation and the lepton number loss have been calculated using a more accurate treatment of the nuclear physics relevant at high densities and high temperatures. He finds, contrary to existing claims that the entropy generation and lepton loss to depend on most variations of the assumptions regarding the input physics, collapse rate and initial conditions, and the electron capture rates on nuclei.

Datta has also investigated the recently discovered millisecond pulsar PSR 1937+214 and finds that it could be close to the onset of rotational instabilities. Conditions of rotational stability imply lower bounds on the radius of neutron stars belonging to this new class of radio pulsars. For six representative high density equations of state, he has constructed numerically critically rotating neutron star models using the prescription of Hartle and Thorne, and obtained these limiting values. The lower bounds on mass are found to be substantially higher than previous estimates.

SOLAR TERRESTRIAL PHYSICS

Hanumath Sastri examined the origin of the reported occurrence, confined to the equatorial electrojet belt, of positive (northward) values for a few hours around local noon in the asymmetric component of the H field, associated with the solar wind corresponding to quiet days with Ap ~ 5. He finds that the conspicuous short-lived positive deviation in the asymmetric component of H field does not manifest if 'abnormal quiet days' (AQDs) and hence the influence of counter-electrojet (CEJ) conditions associated with them are taken into consideration. He therefore points out

that the reported noon time positive swing in the asymmetric component of the H field at electrojet locations on quiet days with Ap_ 5 is primarily due to the changes in the local ionospheric dynamo region rather than in the bulk speed and/or number density of the solar wind. Sastri studied the dependence of the amplitudes of the Preliminary Reverse Impulse (PRI) and Main Impulse (MI) of SC(-+) on the equatorial electrojet strength at the time of its occurrence, using the extensive magnetogram data of Kodaikanal. He finds that the amplitudes of PRI and MI do not exhibit any definite relationship to the electrojet strength prevailing at the time of SC(-+). This finding suggests that the amplitudes of PRI and MI of SC(-+) at electrojet locations are influenced more by the magnitude of the transient change during SC in the dynamo region electric field rather than by the ambient strength of the equatorial electrojet.

Hanumath Sastri has in progress a programme of analysis of ionosonde data of selected equatorial stations aimed to assess the possible influence of the sector structure of Interplanetary Magnetic Field (IMF) on the characteristic behaviour of the equatorial ionospheric F_2-region. Results for the 19th sunspot cycle which are available show a definite effect of IMF polarity on the diurnal pattern of $f_o F_2$ and the post-sunset rise of F-region height. The influence, however, is seen only at the maximum of the sunspot cycle. The analysis is being extended to data for the 20th sunspot cycle.

INSTRUMENTATION

Bhattacharyya, Raghu and Jagadish developed a faint image detection system employing a four stage EMI Image Intensifier and Fairchild CCD type 221. In the system the intensified faint image at the intensifier out-put has been reimaged to the CCD by a wide angle relay lens. The CCD is kept in a cryogenic chamber to permit long integrations. A micro processor based system has been develcped in which the clock pulses required for CCD operations as well as the operation of reading out the charge packets from different pixels, digitization and further integrations are carried out. The digital picture is synthesised in an auxiliary memory bank. The system is to be used in the Coude spectrograph of the 102 cm telescope initially.

Santhanam fabricated a micro processor based system to perform several jobs of on line data processing from focal plane photoelectric instruments. Experiments visualised are fast photometry at sub millisecond sampling rates and multichannel spectrometer and scanner observations.

The system since completed has already been tried successfully at the telescope focus.

Bhattacharyya and Ramamoorthy developed a new photometer/counter system for use in photometry program in which simultaneous digital and analog records could be obtained.

Sastry and his co workers built a digital control system for Gauribidanur telescope for scanning the antenna beam in the North-South direction. Diode phase shifters were also installed in the East-West array to tilt the beam in hour angle. A special purpose digital system controls these phase shifters and provides the following the modes of operation:

1. Tracking in East-West direction for about 42 min.
2. Slew mode for fast scanning in East-West direction.
3. Scan while track: a 4x4 sequential beam matrix tracks a source.

This will be used for locating transient bursts on the sun. An on line interference remover is developed to remove impulsive interference.

Software necessary for retrieving data from the magnetic tapes has been improved and standardised. The applicability of the CLEAN algorithm on very large regions is developed and applied to the galactic survey observations. CLEANING with beams which suppress/enhance selected spatial frequencies is developed to get better estimates of fluxes.

Jain has developed an instrument for the measurement of linear polarisation of non magnetic white-dwarfs. The instrument employs an ADP crystal for chopping and synchronous detection of polarised light.

Scaria continued the work on construction of Iris photometer for determination of photographic magnitude from Schmidt plate. Considerable progress has been achieved.

In the optical shop further work on the optical components of the Infrared Telescope progressed. The rough grinding of the primary mirror was commenced and the 4,5 & 6 coude plates have been finished to an accuracy of $\lambda/4$ accuracy. Further work in this project is being continued.

Design of Hartmann screen for the 2.34 M mirror was finalised and fabrications started. A computer reduction procedure and programme for the evaluation of the mirror surfaces from the Hartmann data has been

developed. The results appear in the form of a spot diagram of light concentration at the focal plane of the mirror under test and a complete map of the surface departure in terms of λ. The method makes use of the least square procedures for the best fit of the data.

An improvement in the procedure of reduction of wire test data was made to give a unique curve independent of reference chosen and integration error minimised.

A general theory for the interferometric procedure for testing large concave aspheric surfaces using two crossed compensators was developed by Saxena. Further developments of the method by incorporating a two-dimensional detector array like CCD and on line reduction of the data have been taken up. The method of reduction will make up the least square procedure for obtaining a best fit of the surface represented by a Zernik polynomial.

Work on adopting a semi automated procedure of figuring has been started. Basically the processes involved are:

1. Determination and expression of the rate of surface wear produced by a surfacing tool (preferably small tool which can follow the aspheric surfaces more precisely and at certain stages large tool with predetermined pad distribution) which moves over the work surface in a prescribed pattern.
2. Application of wear prediction to specific surface correction using dwell time and pressure of the tool as variable parameters.

The fabrication of prototype 40 cm telescope proposed for UGC-ISRO scheme of expansion of astronomical studies in the universities was completed. The design and fabrication of the prototype of a 8 cm telescope for use in educational institutions was also completed.

Besides the work on 2.34 M primary mirror polishing and 48 inch primary mirror for Physical Research Laboratory, many optical components were produced in the laboratory. These consist of the flats for two big telescopes and coelostat systems for the Indonesia solar expedition as well as several hyperboloids paraboloids spheroidal surfaces for cameras and spectrographs.

Hanumath Sastri and Ramesh completed the overall integration of

the HF phase path sounder and the experimental set up is operating at Solar Terrestrial Relationships Laboratory, Kodaikanal. Logic circuitry has been developed and tested that will enable strip chart recording of the phase path variations of ionospheric reflections, from the quadrature outputs of the phase coherent receivers, with an accuracy of a wavelength of the probing radio wave frequency of 5 MHz. Regular recordings have been initiated.

Development of a direct-calibration type photometer for recording zenith intensities of certain night airglow emissions (OI 557.7 nm, OI 630 nm and OH (7,2) band) is being made by Hanumath Sastri and Saha.

234 cm TELESCOPE PROJECT

The 234 cm telescope project made all round progress in the various fields of operation, and is expected to be commissioned within this year. The dome has been commissioned after elaborate modifications for smooth movements. Several other auxiliary systems in the dome have also been commissioned. The 2.8 M aluminising plant was put in operation and underwent tests successfully. At the Walchandnagar Industries Ltd, the fabrication of the telescope mount components were completed and work on shop assemblies started. The drive and control system for the telescope made satisfactory progress at the laboratories of Bhabha Atomic Research Centre, Bombay. Several auxiliary and display circuit assemblies were completed in Institute's laboratories at Bangalore and underwent successful trials. The stage is now set for the final assembly of the entire telescope at Kavalur. The figuring of the 234 cm telescope primary mirror has reached a stage where the mean errors over the entire surface is around $\lambda/10$. Minor irregularities are being carefully removed before installation of the mirror in the telescope. A powerful on line computer system VAX 11/780 for control supervision and data processing has been ordered. The system will be installed and ready for starting its intended programmes immediately on completion of the main telescope system.

LIBRARY

During the year 1982-83, 291 books and 74 reports were added to the Library. The Library subscribed to 122 journals and continued to receive publications, preprints and reprints from other institutions on exchange basis.

OBSERVING CONDITIONS AT KAVALUR & KODAIKANAL

There were 1620 hours of observing at Kavalur. Photometric skies were available for 505 hours. On 94 nights spectroscopic work was carried out for a duration of 9 hours or more. Average seeing better than 1.5 seconds of arc prevailed on 50 nights. The monthwise distribution of these features are given below.

Table I

HOURS OF OBSERVATION AND SEEING AT KAVALUR

Month	Hours of Spectroscopic work	Hours of possible photometry	No. of nights when spectroscopic work 9 hours or greater was done	No. of nights average seeing bettern than 1.5"
1982 Apr	166	64	10	6
May	119	0	4	0
Jun	61	2	2	0
Jul*	26	0	0	0
Aug	61	2	1	1
Sep	103	6	4	1
Oct	149	20	7	6
Nov	83	14	3	6
Dec	209	44	13	7
1983 Jan	197	104	14	8
Feb	176	93	13	7
Mar	270	156	23	8
	1620	505	94	50

* No Observations due to aluminising the mirror.

Solar observations were made at Kodaikanal tower telescope on 118 days. The monthwise seeing conditions are given below. There was no occasion when the seeing was better than 2".

Table II

No. OF DAYS OF OBSERVATION AND SEEING AT KODAIKANAL

Month and year	Number of days of observation	Seeing	
		Greater than 2 and less than 4"	4" or greater
1982 Apr	18	7	11
May	19	7	12
Jun	4	3	1
Jul	5	2	3
Aug	5	5	4
Sep	4	2	2
Oct	4	1	3
Nov	5	1	4
Dec	7	2	5
1983 Jan	11	4	7
Feb	19	14	5
Mar	17	3	14
	118	47	71

LIST OF ACADEMIC STAFF

M.K.V.Bappu, Ph.D.	Director*
J.C.Bhattacharyya, D.Phil.	Professor
M.H.Gokhale, Ph.D.	Associate Professor
A.Peraiah, D.Phil.	Associate Professor
Ch.V.Sastry, Ph.D.	Associate Professor
G.A.Shah, Ph.D.	Associate Professor
K.R.Sivaraman, Ph.D.	Associate Professor
P.K.Das, Ph.D.	Reader
J.Hanumath Sastri, Ph.D.	Reader
N.Kameswara Rao, Ph.D.	Reader
R.K.Kochhar, Ph.D.	Reader
P.K.Raju, Ph.D.	Reader
S.Sirajul Hasan, Ph.D.	Reader
Vinod Krishan, Ph.D.	Reader
K.C.Abdur Raheem, B.Sc.	Fellow
Bhaskar Datta, Ph.D.	Fellow
Jagdev Singh, MSc.	Fellow
S.K.Jain, Ph.D.	Fellow
R.C.Kapoor, Ph.D.	Fellow
D.C.V.Mallik, Ph.D.	Fellow
T.P.Prabhu, Ph.D.	Fellow
R.Rajamohan, Ph.D.	Fellow
A.K.Saxena, Ph.D.	Fellow
K.K.Scaria, Ph.D.	Fellow
C.Sivaram, Ph.D.	Fellow
P.Venkatakrishnan, M.Sc.	Fellow
G.S.D.Babu, M.Sc.	Research Associate
S.P.Bagare, Ph.D.	Research Associate
A.K.Pati, M.Sc.	Research Associate
A.V.Raveendran, M.Sc.	Research Associate
B.S.Shylaja, M.Sc.	Research Associate
K.R.Subramanian, M.Sc.	Research Associate
G.Thejappa, M.Sc.	Research Associate
N.Gopal Swamy, Ph.D.	Visiting Scientist
Venkatesh, S.L., Ph.D.	Visiting Research Associate
Sushma Vasu Mallik, Ph.D.	Post Doctoral Fellow

The technical, administrative and non-technical maintenance staff numbered 255.

COUNCIL MEETINGS

The Governing Council had one meeting during the year at Bangalore.

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*until 19.8.1982

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SCIENTIFIC MEETINGS

Drs. Bhattacharyya, Kameswara Rao, Mallik and Peraiah attended the XVII IAU General Assembly, Patras, Greece, in August 1982. Drs.Gokhale and Kameswara Rao attended the Colloquium No.71 on 'Activity in Red Dwarf Stars', Catania, Italy in August 1982. Drs.Gokhale and Sirajul Hasan attended the IAU Symposium No.102 on 'Solar & Stellar Magnetic Fields' Zurich, Switzerland, in August 1982. Drs.Mallik and Peraiah attended the IAU Symposium No.103 on 'Planetary Nabulae' London, in August 1982. Dr. Hanumath Sastri attended a course on 'Geomagnetism, Ionosphere and Magnetosphere' at Internation Center for Theoretical Physics, Trieste, Italy during September & October 1982.

Prof.J.C.Bhattacharyya delivered Prof.M.N.Saha Memorial Lecture on 'New Techniques in Observational Astronomy' in January 1983.

Following scientific meetings were attended by scientists of the Institute who vitally contributed to the discussions and proceedings:

Drs.Bhattacharyya, Mallik, Scaria and Sivaraman	Neighbourhood Astronomy Meeting, Bangalore April 1982.
Drs.Bhattacharyya and Sivaram	Summer School, Bangalore, May-June 1982.
Dr.Bhaskar Datta	Delivered six lectures at UGC Advanced Level Institute on Relativity and Cosmology, Gorakhpur, June-July 1982.
Drs.Gopal Swamy	National Symposium on Instrumentation, Bangalore, June-July 1982.
Dr.Bhattacharyya	48th Annual Meeting of Indian Academy of Sciences, Nainital, October 1982.
Drs.Bhattacharyya, Datta, Gokhale, Jain and Sivaraman.	VIII Annual General Meeting of Astronomical Society of India, Gorakhpur, Nov 1982.
Dr.Raju	Invited expert for the RESPOND Program, Physical Research Laboratory, Nov 1982.
Drs.Das, Kapoor, Kochhar, Prabhu, Sivaram and Vinod Krishan	Winter School on Extra galactic Energetic Sources, Bangalore, January 1983.
Dr.Bhattacharyya	Thirty Years Commemoration Symposium, Calcutta, January 1983.