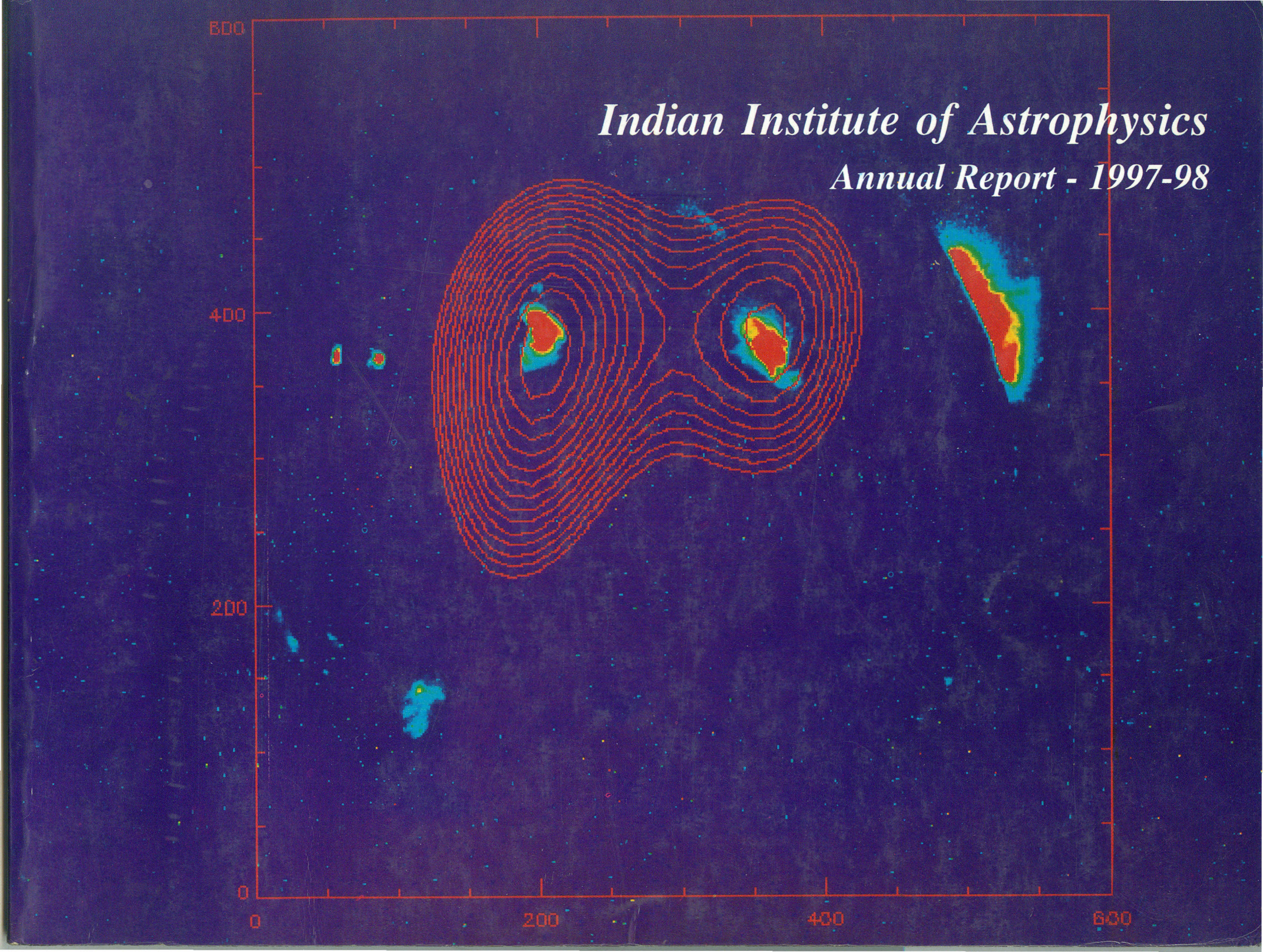
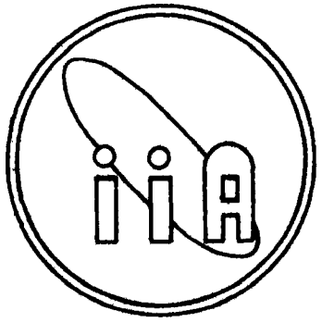
Indian Institute of Astrophysics

Annual Report - 1997-98



INDIAN INSTITUTE OF ASTROPHYSICS



ACADEMIC REPORT
1997-1998

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Editorial Assistance :

Sandra Rajiva

Front Cover : Radioheliogram of active region obtained from Gauribidanur.

Back Cover : Lab simulation of optical interferometry. Interferogram produced with seven holes at High Angular Resolution Laboratory, Bangalore.

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[1] Until May 15, 1997

[2] W.e.f May 16, 1997

Highlights of the year 1997-98

This year has been one of the most eventful years in recent times, marked by new initiatives, startling astronomical discoveries and academic honours in recognition of individual excellence. These achievements are supported by a body of systematic work on a variety of areas of physics and astrophysics.

Astronomical studies in India through optical and infrared wavelengths have always been maintained at a high standard with well planned observations from observatories in India and from international facilities including the Hubble Space Telescope. Observations from India are all the more crucial for studying how the intensity of light emitted by stars and quasars vary with time. This is because as the earth rotates the astronomical objects rise above the horizon at a particular time and set after about 12 hours. We can measure accurately the intensity of the emitted radiation only when the astronomical object is high in the sky, say only for about six hours each day – that too only if the star rises and sets at night. How can we measure precisely the variations of a star, if the typical time over which it varies is more than the six hours of observations available to us? This is accomplished through international collaborations: when the star sets in India it has already risen at La Palma in the Canary Islands (longitude $\sim$ 20 degrees west). The observatory there can continue the observations and when it sets at La Palma it is accessible to observations from observatories in America. The chain of observations thus continue and we in India can pick it up again when the Australian observatories (longitude about 160 degrees East) end their observations when the star is low on their western horizon. Thus we become essential and equal partners of international collaborations studying some of most exciting astronomical phenomena today. Our participation until recently was hampered by the cloudy skies that cover most of the Indian sub-continent, as a consequence of the summer and winter monsoons which prevent proper astronomical observations. Teams from the Indian Institute of Astrophysics with untiring efforts lasting over several years have discovered a remarkably good site at Hanle in southeastern Ladakh which is completely free from any interference by the monsoons. Moreover with its high altitude of 15200 ft., the skies there are comparable in quality to the best sites in the world located in Hawaii and in the Chilean Andes. Encouraged by this and having noted IIA's ability to fabricate telescopes and run observatories, the Government of India has entrusted the Institute with the task of setting up the Indian Astronomical Observatory at Hanle, with a sanctioned outlay of Rs. 38.49 crores. A dedicated team of about 20 scientists, engineers and administrators of the Institute are braving the cold and the thin high altitude air and are working very hard to accomplish the near impossible mission of setting up a 2-m aperture telescope at Hanle by October 2, 1999. Active and generous cooperation by various departments of the Government of India would help this team accomplish this mission, despite the challenges posed by the high mountains and place India prominently on the International scene. It is a matter of much satisfaction that astronomical activities in general and the upcoming observatory at Hanle are of great benefit to our Nation: Knowledge of the precise astronomical coordinates of the stars observed by the sensors aboard the Indian Remote Sensing satellites help to locate it accurately and thus provide the bases for preparing the maps depicting the earth-resources, ecological status and geological features. Laser-ranging of the satellites is possible year round from Hanle, improving the knowledge of their trajectories, so very essential for planning our satellite launches and preparing the IRS maps.

To return to the task on hand of setting-up the Indian Astronomical Observatory at Hanle, the 2-meter infrared and optical telescope has been designed and ordered, the 'first-light' focal plane instruments have been conceived and orders for their fabrication await the release of project funds. We have just started the construction of a facility to remotely control the telescope using a satellite communication link from a station at Hoskote, on the land donated by the Government of Karnataka, near Bangalore. The land for the observatory at Hanle measuring about 600 acres is provided by the Jammu & Kashmir government to IIA on a long term lease on extremely generous terms. All the ground work for the satellite communication link both at Hanle and at Hoskote is complete, and ready to be switched on as soon as the frequency allocation is made

In the current decade, it is becoming increasingly evident that the mac-

roscopic world of astronomy and cosmology is intimately connected with the microscopic world of the atoms and elementary particles. The 'gauge' symmetries enjoyed by the particles and fields, and indeed their spontaneous break down is believed to be responsible for the creation of the Universe as we see it today. Thus a holistic approach to the full understanding of either field is called for. Keeping these ideas in mind a beginning has been made by bringing together several physicists under the 'Non-Accelerator Particle Physics' group. As I will explain below, this group has already made a very important discovery which has opened up a new avenue for the study of the breakdown of mirror symmetry in atoms, technically termed parity non conservation.

Following up on the general rules, which govern the effects of parity non conservation (PNC) in atoms, the non accelerator particle physics group at the Institute has made the important discovery that the ions Ra+ have features that makes it an ideal system for the study of PNC effect. Even though electrons in the atoms are held by electrical forces, the PNC effect in atoms arises because there exists a small contribution to the binding by the radioactive force or "weak interaction" which is mixed with the electrical forces as shown by Abdus Salam and others. What our group has found is that there are transitions in the Ra+ ion which will not only allow the study of the usual PNC effect with unprecedented precision but also provide a clean probe into the effects of the "anapole moment" a closely related phenomenon. The paper describing their analysis has been published with much international acclaim in the Physical Review.

The main activity at IIA is of course Astronomy and Astrophysics – with interest covering a whole gamut of topics: Studies of the upper atmosphere and the ionosphere as a part of the Solar Terrestrial Energy interrelationship Program, Comets and asteroids - their orbits, dust shells and jets, theoretical and observational studies of the Sun, including a variety of phenomena like eclipses, chromospheric line emissions, radiative transfer, magnetohydrodynamics of flux tubes etc., stellar and galactic astronomy and high energy astrophysics. Amongst the various findings made by our scientists we highlight here a few studies which give the flavour of the discovery and excitement, that pervade these fields.

Anybody who has looked at the night sky from a place away from city lights, perhaps when hiking in the mountains, will agree that stars are indeed spectacular. They are even more so near the end of their life on the "main sequence" by which time they have exhausted their ability to burn hydrogen in their cores. What happens when they leave the main sequence substantially depends on their mass; in every instance we may expect some astronomical fireworks. After hydrogen burning (fusion) in the core is complete it shrinks under its own gravity and the temperatures in the core become high enough for helium nuclei to fuse together to form carbon with rapid release of huge amounts of energy. As a consequence the outer regions of the star containing unprocessed hydrogen and other elements rapidly expand to more than 100 times the size of the Sun into a "red giant". Thereafter, usually much of the star evaporates away in fast expanding wind. If the initial mass of the star is less than about 5 solar masses then a core of mass less than 1.4 $M_\odot$) collapses to form a white dwarf as predicted more than 60 years ago by Chandrasekhar. When such an object forms its surface is effectively at a temperature of 100,000 degrees Kelvin and consequently emits copiously ultraviolet radiation which illuminates the surrounding gas and makes it glow by fluorescence, in what William Herschel named as a 'planetary nubula'. The whole process of the transformation from a red giant to a planetary nebula takes about 10,000 years, and the nebula itself fades away in about the same time as the star cools down to a typical white dwarf and also the gas slowly expands away.

Thus it is most remarkable that Parthasarathy and his colleagues discovered a star which was in the process of turning into a planetary nebula. What was surprising was the speed with which this object had evolved. They estimate that the nebula must have formed within the last 20 - 40 years. They have recently taken excellent pictures of this object with the wide field planetary camera of the Hubble Space Telescope. These pictures reveal a wide variety of interesting astronomical features. This object because of its shape has been named the 'sting ray' nebula and its picture has been printed on the cover of Nature along with their paper in a recent issue.

Another equally remarkable discovery has been made by Kameswara Rao and his colleagues – they have seen what appears to be a reverse

Inauguration of the Indian Astronomical Observatory on 16th October 1997

evolution of a star known as the 'Sakurai Object' from being a hot dwarf with a surface temperature of about 50,000 degree Kelvin into a bright yellow supergiant with a surface temperature of about 5000 degrees Kelvin. As the authors express it, this is a 'born again giant': Originally it was a redgiant on its way to become a common white dwarf. Through a complex set of physical processes involving helium burning in the core described in detail in their papers, hydrogen from the surface layers is convected into the star to refuel it. The additional energy release has caused the 'photosphere' to expand, and simultaneously cool the star to lower temperatures. The spectral observations also provide evidence for the process of element synthesis in the star called the s-process where neutrons are added slowly to nuclei and heavy elements are built up along the track of radioactively stable nuclei.

If the mass of the star on the main sequence is large, say in the range 8 - 20 $M_{\odot}$, then at the end of nuclear burning when all the fuel is exhausted, the core collapses under its own gravity and the star explodes as a supernova whose brightness exceeds that of one billion suns. These supernovae are so bright that they can be observed with modern telescopes even when they occur in galaxies at the edge of the Universe. Their study provides a fund of information on many aspects of physics, astrophysics and cosmology, for example on the properties of neutrinos, synthesis of heavy elements and the value of Hubble constant describing the expansion rate of the Universe.

Often such a supernova leaves behind a 'neutron star' of mass in the range about 1 - 2 $M_{\odot}$. The radius of the star is only about 10 km which makes it one of the densest object known to man - a tiny part of such a material the size of a mustard seed will weigh more than 10 million tons! Theorists of the Institute are experts on the physics of such objects and have recently computed the equilibrium sequences of rotating neutron stars, assuming new realistic equations of state. Such calculations are crucial in the understanding of the quasi periodic X-ray emissions from such objects, which occur when they are orbiting around a companion star.

In many instances, the neutron stars are threaded by intense magnetic fields, 10^{12} Gauss or more, and are rotating rapidly with periods of less than a second. As electrons stream along the open field lines near the poles of such an astronomical object, radiation at various frequency bands emanate from it. Because of the spin such an object looks like a light house producing periodic pulses; it is therefore apty called a pulsar. Recently IIA scientists have made a detailed study of the physics and geometry of such pulses including the effects of strong gravity expected close to such massive and condensed objects.

Black holes are even more extreme type of objects. In fact if the mass of the collapsing core is more than 4 $M_{\odot}$ it will end up as a black hole. There are also enormous black holes of mass more than a million solar masses at the centres of active galaxies and quasars. These accrete matter from the surrounding regions and as the matter falls into the deep potential well of the black hole it will emit radiation at various wavelengths from infrared to even high energy gamma rays. The recent measurements of the gamma ray spectrum of the object 2EG J1746-2852 by the EGRET instrument aboard the satellite borne Compton Observatory confirms the theoretical predictions of the spectrum made by IIA scientists, and indicates the presence of strong shocks in the accretion flow. The rapid variability of the intensity of the emitted radiations observed by the astronomers of the Institute, tend to support the idea that quasars and active galactic nuclei are indeed powered by accretion of surrounding material on to super massive black holes.
I have given here only a sample of some of the research findings of the members of the Institute. More details may be found in the accompanying report and the extensive list of papers provided at the end of this report. Besides purely scientific work, welfare measures and training programs, particularly for junior staff members of the Institute have been initiated. The astronomical community of the Institute , of the nation and indeed of the world is keenly awaiting the commissioning of the 2m telescope telescope at the Indian Astronomical Observatory, Mt Saraswati, Digpa Ratsa Ri, Hanle, Southeastern Ladakh, India.

Ramanath Cowsik
Director

SUN AND SOLAR SYSTEM

1. SOLAR PHYSICS

1.1 GLOBAL PROCESSES

1.1.1 On Sun's Spin-Orbit Coupling

Sum, Σ_L, of the angular momenta of sun and planets on first day of each month from January 1800 to December 2000 was computed using barycentric positions of sun and planets given by the JPL ephemeris DE403, which is much more accurate than the Bretagnon-Simon ephemeris used earlier. The variations in Σ_L were found to be much smaller than those evaluated using Bretagnon- Simon ephemeris and larger than the computational error, but comparable to the observational errors in the past astronomical data used in the ephemeris. It is inferred that it is difficult to estimate the solar spin-orbit coupling using even the JPL ephemeris.
(M. H. Gokhale and K. N. Kutty)

The part, $\mathbf{T}_{dis}$, of the gravitational torque exerted on the sun by other bodies in the solar system, which gets discounted in the "point mass approximation"(PMA), is expressed analytically in terms of the instantaneous relative positions of the sun and the other bodies, taking into account the finite size of the sun. From known properties of the planetary orbits it is shown that $\mathbf{T}_{dis}$ is $\sim 3.10^{33}$ dyne cm, and has frequencies near the conjunction frequencies $\nu_{p,p'}$ of planetary pairs. Since the main (observationally indicated) torsional MHD mode contributing to solar magnetic cycle has its frequency near the jupiter-saturn conjunction frequency, $\nu_{J,S}$, it is possible that $\mathbf{T}_{inert}$ can maintain that mode with a quasi-steady state. The quasi-steady toroidal field amplitude will be $\sim 10^4 - 10^5$ Gauss depending upon the radial extent of the torsional mode. Corrections due to such spin-orbit coupling, in the orbital parameters given by JPL ephemeris might be ignorable at the level of accuracies of the past astronomical data used in the ephemeris.
(M. H. Gokhale)

1.1.2 Sun's Torsional MHD Oscillation Modes

Frequencies and eigen-functions of a few of sun's toraional MHD oscillations have been calculated assuming the model computed by Hiremath and Gokhale (1995) for the steady part of sun's poloidal magnetic field. The preliminary results indicate that the fundamental mode may contain odd Legendre orders upto $l \sim 17$.
(M. H. Gokhale and H. M. Antia*)

1.1.3 Solar Global Seismic Model and Neutrino Fluxes

We continued the development of solar seismic model by solving the stellar structure equations with the constraint of the sound speed inferred from helioseismology. We used the sound speed of Takata, (University of Tokyo), inverted by the frequency data of LOWL and frequency data obtained from the observations at the South pole, Antarctica. For solving the stellar structure equations, auxiliary information such as equation of state, opacity and nuclear energy generation are needed. Since, MHD equation state tables contain for $Z = 0.02$ only, we adopted the OPAL equation of state tables where we get for wide range of Z values. As for opacity tables, we used the latest version of OPAL opacity tables. We continued to use in this calculation Bahcall's routine for the nuclear energy generation. The summary of the work is as follows. We solved the basic stellar structure equations with the imposition of sound speed, inferred from the helioseismology, and developed a *global* seismic model which consists of two parts, *viz.*, the radiative core and the convective envelope. In the region of the radiative core, we solved all the four structure equations and deduced the mass, luminosity, pressure, temperature, density and hydrogen and helium abundances. We considered the mass and the pressure as initial conditions at the base of the convection zone and solved the equations of conservation of mass and hydrostatic equilibrium in order to satisfy the outer boundary condition of one solar mass. In the convective envelope, temperature has been obtained by the equation of state only.
We found that the *global* seismic model that satisfies one solar mass at the surface is a strong function of the sound speed profile near the center and is a weak function of either depth of the convection zone or heavy elemental abundance Z. It is also found that the sound speed profile which deviates near the center by $\sim 0.22\%$, from the sound speed profile of the evolutionary model, satisfies one solar mass at the surface. The deduced global structure profiles are almost similar to the structure profiles of the evolutionary models. From the deduced

property of the super adiabatic gradient, $(\nabla - \nabla_{ad})$, in the convective envelope, we found that $(\nabla - \nabla_{ad})$, depth of the convection zone and local minimum of the first zone of helium ionization are related with one another This important property enabled us to estimate the base of the convection zone to be $0.718 R_{\odot}$.

We used the seismic model for the estimation of the neutrino fluxes and capture rates of the chlorine (Homestake), gallium (GALLAX & SAGE), and Kamiokande experiments. It is found that estimated capture rates are significantly larger than the capture rates obtained from the observations
(K M Hiremath and H Shibahashi*)

1.1.4 Consistency of the Rotational Solution in the Solar Convective Envelope

Using Chandrasekhar's MHD equations, we have continued the modeling of solar internal rotation. After solving the basic equations, we used to compare the solution of rotation with the rotation inferred from the helioseismology. In this way, from the previous study, we concluded that the base of the convection zone rotates differentially. However, some of the helioseismic inferences are not in full agreement with our conclusion. Moreover, helioseismic studies require *a priori* information regarding the internal rotation in their inversions. Hence, in order to get an independent conclusion regarding the state of rotation near base of the convection zone, we undertook the following study whose summary is as follows.

It is shown that the steady part of rotation in the Sun's convection zone can be determined as an analytical solution of Chandrasekhar's MHD equations in an incompressible medium of constant diffusivity. The solution yields qualitatively the isorotation contours similar to helioseismologically inferred isorotation contours. Instead of comparing the isorotation contours, obtained from the solution of MHD equations, with the helioseismologically inferred isorotation contours, consistency of the solution is checked independently. It is found that solution of the MHD equations is consistent if base of the convection zone rotates *differentially* rather than rigidly.
(K.M. Hiremath)

1.2 LOCAL PROCESSES

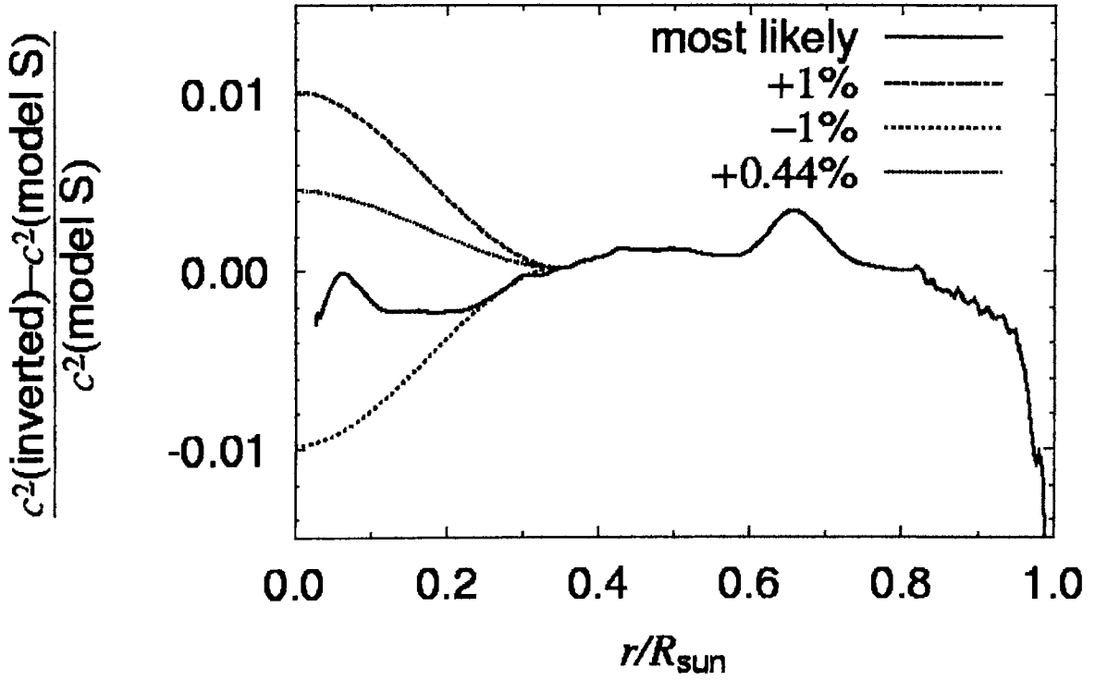
1.2.1 Spectral Line Radiation from Solar Small-Scale Flux Tubes

We examine the spectral line radiation from small-scale magnetic flux tubes in the solar atmosphere. This is a continuation of work by Kneer, Hasan & Kalkofen (1996, Astron. & Astrophys. 305, p. 660). The motivation of this work is to develop flux tube models which agree with observations.

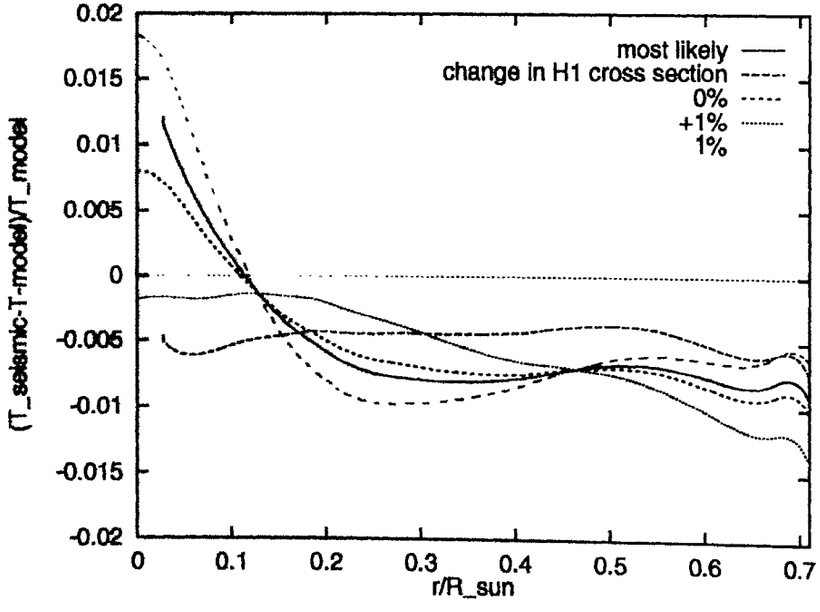
One method of determining the physical parameters that reproduce the observations is to apply inversion techniques, i.e., to find a set of parameters by a least squares fit of the calculated intensities in comparison with observation. In the present investigation we prescribe a model for the temperature as a function of height in the external atmosphere and calculate flux tube models. Earlier we adopted an atmosphere resembling the empirical quiet Sun model for the ambient medium. In the present study, we iteratively adjust the temperature structure of the external atmosphere to fit the Stokes profiles with those obtained from observations.

The spectral line radiation from the tubes is determined using the procedure adopted in Kneer, Hasan & Kalkofen (1996). Emergent intensities, including Stokes profiles, are calculated from rays parallel to the tube axis. From the models we determined the emergent intensity of the radiation field as the weighted mean of the contributions from the flux tube and the surrounding gas. We then reduced the mismatch between observed and computed intensities by modifying the atmosphere external to the flux tube and adjusting the internal atmosphere consistent with the modification.

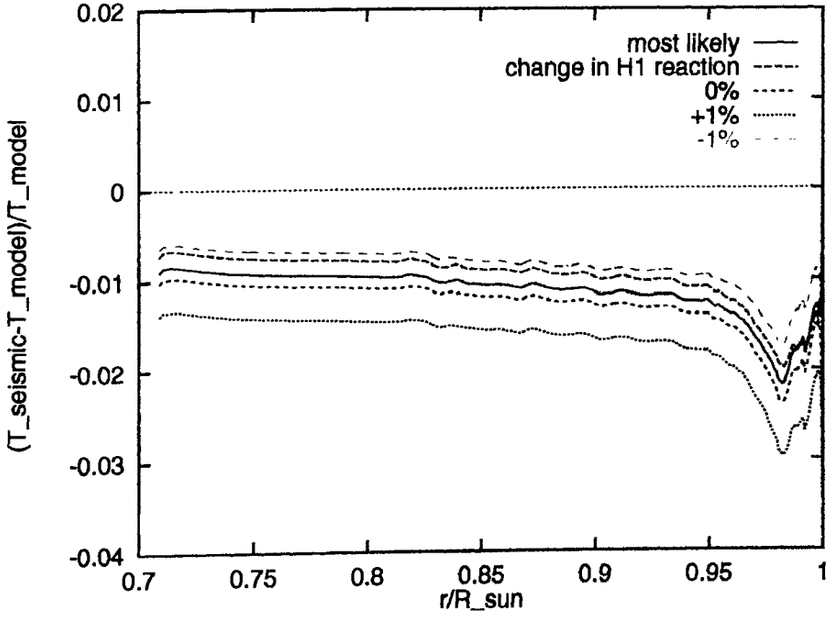
From the comparison of the flux tube and the ambient medium with the quiet Sun we note that, at a depth of about 200 km below the photosphere, the flux tube (and the ambient medium) is cooler than the quiet Sun, reflecting the strong inhibition of convection by the magnetic field in the flux tube, an effect that extends into the surrounding medium; Numerical simulations reveal that the radiative cooling induces inflow from the sides towards the magnetic tube and convective downflow, which amplifies the area involved. Above this depth, the flux tube is



The inverted squared sound speed used as the imposition in solving stellar structure equations. We modified the most likely profile in $r/R_\odot < 0.35$, and found that the curve labelled "+0.44%" satisfies the outer boundary condition $\Delta M = 0$.



The relative difference in the temperature between seismic solar model and standard solar model S in the region of radiative core.



The relative difference in the temperature between seismic solar model and standard solar model S in the region of convective envelope.

hotter than the quiet Sun.
Comparing our models for the flux tube and the ambient medium we see that the flux tube is hotter than the ambient medium above the base of the photosphere, showing the effect of the longer mean free path in the tube and cooler below, presumably owing to the reduced convective flux because of the strong magnetic field in the flux tube.
Our models of the flux tube and the surrounding atmosphere reproduce the observed intensities. There is agreement among the models that small-scale flux tubes, including also the nearby outside atmosphere, have a much flatter temperature structure than the quiet solar atmosphere. To arrive at the observed average continuum intensities (at moderate spatial resolution) and the observed Stokes profiles, the flux tube itself should appear only moderately brighter in the continuum than the quiet Sun, at disc centre, while the nearby gas exhibits lower intensity. This is in agreement with observations. In contrast, the higher layers in the flux tube are hotter than the undisturbed atmosphere. This can be understood by the radiative heating from the subphotospheric layers of the partially evacuated magnetic flux tube.
(S.S. Hasan, F. Kneer* & W. Kalkofen*)

1.2.2 Depth Dependence of Magnetic Fields in the Convection Zone

It is generally accepted that the small-scale magnetic field at the solar surface is structured in the form of vertical magnetic flux tubes with field strengths around 1500 G and diameters of about 100 km. Various observations have determined that flux tubes occur preferentially at the intergranule boundaries, which are also the sites of downflows. This suggests that flux tubes are surrounded by plumes of down flowing material, in which the temperature is lower than the average surrounding temperature. We find that this has interesting consequences for the depth variation of the magnetic field.
In the present investigation we develop a theoretical model for the equilibrium structure of a vertical flux tube by including the presence of downflowing plume just outside the flux tube. Physically, the Reynolds stresses associated with the downflowing gas, effectively increases the external pressure, leading to a larger field strength (on account of horizontal pressure balance). This is based on earlier work by van Ballegooijen (1984, in: *Small scale dynamical processes in quiet stellar atmosphere*, ed. S.L. Keil, Sunspot: National Solar Obs., p.260) where the stresses for turbulent flows in the convection zone were estimated using mixing length theory. It was found that the field strength in the photosphere could be determined by specifying its value at the base of the convection zone. The calculations showed that the surface value was insensitive to the choice of strength at the base of the convection zone. However, the surface value calculated using the above model turned out to be smaller by at least a factor of 2 than that suggested by observations. In the present investigation, we re-examine this question by using numerical simulations to compute the Reynolds stresses just below the photosphere. This refinement leads to a much better fit of the computed field strength at the surface with observations.
The calculations show that the downflows in the immediate surroundings of flux tubes play an important role in determining the magnetic field strength as function of depth in the convection zone. Using a simple model of the convection, we are able to reconcile the presence of relatively weak fields in the deeper layers $\epsilon \sim 10^{-5}$ with the existence of kilogauss fields at the solar surface $\epsilon \sim 1$ (ϵ is the ratio of magnetic to gas pressure). The surface field strength is virtually independent of the field strength at the base. The predicted surface field strength of 1000 G is somewhat smaller than the observed values. This may be due to the fact that the flux tubes are actually located in the coolest parts of the downflows (i.e, cooler than the average downflow). Alternatively, the flux tubes may be cooler than their local surrounding in the first few 100 km below the surface due to radiative transfer effects. Further refinements to the model are being worked out.
(S.S. Hasan & A. van Ballegooijen*)

1.2.3 MHD Waves

The dispersive characteristics of magneto-acoustic waves in solar atmosphere for a structured plasma is studied. In this study, the propagation vector as well as the magnetic field are assumed to be non parallel to the interface of the plasma which has a discontinuity in the density and the magnetic field. The fluid is assumed to be infinite. The effect of shear flows on the propagation characteristics of magneto-acoustic waves is also being studied. The dispersion relation for a fully compressible,

infinite fluid, with shear and inclined magnetic field with density discontinuity has been derived Limiting cases of plasma parameters will be worked out The dispersion relation will be solved numerically for various parametric values describing the model The nature of these modes for low β plasma limit is being studied
(A Satya Narayanan, P Joardhar, V. Nakariakov*)

1.2.4 Hydrodynamics

The effect of uniform rotation and gravity is being considered to study the temperature of self-organised flows for quasi two dimensional flows. In addition to studying self-organisation in hydrodynamic flows, we propose to study with magnetic flows The conservation of energy and enstrophy (potential) for the above has already been proved. We have set up a variational formulation taking into account the above new effects We are looking for closed form solution of the above variational equation We propose to study plasma vortices in the above system.
(A Satya Narayanan and Chandra Das*)

1.2.5 Dynamical Behaviour of Umbral Depression in Sunspots

Our detailed study confirms the already reported preliminary findings that a large proportion of spots do not have the umbral depression and hence do not display the Wilson effect. These results have been infer red from accurate measurements on 435 spots selected out of 2000 spot groups observed during the solar maximum 21 at the Kodaikanal observatory during 1979-82 A careful investigation of the phenomenon has been completed We find the interesting new insight of a dynamical behaviour of the umbral (Wilson) depression or an 'elevation,' of the umbra which depends on whether the spot is magnetically unipolar or bipolar, that is whether or not the given spot has an accompanying opposite polarity spot or not The umbral elevation is seen in very 'active' phases of spots in terms of flaring in the region and also the associated X-ray emission variability apparantly from the loop tops in the bipolar spots. The dynamical behaviour of spot umbrae has a significant bearing on many other related phenomena of the spots and we are examining these aspects in the light of recent developments in sunspot observations in high resolution and from space platforms.
(S.P.Bagare and S.S.Gupta)

1.2.6 Morphology and Evolution of Ca II Network Cells

Studies on the Ca II K data obtained from Antarctica were continued. The dependence of lifetimes of the network is quantitatively explained in terms of diffusion rates of magnetic elements. The diffusion rate is estimated to be about 125 $km^2 s^{-1}$ in the quiet network and 70 $km^2 s^{-1}$ in the enhanced network, in agreement with the observed ratio of the respective lifetimes. At present we are studying cell morphology by a study of individual cells. Our preliminary results indicate an interesting correlation between cell scales on the one hand and cell shape and temperature contrast on the other. Larger cells were found to have more corrugated walls and hence less circular shapes than smaller cells. Temperature contrast for larger cells was found to be greater.
The dependence of correlation lifetime on length-scale was studied. The form of the life-scale relation is inferred by comparing the distribution of the two parameters. A linear dependence of lifetime on cell area, with a least squares fit slope of 3.34×10^8 sq-km/s, is deduced. The relation can be explained by assuming cells evolve by a diffusion process of the magnetic field elements.
Hagenaar et al.1997 (ApJ,bf 481.988) have applied a method of tessellation to Ca II images. They have interpreted the tiles as actual network cells, which leads them to claim that cell length-scales are typically in the range 13-17 Mm, which is close to half the traditional value. The method of tessellation we employ yields a length-scale spectrum in agreement with theirs. But by examining the relative positions of individual tiles and cells at close-up, we find that they do not correspond to each other. Rather tiles tend to coincide with network elements, which explains their relative smaller sizes.
(R. Srikanth, Jagdev Singh, K.P. Raju)

1.2.7 Modelling of Coronal Emission Line Profiles

A radiative transfer model of coronal green line [Fe XIV] 5303 A is developed. The effect of mass motions in coronal loops on emission line profiles is examined. The various loop parameters such as electron density, kinetic temperature and loop geometry are varied and the resulting profiles are obtained. The model line profiles were found to agree with the observed line profiles.
(K.P. Raju)

1.2.8 Coronal Loops

The stability of coronal loops is being studied. The steady state of the loop is expressed as superposition of Chandrasekar - Kendal functions which form an orthogonal set. The velocity is expressed as superposition of these modes. The pressure and temperature is derived from the ideal MHD equations. Once, the steady state solution is derived, the conventional procedure of studying the stability is the normal mode approach. However, this approach would lead to an eigenvalue problem which in general is hard to study. The alternative is to use the theorems of dynamical systems where the stability of the system is determined from the eigenvalues of the matrix which is calculated from the stagnation point of the flow. This approach was successfully adopted for studying the stability of self-organised flows for quasi two dimensional system. In this study, we hope to study the stability of the coronal loops using the above result. We have already determined the steady state solution of the coronal loops in three dimensions. The stability is underway and will be completed shortly.
(A. Satya Narayanan)

1.2.9 Analytical Model for Solar Quiescent Prominences

Based on reasonable assumptions and mathematical approximations a one dimensional, analytical model for solar quiescent prominences is constructed, which is in both magneto-hydrostatic and thermal equilibrium. Thermal equilibrium here is a balance among thermal conduction, radiation and wave heating. The wave heating (H) is assumed to be equal to a constant (E_H) times the product of pressure (p) and density (ρ). We find the limit on the value of E_H for existence of prominence type solution. For given values of E_H, temperature at the center of prominence (T_0), gas pressure at the center of prominence (p_0) and the temperature at the edge of prominence(T_*), we found the following limits on the variables for the existence of the equilibrium: (1) the lower limit on the value of gas pressure at the edge of prominence (p_*), (2) the upper and lower limits on the length of the magnetic field line from the center to the edge of the prominence and (3) the upper limit on the value of $W_0 sec\phi_0$ where W_0 is the width of the prominence and ϕ_0 is the shear angle.
For specified values of T_0, T_*, p_0, E_H the existence of the solution depends on the value of $W_0 sec\phi_0$. Depending on this value there exist either no solution or one solution or two solutions. In the latter case In Type 1 solution, equilibrium is nearly isobaric and the magnetic field is strong and nearly horizontal. Conditions in this solution approach those in a real prominence as $W_0 sec\phi_0$ approaches its maximum value. In Type 2 solution , there is a large variation of gas pressure from the center to the edge, and the magnetic field is weak and nearly vertical. Conditions in this solution approach those in a real prominence as $W_0 sec\phi_0$ approaches its maximum value.
The same problem is being extended to a quasi two dimensional prominence model. In the quasi two dimensional problem,the number of equations are one less than number of unknowns,thus we have to introduce one more equation, or an additional constraint on the physical variables involved in this problem. By assuming the sum of magnetic pressure and plasma pressure as constant the following results were obtained.
1. For a given field strength, there exists a maximum value of shear angle up to which only the solutions of magnetohydrostatic equations will exists. This value is decreasing with the increasing field strength.
2.For a very low value of field strength there is a minimum value of shear angle above which only prominence type of solution will exist. This value increases with the increasing field strength.
(B.S. Nagabhushan)

1.2.10 Enhanced Coronal Heating in 5303

Observations show that, the enhanced coronal heating marks the strongest magnetic field found on the Sun, which are found in active regions having sunspots. As the sunspots are poor indicators of the lifetime of active regions, we are studying with respect to calcium plages. This activity is a magnetic phenomenon and at times it is related with micro and sub flares also. The Stanford magnetograms and flare data published in Solar Geophysical Data is being used. To begin with we have started from Sunspot minimum year (1985 and 1986). The data collection for these two years is over. The preliminary results indicates; (1) A strong gradient of the magnetic field is required for the observed enhanced coronal intensity in 5303. (2) The disappearance of the observed coronal intensity more or less coincides with the disappearance

of underlying calcium plages. (3)The activity in the underlying active regions in the chromosphere indicate the activity in the corona.
(B S Nagabhushana, K B. Ramesh and Baba Varghese)

1.3 INSTRUMENTATION

1.3.1 Laboratory simulation of interferometric imaging

Interferometric imaging is one of the methods to achieve higher spatial resolution An astronomical source was simulated in the lab and imaged interferometrically. A glass plate sprayed with silicon oil was used to distort the wavefront. A mask containing several holes was placed in the parallel beam In such cases, several sets of fringes modulated by the diffraction pattern of a single hole, are formed at image plane. The contrast of the fringes gives visibility amplitude of the source The position of the fringes with respect to that of a point source gives the visibility phase Using the closure phase technique used in radio astronomy, visibility phase is calculated. The object is reconstructed by Fourier inversion.
(R Sridharan)

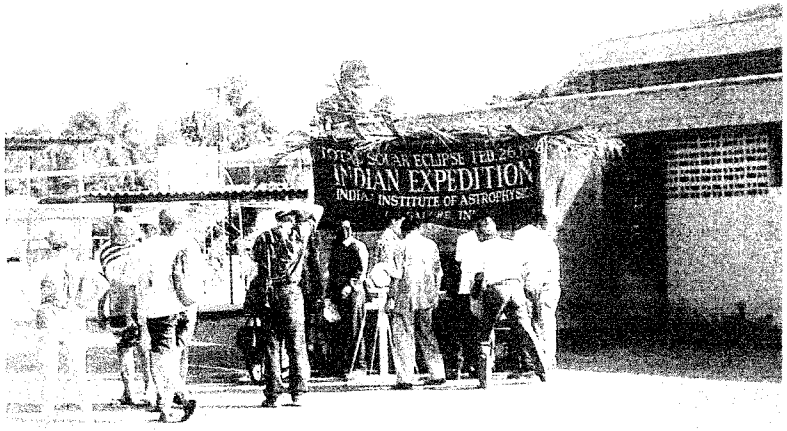
2. SOLAR TERRESTRIAL PHYSICS

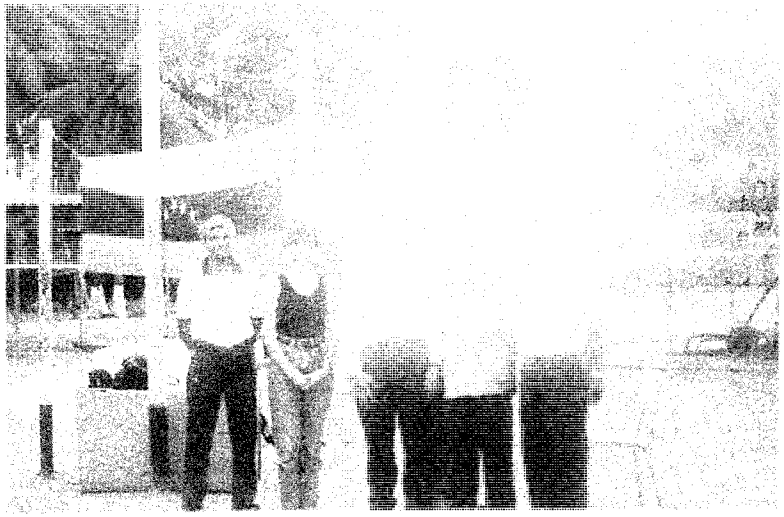
2.1 Equatorial Ionosphere

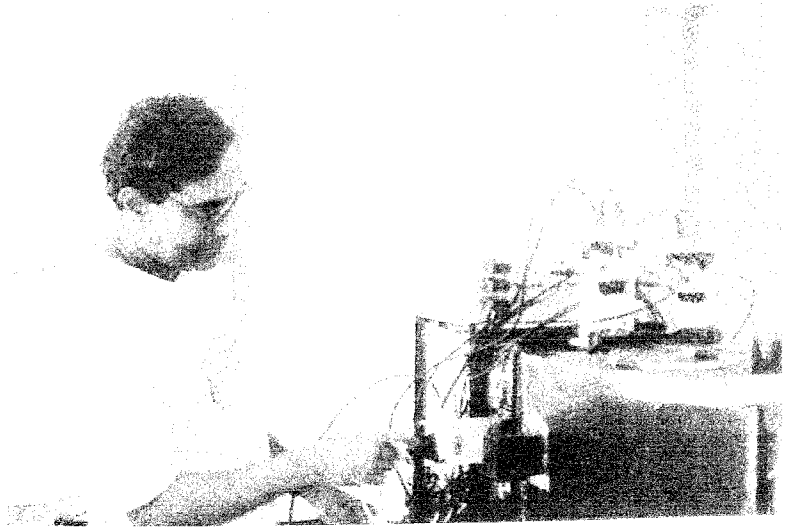
The regular sunset enhancement of upward drift of equatorial F region plasma is observed to be abnormally large on certain quiet days ($Ap \leq 5$) as manifested by an anomalous increase of F region height. We explored the origin of this extreme form of the quiet-time variability of postsunset vertical drift/height through case studies using data from the Kodaikanal ionosonde and the magnetometer network in the country. It is found that on the days with an unusually large dusktime increase of F region height over Kodaikanal, the diurnal profile of the equatorial electrojet (EEJ) strength is severely distorted (with a shift, in some cases, of Sq(H) phase from the usual time interval, characteristic of the abnormal quiet days, AQD) with enhanced EEJ conditions in the postnoon period (1300-1600 LT). This is accompanied, near the magnetic equator, by higher values of F layer peak height (*hpF2*) and lower values of peak electron density (*f0F2*) in the early evening period (1600-1800 LT), compared with the monthly median/quiet day mean values These changes in EEJ and *hpF2/f0F2* are consistently seen in all cases studied. We interpret that the perturbations in plasma density distribution of equatorial F region, increase the thermospheric zonal wind and its local time gradient as well as the ratio of flux-tube-integrated Pedersen conductivity of the F to E region. These modifications just prior to sunset, prompt an efficient F region dynamo action, resulting in the observed abnormally large dusktime increase of F region height. The study strengthens the view that the postsunset behaviour of the equatorial ionosphere is sometimes predetermined by the properties of the thermosphere-ionosphere system in the early evening hours.
(J.H. Sastri)

In-depth case studies are made to characterise the features of the dynamics of the ionosphere-thermosphere system that favour the occasional postsunset onset of range spread-F at Fortaleza, Brazil (dip latitude 1.8 S) during the June solstice. This is the season in which frequency spread F is typically seen while range spread F is remarkably inhibited at Fortaleza. The onset of range spread-F studied is thus an

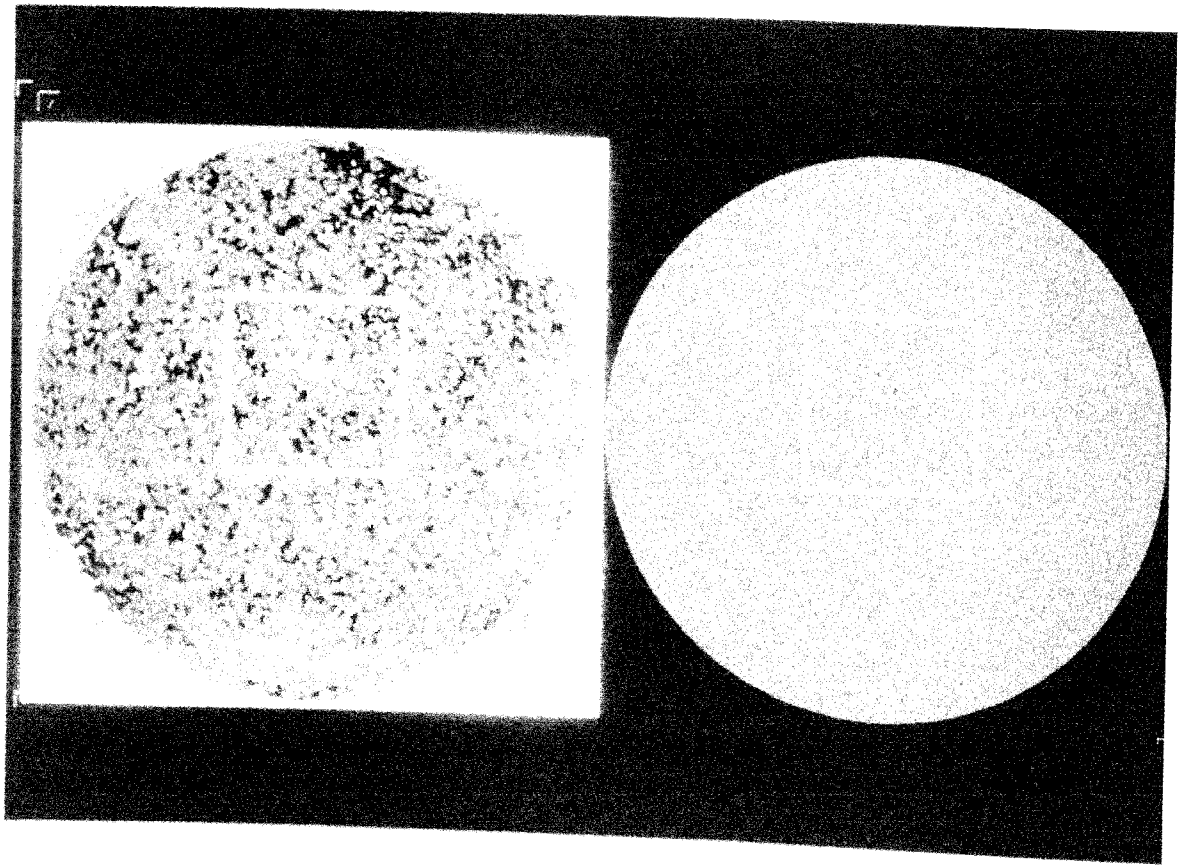
Indian expedition that observed the Total Solar Eclipse of 26th February 1998 from Venezuela



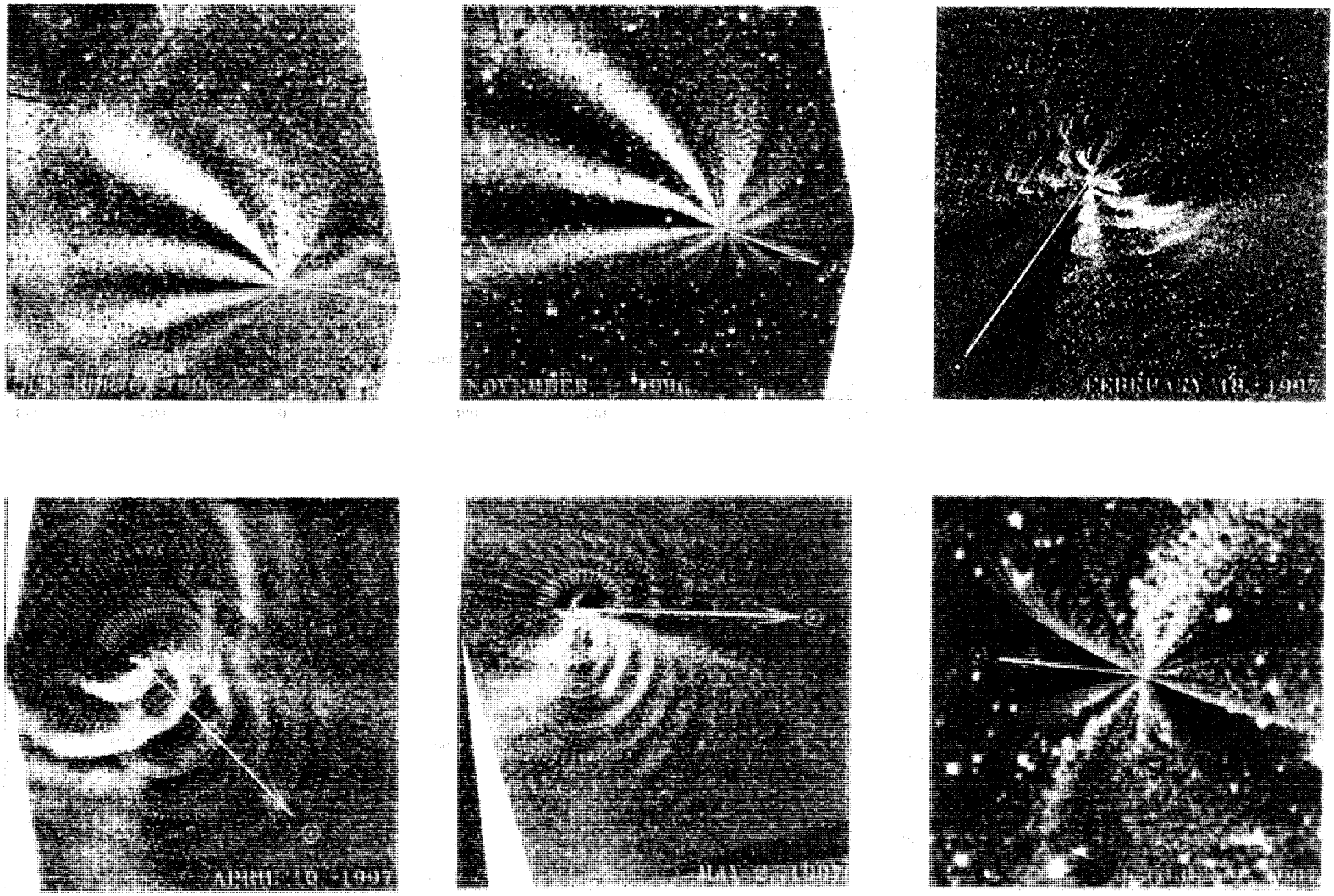




Magnetic Control of He II Excitation



overlaid by SOHO / MDI magnetogram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exception to the rule and has relevance to the topic of day-to-day variability of equatorial spread F of much current research. The satisfying outcome of the work is the unambiguous identification of differentiable ambient ionospheric conditions between days of range spread F and frquency spread F. It is found that an impulsive and large F layer vertical drift (20 - 60 m/sec) prevails in the early evening hours on days of range spread F, in contrast to the average pattern of a slowly varying vertical drift of moderate amplitude (15 - 18 m/sec). There is no significant change in the pattern or magnitude of low-latitude meridional winds between the days of range and frequency spread F at Fortaleza. This suggests that meridional wind variability does not play a important role in creating favorable conditions for range spread F on a day-to-day basis in the June solstice. The prerequisite for the occasional occurrence of range spread F is the presence of an impulsive and large vertical plasma drift, a condition favorable for destabilization of the bottomside F layer through Rayleigh-Taylor (RT) instability mechanism. Evaluation of the generalized RT growth rates for the specific events supports the interpretation. The anomalously large F layer vertical drift seen on range spread F days is associated with moderately disturbed geomagnetic conditions as well as quiet conditions. Short-lived prompt electric field disturbances due to auroral substorm activity is ascertained to be the cause of the large F layer uplifts under disturbed geomagnetic conditions.

(J. H. Sastri, M. A. Abdu*, I. S. Batista* and J. H. A. Sobral*)

2.1.2 Electrodynamic Coupling of High Latitude-Low Latitude Ionospheres

We have studied the geomagnetic and ionospheric manifestations of DP2 activity that occurred on April 7, 1995 using the high time resolution measurements of F layer vertical drift, Vz over Kodaikanal, India with the HF Doppler radar and magnetometer data of IMAGE network in Scandinavia and at Alcantara, Brazil. Quasi-periodic fluctuations in dusktime (1730-1900 LT) F layer vertical drift occurred over Kodaikanal *coherent* with DP2 type magnetic fluctuations (period $\sim$ 25 minutes) at the dayside dip equator (Alcantara) and auroral/subauroral latitudes (IMAGE network stations). The DP2 -associated vertical plasma drifts are upward (amplitude 13-33 m/sec) implying eastward electric field disturbances. These *firstever observations* of ionospheric plasma motions due to DP2 electric fields at the duskside dip equator are in agreement with the two-cell equivalent current system proposed for DP2. The results demonstrated that the transient component of the magnetospheric electric field responsible for DP2 magnetic fluctuations penetrates, through the polar ionosphere, to the equatorial ionosphere on the duskside as on the dayside. An additional observation is that the amplitude of the plasma drift fluctuations increases towards the nightside – suggesting a contribution of sunset electrodynamics to the observed signature of DP2 electric fields.

(M. A. Abdu*, J. H. Sastri, H. Luhr*, H. Tachihara*, N. B. Trivedi* and J. H. A. Sobral*)

3. SOLAR SYSTEM STUDIES

3.1 COMETS

3.1.1 Studies of Comet Hale-Bopp

The comet was imaged using the Vainu Bappu Telescope at Kavalur during April - October 1997. The radial and rotational shift algorithm by Larson and Sekanina (1984) was applied to the flat fielded images to suppress the strong radial intensity gradient in the coma to enhance smaller fluctuations like the jets and the shells. The computer code developed during the previous year was considerably modified. The main improvement was to use a realistic size distribution of the grains to compute i) velocity of ejection v_{gr} and ii) the acceleration due to solar radiation pressure. The ratio of the force due to solar radiation pressure on the grain to the gravitational force β, was allowed to vary from .06 to 1.2 . The terminal velocity v_{gr} to which the grains are accelerated was calculated using the relation by Sekanina (1981):$1/v_{gr} = a + b/\sqrt{\beta}$ where a and b are coefficients which depend on the velocity of the gas driving the dust, dust and gas production rates, nature of the dust grains and the nuclear radius. The observed shell structures were compared with the structures predicted using this model. The fitted a and b values were used to estimate the lower limits on the production rates of gas and the dust to gas production ratio. The derived gas production rate of 1.9×10^{-5} g.cm^{-2}s^{-1} on 10 April, 1997 yields an evaporation rate of water of 6 molecules cm^{-2} s^{-1} from the active regions. Comparing this with the water production rate of Q=4×10^{30} molecules s^{-1} by Schleicher et al. (1997) near perihelion and assuming that at least 60% of the emissions are from the prominent active region at 65° latitude, the area should be at least 11 % of the total surface of the comet with a radius of 17 km.
(R.Vasundhara and Pavan Chakraborty)

3.1.2 Spectrophotometric Studies of Comet Hale Bopp

The Spectro-polarimetric observations of comet Hale-Bopp on 24th April 1997 were carried out using the polarimetric unit with the B & C spectrograph at the cassegrain focus of the VBT. The slit of length 8mm (=48 arcsec) positioned along the North-South direction included a prominent spiralling jet. Sections of the spectra perpendicular to the dispersion axis were extracted to study the variation of polarization with cometo-centric distance in the coma. Lower polarization on the comet centroid (7% at 6000 $\AA$) compared to significantly higher polarization on the coma at 40 arcsec south was observed. The solar phase angle on the date of observation was 49.1 deg. The continuum polarization decreases from the red towards the blue.
(Pavan Chakraborty and R.Vasundhara)

3.1.3 Shell Structures of Comet Hale Bopp

Images obtained by Dr. Andreas Hänel and Erwin Heiser from the University of Osnabrück were used to investigate changes in the jet and shell structures during the period September 1996 - May 1997. Most of the structures can be explained as arising due to ejections from persistent active regions at comet-o-centric latitudes near +65°, +55°, -5° to -15°, -35° and -65°. The best fitting pole positions vary between 255°± 10° and 275°± 10° in right ascension and -45°± 10° to -75°± 10° in declination. Lower limits on the dust and gas production rates at various epochs were estimated.
(R.Vasundhara, Pavan Chakraborty, Andreas Hanel* and Erwin Heiser*)

3.2 JOVIAN SATELLITES

The recent series of the mutual events of Jovian satellites occurred during April 1997 to January 1998 and were observed using the VBT and the 102 cm Telescope. These observations were carried out as part of the International campaign organized by the Bureau des Longitudes, Paris. The eclipse and occultation events were recorded by obtaining a series of small CCD frames with a resolution of 12 - 15 seconds. The data will be used to extract the sky plane separation between the satellites to an accuracy of 0.05 – 0.1 arcsec. These results will help to determine the orbital parameters of the satellites and to look for secular changes in their mean motions.
(R.Vasundhara)

STARS AND STELLAR SYSTEMS

1.STARS

1.1 EVOLVED STARS

1.1.1 Chemical Compositions of the SRd Variable Stars

Chemical compositions are derived from high-resolution spectra for four stars classed as SRd variables in the *General Catalogue of Variable Stars*. The present sample clearly shows that the SRd stars in the GCVS are a mixed bag. Two of the four stars are most likely not variables: RX Cep has been declared on good evidence to be of constant magnitude, and the evidence of photometric variability for XY Aqr has never been published. Both are disk stars of nearly solar metallicity but one is a F-type subgiant and the other a late G giant. The list of SRd stars should be pruned of this pair of stars. Two stars that are undisputedly Srd variables are SV Uma and AB Leo and have large radial velocities and are metal-deficient. The [Fe/H] values of -1.4 to -1.6 are similar to values reported for disk RV Tau variables to which SRds may be related. There is, however, a distinct difference in the compositions of these high-velocity SRds and the disk RV Tau variables. The latter show strong evidence for a photosphere affected by severe dust-gas separation. A well-known signature of dust-gas separation: an anomalously high [Zn/Fe] and an unusually low [Ca/Fe] ratio are not found for the SRds shows that these stars are not affected by a dust-gas separation, as are the disk RV Tau variables.

This result is not surprising for two reasons. First, the cool SRds almost certainly possess an extensive convective envelope that must negate the effects of a wind in which the dust-gas separation occurs. Second, analyses of RV Tau-like variables in globular clusters and of high-velocity RV Tau variables do not show abundance anomalies that suggest that the dust to gas ratio in a wind off a truly metal-poor star is so low that the dust cannot drift out against the drag exerted by the gas. There is no convincing observational evidence for a dusty circumstellar shell around AB Leo and SV UMa. In short, AB Leo, SV UMa, and TY Vir are metal-poor not metal-depleted.

(Sunetra Giridhar, D.L.Lambert* and G.Gonzalez*)

1.1.2 Abundance Analyses for Field RV Tauri Stars

Abundance analyses are presented and discussed for five RV Tauri variables. Three stars - DS Aqr, V360 Cyg, and V453 Oph - are RV C stars by spectroscopic classification, i.e., metal lines are weak. They are shown to be metal-poor with [Fe/H] from -1.0 to -2.2 with normal abundances of other elements. By contrast, AD Aql and AC Her are RV B stars with an odd abundance pattern: elements that condense into grains at a high temperature are underabundant (i.e., [Fe/H] = -2.1 for AD Aql) but elements with a low condensation temperature are much less underabundant (i.e., [S/H] 0.0 and [Zn/H] = -0.1 for AD Aql). This abundance pattern is ascribed to a separation of dust and gas in the upper atmosphere of the star. The present analyses with previously published results are used to investigate the systematics of the dust-gas separation in RV Tauri variables. The process is inoperative in stars with an initial metallicity of about [Fe/H] $\leq$ -1.0: RV C stars and similar variables in globular clusters are immune to the dust-gas separation. The process achieves more severe effects in RV B than in RV A stars. The strength of the abundance anomalies attributed to dust-gas separation is not correlated with reported infrared excesses. After correction for the effects of the dust-gas separation, there is no strong evidence from the abundances that evolution along the AGB and experience of the third dredge-up preceded the formation of the majority of the RV Tauri variables.

(Sunetra Giridhar, D.L Lambert* and G Gonzalez*)

1.1.3 Abundance Similarities between the R CrB Star V854 Cen and the Born-Again Sakurai's Object

The elemental abundances of the mildly hydrogen deficient R Coronae Borealis [R CrB] star V854 Cen have been estimated. The R CrB stars have been divided into majority and minority classes judging by their abundance patterns. Class assignment has previously been unambiguous but V854 Cen has traits of both the minority and majority class Neither V854 Cen nor the three obvious minority members show any clear abundance signatures of having been affected by e.g. dust-gas separation as often observed in post-AGB stars. By chemical composition, V854 Cen closely resembles Sakurai's object, which has probably recently experienced a final He-shell flash. Therefore V854 Cen and

Sakurai's object may share the same evolutionary background, which would add support for the final-flash scenario as a viable origin of the R CrB stars. Most of the few differences in abundances ratios between the stars could if so be attributed to milder H-ingestion in connection with the final He-shell flash of V854 Cen. The identification of either the majority or the minority group, if any, as final flash objects, remain uncertain, however, due to the unclear membership status of V 854 Cen

(M Asplund*, B Gustafsson*, N.Kameswara Rao*,and D. L. Lambert*)

1.1.4 Spectral Classification of Unidentified IRAS Sources with $F_\nu(12\mu m) \geq F_\nu(25\mu m)$

Spectral types of a large number of unidentified IRAS Point Sources with $F_\nu(12\mu m) \geq F_\nu$ ($25\mu m$) were determined; the majority are faint, oxygen-rich[M-type] or carbon-rich giant stars. The Guide Star Catalog has been used to find the photographic magnitudes of the newly classified IRAS sources with quality-3 flux densities at 12 μ in order to determine their B_j -[12] colour index. The dependence of this and of the IRAS indices on spectral type is determined and discussed. The mean [12]-[25] colour of the M-type stars is found to increase monotonically from M3 to M6 and then levels off. Comparison of the [12]-[25] colours of these faint IRAS M stars with those of Bright Star Catalog M stars indicates that, at all types, the mean[12]-[25] index of the former group is higher than that of the latter by at least 0.2 magnitude, and this is found to be significant at the 95% confidence level. Comparison of the quality-3, mean [25]-[60] colours of the newly-classified, faint M stars with those of BSC stars over the same spectral type also shows the same trend. Possible reasons for this difference are discussed The percentage of variable sources as a function of spectral type is seen to sharply increase from a nearly constant value of about 25% for sources of spectral type M3 to M7 to a value of about 50% at M10. The mean[12]-[25] colours of the IRAS unidentified sources (within the limits of the errors on their mean values) appear to be rather insensitive to the degree of variability.

(K.V.K.Iyengar and D.J. MacConnell*).

1.1.5 Birth and Early Evolution of Planetary Nebula

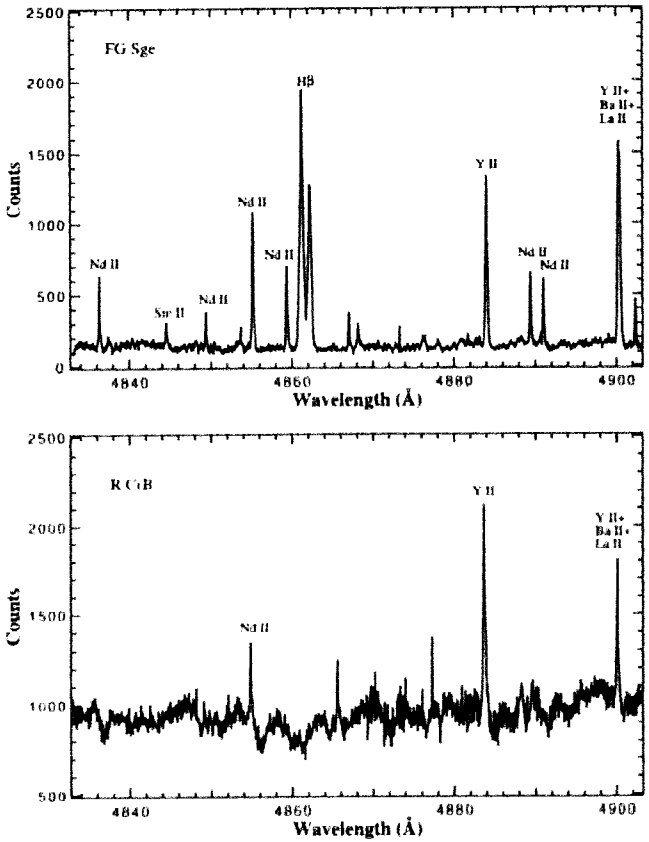
The final expulsion of gas by a star as it forms a planetary nebula - the ionized shell of gas often observed surrounding a young white dwarf - is one of the most poorly understood stages of stellar evolution. Such nebulae form extremely rapidly (about 100 years for the ionization) and so the formation process is inherently difficult to observe. Particulary puzzling is how a spherical star can produce a highly asymmetric nebula with collimated outflows. Here we report optical observations of the Stingray nebula, which has become an ionized planetary nebula within the past few decades. We find that the collimated outflows are already evident, and we have identified the nebular structure that focuses the outflows. We have also found a companion star, reinforcing previous suspicions that binary companions play an important role in shaping planetary nebulae and changing the direction of successive outflows.

(M. Bobrowsky*,K.C.Sahu* and M.Parthasarathy)

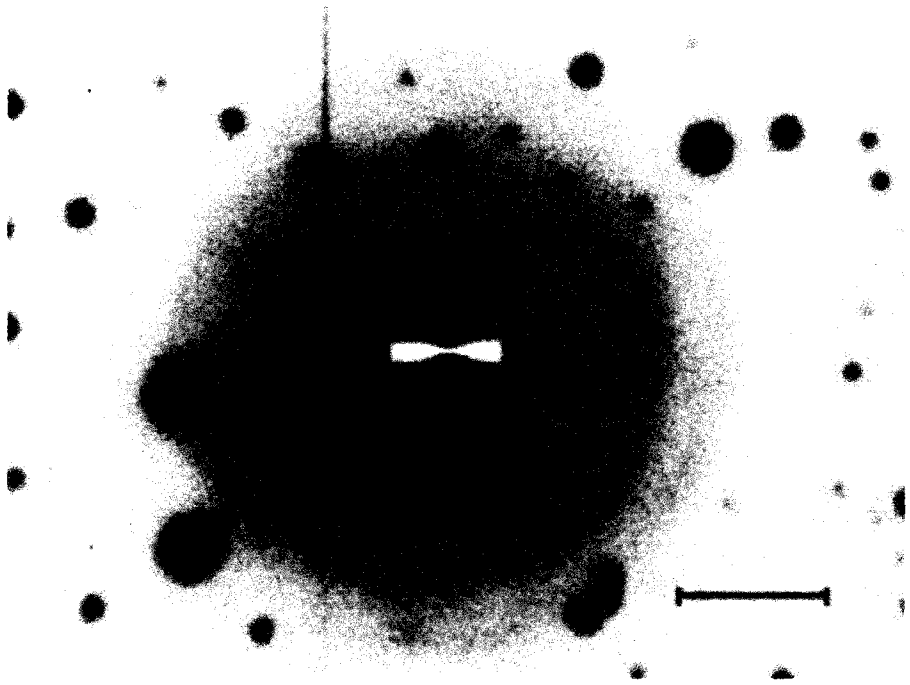
1.1.6 Chromospheric Activity in Cool Stars and the Lithium Abundance

A study of the Li I 6707.8A line was undertaken in both chromospherically active and quiet stars in order to explore the interdependence between chromospheric activity, age and the lithium abundance. The analysis completed in 49 dwarfs, giants and supergiants shows that although a few of the active stars are Li-rich, there does not exist a one-to-one correlation between Li abundance and chromospheric activity. There is almost an equal number of inactive stars which are Li rich. Otherwise, depletions are large especially in giants, much more than predicted by model calculations. There is a large spread in Li abundances; for most of the giants and supergiants, the abundance log N(Li) lies roughly between -0.3 to +0.7. A similar large range in Li abundances is found for giants not selected on the basis of chromospheric activity. A significant Li excess is not a general property of active giants. The above observations suggest that there are parameters besides the activity related ones controlling the lithium abundance in these stars. Further work on this problem is in progress for an enlarged sample including several more subgiants, giants and supergiants.

(S.G.V. Mallik)



Portion of the 1996 June spectrum of FG Sge is shown in the first panel. The Hβ line is produced in the fossil nebula. A spectrum of R CrB from February 1996 (in the middle of a deep minimum) is shown in the second panel. Some absorption lines are weakly present in the spectrum of R CrB.



TV guider image of FG Sge obtained on 1996 June 10 with the Keck 10m telescope during the spectroscopic observation. The slit is visible as a white horizontal bar in the centre of the frame. The visual magnitude of FG Sge at that time was about 15.3. The scale bar on the lower right is equal to 10". North is at the top, and east to the left.

1.2 VARIABLE STARS

1.2.1 Detection of New Be Stars

A large number of An and Bn stars (in total 119 An/Bn stars) were observed using the Coude Echelle and the UAGS spectrograph at the 1m reflector of VBO, Kavalur. Mainly the spectra of these stars were obtained in the H_α region and from this survey nine new Be stars have been detected.
(K.K. Ghosh, K.M.V. Apparao and S. Pukalenthi).

We also obtained time-resolved spectra of many Be stars and detected phase variations (B to Be to Be-shell or vice-versa) of five stars. These results may help us to understand the physics of Be phenomenon
(K.K.Ghosh, C. Velu, and M.J. Rosario).

1.2.2 International campaign on δ Scuti Stars BN Cnc and BV Cnc

As a part of the Small Telescope and CCD Camera (STACC98) International Campaign on monitoring of δ Scuti stars involving several observatories all over the world, spectra of the δ Scuti stars BN Cnc and BV Cnc in the Praesepe cluster were obtained using the OMR spectrograph on the VBT in February 1998. The reductions are completed and analyses are under progress. The data obtained from this campaign, which includes both photometric and spectroscopic observations, will be used to study stellar seismology in these objects.
(G.C. Anupama)

1.2.3 Novae

Monitoring of novae at quiescence has been initiated using the OMR spectrograph at the VBT. Medium resolution spectra of classical novae Nova Cas 95, V603 Aql, HR Del, GK Per and T Aur were obtained. Medium resolution spectra of the recurrent novae with giant secondaries; T Crb, RS Oph, V3890 Sgr and V745 Sco were also obtained. These spectra are being studied in detail to understand this peculiar class of novae better.
(G.C.Anupama)

1.2.4 Supernovae

Spectra of the Type Ia supernova SN1997bp in the wavelength region 3600–8100 Å were obtained on 1997 April 19 using the OMR sectrograph on the VBT. The spectrum indicated that the supernova was in its early post-maximum phase. Comparison with the spectra of other supernovae indicated the supernova was about 6 days past maximum. The mean absorption velocity of -12930 ± 1800 km/s is consistent with the phase of the supernova as well as with the Hubble type of the host galaxy.

Monitoring of the bright Type II supernova SN1998S was initiated using the 2.3m VBT and the 1-m telescopes at VBO. Spectroscopic as well as photometric data have been obtained by several observers. Spectra obtained in 1998 March when the supernova reached maximum show an extremely blue continuum. Later spectra show a reddening of the continuum.
(G.C. Anupama)

2. THE INTERSTELLAR MEDIUM

2.1 THE PUPPIS OB III ASSOCIATION

An optical polarimetric study of members and field stars in the region of the Puppis OB III association has been made. The association members are found to have larger values of polarization than the field stars. In the direction of the association there are two regions of polarizing interstellar medium with magnetic fields that are nearly at right angles to each other The observed ratio of polarization to reddening for stars in this direction is about a factor of 3 smaller than the mean interstellar value indicating either a very poor efficiency of dust grain alignment, or a magnetic field configuration that is predominantly longitudinal.
(H C Bhatt)

2.2 STAR FORMATION

The observed mass spectra for stars and interstellar clouds are compared. Stars are born from clouds, but their mass spectra are fundamentally different A new model is proposed in which the Salpeter function representing the stellar mass spectrum is shown to result from the parent cloud mass spectrum. Stars form in the cores of the clumps in a cloud and grow by accretion The accretion energy is deposited into the clump and disrupts it when the star has grown to a limiting mass. The limiting mass is derived. Combined with the observed clump mass spectrum, this leads to the Salpeter function for the stellar mass spectrum. Several other observed features of clouds and stars also follow.
(H.C.Bhatt)

3. STELLAR SYSTEMS

3.1 THE GALAXY

3.1.1 Phase space structure and size of the halo of galactic dark matter

With the intention of probing the phase space structure of the dark matter halo of the Galaxy we model the halo in terms of isothermal and reduced isothermal distributions. The gravitational field of the visible matter is modelled in terms of a spheroidal bulge and a double exponential disk like distribution. Self-consistent solutions of distribution of the dark matter is obtained including self-gravity and that due to the visible matter by solving the Poisson equation in an axisymmetric approximation. The results when compared with the rotation curve of the Galaxy and the radial velocities of globular clusters and dwarf spheroidals yield $< v^2 >_{DM}^{1/2} \sim 600 km\ s^{-1}$ and size of the dark matter halo $r_x \geq 300$ kpc.
(R.Cowsik, Charu Ratnam and P.Bhattacharjee)

3.2 GALAXIES

3.2.1 Massive Star Formation in the IR Bright Galaxy NGC 972

Optical broad band and H_α images obtained with VBT were analyzed. Maps of B/R color revealed peculiar morphology and complex dust distribution. Massive star formation activity in this galaxy is evident from the continuum subtracted H_α image, which shows the presence of circumnuclear activity and disk star formation within a radius of 3.4 kpc. The circumnuclear star forming regions are distributed in a ring of radius 630 pc and closely associated with an inner dust ring. Aperture photometry was performed on the individual HII regions and we estimate an age ≤ 5.4 Myr for the nuclear starburst using evolutionary synthesis models. The H_α luminosity of the nucleus is comparable to that of starburst nuclei. The emission-line ratios of NGC 972 are also

indicative of a nuclear starburst, which is powered by photoionization by a large number of hot massive stars. The enhancement of low ionization lines compared to normal HII regions can be attributed to the influence of dust on the thermal properties of the nebula or to contribution of shocks from supernova remnants. The star formation rate is estimated as 0.32 $M_{\odot}\mathrm{yr}^{-1}$ for the nucleus and 2.1–2.7 $M_{\odot}\mathrm{yr}^{-1}$ in the inner 3.6 kpc of the galaxy.
(Swara Ravindranath and T.P.Prabhu)

3.2.2 Near Infrared (NIR) and Optical Morphology of the Dusty Galaxy NGC 972

Near infrared (NIR) and optical surface photometric analyses of the dusty galaxy NGC 972 are presented. The photometric profiles in the $BVRJHK$ bands can be fitted with a combination of gaussian and exponential profiles, corresponding to a starburst nucleus and a stellar disk respectively. The exponential scale length in the B-band is 2.8 times larger than in the K-band, suggesting a central B-band optical depth as high as 11. A bulge is clearly absent even in the NIR bands and hence the galaxy has to be of a morphological type later than the usually adopted Sb type. Relatively low rotational velocity and high gas content (15% in HI) also favor a later type, probably Sd, for the galaxy. Only one arm can be traced in the distribution of old stars; the second arm, however, can be traced in the distribution of dust and HII regions. Data suggest a short NIR bar, which ends inside the nuclear ring. The slow rising nature of the rotation curve rules out a resonance origin of the the nuclear ring. The ring is most likely not in the plane of the galaxy, given its circular appearance in spite of the moderately high inclination of the galaxy (50°). The off-planar nature of the star forming ring, the unusually high fraction (30%) of the total mass in molecular form and the presence of a nuclear starburst, are probably the result of a merger of a gas-rich dwarf galaxy or an intergalactic gas cloud.
(Y.D. Mayya,Swara Ravindranath and L. Carrasco *)

3.2.3 Properties of H II Regions in NGC 1365 -The Luminosity Function

We present the H II region luminosity function for 98 H II regions which we have identified in the barred galaxy NGC 1365. Aperture photometry was carried out on the H II regions identified on the H_{α} emission line image to obtain the fluxes. The diameters of the H II regions were measured after removing the effects of seeing by performing a weiner deconvolution and image restoration. The H_{α} luminosities and linear isophotal diameters of the H II regions were calculated using the Cepheid distance to NGC 1365 which is 18 ± 2 Mpc. Earlier studies have shown various interesting correlations between the properties of H II regions belonging to various Hubble types. We find that these correlations between the absolute magnituides and diameters with the H_{α} luminosity, holds good even for H II regions within the same galaxy. We attempt to explain the various correlations and the H_{α} equivalent widths in terms of the evolution of the embedded stellar clusters and the assumed IMF. The correlation between the diameters and Balmer line luminosities are typical of ionization - bounded Strömgren sphere with deviations at high luminosities. We find that the H II region luminosity function (LF) can be fitted with a power law of slope -2 29 ± 0.11, which is consistent with the LF slopes found for other galaxies of same Hubble type. Also, the size distribution for the H II regions can be approximated by an exponential law.
(Swara Ravindranath and T.P. Prabhu)

3.2.4 Morphological Study of Luminous Elliptical Galaxies

The program of morphological studies of luminous elliptical galaxies with and without significant radio emission was broadly completed as far as acquisition of data is concerned. The objective of the study was to determine why only a small fraction of them are powerful radio sources. Powerful radio galaxies exhibit peculiarities in optical morphology which are indicative of galactic mergers. Image data has been acquired for about a dozen objects in each category, i.e. galaxies without significant radio emission and powerful radio sources, and these are being analysed for studying morphological structure
(A.K.Pati and L. Saripalli)

3.2.5 Oscillating Jet Structures in Radio Galaxies

A program aimed at understanding the occurrence of precessing and/or oscillating jet structures in radio galaxies was begun in early 1997. A

sample of sources with peculiar radio jet structures has been put together, for optical (photometry and spectroscopy) investigations using the VBT. The motivation of the observational program is to look for evidence of morphological disturbances that could point to galaxy interactions/mergers as being the perturbation causing the precession. Imaging is being done initially in broad band B,V,R & I filters; narrow band imaging in H_α and [O III] are proposed but require redshiftd filters. The objects in the sample occur in clusters of galaxies. Initial data obtained at the VBT for the object 3C464, a very steep spectrum radio source associated with the central cD galaxy in the cluster Abell 2626 shows a peculiar optical morphology, with evidence for more than one nuclear concentration and several smaller galaxies surrounding the cD. Spectrocopy of individual knots and smaller galaxies will be attempted to establish association with the cD. Multifrequency radio data on this object is being obtained from VLA archives to study the radio structure on different scales.
(A.K Pati)

3.2.6 Optical Counterparts of Gamma-Ray Burst Sources

This work establishes the technique to be used for detecting objects of unusual photometric color in deep images of the GRB fields. The recent detection of the optical counterparts of three GRBs, the apparent association of these with very faint, distant galaxies, the large energetics involved and the likelihood of 'fireball' type events being responsible, necessitates a change in approach to this program.
(S. Bhargavi, R. Cowsik and A K. Pati).

3.2.7 Groups of Galaxies

Continuing the project on studies of compact groups with X-ray emission, spectra of the galaxies in the group HGC62 were obtained using the OMR spectrograph in 1998 February. The spectrum of HCG62a confirms the previous detection of H_α emission in this galaxy based on images from the VBT.
(G.C. Anupama)

3.3. ACTIVE GALACTIC NUCLEI

3.3.1 Photometric Monitoring of Blazars

The photometric monitoring of blazars was continued; the aim of this study is to determine variability in magnitude and colour (if any) of this class of objects over a variety of timescales ranging from hours to years. A large part of the data acquired over the last three years for 5 blazars has been reduced. The remaining reductions and analysis will be completed and the first results of this long term program will be put out at the earliest.
(A.K Pati and K.K. Ghosh)

Monitoring of the blazars AO0235+16 and Mkn421 was done using the VBT and 1m telescopes at VBO, as part of the Whole Earth Blasar Telescope (WEBT) network of telescopes. This program is an activation of telescopes around the world, to attempt continuous monitoring of blazars especially when they are being observed at high energies (X-ray & γray) by satellite-based instruments (e.g. EGRET, SAX).
(A.K. Pati and P. Shastri)

3.3.2 Microvariability in Broad Absorption Line Quasars

Photometric observations were obtained for about 6 BAL QSOs using the VBT during 1997 March and April to study the optical microvariability phenomenon in these objects. Intra-night variations of ~5% were detected on time scales of ~1 hr in QSOs 0846+156 and 0856+172. Further, the mean magnitude level decreased in the two objects by ~0.06 and ~0 15 magnitude respectively during the period of observations. The observed light curves are quite similar to those previously seen in flat spectrum radio-loud sources, especially the BL Lacertae objects, and can provide important constraints for the origin of microvariability and also a possible evolutionary link between the radio-loud and the radio-quiet QSOs.
(G.C.Anupama and A. Chokshi)

3.3.3 Continuum Emission from Active Galactic Nuclei

The physics of active galactic nuclei (AGN) and related objects is one of the most actively pursued areas of astrophysics. Their large luminos-

ities over the entire electromagnetic spectrum combined with extremely short time variability has simulated a large number of astrophysicists to propose rather unconventional ideas. A variety of radiation mechanisms like, thermal, synchrotron and Compton processes have been proposed to account for the complex continuum emission. It is only recently that the role of plasma radiation mechanisms has been shown to be of the utmost importance. It is demonstrated how a combination of the stimulated Raman and Compton scattering processes accounts for the major part of the spectrum, taking 3C273 as an example.
(V.Krishan)

4. DEVELOPMENT

4.1 UV PAYLOAD

A large effort has gone into the proposed Ultra-Violet Imaging Telescope planned as part of an Indian multiwavelength astronomy satellite. Two concepts for the telescope have been developed at this stage. The primary purpose of the UVIT will be an all-sky survey in two bands within the range 1300 -3000 Å. Pointed mode programs are also to be accommodated through broadband as well as narrow band line filters. Low resolution field spectroscopy as well as polarimetry in the UV is also planned.
(N. Kameswara Rao and A.K. Pati)

4.2 OMR SPECTROGRAPH AT THE VBT

The mis-alignment detected in the long focus camera caused during transportation was corrected in IIA's Photonics Lab. All the optical elements in the camera were individually tested by the personnel of the Photonics Lab and found to be according to the specifications given by the manufacturer. The camera was tested on the spectrograph at VBT and test images of the calibration sources were obtained. All images show a background 'ghost' image at a maximum of 3% level. The images are being studied to detect the source of the 'ghost'. A software to clean the images of this background is being developed.
(T.P. Prabhu, G.C. Anupama and R. Surendiranath)

4.3 SPECKLE INTERFEROMETER

The newly developed speckle interferometer for the 2.34 meter Vainu Bappu Telescope (VBT), at Vainu Bappu Observatory (VBO), Kavalur, is being used regularly at the Cassegrain end of the said telescope to record speckle-grams of various objects. The technical details of this sensitive instrument and the design features are described reported in the journals (Saha et al., 1998, 1997b). Further development of this incorporates a nano-adjusting mechanism which helps in ultra fine focusing of the microscope objective. Flexure mechanism is being developed to achieve the nano-metric motion of the same. An arrangement for the micro-metric $x - y$ movement of the detector to ensure its position precisely is being developed.
(S.K. Saha)

4.4 MEASUREMENT OF r_o

The flat wavefront enters the telescope warped significantly by virtue of its passage through a turbulent atmosphere containing a distribution of cells differing in size and refractive index. These cells move rapidly across the path of the light, which could be due to the winds at various heights, convection in and around the dome, off the surface of the telescope structure etc. If the exposure time is shorter (<20 msec) than the evolution time of the phase inhomogeneities, then each patch of the wavefront with diameter r_o – Fried's parameter – would act independently of the rest of the wavefront resulting in multiple images (speckles) of the source. The night time variations of Fried's parameter at the 2.34 meter VBT site were computed using the speckle interferometric technique. Specklegrams of 15 point source (unresolved stars) in and around 30° zenith were analyzed and computed.
(S K Saha and V. Chinnappan)

THEORETICAL ASTROPHYSICS

1. COSMIC RAYS

1.1 ORIGIN OF EXTREMELY HIGH ENERGY COSMIC RAYS

The difficulties faced by conventional "bottom-up" acceleration scenarios in explaining the observed Extremely High Energy Cosmic Ray (EHECR) events with energies above $\sim 10^{11}$GeV, have recently led to increasing interest in a possible "top-down" non-acceleration scenario for the origin of these EHECR events. A particular realization of such a top-down scenario of origin of EHECR involves the so-called Topological Defects (TDs) such as cosmic strings, magnetic monopoles, domain walls, and various possible hybrid systems consisting of these objects. The TDs could have been produced in symmetry breaking phase transitions in the early universe envisaged in grand unified theories (GUTs) of elementary particle interactions.

In the TD scenario of origin of EHECR, particles can be directly created with energies up to $\sim 10^{16}$GeV (a typical GUT energy scale) from decays of massive "X" particles (Higgs bosons, gauge bosons, superheavy fermions, etc.) released due to collapse and/or annihilation of certain TDs, thus avoiding the need for any acceleration mechanism.

It is shown that cosmic topological defects in a wide class of supersymmetric theories can simultaneously be sources of Higgs bosons of mass $\sim$ TeV, the supersymmetry breaking scale, as well as superheavy gauge bosons of mass $\sim \eta \gg 1$TeV, η being the gauge symmetry breaking scale. Decays of these TeV Higgs bosons may contribute significantly to the extragalactic diffuse gamma ray background (EDGRB) above $\sim$ 10 GeV, while the decays of the superheavy gauge bosons may explain the observed extremely high energy cosmic ray (EHECR) flux above 10^{11}GeV. It is also shown that cosmic strings with η much above 10^{14}GeV overproduce both EDGRB and EHECR, and hence are ruled out, *if* massive particle radiation (rather than gravitational radiation) is the dominant energy loss mechanism of cosmic strings as on the other hand cosmic strings with $\eta \sim 10^{14}$GeV in supersymmetric theories may simultaneously explain the EHECR above 10^{11}GeV as well as the EDGRB above 10 GeV (which is difficult to explain otherwise in terms of emissions from conventional sources such as AGNs, Blazars, etc.)
(P.Bhattacharjee,Q. Shafi*,F. Stecker*)

In another piece of work on this subject, it is pointed out that there may exist an intriguing connection between the observed EHECR and the Baryon Asymmetry of the Universe (BAU), namely that the EHECR and the BAU may have a common origin in baryon number violating decays of the massive X particles released from cosmic topological defects such as cosmic strings and magnetic monopoles. The basic idea is that X particles produced by TDs in the recent epochs produce the EHECR, while the BAU is created by baryon number violating decays of the X particles released from TDs in the early Universe. The X particle production rate fixed by the requirement to explain the observed EHECR flux is also able to explain the BAU. In other words, if TD processes are indeed responsible for the EHECR, then the same TD processes might also have been responsible for creation of the entire "low" energy baryonic material content of the Universe Thus, in this scenario, the baryonic content of the Universe is a dynamically evolving quantity, and the observed extremely high energy cosmic rays observed today represents the baryon creation process itself "in action" in the Universe today.

A definitive prediction of this scenario is that the EHECR should contain baryons as well as antibaryons with a small asymmetry between the two. It remains, however, as a challenge at this stage to devise an experimental scheme that would enable one to distinguish EHECR air-showers initiated by baryons (protons) from those initiated by antibaryons (antiprotons), thereby to test the prediction experimentally
(P. Bhattacharjee)

2. NEUTRON STARS AND PULSARS

2.1 RAPIDLY ROTATING NEUTRON STARS

For four newly suggested realistic equations of state of neutron star matter, we have constructed equilibrium sequences of rapidly rotating neutron stars in general relativity The sequences are the normal and supramassive evolutionary sequences of constant rest mass. We find that for these equations of state, the maximum gravitational mass rotating models occur (in central density and rotation rate Ω) before the maximum-Ω models We have also calculated the radius of the marginally stable orbit and its dependence on Ω, relevant for modeling of kiloHertz quasi-periodic oscillations in X-ray binaries
(B Datta, A V Thampan and I Bombaci*)

2.2 ACCRETION LUMINOSITIES

A general relativistic calculation was done for the boundary layer and disk luminosities for accreting non-magnetic neutron stars in rapid rotation Rotation increases the disk luminosity and decreases the boundary layer luminosity Also calculated are the angular velocity profiles of particles in Keplerian orbits around the rapidly rotating neutron stars The results will have applications in modeling the spectra of persistent emission of the lower luminosity X-ray burst sources, because the neutron stars in such systems are believed to be rotating close to the equilibrium with the Keplerian period of the disk inner edge. This study also suggests that an inner disk torus can be formed (in the absence of a substantial radiation pressure), purely as a consequence of accretion flow in rotating general relativistic space-time when the accreting neutron star is close to the centrifugal mass shed limit This result can explain the mass accretion during X-ray quiescence in low-mass X-ray binaries
(B Datta and A V Thampan)

2.3 KHz QPSOs

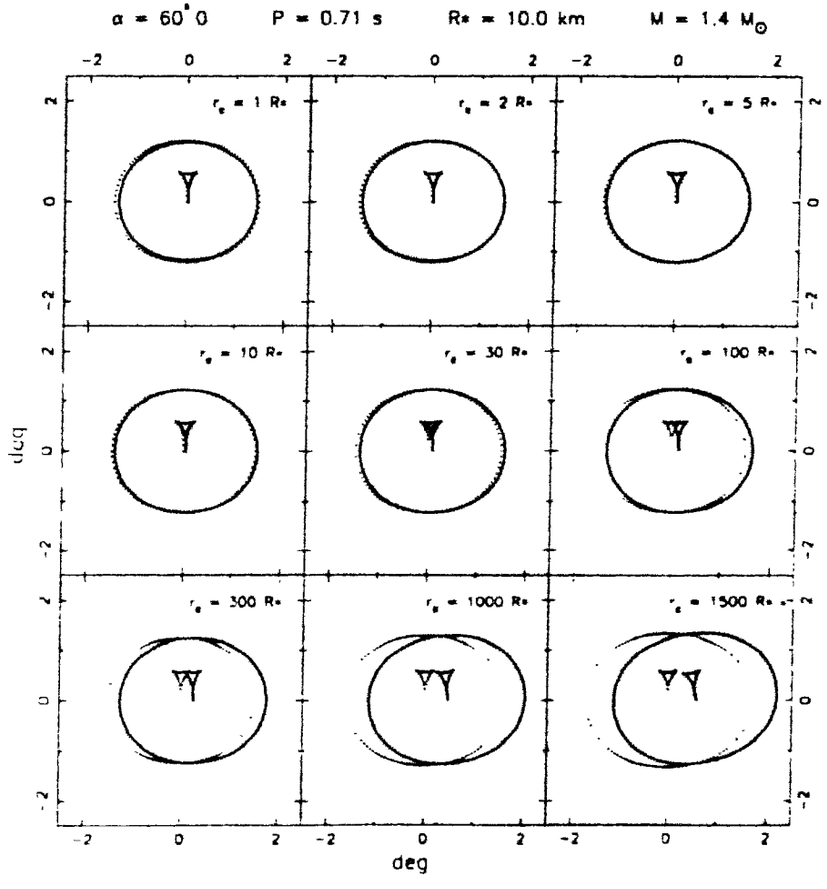
Kilo Hertz quasi-periodic oscillations (kHz QPOs) in low-mass X-ray binaries may represent the orbital frequencies of innermost Keplerian orbits around accreting neutron stars. This can be used to derive constraints on the mass of the neutron star and the equation of state. It is pointed out that without the knowledge of the neutron star spin rates, identification of kHz QPO frequencies with Keplerian frequencies at the innermost stable orbit does not yield a firm constraint on the neutron star mass, but admit a range of values of the mass and radius.
(B Datta, A V. Thampan and D Bhattacharya*)

2.4 BENDING OF LIGHT NEAR PULSARS

The effects of the neutron star's gravitational field, viz. the change in the stellar dipole magnetic field geometry and the light bending, have been considered mostly in the context of X-ray pulsars We have done such an analysis for radio pulsars in the framework of the polar cap model, which is valid for arbitrary inclination angles between the stellar rotational and magnetic axes It incorporates all the kinematical effects, namely the special relativistic aberration and the above mentioned two general relativistic effects As expected aberration would be significant if the radiation emanates from higher altitudes although the magnetospheric effects may counter it The two general relativistic effects also have opposing nature We find that these amount to atmost a 4 % squeeze of the pulsar beam for a typical neutron star (mass 1.4 $M_\odot$ and radius 10 km) independent of the stellar magnetic moment and the inclination of the oblique rotator Inclusion of all the kinematical effects thus essentially leaves the Goldreich-Julian type beam unaltered. Using the results of our study of the general relativistic corrections to the size of the polar cap, the agreement between the formula derived earlier by Rankin and the geometrical one was seen to improve further. Gravitational effects make the polar cap size also depend on the pulsar mass It is shown that the Rankin formula constrains the pulsar mass to be less than 2 5 $M_\odot$. Also the concomitant constraint on pulsar radius 10 km indicates that softer equations of state for the neutron star matter, especially the one by Wiringa, Fiks and Fabrocini, (i.e., compact neutron stars) are favoured
(R.C. Kapoor)

2.5 PROPER MOTION AND SPIN OF PULSARS

It is suggested that the proper motion and the spin of pulsars at birth are causally connected Accordingly, the observed mean values of parameters can be attributed to the recoil momentum and torque impulse



The effects of a neutron star's gravitational field, viz the change in the stellar dipole magnetic field geometry and the light bending, for radio pulsars, are shown in the framework of the polar cap model for arbitrary inclination angles between the stellar rotational and magnetic axes

imparted to the neutron star by anisotropic and asymmetric emission of neutrinos during the collapse of the core in a supernova.
(R.Cowsik)

3. BLACK HOLES

3.1 GENERAL RELATIVISTIC ANALOGUES OF INERTIAL FORCES

3.1.1 Gyroscopic Precession and Centrifugal Force in the Ernst Spacetime K

The phenomenon of gyroscopic precession in the Ernst spacetime is studied within the frame work of Frenet-Serret formalism General formulae are obtained for circular orbits. At the same time general relativistic analogues of inertial forces such as gravitational and centrifugal forces are also investigated in the Ernst spacetime. Reversal of gyroscopic precession as well as centrifugal force is considered at the circular photon orbits. These phenomena are examined in the Melvin universe as a special case of the Ernst spacetime by setting the mass parameter equal to zero.
(K. Rajesh Nayak and C. V. Vishveshwara)

3.1.2 Gyroscopic Precession and Inertial Forces in Axially Symmetric Stationary Spacetimes

We study the phenomenon of gyroscopic precession and the analogues of inertial forces within the framework of general relativity. Covariant connections between the two are established for circular orbits in stationary spacetimes with axial symmetry. Specializing to static spacetimes, we prove that gyroscopic precession and centrifugal force both reverse at the photon orbits. Simultaneous non-reversal of these in the case of stationary spacetimes is discussed. Further insight is gained in the case of static spacetime by considering the phenomena in a spacetime conformal to the original one. Gravi-el ectric and gravi-magnetic fields are studied and their relation to inertial forces is established
(K. Rajesh Nayak and C. V. Vishveshwara)

3.1.3 Equilibrium of a Charged Test Particle with Spin . in the Kerr-Newman Spacetime: Interation Analysis

A charged test particle with spin placed in the combined gravitational and electromagnetic fields of the Kerr-Newman black hole is considered Such a particle in equilibrium can be used as a probe of the various interactions involved. These include electromagnetic forces, gravi-electric and gravi-magnetic forces and the interaction of the spin with the angular momentum of the source mediated through through the rotation of the spacetime itself. All these interactions are studied in detail Further, connection is made with the general relativistic analogues of inertial forces, namely gravitational, centrifugal, and Coriolis-Lense-Thirring forces.
(J M Aguirregabiria*, A Chamorro*, K Rajesh Nayak, J Sumaga* and C V Vishveshwara)

3.2 BLACK HOLES IN COSMOLOGICAL BACKGROUNDS

Although there is a great deal of information available in the case of isolated, asymptotically flat black holes, very little is known about the detailed behaviour of the black hole in cosmological backgrounds In order to understand the latter, we have made systematic studies on some of the properties of black holes imbedded in the static Einstein universe using exact solutions derived by Vaidya We have verified that the black holes, both rotating and static, are in fact null surfaces The nature of the energy-momentum tensor in these spacetimes have been analysed In the case of spherically symmetric, static black holes physical phenomena such as scattering of scalar waves have been studied These considerations are being generalized to black holes in Robertson-Walker cosmological background
(K Rajesh Nayak and C V Vishveshwara)

4. TURBULENCE

4.1 ANISOTROPIC KINETIC ALPHA EFFECT

The study of formation of coherent structures in a turbulent medium has provided considerable experimental and theoretical evidence that such features are a consequence of 'self-organisation' of the flow These

ideas are being explored in order to understand the large scale structure of the universe. The role of turbulence in producing such an organisation needs to be investigated. Be it the observed hierarchy of structures (galaxies, clusters of galaxies, superclusters.. etc), or the granulation scales on the sun, all such order could be the fallout of a self-organised system! What causes this self-organisation is a type of inverse-cascade of energy in the system. This inverse cascade could be the result of a large-scale-instability, whose existence has been shown for the case of an incompressible forcing, and is, since, known as the Anisotropic Kinetic Alpha effect (AKA). The AKA effect is also the analogue of the well-known alpha effect for the generation of large scale magnetic fields from small scale fields A perturbative expansion of the compressible Navier-Stokes equation shows that the solvability condition for the set of linear partial differential equations obtained with multi-scale analysis resembles the dynamo-like equation for magnetic fields. The key requirement for the AKA instability to manifest itself is the lack of reflectional symmetry in the medium (parity non-invariance). We confirm the presence of a three dimensional large scale instability leading to inverse cascade of energy. Moreover, the transformation of energy from the compressible modes (acoustic modes) to helical modes is observed. The detailed evolution of the energy, helicity, vorticity and mass density spectra is being studied.
(R.D. Prabhu, V. Krishan and Amit Basu*)

5. RADIATIVE TRANSFER

5.1 REFLECTION EFFECTS

5.1.1 Reflection Effects in Close Binaries

In earlier work we studied the reflection effect in 2-Dimensional geometry to see how the radiation filed will change if we calculate the reflected radiation by the transfer equation in a close binary system. It was shown that even a 2- Dimensional calculation of the reflected radiation changes the radiation field considerably. We made an attempt to calculate the reflected radiation from the extended surface of the components of a close binary system assuming 3-Dimensional Cartesian coordinate geometry. The specific intensity of the radiation field received by an observer at infinity is estimated along the line of sight. We assumed a purely scattering medium and in calculating the radiation we excluded the radiation occulted by the central star and the radiation in the shadow cone. The secondary component is assumed to be kept at different points in its orbit which is assumed to be circular. The amount of radiation received by the observer at infinity depends on the position of the secondary component.
(A.Peraiah and M. Srinivasa Rao)

5.1.2 Effects of Reflection on Spectral Line Formation

The atmospheres of the components of a close binary system are distorted mainly by two physical effects: (1) rotation of the component and (2) the tidal effect due to the presence of its companion. The effects make the atmospheres of these stars non- spherical. Nonsphericity changes the density distribution of the matter through which the radiation passes and as a consequence , the lines formed in such medium are modified. In addition to this, the presence of the secondary component's light falling on such distorted components atmosphere will affect the line profiles formed in the atmospheres. We adopted a spherical polar coordinate system. The radial distribution of the source function is obtained from the solution of the radiative transfer equation in spherical symmetry either in the rest frame or in the comoving frame of the gas. However, as we are investigating the combined effects of rotation and radial motion on the formation of lines, we have assumed a source function which varies as a $1/r^2$. With this assumption, we can estimate the specific intensity $I(\tau_L)$ at the boundary of the each shell, for calculating the flux. We have assumed two types of variations for the velocity satisfying the law of continuity:
(1) increasing linearly with radius and
(2) a constant velocity throughout the atmosphere.
The density changes as $1/r^3$ and $1/r^2$ so that the equation of continuity is always satisfied.
(A.Peraiah, M. Srinivasa Rao and B.A.Varghese)

5.2 RADIATIVE TRANSFER IN SPHERICAL GEOMETRY

A numerical solution based on finite-differences is proposed for solving the line transfer equation in a spherically symmetric atmosphere. We discretize the curvature term in the equation by the backward difference scheme for the outward-going ray from the atmosphere and by the forward- difference scheme for the backward-going ray. As the radiation field is highly anisotropic in the far-wings of the line, the accuracy of the method is improved by computing the source function first using the numerical scheme for a limited set of rays. The intensity in the line is then computed with the known source function using the formal solution of the transfer equation with a large grid of rays. The numerical solutions are compared with the published results for an atmosphere having an outer radius R surrounding a core of radius $R_c(= 1)$ and we consider two cases :

1) the core is hollow;

2) the core is perfectly absorbing and emits radiation in a specified direction.

The differences in values of the source functions obtained applying our method and those of the other method using a different form of the transfer equation are not significant. Another salient feature of this method is that one can enforce the non-negativity of the solution quite easily. In future we would like to use this method for atmospheres where scattering by small particles (i.e.,Mie scattering) is an important physical mechanism.

(D. Mohan Rao)

6. ATOMIC PROCESSES IN ASTROPHYSICS

There are several quantities that are needed to understand atomic processes in astrophysics.For example,a knowledge of transition energies and oscillator strengths may be necessary to determine abundances,temperatures and various other properties of celestial objects. We have carried out calculations of excitation energies and oscillator strengths on two atomic species of astrophysical interest–carbon and calcium using Multi-Reference Many-Body Perturbation Theory.

(Sonjoy Majumder, Rajat Chaudhuri and B.P.Das)

7. STELLAR DYNAMICS

7.1 MERGER OF GALAXIES

Simulations of merging of equal mass galaxies were performed to compare the relative change in energy obtained from numerical simulations with those computed using impulse approximation The comparison showed disagreement in close collision that resulted in merger and agreement, within a factor of two, in wide encounters

(P.M.S. Namboodiri)

7.2 TIDAL EFFECTS IN INTERACTING GALAXIES

The tidal effects produced in a deeply penetrating collision between two spherical galaxies, one twice as massive but less dense than the other, were studied by numerical simulations The galaxies were initially placed on a hyperbolic relative orbit The collision parameters were so chosen that the primary (bigger) galaxy was just below the limit of disruption and the relative velocity of the pair is slightly in excess of the escape limit. The collision produced greater tidal damage in the primary. The primary developed a core-halo structure and showed overall expansion while the secondary showed contraction in the inner region and less significant expansion in the outer parts The initially hyperbolic orbit was transformed into a parabolic one as a result of the collision. The results also indicated that the tidal interaction did not induce appreciable rotation in hyperbolic collision The angle of deflection of the orbit computed from the numerical work was found to be larger than that obtained using analytical formula This was attributed to the large tidal effects of the bigger galaxy.

(P.M.S. Namboodiri, K.S.Sastry* and K S.V S Narasimhan*)

7.3 DEVELOPMENT

One more board has been installed in the GRAPE system – a parallel computing machine dedicated for galaxy simulations (obtained from Professor Sugimoto of the University of Tokyo under the India - Japan collaborative programme) Several test runs have been performed to check this new board.

(P.M S Namboodiri)

PHYSICS

1. NON-ACCELERATOR PARTICLE PHYSICS

1.1 ATOMIC PROBES OF PHYSICS BEYOND THE STANDARD MODEL

1.1.1 Parity Violation in Atomic Ions Using Laser Cooling and Trapping

To observe parity violation An experiment involving trapping and laser cooling of Ra+Ba+ and Yb+ has been proposed. Apart from being promising probes of physics beyond the Standard Model these ionic systems can be used to observe the unclear anapole moment in a clear way. Fearibility Studies for carrying out such an experiment at IIA are underway.
(B.P.Das)

1.1.2 Parity Nonconservation Arising from Neutral Weak Currents

Parity Nonconservation(PNC)in atoms is a promising probe of physics beyond the Standard Model.We have developed Coupled-Cluster approaches for atomic PNC.The formal part of this work is complete. We shall soon be writing codes based on this method
(K.P.Geetha, N.Barat, P.K.Panda, Rajat Chaudhuri, B.P.Das)

1.1.3 Electric Dipole Moments of Atoms

Atomic Electric Dipole Moments(EDMs) are excellent probes of physics beyond the Standard Model. We have applied the Epstein-Nesbet Perturbation Theory,Coupled Electron Pair Approximation(0) and (2) to atomic EDMs.Calculations using these methods have been carried on ytterbium,which may be a good candidate for observing the EDM.
(Angom Dilip Singh and B.P.Das)

1.1.4 Atomic-Nuclear Interface

We have proposed a new method to observe the nuclear anapole moment using laser cooling and trapping.Singly ionized barium and radium are good candidates for such an experiment. We have also carried out theoretical studies to determine the feasibility of observing the nuclear anapole moment in atomic ytterbium–our results clearly favour ytterbium.
(Angom Dilip Singh, K.P.Geetha, C.S.Unnikrishnan and B.P.Das)

1.2 INSTRUMENTATION

Two experiments on non-accelerator particle physics were initiated this year. In one of these, a prototype of a sensitive torsion balance was tested inside a vacuum chamber. This experiment aims to investigate the Casimir effect.
Another experiment to measure the Casimir-Polder force was initiated using an atomic beam of helium. The atomic beam was generated using a hypodermic needle. Other equipment like the electron beam gun for electron impact ionisation and a channeltron for ion detection were set up.
(D. Suresh, G. Rajalakshmi and R. Cowsik)

2. GRAVITATION

2.1 NONLINEAR NON-RELATIVISTIC GRAVITY

Here the phenomenological theory of gravitation is proposed, based on a pre-relativistic approach to electromagnetism. The general relativistic, purely geometric spacetime conception is criticized. Space itself is assumed to have physical substance. This substance, the ether, manifests by its permeability. Gravitational fields do not curve space, but rather distort the ether, and affect its permeability. The permeability determines the speed of light, which is varying like in a dielectric medium. The theory is only in certain limits Lorentz invariant, the concept of a uniformly moving observer is likewise only approximate, and so is the principle of equivalence. Nonlinear field equations for the scalar gravitational field as well as the permeability tensor of the ether are constructed in a way to fit the classical experiments on gravitation. Estimates on the variation of the speed of light in our solar system are given.
(Roman Tomaschitz*)

2.2 COSMIC ETHER

A pre-relativistic approach to particle dynamics is explored in an expanding Robertson-Walker cosmology. The receding galactic back-

ground provides a distinguished frame of reference and a unique cosmic time In this context the relativistic, purely geometric space-time concept is criticized. Physical space is regarded as permeable medium, the cosmic ether, which effects the world-lines of particles and rays. We study in detail a Robertson-Walker universe with linear expansion factor and negatively curved, open three-space; the permeability tensor of the ether we choose in a way that the semiclassical approximation is extact. Galactic redshifts depend on the refractive index of the ether. In the local Minkowskian limit the ether causes a time variation of mass, which scales inversely proportional to cosmic time. In the globally geodesic rest frames of galactic observers the ether manifests in an unbounded speed of signal transfer, in bifurcations of world- lines, and in time inversion effects.
(Roman Tomaschitz*)

2.3 GLOBAL METRICAL DEFORMATIONS AND THE MICROWAVE BACKGROUND

An account on the chaoticity of galatic world-lines in an open universe is given. A new type of cosmic evolution by global metrical deformation, unpredicted by Einstein's equations, is pointed out. Physical effects of this evolution are backscattering of electromagnetic fields and particle creation in quantum fields. We review in an untechnical way how global metrical deformations of the open and multiply connected spacelike slices induce angular fluctuations in the temperature of the cosmic microwave background radiation.
(Roman Tomaschitz*)

FACILITIES

1. ELECTRONICS

1.1 CCD PROJECTS

1.1.1 IIA-IISc Collaborative Work on CCD Dewars

IIA in collaboration with the Center for Cryogenic Facility (CCF), IISc, Bangalore has designed and developed three cryogenically cooled CCD dewars for IIA's internal use. While the CCF is responsible for building dewars, IIA provided the CCD mounts, internal wiring, testing and imaging. The following is the status of these three dewars.

Model 1: A P8603 CCD (578 × 385) has been mounted. The required wiring inside the cryostat has been carried out and the necessary cables as adopted to the Universal CCD controller were completed. The system was subjected to lab and field tests and test images were obtained. The performance was found to be satisfactory.

Model 2: This cryostat is planned for the Thomson THX7897 (2K × 2K) three-side buttable CCD. It gives a holding time of 18 hrs. A suitable mount for this device has been made and integrated with a mechanical sample. The sample would be replaced by an engineering grade CCD during the initial tests with the quad-read controller and subsequently, a scientific grade device will be installed in the cryostat.

Model 3: This cryostat is light weight with an aluminium body,and is now undergoing tests for vacuum integrity. A 60 mm clear aperture quartz window is used as an optical port. A hermetically sealed connector is being used for the electrical feed through. A mount for Loral 2K x 2K CCD is designed and integrated with a mechanical sample in the cryostat. A heater resistor and temperature sensor are provided on the CCD mount in order to set and maintain desired temperature.

(B. Nagaraja Naidu, R. Srinivasan, N. Jayavel, A.S. Babu and CCF Staff at IISc*)

1.1.2 IIA's In-house CCD Dewar

In-house efforts are being continued for building a CCD dewar. The dewar is designed to give a hold time in excess of 24 hr. The dewar consists of two parts viz., the liquid nitrogen (LN2) container housing and the CCD Camera head. The chamber housing encloses a three liter capacity liquid nitrogen container, molecular sieve, fill & vent structure and a vacuum port. The CCD camera head contains a CCD mount, an optical window and hermetically sealed connector for electrical signals feed through. These two parts are vacuum sealed by an O-ring. Super insulation foils are wound on the LN2 container and the side plates to reduce the heat load on the LN2 container. The dewar is initially checked for its vacuum integrity and for possible leaks. No leaks were found. The dewar is subjected to baking continuously around 60 deg. C while being evacuated for four cycles each of 10 hr. duration to remove the absorbed water vapor from the inner surfaces of the dewar. The dewar holds liquid for about 21 hr. A suitable CCD mount is being designed for this dewar. The mount contains a PCB that holds the CCD (SITe 1K) and the associated pre-amplifier electronics

(B. Nagaraja Naidu, Sahay Nathan, R. Srinivasan and B.R Madhava Rao)

1.1.3 A New PC Interface Card for Universal CCD Controller

A new interface board has been designed and developed for a CCD controller to operate from linux environment. This interface board conforms to ISA XT/AT bus and switchable data bus width allows the board to interface to PC XT (8 bit) or PC AT (16 bit) systems. The host computer sends the commands to the UC over a parallel 16 bit data lines which are differentially driven. The serial data from the controller are clocked into the interface board and is then converted into parallel data in a set of shift registers. Two 4K FIFOs are configured as 4K x 16 bit to allow the host to receive data at it's own bit rate independent of the data coming-in from the controller. FIFO's status bits can be monitored to perform the data transfer from FIFO to host. A 16 bit general purpose digital I/O are provided for user defined applications such as instrument control.

(B. Nagaraja Naidu, R. Srinivasan and A.V Ananth)

1.1.4 Linux based software for image data acquisition for IIA controller

Currently efforts are on to develop a X-window based image data acquisition and processing for the controller developed at IIA, for Linux (a public domain UNIX) environment. The software involves development of a device driver for an I/O interface board, a C based application pro-

gram with calls to X tool kit using Athena widgets for GUI (Graphical User Interface) Programming. The GUI part of the application is ready for testing. The device driver related part needs to be completed. This is an extension of the work carried out earlier. The difference being a GUI part developed earlier, used X lib calls and the hardware platform was the commercially available astromed controller.
(A.V.Ananth and K. Abhimanyu*)

1.2 OTHER INSTRUMENTATION PROJECTS

1.2.1 The 1024 Channel Correlator System

The 1024 channel digital correlator built using the IC chips imported from Japan was successfully constructed and installed at the Gauribidanur radio observatory. The digital system was interfaced with the analog receiver unit (which was built at Gauribidanur itself) and various tests were carried out to understand and check different aspects of the combined system. From April 1996 onwards, regular two-dimensional mapping of the Sun is being carried out. As the tracking system and multi-frequency observing capability has not been installed yet, only single frequency observations are being made, during the transit of the source over the local meridian at Gauribidanur. The interesting results that have been obtained so far are summarized below:

1. It was found that the coronal loops connected with the solar noise storm emission (the only activity connected with the sunspots in the absence of any flares) have a lower density limit and they don't extend into the outer layers of the Sun's atmosphere.
2. Radio signatures of the pre-event corona before the onset of a coronal mass ejection (CME) have been obtained on several occasions. It is being speculated that the onset of radio noise storms and changes in the geometry of existing coronal holes can be considered as precursors for some of the CMEs. Analysis of data along with those obtained at other wavelength bands are being carried out to get a complete picture of these events at different levels of the solar atmosphere.

As it is required to track these mass ejections as they travel into the inter-planetary space, design tests for the installation of a tracking system are being carried out now.
(R. Ramesh, K.R. Subramanian, M.S. Sundarajan, E. Ebenezer and Ch.V. Sastry)

1.2.2 128 KBPS Satellite Communication System

A satellite communication system has been procured from M/S India Satcom Ltd to facilitate remote operation of the 2-M Infra-Red Optical telescope coming up at Hanle. The communication link has been configured, in close consultation with the ISRO engineers to operate in extended C-band at 128 KBPS in Single Channel Per Carrier mode. The siting - clearance for Hanle and Hoskote has been obtained from DOT, the NOCC test at Hoskote has been successfully conducted and the test at Hanle is being scheduled.
(R. Srinivasan, A.V. Ananth and G. Srinivasulu)

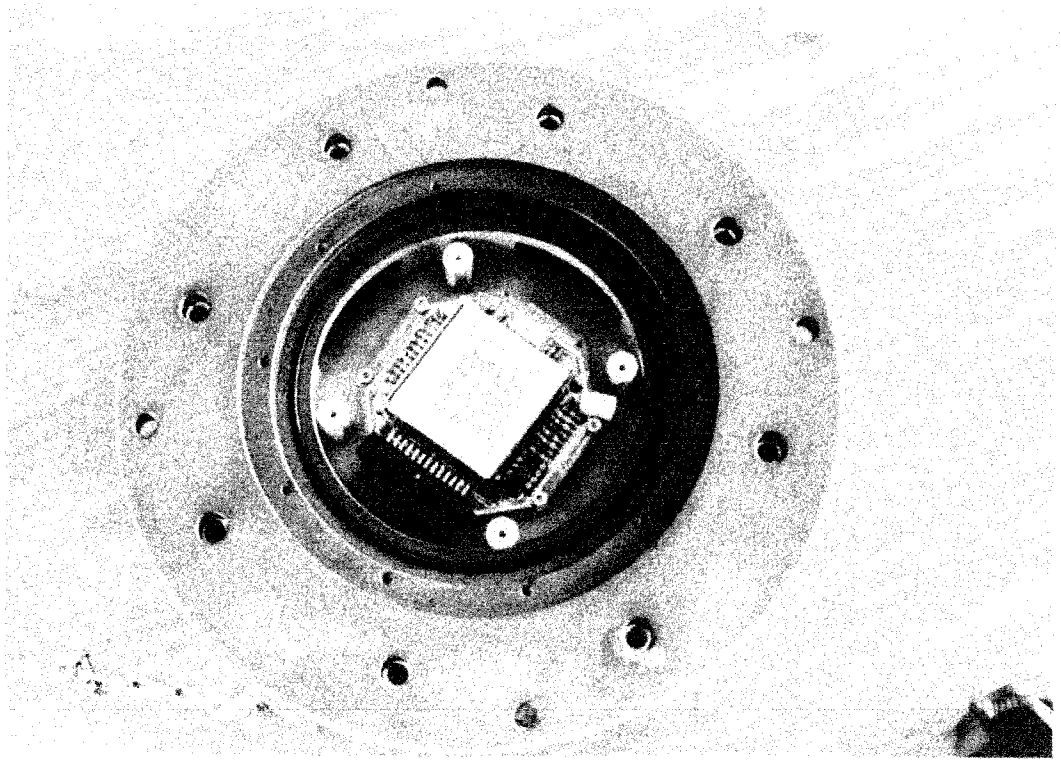
1.2.3 Microthermal Data Acquisition System

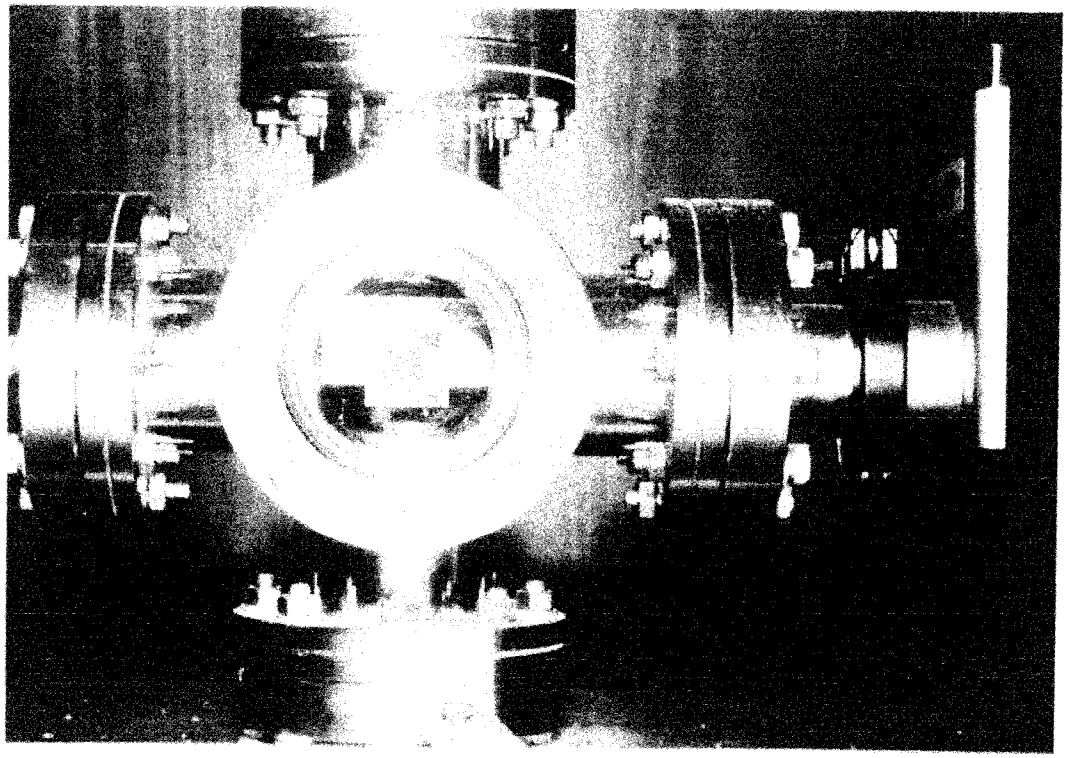
The turbulence in the atmosphere is characterised by the random spatial and temporal variations in temperature and is represented by CT-2. Microthermal measurements measure this temperature difference between two horizontally separated points. A microthermal data-acquisition system has been developed to characterise the thermal profile of the site where the 2-M telescope at Hanle is proposed to be installed. The probes were configured using matched pairs of PT-100 thin film resistors. The design involved an excitation system for matched differential sensors in a bridge configuration, a phase-sensitive detector and a PC interface to acquire and compute the CT-2 parameter. A tower of 48 feet in height was built.The probes were mounted on the tower at four different levels and the pair of probes at each height was separated by two meters.At each height a temperature sensor (AD 590) is placed to measure the average temperature at that height. The initial trial was conducted at Hosakote campus with the PT-100 and AD-590 sensors mounted on the tower.
(R. Srinivasan, T.P.Prabhu, Rajalakshmi, Faseehana Saleem and J.P.A. Samson)

1.2.4 Electronic Instrumentation For Solar Eclipse

A 6-channel precision photometry was required to record the photons in the wavelengths covering 4700-4861 Angstrom, at 5 pre- fixed coronal positions, between 1.2 - 2.0 solar radius. The simultaneous observations

CCD Development program





will help in cancelling-out extraneous variations such as sky, any cloud and transparency variation in the line-of-sight and record accurate light level in the given wavelengths. The electronic system was built utilising the following sub-systems:

1. Photmultipliers and their housing for the High voltage chain
2. Pulse amplifiers and discriminators
3. Pulse counter interface cards for the lap-top computer
4. High-speed data-acquisition program and reduction software
5. Stepper-motor drive with digitally selectable frequencies
6. Low and high-tension power Supplies

The system was integrated and tested for satisfactory performance at Bangalore. Later in the eclipse site at Don-Bosco, the integrated system worked satisfactorily and the coronal data could be successfully recorded during the event. The analysis of data is in progress.

1.2.5 Modifications on Polarimeter at 1 Metre Telescope

The polarimeter at 1 meter telescope, VBO has been modified for IBM-PC/AT computer and the software for data acquisition and analysis has been developed to run on the same platform. A set of new software commands have been implemented for case of operation. On-line display of data and results are also possible. The instrument has been tested on the telescope for its hardware and software functionality. The major improvement in the new instrument is the increased observing efficiency. The observations of standard stars show that the long term stability in position angle measurement is within +1 deg. A 9.5 mag star through V filter can be observed in 15 minutes to give an accuracy of + 0.15under average sky conditions at VBO.
(G.Srinivasulu and A.V.Raveendran)

2. COMPUTER DIVISION

2.1 ADDITIONS TO BANGALORE CENTRE

A new camera system to obtain hard copy of screen images has been installed. This will produce film negatives, slides and polaroid output, and is useful for projection purpose. The augmentation in the form of PCs for individual scientific needs and for specific applications were added to the LAN at Bangalore campus and also VBO, Kavalur. The software additions included packages like Mathematica, Mcsyma and super mongo on various platforms. A recent enhanced version of IDL has been ordered (IDL 5.0) for the ultra sparc system and is likely to be installed shortly. In order to meet the increasing need for disk space on the power challenge system a 23 GB hard disk has been ordered. This will be installed shortly.
(J.S Nathan, K.N Kutty and A.V. Ananth)

2.2 FACILITIES FOR HOSAKOTE AND HANLE

The computer requirements for communication between Hosakote and Hanle have been finalized for the 2 m project. It is also expected to meet the requirements for telescope and back-end instrumentation and provide user interaction for remote operation of facilities at Hanle. Presently efforts are on to plan a suitable Lan for Hosakote and Hanle.
(A. V Ananth)

3. ELECTRICAL ENGINEERING

3.1 DIESEL GENERATOR SET

In order to create a durable solution to the erratic power supply to the Bangalore campus, especially during summer months, it was decided to install a large capacity (200 KVA) diesel generator set. This required a major effort by the electrical engineering division Various details had to be looked into including the 200 KVA grouting, connecting all cables to the new panel board, co-ordinating with CPWD and KEB signing of agreement, carrying out 'B' and 'C' checks for the D.G set, installation of diesel storage tank, etc. Two technical personnel were deputed for training by Kirloskar Cummins Ltd in operating and running of D.G. sets. Steps were taken to train these personnel through correspondence course by Cummins.
(K. Padmanabhan and V. Chinnappan)

3.2 KAVALUR FACILITIES

Indented necessary cables and switchboard fabrication was done through CPWD on a time bound programme for the liquid nitrogen plant at Kavalur. Installation of the L.T. panel with suitable earthing was effected. Changes suggested by the supplier were incorpor-

ated in the works. Feeder-pillar box for Kavalur residential quarters was indented and the fabrication work was taken up after the technical discussions with CPWD. The unit has since been installed and made use of 15 KVA unit was commissioned at Kavalur. Kavalur transformer/dimmerstat/stabilisers oil filtration work was done. Breathers were replaced with new units.
(K. Padmanabhan and K S. Subramanian)

4. PHOTONICS

4.1 INSTRUMENTATION

4.1.1 Wavefront Sensing

The mathematical formulation for the theoretical simulation of the method of polarisation shearing interferometry using two crossed Babinet Compensators has been worked out. The data reduction procedure developed earlier has been improved. Efforts are on to retrieve the unknown values of the aberrations and thus reconstruct the wavefront. Currently, work is in progress for improving the accuracy of these methods and also to enhance the speed of implementation.
(A.K. Saxena and J.P. Lancelot)

4.1.2 Instrumentation for Observing Solar Corona During Total Eclipse

A 5 channel photometer with additional central integrated light channel was designed and fabricated at the Photonics Division of the Institute. Another instrument for fast CCD recording of solar corona during totality was also made ready for observation. The instruments were fully tested before shipment. Preliminary results of the successful observations were presented in a seminar on 7th April 1998.
(R. Cowsik, J. Singh, A.K. Saxena and R. Srinivasan)

4.1.3 Thin Gold Film Coating

The 12 inch vacuum coating plant has been modified to accomodate two heating sources. Tantalum and Molybdenum boats were procured for holding chromium and gold respectively. Suitable mechanical modifications were made to hold both the boats inside the chamber. Glass substrates were first base-covered with chromium and subsequently with gold. The gold coated substrates were subjected to transmission test and reflectivity test using fibre optics spectrometer. The results were comparable with the standard gold coating applications. An alternate method of gold coating using laser ablation method is being developed in collaboration with Prof. Thareja of IIT Kanpur. Dr. Ratna Sircar of Feroze Gandhi College, Rae Bareli, has been coordinating the work at IIT Kanpur.
(A. K, Saxena, K. Ramankutty. J.P.A. Samson and J.P. Lancelot)

4.2 MAINTENANCE

4.2.1 Re-aluminising of Primary Mirror of VBT

The 2.8 m coating plant preparation and trial runs were done for aluminising the VBT primary mirror, which was carried out in July 1997. A thicker coating of aluminium was provided for better reflectivity and longer life. The quality of the coating turned out to be better than previous coatings.
(A.K. Saxena, aluminising team and mechanical team)

4.2.2 12 Inch Coating Plant

Several jobs of coating small optics like 6 inch mirrors, flats, glass slits and gold coating on stainless steel flats and copper flats for CCD development work etc, were executed.
(K. Ramankutty, J.P.A. Samson and Nirmal Kumar)

4.2.3 Coating Plant Maintenance at VBO

Maintenance of the 60 inch vacuum coating plant was taken up. A new water cooling pump was installed for the rotary pump and the diffusion pump. Trial runs showed satisfactory performance.
(J.P.A. Samson and Nirmal Kumar)

4.2.4 Grinding Machine Maintenance

The grinding machine (which was used for VBT optics) was thoroughly overhauled in order to take up the surface generation of the 40 inch primary mirror.
(V. Gopinath, V. Robert and J.P. Lancelot)

4.3 EXTERNAL PROJECTS

4.3.1 Synchrotron Radiation Beam Line (SRBL) Optics

This project is a collaboration with BARC. As reported earlier, one flat mirror and one spheroidal mirror had been successfully figured. The surface profile of the spheroidal mirror was measured at Brookhaven National Laboratory (USA). A shearing interferometer is being set up for the slope errors of the spheroidal mirror.
(A.K. Saxena, R. Cowsik, R. Ismail and J.P. Lancelot)

4.3.2 VHRR Sun Shield Panels

This project is a collaboration with ISRO. The work on the 6th set of the Very High Resolution Radiometer (VHRR) sun shield panels is in progress. Details for the extension of this facility, as well as the technology for the future requirements of ISRO are being worked out.
(A.K. Saxena)

5. MECHANICAL ENGINEERING

5.1 REPAIR OF LATHES

The sliding surfaces of two lathes (LB 17 and LB 20), supplied by M/S. Hindustan Machine Tools about thirty five years ago, have worn out to the extent of about 100 micron at its maximum point. The wear of the sliding surface prevents the job being turned from conforming to the required concentricity and straightness. To avoid this slight ovality and taper it was essential to re-scrape the sliding surface to correct for the errors. This was done by specialised skilled mechanics, using blue marking transferred from the surface plate onto the sliding surface needing correction. The high point on the sliding surface were carefully scraped using a scraping tool. This was a major maintenance work involving dismantling of saddle, apron, cross-slide, tailstock, headstock and improving their surface flatness to achieve the conditions as per original test chart. Similar work was carried out on HMT lathes LB 17 and LB 25 at Kavalur workshop also. It is observed that the geometrical accuracy of the job turned after re-scraping is very much high.
(B.R. Madhava Rao, A. Selvaraj and F. Gabriel)

5.2 MAINTENANCE

5.2.1 Vainu Bappu Telescope, Kavalur

Support of the mechanical worksops was offered for aluminising of primary and secondary mirrors of VBT. It involved cleaning and lubrication of some of the precision mechanism like mirror supports, drive for mirror shutters. A coat of Duco black paint having matty finish was given to avoid shiny metalic surface around the path of starlight During this exercise, telescope accessories like the 10 tonne dome crane and mirror carriage were serviced and tested before their use with mirror system. Several other tasks performed included, making arrangements to prevent rain water leakage at the dome and shutter joints, providing an encoder having 128 turn and 16 bit for the cassegrain position angle device for observation of extended objects, mounting an LVDT adjacent to the cassegrain/prime focus to obtain backlash free reading of the focus position at the prime and cassegrain foci, providing anti-vibration mounts for VBT hydrostatic bearing motor and pumps to reduce the vibration of the system, and periodic cleaning & lubrication related to moving parts of telescope, dome and its supporting systems.
(F. Gabriel and B.R. Madhava Rao)

5.2.2 1 Metre Telescope

Mechanical support was given to mount 35 mm cameras onto the telescope mount to obtain photographs of comet Hale-Bopp Arrangement was done for pressurised liquid nitrogen filling to CCD dewar during observation. Since the moving of the heavy and long, dry nitrogen cylinder to the observation floor was very difficult, a dry nitrogen pipe line was installed from the ground floor of the telescope building to the observation floor along the vertical side of the north pier using seamless steel pipe. This has reduced the time required for filling liquid nitrogen dewar manually . One set of offset guiding unit with acquisition and filter wheel unit was designed and fabricated
(F. Gabriel and B.R. Madhava Rao)

5.2.3 Other works

The siderostat clock drive was replaced by a stepper motor for the Kodaikanal spectro lab.
(F. Gabriel and B.R. Madhava Rao)

6. THE HANLE 2-M TELESCOPE PROJECT

With the clearance of the EFC Memo for the 2-m Telescope Project by the Govt of India, the Project formally took off in May 1997 The vendor of the 2-m telescope was earlier identified as M/s Electro-Optic Pty Ltd of Australia and the telescope to be manufactured by their subsidiary M/s EOS Technologies Ltd, Tucson, U.S A An agreement was signed in July 1997 and the process of design and manufacture initiated

Discussions on the design commenced in November 1997 and continued through the year The primary mirror blank of ULE material was ordered from M/s Corning Inc , in December 1997 and is expected to be ready for delivery in May 1998.

M/s Stup Consultants Ltd , Bangalore, were appointed consultants for the telescope enclosure, and the concept design and tender documents were shaped up during the year Tender pre-qualification bids were invited and evaluated

It is planned that up to 4 first-light instruments should be available at the Cassegrain focus, and a queuing mirror would select one of these remotely within tens of seconds One of the first-light instruments would be a 4K × 4K mosaic CCD to be developed in-house, and another a faint object spectrograph camera (FOSC) to be fabricated in collaboration with the Copenhagen University Astronomical Observatory, Denmark Specifications of IR instruments are being reviewed

A noteworthy event at the site was Bhoomi Pooja (Propitiation of Mother Earth) by R. Cowsik and laying of the Foundation Stone for the Observatory by H E Gen (Retd) K V. Krishna Rao, PVSM, the then Governor of J & K State, on 16 October 1998. The area designated for the 2-m telescope and the attendant facilities on the Dikpa-ratsa Ri ('Scorpion Mountain') was named as Mt. Saraswati, after the Hindu goddess of learning.

A Maruti Gypsy car was procured and deployed in Ladakh. This was used for a dry run to test the road conditions between Bangalore, Delhi, Jammu, Srinagar, Kargil, Leh and Hanle. The car also piloted a truck carrying 3 8 m VSAT antenna for the satellite-based communication link. One such antenna was earlier installed at Hosakote. The communication link tests began at both Hosakote and Hanle, and the NOCC tests were conducted and certificates procured for the Hosakote installation A slower VSAT-based subscriber network (RABMN) node was procured for Leh Once installed, it will be possible to communicate betweeen Hanle, Leh, Bangalore and Kavalur using this network.

An order was placed with M/s CEL Ltd , Sahibabad, for a 30 KWp SPV power plant. M/s CEL delivered SPV arrays in October 1997, but deferred the delivery of other material and installation for the summer of 1998. Based on the assessment of total power requirements of the telescope and dome, it was decided to augment the generation of power. Accordingly, an order was placed for a second 30 KWp SPV power plant with M/s TATA BP Solar India Ltd The entire system was ready for transportation by the end of the fiscal year and is planned to be transported and installed at the site as soon as the roads open in summer. Three 30 KVA Diesel Generator sets were procured from M/s Greaves Ltd to work in standby mode in tandem with the two SPV power plants, and also to serve at the base camp. It was also planned to procure two 1 KWP SPV power plants to make the RABMN nodes at Leh and Hanle Base operational round the clock.

A contour map of Mt Saraswati area was made with a contour interval of 1 metre with the help of Border Roads Organization (BRO). A scaled model was also made based on this map The map was used for preparing a layout plan of different facilities in the area including the 2-m telescope building Considerable amount of construction work was undertaken during summer It included fabrication, transportation and erection of a microthermal tower, foundations for the 3.8 m VSAT antenna and for a 16 inch telescope The work on the construction of power house and storage hangar were also initiated.

The BRO is contstructing a road between Hanle monastery and Dikpa-ratsa Ri summit. Vehicles are able to negotiate to the peak since October 1997. The RABMN unit which was installed at the ITBP camp-in 1995, was shifted to the Base Camp Work on installation of two handpumps at this site was also initiated The transfer of government land for the observatory at Hanle and for a Science Centre at Leh progressed satisfactorily.

A contract was finalized with M/s Stirling, Netherlands, and M/s Philips India Ltd., for procurement and installation of a 5 lit/h ca-

pacity liquid nitrogen generator plant.

The cloud cover monitoring in progress has yielded data for over three complete years. The data shows very little change in the annual statistics over the three years. The automated weather station at the summit produced data for more than one complete year; it was relocated at about 400 m east of the earlier location to facilitate site development. The data is periodically downloaded to Bangalore, and analysed.

Measurement of vertical temperature profiles were undertaken at altitudes of 6, 12, 24 and 48 feet from ground close to the planned location of the 2-m telescope. The results show that the temperature rises by about 1° C between 6 and 12 ft., stays nearly constant till 24 ft., and falls by 0.5° C at 48 ft. The local boundary layer thus ends somewhere between 12 and 24 feet. The profile is fairly constant within each night and between different nights. Based on this data, it was decided to fix the height of the 2-m telescope elevation axis to between 8.5 and 10 metres.

Several dignitaries visited the site during the Foundation Laying Ceremony. These included H. E. Gen.(Retd) K. V. Krishna Rao, PVSM, the then Governor of J & K, Gen. P. K. Renjen, GOC, Mr. P. Namgyal, MP, Ladakh, Ven. Sotse Rimpoche of Hanle, Mr. A. K. Goyal, DDC, Leh. Prof. N. Nakai, Nobeyama Radio Observatory visited the site in January 1998 as a part of Indo-Japanese Collaboration in Science. Prof. Nakai undertook site reconnaisance in the area and opined that the Thangchukgiri plain appears to be ideally suited for a millimetre wave array. Dr. R. Siddharth, OSD, DRDO and Ms. V. Hunt, ESA visited the site in February 1998 and were impressed by the quality of the skies and the facilities created by IIA.

(T.P. Prabhu)

LIBRARY

The library added 382 books to its collection and subscribed to 144 journals It continued to receive 100 observatory publications, preprints, newsletters and annual reports. Nearly 300 Inter-Library-Loan requests were handled during this year Eight journals are available electronically in full text form and they are being accessed continuously.

The library automated its circulation procedure. In the new system, the issue and return of documents are effected using scanners and barcodes. New membership cards were issued to all users.

The library introduced a graduate trainee programme. Two post graduates in Library Science from Bangalore University were recruited and training was imparted to them.

Ms A. Vagiswari, Librarian, presented a proposal for networking all astronomy libraries in India at the 18th Astronomical Society of India meeting held in Ahmedabad. Messrs P. Chockkalingam and N. Krishna Murthy (Kodaikanal library) retired from service during the year.

OFFICIAL LANGUAGE IMPLEMENTATION

The Institute has been carrying on the program of implementation of the official language in a systematic way. Administrative and other reports and official documents to be laid in the Houses of Parliament, have been prepared bilingually. These include the Institute's Annual Report and Audited Report. Official circulars have been brought out bilingually. This includes circulars relating to national and other holidays. A facility like "learn a new Hindi word everyday" has been introduced which was well received by the employees. The Hindi version of entries in the service books has been continuing as an essential part of the implementation. "Hindi Divas" was celebrated in the Institute with a large in-house participation. Dictionaries, glossaries, and other reference literature, as well as Hindi books have been made available to the staff members. In the administrative work, an "Incentive Scheme" for drafting notes and letters was started. Four employees have applied to join "Prabodh" class to receive Hindi training.

PERSONNEL

The academic and technical staff as of 31 March 1998 [1] include the following:

Director: R. Cowsik.

Senior Professor: M.H. Gokhale, C.V. Vishveshwara.

Professor: B.P. Das, B. Datta, S.S. Hasan, R.K. Kochhar, V. Krishan, D.C.V. Mallik, M. Parthasarathy, T.P. Prabhu, N.K. Rao, J.H. Sastri, P. Venkatakrishnan.

Associate Professor: H.C. Bhatt, K.K. Ghosh, R.C. Kapoor, R. Rajamohan, A.V. Raveendran, J. Singh, C. Sivaram.

Reader: S.P. Bagare, P. Bhattacharjee, S. Chatterjee, P.K. Das, S.S. Gupta, S. Giridhar, S. Mohin, K.N. Nagendra, P.M.S. Namboodiri, A.K. Pati, V. Raju, K.E. Rangarajan, D. Mohan Rao, K.R. Subramaniam.

Fellow: G.C. Anupama, R.K. Chaudhuri, R. Kariyappa, S.V. Mallik, M.V. Mekkaden, B.S. Nagabhushana, A. Satya Narayanan, K P. Raju, P. Shastri, K. Sundara Raman.

Research Associate: K.M. Hiremath, K. Jayakumar, K. Kuppuswamy, J.V.S.V. Rao, M.S. Rao, M.J. Rosario.

Head Photonics Division: A.K. Saxena.

Senior Principal Scientific Officer : A.V. Ananth, R. Srinivasan.

Principal Scientific Officer : G.S.D. Babu, V. Chinnappan, B.R. Madhava Rao, M.S. Soundararajan, G. Srinivasulu.

Scientifc Officer SD : K.B. Ramesh, S.K. Saha, R. Surendiranath, J.P.L.C. Thangadurai.

Scientific Officer SC: P.S.M. Aleem, J. Javaraiah, D. Karunakaran, B.A. Varghese, L. Yeshwanth.

Senior Engineer (Civil Works & Estates . N. Selvavinayagam.

Engineer (optics): H. R. Sharma[n]

Engineer (Elec & Comp): M. Prakash[n], A N Rout[n].

Librarian : A. Vagiswari.

Assistant Librarian B : C. Louis.

Technical Officer : M. Mohammed Abbas, S S Chandramouli, A.T.A. Hameed, S. Muthukrishnan, B. Nagaraj Naidu, R Muralidharan Nair, J S Nathan, K G. Unnikrishnan Nair, K Narayanankutty, K. Padmanabhan, K.S. Ramamoorthy, J.P.A. Samson

Technical Associate : A M. Batcha, F Gabriel, N Jayavel, P K Mahesh, G.N. Rajasekhara, K. Rangaswamy, A Selvaraj, R Selvendran, N. Sivaraj, K.S. Subramanian, G S Suryanarayana, K C Thulasidharan, A.V. Velayuthan Kutty

Electronics Engineer : F. Saleem.

Documentation Associate S. Rajiva

Mechanical Associate . T. Johnson.

Project Officer : B.C. Bhatt

Distinguished Professor V.K. Gaur

[1] superscript 'n' denotes new entrant during the year

Emeritus Professor : K.R. Sivaraman

Visiting Scientist : J Bagchi, A. Goswami, J. Vijapurkar.

Visiting Fellow : P. Joarder, Manoj K. Samal, Annapurni Subramanian.

Graduate Students. S. Banerjee, S. Bhattacharyya (JAP), S.G. Bhargavi, P J Chakraborty, Geetanjali Gauba", K.P. Geetha, A.D. Jana, Preeti Kharb", V Krishnakumar, S. Majumdar, S. Mazumdar (JAP), P. Manoj", R. Nayak, G Pandey, R D. Prabhu, G. Rajalakshmi, S.P K Rajaguru, B.S. Ramachandra, R. Ramesh, C. Ratnam, B Ravindra", S. Ravindranath, Amitava Roy", M. Sharma, A.D.K Singh, T. Sivarani, R. Sridharan, K. Sankarasubramaniam, R. Srikanth, D. Suresh, A V Thampan, D. Virlal.

Personnel who retired from service during the year:
Professor A. Peraiah.

Personnel who resigned from service during the year:
Dr Arati Chokshi, Professor Palash B. Pal, Mr Probhjot Singh.

Graduate Students who left the Institute during the year:
Dr Deepankar Banerjee, Mr Anupam Muzumdar, Dr R. D. Prabhu, Ms Sushila Rajagopalan.

APPENDIXES

APPENDIX A

PUBLICATIONS [1]

In Journals

*Abdu, M.A., Sastri, J.H., *Luhr, H., *Tachihara, H., *Trivedi, N.B., *Sobral., J.H.A. *Geophys. Res. Lett.* **425**, 511.
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Anupama, G.C., Chokshi, A. (1998), *ApJ* **494**, L147
Short Term Variability in Broad Absorption Line QSOs

Anupama, G.C. (1997) *AJ* **114**, 2054
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*Asplund, M., *Gustafsson, B., Kameswara Rao, N., *Lambert, D L (1998), *A & A*, **332**, 651
Abundance Similarities between the R CrB Star V854 Cen and the Born-again Sakurai's Object

Bhattacharjee, P. (1998) *Phys. Rev. Lett.*, **81**, No. 2
Cosmic Topological Defects, Highest Energy Cosmic Rays, and the Baryon Asymmetry of the Universe

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Cosmic Thermal Neutrino Background: Can it be Detected?

Bhattacharjee, P., *Shafi, Q., *Stecker, F. W. (1998) *Phys. Rev Lett.*, **80**, 3698
TeV and Superheavy Particles from Supersymmetric Topological Defects, the Extragalactic γ-ray Background, and the Highest Energy Cosmic Rays

*Bilham, R., *Blume, F., *Bendick, R., Gaur, V K. (1998) *Current Science*, **74**,
Geodetic Constraints on the Translation and Deformation of India: Implications for Future Great Himalayan Earthquakes.

*Bobrowsky, M., *Sahu, K.C., Parthasarathy, M., *Garcia-Lario, P. (1998), *Nature*, **369**, 469
Birth and Early Evolution of a Planetary Nebula

Chaudhuri, R.K., *Mudholkar, A., *Freed, K F *Martin C.H., *Sun, H (1997) *J. Chem Phys*, **106**, 9252
Application of Effective Valence Shell Hamiltonian Method to Accurate Estimation of Valence and Rydberg States Oscillator Strengths and Excitation Energies for $\Pi-$ Electron Systems

Chaudhuri, R K, *Freed, K F (1997) *J. Chem Phys*, **107**, 6699
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Application of Effective Valence Shell Hamiltonian Method to Accurate Estimation of Oscillator Strengths and Excitation Energies for Mg-like Ions

Datta, B., Thampan, A V, *Bombaci,B (1998), *A & A*, **334**, 943
Equilibrium Sequences of Rotating Neutron Stars for New Realistic Equations of State

Gaur, V.K, *Gupta, P K, *Niwas, S. (1997) *J Geophysics*, **62**, 775
Straightforward Inversion of Vertical Electrical Sampling Data

Gaur, V K., *Priestley, K (1997) *Proc Ind. Acad Sci (Earth and Planet. Sci.)*, **106**, 1
Shear Wave Velocity Structure Beneath the Archaian Granites Around Hyderabad, Inferred From Receiver Function Analysis

Geetha, K P, Angom Dilip Singh, Das, B P. *Unnikrishnan, C S (1998), Rapid Communication, *Phys Rev A*, in press
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[1] * denotes collaborator outside the Institute

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*Hagyard, M J,, *Stark, B , Venkatakrishnan, P. (1998) *Solar Phys*, (in press)
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Iyengar, K.V.K , *MacConnell, D.J. (1998), *A & A Suppl. Ser.* (in press)
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Excitation of Longitudinal Modes in Solar Magnetic Flux Tubes by p-Modes

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Mallik, D.C.V., (1998) in Proc. UPSO 104 cm Sampurnanand Telescope Silver Jubilee Workshop, *BASI*, **26**, 511.
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Fabry-Perot Interferometric Observations of the Solar Corona in Green Line.

Ramani, M., Cowsik, R., Singh, J , Krishnakumar, V , Bannerjee, D (1997), *KOB*, **13**, 65
Photometry of Solar Corona Using IAF Aeroplane

Saxena, A.K , Cowsik, R. 1998 in Proc of SPIE conference on Materials Manufacturing and Measurements for Synchrotron Radiation Mirrors, SPIE 3152, in press
The Development of Technology for Vacuum Ultraviolet Plane Grating Monochromator to be used with XUV Synchrotron Source of INDUS-1

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*Shibahashi, H., Hiremath, K.M., *Takata,M., (1997), IAU symposium 185, Kyoto, Japan, in press
A Seismic Model of the Solar Convective Envelope.

Singh, J., et al. (1997), *KOB*, **13**, 37
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Ultra Low Spatial Resolution Photometry in Near IR to Detect Dust Ring.

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Results of 1995 Eclipse Observations and Observing Program for 1998 and 1999 Eclipses

Singh, J , Gupta, S.S , and Cowsik, R. (1997), *KOB*, **13**, 47
High Resolution Multi-Slit Spectroscopy of Solar Corona in Two Emission Lines.

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Reflection Effect in Close Binaries

*Timothy, J.G., Saxena, A K., et al (1997), in Proc of SPIE 3114 on "EUV, X-ray, and Gamma-ray Instrumentation for Astronomy VIII"
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Vasundhara, R., Pavan Chakraborty, *Andreas Hanel, *Erwin Heiser, 1998, in Proc of the First International Conference on Comet Hale-Bopp held at Tenerife during 2-5 February, 1998 Earth Moon and Planets (in press)
Modeling Dust Jets and shells from Comet Hale-Bopp

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Invited Review

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Supernova 1987A: Ten Years After

Mallik, D.C V , (1998) *Curr. Sci.*, **74**, 735
Twenty Five Years of Observational Astronomy at the Indian Institute of Astrophysics

Attendance in Conferences, Workshops and other Scientific Meetings

UPSO 104-cm Sampurnanand Telescope Silver Jubilee Workshop, Naini Tal, 1997 April 7-9, **S.Giridhar, R.Kariyappa, D.C.V.Mallik, S.V.Mallik, A.K.Pati**

International Conference on Relativistic Jets in Astrophysics, Krakow, Poland, 1997 May 27-30, **P. Shastri**

8th Meeting of Marcell Grossmann, Jerusalem, Israel, 1997 June, **R.Cowsik**

Solar Physics Division of the American Astronomical Society, Boseman, Montana, USA, 1997 June 26-30, **S.S.Hasan**

Tenth Cambridge Workshop on Cool Stars, Stellar Systems and the Sun, Cambridge, USA, 1997 July 16-21, **S.S.Hasan, V. Krishnakumar, K. E. Rangarajan**

SPIE meeting on Optics and Optical engineering, San Diego, 1997 July 26 - August 2, **A.K.Saxena**

Indian National Science Academy, New Delhi, 1997 October, **R.Cowsik**

Conference on 'Parity Violation in Electron-Hadron Electroweak Interactions, Paris, 1997 October 27-31, **B.P.Das**

International Workshop on Observing Giant Cosmic Ray Air Showers from $> 10^{20} eV$ Particles from Space, College Park, Maryland, USA, November 1997, **P.Bhattacharjee**

10th National Space Science Symp., Ahmedabad, 1997 November 26-27 **D.C.V.Mallik, J.H. Sastri, C. Uberoi, P. Venkatakrishnan**

ISTEP programme group meeting, PRL, Ahmedabad, 1997 November, **J.H. Sastri, C. Uberoi, P. Venkatakrishnan**

XVIII Meeting of ASI, PRL, Ahmedabad, 1997 November 28-December 1, **S. Giridhar, A. Goswami, S.S. Hasan, P. Joarder, R.C. Kapoor, V. Krishan, D.C.V. Mallik, M. Parthasarathy, A.K. Pati, K.P. Raju, K.B. Ramesh, N. Kameswara Rao, T. Sivarani, P. Venkatakrishnan**

Plasma Society of India, PRL, Ahmedabad, 1997 December 2-5, **V.Krishan**

8th International Workshop on Technical and Scientific Aspects of MST Radar (mst8), Bangalore, December 15-20, 1997 **J. H. Sastri**

Indian Association for General Relativity and Gravitation, Pune, 1997 December **R. Cowsik**

15th International Conference on General Relativity and Gravitation, Pune, 1997 December 16 - 21, **R.C. Kapoor**

DAE Nuclear Physics Symposium, Bangalore University, Bangalore, 1997 December 24-30 **S.P.Bagare, B.P.Das**

International Conference on Astrophysical Fluids : From Atomic Nuclei to Stars and Galaxies, Haifa, Israel, 1998 January 12-15, **V.Krishan**

3rd UCLA International Symposium on Sources and Detection of Dark Matter in the Universe, Marina del Rëy, California, USA, 1998 February, **P.Bhattacharjee**

Mini-workshop on Cosmic Ultrahigh Energy Neutrinos and their Detection, Maria del Rey, California, USA, 1998 February, **P.Bhattacharjee**

New Initiatives in Solar Physics Research, IIA, Bangalore, 1998 February 20-21, **Solar group**

Seminar on Radar remote sensing of the atmosphere, National MST Radar Facility (NMRF), Gadanki, March 2-3, 1998, **J.H.Sastri**

IUCAA Sponsored Introductory School in A & A, Department of Physics, Bangalore University, Bangalore, 1998 March 2-6, **S.P.Bagare**

DAE Symposium on Nuclear Physics, 1998 March 5-6, **B.P.Das**

Physics of Cooled and Trapped Atoms and Ions, Mumbai, 1998 March 5-8, **B.P.Das**

SPIE Conference, Kona, Hawaii, 1998 March 20-28, **A.K.Pati**

Colloquia and Invited Talks at Conferences, Workshops and Seminars

Bagare, S P
The Physics of the Sun
IUCAA sponsored introductory school on Astronomy and Astrophysics for College Teachers in Physics, Department of Physics, Bangalore University
1998 March 2-6

Bhattacharjee,P.
Ultrahigh energy from cosmic rays from topological defects - Cosmic strings, monopoles necklaces and all that
International Workshop on Observing Giant Cosmic Ray Air Showers from 10^{20} eV Particles from Space College Park, Maryland, USA
1997 November

Ultrahigh energy neutrinos from topological defects
Mini-Workshop on Cosmic Ultrahigh Energy Neutrinos and their Detection
1998 February

Cowsik, R
Dark matter : An introduction
8th Marcell Grossman Meeting Jerusalem, Israel
1997 June

Dark matter in the universe
Summer School in Astronomy and Astrophysics, Bangalore
1997 June

Astral diamonds and rubies
Indian National Science Academy, New Delhi
1997 October

Accretion - powered astronomical sources
Indian Association for General Relativity and Gravitation, Pune
1997 December

Das, B P
Parity nonconservation in atomic Ytterbium
University of Oxford, England
1997 October 6

Atomic probes of the unification of fundamental forces
PRL, Ahmedabad
1998 February 26

Nuclear anapole moment
DAE Symposium on Nuclear Physics, Bangalore
1997 December 26

Atomic probes of the unification of fundamental forces
IUCAA, Pune
1998 March 2

Parity non-conservation in atomic ions using laser cooling and trapping
Conference on Physics of Cooled and Trapped Atoms and Ions, Mumbai
1998 March 6

Ghosh, K.K
Physics of jets in AGN
Meudon Observztory, Paris
1997 December 22

New insights in understanding the blazers
ISAS, Japan
1998 February 20

Giridhar, S.
Spectroscopic studies of selected F-G supergiants
UPSO 104-cm Sampurnanand Telescope Silver Jubilee Workshop, Nainital
1997 April 7-9

Surface compositional changes encountered during last stages of stellar evolution
XVIII ASI meeting, PRL, Ahmedabad
1997 November 28 - December 1

Krishan, V.
Role of inverse cascade in turbulent media
Plasma Society of India, PRL, Ahmedabad
1997 December 2-5

Inverse cascade of energy in astrophysical fluids
Haifa, Israel
1998 January 14

Turbulence and order in astrophysical fluids
Jawaharlal Nehru Center, Indian Institute of Science
1998 February 23

Mallik, D.C.V.
Observational studies of planetary nebulae with moderate size telescope
UPSO 104 cm Sampurnanand Telescope Silver Jubilee Workshop, Nainital
1997 April 7-9

Stellar structure and evolution (7 talks)
UPSO, Nainital
1997 September

Rapporteur talk
XVIII ASI meeting, PRL, Ahmedabad
1997 November 28 - December 1

Prabhu, T.P.
The Hirot Project
National Astronomical Observatory, Mitaka, Japan
1998 March 19

The Hirot Project
Nobeyama Radio Observatory, Nobeyama, Japan
1998 March 25

Sastri, J.H.
Ionospheric Disturbance Dynamo (Plenary Talk)
10th National Space Science Symposium, PRL, Ahmedabad
1997 November

Radar studies of low latitude and equatorial Ionosphere
Seminar on Radar remote sensing of the atmosphere, NMRF, Gadanki, Andhra Pradesh
1998 March

Satya Narayanan, A.
A simple model for sun's internal magnetic field
MPI fur Astrophysik, Garching bei Munchen, Germnay
1997 September 24

MHD surface waves
University of St. Andrews, Fife, Scotland, U.K.
1997 October 2

Axisymmetric MHD equlibrium of a self-gravitating incompressible fluid
Dept. of Physics, UMIST, Manchester, U.K.
1997 October 10

Self-organisation in hydrodynamic flows
ICTP, Trieste, Italy
1997 October 20

Saxena, A.K.
A New Method of Wavefront Sensing for Adaptive Optics and Synchrotron Mirror Fabrication
National Synchrotron Light Source (NSLS) Center.

Venkatakrishnan, P.
The Heliosphere as Viewed from Space (Plenary Talk)
10th National Space Science Symposium, PRL, Ahmedabad
1997 November 28

High Angular Resolution In Solar Physics: Techniques and Applications
New Initiatives in Solar Physics Research, IIA, Bangalore
1998 February 20

Vishveshwara, C.V.
Black holes and rotation
Meeting on the Physics of Black Holes, IISc
1997 December

Paper Presentations at Meetings

Das, B.P.
Enhancement of parity nonconservation in atomic ytterbium

Parity Nonconservation in Ba^+ and Ra^+
Conference on Parity Violation in Electron - Hadron Electroweak Interactions, Paris
1997 October 27-31

Gupta, S.S
Studies on the variation of solar rotation
New Initiatives in Solar Physics research IIA, Bangalore
1998 February 20-21

Gupta, S S , Singh, J
On the eruption of prominences and disappearance of quiescent filaments
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New Initiatives in Solar Physics Research, IIA, Bangalore
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Visits

R. Cowsik, R. Srinivasan and **T. P. Prabhu** visited Japan during 1998 March 17 - 29 under the Indo-Japan Science Cooperation Programme sponsored by the DST and JSPS. **B.P. Das** visted the University of Oxford,England , the Physical Research Laboratory, Ahmedabad, Inter University Centre for Astronomy and Astrophysics, Pune and Bhabha Atomic Research Centre, Mumbai. **K. K. Ghosh** visited the Meudon Observatory during 12-26 December 1997 to work with Van der Riest Christian to finalize the modifications necessary for the SILFID spectrograph that will be installed with the VBT He also visited ISAS, Japan (12 - 22 February 1998) to work with F Makino to finalize a paper on "Simultaneous optical and X-ray observations of BL Lac during the flare state". **S.S. Gupta** was a co-investigator in two Indo-US collaborative projects, and visited the National Solar Observatory, Tucson and Kitt Peak Observatory, USA, during June to Aug., 1997, for observations and data analysis. **K.N. Nagendra** visited Observatoire de la Cote d'Azur, Nice, France for 2 months during 1998 March-April, for continuation of ongoing collaboration on the 'Operator perturbation Method in Radiative Transfer Theory **A. Satya Narayanan** visited the Institute fur Plasmaphysik, Julich, Germany on Sept 11, 1997, the FOM - Institute voor Plasmaphysics, Nieuwegein, The Netherlands on Sept 16, 1997, the Max Planck Institute fur Astrophysik, the European Southern Observatory, the Institute fur Plasmaphysik, the Max Planck Institute fur Extraterrestrial Physik (All in Garching bei Munichen, Germany) between Sept 19 - 30, 1997, the Department of Mathematical and Computational Sciences, University of St Andrews, Fife, Scotland, U K between Oct 1 - 10, 1997, the Department of Physics, UMIST, Manchester, U K between Oct. 10 - 11, 1997 and participated in the Autumn College on Plasma Physics helf at ICTP, Trieste, Italy from Oct 13 - Nov 7, 1997 **A.K. Saxena** visited the Brook Haven National Laboratory, New York U S.A for technical interactions with Prof Peter Z Takacs, Head, Optical Metrology Division **P. Shastri** visited the Copernicus Astronomical Centre, Poland from 15-26 May, 1997 under an INSA exchange programme.

APPENDIX B
HRD ACTIVITIES

Teaching

S.P.Bagare coordinated IIA's guest lectures program for the M.Sc. Astrophysics specialisation course 1997-98 of the Bangalore University. The following courses were given (names of lecturers in parantheses) : *Planetary Physics* (Ramesh, K.B.), *Solar Physics* (Bagare, S.P.), *Interstellar Medium*, (Bhatt.H.C.), and *Galactic Structure* (Sivaram, C., Anupama, G.C. and Prajval Shastri).
S.P.Bagare served as an exteral examiner for M.Sc.Physics examination of the Bangalore University for 1997-98.
R.C. Kapoor was an examiner for an M.Phil. thesis submitted to the Post Graduate Department of Physics, The University of Kashmir, Srinagar.
R.Cowsik continued his Distinguished Visiting Professorship at the McDonnell Center for the Space Sciences, Washington University, USA for three months for carrying out teaching and research.
B.P. Das and P. Venkatakrishnan taught one-semester courses on Quantum Mechanics and Stellar Physics respectively, for PhD students, while S.K. Saha gave a month long course on 'Speckle Interferometry'.
S.S.Gupta, S.P.Bagare and Jagdev Singh guided two M.Phil. students of Bharathidasan University, Trichy for their projects in Solar Physics at the Kodaikanal Observatory, during 1997-98.
S.P. Bagare, K.E.Rangarajan, and R. Vasundhara gave several lectures on *Recent developments in our understanding of the solar atmosphere*, *Spectral line formation*, and *Solar System Objects* respectively, to the B.Sc. (Hons) students of St.Josephs College, Bangalore.
A week's training was conducted to the 2nd year B.Sc. (Instrumentation) students of Jyoti Nivas College,Bangalore, as part of their course curricula. J.P.Lancelot coordinated the course work.
Three students of (II B.Sc. Instrumentation) Jyoti Nivas College completed their project work on "Long Trace Profilometer - Data Acquisition and Reduction" as part of their course work, under the guidance of A.K. Saxena.
K. Sundara Raman delivered 4 lectures covering the topics Sun, Solar System, Stars, Stellar Evolution, Galaxies and their Formation to 12th standard students of Zion Matriculation Higher Secondary Schooli, Kodaikanal during November 1997. He also gave lectures titled *Introduction to Astronomy and Astrophysics* to B.Sc and M.Sc physics students at St. Joseph's College and at National College, Tiruchirapalli during March, 1998.

Ph.D. Programme

D. Banerjee obtained his Ph.D. Degree from the Bangalore University under S.S. Hasan's supervision. R.D. Prabhu submitted his Ph.D thesis on "Exploring Inverse Cascade in Astrophysical Turbulence" under the guidance of V. Krishan. R. Srikant (JAP) completed his thesis work under the supervision of Jagdev Singh. K.C. Srinivasan obtained his Ph.D. degree under the guidance of K.K. Ghosh and K R. Radhakrishnan, from the Bharathidasan University, Tamil Nadu. K Sundara Raman submitted his thesis on "Studies on dynamics of active regions and sunspots" to Bharathidasan University, Tamil Nadu

Ms Geetanjali Gauba, Ms Preeti Kharb, Mr P. Manoj, and Mr B. Ravindra are the new entrants this year for the PhD programme.

Summer Projects Programme

Rangarajan was the co-ordinator for the Summer projects students' programme. This is a new programme started in the Institute to spot young talented students and attract them to research in astronomy The programme was widely publicized in January by sending posters to a large number of educational institutions. Selection of the participating students was made after a careful scrutiny of the applications. Several students from various universities entering their final year M.Sc. degree courses participated in this programme this year.

Visiting Students Training Programme

The Visiting Students Research Training Programme was also started. In this programme students work on specific goal oriented projects of relatively longer duration (4 to 6 months). These projects are expected

to make useful contributions to the Institute's ongoing research programmes. We have selected two students this year to participate in this programme. Mr. Kumar Abhimanyu from BIT, Ranchi is working with Mr. Ananth on Interface programme for CCD controller. Mr. V. Manjunatha Rao is working with Prof. Jagdev Singh on the software development for analysing solar images.

Summer School in Astronomy and Astrophysics

A summer school in Astronomy and Astrophysics was organised jointly by Raman Research Institute and IIA during May 26 – June 21, 1997. About thirty students from across the country participated. Board and lodging were provided at the Indian Institute of Science and lectures were held in the Department of Physics Lecture Hall. Lectures covering a wide variety of topics were delivered. Those given by the IIA staff are : *The Solar System* (R. Vasundhara), *Interstellar Matter* (D.C.V. Mallik), *Compact Stars, Standard Cosmology* (B. Datta), *High resolution at optical wavelengths* (P. Venkatakrishnan), *Solar Eclipses* (J. Singh), and *Infrared Astronomy* (H.C. Bhatt).
Participants were taken to VBO, Kavalur over a weekend. Several short term projects were also done by them under the guidance of the scientists in IIA. D.C.V. Mallik (IIA) and R. Nityananda (RRI) were the convenors of the summer school.

Winter School at Kodaikanal

S.S. Gupta and Jagdev Singh were directors of Winter School held at Kodaikanal (Jan 27-31, 1998). Jagdev Singh spoke on *The solar corona* and *Solar Instruments - CCD & Solar Observations - Advantages of high altitudes*. S.S. Gupta lectured on *Solar Atmosphere, Solar Differential Rotation, Solar Prominences*, and *Coronal Mass Ejections*. K. Sundara Raman lectured on *Basics of Astrophysics*, and *Solar Flares*.

APPENDIX C

Vainu Bappu Observatory

Sky Conditions at VBO

Year	Month	Spectroscopic (hrs)	Photometric (hrs)
1997	April	150	34
	May	131	29
	June	82	32
	July	17	0
	August	33	8
	September	41	6
	October	75	9
	November	23	1
	December	120	20
1998	January	202	36
	February	201	44
	March	238	78
	Total	1313	297

Kodaikanal Observatory

Spectro/photoheliograms and seeing conditions at Kodaikanal

Year	Month	No. of photographs in				SEEING*				
		Hα	Kfl	Hpr	PHGM	5	4	3	2	1
1997	April	26	8	19	24	-	2	10	10	2
	May	24	17	18	13	1	-	10	2	-
	June	6	6	4	7	-	-	4	1	2
	July	2	2	1	1	-	-	1	-	-
	August	2	2	2	4	-	-	3	1	-
	September	9	7	3	11	-	-	1	6	4
	October	5	5	4	6	-	-	2	-	4
	November	11	14	8	12	-	-	7	3	2
	December	16	13	11	13	-	1	8	1	3
1998	January	30	23	19	19	-	5	5	7	2
	February	23	26	20	24	-	7	15	2	-
	March	26	27	24	30	-	11	14	4	1
	Total	180	150	133	164	1	26	80	37	20

Kfl = K-floculus
Kpr = Hx Prominence
PHGM = Photoheliogram

*(1- Very poor, 2- Poor, 3- Fair, 4-Good 5- Excellent)

Solar Tower Tunnel Observations

Year	Month	Total number of days of observations	Seeing (in arcsec)								
			1 to 2	2	2 to 3	3	3 to 4	4	4 to 5	5	>5(poor)
1997	April	18	-	1	2	12	2	1	-	-	-
	May	11	-	3	-	7	-	1	-	-	-
	June	1	-	1	-	-	-	-	-	-	-
	July	-	-	-	-	-	-	-	-	-	-
	August	7	-	-	1	6	-	-	-	-	-
	September	8	-	1	-	6	1	-	-	-	-
	October	5	-	-	-	4	1	-	-	-	-
	November	3	-	-	-	3	-	-	-	-	-
	December	6	-	-	-	6	-	-	-	-	-
1998	January	22	-	1	4	15	-	2	-	-	-
	February	23	-	1	-	21	-	1	-	-	-
	March	25	-	1	8	13	2	-	1	-	-
	Total	129	-	9	15	93	6	5	1	-	-