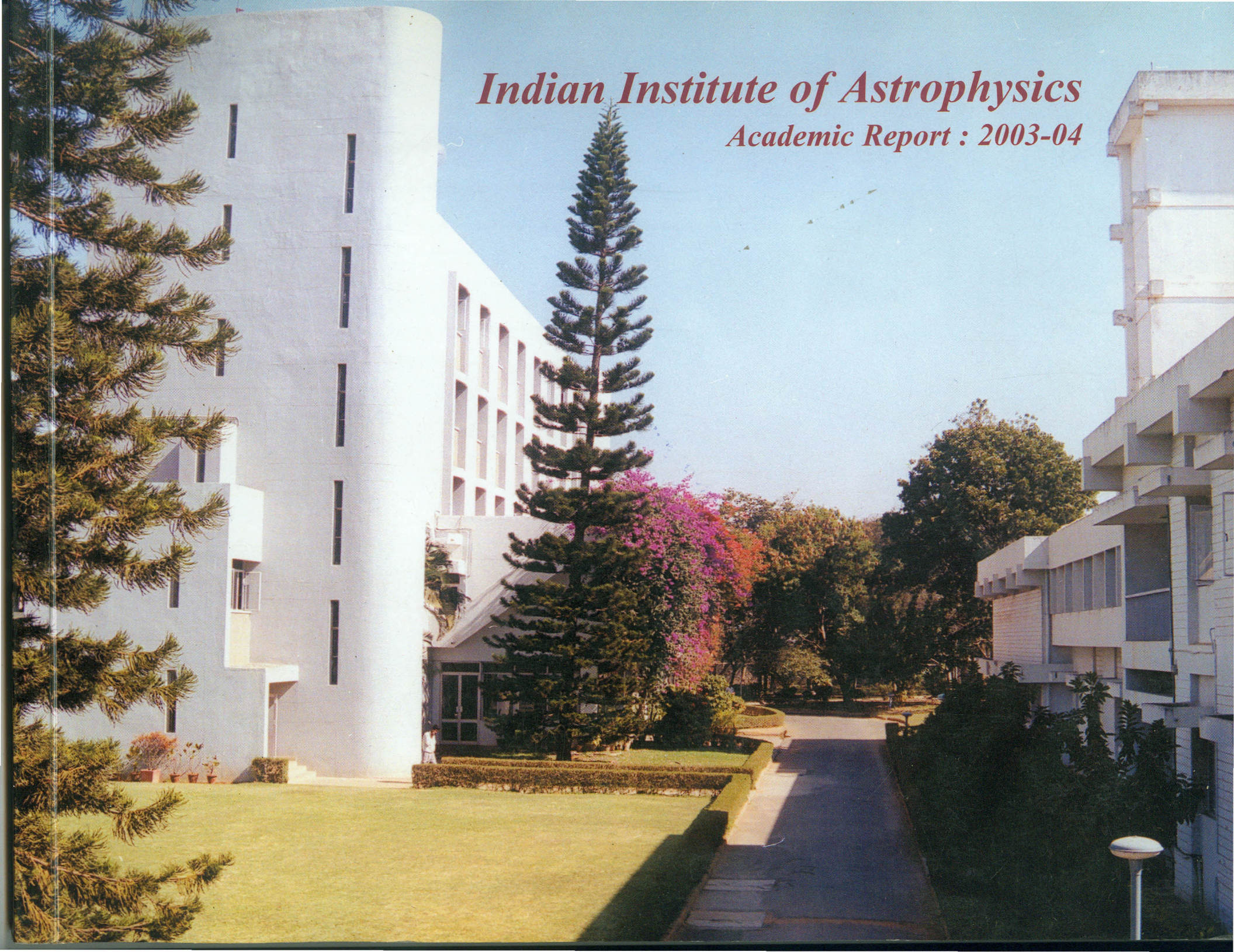
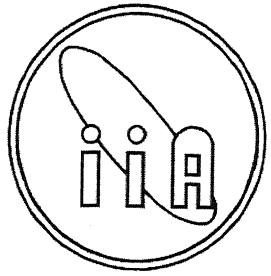


Indian Institute of Astrophysics

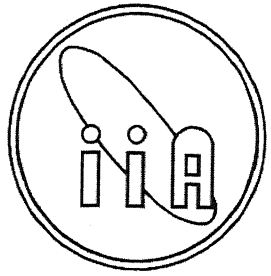
Academic Report : 2003-04

INDIAN INSTITUTE OF ASTROPHYSICS



ACADEMIC REPORT
2003-04

INDIAN INSTITUTE OF ASTROPHYSICS



ACADEMIC REPORT
2003-04

Indian Institute of Astrophysics
Academic Report : 1-4-2003 - 31-3-2004

Edited by : R.C. Kapoor
on behalf of
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Front Cover : IIA, Bangalore Campus; the Annexe building is on the left and the Photonics Division on the right.

Back Cover : First phase of the Brazilian Decimetric Array at the Instituto Nacional Pesquisas Espacias, Sao Jose Dos Campos, Brazil (a collaborative programme of IIA and INPE).

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Bicentennial Lecture

M.K. Chandrasekharan gave the 17th IIA Bicentennial Commemorative Public Lecture on 'Biological Clocks in Bats, Mice and Humans', on June 18, 2003.

Honours & Awards :

S. Giridhar

- Elected Vice President of the IAU Commission 45 on "Stellar Classification" for the triennium 2003-2006.

M. Parathasarathy

- Elected Vice President of the IAU Commission 29 on Stellar Spectra for the triennium 2003-2006. He was also a member of the Scientific Organizing Committee (SOC) of the IAU Symposium 224, 'The A-star Puzzle'.

C. Sivaram

- Awarded Honorable Mention by the Gravity Research Foundation, USA for his essay 'On testing gravity's hidden strengths'.

S.N. Tandon

- Elected President of the Astronomical Society of India.

S.S. Hasan

- Elected Vice-President of the Astronomical Society of India.

Honourable Members of the Parliamentary Standing Committee on Science and Technology, Environment and Forests during their visit to Indian Astronomical Observatory, Leh / Hanle, during June 8-12, 2003.

The year in review

The year 2003-04 is a noteworthy one in the annals of the Institute for several reasons. It marks, among other things, the definitive widening of the astronomical research facilities at the Institute through forays into new domains, namely, space-based astronomy and astronomy from high mountain sites. This scenario is epitomized by the visibly enhanced momentum in the development of the UVIT payload for ASTROSAT, the multi-wavelength astronomy satellite due to be put in orbit by the Department of Space (DOS), and in the fabrication of the prototypes of the high altitude gamma- ray (HAGAR) telescope- a collaborative project with TIFR, Mumbai. Significant change took place in the management of the Institute as well. The reins of the Institute were placed in my reluctant hands by the Governing Council by appointing me initially as the Officiating Director and, after Professor Ramanath Cowsik relinquished the Directorship, as the Acting Director. The Governing Council of the Institute, comprising of enlightened and reputed scientists, and senior officials of the Department of Science and Technology provided constant guidance and unreserved encouragement on matters related to scientific programmes and management which helped the Institute sail through the rather unsettled times that characterized the year, 2003-04.

Scientific research was conducted at the Institute with vigor and commitment covering a wide canvas of subjects: Solar Physics, Solar-Terrestrial Physics, Solid Earth Geophysics, Stellar Physics, Galactic and Extra-galactic Astronomy, Gravitation and Cosmology and Non-Accelerator Particle Physics. The outcome in the form of research publications in reputed and refereed journals, invited and contributory presentations in domestic and International scientific meetings, the manifold collaborations with individual scientists/ organizations both within and outside the country, stand testimony to the vibrancy of our academic pursuit.

A highlight of this year's activity is our participation in the Indian expedition to Antarctica. Instrumentation was specially designed and got fabricated in-house in just a month to fly to and observe the Total Solar Eclipse of 23 Nov, 2003 from the Indian station, Maitri, Antarctica. This was surely a challenging job in view of the adverse snow conditions and high scatter from snowy ground. The sky transparency however turned out to be excellent and our team captured the solar eclipse event for posterity. Broadband photometry and narrow band imaging of the solar corona as also observations of the elusive shadow bands were done. In the following I shall endeavor to give a flavor of our research activity and, for more information, the interested reader is referred to the details documented in the latter parts of this report.

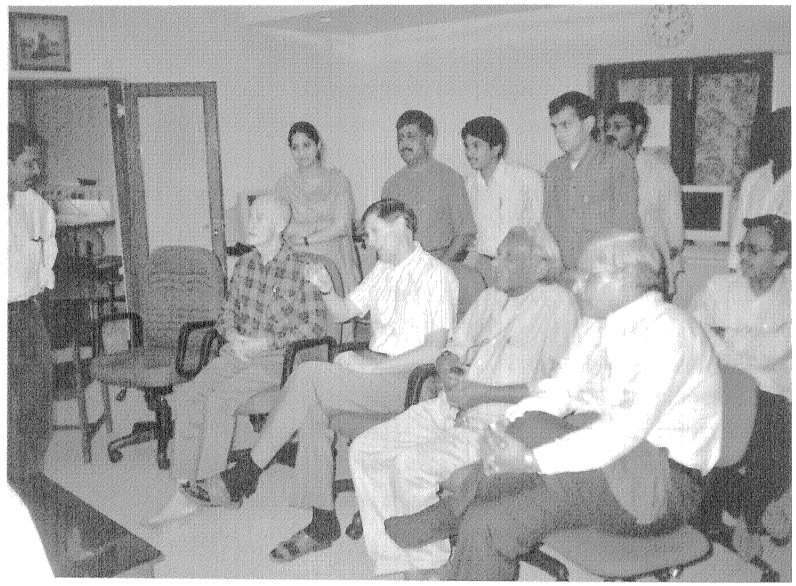
The state of near-Earth space environment is significantly controlled by various forms of solar activity, especially the coronal mass ejections (CMEs). Observations with the Gauribidanur decameter radio telescope have given important information with which one can establish the onset of a CME and relate it to solar surface activities. CCD observations of the newly developed optical nebulosity associated with the infrared source IRAS 05436-0007 using the Vainu Bappu Telescope (VBT) and the Himalayan Chandra Telescope (HCT) revealed a P Cygni profile implying mass outflow. Studies of abundance of Lithium in the Alpha Persei cluster stars indicate that besides mass, age and metallicity, rotation may control the behavior of Lithium in these stars. Important work has been done to understand the circumstellar dust shells around hot post-AGB stars. Chemical composition patterns and evolutionary status of UV bright stars continue to be investigated with the ESO VLT 8-metre telescope and the Japanese Subaru 8 m telescope. The optical afterglow of gamma ray burst (GRB) events is a subject of much observational activity with the HCT. A detailed study of the various processes of production of GeV-TeV gamma rays from GRB sources and their possible detection is in progress. A meticulous study of the Large Magellanic Cloud (LMC) has brought out evidence of a mis-aligned secondary bar within the off-centred primary bar, the most striking feature of the LMC. It is suggested

Professor Sunanda Basu, Boston Univ. and Professor Santimay Basu, AFRL, Hanscom on visit to the CREST, Hosakote.

that the recent star formation and the gas distribution in the LMC could be driven by the mis-aligned secondary bar.

An attempt to obtain emission altitudes in radio pulsars using aberration-retardation phase shift in the pulse components of a millisecond pulsar indicates presence of sweep back in the magnetic field due to plasma inertia. The Institute is engaged in the development of data handling/analysis software for the Indo-Israeli space mission TAUVEX (projected launch early 2005), aimed at Ultraviolet (UV) observations of large fields of view of the sky. This effort is a forerunner and the launch pad for the Indian ASTROSAT mission, for which the Institute is developing the UVIT payload.

Several distinguished persons from the worlds of public life and science visited the Institute during the year and we are enriched by the interaction. The Parliamentary Standing Committee on Science & Technology, Environment and Forests visited the Indian Astronomical Observatory (IAO), Leh/Hanle, Ladakh during June 8-12, 2003 under the chairmanship of Hon'ble Sri C. Ramachandraiah ; 28 Hon'ble Members of the Committee participated in this study visit. The Committee was briefed at Leh about the history of the Institute, its achievements including the successful establishment of IAO at Hanle and the major new initiatives being taken to develop IAO such as the Large Binocular Telescope (LBT) project. A sub-group of the Committee including three Hon'ble lady members led by Hon'ble Sri Ramachandraiah visited IAO on Mount Saraswati, Hanle, braving the elements and the long, arduous journey from Leh. The Hon'ble Members were delighted to see the real time remote operation of the Himalayan Chandra Telescope (HCT) from CREST, Hosakote and appreciated the successful completion of the mammoth task of setting up of the world's highest observatory by the Institute. From the observing platform of HCT, the Committee had a lively video conference with Professor B. V. Sreekantan, Chairman of the Governing Council,



Professor Robert E. Williams and V. Radhakrishnan (seated L-R 2nd and 3rd respectively) on a visit to the CREST, Hosakote.

Honourable Members of Parliament Shri. S. Murugesan and Smt. Margaret Alva at Leh with IIA staff.

Professor R. Cowsik and other senior academic and technical staff of the Institute during which the idea of creating a Science Cadre (similar to IAS, IFS) by the Government of India to motivate and retain bright young persons in the pursuit of Science was mooted. The Committee opined that the infrastructure facilities need to be further improved as regards the road between the base camp and mount summit of IAO, and the 60 km stretch from Loma to Hanle to attract international participation in future mega projects like LBT. We were also fortunate to have had the graceful visit of His Holiness Dalai Lama to IAO, Hanle during June 28-29, 2003.

Professor M. K. Chandrasekharan of the Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR), Bangalore, delivered the 17th IIA Bicentennial Commemorative Public Lecture on " Biological Clocks in Bats, Mice and Humans", on June 18, 2003. The lecture proved to be stimulating with wide spread and enthusiastic queries from the audience. Professor Robert Eugene Williams, Distinguished Research Scholar and a former Director of the Space Telescope Science Institute, Baltimore, MD, USA, and Professor V. Radhakrishnan, Distinguished Professor-Emeritus, Raman Research Institute, Bangalore visited the Hosakote campus. Both were much impressed by the remote operation of HCT. Professor Williams also visited the Koramangala campus and gave a very informative talk on "High resolution emission line spectroscopy: Implications for line identifications and element abundances". Among the other eminent visitors to CREST, Hosakote were Professor Sunanda Basu, Boston University, Center for Space Research, USA and Chair, Science Steering Group for CAWSES (Climate and Weather of the Sun-Earth System -a SCOSTEP-sponsored International Program), Dr Robert McCoy, Office of Naval Research, Arlington, VA, USA, and Professor Santimay Basu, Air Force Research Laboratory, Hanscom AFB, Mass, USA.

Honourable Members of the Parliamentary Standing Committee on Science and Technology, Environment and Forests during their visit to Indian Astronomical Observatory, Hanle, during June 8-12, 2003.

Dr McCoy gave a seminar on " UV Remote Sensing of the Upper Atmosphere" and had discussions with UVIT payload team members on UV instrumentation.

Death has snatched away an accomplished scientist and a genuine well-wisher of the Institute. Professor Robert M. Walker, Honorary Fellow of the Institute and founder-Director, McDonald Center for Space Sciences, Washington University, St. Louis, USA passed away in Brussels, Belgium on February 12, 2004. A memorial meeting was held in the Institute on May 6, 2004.

The multi-faceted efforts to identify, motivate and nurture bright youngsters to take up scientific research continued. The annual Summer School in Physics and Astrophysics was held in Kodaikanal where gifted researchers lectured on well chosen topics to students selected from all over the country. The programs to select and guide students through their doctoral studies, including the inter-institutional ones, JAP and JEST continued. So also is the scheme to train promising young engineers on advanced technology projects. These measures are expected to provide the human resources for the future programs of the Institute as well as of other institutes in the country. The need to increase the floor space for working and living and other infrastructure facilities for the student community and visiting scientists in the Koramangala campus is being increasingly felt and plans are drawn to adequately address this problem. Once implemented, these initiatives will help us continue to attract senior visiting scientists and graduate students in good number. The Mother Teresa Women's University, Kodaikanal and the Institute signed a Memorandum of Understanding (MoU) in the areas of mutual interest of research and teaching in astronomy, astrophysics and allied fields.

Various staff welfare measures were implemented as in the past. Regular assessment of staff for career advancement was done as per the norms in practice.

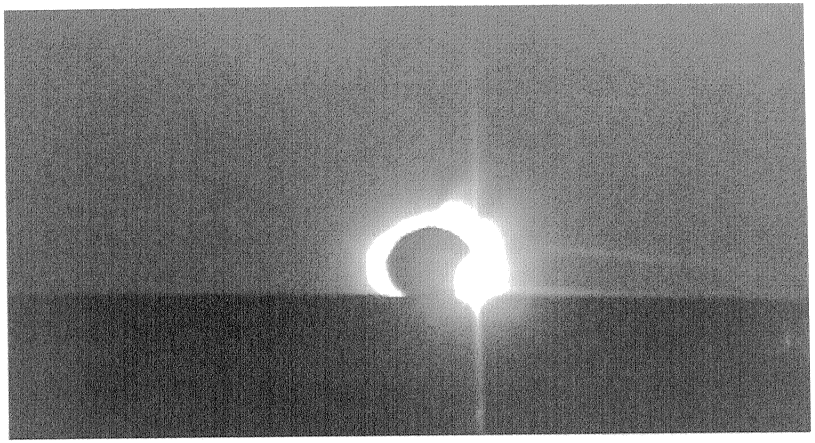
The observational and experimental facilities and other support infrastructure at various campuses of the Institute, namely, Kodaikanal Observatory, Vainu Bappu Observatory, Kavalur; Decameter Radio Observatory, Gauribidanur; Indian Astronomical Observatory, (IAO), Hanle and CREST, Hosakote were well maintained. These were used either in isolation or in combination with other national and international facilities and the variety of astronomical data resources available in the public domain for a multitude of research programs. The 2-m Himalayan Chandra Telescope (HCT) at IAO was fully operational; the telescope time was oversubscribed and observation time was allotted through three cycles to astronomers from national and International organizations and universities. The results based on analysis of data obtained with HCT were communicated to reputed journals.

I am happy to conclude this brief review of activities of the year by placing on record that the contributions of scientists at the Institute have earned wide spread recognition, notably, honorable mention by Gravity Research Foundation, Presidentship and Vice-Presidentship of the Astronomical Society of India, Vice-Presidentship of Commissions 29 (Stellar Spectra) and 45 (Stellar Classification) of the International Astronomical Union (IAU).

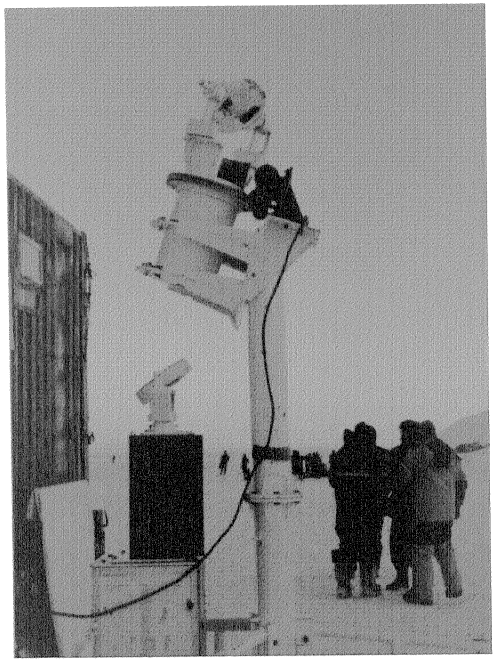
I earnestly hope that this legacy of achievements continues to get strengthened in the years to come and the Institute has a bright future.

J. H. Sastri

Acting Director



▲The Total Solar Eclipse of 23rd November 2003, observed from Maitri.

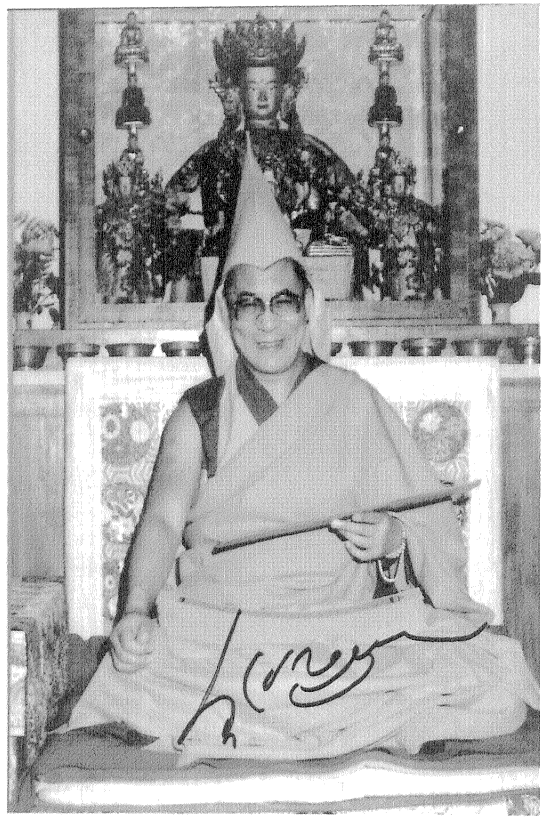


◀ The Antarctica Solar Eclipse expedition team ready with instruments set for observations.

Date	Name & Address	Remarks
03/6/28	Dalai Lama	Even when I was in Tibet I had great interest in Astronomy. I am very happy that this time I am able to see clearly some of the constellations. I pray for the long lasting success of the staffs and their supporters.

Entry into the Visitors Book at the IAO, Hanle by His Holiness the 14th Dalai Lama when he visited the Observatory during June 28-29, 2003.

His Holiness the 14th Dalai Lama with members of the IAO.



SCIENTIFIC RESEARCH

1. Solar physics

Solar rotation studies : Resolution of the controversy over the dual rotation rates on the solar surface : In a recent study (reported in detail in the Annual Report of 2002 – 2003 titled "Variation of rotation rate with age of sunspot groups", pages 8 - 10) we have shown that the rotation rates of sunspots decelerate as they age and lie in the range of 340 to 470 nHz. It was also shown that the deceleration in the rotation rates mimic the rotation rate profiles for different latitudes in the solar interior as determined from helioseismology observations with a remarkable degree of agreement. This was used to interpret that the rotation rates exhibited by the sunspots reflect the plasma rotation rate of the layer in the interior at which the foot points of the magnetic flux of the spots are anchored. Following this, it was also shown that for sunspots of long life span of 6 – 8 days (and hence of large area) these anchoring depths lie initially below the base of the convection zone. As the spots age , the anchoring depths of their foot points progressively rise towards the solar surface and finally reach the very shallow subsurface layers where the anchor depths of the foot points of the spots of short life span (1- 2 days) are located since their first appearance on the solar surface.

Using the method developed in the above paper to estimate the anchor depth of the foot points of any magnetic feature once its surface rotation rate is known , we resolve a long -standing controversy that has existed for almost two decades among the solar astronomers.

The paradox is as follows : The analysis of the photospheric magnetic fields from the same data source (namely the daily Mt.Wilson magnetograms and the Kitt peak magnetograms) by two different methods of analysis led to two vastly differing rotation profiles : (i) Snodgrass obtained in 1983 a **differential rotation profile** when he cross-correlated the full disk magnetograms pairs (within1-3 days) and determined the rotation rate by measuring the rate of longitude displacement of the pattern ; and (ii) Stenflo in 1989 obtained a rigid rotation profile by autocorrelation of the synoptic magnetic maps and determined the rotation from the pattern recurrence at the central meridian.

To resolve this paradox we first listed all the magnetic features (of different length scales and lifetimes) so far detected on the solar surface , the amount of flux they bring out to the surface , their appearance in relation to the phase of the 11 – year solar activity cycle and finally their rotation rates. We then show that because of the different spatial resolution imposed by the grids and of other limitations inherent in the two methods, Snodgrass's analysis tends to pick only those magnetic elements that show differential rotation while Stenflo's analysis gives weightage to structures that show rigid rotation.

The magnetic features are :

1) Sunspots and spot groups that show differential rotation with latitude.
2) Ephemeral active regions with scale size 10 – 20 arc sec and whose number varies in phase with the sunspot cycle . They show differential rotation.
3) Polar faculae of scale size 10 – 15 arc sec that appear above ~50 deg latitudes with the beginning of every solar cycle. The number of polar faculae varies in anti phase with the solar cycle. They also show differential rotation.
4) Intra network flux elements with size in the range of 1-2 arc sec that occur ubiquitously on the solar surface and bring out in a day magnetic flux almost four orders of magnitude more than that by all the sunspot regions put together.
5) In addition to the well resolved individual structures listed above, there are the large –scale unipolar regions both during the solar maximum and minimum periods. But their compositions are different : during solar

*Collaborators from other Institutions.

maximum years, the unipolar regions are formed out of the following polarity elements broken off from the decaying active regions as well as the ephemeral active regions. These large-scale regions appear as poleward migrating plumes on the synoptic magnetic maps. During this poleward movement, the individual flux elements within the plumes as they pass through different latitude zones, show a rotation rate appropriate to the latitude zone they currently pass through - i.e. they show differential rotation. Whereas, the plumes rotate as a single unit at the rate of its active region source tilted back in longitude, similar to a smoke stack i.e. the plumes show a rigid rotation at the rate of the active region source. During the solar minimum, the large-scale unipolar regions are made up mostly of the inner network flux elements as the sunspots are too sparse.

The spatial resolution in Snodgrass's analysis is able to pick up the sunspots, ephemeral active regions and hence records their differential rotation rates. The plumes which form as a varying component, appear smeared over the data window. However their rigid rotations appear as adjunct features in the rotation profiles.

Whereas Stenflo's analysis with a lower spatial resolution does not resolve the individual features – sunspots, ephemeral active regions, polar faculae or the inner network elements, but picks up the rotation rate of the gross structures, namely, the large-scale unipolar regions. His analysis tracks the large-scale regions formed by the inner network elements during the solar minimum and the plumes during the solar maximum and so records a rigid rotation that remains an invariant over the solar cycle, although the structures that give rise to the rigid rotation during the two epochs are different.

We now project the rotation rate of each of these features on the rotation profiles in the solar interior published from helioseismology observations to estimate the respective anchor depths of their foot points in the solar interior.

The foot points of the sunspots and the ephemeral active regions that show differential rotation are seen to be anchored in the layers within the convection zone. This is to be expected from the study reported in last year's annual report that the anchor depths of the foot points of the magnetic flux of active regions rise progressively towards the solar surface as they age and in the terminal stages of their lives, the flux is virtually confined to the layers just beneath the solar surface thus setting the scene for the flux from decaying active regions to disperse. The flux loops of the plumes, although show rigid rotation, are really confined to the very shallow layers just beneath the solar surface since they also consist of elements from decaying active regions .

Whereas, the large-scale regions formed by the inner network elements (which are not recycled flux) show a rigid rotation that correspond to the rotation rate of the plasma layers at depths corresponding to radial distances of $0.66 - 0.68$ or in the tachocline. It is therefore inferred that the anchor depths of the source of flux of the inner network elements lie in these deep layers.

The way these elements are brought to the solar surface in a short time can be understood in terms of the balloon man analogy. The balloon man walks along the bottom of a lake releasing balloons continuously as he walks. As old balloons burst and the new ones rise the line of balloons appears to move as a whole. The balloon man represents the source field in the deep interior and his walking represents the rotation rate of this layer. The short time correlation would pick up the rate of the individual balloons, while the autocorrelation would pick up the rate of motion of the moving line which reflects the rate of rotation of the source.

This settles the long-standing puzzle over the co-existence of two different rotation rates derived from the same surface magnetic data and also establishes that the inner network flux elements constitute a fundamental component of solar magnetism.

(K.R. Sivaraman and M.H. Gokhale)

Polar activity cycle on the Sun : The magnetic fields observed on the solar surface emerge in the form of sunspot active regions at latitudes

< 40 deg and in the form of polar faculae (pf) at higher latitudes, whereas the large-scale unipolar regions pervade all over the solar surface. Although there are indirect evidences from our earlier studies that these manifestations of the magnetic fields are closely related, the actual way they are interrelated remains a puzzle. It is known that the pf, like the sunspots, possess kilo gauss magnetic fields and occur in anti phase with the solar cycle in the sense that the maximum number of pf elements occur in the high latitude regions during the minimum phase of the sunspot cycle. The two components of activity – the sunspot and the polar faculae – occur on either side of the 40 deg latitude in each hemisphere. This is the latitude belt where $d\Omega / dr$ reverses sign. Studies so far on pf have shown that they appear around latitude + / - 40 deg soon after the reversal of the polar fields take place and progressively extend up to the poles with time.

Using the Kitt Peak synoptic magnetic maps for the period 1975 – 2000 we derived the latitude – time distribution of the magnetic elements on the solar surface. From this it is seen that the magnetic flux elements of the size and polarity sign as the pf (appropriate to the solar cycle 21 and 22) made their appearance at latitudes around 40 – 45 deg as early as 4 to 5 years before the epoch of the polar reversal.

This shows that the polar faculae cycle commences almost simultaneously with the commencement of the sunspot cycle and the two run concurrently over the duration of the sunspot cycle. While the zone of appearance of the sunspots progressively shifts towards the equator, that of the pf steadily progresses polewards and fills the high latitude regions up to the poles , until the next polar field reversal.

(V.I. Makarov*, A.G. Tlatov* and K.R. Sivaraman)

Broad band photometry of the solar corona during the total solar eclipse of 23 November 2003 : IIA participated in the Indian expedition to Antarctica, organized and supported by the Department of Ocean Development, Government of India, to carry out scientific observations during the total solar eclipse whose path crossed the region of the Indian station Maitri, on 23 November 2003. Video and digicam recordings of the corona were carried out during the totality from a selected location 25 km away from Maitri. The video record at 25 frames shows structures out to about 2.5 solar radii. Spica and Jupiter are recorded in some of the frames. The digicam wide angle frames show the moon's shadow with sunlit regions at extreme ends of the horizon. The diamond rings were recorded for four seconds before second contact and for an unusually long duration of close to 30 seconds after the third contact. The duration of totality at the site was about 76 seconds. The duration predicted for the station Maitri was 79 seconds. Photometric analysis and a study of the circumstances of the totality are being carried out.

(S.P. Bagare and S.S. Gupta)

Narrow band imaging of the solar corona during the Antarctic totality : A 20 cm heliostat specially designed and built at IIA for the total solar eclipse in Antarctica on 23 November 2003, a 15 cm CZ objective, narrow band (2 to 3 Å) filters at 7892, 6563, 6374, 5694, and 5303 Å with a fibre bonded CCD camera and a 2k x 2k CCD camera were used to obtain frames during the totality. Significant effort went into assembling the instrumentation and in setting it up at the site. However snow drift which occured close to ground and a high scatter from ground snow seemed to have affected the images. Efforts are however on to retrieve useful information from the recorded frames.

(S.P. Bagare, V.K. Verma*, S.S. Gupta and Ramesh Chandra*)

Shadow band observations at Antarctica on 23 November 2003 : Shadow bands which are generally observed during total solar eclipses are very elusive and difficult to record due to low contrast. Very few recordings of the bands are available so far. The totality observed from near Maitri in Antarctica was specially suited for shadow band observations. Observations were planned to take advantage of this occurrence. The passing bands were

first seen 4 minutes before the second contact, and for a full 7 minutes after the third contact. The high contrast at egress reduced drastically in about 4 minutes but the bands were recordable for a full 7 minutes. We attribute this rare phenomenon to the low altitude of the Sun at totality, the excellent transparency of Antarctic sky, the advantageous location of our observing site mid-way between the central and outer line of moon's shadow, and to the presence of intermittent heavy winds. The camera was right and special precautions were taken to be able to capture the entire phenomenon.

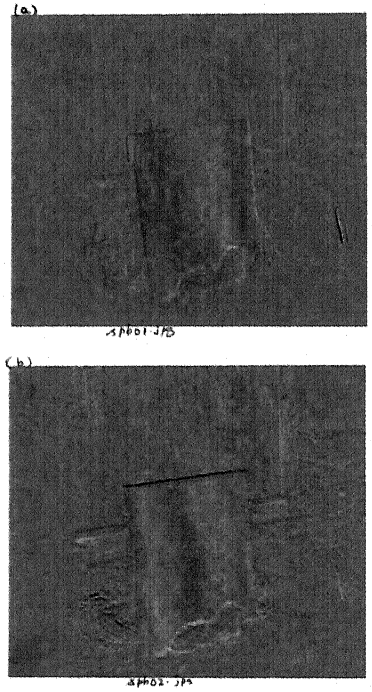


Figure 1. Shadow bands on a 1m square board (seen with the frames) recorded at a site near Maitri in Antarctica on 23 November 2003. Figure (a) is an image processed using six frames of 40 ms exposure each taken close to ingress, while (b) is a similar image processed using frames taken around egress. Changes in the direction, width, and pattern of the bands are readily noticeable. The bands, with varying contrast and speed, were recorded for a total of about 11 minutes at a rate of 25 frames per second.

Image processing techniques of frame grabbing, frame registration, and cross correlation are being used to study the images. Well formed bands are seen with some structure, specially around ingress and egress. The bands are typically 20 to 30 cm wide and travel at speeds of 2.5 to 3.0 m/s. The time series of intensity measurements are being subjected to power spectrum analysis to study the turbulence spectrum in the terrestrial atmosphere during the totality.

(S.P. Bagare, H.O. Vats* and S.M. Bhandari*)

Long-term behavior of the solar activity cycle : Oscillatory theory revisited : It is believed that solar activity is produced and maintained by the turbulent dynamo below the base of the convective envelope. Though the dynamo models produce stunning results of the butterfly diagrams, non-linear behavior such as different amplitudes and widths of the butterfly diagrams of the solar cycle cannot be reproduced. This is mainly due to the parametrization of the non-linear behavior of the basic MHD equations and many unknown free parameters are used in the calculations (Hiremath 2001, BASI, 29, 169 and references therein).

Alternatively, one can visualize the solar cycle and activity phenomena as manifestations of the long period global MHD oscillations of the magnetic field structure of primordial origin (Hiremath, K. M and Gokhale, M. H, Ap.J., 448, 437 and references therein). In order to confirm this view, we model the solar activity cycle as a forced and damped harmonic oscillator which consists of two parts, viz., sinusoidal and transient parts. The solution of such a non-linear system is fitted separately to the data of each solar activity cycle of Zurich sunspot numbers for the years 1755-1996 (cycles 1-22) and the results are as follows : (i) except a long-term decreasing trend in the phase, the period (~11 *yrs*) and amplitude of the sinusoidal parts remain constant for all the solar cycles, (ii) amplitude of the transient part is phase locked with the phase of the sinusoidal part , (iii) for all the cycles, the periods

and phases of the transient part remain approximately constant except during the cycles 4-7 and 12-13 when periods and phases drastically change their magnitudes and, (iv) the decay factor (γ) of the transient part approximately remains constant for all the cycles and is less than 1.

These results confirm our hypothesis and suggest that solar activity cycle mainly consists of persistent oscillatory part due to long period (~22 years) Alfven perturbations which is supposed to originate near the solar core and travel along the poloidal part of the magnetic field structure (Hiremath K. M and Gokhale M. H, ApJ, 448, 437) modulated by random perturbations (due to turbulence in the convective envelope) of the toroidal part of the magnetic field structure (Hiremath 2001, BASI 29, 169). Both the parts of magnetic field structures are of primordial origin.

(K. M. Hiremath)

The flares associated with the abnormal rotation rates of the bipolar sunspots : reconnection probably below the surface : The sunspots are supposed to be associated with many solar activity phenomena like flares, prominences, coronal mass ejections, etc. It is believed that the magnetic reconnection is one of the physical phenomena in releasing the required amount of flare energy. However, it is not known at what level of the solar region reconnection events take place. Moreover, it is not known why some sets of sunspots trigger flares and others do not. Though much quantitative and statistical evidences are lacking, most of the previous studies clearly indicate that the occurrence of the flares is associated with the complex movement and magnetic topology of the sunspots. That means flares may be attributed not only to magnetic flux build up and reconnection but also to dynamics of the sunspots that acquire during the course of their rising from the convection zone towards the surface. In the present study we use the information of dynamics of the sunspot groups, especially the rotation rate dynamics, for understanding the genesis of the flares.

Using both the data sets of positional measurements of the bipolar sunspots taken from daily white light pictures and the occurrence of Hα flares from the Kodaikanal Observatory, we study the association between the rotation rates of the bipolar sunspots and triggering of the flares.For the years 1969-1974, we compute daily rotation rates of the leading and the following spots of the bipolar sunspot groups during their life span. We define *abnormal rotation rate* as follows. During the course of their evolution, we compute the daily rotation rates ω_i for each pair of the bipolar spots and then compute the mean $\bar{\omega}$ with their standard deviation σ for the whole life span. If the absolute value of the difference $(\bar{\omega} - \omega_i) > 1\sigma$, then we consider the corresponding rotation rate at that date as *abnormal rotation rate* of the spot. We find that either leading or following or both of the bipolar spot groups which have abnormal rotation rates during the course of their evolution are strongly associated with the occurrence of flares in the later stage of their life span. Other important findings are : (i) the abnormal rotation rates and the flares occur during the 50-80% of their life span of the spot group and , (ii) abnormal rotation rate of about 2deg/*day* is required for triggering the flares. The strong relation between the occurrence of abnormal rotation rates of the sunspot groups and the occurrence of the flares enabled us to estimate from the previous study (Hiremath, K. M. 2002, A&A, 386, 674) the probable region of the depth ($0.935R_\odot$) of reconnection below the solar surface. Helioseismic inferences show a strong rotational shear around this region that might have led to unknown dynamic instability of the flux tubes which eventually merge part of the flux tubes leading to triggering of the flares.

(K. M. Hiremath and G. S. Suryanarayana)

Flares associated with the abnormal rotation rates and longitudinal minimum separation of the bipolar sunspots : In the previous study, owing to strong association between the occurrence of abnormal rotation rates of the sunspots and the occurrence of the flares, it is

possible to estimate the probable region of the depth of magnetic reconnection below the surface. In order that such reconnection events occur, closer approaching of their foot points and contact of the flux tubes below the surface may be necessary. In this study, we search for such events and show that at the time of minimum approaching distances between the leading and the following spots, triggering of flare occurs.

For the years 1969-74, we use both the data sets of positional measurements of the bipolar sunspots taken from daily white light pictures and the flare events in the $H\alpha$ pictures from the Kodaikanal Observatory. We compute rotation rates of the leading and the following sunspots and, rate of change of longitudinal separation during their life times. We find that (i) the bipolar spots that are associated with the abnormal rotation rates (i.e, the rotation rates which are greater than 1σ from the mean rotation) which approach at the separation rate of 1–2 *deg / day* also experience approaching minimum longitudinal separation ($\sim 6^{\circ} - 10^{\circ}$) of their foot points during the course of their evolution, (ii) such spots that have minimum separation eventually trigger the flares and, (iii) the events of abnormal rotation rates and the minimum approaching distances of the foot points on an average occur between 50-80 % of the life spans indicating the depth of annihilation of magnetic energy probably below the surface. All these results of the present and previous studies support the conventional physical scenario of magnetic reconnection of the flux tubes that may be responsible for triggering the flares.

(K. M. Hiremath and G. S. Suryanarayana)

Hall-magnetohydrodynamics turbulence : Turbulence is as ubiquitous in nature as it is elusive.The fact, that it is not mere randomness, merits more exploration.Coherent structures, correlated motions and well-defined patterns are observed on a variety of spatial and temporal scales in otherwise turbulent media. Organized states of matter and motion can be seen in convection cells, cloud complexes, tornados,cyclones,zonal flows on planetary surfaces,the Red Spot of Jupiter, solar and stellar granulation, spiral patterns of galaxies and perhaps ourselves! The universality of its (turbulence) existence has inspired the investigators to look for universal characteristics such as the large Reynolds Number, a consequence of the large nonlinearity.The dimensional arguments of a la Kolmogoroff to delineate the spectral distributions has proved to be another rewarding route to pursue this otherwise forbidding field.The Taylor Relaxation hypothesis is a further attempt to understand the evolution of any nonlinear system in terms of its global properties such as the invariants.The macroscopic turbulence is often modeled using ideal magnetohydrodynamics.We determine the spectra of the velocity and the magnetic field fluctuations within the framework of the two fluid picture including specifically the Hall effect. It is shown that the Hall magnetohydrodynamics (HMHD) supports three quadratic invariants viz the total energy, the magnetic helicity and the generalized helicity. The nonlinear states depart fundamentally from the Alfvenic state challenging the much believed concept of the equipartition of the kinetic and the magnetic energy densities. Using the dimensional arguments "a la Kolmogoroff", we derive the spectral energy distributions corresponding to the three invariants. These distributions are stringed together by invoking the hypothesis of the selective dissipation which has proved its efficacy in the two- dimensional hydrodynamic turbulence. We apply the results to three different situations namely : (1) the solar wind spectra, (2) the solar atmospheric turbulence, the solar granulation and (3) the laboratory experiments.

The model reproduces in the inertial range the three branches of the observed solar wind magnetic fluctuation spectrum - the Kolmogorov branch $f^{-5/3}$ steepening to $f^{-\alpha 1}\}$ with $\alpha 1 \simeq 3$-4 on the high frequency side and flattening to f^{-1} on the low frequency side. These fluctuations are found to be associated with the nonlinear Hall-MHD Shear Alfven waves. The spectrum of the concomitant whistler type fluctuations is very different from the observed one. Perhaps the relatively stronger damping of the whistler fluctuations may cause their unobservability.

The additional structure imparted to the spectral laws (by the inclusion of the generalized helicity) allows us to reproduce, remarkably well, the essentials aswell as the details of the observed spectra of the motions and the magnetic fields of the solar atmosphere on the scales of a few thousand Km.

In a recent study, the properties of the large scale turbulence have been investigated theoretically and experimentally concluding that the kinetic energy spectrum goes as $k^{1/3}$ at large spatial scales and citing a few examples for the existence of such a spectrum in natural systems. We show that the 1/3 spectrum for the kinetic energy is a direct consequence of the magnetic helicity invariant of the Hall- MHD turbulence. We present the simultaneous kinetic and magnetic energy spectra and propose the verification of the latter in the laboratory and natural systems. The paper ends with some possible future directions of research in this field.

(Vinod Krishan & S.M.Mahajan*)

A new Multidimensional Dynamical Model for the Magnetic Network on the Sun : It is well known that the magnetic field plays a key role in the dynamics and activity on the Sun and other late-type stars. Recent observations have revealed the presence of a rich spectrum of waves with different periods in the magnetic network of the Sun.

Earlier work by us on the above subject focused on kink (transverse) and sausage (longitudinal) waves excited in vertical magnetic flux tubes, extending through the photosphere, when their footpoints are displaced by granular impacts. These calculations employed the thin flux tube approximation, which breaks down in the chromosphere. Furthermore, this approximation also precludes a study of the interaction between wave modes excited in neighboring flux tubes. In order to overcome this limitation, we have as a first step in this direction, developed a 2-D MHD model for the magnetic network on the Sun.

The model consists of individual magnetic elements rooted in intergranular lanes, with a horizontal size of 100 km in the photosphere. These tubes expand upward and merge with their neighbors at a height of about 600 km. Above this height the magnetic field is uniform. An equilibrium configuration based on this model has been constructed by solving the magnetostatic equations in 2-D.

Waves are generated in the medium by means of an impulse at the lower boundary. For transverse driving this generates fast MHD waves within the flux tubes and acoustic waves at the interface of the tubes and the field-free medium, but not otherwise in the field-free gas. The acoustic waves at the interface, which were not previously recognized, are due to compression of the gas on one side of the flux tube and expansion on the other. These waves travel upward along the two sides of the (2-D) flux tube and enter it, where they become longitudinal waves that heat the atmosphere. Preliminary calculations show that the generation of longitudinal waves and shock formation through this mechanism is extremely efficient and can be an important source of heating for the atmosphere.

The aim of this work is to: (a) examine the relative importance of transverse and longitudinal waves in the magnetic elements; (b) assess their contribution to the dynamics and the heating of the upper atmosphere by waves; (c) study the interaction of wave modes generated in neighboring flux tubes; (d) provide observational signatures that constrain theoretical mechanisms; and (e) extend it to the atmospheres of other late type stars.

Broadly speaking, the above investigation has wide implications for understanding processes occurring in the atmospheres of stars where magnetic fields are important.

(S.S.Hasan, A. van Ballegooijen*,and W. Kalkofen*)

Modulation in the solar irradiance due to surface magnetism during cycles 21, 22 and 23 : Magnetic field indices derived from synoptic magnetograms of the Mt. Wilson Observatory, i.e. Magnetic Plage Strength Index (MPSI) and Mt. Wilson Sunspot Index (MWSI), are used to study the effects of surface magnetism on total solar irradiance variability during solar cycles 21, 22 and 23. We find that most of the solar cycle variation in the total solar irradiance can be accounted for by the absolute magnetic field strength on the solar disk, if fields associated with dark and bright regions are considered separately. However, there is a large scatter in the calculated and observed values of TSI during solar cycle 21. On the other hand, the multiple correlation coefficients obtained for solar cycles 22 and 23 are 0.88 and 0.91 respectively. Furthermore, separate regression analyses for solar cycles 22 and 23 do not show any significant differences in the total solar irradiance during these cycles. Our study further strengthens the view that the surface magnetism indeed plays a dominant role in modulating solar irradiance.

(Kiran Jain and S. S. Hasan)

Effect of a magnetic field on stellar g-mode oscillations : Application to SPB stars : We have begun calculations to study the effects of an internal magnetic field on the g-modes in SPB stars (slowly pulsating B stars). Recent observations have established that a number of B-type stars exhibit coherent periodic brightness variations with a a semi-amplitude of several mmag and a period of between 1 and 3 days. In fact, it has been shown that these stars are multiperiodic with several independent frequencies simultaneously present in a single star. The length of the periods and the phase relation between the light and colour curves clearly point towards pulsations in the high-order g-modes. There is some observational evidence which also suggests that SPB stars possess surface magnetic fields. In our work, we attempt to examine the effects of the magnetic field on the mode frequencies and the angular structure of the surface amplitudes. As a first step in this direction, the equilibrium model for a 4 solar mass star, with log $(L/L_{\odot})$ =~2.51 and log T_{eff} = 4.142 was constructed using the stellar evolution code CESAM. The eigenfrequencies and eigenfunctions were then computed of the g-modes for mode orders up to 30 using an adiabatic stellar oscillation code. In the next step, we will calculate the frequency shift of the modes for a dipole magnetic field using a perturbation technique, assuming that the field is weak. Subsequently we will relax this assumption and calculate the eigenfrequencies and eigenfunctions self-consistently by solving the sixth order system of MHD equations for the adiabatic oscillations of a magnetized fluid.

(S.S. Hasan and J.P. Zahn*)

Influence of the solar activity on the Indian Monsoon rainfall : We continued the study of influence of solar activity on the Indian Monsoon rainfall. Aim of the present study is to search for a possible association between the sunspot activity and the Indian Monsoon rainfall variability. Since cloud and rain formations are function of ambient temperature, it is more likely that the temporal variations of rainfall on 11-22 years or longer time scales may be due to temporal variation in forcing of the solar radiation. It is well established from the satellite observations that the sunspot activity shows a similar temporal behavior as that of irradiance variations. Assuming that such correlation between the sunspot and the irradiance activities may also exist before the era of satellite observations, we consider the occurrence activity of the sunspot data for the present analysis.

We consider 130 years (1871-2000) occurrences of the sunspot numbers and the Indian Monsoon rainfall (B. Parthasarathy et al. 1993, Proc. Indian. Acad Sci., (Earth Planet Sci), 102, 121; http://www.tropmet.res.in) occurrence variability for correlative and periodic analyses. Following methods are used to know the influence of solar activity on the rainfall variability: (i) using correlative analysis, we study the *long* (> 1 yr) term influence of the solar activity and, (ii) both the data sets are subjected to the Fourier and the wavelet transforms for detecting

periodicities. If periods detected in the rainfall variability are almost similar to the periods detected in the sunspot activity, we can safely conclude that the solar activity indeed influences the rainfall variability. The important results of this continued study is as follows : (i) for the whole years 1871-2000, the *spring* and *southwest monsoon* rainfall variabilities have significant positive correlations with the sunspot activity during the corresponding period, (ii) there exists a inverse relationship (the amplitude of rainfall occurrence variability is small when the amplitude of the sunspot activity is large) between both the variabilities during a particular period of the solar cycle, (iii) the FFT and the wavelet analyses of the *southwest monsoon* rainfall variability show the periods 2.7 yr, 16 yr and 22 yr respectively (similar to the periods found in sunspot occurrence data), (iv) the rainfall variability is lagging by 1-3 years behind the sunspot activity, (v) both the sunspot and the rainfall variabilities consist of long-term (> 22 years) *"steady parts"* with the opposite behaviors (that have feeble correlation) and short-term (1-22 years) *"fluctuating parts"* with the almost similar behaviors (that have strong positive correlation) and, (vi) there is a long term trend indicating a gradual decrease of occurrence of rainfall variability by nearly 2.3 ± 1.3 mm/yr and increase of sunspot activity by nearly 3.9 ± 1.5 sunspots/yr compared to the activity of previous solar cycle.

The result (ii) is interpreted as follows. The recent satellite observations show that there is a positive correlation between the cloud cover in the Earth's atmosphere and the flux of the GCR (galactic cosmic rays). Since flux of the GCR is anti-correlated with the sunspot activity, one would also expect a similar relationship between the amplitudes of the rainfall and the sunspot variabilities as we obtained from the present study. The GCR activity is the source of ions in the earth's atmosphere. We know that the condensation of water vapor into water drops is mediated by the ions in the atmosphere. Thus any change in the GCR activity correspondingly affects the rainfall variability. To put it in a precise way, as the intensity of the GCR is inversely proportional to the solar activity, increase in solar activity results in reducing the intensity of the GCR flux. This ultimately results in both reducing the activity in nucleation of the cloud particles and suppression of the rainfall variability.

The result (vi) is interpreted as follows. There are few studies which show that a steady increase of the anthropogenic pollution in the earth's atmosphere suppresses the precipitation that may affect the long term rainfall variability. However, it is more likely from the following reason and argument that, long term decrease in the rainfall variability may be due to increase of pollutants of natural origin. During the pre-monsoon season, the Arabian sea is mainly loaded with the enhanced aerosols such as sea salts, etc., of natural origin. If we assume that increase of sea and land surface temperatures may be due to feeble solar signal, correspondingly, there may be increase of concentration of the aerosols of natural origin in the atmosphere resulting in suppression of the long-term rainfall variability. Moreover, by the fact that Monsoon rainfall variability is connected with the global precipitation, the decrease of the rainfall variability from 1871 onwards is also consistent with the decrease of the global mean precipitation. Hence, *it is unlikely that long term decrease in the rainfall variability is either due to increase of the concentration of carbon dioxide in the earth's atmosphere or due to increase of pollutants of anthropogenic origin.*

Owing to long term positive and significant correlation of the *spring* and *southwest monsoon* rainfall variabilities with the sunspot activity, it is suggested that solar activity may be included as one of the crucial parameters in modelling and predicting the Indian monsoon rainfall.

(K. M. Hiremath and P. I. Mandi*)

Estimation of the three-dimensional space speed of a solar coronal mass ejection using metric radio data : Studies of the influence of solar activity on our terrestrial environment have taken on increasing importance in recent years, as the realization of just how damaging space influences can be. It is well accepted now that the state of

near-Earth space environment is significantly controlled by coronal mass ejections (CMEs), the most-geoeffective manifestation of solar activity. The observations made with conventional 'white light' coronagraphs are the historical and empirical foundations of our present knowledge of CMEs. Also, the most detailed CME studies to date have been made from white light coronagraph observations of events originating near the solar limb. But, by their very nature, the coronagraphs have an occulting disk to block the direct photospheric light and so the early life/kinematics of a CME in the low corona cannot be studied using them. The latter is very important, particularly in the case of 'halo' CMEs which originate from the front side of the Sun since they are more likely to reach Earth's environment. One needs non-coronagraphic data for a detailed study of the onset phase of eruptive events that occur from regions close to the central meridian of the Sun. Viewing in the plane of the sky doesn't allow us to determine their initial speed, particularly along the line of sight. The latter is considered to be a crucial input for predicting the arrival time of a CME at 1 AU. Again, what one measures usually from a time-lapse movie of the images obtained with a coronagraph is the speed at which a CME spreads in the plane of the sky. This will at best be only a lower limit to the true speed (space speed) especially in the case of an Earth-directed 'halo' CMEs since they lie away from the plane of the sky. Attempts to obtain the true speed of a CME whose source region lies on the solar disk is one of the widely pursued area of research in CME studies. Ray tracing analysis of the thermal radio counterpart of a CME in the metric wavelength range play a vital role in this connection since one can localize the position of the associated density enhancement in a three-dimensional space. Also it is to be noted that radio observations do not have the limitation of an occulting disk and CMEs can be detected early in their development.One can observe activity at any longitude similar to that at EUV and X-ray wavelengths. Again, the frontal structure of a CME has a large optical depth at meter wavelengths and can be readily observed. Making use of the above mentioned advantages, we have developed an independent method to estimate the three-dimensional space speed of a CME, close to its onset, using metric radio data. The scheme was tested on the 'halo' event observed with the Gauribidanur radioheliograph (GRH) on January 21, 1998 and its estimated space speed is 580 km s^{-1}. We also separately calculated the speed along the line of sight and in the plane of the sky, and the value is $\approx$ 318 and 485 km s^{-1}, respectively. This is a very promising result since one can establish the onset of a CME more accurately and relate its activtities to both the surface of the Sun and in the interplanetary, near-Earth space.

(R. Ramesh and C. Kathiravan*)

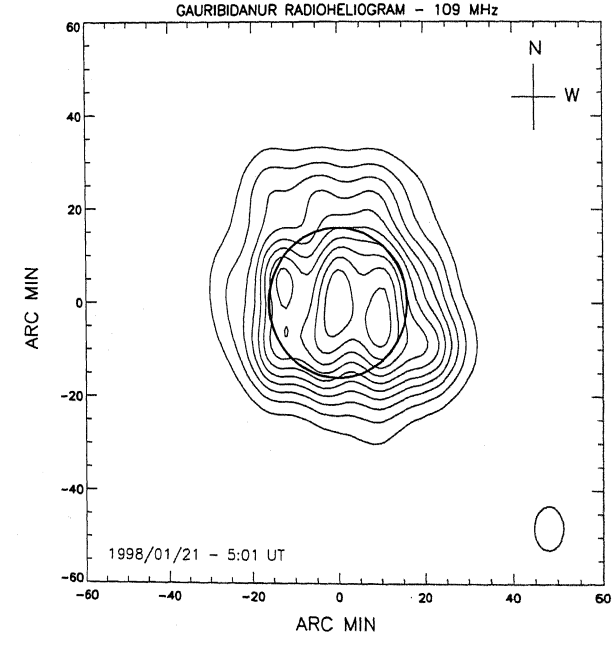


Figure 2. Radioheliogram obtained with the GRH at 109 MHz on January 21,1998 at 05:01 UT. The peak brightness temperature is ~ 1.21 x 10^6 K and the contour interval is 1 x 10^5 K.The open circle at the center is the solar limb. The instrument beam is shown near the bottom right corner.

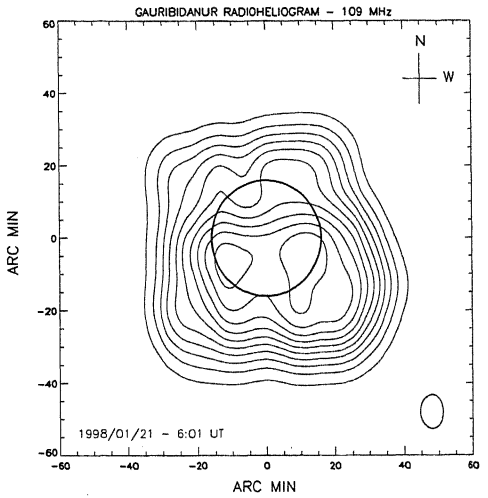


Figure 3. Same as in Figure 2, but obtained at 06:01 UT. The peak brightness temperature is ~ 1 x 10^6 K and the contour interval is 1 x 10^5 K.

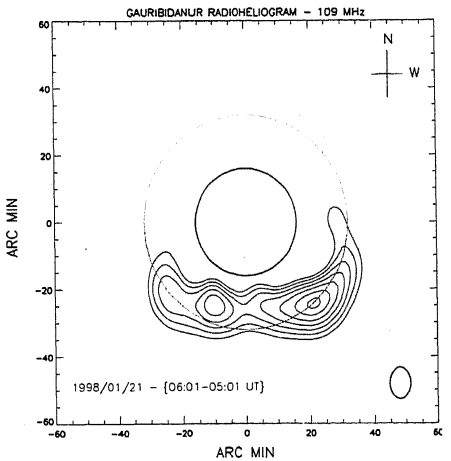


Figure 4. Difference map obtained by subtracting the radioheliogram in Figure 2 [(05:01 UT) from that in Figure 3 (06:01 UT)]. Only contours with levels greater than 50% of the peak value are shown here. The enhanced radio emission in the southern hemisphere corresponds to the leading edge of the CME which lifted-off from the Sun around 05:40 UT on that day. The outer bigger circle in the map is at a distance of about 2.2 $R_\odot$ from the center of the Sun.

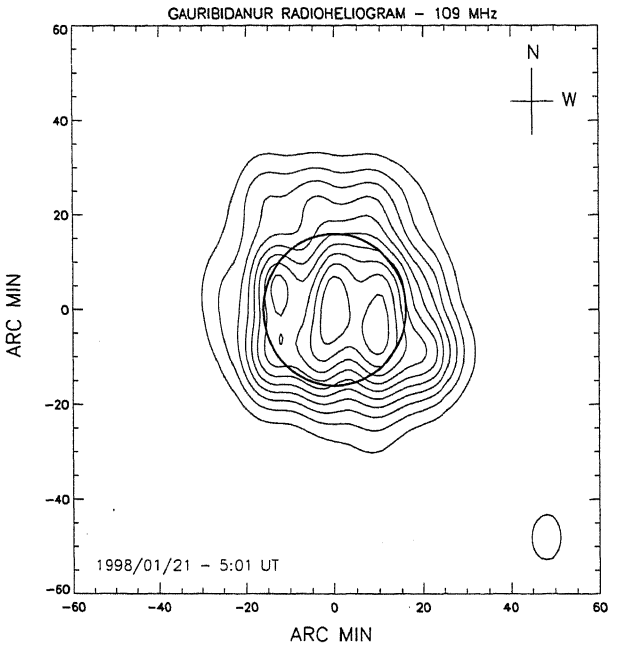


Figure 5. Radio brightness distribution of the Sun obtained through ray tracing calculations of the GRH data obtained at 06:01 UT (Figure 3). There is a good correspondence between the two distributions.The numbers s1-s16 indicate the location of the centroid of the various discrete sources used in our ray tracing calculations. The sources s8-s13 correspond to the enhanced emission off the south limb of the Sun in Figure 4. We localise the position of the latter from the three-dimensional position co-ordinates of the discrete sources used in our ray tracing calculations. A displacement in their position with time helps us to calculate the speed of the event in three dimensional space.

Tracking system for the Gauribidanur radioheliograph : In its earlier configuration, the GRH was operated mainly as a meridian transit instrument and we were able to obtain only a few images of the Sun everyday. We have been working on the various aspects of an electronic tracking system using remote controlled diode switches for the last 2 years, and have recently installed a full-fledged tracking unit for the GRH. The new system allows us to observe Sun and other sidereal sources for about 6 hrs everyday. We expect

to understand the temporal evolution and behaviour of the transient energy releases from the Sun in a better way with such a continuous data set. The following figure 6 shows the radio emission from the solar corona at 75 MHz observed on October 26, 2003. This particular event is presented here since the enhanced activity seen in it was associated with one of the strongest flare/ CME activity on the solar atmosphere. It gave rise to serious consequences in the near-Earth space environment, and we were able to observe it right from its initiation due to continuous tracking of the Sun.

(R. Ramesh, C. Kathiravan*, M.S. Sundara Rajan and K.R. Subramanian)

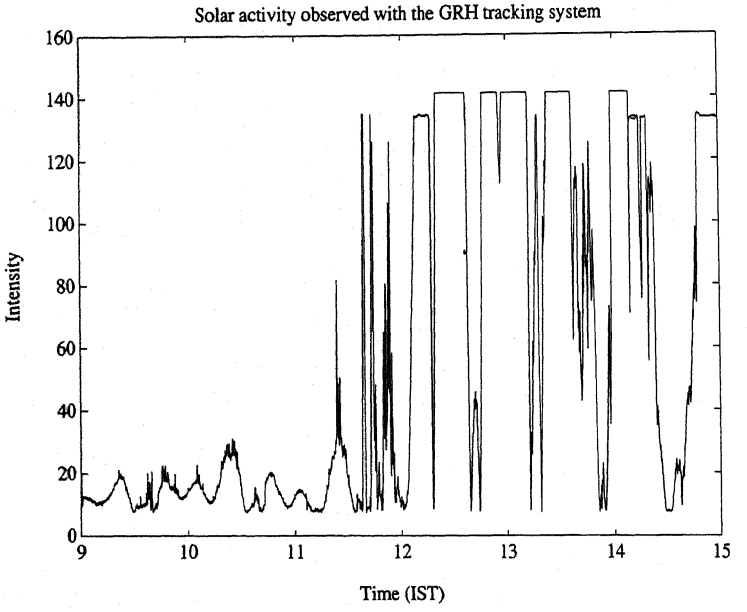


Figure 6. Solar activity observed with the GRH tracking system on October 26, 2003 at 75 MHz. Radio emission from the Sun was monitored continuously for a period of about 6 hrs starting from 09:00 hrs (IST). One can clearly notice enhanced emission starting from about 11:30 hrs and which continued till the end of the observations at around 15:00 hrs.

Antenna system for the study of polarized radio emission from the solar corona : Aperture systhesis is a powerful technique in radio observations and can be used to obtain all the four Stokes parameters independently, providing a complete measurement of the polarization state of the received radiation. If the accuracy of polarization measurements can be sufficiently improved to allow synthesis of linear/circular polarization distributions over extended sources like Sun, the results, combined with radiation theory, can provide valuable information on the structure and strength of the internal source magnetic field. In radio astronomy, transformations occur during the propagation and reception of radio waves that act to change the state of polarized radiation. Some of these transformations, such as Farady rotation in the ionosphere or the interstellar medium, arise from propagation effects that may themselves be of astrophysical interest. Using the formula for the response of a correlation interferometer to partially polarized radiation, we have developed observation and calibration techniques to carry out observations of polarized radio emission from the solar corona. We have been working on the various mechanical/hardware/software work in connection with the setting up of a new antenna system for the observations of polarised radio emission from Sun and other galactic/extra-galactic sources in the frequency range (30-150 MHz), for the last 1 year. The antenna system is now up and is used for regular observations. We expect the above mentioned antenna system to reveal useful information particularly on the coronal magnetic field at heights $\geq 0.3\ R_{\odot}$ above the photosphere. The following figures 7 and 8 show observations carried out with the above antenna set-up on Virgo A (3C274, M87) and Sun on June 4, 2004.

(R. Ramesh, C. Kathiravan* and M.S. Sundararajan)

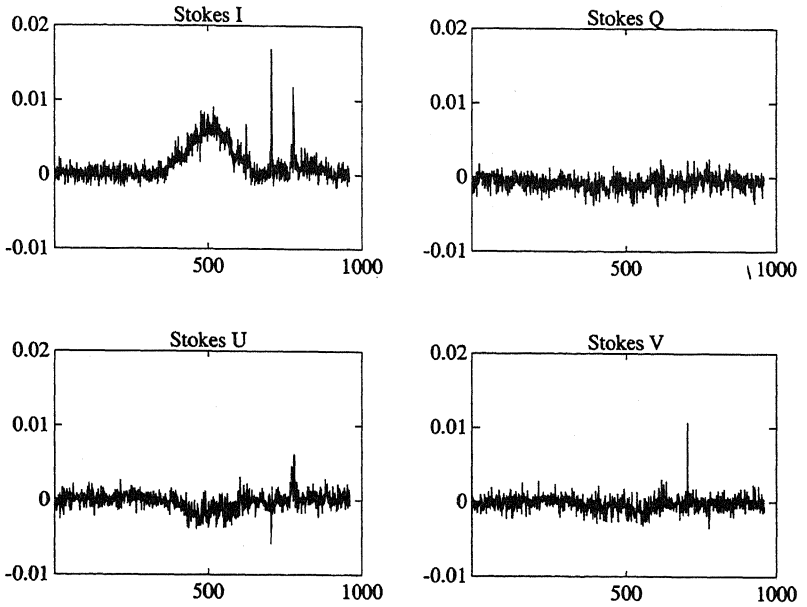


Figure 7. Polarisation observations on Virgo A (3C274, M87) using the new antenna setup at the Gauribidanur radio observatory at 75 MHz. The abcissa and ordinate correspond to sample number and visibility amplitude (in arbitrary units), respectively in all the 4 plots. The sample interval used is 1 sec. One can clearly notice that Q,U & V output are almost zero. This is expected since the radio emission from Virgo A is considered to be unpolarised in our frequency range. Also it indicates that the instrumental errors which are very crucial for any polarisation observations are very minimal in our case. We intend to use it as a calibrator source for our observations.

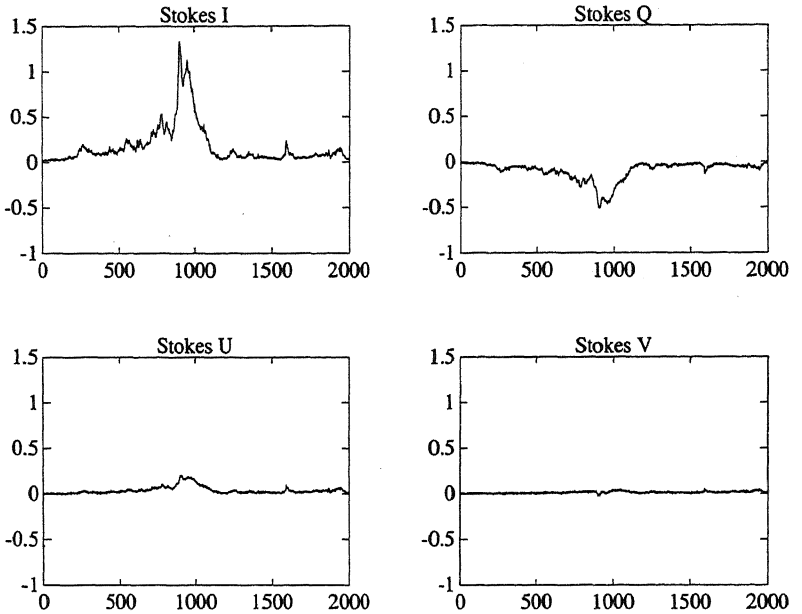


Figure 8. Polarised radio emission from the solar corona observed on June 4, 2004 at 75 MHz in association with a Hα / X-ray flare. The sample interval used is 100 msec. One can clearly notice that there is a significant amount of linear polarised emission. A detailed analysis of this event will be reported elsewhere.

Existence of nanoparticle dust grains in the inner solar corona? Motivated by the paper of Habbal et al. (2003), we have made spectroscopic observations in the wavelength range of 1072.8 – 1079.0 nm of the solar corona above the coronal hole region on several days using a coronagraph. We made raster scans above the coronal hole region as well as other coronal regions for comparison. The exposure time of 200 s at a single location permitted us to detect signal of the order of 10^{-7} of the solar disk brightness. We did not find any indication of emission around 1074.7 nm due to fluorescence from silicon nanoparticle dust grains in the coronal hole region in the inner corona proposed by Habbal et al. (2003).This may be due to

absence of silicon nanoparticle dust grains in the coronal hole region or due to the detection limit.

(Jagdev Singh, Takashi Sakurai*, Kiyoshi Ichimoto*, Masaoki Hagino* and Tetsuya T. Yamamoto*)

Spectroscopic studies of steady coronal structures: Complex nature of intensity ratio variations with height of Fe X - XIV emission lines : We have obtained spectroscopic observations in coronal emission lines choosing simultaneously two lines, one [Fe x] 6374 Å and the other [Fe xi] 7892 Å or [Fe xiii] 10747 Å or [Fe xiv] 5303 Å. Now we have studied the intensity ratio and ratio of FWHM of these lines with respect to those of 6374 Å as a function of height above the limb. We found that intensity ratio of 7892 Å and 10747 Å lines with respect to 6374 Å line increases with height and that of 5303 Å to 6374 Å decreases with height above the limb. This implies that temperature in coronal loops will appear to increase with height in the intensity ratio plots of 7892 Å and 6374 Å, and 10747 Å and 6374 Å whereas it will appear to decrease with height in intensity ratio of 5303 Å to 6374 Å line versus height plot. The normalized FWHM (with respect to wavelength) ratio of 6374 Å to all the other 3 lines increases with height but from systematic different values at the limb. The value is about one in case of 6374 Å and 7892 Å emission lines at the limb indicating a common temperature and nonthermal velocity in the coronal loops at the limb. It is about 0.7 at the limb in case of 6374 Å and 5303 Å lines and becomes about one after 120" height above the limb. The varying ratios with height indicate that relatively hotter and colder plasma in coronal loops interact with each other. Therefore, the observed increase in FWHM with height above the limb of coronal emission lines associated with plasma at about one MK may not be due to increase in nonthermal motions caused by coronal waves but due to interaction with the relatively hotter plasma.

(Jagdev Singh)

Post-flare pulsations in the 54-78 MHz frequency band : The study of the temporal oscillations in the solar corona is important from the point of view of periodic particle acceleration, coronal heating and oscillatory structures. Quasi-periodic pulsations with periods mostly around 13 seconds in the frequency range of 54-78 MHz have been observed with the Gauribidanur solar radio spectrograph, following the firxt X2 flare that occured on 24 November, 2000. Assuming an impulsively generated propagating MHD wave in a coronal loop for the pulsations, the coronal magnetic field at 1.6 solar radii was derived as 6 Gauss and the radius of cross section of the loop as 11,000 km.

(K.R. Subramanian and E. Ebenezer)

Brazilian decimetric array : The Instituto Nacional Psequisas Espacias (INPE), Brazil is building a radio telescope called the Brazilian Decimetric Array (BDA) for the study of the sun and galatic radio sources. As per the MOU signed between IIA and INPE in June 2002, for the development of correlator systems for the BDA, in the first phase, a 32 channel digital correlator system was designed and developed at IIA. The system was officially handed over to the Director of INPE on April 7, 2003. This correlator system was interfaced with the receiver system of an interferometer array situated at INPE, Sao Jose Dos Campos, Brazil. This East - West interferometer consists of 5 parabolic dish antennas of 4 m in diameter operating at 1.5 GHz with baseline separation of 8 meters. Figure 9 shows the picture of the 5 antenna system (see also the back wrapper). Figure 10 shows the IIA - BDA correlator system in the receiver room. Regular observations of the Sun in the meridian transit and tracking modes were carried for about 6 months to check the performance of the entire system. Figure 11 shows a typical example of interferometer fringes obtained at shortest (8 meter) and longest (32m) baselines. The fringe spacing at different baselines agreed well with the theoretical beamwidths.

(M.S. Sundarajan, K.R. Subramanian, R. Ramesh, E. Ebenezer, H.S. Sawant*, A. Neri*, J.R. Cecatto* and M.R. Sankraraman*)

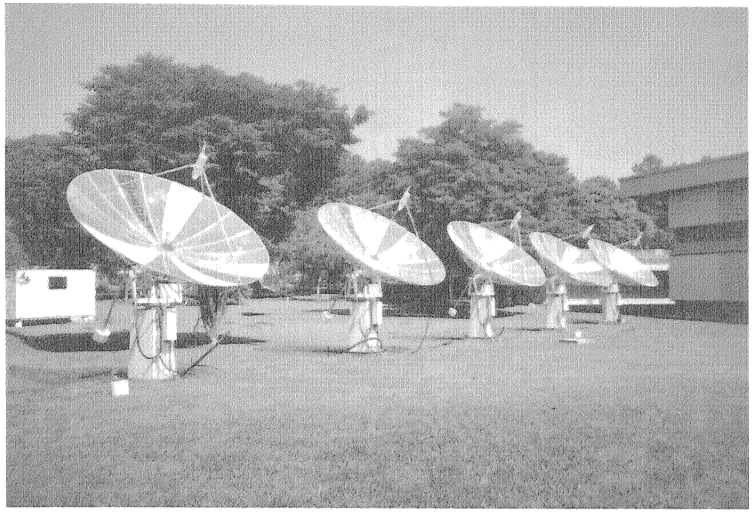


Figure 9. First phase of Brazilian Decimetric Array, consisting of 5 parabolic antennas with baseline separation of 8 meters.

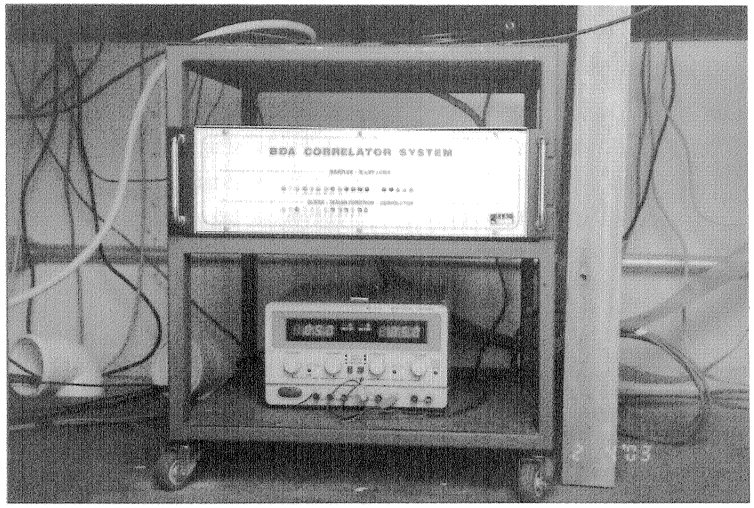


Figure 10. IIA-BDA 32 channel correlator system in the receiver room.

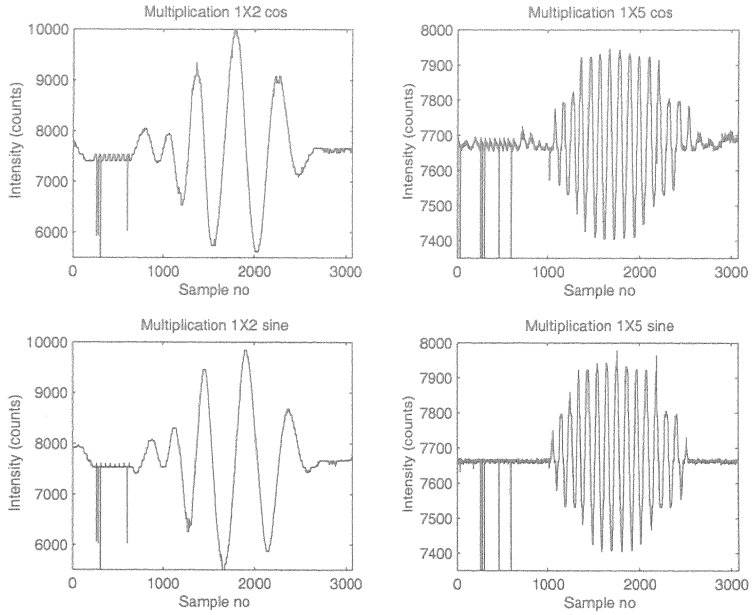


Figure 11. Typical example of interferometer fringes obtained on the Sun. The figure above on the left shows the cosine and sine fringes for the shortest baselines (8m) and on the right shows the same for a baseline of 32 meters.

2. Solar system studies

Astrometry of the Galilean satellites from their mutual events : The mutual event light curves of the Galilean satellites of Jupiter of the campaign of 2002-03 (PHEMU03) by 'Institut de méchanique céleste et de calcul des éphémérides, Paris, are being analyzed using the model which was used in the PHEMU97 campaign. Preliminary results indicate residuals in the right ascension of 2.2, 4.2, 7.1 and 3.7 milliarcesconds for Io, Europa, Ganymede and Callisto respectively when compared with the recent satellite dynamics theory L1 by V. Lainey.

(R. Vasundhara, J.E. Arlot*, V. Lainey*, W. Thuillot*)

Comet 81 P/Wild 2 : Investigations of the dust morphology of Comet 81P/Wild 2 in the I and R band images obtained on May 15, 1997 from the Vainu Bappu Observatory were completed. This comet was visited by NASA's STARDUST mission on 2 January, 2004. Ground based studies of this kind are important in investigating the precession of the rotation pole axis. There are two approaches to derive the pole solutions from dust morphology : 1) From the variation of the position angle of the fans at different epochs, 2) By carrying out Monte Carlo simulations of the dust grains in the fans. The former approach requires a large number of images at different viewing geometries throughout the apparition. The illuminating geometries at times may be such that the source may not be illuminated over the entire cycle. The apparent position angle of the fan will deviate substantially from the true value. Our model is based on the second approach and is very robust. In the present investigation we model the trajectory of the ejected grains, moving under the influence of solar radiation pressure forces to simulate the observed morphology of the fan. In addition to the data from VBO, we also used the published images on 11 December 1996 and 1 April 1997 by Schulz, R., et al. (Astron. Astrophys., 2003, 398, 345) obtained at Siding Spring to model the dust trajectories out to 10^5 km. For comet Wild 2, using this model we derive the pole position of $\alpha_p = 297^\circ \pm 5^\circ$ and $\delta_p = -10^\circ \pm 5^\circ$. Broad sources at $+80^\circ \pm 5^\circ$ and $-25^\circ \pm 5^\circ$ latitudes best explain the northern and southern fans respectively.

(R. Vasundhara and Pavan Chakraborty*)

3. Solar-terrestrial physics and geophysics

Equatorial effects of magnetospheric substorms : Work on the equatorial ionospheric signatures of magnetospheric susbtorms continued focussing on issues related to the recent finding of the occasional appearance of a positive H-field bay in the afternoon sector (instead of the expected negative bay) in association with the substorm expansion phase onset. Recently published work by other groups on the subject indicates that during periodic substorms that occur under a prolonged steady IMF, the low latitude ionospheric electric field is eastward (westward) on the day side (night side), whereas the H-field perturbation is a positive bay both on the day side and night side. This result when coupled with the recent work of our group suggests that the nature of the geomagnetic H-field response to substorms depends on the type of the substorm. Case studies of a large number of well-identified substorms are in progress to establish this inference and gain a better understanding of the physical mechanisms underlying the equatorial electric field and magnetic field effects of substorms.

(J. H. Sastri)

Dayside equatorial geomagnetic field in relation to sudden magnetospheric compressions : The geomagnetic storm sudden commencement (ssc) due to a sudden magnetospheric compression manifests in two basic forms in the day side dip equatorial region, namely, as a sudden positive impulse termed ssc(+), and as a positive impulse preceded by a sharp negative impulse termed ssc(-,+) or ssc*. The factor(s) that determine this bi-modal response of the equatorial geomagnetic field to sudden magnetospheric compressions are not known. As a step in the direction of identifying the causative factors, we have performed a statistical study of the characteristics of the daytime (06-18 IST) ssc's recorded at Kodaikanal Observatory (10.25 N, 77.5 E) over the period 1957-2002. A total of 475 ssc's have been analyzed out of which 136 (28.6 per cent) are of sc* type. We find that the average value of the amplitude of the positive main impulse (mi) of ssc* is higher than that of the conventional ssc. This difference is statistically significant at 99 per cent level and persists even when the analysis is restricted to the interval, 09-15 IST with a high occurrence (82 per cent) of ssc*. The finding indicates that the contribution of ionospheric currents of polar origin gain prominence when ssc* is excited at dayside dip equatorial latitudes, when compared to the conventional ssc (+). The large event-to-event variability that one sees in this physical situation could be due to the facts that the eventual ground-level manifestation of the effect of magnetopsheric compression depends on several factors like the characteristics of the causative interplanetary shock (strength and orientation) and the ambient interplanetary magnetic field orientation, and the state of the magnetopsheric and ionospheric environments.

(J. H. Sastri, J. V. S. V. Rao* & R. Subbiah*)

Regular data acquisition in the monitoring mode continued with the experimental facilities in Kodaikanal Observatory (HF Doppler Radar..etc)

(J. H. Sastri, J. V. S. V. Rao* and staff of I& M section and STR Laboratory)

Earth system : Research programmes relating to the earth system structure and processes at IIA, are aimed at: a) refining our understanding of selected critical segments of planet earth which may shed light on planetary structure and processes generally, particularly their early structurization and rheological structure, and b) quantification of the chemical interactions, notably Green House Gases between the various geospheres.

Two regions were selected for the former study, capable of discriminating between contending hypotheses. These are : Ladakh and Northeastern India. Broadband instruments were accordingly installed at two sites in Ladakh : Leh and Hanle. These have yielded significant data which are currently

being analysed. Those from 9 sites in northeast India, have now been analyzed. Highlights of the results (figures 12, 13, 14), include : * that the upper elastic crust under Shillong is the thinnest in the region and is strong all the way upto the Mohorovicic discontinuity at its base, contrary to earlier less well resolved results, * that the Indian crust underthrusts the Himalaya and southern Tibet, all the way upto Lhasa, * that the Shillong plateau is supported not by hydrostatic isostasy but dynamics, that is by the strength of the lithosphere which is under compression by Indo-Eurasian plate convergence earlier determined by us to be at the rate of 40 mm/year, with an uncertainty of 3 mm/yr.

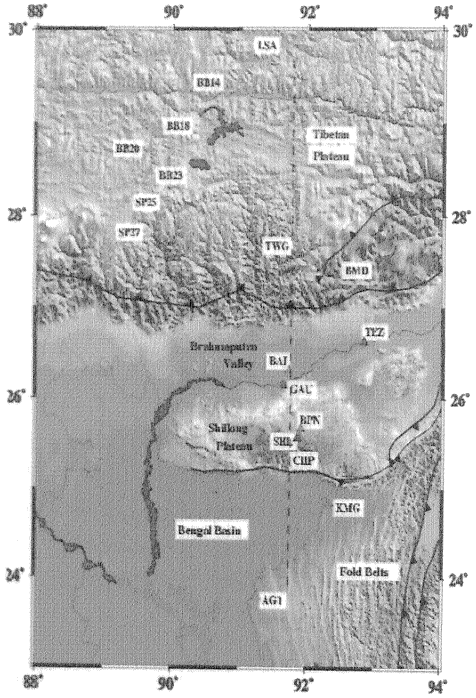


Figure 12.

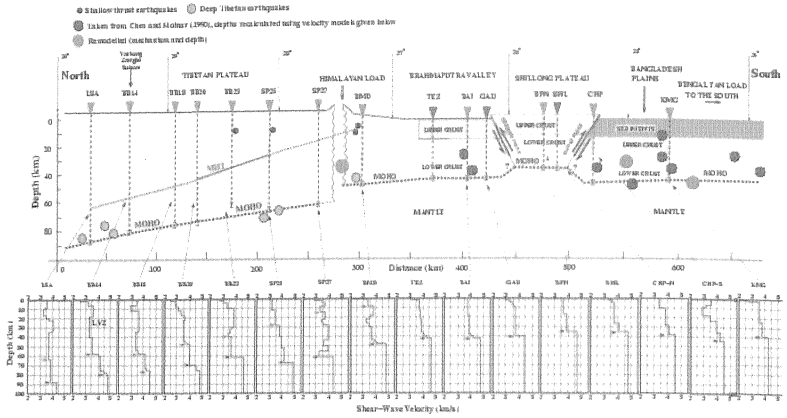


Figure 13.

Quantification of CO2 fluxes between the atmosphere and the earth's surface oceans and the terrestrial biosphere, is the basic goal of this study aimed at refining our understanding of the Global Carbon Cycle, so that future prognostications of atmospheric CO2 concentrations and the resulting climate state may be made for various future emission scenarios. This is an Indo-French collaborative project jointly with C-MMACS at Bangalore, and LSCE/ CNRS, France. The first part of the project consists in installing an ultra high-precision CO2 analyzer (100 parts per billion) for continuous measurements of CO2 concentrations at Hanle. Various aspects of this activity are currently being organized and the set up is expected to become operational by the summer of 2005. Meanwhile, an Inverse Atmospheric Transport Model is being implemented at C-MMACS, to invert CO2 concentrations in terms of CO2 fluxes.

(V.K. Gaur)

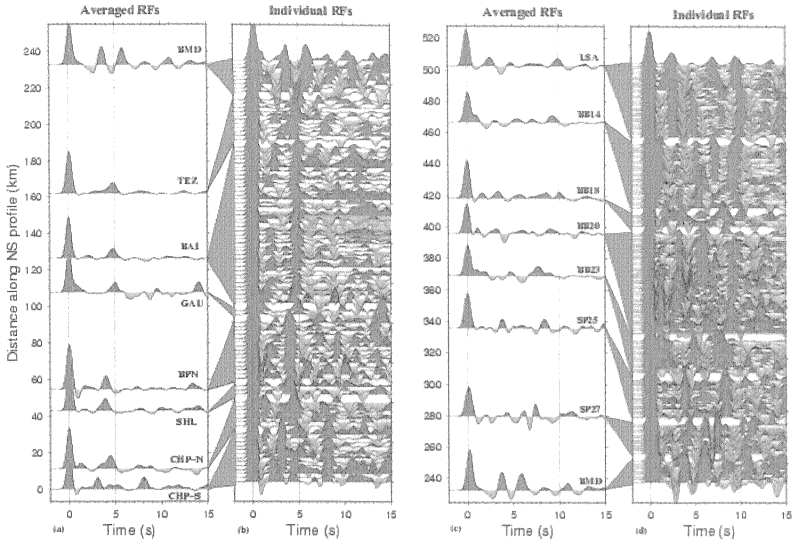

Averaged RFs
Individual RFs
Averaged RFs
Individual RFs
Distance along NS profile (km)
BMD
TEZ
BAI
GAU
BPN
SHL
CHP-N
CHP-S
LSA
HB14
HB18
HB20
HB23
SP25
SP27
BMD
Time (s)
Time (s)
Time (s)
Time (s)
(a)
(b)
(c)
(d)

Figure 14.

4. Stars and stellar systems

A high-resolution spectroscopic analysis of the supergiant HD 165553 : The results of an analysis of a high resolution spectrum of the spectroscopic binary HD 165553, obtained with a spectral resolution of ~ 60000 are presented. A detailed chemical composition study indicates that the star is a normal supergiant with essentially solar composition except for elements C and Na for which we present plausible reasons associated with stellar evolution. The star is a single-lined spectroscopic binary; there is no evidence of double lines in its spectrum. Comparison of the star's spectrum with the spectrum of γ Cyg, a supergiant of spectral type F8 Iab, indicates that the star is of a later spectral type; we assign a spectral type G Iab for the star. The heliocentric radial velocity of the star is estimated to be –4.5 km s^{-1} ± 1.5 km s^{-1}.

(Aruna Goswami, N Kameswara Rao, D L Lambert*)

Chemical compositions and circumstellar environment of the variable star QY Sge : Chemical composition studies of the variable star QY Sge show abundance anomalies suggestive of a pattern exhibited by the warmer RV Tauri variables. Abundance analysis indicates a near-solar atmosphere with highly condensable elements depleted by several factors. Evidence of broad Na D emission features in its spectrum, a characeristic feature of R CrB type stars taken at minimum, however, raises the question of its spectral classification. We address this question through a comparative analysis of its spectrum with those of γ Cyg, 89 Her and R CrB taken at minimum in addition to abundance analysis. We also discuss a possible physical scenario of the circumstellar environment accounting for the characteristics of the distinct spectroscopic features.

(Aruna Goswami, N Kameswara Rao, D L Lambert*)

Lithium abundances of the local thin disc stars : Lithium abundances based on high quality (S/N approx 300-600) and high-resolution spectra (R approx 55,000) for a sample of 181 nearby F and G dwarfs in Galactic thin disk with accurate *Hipparcos* parallaxes are investigated. The stars are on circular orbits about the Galactic centre and, hence, are identified as belonging to the thin disk. This sample is combined with two published surveys to provide a catalogue of lithium abundances, metallicities ([Fe/H]), masses, and ages for 451 F-G dwarfs, almost all belonging to the thin disk. The lithium abundances are compared and contrasted with published lithium abundances for F and G stars in local open clusters. The field stars span a larger range in [Fe/H] than the clusters for which [Fe/H] ~ 0.0 ± 0.2 (see Figure 15). The initial (i.e., interstellar) lithium abundance of the solar neighborhood, as derived from stars for which astration of lithium is believed to be unimportant, is traced from log ϵ (Li) = 2.2 at [Fe/H] = –1 to log ϵ (Li) = 3.2 at + 0.1. This form for the evolution is dependent on the assumption that astration of lithium is negligible for the stars defining the relation. An argument is advanced that this latter assumption may not be entirely correct, and, the evolution of lithium with [Fe/H] may be flatter than previously supposed.

A sharp Hyades-like Li-dip is not seen among the field stars and appears to be replaced by a large spread among lithium abundances of stars more massive than the lower mass limit of the dip. Astration of lithium by stars of masses too low to participate in the Li-dip is discussed. These stars show little to no spread in lithium abundance at a given [Fe/H] and mass.

(David L. Lambert* and B. Eswar Reddy)

Abundance surveys in F and G disk dwarfs : Recently, we have completed photospheric abundance survey for 26 elements from carbon to europium in 181 F- and G-disk dwarfs. Kinematic parameters showed that the vast majority of stars belong to the Galactic thin disk. For all of the

elements we found scatter in [X/Fe] (where X = C, N, O, ...) at a fixed [Fe/H] is entirely attributable to the small measurement errors. Tight limits are set on 'cosmic' scatter. By combining our sample with published studies we could identify two groups of disk population stars: thin and thick. Thick disk stars are segregated from thin disk stars in their kinematics as well as in abundances, particularly, α-process elements. Unfortunately, the different sources combined in the study-with the expected systematic effects among them did not allow us to make a conclusive characterization of the thick disk. There are stars that seem to share thin and thick disk properties, and it is unclear whether those are due to systematic errors in the samples from the literature. Completing a thick disk study parallel to that of our thin disk study will make it possible to chemically tag the stars by performing a strictly differential analysis and we may be able to answer the following questions : a) Are thick and thin disk stars separated chemically? b) Are there abundance gradients with Galactocentric distance in the thick disk? c) Are the thick and thin disk populations discrete entities or extrema of the same population? The answers will shed light on the formation and evolution of the Galaxy's thin and thick disks. Thick disk sample of 200 stars is selected based on kinematics defined in our paper I. The present survey covers large number of stars (200 against 21 Bensby et al. 2003) and elemental species (26 elements: C to Eu) in Galactic thick disk than any other earlier study. The required high-resolution spectra were obtained from various telescopes (2.3 m telescope at VBO, Kavalur, 2.7 m and 10~m (HET) telescopes at McDonald observatory, Austin) and this work will be published soon.

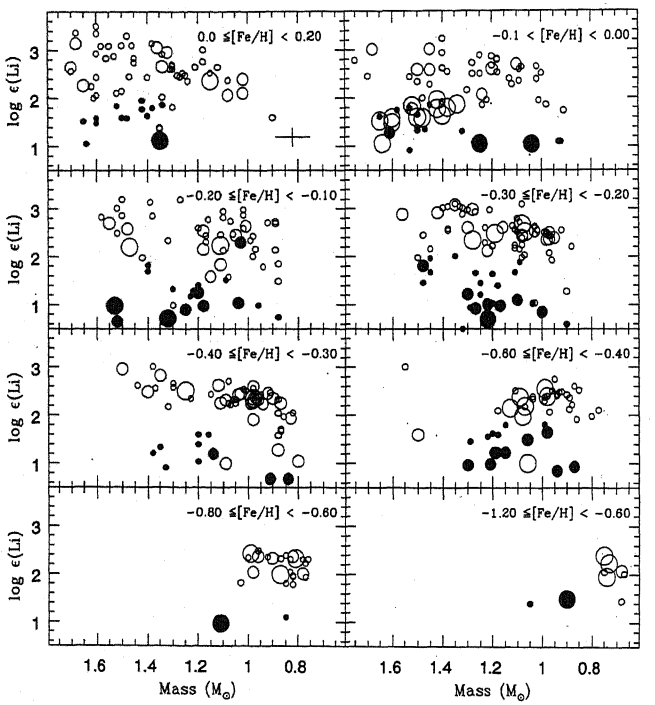


Figure 15. Li abundance versus stellar mass in eight different [Fe/H] bins.Filled circles denote upper limits to the lithium abundance. Open circles refer to measured abundances. The three sizes for the circles identify the accuracy of the *Hipparcos* parallax, a major influence on the derived mass. Stars with a parallax error ≥ 10% are assigned the biggest circle. Stars with an error of 5% to 10% are shown with the middle-sized circle. Those stars with a 5 % or smaller error are given the smallest circles.

(B. Eswar Reddy, David L. Lambert* and C. Allende Prieto*)

Chemical compositions of evolved stars of high galactic latitude : We have completed detailed abundance analysis of a large sample of evolved stars with IR fluxes. We find that HD 27381 shows significant metal deficiency and also the influence of convective mixing which has brought the product of NaNe cycle to the surface. The similar effect on smaller scale is seen for HD 10285 and HD 25291. The high galactic latitude B type supergiant HD 137569 is found to be a hot post-AGB star showing very large depletion of C, Mg, Si and Fe. A comparison of this star with other hot post-AGB stars and PNe give good evidence of the possible evolutionary link between these objects. Our analysis of HD 172324 show unusually low value of N/C ratio which indicates that either the star has evolved directly from the main sequence or had subsolar primordial N abundance. The observed variations in radial velocities, significant variations in emission components of hydrogen line profiles and doubling of OI lines at 7774Å are suggestive

that HD 172324 may be a pulsating variable. Among the coolest members of the sample we find HD 198343 showing enhancement of light s-process elements Y and Zr.

(Sunetra Giridhar and A. Arellano Ferro*)

Discovery of a new T Tauri double-lined spectroscopic binary : We find the star HD 34700 to be a double-lined spectroscopic binary. We also identify it as a weak-line T Tauri object.The spectra of both components are very similar and both show the Li I feature at 6708Å. Strong arguments in favour of the binary nature of the star as opposed to other possibilities are offered. It is very likely that the companion is also a T Tauri star of similar mass. We present a list of the lines identified and the radial velocities of the two components for three consecutive nights the observations were made.

(A. Arellano Ferro* and Sunetra Giridhar)

CCD photometry of the RR Lyrae stars in NGC 4147 : We have carried out CCD photometry in V and R bands for RR Lyrae known to exist globular cluster NGC 4147. The periodicities for most variables are revised and new ephemerides are calculated. Blazhko effect has been detected in V2 and V6 and it is likely to be present in V13. Three previously reported variables V5, V9 and V15 are found to be non-variables. A new variable V18 has been discovered with a period of 0.49205 days and amplitude of variability of 0.15mag. Using the Fourier decomposition approach of the light curves the physical parameters of RRab and RRc groups were estimated. We estimate [Fe/H] of – 1.22 and distance of 16.8 kpc which is smaller than the earlier distance estimate. The cluster belongs to Oosterhoff type I. With the newly derived [Fe/H] and distance the cluster fits very well into the Oosterhoff type-metallicity and metallicity - temperature sequence found in globular clusters. A comparison with models ZAHB indicate that the RRab stars have not yet evolved off the horizontal branch, a result consistent with the mean period of the RRab variables and the metallicity derived in this work.

(A. Arellano Ferro*, M.J. Arevalo*, Carlos Lazaro*, Mannuel Rey*, D.M. Bramich* and Sunetra Giridhar)

The light curves of RR Lyra variables V10 and V17 in the NGC 4147 obtained using IAO observations during May 8-10,2003 are given in Figures 16 and 17.

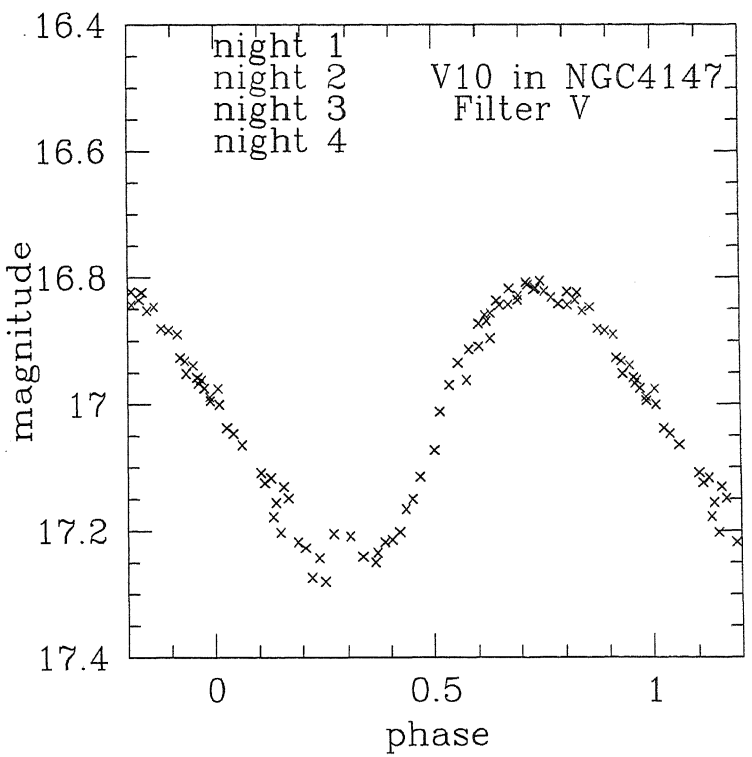


Figure 16.

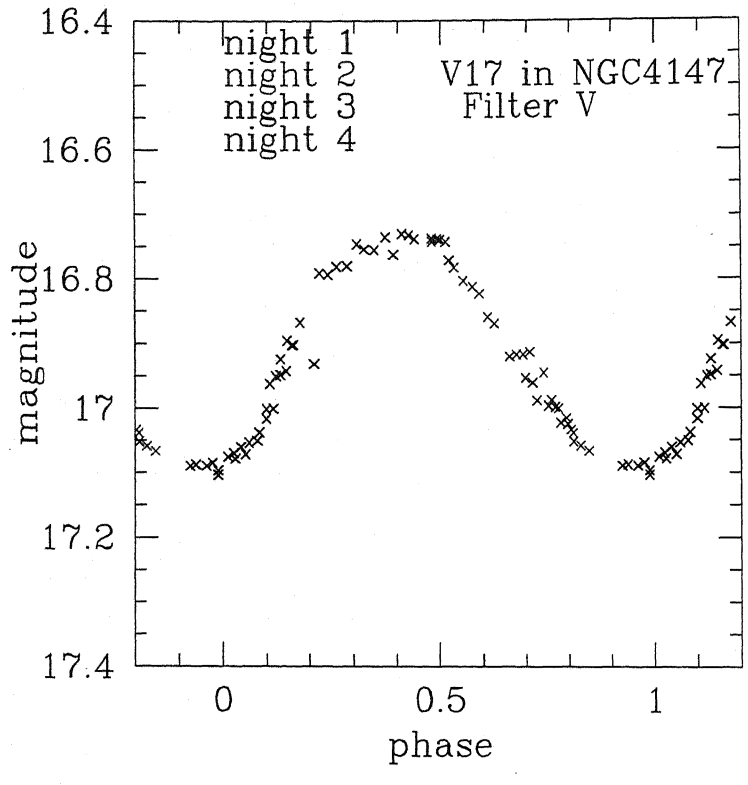


Figure 17.

Magnetic fields in cometary globules: CG 12 : We have made optical linear polarization measurements of stars in the region of the relatively isolated cometary globule CG 12 in Centaurus at a galactic latitude b = 210. A polarization map representing the geometry of the magnetic field in the cloud is produced. In the lower-density outer parts of the cloud, the field is more or less parallel to the cometary tail and other elongated structures like the bipolar molecular outflow from near the infrared source IRAS 13547-3944 and the nebulosity around star 2 embedded in the cloud. Polarization vectors for the more highly reddened stars in the head region of the globule are found to be more or less parallel to the long axis of the elliptical, high-density C18O core of the cometary globule head.

(H. C. Bhatt, G. Maheswar and P. Manoj)

The new optical nebulosity associated with IRAS 05436-0007: We have made CCD observations of the optical nebula associated with IRAS 05436-0007 (cf. IAUC 8284) at the 2.3-m Vainu Bappu Telescope (VBT) and the 2-m Himalayan Chandra Telescope (HCT). VBT R-band CCD imaging on Feb. 19.7 UT yields magnitudes 16.8 in a 6" aperture and 13.6 in an 80" aperture. HCT CCD imaging on Feb. 22.7 gave V = 18.1, R = 16.5, and I = 14.5 in a 6" aperture, and V = 14.0, R = 13.2, and I = 12.1 in an 80" aperture. An optical spectrum (resolution of 0.12 nm/pixel) with the HCT (+ HFOSC) on Feb. 23.7 shows Hα and near-infrared Ca II triplet lines in emission. Hα shows a P-Cyg profile with an eqivalent width of the emission component of 3.2 nm, the absorption component having a peak at a velocity of 460 km/s. The O I line at 777.3 nm is seen in absorption with an equivalent width of 0.24 nm.

(G. Maheswar and H. C. Bhatt)

Novae

The nebular shell of the old nova GK Persei : The analyses of the low frequency radio observations of the shell of nova GK Per obtained using the GMRT, in the 327 MHz, 610 MHz and 1440 MHz bands and the narrow band images of the shell obtained from the 2-m HCT using the HFOSC are complete. The analyses indicate the flux in the 20cm band has decreased compared to the previously reported estimates made in 1984, while the flux in the other bands has not changed within errors. In order to confirm this result, more data were obtained in the 1280 MHz band. The

optical data indicate the shell is expanding into a less dense medium and hence the energy due to shock has reduced. Interpretation of the results is under progress.

(G.C. Anupama and N.G. Kantharia*)

Novae in outburst : Two novae in outburst, Nova Sct 2003 and Nova Sgr 2004 have been observed using the 2m HCT. The observations of Nova Sgr 2004 are continuing.

(G.C. Anupama and P.S. Parihar)

Supernovae

Optical monitoring of low redshift supernovae : Supernovae SN 2003du, SN 2003gs, SN 2003hv and SN 2003hx, SN 2004A, SN 2004C, SN 2004ab and SN 2004as were monitored in the *UBVRI* bands and also spectroscopically from IAO, Hanle, using the HFOSC instrument on the 2m HCT. SN 2004A, SN 2004ab and SN 2004 continued to be monitored. The analysis of the data on SN 2003du and SN2003gs is under progress.

A collaboration on supernova monitoring with the Italian Group has been established.

(G.C. Anupama and D.K. Sahu)

Gamma-ray Burst Sources : A project to monitor the optical afterglows of GRB events using the 2m HCT has been initiated, with members from IIA, RRI, and State Observatory, Nainital.

GRB 030226 : The GRB 030226 was observed in the optical *UBVRI* bands using the 2m HCT and 1m telescope at the State Observatory, Nainital. Observations in the millimeter bands were also made using the Plateau de Bure Interferometer. The optical data show an early R band flux decay slope of 0.77 ± 0.04, steepening to 2.05 ± 0.04 about 0.65 ± 0.03 day after the burst. Interpreted as the "jet break", this indicates a half opening angle of $\sim 3.2^{\circ}$ for the initial ejection, for an assumed ambient density of $\sim 1 cm^{-3}$. Broadband spectra show no appreciable evolution during the observations and indicate the presence of synchrotron cooling frequency υ_c near the upper edge of the optical band. From the broadband spectra an electron energy distribution index $p = 2.07 \pm 0.06$ and an intrinsic extinction of $E(B-V) \sim 0.17$ are estimated. The upper limits to the millimeter fluxes are consistent with these derived parameters.

(S.B. Pandey*, R. Sagar*, G.C. Anupama, D. Bhattacharya*, D.K. Sahu, A.J. Castro-Tirado* and M. Bremer*)

Searching for GRB remnants in nearby galaxies : Gamma Ray Bursts (GRBs) are expected to leave behind GRB remnants, similar to how "standard" supernovae (SN) leave behind SN remnants. The identification of these remnants in our own and in nearby galaxies would allow a much closer look at GRB birth sites, and possibly lead to the discovery of the compact object left behind. It would also provide independent constraints on GRB rates and energetic. We have initiated an observational program to search for GRB remnants in nearby galaxies. The identification is based on specific line ratios, such as $OIII/H_{\beta}$ and $HeII/H_{\beta}$, which are expected to be unusually high in case of GRB remnants according to the theoretical predictions of Perna et al. (2000). The observing strategies and preliminary studies from a test run at 2.34 m VBT as well as archival data from planetary nebulae surveys of spiral galaxies are discussed.

(S.G. Bhargavi, J. Rhoads*, R. Perna*, J. Feldmeier* and J. Greiner*)

Reddening in stars of the alpha Per cluster : We have continued the study of Li in the alpha Persei cluster based on the high resolution data of 80 stars obtained at the Kitt Peak and McDonald Observatories. We have had to do a detailed probing into the choice of temperature for each star, it being the most critical parameter dictating the lithium content of the star. For slowly

rotating stars, it was possible to determine spectroscopic temperature which is reddening-independent. For the rapidly rotating stars, we had to rely upon photometry and colour-temperature relations. This was complicated because of variable reddening across the cluster. We did this first for all the stars of the cluster for which both uvby and H_β photometry exist (H_β being a reddening-free parameter) by computing the H_β temperature and consequently E(b–y). This was repeated for stars for which both spectroscopic T and uvby photometry exist. This exercise showed that reddening indeed is variable. We opted for an average value and applied it to the V–I colours for all our programme stars to obtain temperatures. The dispersion in reddening across the cluster leads to an uncertainty in temperature to ± 200 – 300K. We also compiled data on our stars of all possible colour indices, B–V, V–R, V–J, V–H, V–K, with appropriate colour transformations and applied the average reddening to intercompare temperatures derived in each case. The differences here also amount to uncertainty in temperature in the same range, i.e. ± 200 – 300K.

(Sushma Mallik, S. Balachandran* and D.L. Lambert*)

Lithium in stars of alpha Per cluster : With the above estimated temperature and an appropriate choice of model atmosphere as input, the MOOG code was run to obtain synthetic spectrum for each star in the Li region. Parameters like rotational velocity, *v sin i* and lithium abundance, log N(Li) were varied until the best fit to the observed was obtained. The Li abundance thus determined is accurate to within ± 0.2 – 0.3 for uncertainty in temperature of ± 200 – 300K. The hotter stars (6000-7000K)tend to retain Li that they were endowed with at birth. However, it drops to less than 1.0 for stars cooler than 5000K. The most noticeable feature of the plot between log N(Li) and T is the large scatter in Li abundance observed at each T, especially for cooler stars, in spite of the fact that they are of the same mass, age and metallicity. It is clear that there is at least a fourth variable, perhaps rotation, besides these three that controls the behaviour of Li in stars of a given cluster. It is striking to note that the K stars which have most likely just arrived on the main sequence and should still be rapidly rotating show unusually low Li. Have they spun down already? A detailed enquiry into understanding the mechanisms of Li depletion is in progress.

(Sushma Mallik, S. Balachandran* and D.L. Lambert*)

Large Magellanic Cloud Bar: Evidence of a warped bar : The geometry of the LMC bar is studied using the de-reddened mean magnitudes of the red clump stars (I_0) from the OGLE II catalogue. The value of I_0 is found to vary in the east-west direction such that both the east and the west ends of the bar are closer to us with respect to the center of the bar. The maximum observed variation has a statistical significance of more than 7.6 σ with respect to the maximum value of random error. The 2D figure of the region studied is shown in Figure 18, where the variation in I_0 is shown as a function of RA and Dec. At locations RA= 79°.5 and Dec = – 69°.6 and RA = 84°.5 and Dec = –70°, the I_0 values are higher indicating that these regions are located at a larger distance. The regions in between the above points are closer to us. The eastern most regions are closest, as indicated in the figure. At RA = 84°.5, another feature which can be noticed is that along the declination axis, there is a change in the relative distance. This is such that the northern regions are farther and the southern regions are closer. The difference in I_0 is more than 3.8 times the $\Delta_{max} I_0$. The center of the LMC is taken to be $05^h19^m38^s.0$ –69°27′5″.2 (J2000.0). Then the center lies near the fainter I_0 points located around RA = 79°.5. Thus the regions westward of the center are also found to be closer. It can be seen that there are variations in the I_0 magnitude along the bar. Most striking feature is the wavy pattern in I_0. The eastern side of the bar is closer to us, when compared to the bar region near the center. So also is the western side closer to us. We see an M-type variation in I_0 along the RA. Thus the features indicate that the bar of the LMC is warped.

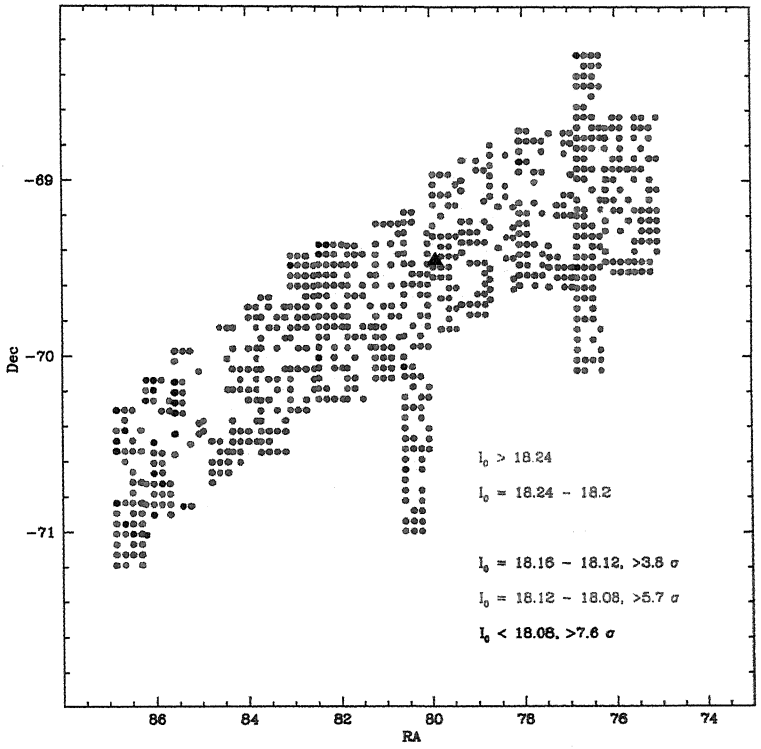


Figure 18.

The LMC bar is thus found to show structures. The presence of warp in the bar indicates that the bar is dynamically disturbed. Since the bar is located well within the tidal radius of LMC, the tidal effects due to LMC-SMC-Galaxy interaction may not be the cause of the disturbance. On the other hand, if the bar is not aligned with the disk, then the disk can induce perturbations on the bar. This in turn can create structures in the bar. Therefore, it is necessary to find out the geometry of the bar and the disk, which would throw light on the source of perturbations in the bar.

(Annapurni Subramaniam)

Evidence of a mis-aligned secondary bar in the Large Magellanic Cloud : The off-centered stellar bar is one of the most striking features of the Large Magellanic Cloud (LMC). On the other hand, this is one of the least studied and understood feature of the LMC. Evidence of a mis-aligned secondary bar, within the primary bar of the Large Magellanic Cloud (LMC) is presented. The density distribution and the de-reddened mean magnitudes (I_0) of the red clump stars in the bar obtained from the OGLE II data are used for this study.

The two-dimensional distribution of the red clump star density on the X-Y plane is shown in the top left panel of figure 19. The figure shows maximum density near the center which decreases radially outwards. The main feature is the elongation of the central density to the eastern side, and this elongation is then carried outward as ellipses. This is found to be the origin of the elliptical pattern found in the bar. The major-axis of the ellipse is found to turn very clearly in the east side. This is indicative of isophotal twist.The maximum density at each radial point is estimated and its variation with respect to radius is shown in the bottom panels of Figure 19. The profiles are different for the east and west sides of the bar.The profile on the east side is characterised by a shallower slope upto 0°.6 and a steeper slope upto 1°.9. The points are connected using a smoothing function which takes average of the two neighbouring points. The profile for the east side is very similar to the magnitude variation along the major axis of a double barred galaxy (eg. NGC 1291). The prominent peak corresponding to the bulge is missing here with the rest of the profile looking very similar. NGC 1291 is considered as a prototype of double-barred galaxies.The west side profile is different, with the slope similar to that seen between 0°.6 and 1°.9 for the eastern side and a rise in the profile at 1°.3. The variation of the PA of the major axis as a function of radial distance is shown in the top right panel of Figure 19. Considerable change in the PA with radial distance can be noticed. Turn over of the PA at a radial distances of 0°.8, 1°.4 and 1°.9 on the eastern side and 1°.3 on the western side could be noticed. Thus the turn over of the PA is well correlated with the changes in the density profile.These variations thus suggest structures in the bar close to the center, with the possible existence of a secondary bar.

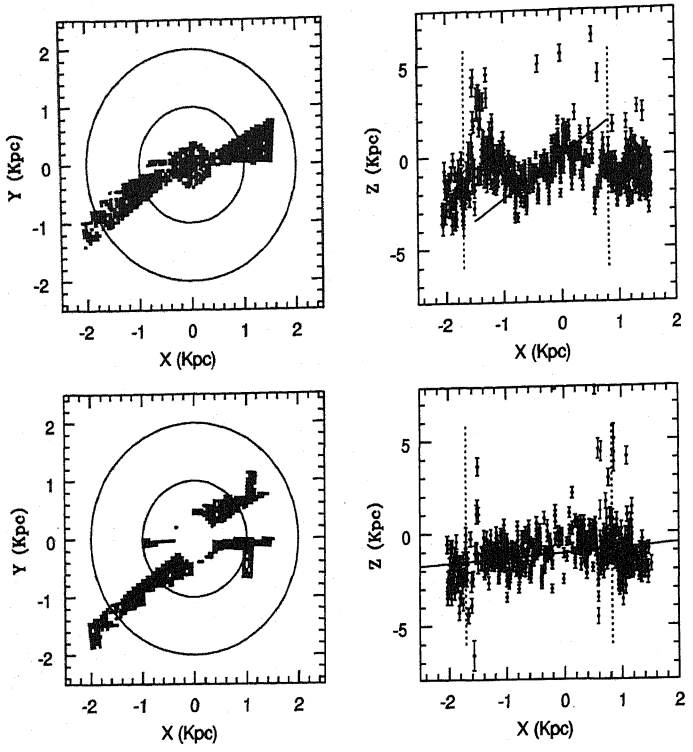


Figure 19.

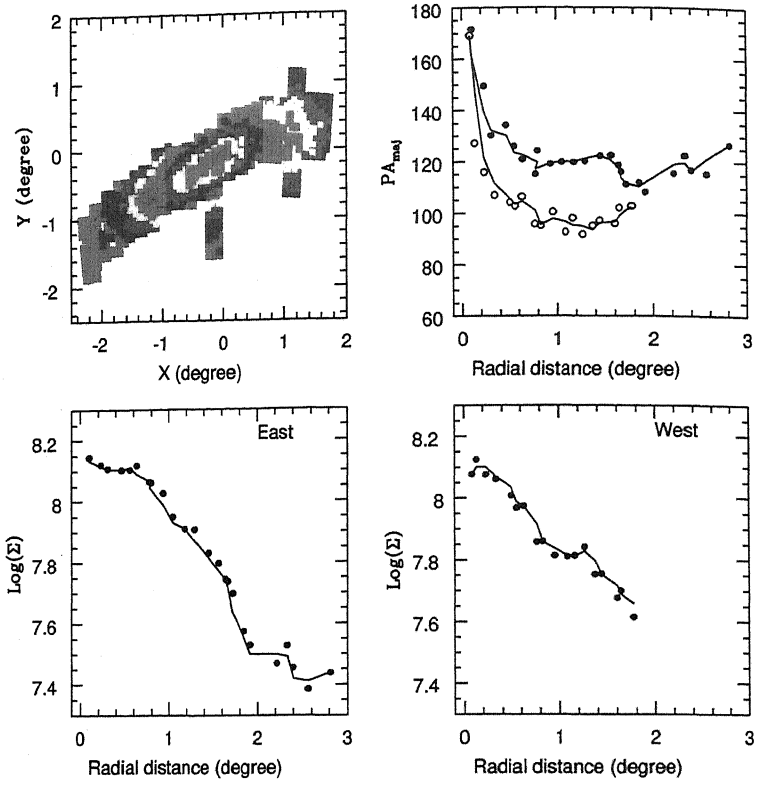


Figure 20.

The bar region which predominantly showed a wavy pattern in the line of sight in Subramaniam (2003) was located. These points are shown in the top panel of Figure 20, where, the left panel shows the X-Y plane and the right panel shows the X-Z plane. In the X-Y plane, the points with $Z > 0$ are shown as filled circles. In the X-Z plane, the dotted lines correspond to the location where a change in radial density profile was noticed in Figure 19, at radial distances of $1^{\circ}.9$ and $1^{\circ}.3$ in the east and west sides respectively. Within these two lines, a well defined S-pattern can be noticed. The variation seen in the feature is statistically significant, as indicated by the error bars. The S-pattern consists of the central bar inclined in the line of sight with trailing pattern on both ends. This feature is considered as the mis-aligned secondary bar. This feature is statistically significant and does not depend on the considered value of I_0 for the LMC center. The rest of the bar regions were not found to show the warp or the wavy pattern, as seen from the bottom panel of figure 20. The secondary bar is found to be considerably elongated in the Z-direction, with an inclination of $66^{\circ}.5 \pm 0^{\circ}.9$, whereas the undisturbed part of the primary bar is found to have an inclination of $15^{\circ}.1 \pm 2^{\circ}.7$, such that the eastern sides are closer to us with respect to the western sides of both the bars. The PA_{maj} of the

secondary bar is found to be $108^{\circ}.4 \pm 7^{\circ}.3$. The streaming motions found in the H I velocity map close to the LMC center could be caused by the secondary bar. The recent star formation and the gas distribution in LMC could be driven by the mis-aligned secondary bar.

(Annapurni Subramaniam)

On the determination of age, and mass functions of stars in young open star clusters from the analysis of their luminosity functions : Based on the CCD observations of remote young open clusters NGC 2383, NGC 2384, NGC 4103, NGC 4755, NGC 7510 and Hogg 15, we construct their observed luminosity functions (LFs). The observed LFs are corrected for field star contamination determined with the help of galactic star count model. In the case of Hogg 15 and NGC 2383 we also considered the additional contamination from neighboring clusters NGC 4609 and NGC 2384 respectively. These corrections provided the realistic pattern of cluster LF in the vicinity of the MS turn on point and at fainter magnitudes, revealed the so called H-feature arising due to transition of the Pre-MS phase to MS, which is dependent on the cluster age. The theoretical LFs were constructed representing a cluster population model with continuous star formation for a short time scale and a power law Initial Mass Function (IMF) and these were fitted to the observed LF. As a result we are able to determine for each cluster a set of parameters, describing cluster population (the age, duration of star formation, IMF slope, and percentage of field star contamination). It was found that in spite of the non-monotonic behavior of observed LFs, cluster IMFs can be described as the power law functions with slopes similar to Salpeter's value. The present Main Sequence turn on cluster ages are several times lower than those derived from the fitting of theoretical isochrones to turn off region of the upper Main Sequences.

(Annapurni Subramaniam)

Estimation of the micro-lensing optical depth in the LMC : The microlensing (ML) events observed towards the LMC were supposed to identify and put a limit on the Massive compact halo objects in our Galaxy. On the other hand, the ML events showed that many events may originate in the LMC itself. This required a relatively large value of the optical depth in the LMC, given the fact that the LMC is physically thin. Attempts to identify the stellar population responsible for increasing the optical depth in LMC gave negative results. The recent studies suggesting a mis-aligned secondary bar within the primary bar of the LMC could result in increased depth in the central regions. We plan to use a three component model (disk, primary bar and secondary bar) to estimate the map of the optical depth in the LMC. The preliminary analysis of this model was found to be encouraging. The detailed analysis is in progress.

(Annapurni Subramaniam)

UV(IUE) spectra of hot post-AGB candidates : Analysis of the low resolution UV(IUE) spectra (1150 to 3200 Å) of 15 hot post-AGB candidates is presented. The UV(IUE) spectra of 10 stars suggest partial obscuration of the hot stars due to circumstellar dust. The reddened continua of these 10 stars were used to model and estimate the circumstellar extinction. The circumstellar extinction law was found to be linear in λ^{-1} in the case of IRAS 13266–5551 (CPD-55 5588), IRAS 14331–6435 (Hen3-1013), IRAS 16206–5956 (SAO 243756), IRAS 17074–1845 (Hen3-1347), IRAS 17311–4924 (Hen3-1428), IRAS 18023–3409 (LSS 4634(, IRAS 18062+2410 (SAO 85766), IRAS 18371–3159 (LSE 63), IRAS 22023+5249 (LSIII+5224) and IRAS 22495+5134 (LSIII+5142). There seems to be no significant circumstellar extinction in the case of IRAS 12584–4837. (Hen3-847) shows several emission lines including that of HeII. It may be a massive young OB-supergiant or a low mass star in the post-AGB phase of evolution. IRAS 16206–5956 (SAO 243756) and IRAS 18062+2410 (SAO 85766) show variability in the UV which in addition to stellar pulsations may be attributed to a dusty torus in motion around the hot central stars. The UV spectrum of the bipolar PPN, IRAS 17423–1755 (Hen3-1475) indicates that the central B-type star is obscured by a dusty disk. The stars were placed on the log g–log $T_{\rm eff}$ diagram showing the post-AGB evolutionary tracks of Schönberner. Terminal wind velocities of the stars were estimated from the CIV and NV

stellar wind features. The presence of stellar wind in some of these stars indicates ongoing post-AGB massloss.

(G. Gauba and M. Parthasarathy)

Circumstellar dust shells of hot post-AGB stars : Parameters of the circumstellar dust shells of 15 hot post-AGB stars have been derived using a radiative transfer code (DUSTY). Combining the optical, near and far-infrared (ISO, IRAS) data of the stars, we have reconstructed their spectral energy distributions (SEDs) and estimated the dust temperatures, mass loss rates, angular radii of the inner boundary of the dust envelopes and the distances to these stars. The mass loss rates (10^{-6} – 10^{-5} $M_{\odot}$ yr^{-1}) are intermediate between stars at the tip of the AGB and the PN phase. We have also studied the ISO spectra of 7 of these stars. Amorphous and crystalline silicate features were observed in IRAS 14331-6435 (Hen3-1013), IRAS 18062+2410 (SAO 85766) and IRAS 22023+5249 (LSIII + 5224) indicating oxygen-rich circumstellar dust shells. The presence of unidentified infrared (UIR) band at 7.7 μ, SiC emission at 11.5 μ and the "26 μ" and "main 30 μ" features in the ISO spectrum of IRAS 17311-4924 (Hen3-1428) suggest that the central star may be carbon-rich. The ISO spectrum of IRAS 17423-1755 (Hen3-1475) shows a broad absorption features at 3.1 μ due to C_2H_2 and/or HCN which is usually detected in the circumstellar shells of carbon-rich stars.

(G. Gauba and M. Parthasarathy)

High resolution spectroscopy of the hot post-AGB stars : IRAS13266-5551 (CPD-55 5588) and IRAS17311–4924 (Hen3-1428): The high resolution spectra covering the wavelength range 4900 Å to 8250 Å of the hot post-AGB stars IRAS13266–5551 (CPD-55 5588) and IRAS17311–4924 (Hen3–1428) reveal absorption lines of C II, N II, O II, Al III, Si III and Fe III and a rich emission line spectrum consisting of H I, He I, C II, N I, O I, Mg II, Al II, Si II, V I, Mn I, Fe III, [Fe II] and [Cr II]. The presence of [N II] and [O I] lines and absence of [O III] indicates low excitation nebulae around these stars. The components of Na I absorption lines indicate the presence of neutral circumstellar envelopes in addition to the low excitation nebulae around these two hot post-AGB stars. The H_{α} lines show P-Cygni profiles indicating ongoing post-AGB mass loss. From the absorption lines, we derived heliocentric radial velocities of 65.31 ± 0.34 kms^{-1} and 27.55 ± 0.74 kms^{-1} for IRAS13266-5551 and IRAS17311-4924 respectively. High galactic latitude and large radial velocity of IRAS13266-5551 indicate that it is a high velocity star belonging to the old disk population. Preliminary estimates for the CNO abundances in IRAS13266-5551 are obtained.

(G. Sarkar, M. Parthasarathy and B.E. Reddy)

Chemical composition of UV-bright star ZNG 4 in the globular cluster M13 : We present a detailed model-atmosphere analysis of ZNG 4, a UV-bright star in the globular cluster M13. From the analysis of a high resolution (R ≈ 45,000) spectrum of the object (obtained with HDS, Subaru 8m telescope), we derive the atmospheric parameters to be $T_{\rm eff}$ = 8500 ± 250 K, log g = 2.5 ± 0.5 and [Fe/H]= –1.5. Except for Magnesium and Chromium, all other even Z elements are enhanced with Titanium and Calcium being overabundant by a factor of 0.8 dex. Sodium is enhanced by a factor of 0.2 dex. The luminosity of ZNG 4 and its position in the color-magnitude diagram of the cluster indicate that it is a Supra Horizontal Branch (SHB) (post-HB) star. The abundance pattern of ZNG4 indicates that diffusion and radiative levitation processes seem to be in operation in M 13 post-HB stars even at $T_{\rm eff}$ of 8500K.

(S. Ambika, M. Parthasarathy, W. Aoki*, T. Fujii*, Y. Nakada*, Y. Ita* and H. Izumiura*)

Chemical composition and evolutionary status of nine UV-bright stars in five globular clusters from VLT/UVES spectra : We have derived the chemical composition of nine UV-bright stars belonging to five Galactic globular clusters of various metallicities ([Fe/H] from –1.0 to –2.4 dex). The analysis is based on high resolution spectra

obtained with the UV-Visual Echelle Spectrograph (UVES) at VLT-UT2. The evolutionary status of the stars is assessed from the chemical analysis and location in the H-R diagram.

The star ID7 in NGC 5986 is confirmed as a bona fide post-asymptotic giant branch star (post-AGB) whereas the high-luminosity star ID6 has probably left the AGB before the third dredge-up. ZNG 1 in NGC 6712 shows an overabundance of sodium, oxygen, and silicon similar to overabundances we find in the UV-bright star ID6 in NGC 5986; both stars could be in a post-early-AGB (PEAGB) phase of evolution. The UV-bright star ZNG 7 in NGC 6218 seems to be an AGB star. The star V-4 and ZNG 5 in NGC 6656 are in a post-horizontal-branch phase of evolution, with V-4 being significantly overabundant in heavy elements. The origin of these overabundances is discussed in the context of the evolutionary versus primordial scenario. The three UV-bright stars K 260, K 996 and K 1082 observed in the very metal-deficient globular cluster NGC 7078 are post-horizontal-branch stars, one of them being slightly enriched in s-elements but with a luminosity too low for third dredge-up to have occured. The abundance patterns of K 1082 in NGC 7078 seem to indicate the presence of mild diffusion and a radiative levitation process, already reported in the blue HB stars of M 13 (Behr et al. 1999, ApJ, 517, L135) and NGC 6752 (Moehler et al. 1999, A&A, 339, 537).

(G. Jasniewicz*, P.de Laverny*, M. Parthasarathy, A. Lebre*, F. Thevenin*)

Coordinated monitoring of blazars : Observations of several TeV and Radio-Quiet QSOs were made in the V,R bands using the 2m HCT. These observations were coordinated with those made from the State Observatory, Nainital, the gamma-ray array telescope at Pachmarhi and the GMRT. The project is being coordinated by Gopal-Krishna (NCRA).

(G.C. Anupama and D.K. Sahu)

High energy gamma ray astronomy from PACT : The data was taken on several sources like Crab, MKN 421, Geminga etc with the Pachmarhi Atmospheric Cerenkov experiment run by the TIFR gamma ray astronomy group. Preliminary analysis has shown very high energy gamma ray emission at high significance from the Crab nebula. The Crab pulsar and Geminga also show gamma ray emission but at higher energies. The interesting BL Lac object MKN 421 has been observed for the last two years. Instances of the flare up of the source has been seen in data from early part of 2004.

(P.R.Vishwanath with members of the TIFR high energy gamma ray group)

5. *Theoretical astrophysics and cosmology*

Radio emission altitude in millisecond pulsars : The radiation by relativistic plasma particles is beamed in the direction of field line tangents in the corotating frame, but in an inertial frame it is aberrated towards the direction of rotation. The angular velocity of corotating plasma can be smaller than the pulsar angular velocity on some field lines, which lie outside the meridional plane. We have revised the formula of aberration phase shift by taking into account the colatitude of emission spot and the plasma angular velocity.

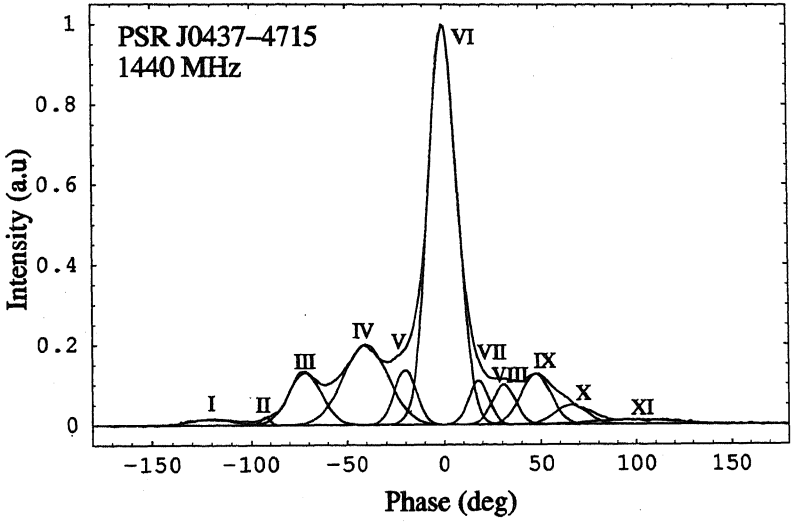


Figure 21. Average pulse profiles (red curve) of milli-second pulsar PSR~J0437-4715. Gaussians are fitted to the components : I, II, III, IV, V, VI, VII, VIII, IX, X, XI. The component VI is the core and the remaining ones are conal components.

By fitting Gaussians to the average profile of milli-second PSR J0437-4715, we have detected 11 emission components (Figure 21). Using the aberration–retardation phase shift of conal components relative to the core (VI), we have estimated the emission height of conal components (I, II, III, IV, V, VII, VIII, IX, X, XI). We find core is emitted from lower altitude while the conal components are emitted from higher altitudes. In the case of PSR J0437-4715, we find a clear evidence for the magnetic field sweep back due to the plasma inertia.

(R. T. Gangadhara)

OGLE II : Over the past years, three experimental teams like OGLE (Optical gravitational lensing experiment), MACHO (MAssive Compact Halo Objects), EROS (Experience de Recherche d'Objects Sombres) have monitored millions of stars in the Magellanic Clouds and Galactic bulge for variability which has resulted in a huge photometric database. These databases are very well suited not only for micro lensing studies but also for many other issues of modern astrophysics, including the distance scale, variable stars, star clusters etc. In particular OGLE II project provided a group of blue variable stars in the Magellanic Clouds showing simultaneously two kinds of photometric periodicity: a short-term variability with typical amplitude $\Delta \sim 0.05$ mag and period P_1 between 4 and 16 days and a sinusoidal, long-term cyclic oscillation with much larger amplitude $\Delta \sim 0.2$ mag with period P_2 in the range of 150-200 days and also both the periods are coupled with some relation. To explain the double periodic variability we are planning to use photometric database OGLEII which span several years of data in the Magellanic Clouds including huge number of light curves. We are trying to model some of these variables and try to derive physical parameters using Wilson-Devinney code. This work is in progress.

(M. Srinivasa Rao)

Radiative transfer effects in rotating stars : A general expression for the gravity darkening of the tidally and non-uniformly rotating Roche components of close binary system equations are used, for calculating the rotational effects on line profiles in an expanding atmosphere. We have considered a non-LTE two level atom approximation in an extended atmosphere. We have also used Von Zeipel's theorem for giving incident radiation at the maximum optical depth ($\tau = \tau_{max}$) in the atmosphere. These calculations are done with uniform rotational velocity 1, 4, 8 mtu (mean thermal units). It is found that rotation is diluting the radiation field which is similar to the expansion velocity.

In the next case we studied rotational aspects which make outer layers of the star distorted.The distortion is measured in terms of the ratio of angular velocities at the equator and pole (X), mass ratio of the two components $\frac{m_2}{m_1}$, the ratio of centrifugal force to that of gravity at the equator of the primary (f) and ratio of the equatorial radius of the primary to the distance between the centres of gravity of the two components $\frac{r_e}{R}$. A seventh degree equation is obtained to describe the distorted surface in terms of the above mentioned parameters. We have used $X = 10$ for non-uniform rotation throughout and used values $f = 0.1$ and 0.5, $\frac{m_2}{m_1} = 0$, and $\frac{r_e}{R} = 0.1, 0.5$. The equation of line transfer is solved in the comoving frame of the expanding atmosphere of the primary using complete redistribution in the line. We used a linear law of velocity of expansion so that the density varies as r^{-3} where r is the radius of the star, satisfying the law of conservation of mass. We found that rotation broadens the line profile, and we also obtained P-cygni type of line profile.

(M. Srinivasa Rao)

Ultrahigh energy cosmic rays and GeV–TeV gamma rays from Gamma Ray Burst (GRB) sources : The origin of the observed Ultra-High Energy Cosmic Ray (UHECR) events above 10^{20} eV continues to be one of the major unsolved problems in contemporary physics and astrophysics. Gamma Ray Burst (GRB) sources have been proposed as one *possible* class of sources of the observed UHECR including those above 10^{20} eV. This requires protons to be accelerated to energies of $\gtrsim 10^{21}$ eV within GRB sources. The synchrotron radiation of these protons in the ambient magnetic field within the GRB source as well as the process of photo-pion production by protons in the ambient radiation field within the GRB source would then give rise to a high (GeV–TeV) energy gamma ray component in addition to the usual low (keV–MeV) energy gamma ray component of GRBs. While the TeV photons are likely to be absorbed due to $e^+ e^-$ pair production process on the intergalactic infrared background except for very closeby GRBs, the sub-TeV (tens to hundreds of GeV) gamma rays from a large fraction of GRBs would survive and may be detectable by the up-coming satellite-borne gamma ray detectors such as GLAST as well as ground based detectors such as MILAGRO, HEGRA, MAGIC, etc., depending on the spectrum, intensity and duration of emission of these gamma rays. The detection (or even non-detection) of the predicted high energy gamma ray component may allow us to test the hypothesis of GRB origin of UHECR and also provide important clues to the nature of GRB sources in general. With this motivation, we have undertaken a detailed study of the various processes of production of GeV–TeV gamma rays from GRB sources within the context of the hypothesis that the observed UHECR originate in GRB sources. The major new element in our analysis of the problem is the calculation of all the relevant processes of high energy gamma ray production and their attenuation involving protons and electrons in a *self-consistent* manner.

(P. Bhattacharjee)

B–L cosmic strings and baryogenesis : Cosmic strings arising from breaking of the $U(1)_{B-L}$ gauge symmetry that occurs in a wide variety of unified models can carry zero modes of heavy Majorana neutrinos. Decaying and/or repeatedly self-interacting closed loops of these "$B - L$" cosmic strings can be a non-thermal source of heavy right-handed Majorana neutrinos whose decay can contribute to the observed baryon asymmetry of the Universe (BAU)

via the leptogenesis route. The $B-L$ cosmic strings are expected in GUT models such as $SO(10)$, where they can be formed at an intermediate stage of symmetry breaking well below the GUT scale ~ 10^{16} GeV; such light strings are not excluded by the CMB anisotropy data and may well exist. We estimate the contribution of $B-L$ cosmic string loops to the baryon-to-photon ratio of the Universe in the light of current knowledge on neutrino masses and mixings implied by atmospheric and solar neutrino measurements. We find that B-L cosmic string loops can contribute significantly to the BAU for $U(1)_{B-L}$ symmetry breaking scale $\eta_{B-L} \gtrsim 1.7 \times 10^{11}$ GeV. At the same time, in order for the contribution of decaying $B-L$ cosmic string loops not to exceed the observed baryon-to-photon ratio inferred from the recent WMAP results, the lightest heavy right-handed Majorana neutrino mass M_1 must satisfy the constraint $M_1 \leq 2.4 \times 10^{12}\ (\eta_{B-L}/10^{13}\ \text{GeV})^{1/2}$ GeV. This may have interesting implications for the associated Yukawa couplings in the heavy neutrino sector and consequently for the light neutrino masses generated through see-saw mechanism.

(P. Bhattacharjee, N. Sahu* and U. Yajnik*)

Galaxies : Dynamics : VV 117 (NGC 2444/2445) is an interacting pair of galaxies consisting of an E4 elliptical galaxy and an Sc spiral galaxy. The spiral is in a disturbed state with a chaotic nucleus. Observations suggest that the disturbed nucleus is produced during the interaction of the spiral with the elliptical galaxy. A series of N-body simulations have been performed using the GRAPE system computer to study the dynamics of this pair of galaxies. The simulations use various values for the impact parameter and the velocity of collision to determine the best plausible model for the pair. In the simulations, NGC 2444, having double the mass of NGC 2445, undergoes penetrating collisions with the latter in a hyperbolic or parabolic orbit. Numerical results show that after the collision the orbit becomes bound and the best suitable model for the pair is that in which NGC 2445 has either just emerged from the first collision or is on the verge of a second collision which is expected to culminate in the merger of the two galaxies. Both these models are seen to represent satisfactorily the observed features of the interacting pair of galaxies VV 117. It may also be pointed out that the impact parameter is seen to be more important in producing tidal damage in the less massive system with regard to change in structure and mass loss.

(P.M.S. Namboodiri)

Astrophysical magnetic fields: Limits on dynamo generated fields by magnetic helicity : Magnetic fields correlated on kiloparsec scales are seen in spiral galaxies. The origin could be due to amplification of small scale seed fields by a turbulent dynamo. Helicity conservation imposes constraints on dynamo action. We are studying the minimal field strength of the large scale magnetic field that could arise despite the constraint. The calculation of helicity is technically complicated because of open boundaries and the usual form for the MHD invariant needs to be modified to take this into account. The general formalism developed here has several other applications including the solar dynamo.

(Arun Mangalam and K. Subramanian*)

Astrophysical magnetic fields: Non-Existence theorems for MHD flows : Previous work has demonstrated that magnetic field decay is unavoidable under conditions of axisymmetry and in spherical or planar incompressible flows. These known results are encompassed by a calculation for flows described in terms of a generalized poloidal-toroidal representation of the magnetic field with respect to an arbitrary two dimensional surface. In a work in progress, we show that when the velocity field is two dimensional, the dynamo growth, if any, that results, is linear in one of the projections of the field while the other projections remain constant. We also obtained criteria for the existence of and classification into two and three dimensional velocity results which are satisfied by a restricted set of geometries. In addition, the forms of spatial variation of the density and the resistivity that are allowed so that field decay still occurs for this set of geometries was also obtained.

(Arun Mangalam)

Rocket Dynamics and Space Flight : This book by C. Sivaram has reached its final stages after a year long effort. It has Ten main chapters. The topics dealt with include : (1) Dynamics of lunar space flights and lunar landing with special reference to the Apollo 10, 11 etc series of flights (2) Interplanetary flight dynamics (to Mars, Venus, Jupiter, Pluto) including trajectories of ion and plasma rockets. (3) Interstellar Flight Dynamics (4) Relativistic Rocket dynamics discussed in detail (5) Advanced propulsion systems : Photon rockets, antimatter propulsion etc. (6) Dynamics of re-entry of rockets in planets with and without atmospheres (7) Satellite dynamics (8) Laser beam propulsion and trajectory correction (9) ICBMS and ABM's including Laser-ABM systems. (10) Discussion of Lagrange points, L2, L5 etc.

Rakesh Sharma, India's first astronaut has already written a foreword. He has described it as a remarkable effort and has said he has relearnt some things taught during his spaceflight training.

(C. Sivaram)

Motion of panspermia and spores in multistar systems : Possibility of panspermia as precursors to life has been debated for several decades now. Their motion is subject to both gravitational and radiation pressure forces of the present star and is very sensitive to their size. For a system of binary or multiple stars, their motion is more complicated and oscillations of their motion between component stars is possible for a range of sizes. For an extremely luminous star there is a unique critical size for the spore to enter or leave the system. Motion of such spores through systems with high stellar density is also of interest. Interesting estimates have been made.

(C. Sivaram)

Gamma ray laser communication with technologically advanced ETI : Apart from radio and optical (laser) channels, there are several civilizations with high energy photon beams involving x and gamma rays. Recent advances in nuclear lasers suggest possible use of an isomer nucleus of Hf-178, which has a k-mixing state just 20 keV above the isomer, so that nuclei in a sample can be elevated to this state by irradiating them with usual x-rays. Technically advanced ETI's could easily use several kilograms of Hf-178, to create a hundred billion kilowatt gamma ray CW laser, which when focussed through a 10m mirror, could create a 30 km, narrowly centered high energy gamma ray spot size over several hundred parsecs. Future gamma ray telescopes in space could look for such intense monochromatic, narrow beam sources.

(C. Sivaram)

Habitability of exo-Jupiters : As such exo-Jupiters with their very high surface temperatures would be inhospitable to life. But as in the case of Titan or Europa, there could be satelites (moons) of these exo-Jupiters which could have habitable conditions for life. Study is made of possible habitable zones around these exo-Jupiters.

(C. Sivaram)

Smashnova model of gamma ray bursts : An alternate model has been suggested for gamma ray bursts especially for subluminous ones. A white dwarf spiralling very close to a neutron star can be tidally heated and carbon detonation can be triggered (if it is close to the limiting mass). This would cause a type Ia supernova producing iron group elements. The material falling onto the neutron star can make it collapse to a black hole, triggering another explosion where the binding energy of around 10^{53} ergs is released. This may explain some aspects of SN-GRB connection including presence of iron group elements. More details remain to be explored and can explain subluminous bursts.

(C. Sivaram)

6. Physics and mathematics

Polarization of line radiation in the presence of external electric quadrupole and uniform magnetic fields : A general formalism is developed to investigate the nature of polarized line spectra of an atom making a transition from an upper level with spin J_u to a lower level with spin J_l. We have considered not only the uniform magnetic fields parallel to the Z-axis of the Principal Axes Frame (PAF), of the electric quadrupole fields, but also the arbitrary orientation of the magnetic fields with respect to the PAF (Figure 22). In such a case, the upper and lower levels are split due to external fields, into $(2J_u + 1)$ levels and $(2J_l + 1)$ levels respectively, where the levels are not necessarily identifiable with the magnetic substates. They are actually superposition of the magnetic substates. To show the physical significance of the superposition of magnetic substates, we carried out numerical studies on the particular cases of transition $J_u = 1 \rightarrow J_l = 0$ and $J_u = 3/2 \rightarrow J_l = 1/2$. The specific signatures of the polarized line spectra are discussed as a function of the ratio of magnetic and electric field strengths B/A and the electric quadrupole field asymmetry parameter η. We assume the magnetic field strength B equal to four times Lorentz width. The Stokes line profiles arising from contributions of Zeeman term, cross term (due to electric quadrupole field) and the combination of Zeeman and electric quadrupole field effects on the lines are shown in Figures (23) and (24). Notice in panel(a) of both Figures (23) and (24) that the Stokes Q parameter arises only due to the presence of electric quadrupole field which is absent in the pure Zeeman case. A similar effect is seen on the Stokes V parameter in panel (c) of both Figures (23) and (24). In Fig.(24), the upper level with spin $J_u = 3/2$ is split into four energy states. However, the lower level $J_l = 1/2$ is split into two non-degenerate states due to external magnetic fields only. Thus, eight transition components can arise and the behaviour of emitted lines are more complex.

We have continued our work on the polarization of line radiation in the presence of external electric quadrapole and uniform magnetic fields.

(Yee Yee Oo*, K.N. Nagendra, G. Ramachandran, S. Ananthamurthy*, Swarnamala Sirsi*, Vijayashankar)

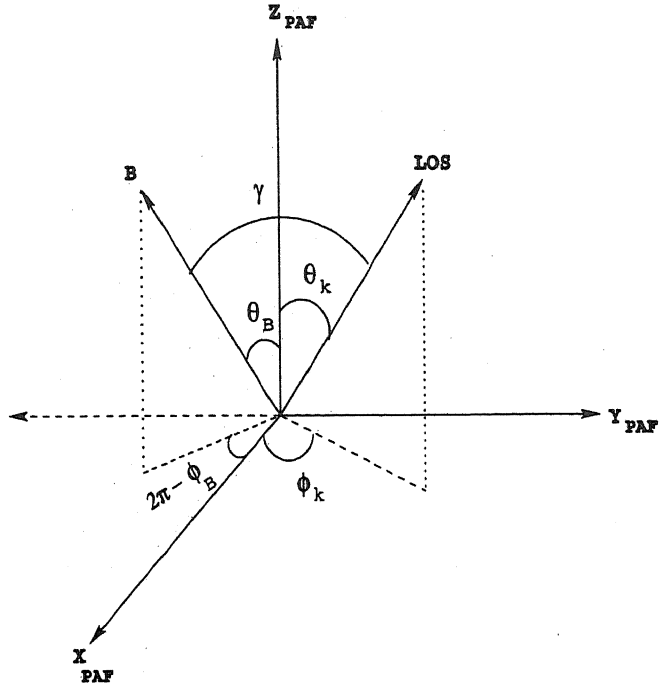


Figure 22. The magnetic field **B** and the direction **k** of emission of radiation identified as line of sight (LOS) with reference to the principal axes frame (PAF) coordinate system. γ is the angle between the direction of the magnetic field and the line of sight.

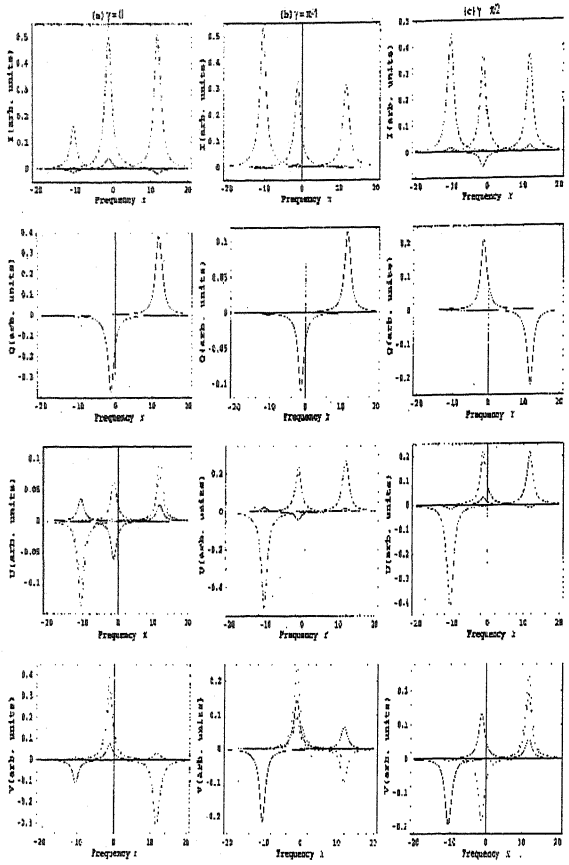


Figure 23. The effect of combined electric quadrupole field and a chosen direction of magnetic field $\theta_B = \pi/6$ and $\phi_B = \pi/4$. The azimuth of the LOS is defined by $\phi_k = \pi/4$ on Stokes line profiles for $\eta = 1$ and R= 1. Panels (a)–(c) represent the emission Stokes line profiles of transition $J_u = 1 \rightarrow J_l = 0$ for different values of the angle γ. The line is assumed to be formed in a medium with temperature $T = 6000\ K$ and natural line width $\Gamma = 2.18 \times 10^8\ s^{-1}$. The three different curves (dashed, solid and dotted) correspond respectively to the Zeeman term contributions, cross term contributions and the combined effect polarizations. The Stokes parameters I, Q, U and V are expressed in arbitrary units. The quantity $x = (\omega - \omega_0)/\Gamma$ is the frequency displacement from the line center in natural width units.

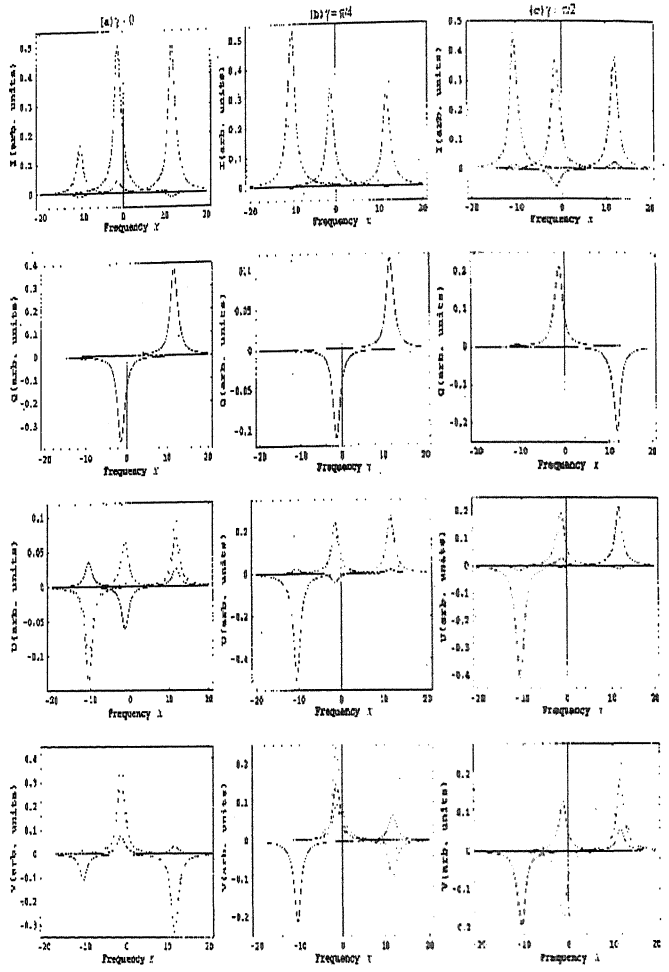


Figure 24. Same as Fig. (23) but for transition $J_u = 3/2 \rightarrow J_l = 1/2$.

Non-Accelertaor Particle Physics : We have made significant progress in our theoretical study of parity nonconservation(PNC) in Ba+.Our result in combination with that of the experiment when completed will certainly have important implications for the Standard Model of particle physics.We have

also improved the accuracy of Cs PNC calculation.Our work on the inclusion of the Breit interaction leading order relativistic correction to the electron-electron Coulomb interaction in atomic PNC is in progress.

We are very close to completing a computer code to calculate the electric dipole moments of closed-shell atoms due to parity and time-reversal violations.It is based on relativistic coupled- cluster theory and has some novel features.We intend to first perform calculations to determine the parity and time-reversal violating coupling constants for mercury.An experiment to observe the electric dipole moment of this atom is currently under way at the University of Washington,Seattle.

(B.K. Sahoo, K.V.P. Latha, C. Sur, R.K. Chaudhuri, Angom Dilip Singh and D. Mukherjee*)

Atomic astrophysics : Forbidden transitions play an important role in astrophysics.The calculation of the rates of these transitions is particularly challenging as they depend on a very high power of the wavelength which in turn depends on the transition energy.

Using the relativistic coupled-cluster theory,we have calculated the 6p(3/2) to 6p(1/2) transition probability for Pb+,and from this quantity we have deduced the lifetime of the 6p(3/2) state.A knowledge of this lifetime is useful in detecting Pb+ in the planetary nebula NGC 7027.

(B.K. Sahoo, C. Sur, R.K. Chaudhuri, B.P. Das, D. Mukherjee* and H. Merlitz*)

Theoretical atomic physics : The relativistic coupled-cluster theory has been applied to gain insights into hyperfine interactions and transition probabilities in heavy atomic systems like singly ionized barium and lead. We have recently extended the unitary coupled-cluster theory to the relativistic regime and have for the first time applied this theory to calculate atomic properties.

(B.K. Sahoo, C. Sur, R.K. Chaudhuri, B.P. Das, D. Mukherjee* and H. Merlitz*)

Modulation properties of spatial light modulator : Holographic data storage (HDS) is a technique of 3-dimensional information storage in photosensitive materials like $LiNbO_3$, $BaTiO_3$ etc. Prior to recording, a data page is usually composed by a pixelated liquid crystal (LC) device called spatial light modulator(SLM). For electrically addressed SLM, the light transmittance of individual LC cell can be controlled separately by a voltage signal applied to the pixel element. The image is transferred onto the light beam that illuminates the SLM. We have studied the intensity and phase modulation properties of a commercially available LC—SLM at various parameters to locate an optimum range of operation that is required to suit its usage in HDS system. Therefore, if the SLM is "biased" to a optimum operating point (governed by relative orientation of polarizer and analyzer and appropriate brightness and contrast control signals) that lies within the maximum linearity of the response curve, then over a certain gray level range the SLM will provide a square law mapping of incremental change in incident light amplitude into incremental change of amplitude transmittance. Experimentally obtained various intensity modulation curves are best described either by power law or sigmoidal functions.

The propagation of light through a twisted nematic liquid crystal cell that is sandwiched between a pair of polarizer and analyzer is described by Jones calculus. Based on this approach we have derived the relation for intensity transmission for parallel ($T_{\parallel}$) and crossed ($T_{\perp}$) configurations of polarizer and analyzer as

$$T_{\parallel} = \left[\cos X \cos\alpha + \frac{\alpha}{X}\sin\alpha \sin X\right]^2 + \left(\frac{\beta}{2X}\right)^2 \sin^2 X \cos^2(\alpha - 2\theta_1 + 2\varphi)$$

and

$$T_{\perp} = \left[\cos X \cos\alpha - \frac{\alpha}{X}\cos\alpha \sin X\right]^2 + \left(\frac{\beta}{2X}\right)^2 \sin^2 X \sin^2(\alpha - 2\theta_1 + 2\varphi)$$

Similarly, the relation for relative phase change is

$$\Gamma = \beta - \sin^{-1}\left(\frac{E_y}{E_x}\right)$$

The equations (1– 3) can be used to determine the physical parameters like twist angle α, the orientation of molecular director Ψ at the input face and maximum phase retardation β_{max}. Our SLM is an electrically addressed LC2002 model from HoloEye Photonics. The device consists of a twisted nematic LC panel (Sony LCX016AL–6; active area: 26.6 x 20.0 mm^2; number of pixels: 832 x 624; pixel pitch: 32 μm) and driver electronics that can be plugged

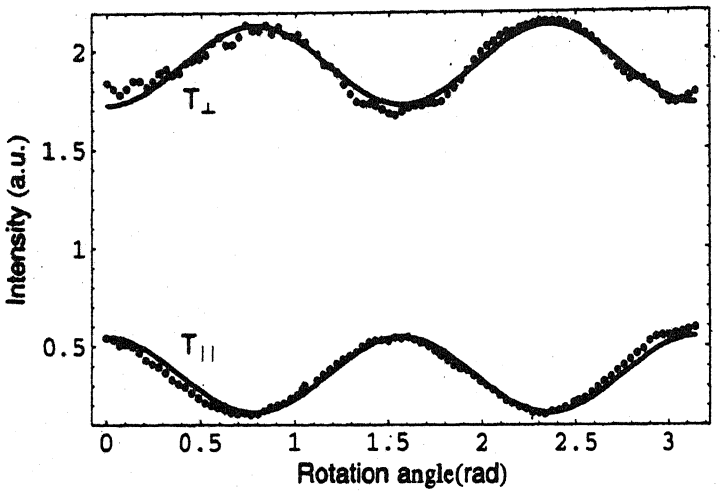


Figure 25. Transmitted intensity in crossed ($T_\perp$) and parallel ($T_\parallel$) orientations of polarizer and analyzer. The dots represent the experimental data and the solid curves are the best fit of the model.

directly to output of the graphics card of a PC. An expanded and collimated He–Ne laser beam at 632.8 nm is used to back illuminate the SLM in *off–state*. For a fixed polarizer orientation θ_1, the analyzer was rotated through 0 to 360° and the transmitted light intensity was monitored using computer controlled optical power meter . Same procedure was repeated for every orientation of the polarizer in step of 1° from 0 to 360°. According to the theory of TNLC given in section 1, a null in transmitted intensity occurs when the polarizer is oriented along the director axes of the molecules at the input face, that is, $\theta_1 = \Psi$ and $\theta_2 = \theta_1 + \alpha + 90°$. The measured values of twist angle α and director orientation Ψ were found to be 90° ± 1° and 45° ± 1°, respectively.

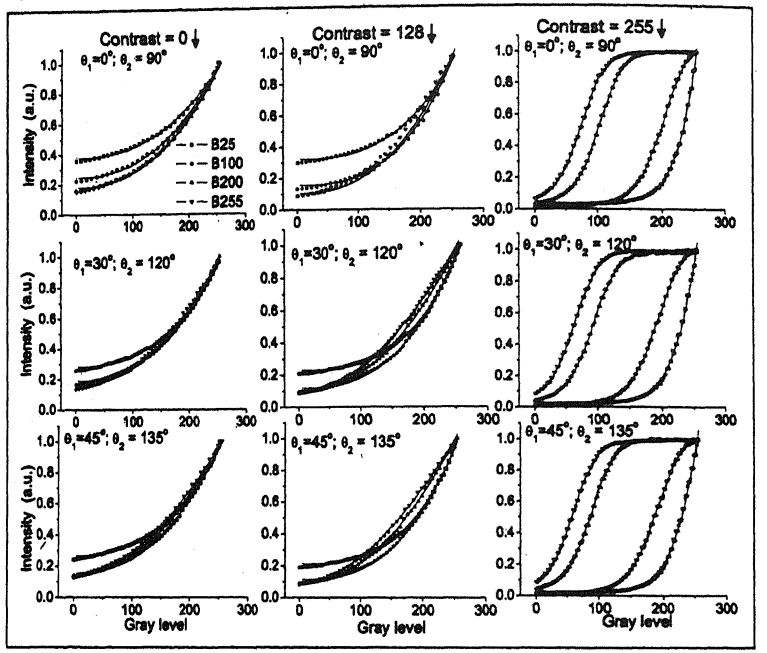


Figure 26. Normalized intensity modulation curves in crossed configuration of polarizer and analyzer. The curves identified with symbols – ■ –, – ● –, – ▲ –, and – ▼ – correspond to brightness (B) control value set to 25, 100, 200 and 255, respectively.

In order to determine maximum phase retardation β_{max}, the polarizer and the analyzer were rotated simultaneously while aligned in parallel or in crossed configuration. Therefore, the transmitted intensity as a function of rotation angle can be predicted by equation (1) and (2). A comparison between the model and the experimental data that was taken every 5° rotation interval, is shown in Figure 25.

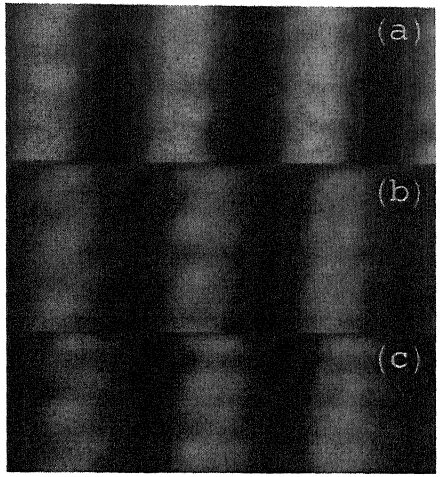


Figure 27. Fringe pattern recorded at : (a) 0 (b) 100 and (c) 250 gray levels, respectively.

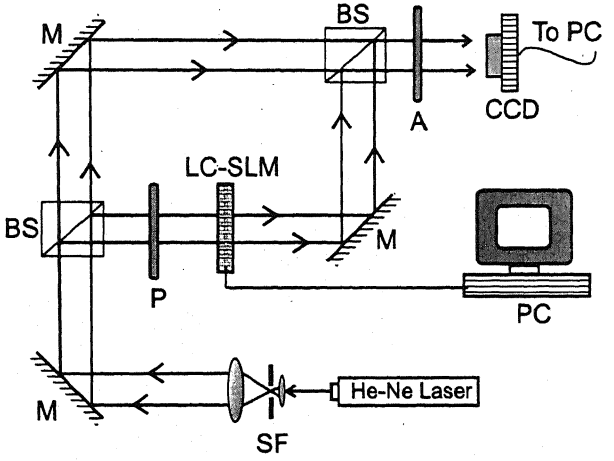


Figure 28. The Mach–Zehnder interferometric setup used in phase retardation measurement of LC–SLM. SF: Spatial Filter; M: mirrors; BS: beam splitters; P: polarizer; A: analyzer; CCD: charge coupled detector.

The intensity modulation is studied by addressing several 8–bit plane gray scale images onto the SLM. The measurements were made at several brightness and contrast settings. Some of the representative curves for crossed configurations of polarizer and analyzer are shown in Figure 26. The measured data is represented by different symbols, whereas thin lines are the nonlinear curve fitting using power law or sigmoidal function.

The phase retardation properties of the LC–SLM were studied using digital interferometry based fringe shift method (see Figure 28).

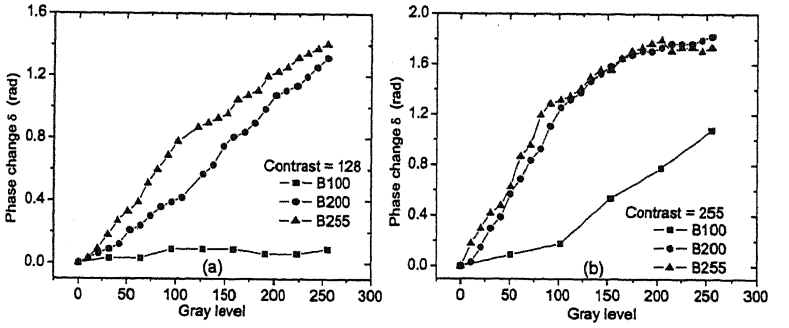


Figure 29. Plot of phase retardation δ versus gray level for LC2002 model.

As in the case of intensity modulation, several 8–bit gray scale images were addressed onto the LC–SLM and the corresponding fringe pattern was captured by a CCD camera (Pulnix TM-1320-15CL; number of pixels: 1300 x 1030; pixel size: 6.7 x 6.7 μm). The procedure was repeated at different brightness and control settings. The high frequency fringing effect due to coherent illumination of CCD is removed by low pass fourier filtering of the image data. Fringe shift can be seen clearly in Figure 27 that shows the three sets of interference pattern recorded on the CCD at different gray levels.

The phase retardation δ between two arms of Mach-Zehnder interferometer can be calculated using relation where Δ is the fringe shift obtained by comparting the line profiles of the interferograms and Λ is fringe period.

The plot of phase retardation versus input gray level is shown in Figure 29. This value is considerably smaller than the β_{max} obtained in *off state*. This inadequacy is partly due to the complex electronics involved in driving the LC–SLM and also the fact that the tilt angle θ is not linear (due to the boundary effects) throughout the cell thickness. The relatively low values of δ also suggest that the device is better suited for applications that required intensity modulations, although, the accompanying phase changes, however small, cannot be decoupled.

(Ravindra Kumar Banyal and B. Raghavendra Prasad)

Enhancement of perturbative convergence through quadratic Pade approximants : It is well known that the perturbative convergence strongly depends on the choice of zeroth (unperturbed) order energy. In certain cases even a judicious choice of zeroth energy may fail to provide sufficiently accurate low order results. Studies have shown that the low order perturbative results can be improved through conventional Pade approximation. Our present study indicates that the low order perturbative convergence can be significantly enhanced through the quadratic Pade approximants. The method has been applied to several molecular systems to assess the relative performance conventional and quadratic Pade approximation.

(Trilisa Perrin*, Karl F. Freed* and Rajat K. Chaudhuri)

Ground and excited state potential energy surfaces of CaOH: evidence for a high lying covalent state : Effective valence shell Hamiltonian calculations are used to map out three-dimensional potential energy surfaces for the electronic states of CaOH radial. Particular attention is paid to clarify nature of non-linear ad quasi-linear states, Renner - Teller couplings and state mixing. The $\tilde{F}\ (^2{}_\pi)$ and $\tilde{G}\ (^2{}_\pi)$ states are both found to possess non-linear local minima due to an avoided crossing.

(Caroline Taylor*, Rajat K. Chaudhuri and Karl F. Freed*)

Relativistic coupled cluster calculation of core ionization potential using normal and seminormal ordered exponential ansatz : In spectroscopic studies ionization potentials (IP), electron affinity (EA) and double IP (DIP) are important in many aspects. For example, in all kind of electron spectroscopy, including photo-electron and Auger the IP, DIPs always play key roles. Specially, the knowledge of core IP provides insights to the choice and tunability of the ionizing beam in all kinds of electron scattering experiments like e-2e, e-3e, γ-2e, Auger decay etc. These experiments are not only important to understand the physics but also to the development of fields like quantum computing through the idea of entanglement involved in these processes. Hence accurate theoretical determination of IP for the core as well as valence electrons may provide some impetus to the physics underlying those experiments. Here, we employ seminormal ordered cluster expansion to incorporate the electron correlation and orbital relaxation effects in the calculation of core ionization potential for inert gas elements.

(Chiranjeeb Sur and Rajat K. Chaudhuri)

Spin observables in $n-p$ fusion at astrophysically relevant energies : A model independent irreducible tensor formalism was developed to discuss the spin observables in *np* fusion. It was shown that the photon polarization arising out of the interference of the dominant isovector $M1$ amplitudes at thermal neutron energies with the small isoscalar $M1$ and $E2$ amplitudes can be studied with advantage in suitably designed polarized beam and polarized target experiments, where the neutron and proton polarizations are either opposite to each other or orthogonal to each other. If A_0^0, A_0^2 denote the scalar and tensor analyzing powers in $\vec{n} + \vec{p} \rightarrow d + \gamma$, it was shown that the contributions $d\sigma_{sm} / d\Omega$ to the differential cross-section from the initial spin singlet and triplet states $|s, m\rangle$, $s = 0,1$ could be determined empirically using

$$\frac{d\sigma_{0,0}}{d\Omega} = \frac{1}{4}\frac{d\sigma_0}{d\Omega}[1+\sqrt{3}A_0^0] \quad (1)$$

$$\frac{d\sigma_{1,0}}{d\Omega} = \frac{1}{4}\frac{d\sigma_0}{d\Omega}[1-\frac{1}{\sqrt{3}}A_0^0-2\sqrt{\frac{2}{3}}A_0^2 \quad (2)$$

$$\frac{d\sigma_{1,1}}{d\Omega} = \frac{d\sigma_{1,-1}}{d\Omega} = \frac{1}{4}\frac{d\sigma_0}{d\Omega}[1-\frac{1}{\sqrt{3}}A_0^0+\sqrt{\frac{2}{3}}A_0^2], \quad (3)$$

where $d\sigma_0/d\Omega = \Sigma_{sm} d\sigma_{sm}/d\Omega$ denotes the un-polarized differential cross-section for $n + p \rightarrow d + \gamma$. The above theoretical results are expected to prove useful. to analyze the experimental data on the fusion reaction at astrophysical energies, which may be forthcoming following the recent experimental studies reported by T.S. Suzuki et al., Astrophys. J. 439 (1995) L59, Y. Nagai et al., Phys. Rev., C56 (1997) 3173 and T. M. Muller et al., Nucl. Instr. Meth. A440 (2000) 736.

(G. Ramachandran and P.N. Deepak*)

Spin observables in Pion production in Nucleon-Nucleon collisions : The first measurements (H.O. Meyer et al., Phys. Rev. , C65 (2001) 027601) of two analyzing powers and five spin correlation coefficients in $\vec{p}\,\vec{p} \rightarrow p\,p\,\pi^0$ were analyzed by P.N.Deepak and G.Ramachandran (Phys. Rev. **C65** (2002) 0276601) to yield empirically the estimates of the initial channel spin contributions, following the model independent theoretical approach developed earlier. (G.Ramachandran, P.N.Deepak and M.S.Vidya Phys. Rev. C62, (2000) 011001(R), G.Ramachandran and P.N.Deepak, Journal of Phys. G: Nucl. Part. Phys. 26 (2000) 1809, Phys. Rev., C63 (2001) 051001 (R). If we ignore the participation of d-waves in the final state at near threshold energies, a set of twelve partial wave amplitudes contribute to the reaction. The threshold amplitude leading to the final Ss state does not mix with the other amplitudes as far as the theoretical expressions for the measured observables are concerned. Hence it is not possible to determine the relative phase between the threshold *Ss* amplitude and the rest of the amplitudes. Apart from this, the existing experimental data lead to 156 bi-linear equations involving the twelve amplitudes in the energy region of the measurements. Approximate solutions for these amplitudes were obtained by least square minimization employing (a) an energy independent approach and (b) an energy dependent approach.

(P.N. Deepak, G. Ramachandran, C. Hanhart* and M.S. Vidya*)

Heavy meson production in NN collisions : A major achievement during the closing decade of the 20th century is the appearance of the modern potential models like Argonne V18, Nijm I and Nijm II, and CD Bonn potentials which describe the world wide elastic NN scattering data with an unprecedented accuary of χ^2 / datum = 1, although the models underlying these descriptions are not all identical. There is still an uncertainty about exact strength of NN tensor interaction, which makes dominant contributions of the order of 70% and 50% respectively to the binding energies of 2H and 3H, apart from outstanding problems like $A_y(\theta)$ puzzle in $\vec{N}d$ scattering and $\iota T_{11}(\theta)$ in $\vec{d} - p$ scattering. An incisive probe of the NN interaction at short distances where quark bags overlap is facilitated through studies, where large momentum transfers are involved, but an increase in energy leads to meson production.In this context, it may also be noted that the interaction is highly spin dependant when a meson is produced. Following several experimental studies on $NN \rightarrow NN\pi$, experimental measurements on production of heavy mesons like ω in pp collisions have been reported recently (F.Hibon et al., Phys. Rev. Lett. 83, 492 (1999), S.Abd El-Samad et al., (COSY-TOF Coll), Phys. Lett.B522, 16 (2001)). It is interesting to note further that ω has spin s = 1 in contrast to the spinless pion. Model independent theoretical work has been initiated to study the vector meson production in NN collisions. The spin structure for the reaction has been identified and partial wave expansions for the irreducible tensor amplitudes have also been obtained. Further work is progressing.

(G.Ramachandran, M.S. Vidya*, P.N.Deeapk*, J.Balasubramanyam* and Venkataraya*)

Multi-variate quasi probability distributions for polarized spin systems : Wigner introduced the notion of quasi probability distributions treating the canonically conjugate variables of position q and momentum p as variates. The simplest assumption to make for describing a statistical assembly of spin-j particles is to assign probabilities p_m to states $|j,m\rangle$, treating the spin operator J_z as a variate, which is, however, valid only for "oriented" spin-systems. A polarized spin $j \geq 1$ system, which does not lend itself to such a description has been referred to as "non-'oriented" by Ramachandran and Murthy (Nucl. Phys., A323 (1979) 403), who have shown that the polarization domain for the new parameters introduced by them using the generators of the group SU (2j+1) is in the elegant form a polyhedron with (2j+1) vertices. Considering J_x, J_y, J_z as variates, we have defined the characteristic function, the moment generating function and the variance-covariance matrix for an arbitrary spin-j system and have shown that Fano statistical tensors characterizing a non-oriented system could be interpreted in terms of moments associated with a multivariate distribution. Earlier, Margenau and Hill had introduced joint probability distributions f_{MH} with respect to any two components for a spin $j = 1$ system and Chandler, Cohen, Lee, Scully and Wodkiewicz studied Wigner-Weyl distributions f_{WW} for $j = 1/2$ taking the spin vector with 3 components. We have introduced a new quasi probability distribution f_{sph} on the surface of a sphere, with a radius $\sqrt{j(j+1)}$ for any arbitrary spin j, which is intuitively more appealing. It is particularly interesting that the Wigner-Weyl distribution f_{WW}, in the classical limit of large j, approaches the f_{sph} introduced by us.

(G. Ramachandran, A. R Usha Devi*, Devi Putcha* and Swarnamala Sirsi*)

Photo and electroproduction of mesons with spins s = 0,1,2 : With the advent of the new generation of electron accelerators like CEBEF at Thomas Jefferson National Accelerator Facility, ELSA at Bonn, ESRF in Grenoble, MAMI at Mainz, Spring8 at Osaka, renewed interest has been generated in incisive studies of photo and electroproduction of pseudo scalar and vector mesons. Since η, ω and ϕ are isoscalars in contrast to π and ρ which are isovectors, the former involve only N^* resonances, whereas the latter involve Δ resonances as well. Empirical determination of these reaction amplitudes involves measurement of several spin observables, apart from the differential cross-section. Photo pion production has been studied most extensively so far, as it involves only four independent amplitudes. The analysis becomes more complicated when vector or tensor mesons are produced. We have initiated a unified theoretical approach applicable generally to photo and electroproduction of mesons with arbitrary spin-parity s^{π}, and isospin I_s using irreducible tensor techniques. Expressing the differential cross section for the reaction in the form

$$\frac{d\sigma}{d\Omega} = \frac{q}{k} \; |\langle f|\mathcal{F}(p)|i\rangle|^2 \tag{1}$$

where (k, 0, 0) and (q, θ, 0) denote the photon and meson momenta in the c.m. frame and p denotes the polarization state of the photon, the hadron spin dependence of $\mathcal{F}(p)$ is brought out in the elegant irreducible tensorial form

$$\mathcal{F}(p) = \sum_{\lambda'=0}^{1} \sum_{\lambda=|\lambda'-s|}^{(\lambda'+s)} ((S^{\lambda'}(\tfrac{1}{2}, \tfrac{1}{2}) \otimes S^{s}(s, 0))^{\lambda} . \mathcal{F}^{\lambda}(\lambda, p)) \tag{2}$$

in terms of the amplitudes $\mathcal{F}^{\lambda}_{\mu}(\lambda', p)$ of rank λ with $\mu = \lambda, \ldots, \lambda-$. The multipole partial wave expansions for these amplitudes have been obtained as

$$\mathcal{F}^{\lambda}_{\mu}(\lambda', p) = \sum_{I=|I_s-1/2|}^{(I_s+1/2)} \sum_{J=|I-s_f|}^{(I+s_f)} \sum_{s_f=|s-1/2|}^{(s+1/2)} \sum_{l=0}^{\infty} \sum_{L=1}^{\infty} C(\tfrac{1}{2} I_s I; \nu_N \nu_s \nu)[\lambda'] \tag{3}$$

$$\times W(\tfrac{1}{2}\tfrac{1}{2} s\lambda; \lambda' s_f) \, W(\tfrac{1}{2} L s_f I; J\lambda) \, \mathcal{F}^{I,J}_{ls_f L}(E) \, \mathcal{A}^{\lambda}_{\mu}(p, \theta),$$

where the partial wave multipole strengths $\mathcal{F}^{I,J}_{ls_f L}(E)$ are dependent only on c.m. energy E, while the dependence on the photon polarization p and meson production angle θ in c.m. frame is entirely taken care of by

$$\mathcal{A}^{\lambda}_{\mu}(p, \theta) = (ip)^{l}(-1)^{p} C(lL\lambda; m_l p\mu) Y_l m_l(\theta, 0), \quad (4)$$

which satisfy an important symmetry property

$$\mathcal{A}^{\lambda}_{-\mu}(-p, \theta) = \pi (-1)^{\lambda-\mu} \mathcal{A}^{\lambda}_{\mu}(p, \theta). \quad (5)$$

For photo production, only the two circular polarization states $p = \pm 1$ contribute, whereas in the case of electro production the longitudinal state $p = 0$ contributes in addition. Our approach identifies in an elegant manner all the photo and electro production amplitudes along with their electric and magnetic multipole partial wave expansions as well. Further studies are in progress.

(G. Ramachandran, M.S. Vidya*, J. Balasubramanyam*)

7. Indian Astronomical Observatory

Himalayan Chandra Telescope :

The 2-m Himalayan Chandra Telescope was made available to the astronomical community during the current year. The opportunity was already announced through IIA web-pages in February 2003 and the Time Allocation Committee was formed. The allotments began in May 2003 in 4-month cycles. Two cycles were thus completed and the third one ongoing as of March 31, 2004.

The dark and grey moon periods are oversubscribed by a factor of 2. The bright moon nights with lower demand are used partially for preventive maintenance of the telescope, site characterization, training, and observatory programmes. During Cycle 1 (May-August 2003) telescope time was allotted to 17 proposals involving astronomers from 14 institutes in 8 countries, during Cycle 2 (September-December 2003), to 21 proposals involving astronomers from 13 institutes in 5 countries, and during Cycle 3, to 30 proposals involving astronomers from 13 institutes in 5 countries. Further maintenance support was negotiated with the manufacturers at no additional cost with the understanding that a financial agreement will be reached soon for future years. Following this, two engineers from EOST visited Hanle for 2 weeks of preventive maintenance and e-mail support continued.

The vacuum coating plant building was completed and the plant was installed and commissioned in October 2003. Some minor works that remain will be undertaken during the next year before routine coating can be planned.

50-cm Telescope of Antipodal Transient Observatory :

The 50-cm telescope of Antipodal Transient Observatory arrived at the site in August 2003 and has been installed in its dome. The dome automation work is also complete, as also the installation of the CCD detector. The integration of the telescope, dome and CCD controls will be undertaken during the next year so that the telescope can work in the scheduler mode.

(T.P. Prabhu)

Distinguished Visitors to IAO, Hanle :

His Holiness the 14th Dalai Lama visited IAO, Hanle, on 28-29 June, 2003, and viewed celestial objects through the 2-m HCT. Prof. S. Kawakami, Osaka City University and Prof. Y. Hayashi, Kyoto University, Japan, visited IAO, Hanle in June 2003 to explore the possibility of establishing a cosmic ray observatory. Prof. K. Ogura, Kokugakuin Observatory, Japan, visited IAO, Hanle in September 2003.

Gamma-Ray Astronomy :

Major Atmospheric Cerenkov Experiment (MACE) :

Scientists of BARC, Mumbai, visited IAO, Hanle in June 2003 to explore the possibility of proposing the MACE at Hanle. The proposal has been completed thereafter and submitted for consideration of the government. Details of collaboration between BARC and IIA will be finalized the next year.

Hagar experiment : The gamma ray energy region in between that of the satellite experiments (~ 10 GeV) and of the traditional Atmospheric Cerenkov experiments (~250 GeV) has not yet been explored. While the total number of astrophysical sources(like AGNs, pulsars etc) at ~10GeV is about 100, the number at ~250 GeV is less than 10. Thus, this is the energy region where photon generating processes seem to cease and thus interesting

information is expected about these sources. There are essentially two methods for atmospheric Cerenkov experiments to reach lower energy thresholds. The first is to use very large size telescopes to collect the meager number of Cerenkov photons at these energies. The second method is to conduct experiments at very high altitudes where the number of Cerenkov photons is high enough to still allow the use of smaller telescopes. IIA, in collaboration with TIFR, has taken the second approach and has started work on a gamma ray experiment (HAGAR) to be conducted at Hanle which will address this exciting energy range.

The Monte Carlo simulations involve the generation of Cerenkov photons at the needed altitude for gamma ray and cosmic ray primaries for various energies and for the geometry of the particular experiment. The transmission and fluctuation of photons and conversion to photoelectrons using proper reflectivity and quantum conversion parameters is a necessary intermediate step. Thus after the telescope response is obtained for all gamma ray and cosmic ray events, different conditions were imposed to generate a triggered event. Later the energy etc distribution of triggered events is studied to find the peak threshold energy and other parameters. These calculations for the proposed setup show that a threshold energy of ~ 50 GeV is achievable with Atmospheric Cerenkov technique at the altitude of Hanle. While a slope of 1.5 was used for the slope of the gamma ray spectrum, a lower (higher) energy threshold was obtained for a steeper (flatter) spectrum source. It was also seen that the threshold also varies with the type of trigger and the amount of chance coincidence accepted. If there are other means to identify gamma ray events, a higher chance coincidence can be tolerated which will yield lower energy thresholds. These simulations are undergoing further refinements.

An atmospheric Cerenkov experiment with 7 telescopes, each with 7 mirrors and a total area of 4.4 sq.mtrs has been proposed for HAGAR. The telescopes will be deployed on the periphery of a circle of radius 50 meters with one telescope at the center. Each telescope will have an alt-azimuth mounting. Each of the 7 mirrors in each telescope will be looked at by a UV sensitive PMT. Two prototype telescopes are being fabricated in a workshop near Hosakote. The fabrication is nearly complete and is expected to be installed in early next year on a pier which is getting ready at CREST.

(IIA-TIFR team)

8. Instrumentation and facilities

Instrumentation activities

The intrumentation group has been involved in setting up the following facilities and developmental initiatives at the various field stations :

VBO, Kavalur

A new satellite link which provides internet access has been setup with the help of M/s. ITI, Bangalore. This is a 64K dedicated link and can be used for e-mail and internet file and image transfers.

A Local Area Network (LAN) based on optical fibre backbone has been setup to connect the 2.34 m, 102 cm and 75 cm optical telescopes. This can accomodate nearly 50 nodes at various telescope buildings. In order to augment the electrical facilities at Kavalur a new 125 KVA generator is also setup. Since Kavalur did not have a weather station a new weather station for measurement of parameters like temperature, pressure relative humidity, wind speed, and wind direction is also being setup. It is proposed to have dehumidifying equipment at various telescopes to maintain optical components at fixed humidity levels and temperature. Presently a prototype unit is working and another one should be available shortly. In order to provide facility for small conferences and meetings a projection system is also proposed.

Developmental activities : A multi channel polarimeter backend is currently under development. The mechanical design and the fabrication of the instrument body have been completed. The sub-assemblies are being integrated. The required printed circuit boards for measurement and control electronics have been completed.

A temperature montoring system for networked temperature measurement and control for measuring temperature gradients in the telescope buildings is also under development.

Kodaikanal Observatory

The Kodaikanal Observatory has also been provided with a 64K satellite link for internet access. This will help with e-mail, internet and file access. Efforts are also on to put up a new power house with HT/LT provision and centralized diesel operating station. This will greatly improve the reliability and flexibility of operations in the campus. A new 125 KVA diesel generator is being setup.

Gauribidanur

Tracking system for the radioheliograph : In its present configuration, the radioheliograph (GRH) is operated mainly as a meridian transit instrument. In order to exploit the full potential of the GRH, efforts are on to develop an electronic tracking system. A prototype has been tested and a full-fledged system is in the offing. An antenna system for the study of polarized radio emission is under development. A new correlator system is being developed for the Brazilian Decimetric Array.

Hanle

The software based on a client/server technology is under development for the 2k*4k optical imager. This will enable users to operate in Linux environment over a WAN link. For the new gamma ray telescope facility planned at Hanle civil, mechanical works and controls are in

various stages of development. Fabrication of two prototypes is currently on. The prototypes will be tested at Hosakote in the coming months. Once the performance is found to be satisfactory, remaining telescopes will be taken up for fabrication.

A coarse guider for better solar observation : The image drift due to mechanical misalignment upto 1 arc – sec (200 microns) are corrected using a quadrant detector (Q.D. 7 from Centronics, UK) based coarse – guider. The imaging diameter is 3 mm.

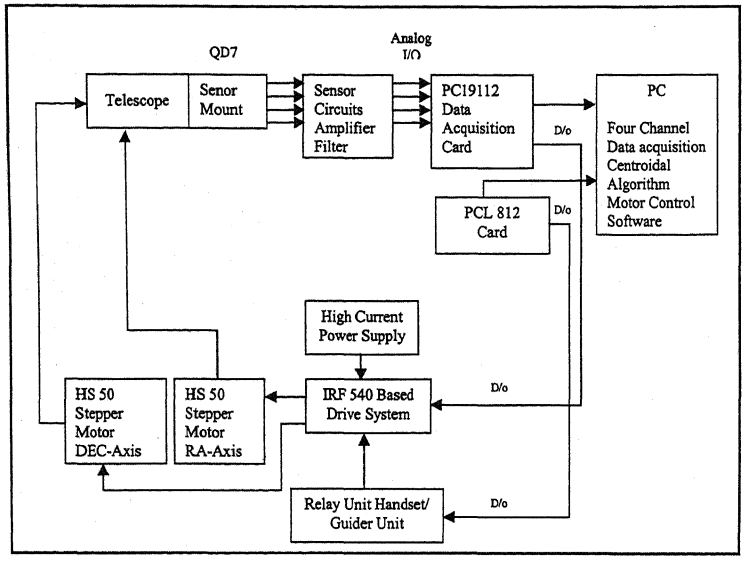


Fig.2 Coarse Guider

Figure 30. Coarse guider.

The sunspot is made to coincide with the center of the quadrant detector. The sunspot becomes a reference and any drift of the image from reference centre point would activate the feedback loop bringing back the image to its reference position. The complete block diagram is shown in Figure 30. The RA and DEC stepper motors (HS 50 stepper motor) are rotated to compensate the X and Y drift in the image. The control code is developed in VC ++. The unit is ready for installation and testing.

(K.C. Thulasidharen, A.V. Ananth and Jagdev Singh)

Queens gate ET50 Fabry - Perot etalon testing : A laboratory test setup for testing Queensgate Fabry - Perot etalon ET 50 procured for Vector magetograph development is made. The etalon CS100 controller is interfaced to IEEE488 PCI card (CEC make). The source code for etalon plate movement and parallelism is developed. The setup in shown in Figure 31.

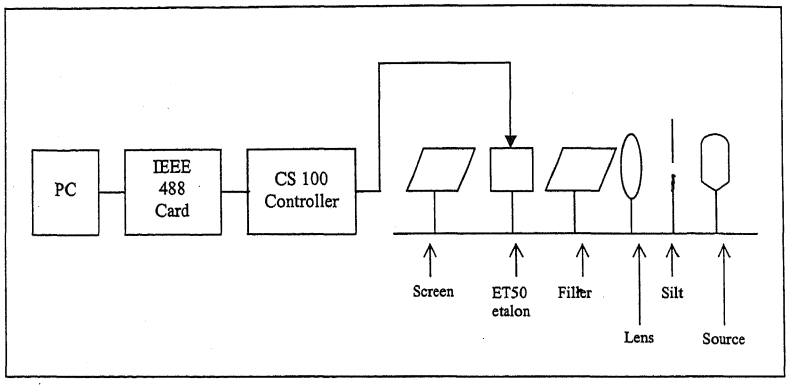


Fig. Etalon Lab Test Setup

Figure 31. Etalon lab test setup.

(K.C. Thulasidharen, A.V. Ananth, Jagdev Singh and K.B. Ramesh)

60 mm Solar Tower Tunnel Telescope modernised control drive – R.A. / DEC : The single phase A.C. Inductor Motor, 1/8th H.P and 1400 R./P.M. is controlled by the GE make Contractors for the Clockwise and Counterclockwise Coarse operations, with the limit control to cutoff the movement when the Coelostat reaches the limits in R.A. and Dec (East / West and North / South) directions, incorporating the Interlock for selecting either A.C. motor - Coarse movement or the Stepper motor - Guide movement. The

Electro-Magnetic Clutch (EMC) operated on 24v D.C. supply is engaged and disengaged through the Solid State Relays (SSR's) for the selection of Coarse motor operation or the Slo-Syn: SS2000D6 Stepper Motor drive (S.S. - S/M) operation of R.A. and Dec. The modular attachment fabricated at our workshop houses the Stepper motor, Electro-magnetic Clutch and the A.C. motor connecting one end to the Gear box where the output is driving the mirror. This can be manually operated with the handset from the

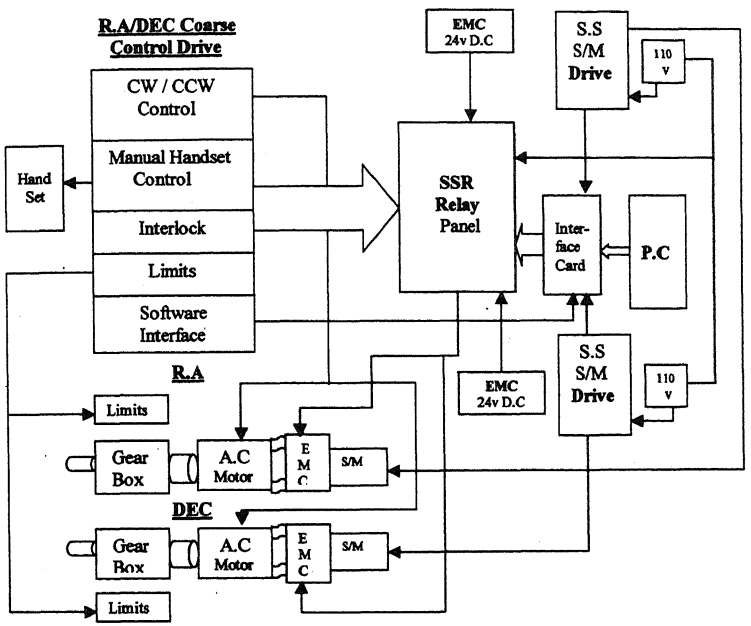


Figure 32. R.A/DEC Coarse Control Drive.

spectrograph and also from the Coelostat Tower. The Coarse movement can also be controlled through the Software from the handset prefixing the 'on' time and 'off' time. The Control code is implemented in C.

(K.C. Thulasidharen, A.V. Ananth, Jagdev Singh and K.B. Ramesh)

Computer centre activities

CCD image acquisition under Linux : This project is an image acquisition software developed under Linux using C++ with GTK. This software uses Client/Server model, where server can be present in the same computer as the client or on a remote system. The Server houses the CCD controller interface, while the client provides the Graphical User Interface for display and commands. The data from the controller come to the Host Interface Card(HIC), which has a FIFO(2,8-bit registers) where MSB is stored in one register and LSB is stored in another. From this register data is then stored in a RAM. Once the 2k x 4k data is transferred, it is stored in file in FITS format. The Host Interface Card contains PIT(Programmable Interval Timer) that is used to set the baud rate and synchronize the clock for serial communication with the DSP board. This project has a provision to get Bias, Dark, Expose, and Exposex. It is equipped with Equalization, Line plot and Histogram plot and Full Width Half Maximum(FWHM) features. The acquisition rate is 4 minutes 23 seconds which is faster when compared to the present Windows based system which is around 6 minutes.

(V. Arumugam and A.V. Ananth)

PMAC encoder reading : PMAC is Programmable Multi-Axis Controller. Setting the PMAC I – Variable, P-Variable, Q-Variable and M-Variable, enables the PMAC ready for encoder reading. The encoders are 17 bit encoders with Quadrature output and PMAC is capable of providing additional 4 bit resolution. The encoder and motors are meant for 75 mm telescope. Preliminary motion program have been developed for proper encoder reading and motor controls. A high level interface has been developed using VC++ with MFC and PMAC DLLs for 73 cm telescope control.

(V.Arumugam and A.V. Ananth)

Status of 2m control software : The autoguider in on axis mode was made functional in April 2002. The first off-axis version of the Autoguider software was made available around July 2002. However because of the hardware problems relating to the motion controllers required for the Autoguider, the software could not be tested and operationalized. In order to test out the Autoguider software, Tim Williscroft a senior software engineer from EOS was deputed for a period of ten days to Hosakote. During this period Autoguider software was tested with the 2m telescope . The guider was tested on a 11th magnitude star. The performance was as under: on axis mode : guiding better than .19 arcsecs over unlimited period of time. off-axis mode: better than 15 arcsec over 65 minutes. The camera used for autoguiding was an Electrim 2000s uncooled CCD camera. The limiting magnitude is around 12th. In addition to testing out the Autoguider,improvements were made in the following aspects of observatory software : 1. Incorporating better features in user GUI . 2. Multiple Linux user interface. 3. Modified user invocable library. 4. Better telescope control software.This software has been tested on the Japanese MAGNUM telescope and is expected to give a tracking performance of 0.5 arcsecs rms over unlimited period of time in openloop. (without an autoguider). However this feature has not been tested on the HCT.

(A.V. Ananth)

Cryotiger based CCD cryostat

Integration and implementation : Present CCD Dewars in use (in our labs) are of liquid nitrogen (LN2) filling type, in which case LN2 will be refilled at definite intervals. It will be difficult to get LN2 at remote places like eclipse camp etc. Moreover transporting it and its storage will add to the overheads. Installing an LN2 plant near observatory will still increase the overheads even though it ensures continuous supply of LN2. All these factors motivate one to think of some LN2 free cryo-cooling system.

Out of available options like sterling type coolers, pulse tube refrigerators, acoustic coolers, optical coolers and JT coolers, JT cooling devices were found to be the optimum one. The compactness, low maintenance, low vibration, operational simplicity and stability involved proved this system to be the optimum one. A cryocooler commercially named as "CRYOTIGER" delivering 10 Watts of refrigeration at 94 K is imported. The necessary cold finger connections were designed to interface cold head and CCD base; also cryostat is modified to suit cold head, cold finger and CCD units. The cryotiger is integrated with the modified cryostat. The unit is made operational; Cool down test (Figure 33) was conducted and the lowest temperature recorded on the CCD base found (in full load test) to be -142° C (achieved in 3 hours).

TIGER stands for Technology In Gas Energy Refrigeration, the science of combining various gases to achieve specific cryogenic properties. This gas technology ensures that the resulting gas mix be able to achieve the desired effects without requiring complex and expensive mechanical devices. The outcome of this technology is the CRYOTIGER cooling system; an extremely cost effective means of reaching and maintaining cryogenic temperatures.

System comprises of a compressor (Figure 34), flexible gas lines (15 m) and cold head (Figure 35); the cold head with the CCD base will be mounted in the cryostat (Figure 36) which is pumped down to 1×10^{-6} Torr. Tip of the cold head can reach lowest temperature of -179° C providing 10W of refrigeration. The gas blend in the compressor (PT14) will be cycled through the compressor, gas lines and JT valve in the cold head. The cooling produced is the result of JT expansion in the cold head. Electricity is the only input needed for the operation; system operates at very low noise levels (56 dBA). The whole system is very compact, portable and is designed for continuous maintenance free operation up to 5 years.

The ultimate lowest temperature attained is -142°C with full load. CCD cooling application requires -120°C -100°C. So it is well suited for these types of

applications. According to manufacturers' test specification the vibration level at the cold head tip is about 20 microns, however vibration tests have been conducted at IIA to find out maximum displacement of the cold tip and also

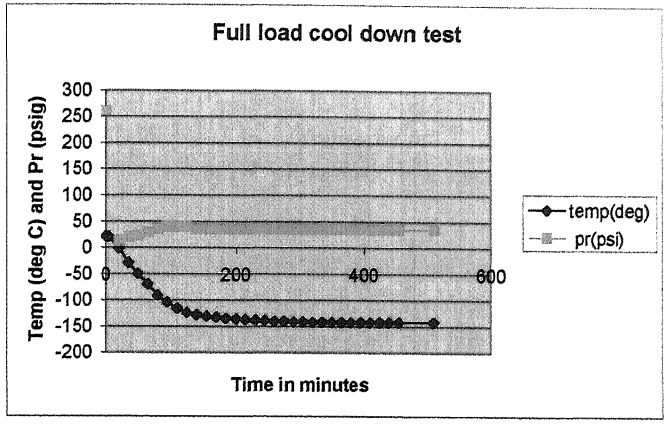


Figure 33. Full load cool down test.

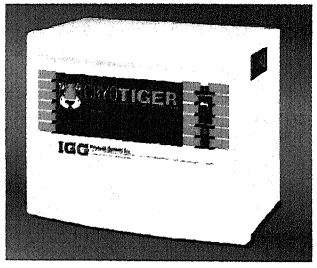


Figure 34. Compressor

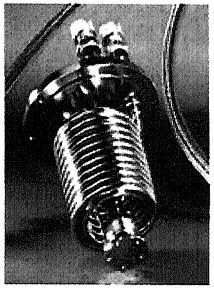


Figure 35. Cold head.

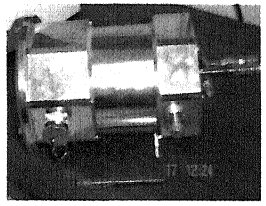


Figure 36. Cryostat

the CCD base. The displacement at the CCD base (Figure 37) is expected to be much less than 20 microns. This is achieved by characteristic design of cold finger (Figure 38), which is in the form of discrete copper strands

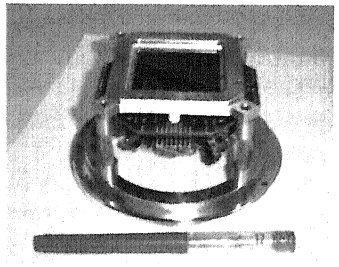


Figure 37. CCD base.

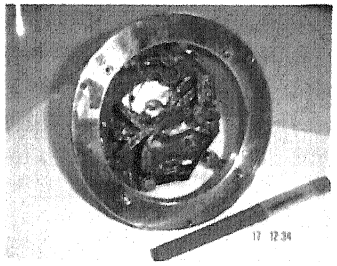


Figure 38. Cold finger connections.

connecting cold tip of cryotiger at one end and CCD base at the other end. Exact vibration levels at the CCD base will be quantified after the experimental data reduction.

(S. Nagabhushana, K. Sagayanathan and A.V. Ananth)

TAUVEX

1. The TAUVEX UV imager : A set of three telescopes designed to observe the entire sky in the UV was accepted by ISRO for launch by a GSLV on the geostationary platform GSAT-4. The projected launch date is early 2005 and scientists from India and Israel are actively collaborating on the mission and the scientific program. More information about the mission can be found at http://www.iiap.ernet.in/tauvex/tauvex.html. TAUVEX will play a crucial role in building up the UV astronomical community for the 2007 launch of ASTROSAT. Major activities at IIA include the software development for the mission.

2. Detector development for space : We (J. Murthy and B. R. Prasad) have a program to develop a photon counting detector for eventual use in space flight. A trainee engineer (Mr. Ginu Rajan) is currently working on this and we hope to have a prototype ready in two years. Our ultimate goal is to develop a payload for doing UV science from space.

3. Simulation of the UV sky : This is an ISRO funded RESPOND proposal to model the sky in the UV with Dr. N. V. Sujatha. In the first part of this work, we have created a model to predict the ISRF at any point in space and are in the final stages of releasing the model and writing the paper. In the next stage, we will apply this model to real data.

4. Modeling of dust scattering : With a student (Ms. P. Shalima) we have created a Monte Carlo model for predicting emission from a number of complex environments. We have reanalyzed old observations of the Coalsack nebula finding that the albedo can be strictly constrained to be 0.4 ± 0.1.

(Jayant Murthy)

Mechanical design section

Design, analysis of design and detailed engineering of the High Altitude GAmma Ray telescope (HAGAR) has been completed. Fabrication of 2 nos. of prototypes is under progress. Shop testing of the prototype will commence by mid - June 2004 and one unit will be installed at CREST, Hosakote and its performance will be monitored. A pier for the same has been constructed at CREST, Hosakote and the pier for the second prototype for IAO, Hanle will be completed in this season. Both prototype units are expected to be ready after fine tuning by the year end.

The telescope employs an alt-azimuth mount and each telescope will house / accommodate 7 slumped back coated mirror of 900mm diameter. It is designed to have a pointing accuracy of half-an-arcmin.

Newly made dome wheel assemblies for the 75cm telescope dome has been installed. Re-designing of 75cm telescope mount is in progress. Design, detailed engineering and preparation of technical specifications will be completed soon.

Major maintenance work like upgradation of VBT mirror carriage unit, re-wiring of 10T EOT crane, repair of hydraulic platform power pack system, changing of oil of the hydrostatic bearing and hydraulic platform etc. have been taken up at the Vainu Bappu Observatory.

A Computer Aided Draughting and Design (CADD) facility has been set up at the Mechanical Design Section at the Koramangala campus of the Institute. This is in addition to the AutoCAD draughting installations. The present installation on a Personal Computer consists of Autodesk Inventor Series 6.0 as the draughting package and Nastran for Windows 2003 as the analysis package.

A custom built de-humidifier system with provision for heating and cooling was manufactured. A prototype of the same was tested at the Vainu Bappu Observatory, Kavalur and five more pieces have been manufactured after some minor modifications as specified by end users. This is for storing optics and filters under controlled conditions to preserve the same at the various field stations of the Institute.

(P.K. Mahesh)

Speckle interferometry

Close binary stars : The speckle interferometer is used at the Cassegrain end of the 2.34 m Vainu Bappu Telescope (VBT), Vainu Bappu Observatory (VBO), Kavalur regularly to record speckle-grams of close binary stars ($\rho < 1''$). In order to obtain specklegrams of these stars, a solid state based non-intensified low light level CCD (L3CCD) that effectively reduces readout noise to less than one electron rms has enabled substantial internal gain within the CCD before the signal reaches the output amplifier. Data analysis of a few close binary stars along with the respective reference stars is in progress. Hundreds of frames of each of these stars are scanned carefully and are being analyzed with the power spectrum followed by the autocorrelation algorithms developed by Saha and Maitra (2001, Ind. J. Phys.

75B, 391) to determine the separation between the primary and its companion. The analysis of the speckle interferometric data of HR6148 obtained from VBT, Kavalur on 28 May 1997 is done and the angular separation between the two stars in the system is obtained.

(S. K. Saha, L.Yeswanth, and V. Chinnappan)

Orbit of binary stars from interferometric data : Finding the orbital elements of a binary system is of paramount importance in the study of binary stars since it is the only way to obtain the masses of the individual stars in that system. Speckle interferometric studies provide the total mass of the system. Combining speckle interferometric results with the spectroscopic results, masses of individual stars can be obtained. We have developed an algorithm based on Kowalsky's method of deriving the elements of a binary system. Unlike Hartkopf's method (Hartkopf et al. 1989, AJ, 98, 1014) where the period (T), eccentricity (e), and the periastron passing time (τ) are required to determine the orbit, this method is straightforward which requires only two parameters such as separation (ρ) and position angle (θ). Plotting the apparent orbit of binary stars using speckle interferometric data is discussed in an article (Saha et al. 2004). The orbit of a couple of binary stars, HR3880 and HR2134 are plotted using measurements binary stars, HR3880 and HR2134 are plotted using measurements obtained from 1975–1993. The measurements include those from various telescopes across the world.

(S.K. Saha and Maneesh Mathew)

Micro-fluctuations of Fried's parameter (γ_0) : The atmospheric coherence is a highly variable parameter depending upon the high velocity wind, it varies from < 1 milliseconds (msec) to ~ 0.1 sec. We have determined the night time variations of Fried's parameter at the 2.34 meter VBT site which were computed using the speckle interferometric technique. The form of transfer function $< |\hat{S}(\mathbf{x})|^2 >$ is obtained by calculating Wiener spectrum of the instantaneous intensity distribution from each of the specklegrams. Here, $\hat{S}$ is the transfer function, $\mathbf{x} = (x, y)$ is 2-dimensional space vector, $< >$ indicates the ensemble average and $||$ stands for the modulus. Measurements of γ_0 at a step of ~ 100 milliseconds (msec) have been carried out.

(S. K. Saha, L. Yeswanth, and V. Chinnappan)

Polar heliostat for total solar eclipse observations from Antarctica : A 20 cm polar heliostat suitable for the latitude of the Indian station in Antarctica, Maitri (71 S), was designed and fabricated in the Mechanical laboratory of the Institute, in a short span of about a month. Some of the available components such as the mirrors, mirror cells, parts of the drive mechanism, the earlier translator unit, stepper motors, etc. were pooled from the field stations at Kavalur and Kodaikanal. The mirrors were aluminized at M/s Hind Hivac, Bangalore. The heliostat and the drive system were assembled and tested at the Bangalore campus in October 2003. Special provisions were made so that two persons would be able to reassemble and align the entire heliostat. The heliostat, the motors, and the electronics worked fine in the cold and windy conditions of Antarctica, first at Maitri, and later at the site of observations of the total solar eclipse on 23 November 2003.

The tripod base of the heliostat has been left behind at Maitri for any possible future use.

(S.P. Bagare, J.P.A. Samson and N. Sivaraj)

Thermal monitoring system for VBT : A system has been developed to monitor, record and to optionally nullify (passive control) the temperature gradients in the VBT building and in the primary mirror cell with a view to improve dome seeing within the building.It has been installed and the temperature data has been obtained on trial basis. Figures 39-42 shows a day's variation of temperature in VBT building at various locations (without any control). Presently the system has 32 temperature probes, which can be expanded.

The hardware configuration of the system consists of: 1) Semiconductor digital temperature sensors 2) Four microcontroller-based slave units 3) A microcontroller based master unit and 4) A computer interface unit; all are connected through a twisted wire network with a common power supply.

The temperature probe is a semiconductor digital sensor DS18B20. It is factory calibrated with a programmable temperature resolution of 9 to 12 ADC bits in the range of -55 degC to +125 degC, with an accuracy ± 0.5 degC in the range of -10 degC to +85degC. The probes can be directly interfaced with digital IO line and data/command transfers are based on 1-wire bus protocol. These probes are located at pre-determined locations, eight in each floor of the building.

The slave control unit is based on a microcontroller. It has a multi-drop network interface with settable node address switches, eight digital IO channels for temperature probes to interface and eight output lines with indicators to activate Solid State Relays (SSRs) for passive control.

The master control unit is also based on the microcontroller. It has one IO channel to connect a temperature probe to measure ambient temperature, one 20-character 4-row LCD, network interface and a power supply unit to provide power for all the slave units over the network.

The PC interface unit is also a network-based microcontroller unit with a 3-wire RS232 interface. The RS232 port is available on a wide range of computer platforms with OS support. Therefore, the data acquisition program can be written on any computer platform.

The software consists of firmware in the microcontrollers and data acquire and plot software running in the PC. All the units are connected through a inexpensive twisted pair cable. The inter unit communication is coordinated by the master unit. The communication is based on packet transfer protocol with CRC check. The microcontroller's 9th bit address-detect-capability has been utilized to uniquely address the slave units over the network. The Master unit sends a packet whenever it needs to communicate with a slave unit. The packet contains to-address (slave unit address), from-address (master address), no. of bytes the packet contains, payload (data/command)and CRC byte. Therefore, the transmission errors can be checked. The slave units are normally in listen mode. All slave units receive the packet's to-address sent on the network and compare with its own switch setting and if the address does not match then it quits from further receiving of the data till next to-address is sensed. The unit that matches the address will receive all the bytes in the packet, calculate CRC and compare with packet CRC byte. If CRCs match then the unit analyzes the command and responds accordingly.

The master unit reads the ambient temperature by communicating with the probe through its IO channel using '1-wirebus' protocol. This temperature is sent to each slave unit and also receives eight temperatures from each of the slave units with packet protocol, as explained. All these temperatures are displayed on the LCD in scroll mode, and are also sent to the computer interface. The above process is repeated.

At regular intervals the slave units send commands to the probe to start a new cycle of temperature reading and reads it through IO channel. This temperature is compared with outdoors temperature sent by master unit and if the difference is more than a degree centigrade, the corresponding relay is switched on. This process is repeated for 8 IO channels.

The computer interface unit receives the data sent by the master and maintains a table of probe number and its temperature. Whenever, computer requests for the temperature by the probe number, for log purpose, the unit supplies the corresponding temperature in ASCII format.

The data log program is written with DELPHI under windows. The program sends probe number to the interface unit and receives the data via COM1 port at pre determined log intervals. The data is written into a file along with

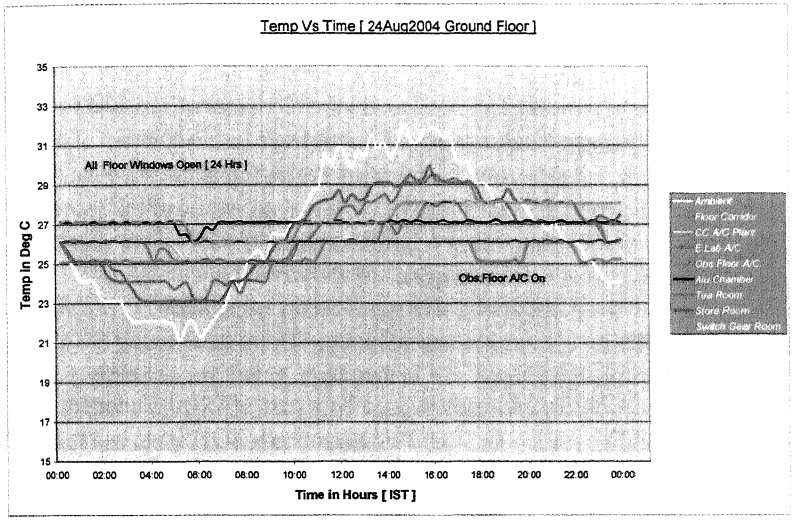


Figure 39.

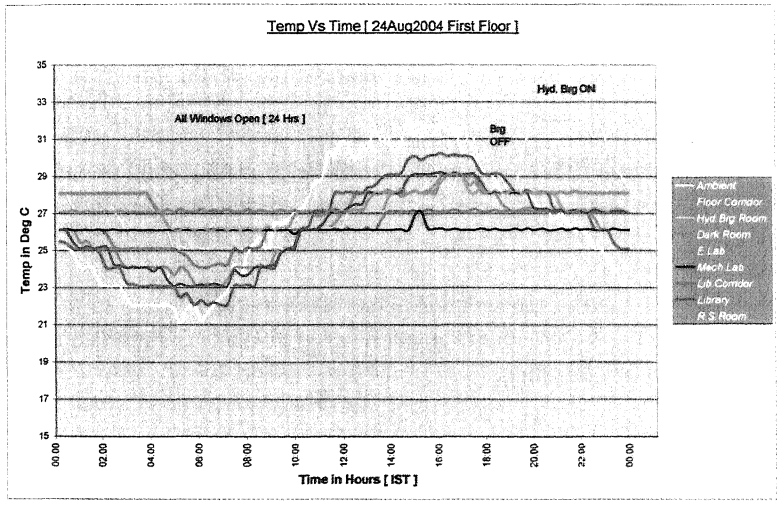


Figure 40.

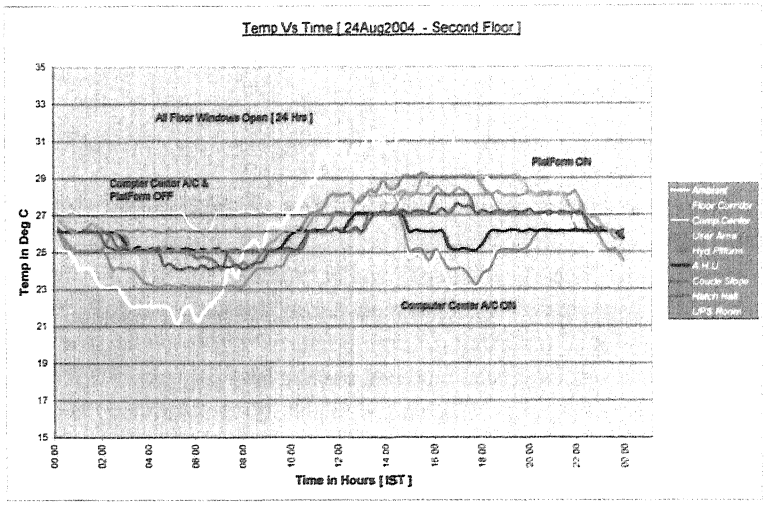


Figure 41.

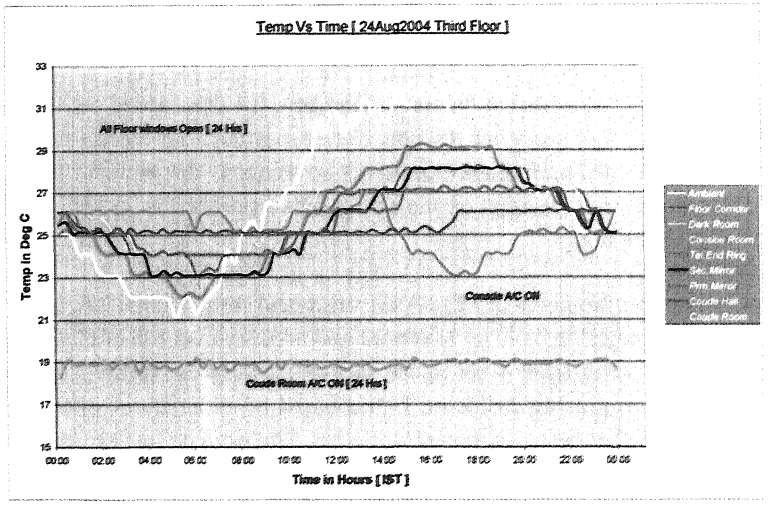


Figure 42.

a time tag. The log time interval can be set from 2 to 60 min. The format of the data storage is compatible with MS-excel so that the data can be seen with the widely available excel package.

(G. Srinivasulu and K. Ravi)

Two-beam spectropolarimeter for Kodaikanal tower telescope : This system consists of a polarizing beam displacer which gives two orthogonally linearly polarized parallel beams to obtain two polarized states of light simultaneously. This method provides increased polarization accuracies by way of removing the seeing induced errors to a large extent. Optical components have been procured and the lab experiments to test the components are in progress. Mechanical mount of the polarimeter is being prepared at the mechanical lab of IIA, Bangalore. Integration of the system and the first field trials are planned during next observing season.

(K. E. Rangarajan, K. B. Ramesh, Jagdev Singh and K. Nagaraju)

Photonics division

1 m telescope : Extensive alignment of the 1 m Zeiss telescope with new Zerodur mirror fabricated at Photonics Division, IIA was carried out. Even though the optical quality of the new mirror matches with the old mirror pretty well, desired performance could not be attained, due to mismatch of the support system. Decision on the change of support system or the entire cell is still pending.

Long trace profilometer (LTP) : After successful completion of the LTP – ver.I, a new project to build an advanced and improved version of the Long Trace Profilometer (LTP – ver.II) for measuring the slope errors /surface profile of long grazing incidence optics based on polarization shearing interferometer has been sanctioned by BRNS. The work on this project has started. The procurement of the components has already begun. The modified concept on the optical head is finalized. These efforts have put India in the map of LTP – Builders in the world. The budget for the new LTP is Rs.44.5 lakhs.

VHRR sunshield panels : The work on the development of sunshield panels for INSAT – 3D imager and sounder coolers is in progress. One set of panels (10 nos.,) as an engineering model with desired specification has been optically polished and delivered to ISRO. Optical polishing of the second set is in progress. Newly setup clean room laboratory of 1000 class, and Veeco profilometer was used for the purpose.

Space optics :

ASTROSAT : A.K. Saxena continues to be a part of Ultra Violet Imaging Telescope (UVIT) – ASTROSAT (Indian Astronomy Satellite to be launched in 2007) team. Optical system design and realization of the optics has been his responsibility. The optical configuration and design details have been finalized. The optical design has been reviewed by the Optical Design Review Committee chaired by Mr.KiranKumar, SAC, Ahmedabad. The same has been approved by the ASTROSAT Review Committee chaired by Dr.George Joseph. The fabrication of the Optics has been entrusted to LEOS, ISRO, Bangalore. We are involved in the monitoring of the progress of the fabrication.

Vacuum and thin film coating : The 2m vacuum coating plant at Hanle has been set up and its performance has been revalidated. The plant is ready for use at site.

The 2.8m and 1.2m vacuum coating plants are more than 20 and 25 years old respectively. The system improvement is being planned. Suitable steps have been taken in this direction.

Adaptive optics : Research work continues towards building a low cost adaptive optics system for astronomical applications. After successfully building wavefront sensors using a Shack Hartmann sensor and CMOS imager, a new hardware for the closed loop control of adaptive mirror was selected

after detailed study. The essential component of the hardware is based on Field Programmable Gate Array (FPGA). These are capable of working in parallel mode so that number of channels of the adaptive mirror can be controlled simultaneously. Real time operating system working on industrial PC bus such as PXI bus is chosen for this configuration. A new algorithm is being tried for the adaptive mirror control.

Research work is in progress to build a new wavefront sensing using polarization shearing interferometric technique which is already established. The aim is to compute the phase using a single record. Work is in progress to obtain the phase of an interferogram by use of an evolution strategy. Suitable optical methods are being explored to use two interferogram methods in which the x-shear and y-shear data are recorded in a single detector. Mr.V.Chinnappan and Mr.J.P.Lancelot are engaged in the above research works leading to their Ph.D.

A.K. Saxena continues to interact with other Adaptive Optics groups working in the country such as IRDE, Dehradun and Udaipur Solar Observatory.

LAMA - optical design concept

The LAMA telescope employs an array of fixed 8-meter liquid-mirror telescopes. These are located in a closely-packed configuration with an overall diameter of 54 meters. Approximately 62% of the light that falls within this area is collected and focussed on a common detector. This gives the array a light-collecting power equivalent to that of a 42-metre telescope.

As LAMA is a zenith pointing telescope, tracking secondary mirrors and active optics allows the array to follow objects for several minutes as they pass overhead. At any given time, the array can point anywhere within a 4-degree diameter circle centered on the zenith. This makes 2400 square degrees, about 6% of the entire sky, accessible to the telescope.

Light from all the telescopes is brought to a common focus in a central beam-combining room. Here the light beams interfere constructively to produce an image with a resolution of several milliarcsec. Moving mirrors, controlled by a phase-tracking system, equalize the optical path lengths from all elements of the array to within a fraction of a micron.

A.K.Saxena has worked with Prof.Paul Hickson, Department of Physics, UBC, Canada, during July to Dec 2003 and finalized the Optical design for the above configuration of LAMA. It involved phase tracking system, path equalization and beam combination. A totally new concept has emerged.

(A.K. Saxena)

9. Library

The Library enhanced its collection of books and journal volumes during the year 2003-04. 641 books and 250 bound volumes of journals were added to the collection, which include the books and journals bought for libraries at Bangalore, Hosakote and Kavalur. The Library also subscribed to 242 journals out of which 131 titles full-text can be accessed electronically from within the campuses at Bangalore and Hosakote.

Three new library trainees have joined the library in the month of May. They are trained in all the sections of the library.

IIA library continues to be a member of the FORSA consortium for various library services. We continue to access the additional journals of Kluwer Publishers, and Nature journal electronically through the consortium. The inter-library loan facility among the FORSA member libraries continues to be active and unique. There were 199 inter-library loan requests from scientists and students, which were taken care of from April 2003 to March 2004.

In the month of September 2003, Dr. A Vagiswari attained Superannuation. As an honour to her long association with the Institute and the invaluable service rendered to the Library, a felicitation function was organized on 1st Oct. 2003. There was a half-day library seminar on the theme "Dynamic Librarianship" which was organized at IIA, to bring together the library fraternity in the city, along with the publishers/vendors community on that day. IIA staff felicitated Dr. Vagiswari in the evening on her Superannuation.

Dr. Vagiswari continues to render her expertise as a Consultant to the Digital Library of IIA.

Digital Library initiatives at IIA:

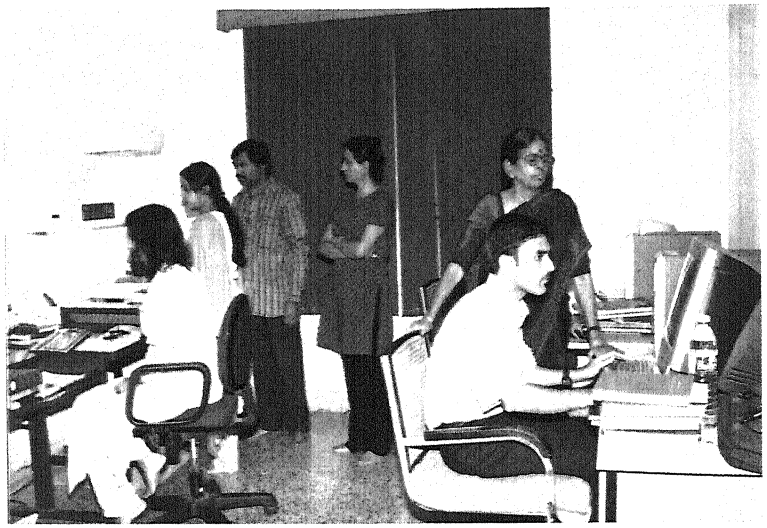
IIA Library has been formally identified as one of the partners of the "Million Book Project" also known as Digital Library of India (DLI) in the month of June 2003, and a MoU was signed between the Director, IIA and the Indian Institute of Science, Bangalore. This is a collaborative project between Carnegie Mellon University, USA and the Indian Institute of Science at Bangalore and Ministry of Communication and Information Technology, Government of India.

During the year two trainees were appointed for this project and a high resolution CCD scanner (Minolta PS 7000) was provided by the Indian Institute of Science. Three computers were purchased for this work. The trainees underwent special training at IISc before commencing the work. They were trained in Scanning, Metadata Verification, Editing and Cropping using different softwares. Other library staff is also participating in the scanning work.

During last 12 months 1,100 old books and 60 theses of IIA staff from our library have been scanned, cropped and OCR'd. The number of pages scanned run to 4,00,000 pages.

The work has been progressing extremely well under the supervision of A. Vagiswari and Christina Birdie. The DLI project had held two important review meetings one at Bangalore and another at Tirupathi. Prof. N. Balakrishnan (IISc, Project Coordinator India), Prof. Raj Reddy (Project Coordinator, USA) were present at these meetings and were appreciative of the work done.

A. Vagiswari and Christina Birdie were also involved in the designing of the metadata for the project to bring out a scientific data form, keeping in view accurate retrieval.



IIA Archives : During the period Oct 2003 – June 2004 efforts were made to collect old records and documents pertaining to Indian Institute of Astrophysics. Many of the old letters/records of Pogson, Ragoonathachary, Evershed and Chidambara Iyer have been collected, organized and put in acid free envelopes. Some newspaper cuttings have also been scanned.

We have contacted state archives of Karnataka for advice on preservation. The Deputy Director Ms. Usha visited the Library and has agreed to give necessary training to Binding Section staff for preservation of very old manuscripts. The staff has already commenced training.

(Christina Birdie)

10. Graduate studies programme

Board of Graduate Studies

A handbook concerning the Board of Graduate Studies Programme was brought out. The book contains information on the rules and regulations pertaining to the graduate students programme, grading system, syllabi and other details. The document serves as a reference source. It will be updated every year.

Memorandum Of Understanding (MOU) was signed between IIA and Mother Theresa University for Women (MTU), Kodaikanal. As per this MOU, female students from IIA can register in that university. Few students from MTU will be trained in IIA. Scientific staff of IIA will be recognised as the faculty of the University. Astrophysics courses will be designed in MTU in consultation with IIA.

Four students, P.Manoj (Bangalore University (BU)), Preeti Kharb (BU), Geetanjali Gauba (BU) and S.K.Shanmugasundaram (IISc) submitted their Ph.D. theses this year. B.S.Ramachandra was awarded the Ph.D. degree for his thesis on "Blackholes in cosmological backgrounds" from Calicut University.

A compulsory seminar course for the students was introduced in addition to mandatory lectures by students. An experimental course is being planned.

BGS conducted IIA Ph.D. entrance test in the month of November, 2003. Three students joined the Ph.D. programme.

IIA was the Bangalore center for JEST2004 exam. A record number of 375 students wrote the test. Special arrangements were made for the students to write the test.

A poster was brought out for the first time to advertise the Kodai Summer School. A topic in Astronomy in addition to other Physics subjects will be covered every year in the school.

Student Training Programmes :

Summer Project Student Programme (SPSP) was continued this year too. Students who have completed third year B.E. or first year M.Sc apply for this programme. The selected student is assigned an individual project under a supervisor from IIA. The project is completed in two months during the summer vacation of the student. The student submits a report and delivers a seminar on the project done. Twelve students participated in the programme this year.

Five students were trained under the Institute's Visiting Students Research Training Programme (VSRTP). The training period varied from 3 to 6 months. These are long term projects, sometimes required as a part of the curriculum in the university.

Biman Medhi, Ph.D. student from Gauhati University is given facilities in IIA to complete his thesis on "Photometric and spectroscopic study of chromospherically active stars" under the Visiting Students Research Programme (VSRP) of BGS. He is making use of CREST facilities at Hosakote campus.

Twenty two research students are working for their Ph.Ds this year. Vineet from JAP joined IIA to do his Ph.D. thesis in the Institute.

Several applications are received every year from lecturers of colleges and universities for part time Ph.D. work under Faculty Improvement Programme (FIP). An uniform procedure has been evolved to select and train college lecturers under this category. Four lecturers are working for their Ph.Ds from IIA this year.

(Vinod Krishan)

11. Conference reports

Kodai School in Physics, June 02-21, 2003

Kodai School, a summer school on Statistical Mechanics, Nonlinear Dynamics and Quantum Mechanics was conducted at the Indian Institute of Astrophysics, Kodaikanal, during June 02-21, 2003. Twenty two final M.Sc., and B.Sc., Physics students selected on an all-India basis attended the course. Ten final M.Sc., Physics students of the Mother Theresa Women's University, Kodaikanal, attended the course as non-registered candidates.

Professor B.V. Sreekantan, Chairman, Governing Council, IIA, inaugurated the school. Professors T. Padmanabhan, IUCAA, Pune; R. Ramaswamy, JNU, New Delhi; G. Rangarajan, IISc., Bangalore; H.S. Mani, S.N. Bose National Centre for Basic Sciences, Kolkata; and C.S. Unnikrishnan, TIFR, Mumbai gave the course lectures. Drs. T.R. Choudhury, IUCAA, Pune and Sourish Basu, IISc., Bangalore, conducted the course tutorials. During the school, Professor V. Radhakrishnan, RRI, Bangalore, gave an evening lecture on "Nautics and Aeronautics – The Wonderful World of Sailboats".

(S.S. Gupta)

Students and teachers of the Kodai School - 2003

12. National and International programmes

Collaborative activities with other institutions

Major collaborative activities continued, or were started with the following Institutes :

University of Calicut, Since March 1999 : mutual cooperation in the common interests of teaching and research in astronomy and related subjects.

Copenhagen University Astronomical Observatory, Denmark, Since April 1999 : Collaboration in the fields of galactic and extragalactic astronomy, and as a specific step towards building and utilization of a low dispersion spectrograph called "Hanle Faint Object Spectrograph & Camera" (HFOSC).

McDonnell Center for Space Sciences, Washington University, St Louis, USA, Since June 1999, to collaborate in the field of astronomical transient phenomena, as specific step towards cooperation on the installation and utilization of two 50-cm aperture telescopes forming the Antipodal Transient Observatory.

ISRO-Satellite Centre, Bangalore : Optical polishing of the sun shield panels of the INSAT-3D space imager and sounder has been continuing at the Photonics Division laboratory.

Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore: 'Inverse modelling of broadband seismograms to determine the shear velocity structure beneath some geodynamically significant parts of the Indian continent'.

Laboratoire des Science du Climat et de L'Environment (LSCE), CEA, Saclay - Orme des Merisiers - France: 'Monitoring of carbon and green house gases concentration at Hanle, and inverse modelling of global fluxes'.

TIFR, Mumbai, Observatoire de Paris, Meudon, France, Laboratorie d' Astrophysique, Toulouse, France & Observatoire de la Cote d'Azur, Nice, France on Dynamies of Solar and Stellar Interiors : Seismology and Activities.

Collaboration in teaching

IIA is an active partner in the Joint Astronomy Programme (JAP) at IISc since its inception in 1982. 17 students from this programme have pursued their doctoral work under the supervision of scientists from IIA.

Scientists from IIA have been regularly participating in teaching programmes at other institutes also, such as Bangalore University and Osmania University etc.

Astronomical Society of India

A major part of the activities of the Astronomical Society of India continued to be centred at the Institute with S.S. Hasan as the Vice President, R.C. Kapoor as Treasurer of the ASI and G.C. Anupama as the Editor of the Bulletin, ASI.

13. Public outreach

Video coverage

One episode of the TV serial Turning Point was videographed at IAO and CREST during the current year, and telecast on the national channel. Reporters of Business India visited the site and published a feature on IAO, Hanle.

Popular lectures

G.C. Anupama gave a talk on the "Transit of Mercury" on the radio channel 'Radio City' on 7 May 2003. She also gave a talk on "Supernovae and other energetic phenomenon" on the Educational Radio Channel 'Gyan Vani' on 23 September 2003.

C. Sivaram published a series of general science articles 2003-04 on "Watson-Crick-Franklin model, 50 years of DNA", Deccan Herald, April 28, 2003; "Overview of Dinosaurs" - Science India, Aug, 2003; "Global Warming", Science India, Sept. 2003; "Communication with ET Civilizations" Science India, Nov. 2003; "Panspermia" Science India, Feb. 2004; "Anthropic principle" Science India, March 2004; "Scientific contributions of Albert Einstein" (in two parts) (on his 125th birth anniversary), Deccan Herald, March 2004.

K. Sundara Raman inaugurated the 'Space Club' at Institute of Road Transport and technology, Erode and delivered a lecture on Astrophysics and Cosmology on 11 September 2003.

K. Sundara Raman delivered the following lecture in the Department of Physics, St Joseph's College, Trichy on 'Introduction to Astronomy and Astrophysics' on 13 August 2003 ; 'Basics of astrophysics' and 'Introduction to Solar Physics' at PGP college of Arts and Science, Namakkal on 12 September 2003 ; 'Universe' at Kodaikanal International School, Kodaikanal on 23 September 2003.

S.P. Bagare gave a popular talk titled 'The excitement and the science of total solar eclipses - recent observations from Antarctica' at the Cambridge Public School, Bangalore, in Feb 2004. Bagare also gave a talk on 'New frontiers in the Physics of the Sun' for science students from degree colleges in Karnataka, at the Bangalore Association for Science Education, JN Planetarium, Bangalore, in March 2004.

National Science Day

The National Science Day-2004 was celebrated in the Institute on 28th of February, 2004. On the occasion, about 500 school children turned up at the

premises along with their teachers, as also B Sc students from the Mysore University. The programme consisted of a viewing of sunspots on the disc of the Sun projected on a screen with the 7.5 cm refracting telescope, a screening of the Institute's film- 'Nungambakkam to Hanle', and a special popular lecture. The lecture entitled 'The Radio Sky' was delivered by Dr. R Ramesh. It was so popular that it had to be given once again. The school children had a thriling experience while visiting the Institute laboratories.

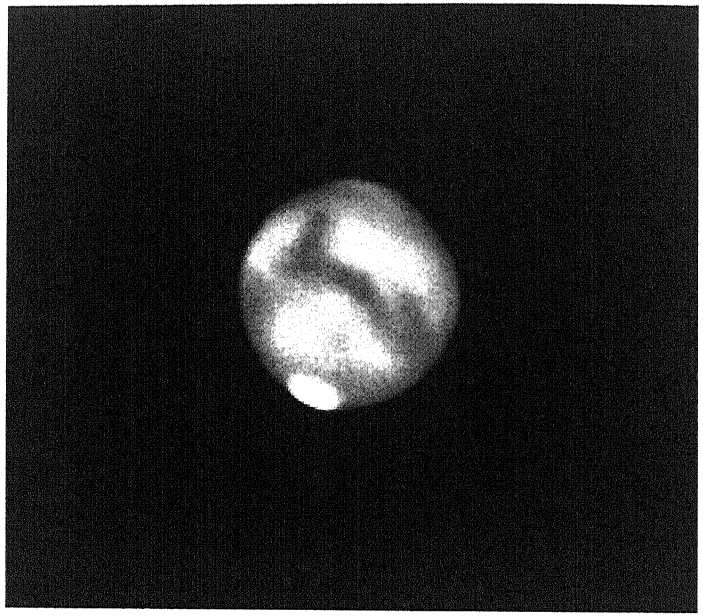
(R.C. Kapoor, R. Ramesh, E. Ebeneezer and Kathiravan)

A tryst with the planet Mars

So far as the planet Mars is concerned, the 27th of August, 2003 was an extraordinary day. This day gave a rare chance to see Mars in its brilliance unprecedented, at an m_v of -2.9, when at 15 22 hours IST, Mars came closest to the Earth, the distance being a mere 5,57,58,006 km, as bright as a plane's landing lights and at its greatest apparent diameter of 25 arc seconds. Mars

R.C. Kapoor, C. Sivaram and S.P. Bagare (all to the right of the dias) in interaction with the visitors.

did not come this close to the Earth at any time in the last 1,00,000 years or so and will not be nearer to us till 28th Aug of the year 2287 when it will be about 70,000 km closer. The near coincidence of opposition and the perihelion was what made this approach of the planet so very close and special. At the Institute elaborate arrangements were made for the public to view the planet through the Carl Zeiss 15 cm reflector. The viewing was however not possible



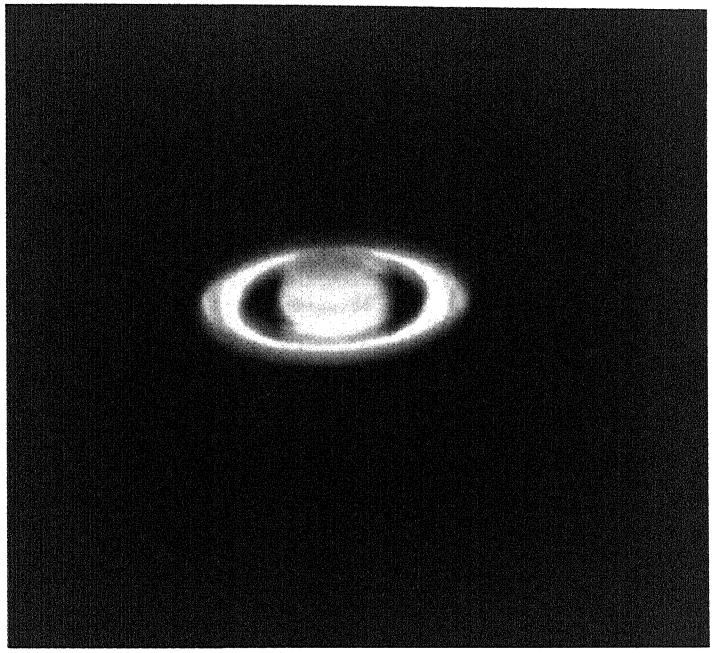
due to heavy rains that evening but an illuminating popular lecture on the planet compensated well for the subdued enthusiasm of the public.

C. Sivaram gave the Public Lecture on 'Rendevouz with Mars', Aug, 27 on the occasion of the nearest approach of Mars to Earth. This was well attended by at least six hundred people. There were many question-answer sessions.

(R.C. Kapoor, C. Sivaram and S.P. Bagare)

Saturn at its closest since 1975

The Earth and the planet Saturn passed closest to each other first time since 1975 last, by 1.28 billion km on the night of 31 Dec 2003/ 1 Jan 2004. As a mark of the occasion and for the purpose of public outreach, images of the planet Saturn combined from three images was taken through a CCD camera



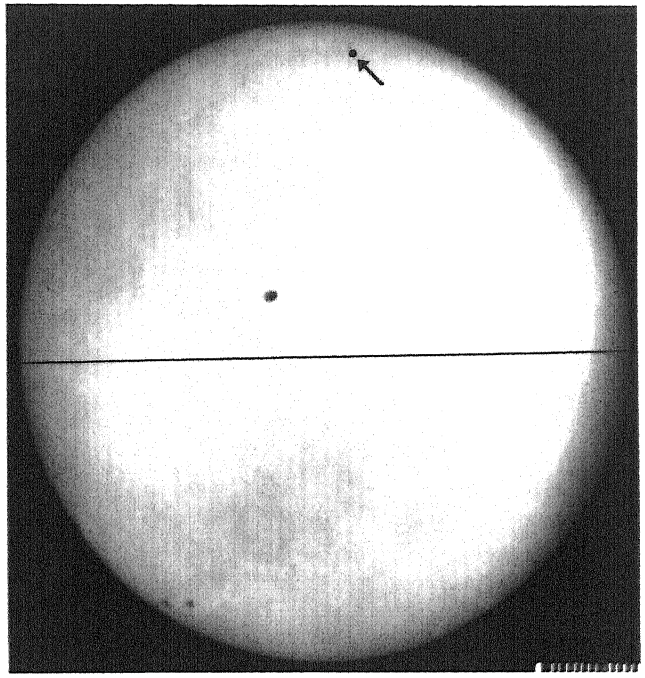
in red, green and blue filters attached to the 1.02 meter Carl Zeiss telescope of the Vainu Bappu Observatory, Kavalur; the image shown here was obtained during the early hours of Dec 31, 2003.

(R.C. Kapoor)

The transit of Mercury

A rare celestial event, transit of the planet Mercury, took place on May 7, 2003. On the average there are 13 such transits of the planet in a century. Such an event, though not as exciting as a total solar eclipse or a comet evoked much interest among the general public. The event was going to be visible from India, beginning at 10 43 hr and ending at 16 00 hr. It is very difficult to observe as the planet is small (2438 km mean radius compared to the 695950 km of the Sun) It appeared as a very small dot against the bright disc of the Sun, virtually indistinguishable from a sunspot.

The Kodaikanal Observatory took white light pictures whereas a 7.5 cm refracting telescope suitably modified to view the image of the sun on a



white screen was installed at the Koramangala campus on the day for a viewing by the general public. A large number of visitors and school children and the media witnessed the event.

(R.C. Kapoor)

Gazania *(Gazania splendens)*, IIA Bangalore Campus

14. Personnel

Academic / Scientific / Technical Staff as on 31.3.2004 includes the following :

Acting Director : J.H. Sastri

Distinguished Professor : Ramanath Cowsik

Senior Professor : B.P. Das, S.S. Hasan, N. Kameswara Rao, M. Parthasarathy, T.P. Prabhu, R. Srinivasan, Vinod Krishan,

Professor : R.C. Kapoor, D.C.V. Mallik, Jagdev Singh, C. Sivaram

Head Photonics : A.K.Saxena

Sr.Principal Scientific Officer : A.V. Ananth

Scientist E : S.P. Bagare, H.C. Bhatt, A.K. Pati, R. Rajamohan, A.V. Raveendran

Associate Professor II : Jayant Murthy

Associate Professor : P. Bhattacharjee, K.N. Nagendra, K.R. Subramanian, Sunetra Giridhar, S. Surendra Gupta, R Vasundhara

Scientist D : G.C. Anupama, S. Chatterjee, R.K. Chaudhuri, P.K. Das, R. Kariyappa, S.G.V. Mallik, M.V. Mekkaden, S. Mohin, P.M.S. Namboodiri, Prajval Shastri, K.P. Raju, K.B. Ramesh, K.E. Rangarajan, S.K. Saha, R. Surendiranath

Sr.Research Scientist : B. Raghavendra Prasad

Principal Scientific Officer : V. Chinnappan

Engineer E : M.S. Sundararajan, B.R. Madhava Rao

Engineer D : N. Selvavinayagam, G. Srinivasulu

Scientist C : B.C.Bhatt, A. Goswami, U.S. Kamath, J. Javaraiah, A. Satyanarayanan, R. Ramesh, D.K. Sahu, S.K. Sengupta, M. Srinivasa Rao, A. Subramaniam, K. Sundara Raman, S. Muneer, Eswar Reddy, P.S. Parihar

Scientist : K.M. Hiremath

Research Scientist : R.T. Gangadhara, Arun Mangalam

Scientific Officer SD : J.P.L.C. Thangadurai

Engineer C : V. Armugam, S.S. Chandramouli, Faseehana Saleem, P.K. Mahesh, S. Narayanan, J.S. Nathan, M.P. Singh, S. Sriram, S. Nagabushana, B. Ravikumar Reddy, P.M.M. Kemkar, R. Ramachandra Reddy

Asst. Librarian C : Christina Birdie

Scientific Officer SC : P.S.M. Aleem, J.V.S. Vishveswara Rao, B.A. Varghese, L. Yeswanth,

Scientist B : P. Bama, E. Ebenezer, B.S. Nagabhushana, N. Shanthi Kumar Singh

Technical Officer : M. Mohd.Abbas, S. Muthukrishnan, B. Nagaraja Naidu, K. Rangaswamy, R. Muraleedharan Nair, J.P.A. Samson, R. Selvendran, K.G. Unnikrishnan Nair

Engineer B : P. Anbazhagan, K. Dhananjay, Dorje Angchuk, P.U. Kamath Sanjiv Gorkha, K.Padmanabhan, K.C. Thulasidharan, Tsewang Dorjai

Documentation Officer : S. Rajiva

Tech. Associate B : F. Gabriel, K. Jayakumar, Joseph Rosario, K. Kuppuswamy, G.N. Rajasekhar, A. Selvaraj, N. Sivaraj, K.S. Subramanian, G.S. Suryanarayana

Technical Associate : A.S. Babu, D. Babu, S. Pukalendhi, A. Ramachandran, K. Ravi, C.V. Sriharsha, A.V. Velayuthan Kutty

Draughtsman D : V.K. Subramanian

STA B : C. Nanje Gowda, Narasimhappa

SMA B : A. Mani

Visiting Distinguished Scientists : Vinod K.Gaur, K.R. Sivaraman

Adjunct Distinguished Professor : S.N. Tandon

Adjunct Scientist : N. Krishnan, C.S. Unnikrishnan

Visiting Sr.Professor : A. Krishnan, G. Ramachandran, P.R. Vishwanath

Visiting Fellow/PDF : S.G. Bhargavi, Chiranjib Sur, P.N. Deepak, Kiran Jain, G. Pandey, N.V. Sujatha

SRF : S. Ambika, K.J. Baliga, R.K. Banyal, M. Gopinath, C.Kathiravan, P. Kharb, K.V.P. Latha, Malay Kumar Nayak, P. Manoj, Rajalakshmi, B.S. Ramachandra, B.K. Sahoo, P. Shalima, G.A.S. Sundaram

JRF : Malay Maiti, B. Mathew, H.S. Nataraj, K. Nagaraj, R.M.C. Thomas, Vijay Shankar, Vigeesh, Vineet Kumar

Faculty Improvement Programme : R. Angiraz, Paniveni U. Shankar, M. Lalitha, V.S. Rohini

Project Consultant : A. Vagiswari

15. Miscellaneous activities

Positions, fellowships and recognitions

P.N. Deepak has been awarded the Alexander Von Humboldt fellowship.

V.K. Gaur is the Academic visitor to University of Cambridge, U.K., and to Laboratoire de Science de Climat et de L'Environment (LSCE), CNRS, France. Membership of committees :
* Chairman, Research Council of NEERI
* Chairman, PAC of ILTP-Earth Sciences of DST
* Chairman, Mission Mode Projects on Earthquake Hazards
* Chairman, PAC on GPS and InSAR Studies of DST
* Member Indo-Russian Joint Council, and of several other committes of CSIR, DST and various Academic Institutions

S. S. Hasan since 1991 is an Associate of the Harvard College Observatory, Cambridge, U.S.A. He is a member of the editorial board of Journal of Astrophysics and Astronomy. He is also Vice-President of the Astronomical Society of India.

R.C. Kapoor has been elected Treasurer of the Astronomical Society of India for the triennium 2004 - 2006.

Vinod Krishan is a Representative Member of the Commission H on Ionosphere Physics of URSI, 2004. She is also a Member of the Subject Expert Commission on Earth and Atmospheric Sciences for Women Scientist Scheme of the DST. She is on the Scientific Organising Commission for Workshops on Theoretical Plasma Physics held every two years at the Abdus Salam ICTP, Trieste, Italy.

K.N. Nagendra continued to hold the position of "Visiting Professor" at the Observatory of Nice, France, for the 11th consecutive year. He was appointed as a "Technical Specialist", and collaborator in a major French CNRS project organised to be conducted at Nice, and Paris, in France, for a duration of 3 years. He was also elected in August 2003 as a Member of the 'Scientific Organising Committee'of the IAU Commission-36, "Theory of Stellar Atmospheres", for the block period 2003-2006. He became a "Life member" of the Indian Physics Association.

A.K. Saxena continues to serve as an expert member of many national scientific project committees of ISRO, IRDE and BARC. He continues to interact with other Adaptive Optics groups working in the country such as IRDE, Dehradun and Udaipur Solar Observatory. He was on sabbatical leave, as a visiting Professor, from 14th July to 16th December 2003 for a period of 5 months at University of British Columbia, Vancouver, Canada. During this period he worked on the optical design of Large Aperture Mirror Array (LAMA) telescope project.

S.K. Saha is a member of the Editorial Board of Asian Journal of Physics.

J. Singh was invited as a Guest Professor by the National Astronomical Observatory of Japan, Tokyo, Japan for one year (June 2003 - May 2004).

C. Sivaram and Ajay Sastri's book 'Introduction to Astrobiology' (published by Universities Press Ltd in January 2004) received some good reviews. Prof. Julian Chela-Flores who regularly conducts conferences on related subjects in ICTP Trieste, described it as an excellent initiative.

Conferences and Meetings attended

G.C. Anupama attended the conference 'Provocative Universe' held at IUCAA, Pune during 2003 June 30–July 2 in honour of Professor J.V. Narlikar. She also attended the International Workshop 'Supernovae and their Connections to gamma-ray Bursts and Pulsars,' Mumbai, India, 19–23 January 2004.

P. Bhattacharjee attended the international workshop on "Supernovae, their connections to Gamma ray Bursts and Pulsars", TIFR, Mumbai, Jan 19–23, 2004, and gave an invited talk. He attended the IUCAA-IITKgp Workshop on High-Energy Astrophysics (HEAP 04), Centre for Theoretical Studies, IITKgp, February 23–25, 2004, and gave an invited talk.

Christina Birdie attended the workshop on "Semantic Web" organized by DRTC at Bangalore in Dec 2003. She also attended "International Conference on Digital Libraries" held at New Delhi in Feb 2004 organized by Tata Energy Resources Institute, New Delhi. Ms. Christina Birdie attended the 24th IATUL conference held at Ankara, Turkey from 2-5 June 2003 and presented two papers. She attended the 94th Special Libraries Association, annual conference held at New York, from June 6-12, 2003. She was presented with the Award of "Diversity Leadership Development" during a special ceremony organized by SLA at the University Club, New York on the 7th June 2003.

R. Cowsik attended the 150th anniversary of The Washington University in St. Louis, September 2003, 'Dark Matter in The Accelerating Universe' was the title of his talk.

R.T. Gangadhara attended XXVth IAU General Assembly, which was held during 13-26 July, 2003 in Sydney, Australia, and made an oral presentation on "Pulsar radio emission from relativistic phase shift". He also attended the scientific workshop on "Supernovae and their connections to gamma-ray bursts and pulsars" at TIFR, Mumbai, between January 19th to 23th, 2004 and made a oral presentation on "Radio studies and Pulsar magnetospheres".

S. Giridhar attended XIII National Space Science Symposium conducted at Kottayam, Kerala during Feb 17-20,2004.

A. Goswami attended the IAU Coll. 193, on 'Variable stars in the local group' Christchurch, New Zealand, July 4-9, 2003 and presented a paper titled 'Chemical compositions and circumstellar environment of the variable star QY Sge'.

S.S. Gupta as a senate member of the Bharathidasan University, Tiruchirapalli, attended the annual meeting of the senate on June 21, 2003 and the 20th annual convocation September 2, 2003. At the Mother Teresa Women's University, Kodiakanal - he attended the "Board of studies meeting - Physics" on May 23, 2003. As an examiner he conducted the "Board meeting' on September 9, 2003 to declare the results of M.Sc., Physics degree examination. He attended the "Technical committee meeting of the Physics dept." on January 1, 2004.

K.M. Hiremath participated in the XIII National Space Science Symposium, 17-20 Feb, 2004, Kottayam, Kerala.

B. Raghavendra Prasad chaired a session on "Nanostructures", Indo-Japan workshop on 'Advanced Molecular Electronics and Bionics', 11-13 Dec. 2003, LSSE Kyushu Institute of Technology, Kitakyushu, Japan.

K.N. Nagendra attended a one day Conference in Jan 2004, called "The Quantum Festival" at Bangalore University, Physics Dept., and served as a Judge for students' poster presentation competition. He also participated in the 'Indian Physics Association' (Karnataka Chapter) General body meeting, and served as a Judge for the state level 'Bondade Memorial Lecture Competition' for MSc, and PhD students.

G. Ramachandran attended Quantum Festival, Guest Lecture Series on Special Aspects of Quantum Mechanics, November 7-8, 2003 organised by Department of Physics, Bangalore University and gave an invited talk entitled : "A Very short course on QED".

S. K. Saha attended Scientific conference on 'Engineering Optics', at CCS University, Meerut, UP, April, 2003 and chaired a session of the Physical Sciences at the 91st Session of Indian Science Congress, Chandigarh, January, 2004.

Jagdev Singh attended the Hida Observatory meeting on 'High resolution solar instrumentation and magnetic fields' held at Kyoto University in the year 2004; The Solar-B Mission and the Forefront of Solar Physics: The Fifth Solar-B Science Meeting, Tokyo, Japan and the annual meeting of Astronomical Society of Japan held at Nagoya, Japan in 2004.

J. H. Sastri participated in the XIII National Space Science Symposium (NSSS-2004) held in MG University, Kottayam during 17-20 February 2004.

K.R. Subramanian attended URSI - INCURSSI 2004 held at New Delhi, November 27-29, 2003 and gave an invited talk on the 32 channel digital correlator system for the Brazilian Decimetric array.

A. Vagiswari attended the workshop on "Forging Collaborative Partnerships: Consortium of Libraries of DAE Institutions and FORSA Member Libraries Meet" organized at TIFR, Mumbai on 28-30 July 2003. She was the chairperson of the technical session on "FORSA Experience".

Invited talks, seminars etc.

G.C. Anupama gave an invited talk "Supernovae of Type Ia: Observational properties and their cosmological use": 30 June 2003 at the Conference 'Provocative Universe,' Pune. She also gave an Invited talk at "The optical observations of SN 2002ap": 20 January 2004 at the Workshop 'Supernovae and their Connections to γ-ray Bursts and Pulsars,' Mumbai, India, 19–23 January 2004 and a Conference Summary: at the Workshop 'Supernovae and their Connections to gamma-ray Bursts and Pulsars,' Mumbai, India, 19–23 January 2004. G.C. Anupama gave talks on "Supernovae of type Ia: Observational properties and their cosmological use": 9 November 2003, HRI, Allahabad. "Astronomy from High Altitudes: The Indian Astronomical Observatory": 15 November 2003, HRI, Allahabad. "The nebular remnant of nova GK Persei": 17 December 2003 at CREST, Hosakote.

S.P. Bagare gave a series of three invited lectures in astrophysics at the '21st Refresher course in Physics,' organized by the UGC Academic Staff College and the PG Dept of Physics, University of Mysore, during July 2003. He participated in the National Space Science Symposium held at Kottayam during 17-20 Feb 2004, and gave an invited talk titled 'Total solar eclipse observations from Antarctica', 23 November 2003. He also gave three invited lectures titled 'Physics of The Sun and the Solar System', 'Role of Spectroscopy in Astrophysics', and 'Observational facilities in India for Astronomy and Astrophysics,' in a UGC sponsered course at the PG Dept of Physics, Dr Babasaheb Ambedkar Marathwada University, Aurangabad, during March 14-17, 2004.

H.C. Bhatt visited the State Observatory, Nainital and gave the following talks: (i) Vega-like stars: 16 May, 2003(ii) Star formation I: 16 May, 2003 (iii) Star formation II: 17 May, 2003 (iv) Magnetic fields in cometary globules: 17 October, 2003.

P. Bhattacharjee gave a Physics Colloquium at the Institute of Mathematical Sciences (IMSc), Chennai, 20 May 2003 Ultrahigh Energy Cosmic Rays: New Physics or Extreme Astrophysics ? He gave a colloquium at Saha Institute of Nuclear Physics (SINP), Kolkata, 11 June 2003 'Origin of Ultrahigh Energy Cosmic Rays: New Physics or Extreme Astrophysics' ?

V.K. Gaur gave invited lectures at more than a dozen institutions in the country as well as at Ecole Normale Superieur, Paris, Institute the Physique de Globe, Paris, and Cambridge University, U.K.

S. Giridhar attended XIII National Space Science Symposium conducted at Kottayam, Kerala during Feb 17-20,2004. She was invited to give a review on "Pre-Main Sequence Stars" at the symposium.

S.S. Gupta gave : three invited lectures in the IUCAA, Pune sponsored "Introductory school on Astronomy and Astrophysics (ISAA), Sept. 22-26, 03", at The American College, Madurai; Two lectures on "The Solar Interior and Atmosphere", "Antarctic Total Solar Eclipse Expedition, Nov. 23, 2003, and valedictory address at the UGC-Refresher course in Physics, Nov. 27-Dec. 17, 03, UGC Refresher Course Center, Physics Dept., Gandhigram Rural Institute - Deemed University, Gandhigram; UGC sponsored guest lecture on "The Solar Corona - Antarctic Total Solar Eclipse Expedition, Nov. 23, 2003" at The Madura College, Madurai, on January 30, 2004 and at the P.G. Physics Association, Physics dept., The American College, Madurai, on March 23, 2004.

K.M. Hiremath gave an invited talk at the SOC of XIII National Space Science symposium on "Structure and Dynamics of the solar interior inferred from Helioseismic studies".

Vinod Krishan delivered the following lectures : Structure Formation through Inverse Cascade at IUCAA, Pune, May 29, 2003; Microbursts from the Radio Sun, during National Symposium on Plasma Physics, Ranchi, November 2003; Self organisation processes in Astrophysics Arena, during Autumn School in Plasma Physics at Abdus Salam ICTP, October 2003.

P.M.S. Namboodiri has participated by invitation in a workshop on "Galaxies: Structure and Dynamics" sponsored by IUCAA at the Department of Astronomy, Osmania University, Hyderabad during 19 - 22, January 2004 and gave an invited talk on "N-body simulations of interacting galaxies" and chaired one session.

S. K. Saha gave the following talks : An invited talk entitled, 'High resolution imaging by employing passive and active approaches', delivered at the Conference on 'Engineering Optics' dedicated to the 60th birth day celebration of Prof R. S. Sirohi, Director, IIT, Delhi on 6th April, 2003 at CCS University, Meerut, UP; 'Single aperture diffraction-limited imaging' - at the Indian Institute of Technology, Delhi, on 8th April, 2003; Invited talk on 'Applications of adaptive optics in astronomy' delivered at the Instruments Research & development Establishment, DRDO, Dehra Dun, on 27th October, 2003; A series of 3 invited lectures on 'Applications of the techniques of coherent optics to Astronomy' at the SERC School on 'Coherent Optics', Baroda MS University, Baroda, December, 2003; Invited talk delivered on 'Astronomical imaging by employing optical interferometry: the future' at the 91st Session of Indian Science Congress, Chandigarh, January, 2004.

J. H. Sastri gave a review talk on 'Space Weather Issues' in the XIII National Space Science Symposium (NSSS-2004) held in MG Univeristy, Kottayam during 17-20 February 2004.

A.K. Saxena delivered a talk on "Long Trace Profilometer" at Univeristy of Stony Brooks, USA. He also delivered a talk on "Setting up of Large Telescopes in India", at University of British Columbia.

J. Singh gave an invited talk on "Spectroscopic studies of steady coronal structures- Linewidth variations with height of Fe x - xiv emission lines in the Solar-B Mission meeting and another talk on "Line-width variations of coronal emission lines with height above the limb", at the Astronomy Department, Kyoto University, Kyoto, Japan.

C. Sivaram gave invited talks on : 'Frontiers in Physics and Astrophysics' at the Symposium on 'Frontiers of Science and Technology, Yuvaraj College, Mysore, on Jan. 5, 2004 : 'Bioastronomy and detection of extraterrestrial life' Bangalore Science Forum, National College, Feb. 4, 2004.

K.R. Subramanian attended the National Workshop on the Prospects of astronomy research in Universities, held at Rajkot, February 25-27, 2004 and gave an invited talk on the Gauribidanur radio heliograph.

Visits

G.C. Anupama visited Harish-Chandra Research Institute, Allahabad, during 2003 November 9–18 and the Osmania University, Hyderabad, 16-17 March 2004.

H.C. Bhatt visited the State Observatory, Nainital and gave talks during May 16-17, 2003.

P. Bhattacharjee visited IMSc., Chennai, during 19–24 May, 2003. He also visited SINP, Kolkata, during 9–14 June, 2003, and gave the Institute colloquium.

B.P. Das visited Eotvos Lorand University,Budapest,Hungary (July-August 2003).

S.S. Hasan visited the Institute for Theoretical Astronomy, University of Heidelberg, Germany (April-May 2003); Centre for Plasma Astrophysics, Leuven, Belgium (May 2003) where he gave a seminar on "Dynamics of the Magnetic Chromosphere on the Sun"; Kiepenheuer Institute, Freiburg, Germany (May 2003) where he gave a seminar on "Waves in the Solar Magnetic Network"; Paris Observatory, Meudon, France (October 2003); Laboratoire d'Astrophysique, Toulouse, France (October 2003); Observatoire de la Cote d'Azur, Nice, France (October 2003).

U.S. Kamath visited Nicolaus Copernicus Astronomical Center, Warsaw, Poland in July 2003 under Indo-Polish Scientists Exchange Programme for collaborative work on Symbiotic Stars.

K.N. Nagendra was invited to Observatoire de Nice, France, for two months during August-September, 2003, to continue ongoing collaboration. He also visited 'Infosys Technologies' training center at Mysore, and studied the planning and operations of the High Quality Conference facilities, Working environment, and outdoor facilities for trainees and employees at the Campus (Oct. 2003).

R. Vasundhara visited 'Institute de méchanique céleste et de calcul des éphémérides, Paris, during March 22 - April 21, 2004.

Teaching and Guidance

G.C. Anupama served as a resource lecturer at the Summer School in Astrophysics conducted by the M.P. Birla Institute of Fundamental Research, in April 2003. She also served as a resource lecturer at the Summer School conducted by the Jawaharlal Nehru Planetarium, Bangalore in May 2003.

S. P. Bagare gave guest lectures on topics in Solar Physics, at the PG Dept. of Physics, BUB, during Jan. 2004. He continued as Co-guide to two students of Physics Research Centre, Virudhunagar, under the Madurai Kamaraj University.

S. Giridhar guided a project student Ms Annie George with her project on 'Stellar Radial Velocities and its Applications' that was towards partial fulfillment of the requirements for the award of M. Sc. in Physics. Giridhar gave two lectures to Summer school students on the 'Overview of the Stellar Astronomy' during May 2003.

A. Goswami supervised a summer project student during May -July 2003 on the topic 'Spectral classification from low resolution spectroscopy'.

K.M. Hiremath guided a summer school student Annie George of final year M.Sc (Physics) C.M.S College, Kottayam, Kerala on the project "Influence of the solar activity on the Indian Monsoon rainfall".

Mr. Jayesh Raj (UP Technical University, Lucknow) successfully completed his project titled " CCD photometry of the open cluster NGC 7655 in UBV passbands and estimation of cluster parameters" under the guidance of **T.P. Prabhu and A. Subramaniam** in July-August 2003.

A. Mangalam delivered a couple of lectures to the summer school students during May 2003 on "Galactic Dynamics". A. Mangalam is a part of the REAP training and research program held by the Bangalore Association for Science Education (BASE), Nehru Planetarium for undergraduate students in Physics in which IIA is a participating institute. He taught a 35 lecture graduate course (with tutorials) on Electrodynamics from Sept 2003 to February 2004 at the Nehru Planetarium for senior B.Sc, Engg and M.Sc students. About 50 problems were given as assignments and discussed in class. A. Mangalam was one of the coordinators of the Summer School program at IIA in 2003 which involves selection and organization of the lecture programme. He was also involved in the selection of students for the Summer School in 2004.

K.N. Nagendra guided an M.Sc. student under the SPSP-Program (the Summer Project Students Program) organized by the BGS. The duration of Guidance was 3 months (May 2003-July 2003).

G. Ramachandran gave a semester course of lectures on "Quantum Electrodynamics" to senior M.Sc Physics students of Bangalore University (2003-04) and guided two students under the Summer Project Students Programme organised by the B.G.S.

C. Sivaram gave the following lectures : "Introduction to Astronomy" : Invited Talk - the Indian Physics, Teacher's Association, August 29, 2003; "Astrobiology" : Invited Talk - BASE : J.N. Planetarium, May 21, 2003; "Nobel Prizes in Physics for 2003" : Invited Talk - Indian Physics, Teacher's Association, Dec. 16, 2003; "Birth and Death of Stars" : Nijalingappa College, Rajajinagar, Oct. 11, 2003; Two radio talks (1) "Astrobiology" Oct. 5 (2) "Slowing down of light and faster than light experiment" Nov. 12, 2003 Twenty talks were given over the year for the certificate course on astronomy and astrophysics conducted by the Birla Institute of Fundamental Research. These were during the months of April, May, August and September, 2003. Two lectures were given at the refresher course conducted by Mysore Univ., Physics Dept., July 2003. Several other lectures were given to students in different colleges on special topics. C. Sivaram also taught the JAP course 'General Relativity and Cosmology' (25 lectures) and gave a Course 'General Relativity and Cosmology' for 2nd year M.Sc. students, Bangalore University, Dept. of Physics, Jan-May, 2004. (20 lectures).

Ms. P. Vijitha (Mother Teresa Women's University, Kodaikanal), is doing her project under the guidance of **A. Subramaniam** from December 2003. This will be completed in mid April 2004. The project is titled " UBV photometry of the open cluster NGC 146".

A. Subramaniam taught the JAP course titled "Observational Techniques - optical, IR and UV astronomy", for the students from JAP, RRI and ISRO. The students were also taken to CREST, Hosakote and VBO, Kavalur, as part of the course. She guided Mr. Claudy Rayan Serrao (Mangalore University) to complete a summer project in May-June 2003. The title of the project was "A study of age and density of stars in the LMC". The project comprised of estimating the density structure of the LMC bar region, for stars belonging to various age groups. The age of the last star formation event in the central region were also estimated and this was used to locate regions which experienced the latest star formation.

K.R. Subramanian taught a course in radio astronomy as guest faculty at the Department of Physics, Bangalore University and served as member of PG exams in Physics, BUB.

K. Sundara Raman evaluated and conducted viva examination of two students who did their M Phil thesis of St. Joseph College, affliated with Bharathidasan University, Trichy and also guided an M.Sc Physics student of St Joseph's College, Trichy in the dissertation titled 'Occurrence of Solar Flares related to sunspot area' during November 2003- March 2004. He also evaluated the answer scripts of the III semester M Sc. (Physics) students of Mother Teresa University, Kodaikanal.

Involvement with Scientific Community, national and international Programmes

G.C. Anupama is a co-PI of the project "Symbiotic binary stars and related objects" approved under the Indo-Polish Exchange Programme. She was a Member of the Organising Committee of the International Workshop "Supernovae and their Connections to gamma-ray Bursts and Pulsars", Mumbai, India, 19–23 January 2004.She is also a member of the Expert Committee constituted by the UGC to review the CAS/DSA Phase-III/IV programme in the Department of Astronomy, Osmania University, Hyderabad.

H.C. Bhatt served as Editor, Bulletin ASI; Member, GMRT Time Allocation Committee; Gave lectures at the The Jawaharlal Nehru Planetarium, Bangalore under the REAP Programme; Examined PhD theses for Kumaun University, Nainital and Osmania University, Hyderabad.

P. Bhattacharjee served on the DST's Experts' panel for evaluating major research proposals. He served as a member of the National Organizing Committee (NOC) of the 16th DAE High Energy Physics (HEP) symposium to be held at Saha Institute of Nuclear Physics (SINP), Kolkata, during 29 Nov – 3 Dec 2004. He is also currently serving as a member of the Organizing Committee of the 29th International Cosmic Ray Conference (ICRC-2005) to be held in Pune, India, in August 2005. He continues to serve in the Panel of Referees for the journals 'Physical Review Letters', 'Physical Review D' and 'Pramana', and has refereed a number of papers for these as well as several other journals. He has been an examiner for a Ph.D. thesis submitted to Utkal University, Bhubaneswar.

S. Giridhar continues to serve as Principal Investigator for a DST sponsored Indo-Max collaborative program and her Mexican collaborator A. Arellano Ferro visited IIA, Bangalore during April-May 2003. He participated in photometric observations with HCT which were made using the remote observation facility at CREST, Hosakote during May 8-10, 2003.

S.S. Hasan is the Indian Principal Investigator of an Indo-French programme on "Dynamics of Solar and Stellar interiors: Seismology and Activity" since October 1, 2001. This is a collaborative programme between IIA and TIFR from the Indian side and Observatoire de Paris, Laboratoire d'Astrophysics (Toulouse) and Observatoire de Cote d'Azur (Nice) on the French side.

K. N. Nagendra in Dec 2003, organized a 3 weeks visit of Prof. Helene Frisch, Research Director of the Observatory of Nice, France, to IIA. Follow up collaboration with Helene Frisch is under progress.

P.M.S. Namboodiri has been an examiner for M.Sc. Astronomy examination of Osmania University, Hyderabad.

J. H. Sastri served as a Member of the Scientific Advisory Committee of Space Physics Laboratory (SPL) of VSSC/ISRO, Trivandrum.

K.N. Nagendra has been a referee for the DST funded Research Project submitted by a Faculty Member of the Physics Department, Bangalore University. He also served as a one member 'specialist consultant' to approve certain proposals by another Faculty Member of the Physics Department, Bangalore University, for procuring Laboratory Equipments for creating new research facilities for MSc and PhD students.

Major organizational efforts

Indian expedition to Maitri in Antarctica for observations during the total solar eclipse of 23 November 2003.

An Indian team of scientists comprising of S.P.Bagare (IIA), S.M.Bhandari (SAC, Ahmedabad), S.S.Gupta (IIA), Ramesh Chandra (SO, Nainital), and V.K.Verma (SO), undertook a scientific expedition to the windy and icy continent of Antarctica during November-December 2003, to carry out observations during the total solar eclipse of 23 November 2003. The risk of poor sky conditions and the very low (almost horizon grazing) altitude of the

Sun at totality notwithstanding, the Department of Ocean Development (DOD) supported the expedition. The various organizational aspects of the entire expedition were co-ordinated by Dr Harsh K. Gupta (Secretary, DOD), Dr P.C.Pandey (Director, NCAOR, Goa), Mr T.V.P. Bhaskara Rao (Director-Logistics, NCAOR), Dr N.Khare (Programme Director, NCAOR). The Indian High Commission in Cape Town provided the enroute support. The local logistics and the warmth of encouragement in an otherwise cold and unfriendly surrounding was provided by the Wintering team at the Indian Station Maitri, led by the Station Commander Dr A.N.Hanchinal. The participating institutions, IIA Bangalore, State Observatory (Now ARIES) Nainital, and SAC Ahmedabad, provided the scientific equipment and logistic support within India. The solar observations planned by the team were co-ordinated and led by S.P.Bagare, while the aerosole observations were planned and conducted by S.M.Bhandari.

The following observations were planned and carried out;

*Broad band photometry (video and digicam recording) during totality,
*Narrow band CCD imaging of the corona during totality,
*Video recording of the shadow band phenomenon, at 2nd and 3rd contacts, and Sun photometer recordings for aerosole studies.

All the instruments were assembled and tested at Maitri, six days before the eclipse. Following a stormy weather in the ensuing days, the skies cleared on the 23rd. All the instruments were moved to the selected location about 25 km south of Maitri, on the glacier. The ambient temperature was around -20 K with heavy winds of over 100 km/hour. The sky was clear and a rare, rather historical and glorious totality was observed and recorded. The highlights of the observations obtained are as follows:

A continuous video recording of the diamond rings and the broad band corona during totality, at the rate of 25 frames per second, was successful. The narrow band images were recorded but the ground scatter from drifting snow and the heavy wind condensations seem to have affected this observation. The shadow band recording was extremely successful with the bands clearly recorded for a duration of close to 11 minutes. Sun photometer recordings were also obtained, before, during, and after the totality. The details for the first three observations are given under Sun and Solar System in the 'Scientific Research' section of this report.

The team members were invited to a meeting of the Parliamentary Advisory Board for DOD, chaired by the honourable Minister for HRD, DOD, and DST, in New Delhi on 10 Jan 2004. S.P.Bagare was invited to present the highlights of the eclipse observations. The successful efforts of the team and the support extended by DOD were specially commended by the Board.

(S.P. Bagare and S.S. Gupta)

Colloquia and talks given by visitors

14 August 2003
Space Interferometry Mission: Planets & More
Shrinivas Kulkarni
California Institute of Technology , USA

5 September 2003
Param padma : The teraflop supercomputer architecture and its environment for high performance computing
Dr Subrata Chattopadhyay
Head, Centre for Tera Scale facilities, Centre for development of advanced computing

28 October 2003
Multi -site spectroscopic observations in stellar physics
Claude Catala
Observatoire de Paris, Lesia, France

2 December 2003
Solar active region oscillations as seen from SOHO,Trace & Spirit
Dipankar Banerjee
Centre for Plasma Astrophysics, K.U.Leuven, Belgium

3 December 2003
Magneto convection in rotating solar convection
S. Tagare
Shadan Institute of Post Graduate Studies, Khairatabad

23 December 2003
How Technologies become common place
Rajesh K. Kochhar
NISTADS : National Institute for Science Technology and Development Studies, New Delhi.

26 December 2003
High resolution emission- line spectroscopy: Implications for line identifications and element abundances
Robert Williams
Space Telescope Science Institute, USA

9 January 2004
Holes in the sky : The Sunyaev - Zeldovich effect
Subhabrata Majumdar
Canadian Institute for Theoretical Astrophysics (CITA), Toronto, Canada

13 January 2004
Differntially rotating magnetized neutron stars
Arun . V.Thampan
SISSA, Trieste,Italy

30 January 2004
Cosmological dark matter and dark energy from cosmic QCD phase transition
Sanjay .K.Ghosh
Department of Physics, Bose Institute, Kolkata

11 February 2004
UV remote sensing of the upper atmosphere
Dr Robert McCoy
Naval Research Office, USA

17 February 2004
Clustering of galaxies in the non - linear regime
Jasjeet Singh Bagla
Harish - Chandra Research Institute, Allahabad

APPENDIXES

Publications

Journals

Ambika S, Parthasarathy M, *Aoki W, *Fujii T, *Nakada Y, *Ita Y, *Izumiura H, (2004) A&A, 417, 293
Chemical composition of UV-bright star ZNG4 in the globular cluster M13.

*Arellano Ferro A, Giridhar S, (2003) A&A, 408, L29.
HD34700: A new T Tauri double - line spectroscopic binary.

Aruna Goswami, Kameswara Rao N, *Lambert D L, (2004) The Observatory, 124, 47.
A high-resolution spectral analysis of the supergiant HD 165553.

*Balachandra Kumar K, Bagare S P, *Rajamanickam N, (2004) Astrophysics and Space Science, 289, 9.
Molecular parameters for D,E,F, and G to A band systems of the astrophysically significant systems of AlF.

*Balachandra Kumar K, *Rajamanickam N, Bagare S P, *Fernendo Gomez M, *Lopez Gonzalez J J, (2003) Astroparticle Physics, 20, 67.
FC factors and r-centroids for astrophysically significant band systems of AlF.

*Basu R, Bhattacharjee P, (2004) Physical Review D 70, 023510.
On the injection spectrum of ultrahigh energy cosmic rays in the top-down scenario.

Bhatt H C, Maheswar G, Manoj P, (2004) MNRAS, 348, 83.
Magnetic fields in cometary globules - III. CG 12.

Bhattacharjee P, (2004) Proc. Indian National Science Academy (INSA), 70A, 135.
Neutrinos and origin of ultrahigh energy cosmic rays.

*Bhattacharjee P, *Gupta N, (2004) Pramana, 62, 789.
Ultrahigh energy cosmic rays and prompt TeV gamma rays from gamma ray bursts.

*Caroline Taylor, Rajat K, Chaudhuri, *Karl F, Freed (2004) J. Chem Phys. (in press).
Ground and excited state potential energy surfaces of Ca OH; evidence for a high lying covalent state.

Chiranjib Sur, Rajat K. Chaudhuri, (2004), (J. Phys. B), 37, 4127.
Relativistic coupled cluster calculation of core ionization potential using normal and semi normal ordered exponential ansatz.

Das B P, Latha K V P, Sahoo B K, Sur C, Chaudhuri R K, Mukherjee D, (2004) J. Theoretical and Computational Chemistry, (in press).
Relativistic and correlation effects in atoms.

Gangadhara R T, (2004) ApJ, (in press).
Pulsar radio emission altitude from curvature radiation (astro-ph/0312081).

Gangadhara R T, Krishan V, (2003) Pramana, 61, 1203.
Centrifugal acceleration of plasma in pulsar magnetosphere.

* Collaborators from other institutions

Gauba G, Parthasarathy M, (2003) A&A, 407, 1007.
UV (IUE) spectra of hot post-AGB candidates.

Gauba G, Parthasarathy M, (2004) A&A, 417, 201.
Circumstellar dust shells of hot post-AGB stars.

Gupta S, *Rai S S, *Prakasam K S, *Srinagesh D, *Chaddha R K, *Priesley K, Gaur V K, (2003) Current Science, Vol. 84, No. 9, 1219.
First Evidence for an Anomalously thick Crust beneath mid-Archaean Western Dharwar Craton.

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Sky conditions

Vainu Bappu Observatory, Kavalur

Time Allocation during 2003-04

I. VBT		Total No. of Proposals received	39
	a.	No. of Spectroscopic Proposals	25
	b.	No. of Photometric Proposals	12
	c.	No. of target of opportunity proposals	2
	d.	Total No. of Nights requested	373
	e.	No. of Nights requested for Spectroscopic work	252
	f.	No. of Nights requested for Photometric Work	121

Sky conditions at Vainu Bappu Observatory

Year	Month	Spectroscopic Hours	Photometric Hours
2003	April	150	15
	May	87	0
	June	28	0
	July	2	0
	August	13	0
	September	32	0
	October	37	0
	November	54	0
	December	163	40
2004	January	148	69
	February	250	112
	March	247	41
	Total	1211	277

Sky conditions at Indian Astronomical Observatory, Hanle

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2003	April	121	145	240
	May	97	131	217
	June	117	137	210
	July	59	118	217
	August	32	126	248
	September	128	173	270
	October	247	269	310
	November	229	253	330
	December	194	227	341
2004	January	77	134	341
	February	188	232	290
	March	139	236	279
	Total	1623	2181	3283

Kodaikanal Observatory

Spectro / Photoheliograms and Seeing Conditions at Kodaikanal

Year	Month	No. of photographs in				Seeing*				
		Hα	Kfl	HαPr	PHGM	5	4	3	2	1
2003	April	21	21	–	23	–	1	16	5	1
	May	15	15	–	23	–	5	10	5	3
	June	11	11	–	22	–	1	12	8	1
	July	4	4	–	7	–	3	4	–	–
	August	8	8	–	19	–	1	17	1	–
	September	19	19	–	22	1	7	12	2	–
	October	12	9	–	17	3	2	4	8	–
	November	4	4	–	14	1	3	7	3	–
	December	18	18	–	24	–	17	7	–	–
2004	January	28	28	–	29	–	14	15	–	–
	February	23	23	–	25	–	10	12	3	–
	March	21	23	–	31	–	7	21	3	–
	Total	184	183	–	256	5	71	137	38	5

Kfl = K–flocculus
HαPr = Hα 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 arc sec) 2	2 to 3	3	3 to 4	4	4 to 5	>5 poor
2003	April	18	1	2	12	–	3	–	–
	May	5	1	–	4	–	–	–	–
	June	5	–	–	2	–	3	–	–
	July	7	–	–	1	–	5	–	1
	August	8	–	–	–	–	5	1	2
	September	5	–	–	2	–	2	1	–
	October	5	1	1	3	–	–	–	–
	November	13	–	–	4	2	5	1	1
	December	10	–	–	3	–	5	–	2
2004	January	19	1	1	7	1	6	2	1
	February	13	1	–	3	4	4	1	–
	March	17	–	–	8	4	4	–	1
	Total	125	5	4	49	11	42	6	8