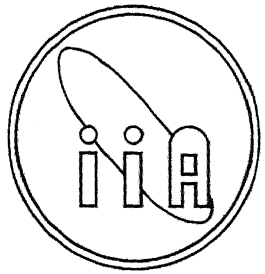
Indian Institute of Astrophysics

Academic Report : 2004-05

INDIAN INSTITUTE OF ASTROPHYSICS



ANNUAL REPORT
2004-05

Indian Institute of Astrophysics
Annual Report : 1-4-2004 – 31-3-2005

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Front Cover : The first telescope of the 7-Unit Himalayan Gamma Ray (HAGAR) Telescope.

Back Cover : Comet 2004 Q2 (Machholz), photographed on the 15th Jan 2005 at 14:00 UT on a 400 ASA Kodak Film in a camera mounted on a 10 cm auxiliary telescope of the 102 cm Zeiss Telescope at the Vainu Bappu Observatory; exposure time : 102 min.

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CONTENTS

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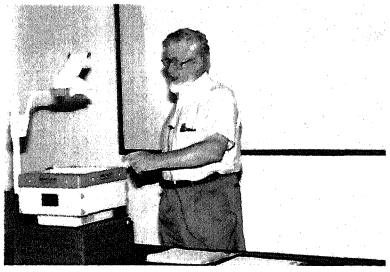
New Honorary Fellow

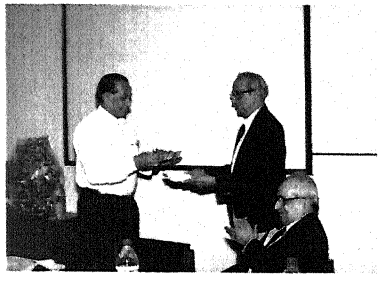
The Council invited **Professor David L.Lambert** to be the Honorary Fellow of the Institute. He is currently the Director of the McDonald Observatory, Texas, Austin, USA.



Vainu Bappu Chair

In memory of Professor M.K. Vainu Bappu, the founder Director of the Indian Institute of Astrophysics, a pioneer in modern Indian optical astronomy and past President of the International Astronomical Union (1979-1982), the Governing Council decided to create a Chair viz. the 'Vainu Bappu Distinguished Professor' to invite distinguished scientists of international strature to this Chair.

Professor Ramanath Cowsik, Department of Physics, Washington University, St Louis, USA was invited as the first Vainu Bappu Distinguised Professor for five years from 1.9.2004.



L to R : Profs. Ramanath Cowsik, B.V. Sreekantan, Chairman Governing Council of IIA and J.C. Bhattacharyya, Member Governing Council.

Honours & Awards :

Ramanath Cowsik

- Elected to the prestigious Foreign Associateship of the National Academy of Sciences, USA.

Jagdev Singh

- Presented the Scientific Achievement Award by the National Astronomical Observatory of Japan, Tokyo, Japan.

C. Sivaram

- The paper entitled 'Dark energy, ripping of black holes and entropy' received Honorable Mention at the 2005 essay competition of the Gravity Research Foundation, Mass, (USA).

Shri. Kapil Sibal, Hon'ble Minister of State (Independent Charge) Science and Technology and Ocean Development, visited the CREST Campus on January 12, 2005; with members of the Governing Council and Academic Staff.

The year in review

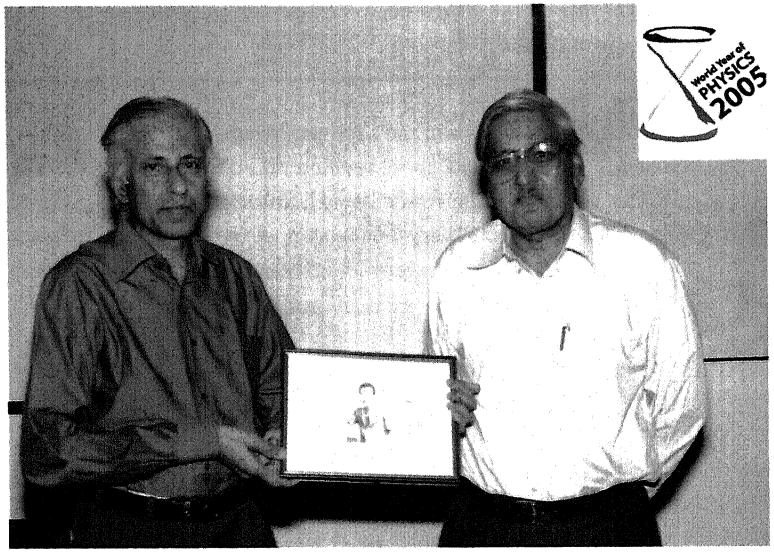
The year in review, 2004-05 witnessed sustained research and development activity at the Institute, interspersed with some momentous events such as the World Year of Physics celebrations, observation of rare astronomical events and related public outreach efforts, awards to individual staff members and so on. The focus of the developmental activity is on the work related to the two major projects of the 10-th plan period: Himalayan Gamma-Ray (HAGAR) telescope, a collaborative project with TIFR, Mumbai, and the Ultra-Violet Imaging Telescope (UVIT) payload for the ASTROSAT mission of the Department of Space, DOS. The first unit of the seven-unit HAGAR telescope has been rigorously tested at Hosakote campus and is readied for shipment to IAO, Hanle for installation there in the summer of 2005. Plans are also drawn to fabricate the other six units of HAGAR and the installation and testing of the entire telescope array is scheduled for the summer of 2006.

Noteworthy progress has been achieved in the design of the various sub-systems of UVIT payload and procurement action for the critical and long-lead time items of the payload. The necessary ground infrastructure, namely, the Test and Calibration Facility (TCF) for the project is fast taking shape at CREST campus, as an integral part of Professor M. G. K. Menon Laboratory for Space Sciences. I am confident that these two projects will be taken to fruition shortly, thereby paving the way for undertaking more ambitious projects by the Institute in the near future, aimed at creating state-of-the art facilities for astronomical research and competitive fundamental science.

The Governing Council of the Institute, comprising of distinguished scientists and senior officials of the Department of Science and Technology provided constant guidance and unreserved encouragement on matters related to scientific programs and management which helped the Institute achieve a high level of overall performance during the year. The Council took two specific measures to enhance the academic profile of the Institute. The first one is the creation of a chair in the memory of Professor M. K.V. Bappu, the founder-Director of the Institute and a former President of the International Astronomical Union (IAU) and invite reputed scientists to the Chair. The second one is the invitation to Professor David Lambert, Director, MacDonald Observatory, USA to the Honorary Fellowship of the Institute. Professor Lambert who has a long-standing association with the R&D activity of Institute has kindly accepted the invitation.

The celebrations of the World Year of Physics (WYP) were Initiated in the institute with the organization of an in-house symposium on 14th March 2005, the birthday of Albert Einstein. Professor B. V. Sreekantan, Chairman, Governing Council delivered the inaugural address. The talks at the meet covered the subjects of the three seminal papers written by Einstein in 1905 and were given by both senior scientists and young researchers. A widely

Prof. B.V. Sreekantan giving the inaugural address of the World Year of Physics 2005 conference at the Institute.



Prof. N. Mukunda was presented the specially prepared Einstein Plaque after his public lecture on 'Einstein's life and legacy' on 14th March 2005 at the Institute.

appreciated element of the symposium was the audio-visual presentation on the life and times of Einstein by IIA students. The day-long meet concluded with an engaging public lecture on 'Einstein's life and legacy' by Professor N. Mukunda of the Center for Theoretical Studies, IISc and Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore. WYP celebrations are continuing at the Institute and some of our academic staff members are also contributing to WYP celebrations of other organizations in a variety of ways.

Our intellectual enrichment through close interaction with distinguished persons from the worlds of public life and science on their visits to the Institute continued during the year in review. Sri Kapil Sibal, Honorable Minister of State (Independent Charge) for Science & Technology and Ocean Development, Government of India, visited CREST campus and interacted for well over three hours with scientists and students of the Institute. He was delighted to see a live demonstration of the remote operations of the 2-m

Presentation of the book 'Chandra' to Sri Kapil Sibal, Honorable Minister of Stat (Independent Charge) for Science & Technology and Ocean Development, Governmer of India.

Unveiling of the HAGAR plaque by Sri Kapil Sibal, Honorable Minister of Sta (Independent Charge) for Science & Technology and Ocean Development, Governme of India.

A delegation led by Prof. E.L. Winnacher, President German Research Foundation with Prof. Hacker, Vice President GRF visited IIA on November 05, 2004. The visit was organized by the DST.

Himalayan Chandra Telescope (HCT) at IAO, Hanle and expressed a keen desire to visit Hanle at the earliest possibility. We earnestly look forward to his visit.

Scientific research was conducted at the Institute with vigor and commitment covering a wide range 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 a sizeable number 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 our academic pursuits. The interested reader is referred to the later parts of this report for the manifold details.

L-R Ms. Yee Yee Oo (Research Scholar ICCR), Prof. K.N. Nagendra, Prof. M. Parthasarathy, Mr. Myo Nyunt (Deputy Minister of Higher Education, Myanmar), Dr. Soe Yin (Rector, Yangon University, Myanmar), Dr. Thein Myint (Director General, Higher Education Cupper Myanmar, Myanmar), Prof. G. Ramachandran

The contributions of scientists of the Institute continue to receive wide-spread appreciation of peers and recognition by academic bodies. The most significant of the latter category is the election of Professor Ramanath Cowsik, Distinguished Professor, to the National Academy of Sciences, USA as its Foreign Associate. He is one of the handful of Indian scientists to have earned this prestigious election. Professor Cowsik has kindly accepted the invitation of the Governing council to the 'Vainu Bappu Chair' at the Institute for a 5-year period.

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 data thus obtained are used to address a multitude of research problems. The 2-m Himalayan Chandra Telescope (HCT) at IAO, Hanle was fully operational and the telescope time was oversubscribed by a factor of 2.5. HCT observations have started yielding scientific returns with 8 papers published in refereed journals during the year. IAO, Hanle is also developing into a multi-science center with effective utilization of the facilities created there for observations, both continuous and long-term type and short-period campaign type, in geophysics and atmospheric science by researchers from other organizations and also our Institute.

Work aimed at development of data archiving and analysis software for the Indo-Israel TAUVEX project continued. The TAUVEX payload is expected to be launched by ISRO, DOS in 2006. This hands-on experience with TAUVEX data analysis is to serve as the launch pad for handling data from the UVIT payload of ASTROSAT.

Concerted efforts to identify, motivate and nurture bright youngsters to take up scientific research continued through organization of the annual Summer School in Physics and Astrophysics at Kodaikanal, in-house Ph.D program and the inter-institutional programs, JAP and JEST, and so also the scheme to train promising young engineers on advanced technology projects. These measures are expected to provide the human resources for the future scientific programs of the Institute as well as of other organizations in the country. Plans are drawn to meet the long-standing requirement of adequate floor space for working and living and other infrastructure facilities in the Koramangala campus, through the construction of the Science Center Complex in the BDA land adjacent to the campus.

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.

Venus Transit, June 8, 2004, visitors in queue to have a glimpse of the eve

The transit of Venus on June 8, 2004 provided not only an opportunity observe a rare celestial event but also mount an effective public outrea program because of its educational value. Observational facilities we accordingly geared up for the event at the Kodaikanal and Bangalore campus of the Institute. The Venus transit proved a big draw and the spectacle w witnessed and appreciated by thousands of visitors from all walks of life.

I wish to conclude this overview on the hopeful note that the saga of vibr scientific research and achievement continues at the Institute in the years come.

J. H. Sastri

Acting Director

The M.G.K. Menon Laboratory for Space Sciences, work in progress.

Recognitions

S.P. Bagare and S.S.Gupta received letters of citation and mementos from the Secretary, Department of Ocean Development, Government of India, during a special ceremony held at NCAOR, Goa in Nov 2004, in recognition of their successful participation in the Special Indian Expedition to Antarctica for the observation of the total solar eclipse of 23 Nov 2003.

S.P.Bagare was elected Leader of the Working Group on Solar Physics, for the proposed Indian participation in the International Heliospherical Year 2007, at a National Workshop held at RAC, Ooty, in July 2004.

H.C. Bhatt and Jagdev Singh were invited to ARIES, Nainital as "Adjunct Professor".

S.S.Gupta was nominated as a Senate Member of the Bharathidasan University, Tiruchirapalli for a 3-year (21/6/01 04) term by the Governor of Tamil Nadu.

Sujan Sengupta was a awarded visiting associate research fellowship for a period of six months in 2004 by Academic Sinica, Institute of Astronomy and Astrophysics, Taipei, Taiwan. He has been elected as a member of the International Astronomical Union (IAU), Division IV (Commission 36).

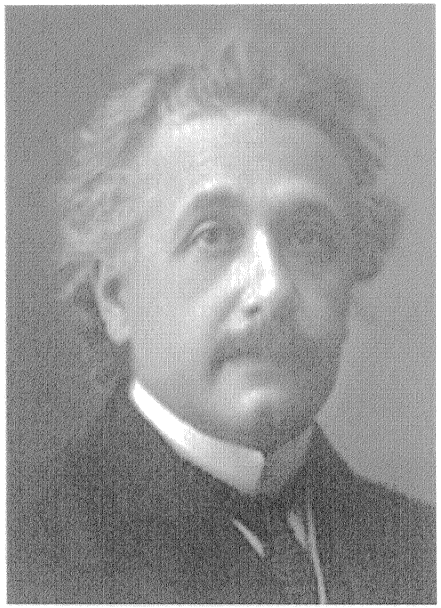
M. Parathasarathy, has been the Vice President of the IAU Commission 29 on Stellar Spectra for the triennium 2003-2006.

Christina Birdie has been nominated as the Co-chair of the scientific Organizing Committee of the forth coming LISA V (Library and Information Services in Astronomy) conference to be held at Harvard University at Cambridge, Massachusetts in June 2006.

She has been elected as the Standing Committee Member of IFLA – SCIE (International Federation of Library Association – Science and Engineering) section headquartered at Netherlands for the year 2004 – 2007.

SCIENTIFIC RESEARCH

In celebration of the
100th anniversary of
Albert Einstein's
papers of 1905



World Year of PHYSICS 2005

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The layout of the Einstein plaque specially made at the Institute.

1. The Sun : observations and theory

Magnetic relaxation of tilts of spot groups as indicator of the subsurface dynamics of parent flux loops : It is known since the observations by George Ellery Hale and his group in 1919 that the axes of the bipolar spot groups appear generally tilted with respect to the East – West direction.

In this study, we follow the long term variation of the observed tilt angles of the axes of bipolar and multipolar spot groups in the two latitude belts < 13° and > 13°. These are from measurements from the Kodaikanal collection of white light images of the sun for the period 1916 – 1987.

Our main conclusions from this study are the following : 1. The parent flux loops of spot groups (BMRs) possess tilts of at least ~ 4° to 7° in latitudes <13° and ~ 9° to 12° in latitudes >13° at the very depths of their origin. These are the tilts of the toroidal field in the tachocline.

2. The initial basic tilts are lower than the inborn tilts in the two latitude belts and this would imply that the Coriolis force acting on the flux loop during its rise through the convection zone tends to reduce the tilt of its top parts from the inborn tilt to the initial basic tilt.

3. After emergence of the top of the flux loop above the surface, the magnetic tension tends to restore the tilt of the flux loop to the original higher value with a relaxation time scale of 5 - 10 days. The implications of our findings on the existing models that explain the origin of the tilt and its evolution are : (1) Conclusion (1) shows that the toroidal field possess a non - zero tilt. Our study thus provides the first evidence that the field in the tachocline is not purely toroidal in configuration but has also a poloidal component. (2) Conclusion (2) contradicts the sign of the effect of the Coriolis force on the parent loop during its rise as inferred in all emergence models (3)The reduction in the tilt in the second conclusion calls for a modification in the existing model of the creation of tilts of spot groups by reviewing either the role of magnetic tension or the topology of the parent flux loops.

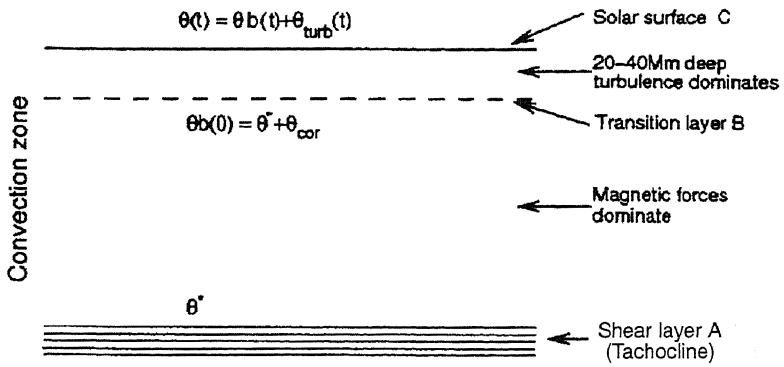


Figure 1. Schematic sketch showing the simplified scenario of the relative effects of magnetic, turbulence and Coriolis forces on the parent flux loop before and after its emergence on the surface (based on the model by Longcope & Choudhuri 2002 Solar Phys. 205, 63). Before emergence: θ * - the "inborn tilt", tilt of the parent flux tubes (of spot groups) at the depths of their origin, θ b(0) – the "initial basic tilt", tilt of the flux loop on the day it arrived at the transition layer B and before turbulence has acted on it. θ_{cor} - the tilt imparted by the Coriolis force during the rise of the flux loop from layer A to layer B, After emergence: θ (t) – tilt of the axis of the spot group observed at time t. θ b(t) - the "basic tilt", tilt of the parent flux loop at the transition layer. $\theta_{turb}(t)$ - cumulative effect of turbulence on the tilt.

Evolution of the active region NOAA 10570 associated with the flares : The structure and evolution of the photospheric magnetic fields observed in the active region NOAA 10570 are analyzed using Kodaikanal photoheliogram and spectroheliogram data. The shear angle changes were evaluated by carefully observing the prominent umbrae belonging to the active region. These changes in the orientation of the umbrae give the rotational motion developed in the sunspot group. It is found that the flux and shear

angle changes observed in the sunspot configurations are related to triggering of flares in the active region NOAA 10570.

Transition probabilities of molecular features observed in sunspot spectra : A number of molecular species such as TiO, MgH, CaH, CH, CN, etc. are known to be present in the sunspot spectra. However, there are a large number of lines for which the absorbers are not yet identified. For some of these lines, a certain known diatoms are suspected to be the absorbers, but the identifications need confirmation. We have computed the transition probabilities for many electronic systems of such select diatomic species, in order to identify the favorable transitions. The molecules studied include AlF, CoH, SrF, and ScF. Further work is in progress to identify the rotational lines due to some of these transitions in the spectra of sunspots.

Some of the molecular lines, especially those that are present only in sunspot spectra, but not in the spectra of solar photosphere, offer excellent diagnostics for the physical conditions in the sunspots observed, particularly since they are not affected by scatter from the neighboring photosphere. The rotational temperature estimated using some of these lines has a significant range of values, which itself needs further investigation.

Observations with the Norikura 25-cm coronagraph : So far we have been taking spectroscopic observations in two coronal emission lines namely, 6374 Å and choosing the other 7892 Å or 10747 Å or 5303 Å, simultaneously, with high spectral and spatial resolutions of coronal regions overlying the active regions. Also, the raster scan covered a region up to a height of 200 arcsec above the limb. The raster scans were obtained with shorter exposure times to study the periodic variations in the line parameters.

Now we have obtained raster scans up to a height of 500 arcsec above the limb with large exposure times, about 10 times the exposure time as compared to earlier one.We are analyzing the data to investigate to what height the FWHM of the green line continues to decrease and up to what height the FWHM of the red and other lines continue to increase. It is believed that solar wind is generated in the polar regions where the magnetic field lines are open. The existence of solar wind is likely to increase the FWHM of all the emission lines. The data is being analyzed to confirm the generation of solar wind in the polar regions.

Proposal for observations of solar corona during total solar eclipse of March 29, 2006 : Multi-slit spectroscopy of solar corona : The profiles of emission lines provide us the information about the physical and dynamical nature of the plasma in the solar corona. The broadening of emission lines have two components (i) thermal due to high temperature of plasma and (ii) non-thermal probably due to turbulence or waves in the solar corona and it is not possible to separate out the two components from the observations made in a single emission line. It is proposed to conduct multi-slit experiment to do the high spatial and high spectral resolution spectroscopy of the solar corona in two emission lines simultaneously to separate out the two component line-widths and study the variation of temperatures or non-thermal velocities separately with height above the limb.

Studies of coronal holes using SOHO data : Intensities, Doppler velocities and linewidths of EUV emission lines in a coronal hole and the nearby quiet sun region have been obtained from Coronal Diagnostic Spectrometer (CDS) observations on board SOHO. The field of view is 1 arc min wide by 4 arc min, with a series of observations made at different spatial locations on the boundary of the north polar hole and its large equatorial extension, the 'Elephant's Trunk'. The formation temperatures of the observed lines vary from 0.083 MK to 1.10 MK and hence they represent increasing heights in the solar atmosphere from the upper chromosphere and transition region to the low corona.

Doppler velocities in the coronal hole show increasing blue shifts with height in the upper transition region and the corona. This agrees well with the picture of coronal holes as the source region of the fast solar wind. Further analysis is underway and it is expected that the findings will give insights to the problem of acceleration of the fast solar wind.

Signatures of coronal holes in Kodaikanal Ca K data : It is generally accepted that the coronal holes show up their signatures as weak emission regions only very close to the corona. This means that there is no significant difference between line intensities inside and outside the coronal holes up to temperatures of about 0.8 MK. This has several important consequences for the energy balance of the transition region. In this study, we examine the Ca K filtergrams from Kodaikanal for signatures of coronal holes. The daily Extreme-Ultraviolet Imaging Telescope (EIT) pictures from SOHO are used to identify the coronal holes. A comparison of EIT pictures with Ca K filtergrams enables us to study the possible differences, if any, between coronal hole regions and outside in the chromosphere.

The solar core fossil magnetic field : The following outstanding problems in solar physics are not yet understood completely. The sunspot cycle and activity phenomena, the unexplained bumps in the helioseismic sound speed difference between the sun and the solar models, the rigid body rotation in the core and differential rotation in the convective envelope and, deficiency in the observed neutrino fluxes. Owing to large diffusion time scale, it is most likely that the sun might have retained the fossil magnetic field in the solar core from its protostar phase. If such a field exists, it is interesting to know its structure and magnitude that may give clue for solving the afore-mentioned problems. In this direction and as a first step, we solve incompressible axisymmetric MHD equations with the constraint from the helioseismic inference that the sun is rotating rigidly in the radiative core and assuming that the form of surface meridional flow extends even below the base of the convective envelope. We solve both the poloidal and toroidal parts of the steady magnetic field structure in the radiative zone. The preliminary results indicate that the solar radiative zone is pervaded by a weak (~1 G) poloidal and moderate (~10 G) to strong (~10^2 to 10^3 G) toroidal field structures.

Initial rotation rates of the leading and the following sunspots : In the present study, we use 8 years (1967-1974) Kodaikanal data of positional measurements of the sunspot groups that have the leading and following sunspots. We compute initial rotation rates separately for these leading and following sunspots. The preliminary results are as follows : (i) for different life spans, the leading sunspots rotate faster than the following sunspots during their initial appearance on the surface and, (ii) the difference between the initial rotation rates of the leading and the following sunspots almost remains same for all the life spans suggesting that bipolar spots constantly maintain their foot point distances while rising from the interior towards the surface.

Solar abnormal activity during Oct-Nov, 2003 : In Oct-Nov 2003, the sun produced very big sunspot groups that attracted the media and the public. The biggest sunspot events that occurred during this period, according to NOAA classifications, are 10484, 10486 and 10488. During the course of their evolution, these spot groups produced many flares and CMEs. However, it is debatable whether these flares were produced either due to dynamical variations or due to change in the emerging flux eruptions or due to both the phenomena.

With a high temporal resolution (~ hours), the positional measurements of sunspots from the Kodaikanal Observatory and Solar Geophysical data are used to study the association between occurrence of the abnormal activities of big sunspot groups that occurred during the period of Oct-Nov, 2003, and occurrence of the flares. The following activity variations during the course of evolution of the sunspot groups are investigated : areas, rotation rates, number of small spots produced in a spot group and longitudinal extents. Among all these activity variations, we find that the spot groups that have abnormal rotation

rates during their life times eventually trigger the flares. This study suggests that the occurrence of abnormal rotation rates of the sunspot groups can be considered as precursor of the flare occurrences.

Profile variations of chromospheric bright points : We determine the structure and dynamics of H2v and K2v grains and determine the mechanism of wave excitation from empirical modeling of time-dependent line profiles. It is found that the calcium grains (bright points) originate in intergranular lanes. The important findings are: (i) The acoustic waves propagate as spherical waves and their velocity grows as V = 1/r x exp (z/2H); (ii) At the formation height of the H2v peak, the empirical temperature fluctuation is 1000 K and in the dynamical simulations is 7000 K; and (iii) The behaviour of 3-min oscillations implies spherical waves.

On the fractal structure of solar supergranulation : We employ fractal analysis to study the complexity of supergranulation structure using the Solar and Heliospheric Observatory (SOHO) Dopplergrams. Our data consists of 200 visually selected supergranular cells, for which we find a broad, slightly asymmetric dispersion in the size distribution, with the most probable size around 31.9 Mm. From the area-perimeter relation, we deduce a fractal dimension D of about 1.25. This is consistent with that for isobars, and suggests a possible turbulent origin of supergranulation. By relating this to the variances of kinetic energy, temperature and pressure, it is concluded that the supergranular network is close to being isobaric and that it has a possible turbulent origin.

Sunspot dynamics : We present results from a time series analysis of data from the Grazing Incidence Spectrometer (GIS), onboard SOHO. Our observations were concentrated at the boundary between the quiet Sun and an active region, close to a sunspot plume. The dominant oscillations in all the lines studied are of periods longer than 5 minutes. Although our observations were not taken directly above the sunspot, the 3-min oscillations, which are normally associated with the umbra, are

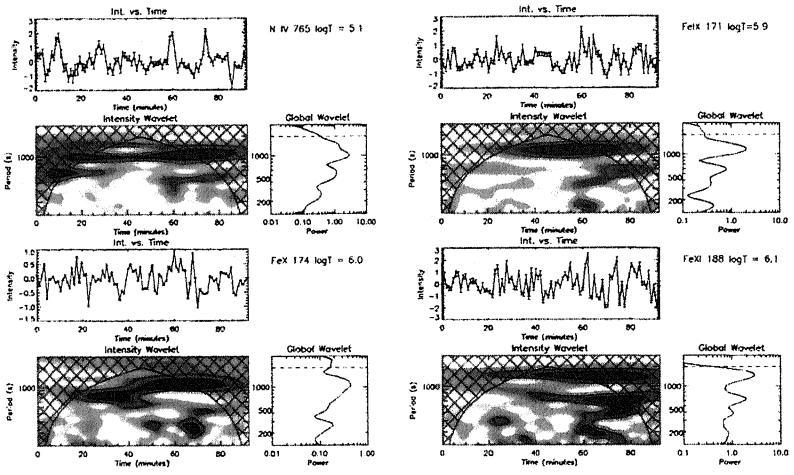


Figure 2. Examples of the wavelet analysis on intensity variations recorded by different temperature lines, as denoted in the upper right corner of each example. In each example,the upper left panel shows the de-trended intensity variation of the line with associated error bars; the lower left panel is the corresponding wavelet transform; and the lower right panel represents the wavelet power integrated over time. The unit of intensity is counts/sec/area. In the wavelet transform panels, white contours circle the region above the 95 % significance level, and the black cross-hatched area indicates the cone of influence, i.e., the region affected by edge effects (A&A, 2005, 434, 751).

seen in several spectral lines, suggesting some leakage perhaps via plume structures. The oscillations of coronal lines form wavepackets and are intermittent with no obvious decay. The average time scale of the intermittence is of the order of 20 minutes, which would correspond to a source size of 2 arcsec.

Full Stokes polarimetry of sunspot NOAA 0743 using Kodaikanal Tower Telescope (KTT) : Spectropolarimetric observations of sunspot NOAA 0743 were carried out using 38cm tunnel telescope at Kodaikanal. 8-stage modulation scheme was applied for full Stokes polarimetry. Observations were carried out on 15, 16 and 17th of March, 2005. The sunspot was located close to disc center during the observations. A sample of spectral images of the Stokes parameters are shown in Fig. 3. The

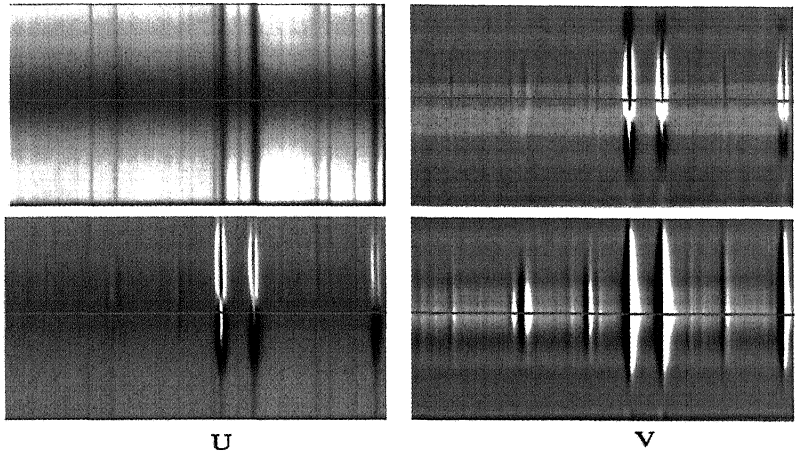


Figure 3. Spectral images of Stokes parameters observed at the sunspot umbral region.

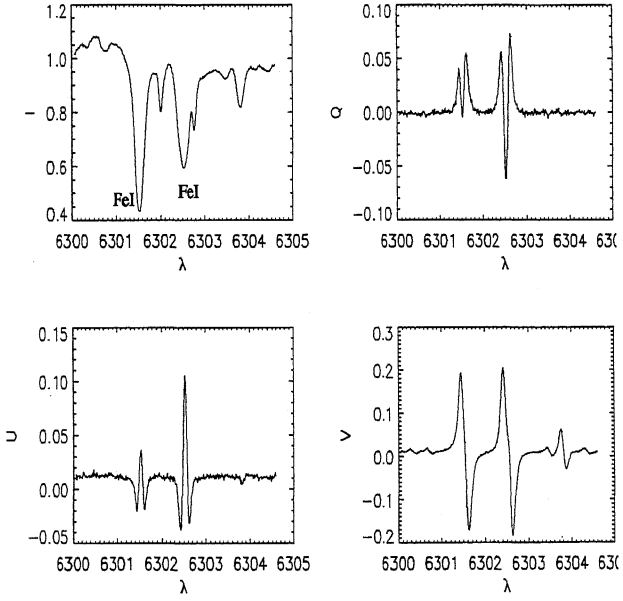


Figure 4. The Stokes profiles corresponding to the spectral images shown in Fig.1 chosen at the indicated location.

corresponding Stokes profiles at the indicated location are shown in Fig. 4. The accuracy in measurement of Stokes parameters is about 0.3 %. When the corrections due to telescope polarisation are made the accuracy will be of the order of 0.2 %.

Identification of the source region of a 'halo' coronal mass (CME) ejection using meter wavelength radio data : The observations with conventional 'white light' coronagraphs are the basis for

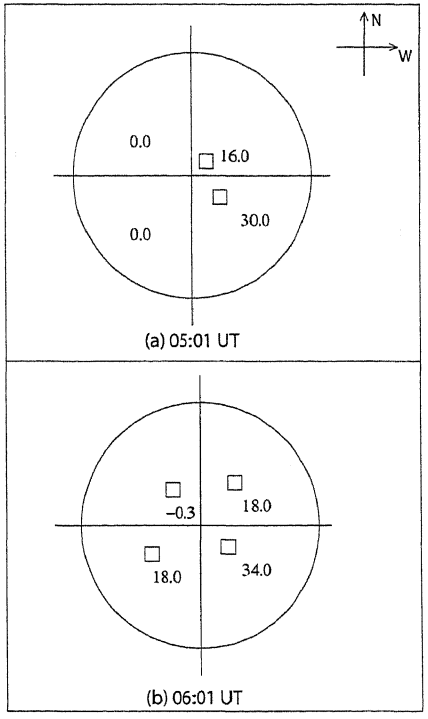


Figure 5. Graphical illustration of the quadrant-wise average density enhancement/depletion before and after the onset of the 'halo' CME of January 21, 1998. The open circles in panel (a) & (b) represent the solar disk. A comparison of the two panels indicates a significant increase of electron density in the south-east quadrant of the corona above the solar disk, after the CME lift-off.

our present knowledge of CMEs. But, by their very nature, the coronagraphs have an occulting disk to block the direct photospheric light and hence the source region of a CME cannot be observed using them. The situation is severe particularly for CMEs directed along the Sun-Earth axis ('halo' CMEs) since they originate close to the center of the visible hemisphere of the solar disk. Radio observations in the meter wavelength range play a useful role in this connection since they do not have the limitation of an occulting disk and a CME can be directly imaged in thermal bremstrahlung emission from the excess elecrons in its frontal structure. The sky-plane speed and acceleration of the latter, particularly in the region of the solar atmosphere beneath the occulting disk of a coronagraph, can be estimated in a straightforward manner. Again, one can observe activity at any longitude similar to X-ray and EUV wavelengths. The 'true' speed of a CME in the three-dimensional space can also be determined through ray tracing analysis of the observed radio brightness distribution. In this situation, we used the metric observations carried out with the Gauribidanur radioheliograph (GRH) to study the pre and post onset phase of the 'halo' CME of January 21, 1998. The change in electron density of the solar corona with time was obtained through a reproduction of the observed two-dimensional radio brightness distribution using ray tracing technique. Our calculations show that the average density above the background in the south-east quadrant of the corona overlying the visible solar disk had increased significantly (from 0 to 18), in the aftermath of the CME lift-off (Figure 5). This indicates that the source region of the event must have been located at a lower level of the solar atmosphere in that area.The rate of mass injection corresponding to the above change in density was found to be $\approx 8.8 \times 10^{15}$ g hr^{-1}.

Seismology of the solar corona through observations of metric Type IV radio burst emission : The plasma parameters like the density, magentic field strength and the Alfven speed in the solar corona are crucial to the understanding of solar flares, acceleration of solar wind and CMEs, and, ultimately, the Sun-Earth connection. The recent observations of oscillations in coronal loops has now raised the feasibility of the development of *coronal seismology*, analogus to helioseismology which provides us with powerful results concerning the interior of the Sun. The seismic information offers the means of determining the local conditions, particularly the coronal magnetic field, a task that has not hitherto proved possible. It is inferred usually from an extrapolation of measurements of the line-of-sight component of the photospheric magnetic field. The observations of transient, pulsating radio emission from the solar corona is a potential diagnostic tool in this connection since radio data can be obtained with a high temporal resolution. Again, the favourable conditions for MHD oscillations occur mainly in the upper part of the corona, i.e. from where the meter wavelength radio emission originate.

Brazilian Decimetric Array (BDA) : The Instituto Nacional Psequisas Espacias (INPE), Brazil is building a decimeter radio telescope for observations of Sun and various galactic, extra-galactic sources. In its present configuration, the BDA has five antennas set-up as an one dimensional array in the E-W direction, and operates at 1.6 GHz. The minimum integration time possible is $\approx$ 100 ms. The length of the longest baseline in the array is 216 m, and the angular resolution is $\approx 1.5'$. The array is located at Cachoeira Paulista and the geographical co-ordinates of the midpoint of the array are Long: $45^{\circ}0'20''$ West; Lat: $22^{\circ}41'19''$ South. The scientists and engineers of the solar radio astronomy group of IIA have designed and developed the backend digital correlator system for the BDA. They have also provided the software for data acquisition, calibration and image synthesis. Figure 6 shows the first East-West one-dimensional brightness distribution of the Sun obtained with BDA at 1.6 GHz. The regions of intense emission in the image corresponds well with the bright regions in the EUV image in Figure 7.

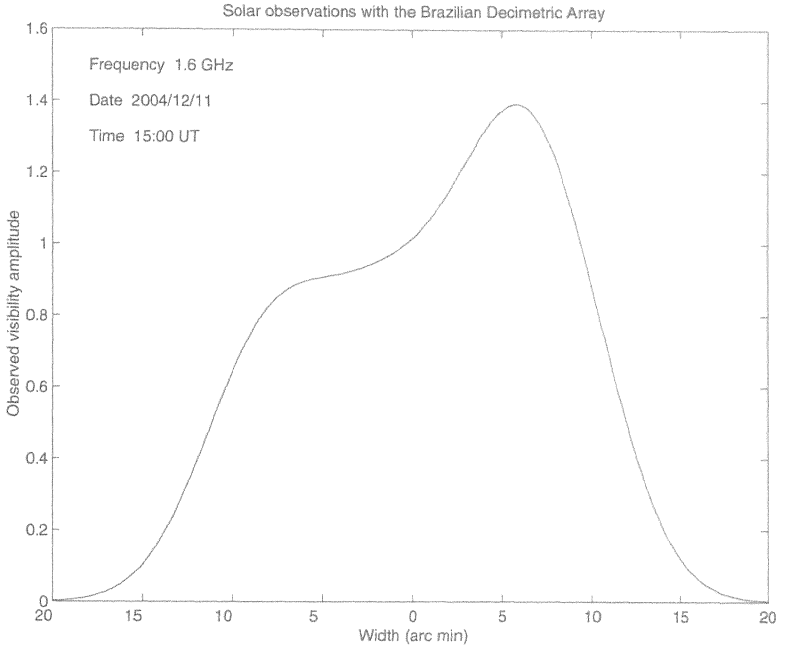


Figure 6. One-dimensional brightness distribution of the Sun obtained with the BDA on December 11, 2004 at 15:00

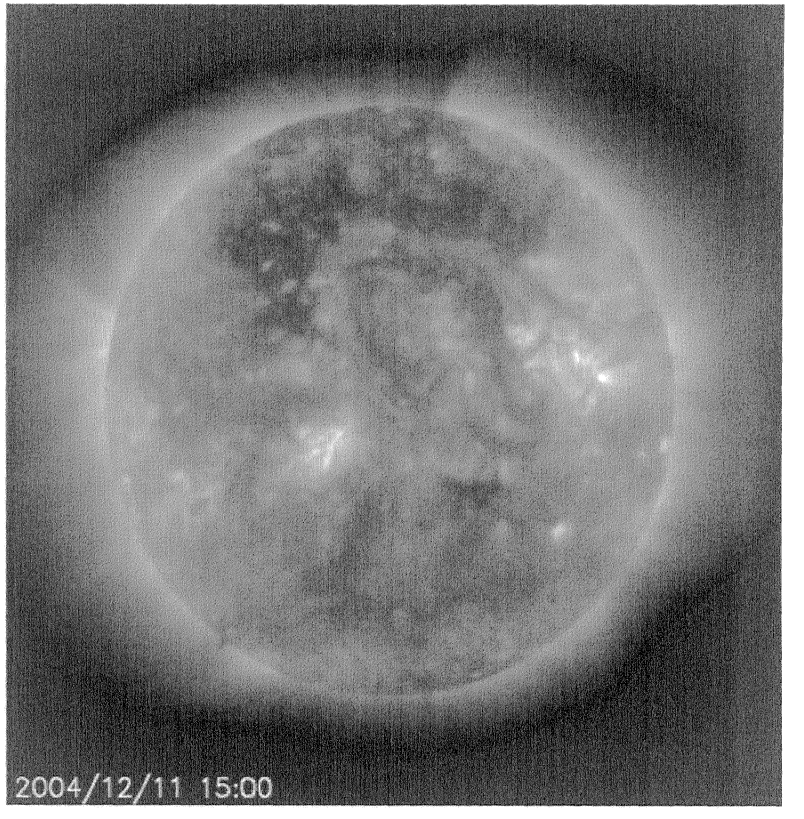


Figure 7. 195 A image of the solar corona obtained with Extreme Ultra-Violet Imaging Telescope (EIT) onboard the Solar and Heliospheric Observatory (SoHO) on December 11, 2004 at 15:00 UT. The enhanced emission in the E-W one-dimensional radio brightness distribution in Figure 6 corresponds well with the bright regions in the EIT image.

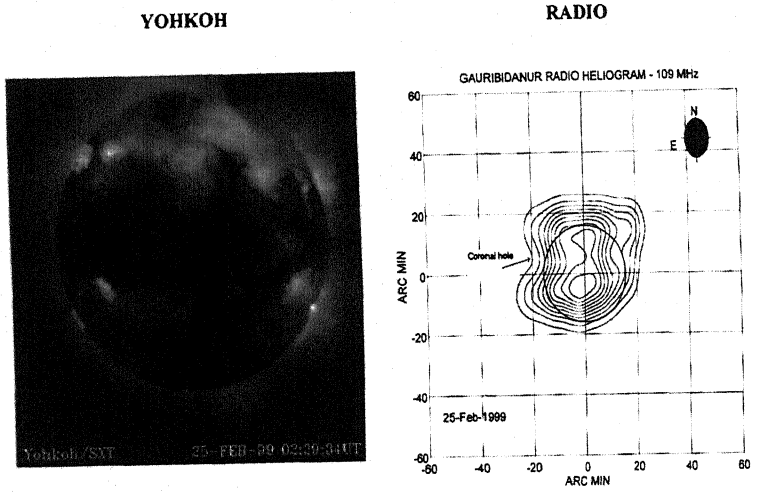


Figure 8. YOHKOH X-ray image and Radio image of the Sun at 109 MHz observed on February 25, 1999 showing equatorial coronal hole.

The noise storm continuum radiation is explained as a consequence of the non-thermal, plasma emission mechanism. The beam density of supra thermal electrons is estimated for the coronal plasma near the source region of storm radiation. Supplementary evidence for the density estimation is provided by way of analyzing the imaging data from the soft X-ray telescope on board the YOHKOH spacecraft, and the Large Angle and Spectrometric Coronagraph, Michaelson - Doppler Imager and Extreme-Ultraviolet Imaging Telescope on board the SOHO spacecraft.

Frequency and time profiles of metric Type I noise storm bursts at high spectral and temporal resolution : Type I noise storms constitute a sizeable fraction of the active Sun radio emission component. Observations of isolated instance of such bursts in the swept frequency mode at metric wavelengths have remained sparse, with several unfilled regions in the frequency coverage. Dynamic spectra of the burst radiation in the 30 - 130 MHz band obtained from the recently commissioned digital high resolution spectrograph at the Gauribidanur Radio Observatory, on account of the superior frequency and time resolution have unravelled in explicit detail the temporal and spectral profiles of isolated bursts. Apart from presenting details on their fundamental emission features, the time and frequency profile symmetry, with reference to custom - specific Gaussian distribution, has been chosen as the nodal criterion to statistically explain the state of the source regions in the vicinity of magnetic reconnection, the latent excitation agent that contributes to the plasma wave energetics, and the quenching phenomenon that causes damping of the burst emission.

Brightness temperature of the quiet Sun at 34.5 MHz. : Observations made during the solar minimum period June - July 1986 and May - June 1987 with the Gauribidanur radio telescope and a grating array were used to study the continuum emission from the quiet Sun. The brightness temperature of the quiet Sun varied from 0.1 to 0.45 million-degree Kelvin and the East- West diameter from 30 to 66 arc min. during the above period. Only a weak inverse correlation was found to exist between the brightness temperature and the size of the quiet Sun and does not strongly support the scattering hypothesis used to explain the low brightness temperature of the quiet Sun at decametric wavelengths.

Multiple large scale MHD shocks related radio emission at decameter wavelengths : Type II radio bursts which occur in sequence called Type II doublet were analyzed for determining their association with flares and or CMEs. It was found that out of 74 Type II bursts, 45 were associated with the onset of CMEs and in that 25 Type II doublets were associated with Halo - CMEs. Two flare peaks occur in 55 % of the cases we have studied. The estimated shock speeds of the two Type II bursts in the Type II doublet shows only a weak correlation.

2. Solar system studies

Comet 2001 Q4 : Comet 2001 Q4 showed rapidly changing dust and shell structures during January - June 2004. The dust morphology in the CCD images from the 102 cm Carl Zeiss Telescope at the Vainu Bappu Observatory, the Himalayan Chandra telescope at the Indian Astronomical Observatory, A 25 cm Newton Telescope at Juillan (France) and 4.) the 36 cm Schmidt-Cassegrain telescope on equatorial Mount (SoTIE, Telescopes in Education) at the Las Campanas Observatory were investigated using our photo-dynamic model (Vasundhara 2002, A&A 382, 342).This model simulates the dust dynamics taking into account the radiation pressure forces on the grains, terrestrial viewing and solar illumination geometries. The direction of the rotation pole which best explains the changing morphology is found to be directed towards the right ascension = 270° ± 10 deg and declination = + 15° ± 10 deg. Fig. 9 shows the observed images and the best fitting simulated images. From the projected separation of the dust features from the comet center, we get the velocities of the dust grains of different sizes. These grains are dragged and accelerated by the expanding gases until they reach a final terminal velocity within a distance of few tens of the nuclear radius. Estimate of the grain velocity and the velocity dispersion from the fits leads us to set lower limits on the dust to gas mass ratio as 24 ± 4.8 and the gas production rate as 0.703 ± 0.18 x 10^{-5} gms cm^{-2} s^{-1} during May 2004. The latitude and relative longitude of the sources of the jets have been estimated. Most of the sources appear to be situated on a common longitude belt. A linear fault line with the jets emanating from weak regions is a possible interesting scenario.

Investigations of dust morphology of comet 2004 Q2 (Machholz) : Comet 2004 Q2 (Machholz) was observed using the 1.02 m (f/13) telescope at the Vainu Bappu Observatory at Kavalur during December 2004 to April 2005. The spatial filter of Larson and Sekanina (1984, A.J. 89, 571) when applied on the R band CCD images delineated dust fans interspersed by intensity enhancements due

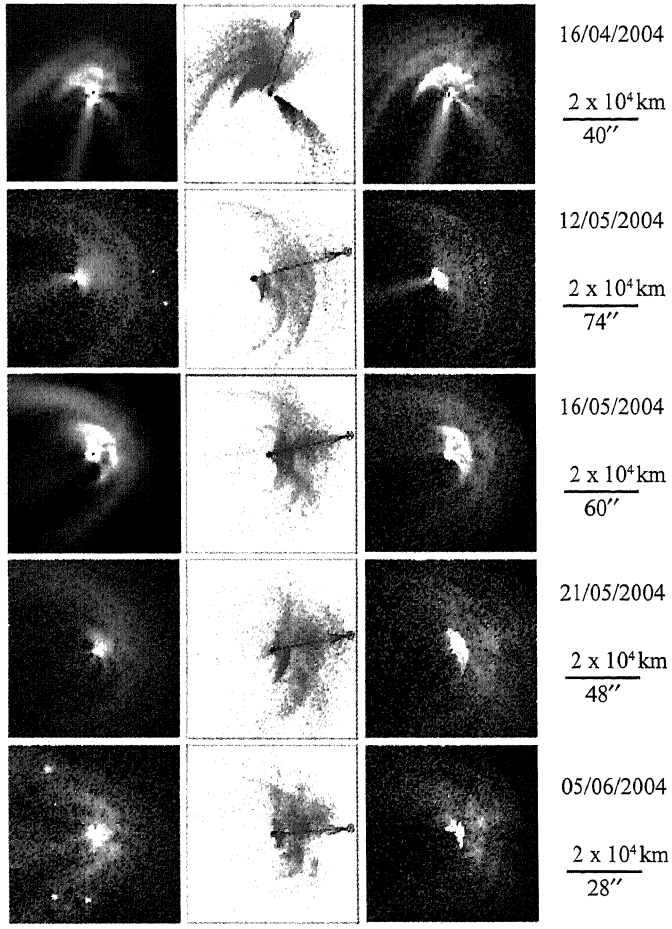


Figure 9. Modeling of jets from comet 2001 Q4. Left : procesed observed image, Middle, simulations Right : Image created from simulations. Colour codes : Black : 82°, Yellow : 45° to 55°, Red : 13° to 20°, Green : -5°, Blue : – 42° to 24°, Cyan : – 63°, Magenta : – 80°

to rotating jets. The dust features were modeled using our model. Astronomical silicate grains of sizes from 0.1 - 30 microns, with velocities determined using Fulle's A(1987, A&A, 171, 327) relation, Vgrain= A $\beta^{1/6}$) were used, where β is the ratio of solar radiation pressure force to the gravitational force on the grain. For a preliminary estimate, 'A' was taken as the gas velocity, V_{gas} = 0.58 $r^{-0.5}$ km/s at heliocentric distance of r AU. With this assumption, we estimate a rotation period (T) of 0.38 ± 0.08 day of the comet's nucleus. Direction of the best fitting North rotation pole of the cometary nucleus is derived as: RA (pole) = 190 ± 10 deg, Dec (pole) = 50 ± 10°.

3. Solar-terrestrial physics and geophysics

Geospheric storms : Ground-based ionosonde and magnetometer data of equatorial, low and mid-latitude stations in the Indian, American and African sectors are used to evaluate the characteristics of the sub-auroral ionospheric storm caused by the severe geomagnetic storm of October 28-30, 1961 [minimum Dst -290 nT], both storms being constituents of geospheric storms. During the magnetic storm recovery phase on 29 October, a persistent and global electric (E) field disturbance was seen in the dip equatorial region with a westward polarity on the dayside (08-14 LT) and eastward polarity on the nights side (22-04 LT). The westward E field disturbance manifested as a marked reduction of the equatorial electrojet (EEJ) strength and a simultaneous disappearance of Esq configuration on ionograms, and the eastward - E-field as an abnormal and significant increase of the height of bottom side F-layer (h'F). Moreover, longitudinally localized and anomalous negative storm effects in Nm F2 with remarkable increase in F-layer height were seen near the dayside dip equator concomitant with the prolonged westward E field disturbance. The equatorial ionization anomaly (EIA) was, nevertheless, clearly seen though the absolute values of Nm F2 testify to the presence of negative storm effect more or less throughout the EIA region. This behavior of Nm F2 is quite anomalous as what is generally expected during a westward E field disturbance on the dayside is a weakening of EIA, with positive effects in Nm F2 in the trough region of EIA (close to dip equator) and negative effects around the crest location of EIA. The global E field disturbances and the abnormal changes in the daytime equatorial F region during the magnetic storm recovery phase are the highlights of the ionospheric storm associated with it, and these are interpreted in the light of the current knowledge of the interactive physical processes that operate in the equatorial ionosphere-thermosphere system during geomagnetic storms.

Equatorial Ionosphere in relation to sudden magnetospheric compressions : A framework of understanding now exists as to the response of Earth's magnetosphere-ionosphere system to sudden magnetospheric compressions prompted by the impact of interplanetary shocks/discontinuities at the day side magnetopause. An important facet of this response is the manifestation of the sudden compression effect in ground-level magnetic field, namely the geomagnetic sudden commencement (SC) at the day side dip equator, which has a direct bearing on the issue of electrical coupling of the high latitude-low latitude ionospheres. Though it is well known that equatorial SC manifests in two forms: the conventional SC with only the main impulse (mi), and SC* with the mi preceded by a preliminary reverse impulse (pri), the factors that determine this bi-modal response are unknown to-date. Moreover, the local time or longitudinal dependence of the pri and mi characteristics at the day side dip equator couldn't be rigorously assessed against the model predictions due to a glaring dearth of simultaneous observations at different longitudes. The operation of sensitive digital magnetometers at longitudinally spaced locations close to the dip equator as a part of Circum-Pacific Magnetometer Network (CPMN) by the group at Kyushu University, Japan provided an unique opportunity to fill this gap in our experimental knowledge of the SC phenomenon. We have carried out a detailed study of the SC waveform at equatorial stations of CPMN covering the Pacific sector and at stations of the Indian magnetometer network for several well identified IP shock/SC events. The objective is to make the first-ever evaluation of the longitudinal (local time) pattern of the dip equatorial appearance of the pri and mi of SC* and ascertain the dependence, if any, of the sensitivity (amplitude per unit change in square root of the solar wind dynamic pressure) of pri and mi on factors like local time, IMF Bz orientation etc. The results are critically discussed in the light of the physical models of SC developed by Araki and others.

4. Galactic and extragalactic astronomy

FIP effect in the abundances of high galactic latitude RV Tauri star CE Virginis : One of the highlights of the VBT echelle spectroscopy during this year is the discovery of surface abundance patterns of the evolved star CE Virgins with respect to the first ionization potential of the element. The study and analysis of the spectra obtained with VBT echelle of the suspected cool RV Tauri star CE Vir show elemental depletions (w.r.t solar) that show no systematic trends with respect to condensation temperature as shown by many RV Tauri type stars but show a strong correlation with First Ionization Potential of the element. Such a pattern is also discovered in other similar star EQ Cas. These correlations are important which suggest effects of magnetic fields in operation and abundance similarities to slow solar wind and solar coronal abundances. This is a positive indication of stellar winds operating in an evolved star that are controlled by magnetic fields.

R Coronae Borealis stars at minimum light - UW Centauri : In the continued investigation of dust production in and around the hydrogen deficient variables of RCB type the star UW Centauri has been observed during its deep light minimum in 2002. The high resolution spectra obtained with CTIO 4-meter telescope obtained in 1991,1992 and 2002 have been analysed. A spectrum from mid-1992 when the star had faded by 3 mag shows just a few differences with the spectrum at maximum light . The ubiquitous sharp emission lines seen in R CrB at a similar drop below maximum light are absent. In contrast, a spectrum from mid-2002 when the star was 5 mag below maximum light shows an array of sharp emission lines and a collection of broad emission lines. Comparisons are made with spectra of R CrB obtained during the deep 1995-96 minimum. The many common features are discussed in terms of a toprusjet geometry.

HFOSC spectroscopy with HCT of high galactic latitude carbon stars : More than 100 objects have been observed in this programme so far, some on more than one occasion. The aim is to assess the census of various type of carbon stars and others at high galactic latitudes as they represent generally low mass stars.

Polarization measurements of post-asymptotic giant branch candidates and related stars : We have obtained UBVRI polarization measurements of 26 post-asymptotic giant branch (post-AGB) candidates and related stars with the 1-m. The extremely metal-poor post-AGB star HR 4049 has been observed several times and the observed percentage polarization and position angle with the orbital phase was studied.

Most of the observed 26 post-AGB candidates and related stars are intrinsically polarized. The polarization measurements indicate asymmetric circumstellar dust shells and disks around these stars. For some objects the steep percent polarization wavelength dependence and large degree of polarization suggest that scattering by circumstellar dust grains may be responsible for the observed polarizations in the blue. We have compared our observations of post-AGB stars from our sample with available HST, mid-IR images and ground-based imaging polarimetric observations.

Star formation in two isolated cometary globules: CG 12 & Gal 96-15 : We present the results of a study carried out to identify pre-main sequence (PMS) stars inside and in the vicinity of two relatively isolated cometary globules CG 12 and Gal 96-15.

In CG 12 we find a number of ROSAT detected X-ray sources characteristics of weak-line T Tauri stars, thought to be as more evolved low-mass young

stellar objects, distributed outside the head of CG 12. There exists a possible age sequence in YSOs associated with CG 12, from relatively more evolved YSOs outside the head region to very young stars found embedded inside CG 12.

For Gal 96-15, as in the case of CG 12, we find a number of ROSAT detected X-ray sources characteristics of weak-line T Tauri distributed outside the head of the cloud. Near-IR excess sources characteristic of classical T Tauri stars are distributed near to and inside the head region. The distribution of more evolved X-ray sources outside and very young PMS stars well inside the head of Gal 96-15 shows a possible age sequence in YSOs associated with Gal 96-15 similar to what we found for CG 12.

Novae

GK Per : Observations have been made of the nebular remnant of the old nova GK Persei 1901, in the optical using the Himalayan Chandra Telescope (HCT) and at low radio frequencies using the Giant Metrewave Radio Telescope (GMRT) during 2002 and 2003. The evolution of the nova remnant indicates shock interaction with the ambient medium, especially in the southwest quadrant.

The nova remnant of GK Per is detected at all the observed radio frequencies and is of a similar extent to the optical remnant. Putting together our radio

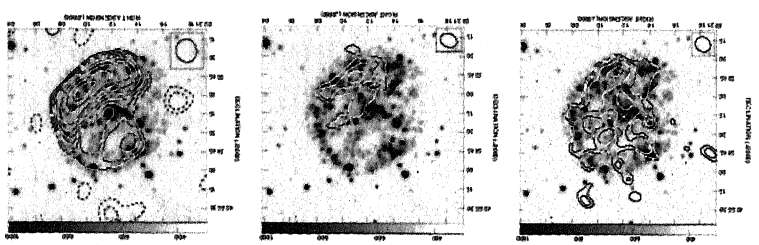


Figure 10.

observations with VLA archival data on GK Per from 1997, we obtain three interesting results: 1. The spectrum above 1.4 GHz follows a power law with an index –0.7 ($S \propto \upsilon^{\alpha}$) and below 1.4 GHz follows a power law with an index $\simeq$ –0.85. This could be due to the presence of at least two populations of electrons dominating the global emission at different frequencies. 2. We record an annual secular decrease of 2.1% in the flux density of the nova remnant at 1.4 and 4.9 GHz between 1984 and 1997 which has left the spectral index unchanged at –0.7. No such decrease is observed in the flux densities below 1 GHz. 3. We record an increase in the flux density at 0.33 GHz compared to the previous estimate in 1987. We conclude that the remnant of nova GK Per is similar to supernova remnants and in particular to the young supernova remnant Cas A.

Supernovae

SN 2003du : UBVRI photometry and optical spectra of Type Ia supernova SN 2003du were obtained at the Indian Astronomical Observatory for nearly a year since discovery.

The apparent magnitude at maximum was B = 13.53 ± 0.02 mag, and the colour $(B - V)$ = – 0.08 ± 0.03 mag. The luminosity decline rate, Δm_{15}(B) = 1.04 ± 0.04 mag indicates an absolute B magnitude at maximum of M_B^{max} = – 19.34 ± 0.3 mag and the distance modulus to the parent galaxy as μ = 32.89 ± 0.4. The light curve shapes are similar, though not identical, to those of SNe 1998bu and 1990N, both of which had luminosity decline rates similar to that of SN 2003du and occurred in spiral galaxies. The peak bolometric luminosity indicates that ~ 0.9 $M_{\odot}$ mass of ^{56}Ni was ejected by the supernova. The spectral evolution and the evolution of the Si II and Ca II absorption velocities closely follows that of SN 1998bu, and in general, is within the scatter of the velocities observed in normal Type Ia supernovae. The spectroscopic and photometric behaviour of SN 2003du is quite typical for SNe Ia in spirals. A high velocity absorption

component in the Ca II (H & K) and IR-triplet features, with absorption velocities of ~ 20,000 km s^{-1} and ~ 22,000 km s^{-1} respectively, is detected in the pre-maximum spectra of days –11 and –7.

GRB 030329 : The afterglow of GRB 030329 was monitored in the radio, millimeter and optical. U B V R_C I_C photometry was obtained from IAO and Nainital for a period of 3 hours to 34 days after the burst. Radio monitoring at 1280 MHz was carried out using the GMRT for more than a year. Simultaneous millimeter observations at 90 GHz and 230 GHz were obtained from the Swedish-ESO Submillimeter Telescope (SEST) and the IRAM-PdB interferometer over more than a month following the burst. These data are used to constrain the double jet model proposed by Berger et al. (2003) for this afterglow. The data can be well fit by a model where the two jets are present either simultaneously or in exclusion of each other. It is also possible that the optical re-brightening seen at the epoch of ~ 1.3 days could be a re-energization of the jet, which resulted in the initially narrow jet being converted into a more energetic wider jet.

Evidence of a counterrotating core in the Large Magellanic Cloud : Stellar radial velocity in the central region of the Large Magellanic Cloud (LMC) is used to estimate the radial velocity curve along various position angles (PA) including the line of nodes (LON). The central part of the radial velocity profile, along the LON, shows a V-shaped profile - a clear indication of counterrotation. The counterrotating region and the secondary bar have similar location and PA. The origin of the counter-rotating core could be internal(secondary bar) or external(accretion).To explain the observed velocity profile, we propose the existence of two disks in the inner LMC, with one counterrotating. This two disk model is found to match the HI velocities as well. Two disks with different LON and velocity profiles can create regions which are kinematically and spatially separated. Predicted such locations are found to match the observed locations where the HI clouds are found to have two velocities.

Spatial variation in reddening in α Per cluster and the colour-magnitude diagram : α Persei, a relatively young, nearby open cluster, is suspected to have reddening varying from star to star across its elongated extent in space. So far it has been possible to determine spatial variation of reddening through Stromgren uvby photometry available for only about 50-60 stars. In our present work, an attempt has been made to study this for as many as 155 stars of the cluster and consequently produce a reddening corrected HR diagram for the cluster. This has been achieved by using a new scheme where the intrinsic colour indices are computed from the observed colour indices (B-V, V-R, V-I, V-J, V-H, V-K) by assuming a large range of trial values of A_v and are then compared with the intrinsic colours of normal main sequence stars of different spectral types. The best fit (with χ^2 minimum) then yields a particular choice of A_v, the spectral type and M_v for each star and consequently the distance. The variation in reddening across the cluster is found to be random; both the high and the low values are evenly spread out. The HR diagram reconstructed with dereddened stars has a well-defined cluster sequence with observational spread drastically reduced. What needs to be explained is the anomalous observation why the K and M dwarfs are so blue. They fall nearly half a magnitude below the ZAMS when plotted on a V vs. (B–V) colour- magnitude diagram as also on a V vs (V-I) diagram.

CH stars at high galactic latitudes : Carbon-rich stars of population II, such as CH stars, can provide direct information on the role of low to intermediate-mass stars of the halo on the early Galactic evolution. Thus an accurate knowledge of CH stellar population is a critical requirement for building up scenarios for early Galactic chemical evolution. In the present work we report on several CH stars identified in a sample of faint high latitude carbon stars from Hamburg survey and discuss their medium resolution spectra covering a wavelength range 4000 - 6800 Å. Estimation of the depths of bands (1,0) $^{12}C^{12}C$ λ4737 and (1,0) $^{12}C^{13}C$ λ4744 in these stars indicate isotopic ratio $^{12}C^{13}C$ ~ 3, except for a few exceptions; these ratios are consistent with

existing theories of CH star evolution. The stars of Hamburg survey a total of 403 objects were reported to be carbon star candidates with strong C_2 and CN molecular bands. In the first phase of observations, we have acquired spectra of ninety one objects. Inspection of the objects spectra show fifty one objects with C_2 molecular bands in their spectra of which thirteen stars have low flux below about 4300 Å,. Twenty five objects show weak or moderate CH and CN bands.

Determination of dust scattering in the far ultraviolet : We have investigated the properties of dust using Voyager and FUSE spectra of diffuse emission near bright stars. We have developed new models which have allowed, for the first time, a precise determination of dust scattering in the far ultraviolet, at wavelengths shorter than 120 nm.

Hot gaseous outflows in Seyfert galaxies : The geometry of the gaseous outflows in Seyfert galaxies is being studied via spectroscopic observations of the absorbing outflows in the ultraviolet regime using the Far-Ultraviolet Spectroscopic Explorer telescope. We particularly targeted the Seyfert galaxies of Type 2, in order to contrast their properties with those of type 1. We find that the OVI line width is narrow in them, as would be expected for Seyferts with obscured nuclei, and also that the doublet ratio appears to differ from that in the Seyferts purportedly oriented pole-on.

The magnetic fields in the nuclear jets of radio galaxies : Using observations with Very Long Baseline Interferometry we have measured polarisation on the pc-scale in the nuclei of Fanaroff-Riley I galaxies for the first time (see Figure 11). This detection implies the presence of ordered magnetic fields within as close as ~1650 Schwarzchild radii of the putative central supermassive black hole. The relatively high fractional polarization in the parsec-scale jets of these galaxies is consistent with the standard scheme unifying low-luminosity radio galaxies with BL Lac objects. This result also suggests that these radio galaxies lack the obscuring tori that apparently depolarise the nuclear emission in the more powerful FR II radio galaxies.

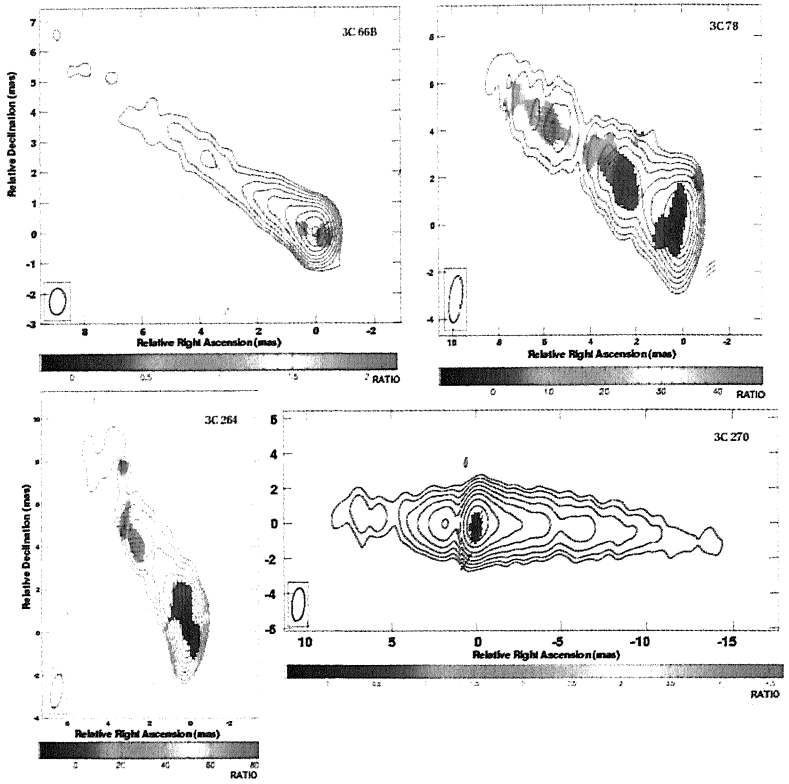


Figure 11. The parsec-scale structure and polarisation of the four radio galaxies of the Fanaroff-Riley I type. Clockwise from top left: 3C 66B, 3C 78, 3C 270 and 3C 264. The contours represent the total surface brightness, and the superposed straight lines represent the polarization electric vectors. The fractional polarisation (in %) is shown in false colour. The surface brightness peaks in mJy/beam are 3C 66B: 118.2, 3C 78: 285.9, 3C 270: 165.3, 3C 264: 136.3. In all cases the lowest contour is ± 0.35% of the peak surface brightness, and the contour levels are in percentage of the peak, increasing in steps of two.

Chemodynamics of the Galactic Thick disk : Using accurate radial velocities combined with the Hipparcos astrometric data, kinematics (U, V, and W) and Galactic orbital parameters Z_{max}, and R_{gcr}) were computed. Assuming the sample is a mixture of three Galactic components: thin, thick and the halo, and the stellar population distribution in (U, V, W) are Gaussian, we assigned stars with probability percentage, %P ≥ 70 as belonging to one of the three components. We assigned 93 for thick disk, 17 for thin disk, 24 for halo. Rest of the stars have ambiguous probabilities to belong to either of the three components (See Figure 12). Entire selected sample stars were subjected to high resolution Echelle spectroscopic analysis.

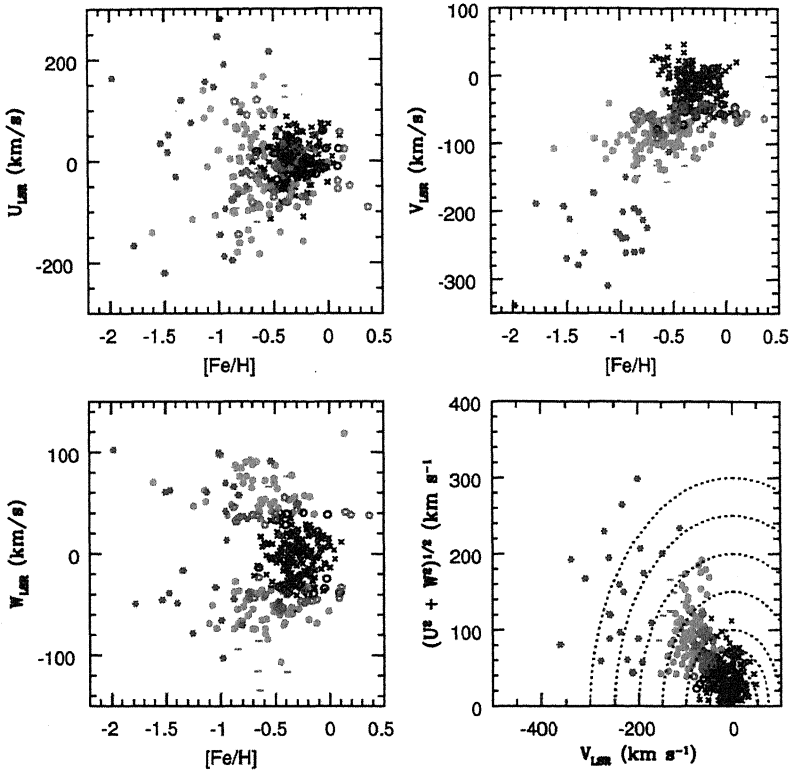


Figure 12. Plots of U_{LSR}, V_{LSR}, W_{LSR} against [Fe/H] for our present sample of stars and that from Redd et al. 2003. Also plotted is the Toomre diagram : $\{(U_{LSR})^2 + (W_{LSR})^2\}^{½}$ against V_{LSR}. The current sample is separated into five different groups based on the probability π : Thick disk (red filled circles), thin disk (black unfilled circles), halo (blue star symbols), stars with equal probabilities between thin and thick (green pentagons) and between thick and halo (magenta bars), and the 173 thin disk stars from Paper I (black crosses).

Quantitative abundance results for 24 elements: C, O, Na, Mg, Al, Si, S, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Y, Ba, Ce, Nd, and Eu were obtained. The thick disk abundance results were compared with the thin disk abundance results from Reddy et al. (2003). α-elements: O, Mg, Si, Ca and Ti relative to iron in thick disk disk sample show a clear enhancement compared to thin disk sample in the [Fe/H] range of 0.3 – 1.2. There are also elements like Al, Sc, V, Co, and possibly Zn that show enhancement in thick disk relative to thin disk stars. For both the thin and thick disk samples results of Na, Cr, Mn, Ni, and Cu are in agreement. The dispersion in abundance ratios [X/Fe] at given [Fe/H] is in agreement with the predicted dispersion due to measurement errors suggesting thick disk stars are originated from well mixed gas similar to our conclusion for the thin disk sample. This is the first comprehensive study of the Galactic thick disk based on such large number of thick disk stars. Our results put severe constraints on Galactic formation models: dissipative collapse vs merger scenarios.

5. *Astrophysics, cosmology and physics*

PRD effects in an irradiated, moving atmosphere in close binary components : It is a well known fact that the photon redistribution occurs due to the scattering during the formation of spectral lines. Complete redistribution at a given frequency point in the line rarely occurs in a stellar atmosphere. Redistribution can occur not only in the frequency but also in angle. The problem becomes more complicated when radial motions of the gases are taken into account. It is the scattering integral which occurs in the source function that introduces major changes in the photon redistribution in frequency and angle. One must take into account for each photon that is scattered on emission and absorption. This is possible only when we consider partial redistributions of the photons scattered into other frequencies and angles. In a spherically symmetric moving medium, the frequency redistribution strongly depends on the angle. This angle dependence of the frequency occurs irrespective of the fact whether we consider angle dependent or angle averaged redistribution functions in a moving medium.

Recently we have studied the effects of partial frequency redistribution function R_{II} angle averaged (R_{II}-A) function in irradiated and moving atmospheres of close binary components. Here the atmospheric extension of the primary component is assumed to be twice of the radius of the primary component in a close binary system. The atmosphere is assumed to be at rest and we have computed the lines using total optical depth 10^4 at the line centre. The irradiation from the secondary component is assumed to be 1, 5 and 10 times the self radiation.The line fluxes in the line of sight are calculated by using the total source functions due to self radiation and due to the irradiation. We obtained double peak emission lines in the case of static medium and emission peaks are reduced in the case of velocity field.

Astrophysical magnetic fields : MHD theory : The classical problem of the magnetic dynamo concerns the question of the amplification or maintenance of the magnetic field in a fluid. It is known that dynamo action is impossible under certain symmetries and are demonstrated by antidynamo theorems.

We have used a generalized toroidal-poloidal representation of the magnetic field to extend the earlier results (Mangalam 2004). Incompressible two-dimensional velocity flows in situations other than in the special cases, lead to linear growth in one of the field components and are otherwise slow. A new approach is taken that lends itself to a unified and simpler exposition of the previous results. In a work in progress a generalized treatment in the language of differential geometry is aimed in order to determine the conditions that satisfy Cowling's theorem.

Cosmology: Demographics of quasar black holes : We produced a model earlier (Mangalam 2003) of a self-gravitating disk collapsing due to Compton drag by the Cosmic Microwave Background which is found to be effective at redshifts $1400 > z \gtrsim 100$. In a work in progress, we show that the model has useful predictions for the peaks of galaxy formation and quasar formation in the Universe consistent with observations. It is proposed that the small $\lesssim 10^5 M_\odot$ objects, that form by this mechanism, by $z \sim 20$ can merge and coalesce by dynamical friction to form the high redshift quasars that are observed.

Dark energy and black holes : Recent cosmological observations imply a universe dominated by dark energy with its associated negative pressure. There are even indications that this may be increasing with epoch and this could ultimately result in the disruption or ripping of all

bound structures. The effects of ambient dark energy on the disruption of black holes ware studied. Also the contrasting effect of dark energy on wormholes is indicated. There are interesting consequence for the formation of naked singularities. Interesting implications for the black hole entropy problem were found.

Cosmological constant : The cosmological constant as a unifying link in physics and cosmology was explored. Apart from being a source for the dark energy now known to dominate the dynamics of the universe, the cosmic vacuum energy could fix the values of the various coupling constants of the fundamental interactions and the particle masses (analogous to the all pervading Higgs field).

The relative proportions of the baryonic matter and dark matter were also sought to be understood.

Astrobiology : Several aspects of bioenergetics were studied and attempts to understand empirical laws such as that of Kleiber and Damuth in the astrobiological context were made.

Emission altitude in radio pulsars with triple profiles : We have been developing an independent method to understand emission altitudes in radio pulsars showing triple profiles. The centers of core and conal components in triple profiles are often non coincident in longitude. Treating these offsets as a generic property we have sought an explanation by attributing different emission altitudes to these components. The offsets are then easily explained as resulting from aberration, retardation and the magnetic field line sweepback. This immediately allows determination of the difference between core and conal altitudes which are much less uncertain than the individual altitudes derived by other methods. Individual altitudes can also be determined by enlarging the current framework to interpret pulse widths. However, only the altitude difference by itself leads to many interesting and surprising consequences.

For instance, for the pulsar PSR 0329+54, we find this to be 60 R* at 408 MHz. The star shows lagging core. Its conal and core widths give r_{cone} as > 27 R* and r_{core} as > 3R*. The longitude offset further constrains the lowest admissible altitudes to the pair 63 R* and 3 R* respectively. Generally both core and conal filling cannot be maximum.

For PSR 1917+00 which shows a leading core, the altitude difference is 31 R* at 1400 MHz. Here the minimum possible altitude consistent with the conal width is 36 R*. We find that the fill ratio f_{core}/f_{cone} is 0.35. The solid angle filling factor ratio will be square of this quantity. Higher altitude combinations consistent with the longitude shift will further reduce this ratio.

The characteristics of emission altitudes implied by these conclusions, though derived for pulsars showing triple profiles, are expected to hold also for all pulsars. These conclusions can be verified and sharpened further by a detailed analysis of observations using both the longitude shifts and the offsets between intensity and polarization centroids as also the variation of the former with emission frequency. This work is in progress.

On the method of estimating emission altitude from relativistic phase shift in 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. We have revised the relation of aberration phase shift by taking into account the colatitude of emission spot and the plasma rotation velocity. In the limit of small angle approximation, aberration phase shift becomes independent of the inclination angle α and the sight line impact angle β. However, at larger altitudes or larger rotation phases, the shift does depend on α and β. We have derived an expression for the phase shift $\delta\varphi$ in the intensity profile by taking into account of aberration, retardation and polar cap currents, and plotted it in Figure 13. The parameter $r_n = \frac{r_{em}}{r_{LC}}$ is the emission height, and r_{LC} is the light cylinder

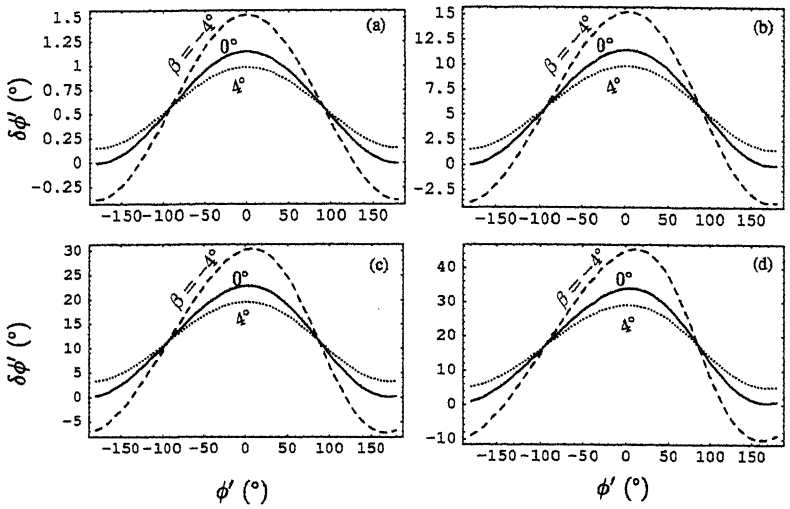


Figure 13. The net phase shift due to aberration, retardation and polar cap current δφ vs phase . Chosen $\alpha = 10^{\circ}$ and r_n = 0.01, ~0.1,~0.2 and 0.3 for panels (a), (b), (c) and (d), respectively.

radius. It shows phase shift is maximum near the meridional plane. We have re-estimated the emission heights of the six classical pulsars, and analyzed the profile of a millisecond pulsar PSR J0437-4715 at 1440 MHz. Using the phase location of component peaks, we have estimated the relativistic phase shift and the emission height of conal components. We find some of the components are emitted from the altitudes as high as 23 percent of light cylinder radius.

Radio emission by particles due to pulsar spin : We present a relativistic model for the motion of charged particles in rotating magnetic field lines projected on to a plane perpendicular to the rotation axis. By making an approximation that the projected field lines are straight, an analytical expression is obtained for the particle trajectory. The motive behind developing this model is to elucidate some of the effects of rotation in pulsar profiles. There is a

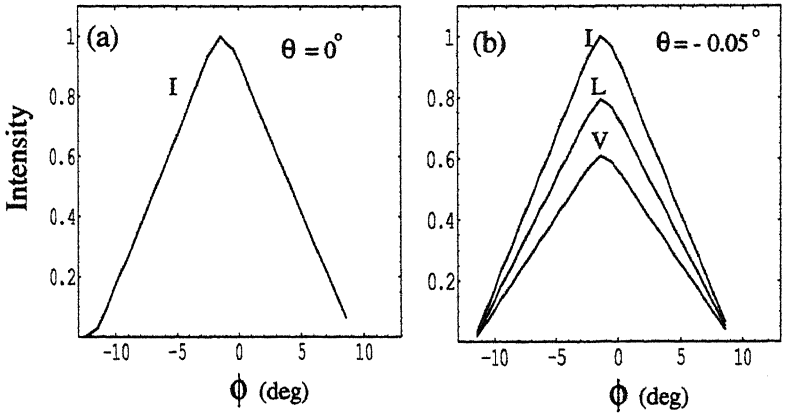


Figure 14. The simulated profiles: panel (a) for sight line inclination $\theta = 0^{\circ}$ and panel (b) for $\theta = -0.05^{\circ}$. The parameter ϕ is the rotation phase. Used Lorentz factor $\gamma_0 = 100$ and initial particle injection distance d_0 = 10km.

significant contribution to the curvature of particle trajectory due to the rotation of pulsar, which is in addition to the inherent curvature of the field lines. We have simulated the pulse profile by considering the radio emission from the rotating field lines (see Fig.14).

The asymmetry in the observed pulse shapes can be explained by considering the aberration-retardation effects. The single sign circular polarization that has been observed in many pulsars, might be due to the relative orientation of sight line with respect to the particle trajectory plane.

Galaxies : Dynamics : Tidal disruption and merging are two important processes in the dynamical evolution of binary galaxies. Galaxies with close companions are expected to merge in a few galactic crossing times. Collisions of galaxies of comparable mass that are moving in marginally bound orbit result in the merger of the galaxies into a single system. Previous work in this field mainly concentrated on the aspect of merger. The present work considers both merging and non-merging collisions of galaxies

by numerical simulations using various values for the impact parameter and their effect on the density profile of the merger remnants and survivors after the encounter.

The important result of the simulations is that they show the existence of a correlation between the effective radius r_e and surface brightness μ_e. The correlation is expressed in the form $\mu_e = -1.31 \log(r_e) + c$, where c is a constant. The survivors of the collision lie in the r_e - μ_e plane close to the line satisfied by normal ellipticals whereas the merger remnants lie on a line slightly to the right of that of normal ellipticals and it has a slope ≈ -2. In distant encounters, the galaxies more or less retain their initial structure.

Scattering of polarized radiation by atoms in magnetic and electric fields : We consider the polarization of line radiation arising due to scattering by an atom, in the presence of external magnetic and electric fields. The purpose of the studies is: (i) to develop a quantum electro-dynamical approach to scattering process in the presence of external magnetic and electric fields of arbitrary strengths and (ii) to demonstrate the properties of the coherence or interference phenomena that are important in the interpretation of the scattering polarization, which is responsible for the polarization of spectral lines in the second solar spectrum.

In calculating the transition amplitudes describing the state of polarization of the scattered radiation, we sum over all the intermediate sub-levels. Because the summation over intermediate levels is carried out before one squares the amplitudes to obtain the intensity of scattered radiation, cross terms can arise and these in fact produce the coherences (or interferences). These interferences give rise to the de-polarization of the scattered radiation involving atomic levels. Finally, we present the Stokes parameters (*I, Q, U, V*) of scattered radiation in terms of the Stokes parameters of incident radiation, through an angle dependent scattering phase matrix, which describes pure angular correlations.

Stochastic polarized line formation — Zeeman propagation matrix in a random magnetic field : The polarized spectral line formation in stochastic (arandom) media is of great astrophysical importance. Not much progress has been done in the past, due to the inherent difficulties in formulating the stochastic radiative transfer equation (RTE). Traditionally, a deterministic RTE is employed, with random properties included only as a line broadening mechanism. In this paper, the effect of a random magentic field with a non-zero mean value on the Zeeman propagation matrix is formulated.

A detailed numerical investigation of the mean coefficients illustrates the two effects of magnetic field fluctuations : broadening of the σ-components by fluctuations of the magnetic field intensity, leaving the π-components unchanged, and averaging over the angular dependence of the π and σ components. For longitudinal fluctuations only the first effect is at play. For isotropic and 2D transverse fluctuations, angular averaging can modify the frequency profiles of the mean coefficients quite drastically with the appearance of an unpolarized central component (dotted and dashed lines in Fig. 15a) in the diagonal absorption coefficient, even when the mean field is parallel to the line of sight. A detailed comparison of the effects of the three types of fluctuations on absorption coefficients is performed in Fig. 16. In general the magnetic field fluctuations induce a broadening of both the absorption profile, and the anomalous dispersion profile, together with a decrease of their absolute values.

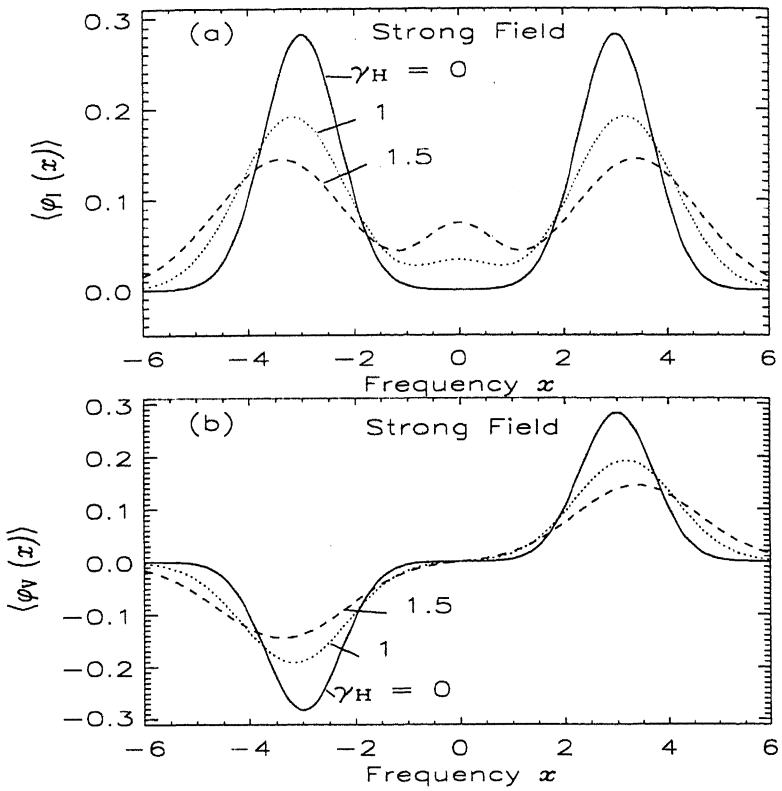


Figure 15. Strong field limit. Mean absorption coefficient profiles $\langle\varphi_I\rangle$ and $\langle\varphi_V\rangle$ for the Stokes *I* and *V* parameters, for a longitudinal mean magnetic field ($\theta_o = 0^o$). Mean Zeeman shift = $\Delta\mathcal{H}_o = 3$ is a measure of the mean field strength. Voigt damping parameter $a = 0$. The curve $\gamma_{\mathcal{H}} = 0$ corresponds to a constant magnetic field equal to $\mathcal{H}^o$. Other values of $\gamma_{\mathcal{H}}$ measure the dispersion of field strength around the mean value $\mathcal{H}_o$.

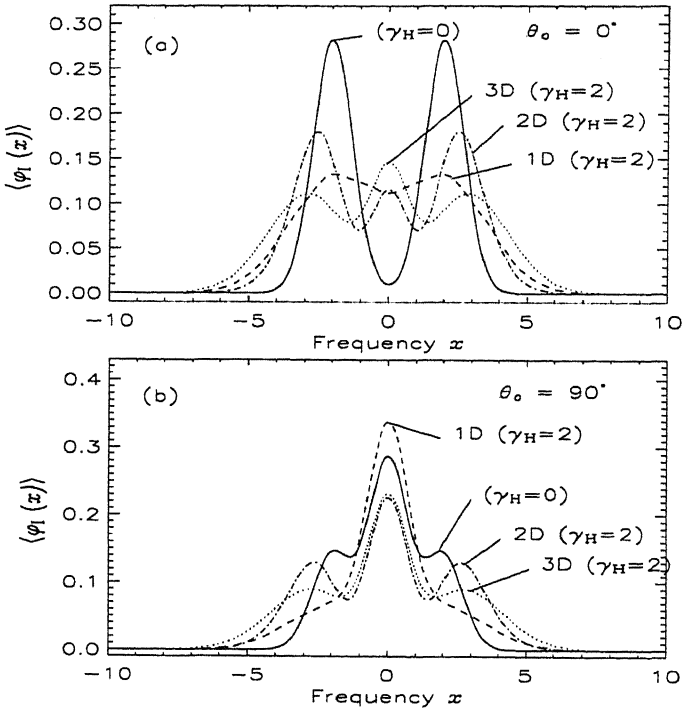


Figure 16. Dependence of $\langle\varphi_I\rangle$ on the turbulent magnetic field distribution function. The model parameters are a = 0, $\Delta\mathcal{H}_o = 2$ and $\gamma_{\mathcal{H}} = 2$. The curves with $\gamma_{\mathcal{H}} = 0$ correspond to a constant magnetic field equal to $\mathcal{H}_o$. Panels (a) and (b) correspond to longitudinal ($\theta_o = 0^o$) and tranverse ($\theta_o = 90^o$) cases, respectively with respect to the line of sight. The symbols 1D, 2D and 3D refer to different distribution functions of the turbulent (fluctuating) field.

Neutrino mass, cosmic strings, matter-antimatter asymmetry and ultrahigh energy cosmic rays : Currently, one of the most attractive scenarios of origin of the observed baryon (B) asymmetry of the Universe (BAU) is that it arose from an initial lepton (L) asymmetry created by the L- and CP-violating out-of-equilibrium decay of heavy ($\gg$ TeV scale) right-handed Majorana neutrinos. The L-asymmetry is partially converted to a B-asymmetry by the electroweak B+L violating [but (B-L) conserving] sphaleron transition process. This scenario has received strong support from the experimental fact (inferred from neutrino oscillation experiments) that the usual Standard Model neutrinos have small (sub-eV) masses, which can be explained naturally through the see-saw mechanism that involves the heavy right-handed Majorana neutrinos. The masses of the heavy neutrinos arise from spontaneous breaking of a $U(1)_{B-L}$ gauge symmetry at a sufficiently high energy scale η_{B-L}. In this work we point out that decay of massive gauge bosons, Higgs bosons as well as the heavy Majorana neutrinos released in the present Universe from decaying and/or collapsing closed loops of the "B-L" cosmic strings that arise from the $U(1)_{B-L}$ symmetry-breaking phase transition in the early Universe would, for $\eta_{B-L} \geq 10^{11}$ GeV, give rise to a hard component of Ultra-High Energy Comic Rays (UHECR) extending to energies beyond 10^{11} GeV. Thus, the observed small neutrino masses, BAU and the UHECR events above 10^{11} GeV — otherwise apparently unrelated phenomena — may, in fact, have a common origin in a $U(1)_{B-L}$ symmetry-breaking phase transition in the early Universe.

Dynamics of dwarf-spheroidals and the dark matter halo of the Galaxy : We have investigated the dynamics of the dwarf spheroidal galaxies in the gravitational field of our Galaxy with particular reference to their susceptibility to tidal break-up. Subsequent to the formation of the Milky Way and its satellites, those dwarf-Spheroidals (dSphs) that had orbits with small perigalacticons would have been tidally disrupted, leaving behind a population with large ratio of transverse to radial velocities. Analyzing the resulting restrictions imposed on the phase space distribution of the dSphs, together with virial arguments, we have obtained a lower bound of ~ 280 kmps for the circular velocity of any test object at a galactocentric distance of ~ 100 kpc. A simple self-consistent model for the phase space structure of the DM particles then yields an estimate of 100 – 150 kpc for the size of the halo of Galactic dark matter. In addition we have found that in order to be consistent with the above lower limit on the rotation speed at large galactocentric distances, the velocity dispersion of the dark matter particles must be ~ 600 km sec^{-1} significantly larger than the "standard" (assumed) value of ~ 300 sec^{-1}. This has important implications for the on-going search for the dark-matter particles in laboratory detectors.

Optical storage / retrieval of astronomical images in photorefractive Fe:Ce $LiNbO_3$: At basic level, a hologram is a record of the spatial interference pattern formed by the mixing of two coherent laser beams. One of the recording beams which carries spatial information is labeled as *object* beam. The other is distinguished by its particular direction of travel and is labeled as *reference* beam. The object beam is reconstructed by illuminating the recorded hologram with the reference beam and vice-versa.

We demonstrated holographic storage of astronomical images in a photorefractive $LiNbO_3$ crystal. A *transmission geometry* for data storage system is shown in Figure 17. The spatial light modulator (SLM) is an optical page composer made of 2-dimensional array of liquid crystal cells. SLM is

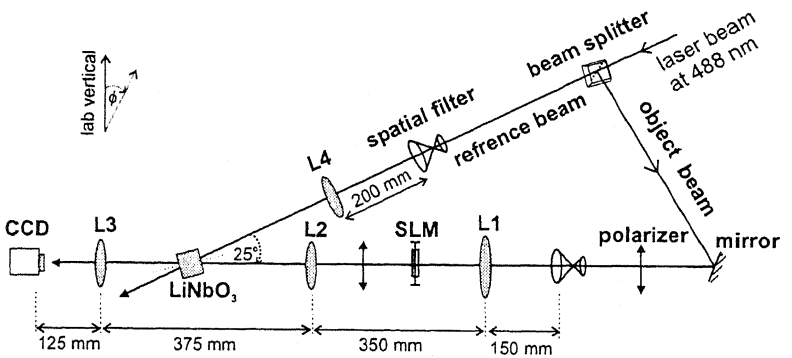


Figure 17. The schematic diagram of holographic data storage system.

addressed by a monitor signal produced by the video graphics card of a PC. Both, SLM and the CCD camera were independently controlled by separate computers.

In the recording scheme shown in Figure 17, the lens L2 takes the Fourier transform of the object beam. The crystal was placed at the Fourier image-plane where the reference beam interferes with the Fourier-transformed object beam. The lens L3 performs the inverse Fourier transforms before imaging the object beam back onto the CCD camera. The crystal was mounted on a modular platform that was designed to store multiple data pages using spatial and rotational multiplexing. The platform comprises of a rotational mount seated on a $x-y$ translation stage, which in turn was placed on a vertical stage. The motion of each stage was controlled by independent actuators with micron level accuracy. The storage medium was a 0° cut Fe:Ce doped $LiNbO_3$ (size = 10 mm x 10 mm x 10 mm).

Atomic and molecular physics : The electronic structure isomers of C_3H_2 and their ions the cyclopropenylidene and propadienylidene are of interest as participants in combustion processes and in interstellar chemistry. Assisted by theoretical calculations of the IR spectrum, the cyclopropenylidene was first detected in the laboratory in 1984 using flash thermolysis and matrix isolation. In 1985, the rotational spectrum of cyclopropenylidene was discovered in interstellar space (TMC-1), and the linear isomer has subsequently been detected in 1988. The cyclic isomer is a rather abundant molecule in interstellar space, yet little is known about its electronic spectrum. Geometries for the ground and low-lying excited states of the ions of these two systems are determined. Vibrational frequencies and adiabatic excitation energies for these states are reported for the first time.

The excited states of HCN : In the flash-photolysis of oxazole, iso-oxazole, and thiozole a transient band system was observed in the region 2500-3050 Å. This band system was attributed to a meta-stable form of HCN, i.e, either HNC or triplet HCN. Theoretical investigations have been carried out on the ground and excited states of HCN to characterize this and other experimentally observed transitions.

Potential energy curves for C2 : Calculations of the ground and excited state potential energy curves of C2 using effective valence Hamiltonian method are benchmarked against full configuration interaction (FCI) and other correlated single reference perturbative and non-perturbative theories. The large non-parallelity errors (NPE) exhibited even by state-of-art coupled cluster calculations through perturbative triples indicate a serious deficiency of these single reference theories.

6. Indian Astronomical Observatory

Optical-Infrared Astronomy

Himalayan Chandra Telescope : The 2-m Himalayan Chandra Telescope entered its second year of allotment during the current year. The third Cycle of allotment ended in April 2004 and Cycles 4-6 were executed during the year. Allotments were made to 16, 19 and 27 proposals during these Cycles, in addition to three Targets of Opportunity programmes. The telescope time was oversubscribed by a factor of 2.5. The results of HCT observations began to appear in print, with 8 papers published in refereed journals during the current year. Six of these had members of IIA as principal authors or collaborators, and are described at appropriate section of this report. Two papers by guest observers are listed below:

1. Kinematics of two dwarf galaxies in the NGC 6946 group, A. Begum, J. Chengalur, 2004, A&A, 424, 509

2. Optical studies of V4332 Sagittarii - detection of unusually strong KI and NaI lines in emission. D.P.K.Banerjee, N.M.Ashok, 2004, ApJL, 604, 57

The primary mirror of HCT was washed with distilled water by the Photonics Division in August 2004. The telescope optics was also aligned accurately in addition to undertaking periodic finetuning of the support system, and other preventive maintenance activities around full-moon when the telescope time was not in heavy demand. The maitenance activities were undertaken by IIA, with some e-mail support by the telescope manufacturers (EOST) at no cost. Since the warranty period of telescope has expired, negotiations were made with M/s EOST for annual maintenance support. The contract agreement is expected to be executed next year.

The webpages of CREST were improved to show the weather information at Hanle automatically. The Michigan Technological University offerred a continuous fish eye night-sky web-camera, free of cost. It has been installed at the site, and is awaiting commissioning after the first phase of network upgradation to be undertaken early next year.

The software for HCT data archive has been developed in collaboration with the Virtual Observatory India team (IUCAA and Persistent Systems Ltd., Pune). The software includes facilities to make observation logs during the night, updating the FITS headers after downloading the data from HCT, a database of detailed information on the data available, and a browser tool. The first part of the software is already implemented. The implementation of the second part, and further development will continue next year after additional hardware is procured.

50-cm Telescope of Antipodal Transient Observatory : The telescope was installed last year. Some mechanical problems were noticed and rectified during the current year. The telescope was aligned well, as a result of which tracking improved enabling first light images.

Gamma-Ray Astronomy

Himalayan Gamma-Ray (HAGAR) Observatory : An atmospheric Cerenkov telescope array is being built at Hanle at an altitude of 4300m above mean sea level for detecting celestial gamma rays. Six telescopes are configred at equidistant locations on a circle of radius 50m and the seventh telescope would be located at the center of the circle (Figure 18). Each telescope has seven para-axially mounted front-coated mirrors of diameter 0.9m with a PMT at the focus of each mirror. The atmospheric Cerenkov light pool created

by the primary gamma rays is sampled through wave-front sampling technique to infer direction and energy of the incident gamma-rays. IIA is collaborating with TIFR, Mumbai, on this project. The foundation stone for the observatory was laid by Shri Kapil Sibal, Hon. Union Minister of State (Independent Charge) for Science & Technology, Govt. of India in January 2005, at CREST, Hosakote.

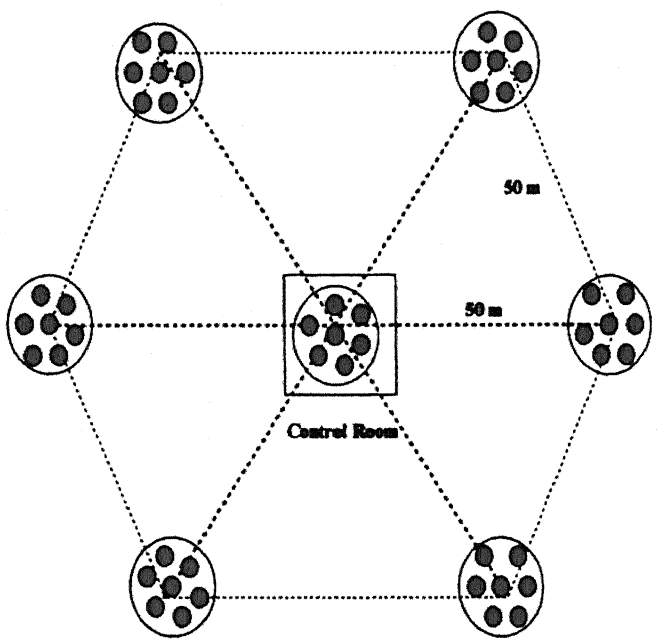


Figure 18. The HAGAR configuration.

The telescope structure is based on Alt-azimuth design. Each of the axis of the telescope is driven by a stepper motor through a chain of gears with a reduction ratio of about 3000:1 for azimuth drive and 3200:1 for elevation drive. The telescope movement control system comprises of two 17 bit rotary encoders (Heidenhain, ROC 417), two stepper motors with drives (Slo-Syn make) besides a Microcontroller-based Motion Control Interface Unit (MCIU). The architecture of the system is based on a PC as host computer and seven front end embedded controllers forming the MCIU. The PC implements the PI control algorithm. The controller basically combines the position loop with the velocity loop. The result of the position error multiplied by proportional gain Kp is added to the integral term and becomes the velocity correction command. The host computer accesses the seven front-end controllers in a Round-Robin method. The front-end embedded controllers implement the motion control system of the telescopes. The host computer determines the position and velocity of each axis and sends the corresponding frequencies to the motion control system. In response to the command sent to the motion control system, the PC receives the telescope position information from the encoders and the status of the command execution. The control system is designed to achieve a steady state pointing of ± 30 arcsec with a maximum slew rate of 30 deg/min for each axis. The resulting blind spot size while tracking stars near zenith is about 1.2 deg.

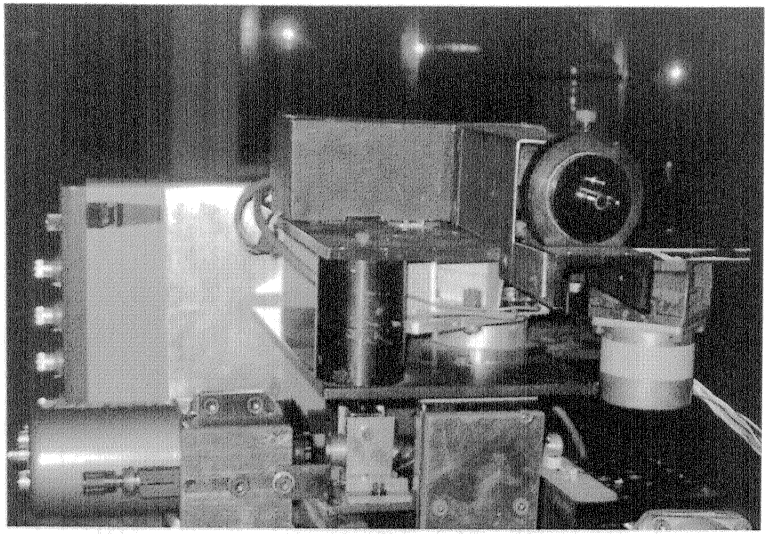
All the seven telescopes movement will be maneuvered by a single control computer sitting in the main control station. Both the axes are controlled to move the telescope to any desired position and then track the object. The PC implements a digital position control system under VC++ and linux.

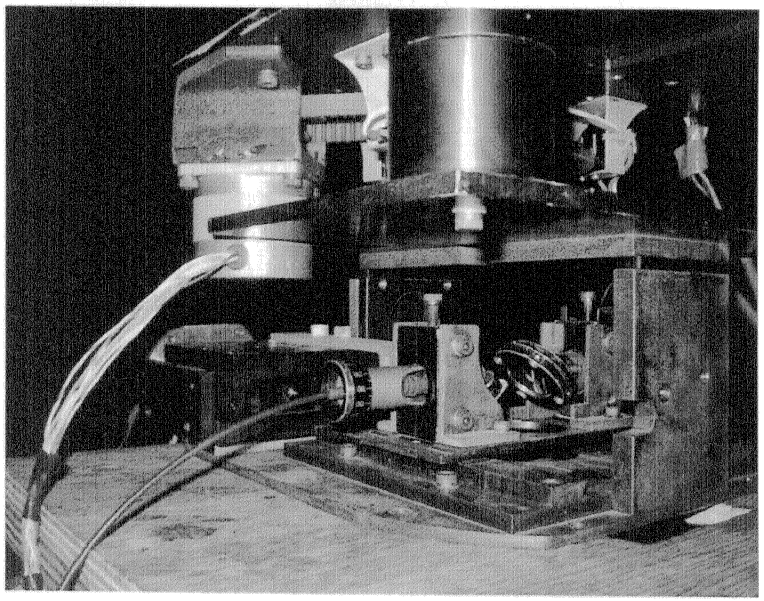
The first telescope of HAGAR was extensively tested at CREST, Hosakote and has since been installed at Hanle during the early part of the summer of 2005. The pier for the telescope including a room for the control electronics has been built already at the site. With a proportional gain of 25 and integral gain of 1, a tracking performance of ± 2 counts (peak to peak) has been obtained with the first unit. Since a beam width of 1 degree is available, this tracking performance of 20 arcsec forms a good figure for the telescope. A detailed point-run calibration by sighting large number of stars will be carried out at the site to establish pointing model of the telescope. This will further improve the pointing and tracking performance.

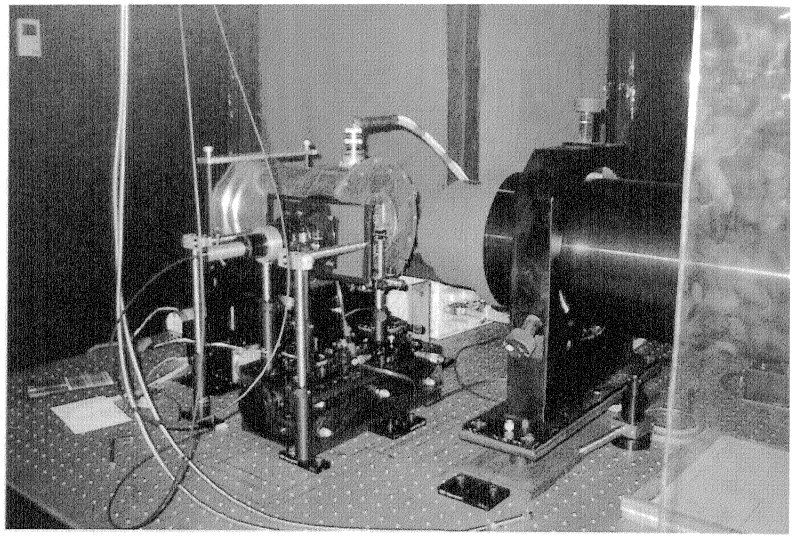
The fabrication of the second telescope was also completed, and it will be installed at site after tests at CREST, Hosakote. Additional telescopes will be fabricated during the next year. The details of infrastructure development for the project were completed and the construction of additional piers, central control room, SPV power station, etc. will be developed next year.

Major Atmospheric Cerenkov Experiment (MACE) : BARC, Mumbai and IIA have signed a broad-based Memorandum of Understanding for cooperation in High Energy Astrophysics. As a part of this collaboration IIA will work with BARC in the development of an imaging Cerenkov telescope at Hanle. The activities will begin during the next year.

Site-characterization for infrared, sub-mm and mm-wave astronomy : The 220-GHz radiometer completed three years of continuous operation during the current year. It is operated automatically as a collaboration between the Raman Research Institute, Bangalore, University of Tokyo and IIA. The results show that the conditions at Hanle are very good for sub-mm observations during 8-9 months in a year. The results also suggest that near-infrared transparency is good all through the year. Direct measurements of water vapour column at Hanle is also undertaken with a hand-held sun photometer. The average water vapour column is 1 mm during January-May and September-December, but increases during the summer months to 3 mm during August. These values corroborate the 220 GHz results that infrared studies are possible all through the year, the conditions being excellent for 9 months.







Prof. B.V. Sreekantan dedicates the Echelle Spectrometer at the VBT.

7. *Instrumentation and facilities*

Fiber fed Echelle spectrometer of VBT : Several programmes have been carried out with the Echelle. The object acquisition unit has been optimised. A new unit planned for the fibers with inclined face plate has been completed and tested. Various fibers have been tried for optimising the transmission. By narrowing the slit one can obtain spectral resolution better than 100000. Stellar spectra have been obtained with such high resolutions.

Programmes that are in progress with VBT Echelle are Hydrogen deficient stars, H -alpha profiles in Late type stars, Weak G-band stars, Semiregular Variables and RV Tauri stars, and Beta Cephei and related stars, Variable Na I D lines in certain line of sights in interstellar medium etc.

UltraViolet Imaging Telescope (UVIT) :

The UltraViolet Imaging Telescope is one of the payloads in ASTROSAT, the first Indian satellite entirely devoted to astronomy. The satellite is designed for simultaneous multiwavelength observations, covering a very wide range from hard X-/ gamma rays to the visible band. Such simultaneous observations have a special role to play in understanding the location and nature of physical processes of emission in variable sources. The satellite is expected to be launched near the end of 2007.

The UVIT would be making images of the sky simultaneously in three channels: 320 nm to 550 nm (may be called visible, though it includes some part of ultraviolet), 180-300 nm (may be called Near UltraViolet), and 130-180 nm (may be called Far UltraViolet). Each of these images would cover about half degree circle and would have an angular resolution of better than 2 arcseconds, which is a factor about three better than that done by the past satellite missions (from NASA) which made images in similar UltraViolet bands, and therefore would show details of the galaxies etc. to much greater distances in the universe. This is done with two, nearly identical, telescopes each with an aperture of 380 mm diameter, in which 40 mm aperture photon counting imagers are used. In each of the three channels, a filter wheel is incorporated for selecting a band.

This instrument is being jointly developed by: Indian Institute of Astrophysics, Bangalore (IIA); Inter University Centre for Astronomy and Astrophysics, Pune (IUCAA); Physical Research Laboratory, Ahmedabad (PRL); Tata Institute of Fundamental Research, Mumbai (TIFR); several laboratories of ISRO: e.g ISAC, IISU, LEOS; Canadian Space Ageny. The payload would be assembled and tested at our Institute, and largest share of the work too is being done at our Institute. Some of the details of the progress are described below, and these clearly demonstrate the intensive nature of inter-institutional collaboration involved in this project.

The structure and thermal control of the instrument are being designed at IIA with active support of ISAC of ISRO. The main optics (mirrors of the telescopes) has been designed at IIA, and is being made by LEOS of ISRO; it may be mentioned that due to the short wavelengths involved, this fabrication is very demanding. Spherical mirrors for a half size model have been made at IIA, and the model has been constructed at IUCAA and is being used to test the attenuation factor provided by the baffles, so that the baffles can be optimised to get an attenuation factor > one billion in the visible for any source > 45 deg. away from the axis. The filter wheels are being designed and fabricated by PRL in collaboration with IISU of ISRO. As already mentioned the detectors are being designed and made in collaboration with CSA, and the image intensifiers for these are under fabrication at Photek (a

company) of UK; these would use Star250 CMOS imagers for recording intensified images, and the tests to verify suitabilty of these imagers for high resolution imaging have been carried out at IUCAA; further, commercial grade Star250 imagers would be screened (for acceptance to use in the payload) by IUCAA/TIFR with support from ISAC of ISRO. Electrical interfaces of payload with telescope are being designed by IIA/ TIFR. Software for processing and using data for astronomy is under development at IIA.

Testing of components/telescope requires a high level of molecular/particulate cleanliness as well as vacuum, and suitable facilities for these tests are being developed at IIA. A small clean room is already functional at IIA, and instruments are being assembled here for testing of components etc., including tests in vacuum. In particular a monochromator/reflectometer is routinely in use for measuring transmission/reflection of samples in ultraviolet and visible channels, covering the full range of 120 nm to 500 nm. This set-up has been extensively used to assess the contamination potential of materials, by observing any reduction in transmission of windows exposed to the materials at high temperature (50 - 100 C) in vacuum. For assembly and testing of the telescopes, a special purpose clean laboratory is being developed at the CREST campus of our institute; the laboratory has an area more than 500 sq. metres, and has three sections with different levels of cleanliness: Class 100,000 for testing of mechanical parts, Class 10,000 for assembly of mechanical parts, Class 1000 (with a Class 100 optical table and access to a vacuum chamber for testing the assembled telescope) for assembly and testing of the telescopes.

Dome control software for 75 cm telescope :

The aim of this project is to automate the dome control for the 75 cm telescope at VBT, Kavalur, as a part of an overall modification/improvement for this telescope.

The design of the software is planned to be similar to the 2m dome control software. The dome control software works in 3 modes viz. manual, automatic local, automatic remote. In manual mode the software has no control over the dome. In automatic local mode the user can command the dome to move to the required azimuth, open the shutter and also put it in tracking mode. In automatic remote mode the functionality remains the same as the automatic local mode except that the user can control it from a remote system over a LAN/WAN.

Using VC++ (MFC) on Windows NT the software(GUI) has been developed for automatic local mode of operation.The software sends commands to the Inverter(Siemens Micromaster 420) through the serial port.The Inverter controls the speed of two AC-motors to rotate the dome. A PCI-1753 I/O card is used to read the position of the dome from an Encoder (BEI manufactured 16bit. Using the GPS facility the UTC time is obtained and displayed.

CCD image acquisition, analysis and processing software using IDL under Linux :

The present image acquisition software was developed using Gtk libraries, with C++ under Linux. As the Gtk versions keep changing maintaining software up to date is difficult. The Interactive Definition Language (IDL) an Imge Analysis and Manipulation package from RSI, USA has lot of built-in widgets and user friendly features particularly for developing GUIs. Hence a new image acquisition system using IDL is proposed and is being developed.

The purpose of the software is to acquire, analyze and process the CCD images. This software has been developed using IDL under Linux platform. The software uses a client / server model where the client can be placed on the same machine as the server or at a remote site. The Client / Server communication programs are written in C. IDL procedures call the C programs

to establish connection between server and client. This software is equipped with file handling, image processing, graphics, and image acquisition facilities viz. *Bias, Dark, Expose and ExposeX*. This software is being developed for 2K x 4K CCD for the 2.34 m telescope at VBO, Kavalur.

TAUVEX : The TAUVEX team has been working on the Indo-Israeli collaborative experiment TAUVEX. The entire processing and analysis software for TAUVEX will be done at IIA. Substantial progress has been made and it is expected that delivery of the TAUVEX software will be made by Dec. 2005. The payload itself is under development in Israel and will be delivered to India by Jan. 2006 in preparation for an Oct. 2006 launch.

Mechanical Engineering Division

Engineering of 75cm telescope : Detail engineering of the mechanical system of the 75 cm telescope has been reviewed and approval for the fabrication of the telescope mount is given. Telescope fabrication will begin soon.

Vainu Bappu Observatory : Upgradation of VBT mirror carriage and over-hauling and servicing of 10 tonne EOT crane at the VBT dome has been taken up. Work will begin during the off season.

Solar image limb tracker for Kodaikanal Tunnel Telescope : A solar image limb tracker system for tunnel telescope based on SPOT-2D bicell sensor was developed at IIA Bangalore. SPOT-2D is a two segmented photo detector with dimension 1.3 mm x 2.5 mm with a gap of 0.127 mm.

Two sensors are used for RA and DEC image drift evaluation. The guider unit is interfaced to PCI 9112 interfaced card. The digital i/o is interfaced to KTT Control System unit. The complete block diagram is shown in Figure 19. The RA and DEC stepper motors are rotated to compensate the X & Y drift in the image. The control code has been developed in C. The unit is undergoing testing at tunnel.

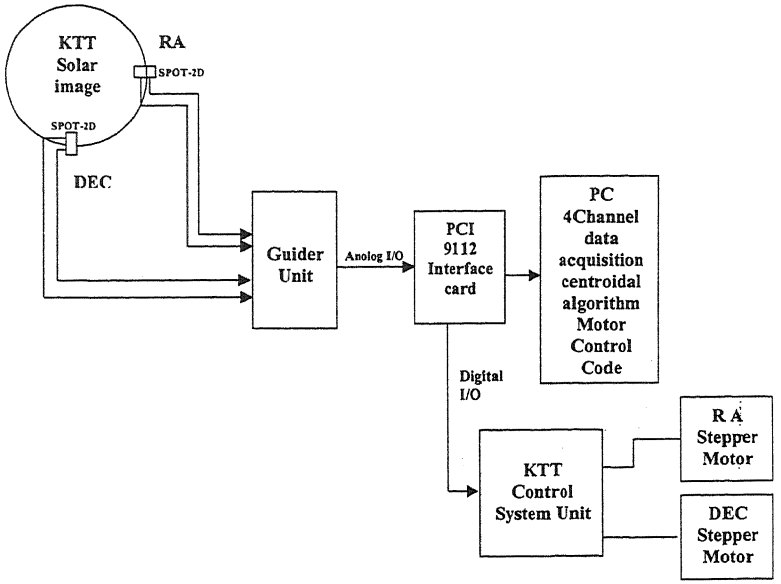


Figure 19. Limb Tracker Unit.

Photonics Division

2 m vacuum coating plant at IAO, Hanle : The primary mirror of the 2m Himalayan Chandra Telescope (HCT) at Hanle was cleaned in-situ and the telescope was realigned to better accuracy. A procedure has been set up to align the telescope from the first principles.

The trial runs of the vacuum coating plant were carried out at Hanle during August 2004. The performance of the coating plant was evaluated. Certain

works are planned to be completed before the plant can be operated on a routine basis.

A team from the Photonics Division was involved in the above work

VHRR sun shield panels for INSAT 3D satellites : Work on the polishing of sunshield panels for INSAT 3D imager and sounder coolers is progressing well. The 2nd set of panels (10 Nos.) as an engineering model with desired specification has been optically polished and delivered to ISRO. Optical polishing of the third set is in progress.

Long trace profilometer : The Long Trace Profilometer (LTP), for the metrology of Synchrotron Beam Line Optics, Version II (improved version) is being built and will be supplied to CAT, Indore, next year. This is funded by BRNS, DAE. This development has placed India in the world map of LTP builders.

Vacuum and thin film coating : Minor works on the 1.2 m and 2.8 m vacuum plants have been taken up in order to meet the urgent requirements. The electrical, electromechanical components and refrigeration units have been serviced. The work is still continuing. Kodaikanal tower mirrors were given a fresh coating. A total of three 60 cm and 9 other smaller mirrors were coated. Work on the 2.8m coating plant upgradation is still pending.

Adaptive optics : Research work continues towards building a low cost adaptive optics system for astronomical applicatiions. Experiments with the closed loop control of the tip tilt mirror and deformable mirror along with the 70 x 70 lenslet array, 300 m diameter and 40 mm focal length Shack Hartmann sensor are in progress. Real time operating system working on industrial PC bus such as PXI bus is chosen for this configuration. A new algorithm developed for the adaptive mirror control is being tested for its efficiency.

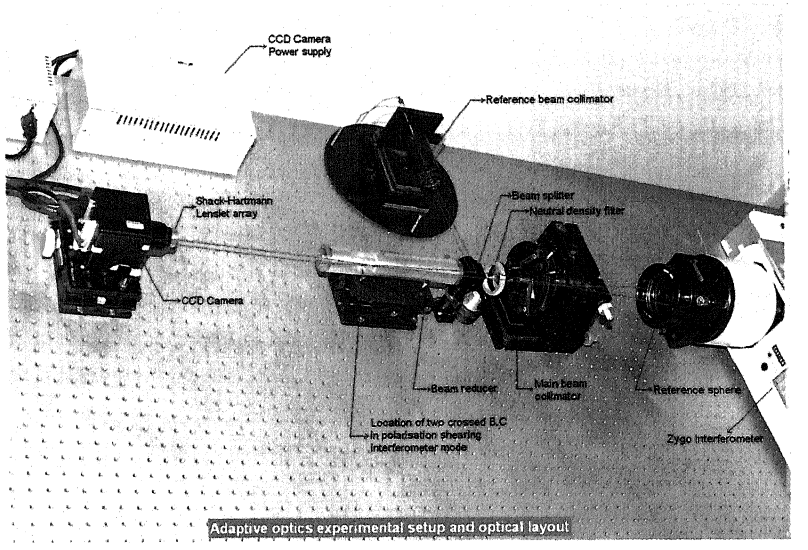


Figure 20.

Research work is in progress to build a new wavefront sensing using polarization shearing interferometric technique which is already established. The algorithm for the reconstruction of the wavefront from a single interferometric record has been developed and being tested.

An adaptive optics optical bench is being created using a 25 cm telescope with wavefront sensors, tip-tilt mirrors and a turbulence plate. A new optical design has been evolved with the provision to use either SH or LSI wavefront sensor. Using a fiber coupled light source a 25 cm collimated beam is reduced to 4 mm to suit the detector geometry. An algorithm for a new Shack Hartmann sensor of 20 x 20 lenslet array, 500 m pitch and 30 mm focal length is being developed in lab view environment. The Figure 20 shows the experimental set up and the optical layout.

V. Chinnappan and J.P. Lancelot are engaged in the above research which will lead 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.

Optical Metrology Lab : The Optical metrology lab with the facilities of testing and certification is fully established and functional. The following state of art facilities are available for optical metrology.

a. Long Trace Profilometer
b. Digital Spherometer
c. Fiber Optic Spectrometer
d. Wyco Profilometer
e. Zygo Interferometer.

WARM Telescope Project : We have prepared the concept report and layout drawings for the study of white light active region motion telescope.

Dehumidifier Installation

A dehumidifier is required to preserve the optical elements in working condition. It provides a chamber with optimum control of temperature and moisture. An air compessor of suitable capacity provides compressed air, under controlled pressure after draining the moisture. One dehumidifier was installed at the CREST campus of IIA.

Speckle Interferometer

Close binary stars : The speckle interferometer is used at the Cassegrain end of the 2.34 meter 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 electron multiplying CCD (EMCCD) is used. Data analysis of a few close binary stars along with the respective reference stars have been carried out. Hundreds of frames of each of these stars are scanned carefully and are 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 HD 91172, obtained from VBT, Kavalur on 7th April, 2002 is done and the angular separation between the two stars in the system is obtained.

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. 2005). The orbit of a couple of binary stars, HD30810 and HR781 are plotted using measurements obtained from 1953-2000. The measurements include those from various telescopes across the world.

8. Library

The Library added 241 books and 647 bound volumes of journals to its collection. The current journal subscription is 242, out of which 131 titles can be accessed full text online within the campus at Bangalore and Hosakote. From this year, the online access to few journals are enabled from Kavalur and Kodaikanal campuses also. Efforts are being made to include more journal titles for online access from those campus in the coming year. As a part of training programme a fresh batch of Library Trainees have joined the Library in Mar 2005. They are trained in all sections of the library and also in the Digital Library Project.

Most of the Inter-library loan requests from scientists and students were taken care of using e-mail and Internet facilities. Library continued to use the facilities of IISc and RRI libraries for interlibrary loan requirements.

IIA library continues to be a member of FORSA (Forum for Resource Sharing in Astronomy) consortium. We have access to online version of additional Springer and Kluwer journals in Astronomy through the consortium. FORSA has a plan to extend its consortium deal of journal subscription to AIP journals next year.

Library acquired a new xerox machine, which has an additional feature of network printing of files in Linux platform. Digital Library Project continued smoothly, and the trainees are trained to use the new metadata form while digitizing.

Christina Birdie has initiated the work of establishing an "Open Access Repository" of IIA publications in the library and will be responsible in maintaining this repository of IIA research papers and PhD theses.

Digital Library Project

Under the guidance of Dr. Vagiswari, all the library staff and trainees are trained to continue the metadata preparation, scanning, editing and OCR ing procedures of digitization process of books in the project. We have completed the digitization of 350 books which are out of copyright, and the scanned images are stored in DVDs and also uploaded in the DLI (Digital Library of India) server at Indian Institute of Science for retrieval. Most of the archival literature belonging to IIA Library has been digitized and available in CDs for retrieval.

IIA Archives

During the year setting up of the IIA Archives and related procedures progressed well. The following work has been carried out under the supervision of Dr. Vagiswari.

1.An archival Policy for IIA laying out the general Principles and Guidelines for setting up of the archives and its functioning was prepared.

2.Metadata for all the volumes digitized is created

3.An informal collaboration with Intach, Bangalore was initiated. Dr. Subbaraman of Intach, an expert on preservation and conservation of old material was invited to the Institute, along with his team, to examine the rare documents and advise on their preservation.

4.Intach provided initial training of techniques involving cleaning and repairing of old maps. 40 very old maps belonging to early 19th century have been cleaned and mounted.

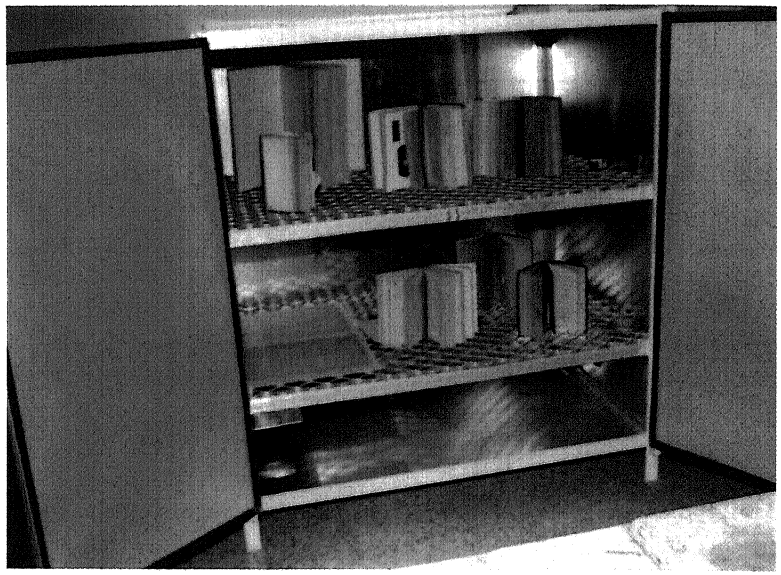
5. Nearly 100 maps which from a part of survey of India reports also belonging to 19th century and which are larger than A3 size have been scanned and kept on DVD's.

6. Special storage boxes were designed and fabricated at IIA binding section for storing handwritten manuscripts belonging to 19th century.

7. Special archival material for repairing and cleaning old books and loose sheets was imported from US.

8. A Fumigation Chamber that was designed by the Library and fabricated in IIA workshop is now ready to use. This chamber will destroy insects and remove fungus which grows on the paper.

9. A team visited the Kodaikanal library and some valuable documents were collected for archiving.



Fumigation chamber designed by IIA Library and fabricated at our workshop. This chamber will clean the fungus affecting archival material.

9. Graduate studies programme

Board of Graduate Studies

U. Paniveni submitted to the Mangalore University her thesis titled "Convective flows on the solar atmosphere" under the supervision of Jagdev Singh.

Maheswar Gopinathan and Kathiravan submitted their Ph.D. theses to Calicut University and Mangalore university respectively. S. Ambika and Shanmuga Sundaram received their Ph.D. degrees from IISc. Ambika's Ph.D. thesis is in the topic "Optical Observational Astronomy" supervised by Prof.M.Parthasarathy and Shanmuga Sundaram worked in the field of "Radio observations of Sun" under Prof. K.R.Subramanian.

Students who have qualified for the fellowship under UGC/CSIR/NET exam are eligible to apply for IIA Ph.D. programme. Candidates having high ranks in GATE (Physics) are also encouraged to apply in addition to the JEST stream.

Twenty five M.Sc. students were selected for Kodai School this year by BGS.

Student Training Programmes

A document was brought out outlining details of the students training programmes in the Institute after a thorough review of the existing programmes. Details of this document are also placed in the Institute website.

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. 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. The supervisors of the projects were involved in the selection of students for the programme. A record number of seventeen students participated in the programme this year.

Three students were trained under the Institute's Degree Students Programme. The training period varied from 3 to 4 months. These are long term projects sometimes required as a part of the curriculum in the university.

Fifteen students worked under the IIA Ph.D. programme this year. Ms.Sampoorna from JAP joined IIA to do her Ph.D. thesis in the Institute.

Three lecturers are working for their Ph.Ds in IIA under Faculty Improvement Scheme of UGC this year.

Hindi Divas was celebrated in the Institute with great enthusiasm.

10. Welfare and other activities

Welfare activities for SC/ST

An officer of the Institute at a senior level functioned as the Liaison Officer to support the welfare of the SC/ST staff members. Several members belonging to these communities were deputed for acquiring specialized training. Housing facilities have been extended to many SC/ST on a priority basis. Special consideration as per the norms during the regular assessment was provided to these categories of employees.

The total staff strength of the Institute as on 31-03-2005 was 365. As per the orders of the Government, 54 posts in scientific and technical categories were exempted from the reservations. Out of 311 positions, 54 members belong to SC and 27 members belong to ST, forming 17.36% and 8.68% respectively, which includes physically handicapped members also.

A Grievarnce Committee was functional to address the grievances of the employees of the Institute.

Further expansion plans

The Institute's efforts since 1994 have finally borne fruit with the allotment of 2.9 acres of prime land by the Govt. of Karnataka, about 1 km from the Koramangala Campus at Bangalore. This is for setting up additional laboratory housing facilities etc. in the future.

Official language implementation

Considerable progress has been made in the progressive use of Hindi in official language implementation. All round efforts have been made to ensure successful implementation of the official language . Section 3/3 of official language Act have been complied with , and Administrative and other reports have been prepared bilingually . These include the Institute's Annual Report, audited report and other administrative reports . Letters received in Hindi are replied in Hindi. On the occasion of Honorable Minister Shri. Kapil Sibbal, visit to CREST Hosakote, all the banners, name plates and necessary sign - boards were prepared in Hindi and in Endlish.To impart knowledge of Hindi, five employees were sent to Hindi Teaching Scheme for Prabodh course. Several queries were received in Hindi regarding Astronomy and Astrophysics were replied to in Hindi. Official circulars have been brought out bilingually. Hindi Divas was celebrated in the Institute. Reference books in Hindi have been made available to the staff members. Several new Hindi books have been bought.

11. Conference reports

Kodai School in Physics and Astrophysics, June 07 – July 03, 2004

A 4-week summer school on Classical Mechanics, Electrodynamics, Special and General Relativity, Gravitation, Physics of the Universe and Solar Physics was conducted at the Indian Institute of Astrophysics, Kodaikanal, during June 07-July 03, 2004. The enrichment course comprised of lectures and tutorials. Nineteen final M.Sc., B.Sc. Physics and B.Tech., students were selected on an all-India basis to attend the course. Eighteen M.Sc., final year Physics students from the Mother Teresa Womens University, Kodaikanal attended the course as non-registered candidates.

On the inaugural day June 07, Professor V.K. Gaur, IIA, Bangalore, gave the welcome address, Professor J.H. Sastri, Acting Director, IIA, inaugurated the school and Professor B.V. Sreekantan, Chairman, Governing Council, IIA, gave the keynote address.

Lectures and tutorials were given by Professor T.R. Seshadri, University of Delhi, Delhi; Professor H.S. Mani, Professor G. Date, Dr. G.M. Hossain, Institute of Mathematical Sciences, Chennai; Professor J.S. Bagla, Dr. Namit Mahajan, Harish Chandra Research Institute, Allahabad; Professor H.M.Antia, TIFR, Mumbai; Dr.S.P. Bagare and Dr. Arun Mangalam, IIA, Bangalore; Dr.S. Gangopadhyay, S.N. Bose National Centre for Basic Sciences, Kolkata and Dr.A.V. Thampan, IUCAA, Pune.

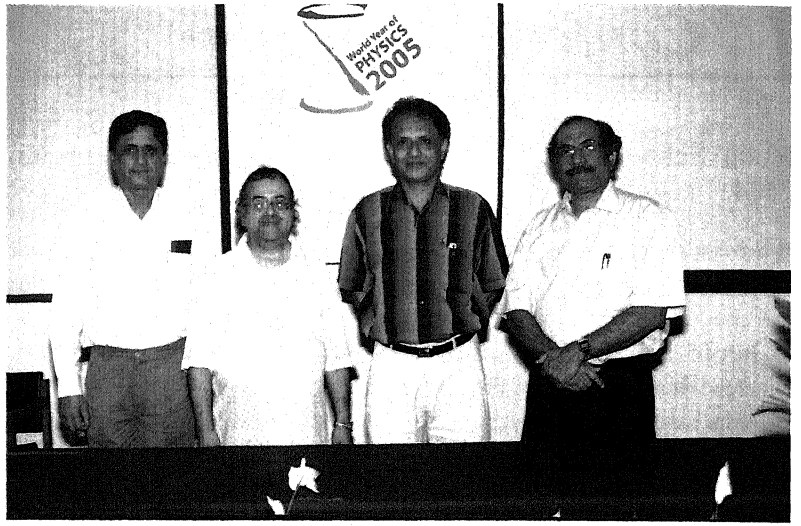
Guest lectures on Transit of Venus on 8/6/04, The Structure and Dynamics of the Sun and Global Positioning System Technology and its applications were respectively given by Dr. S.P. Bagare, Dr. Dipankar Banerjee, IIA, Bangalore and Dr. (Mrs.) E.C. Malaimani, NGRI, Hyderabad.

International Year of Physics - 2005 celebrations

The Institute organized a 'One-day in-house Symposium' on 14th March, 2005 to mark The International Year of Physics 2005, in celebration of 100th anniversary of Einstein's papers of 1905. The Programme consisted of two sessions. The morning sessions consisted of welcome address by Prof. J.H. Sastri, Director (Ag.) and an Inaugural address by Prof. B.V. Sreekantan, Chairman, Governing Council. C. Sivaram set the tone of the Conference by presenting an informative overview of Einstein's revolutionary papers of 1905. This was followed by talks that covered the subject of these papers in greater details- What is Relativity ? by K.V.P. Latha, Relativity, QM, quantum statistics by B.P. Das, Photoelectric effect and

Students and teachers of the Kodai School - 2004.

stimulated emission by Chiranjib Sur, Brownian motion by S. Chatterjee, Relativistic astrophysical amplifier by Prajval Shastri, GTR, cosmology and the cosmological constant by Pijush Bhattacharjee. The afternoon sessions had the following talks- Experimental evidence of Equivalence Principle by D. Suresh, the Einstein - de Haas Experiment by Abhay Karnataki and Einstein - the humanist by M. Sampoorna. There was an audio-visual presentation by IIA students on the life and times of Einstein which was highly appreciated by the audience. A fitting finale to the day long symposium came in the form of a public lecture - 'Einstein's life and legacy' by Prof N. Mukunda.



The one day in house symposium on the 14th March 2005 was organized by R.C. Kapoor, C. Sivaram, S.P. Bagare and P. Bhattacharjee

Participants in discussion.

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.

Students of IIA can register for PhD as well as the facilities would be in principle available to the students of the University. IIA has provided the University with a 45 cm Telescope and supported creation of an observatory and related infrastructure in the University campus.

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.

Continuous Camera Sky Monitoring Project

IIA is collaborating with Michigan Techological University, Houghton, USA, to install a CONtinuous CAMera (CONCAM) at Hanle. The CONCAM is a CCD-based all-sky camera with software designed to show the images on the web, archive and automatically analyze the data. Currently CONCAM units

are installed at 10 observatories. The CONCAM at Hanle will be the 11th, and highest in altitude. It also fills a longitudinal gap between Israel and USA in the northern hemisphere.

Himalayan Gamma-Ray Observatory

IIA is collaborating with Tata Institute of Fundamental Research, Mumbai, in setting up a high-altitude gamma-ray (HAGAR) observatory in Nilamkhul Plain (4300 m altitude), Hanle. The observatory will consists of 7 mounts each of which will have 7 telescopes of 0.9 m diameter. The first of these was tested in CREST, Hosakote, before shipping to Hanle. Other units will follow.

IIA and BARC have signed a Memorandum of Understanding to cooperate in the area of science in general, and specifically in the area of high-energy astrophysics. As a part of this MOU, the Major Atmospheric Cerenkov Experiment (MACE) proposed by BARC, will be built jointly by BARC and IIA.

GPS Stations

IIA continues to maintain and operate the 3 permanent GPS stations of the National Network at Kodaikanal, Hanle and Leh and the data are archived and shared with the Survey of India GPS Data Centre. In addition to this, the Institute has recently established another permanent GPS Station at Bomdilla in Arunachal Pradesh on behalf of the DST. After through testing, this station has now been handed over to Tezpur University for further operation and data archiving.

The Bomdilla Station.

13. Public outreach

Popular Lectures

G.C. Anupama gave a talk on "Astronomical observatories in India" on 26 March 2005 at the B.V. Jagadeesh Science Centre, Bangalore.

S.P.Bagare gave an Invited Public Lecture titled "Venus has a date with the Sun", on 7th June 2004, at the Kodaikanal Observatory, on the eve of the rare celestial event of the transit of Venus. The lecture was well attended and drew a large participation to view the event on the following day, the day of the transit.

B.C. Bhatt lectured to students at Birla Institute of Fundamental Research, Bangalore.

P. Bhattacharjee gave a public lecture on Ultrahigh energy cosmic rays: "Physics and astrophysics at extreme energies", at the Nehru Planetarium, 3 June 2004.

S.S.Gupta as Chief Guest addressed and distributed the certificates to students on the annual day of the Ambedkar Industrial Institute on 7/7/04 held at the Sacred Hearts College, Shanbaganur, Kodaikanal; He interacted with the women Vice-Chancellors of India during the round table meeting on 6/9/04 conducted by the Mother Teresa Womens University, Kodaikanal; At the School of Distance Education, Research and Extension Center of the Mother Teresa Womens University, Madurai he attended the Physics Research committee meeting on 29/4/04, interviewed and selected students for external Ph.D. registration. He attended the subject expert committee meeting for external Ph.D., candidates on 8/9/04. At the University of Madras, Chennai, on 14/6/04 he held discussions and evolved guidelines to offer Credit Transfer in Astrophysics subject for the M.Sc., (Physics) students between the Mother Teresa Womens University, Kodaikanal and the University of Madras, Chennai; Gave the valedictory address on 8/10/04 at "MAGNAcom 04" - an inter collegiate meet of students at Kodaikanal Christian College, Kodaikanal; As Chief Guest he gave the inaugural address on 7/1/05, on the occasion of the recognition of the Physics department as a research center in Physics of the Madura College, by the Madurai Kamaraj University, Madurai. He made arrangements at the museum to show the Transit of Venus on 8/6/04 to students and to the general public.

A. Mangalam gave a popular talk on "Magnetic fields of Galaxies" to College students at the Nehru Planetarium in July 2004.

In connection with the year of physics, **C.Sivaram** gave about twenty popular lectures on Einstein's work and related fields in several colleges and schools in Bangalore and Mysore. Also two radio talks were presented.

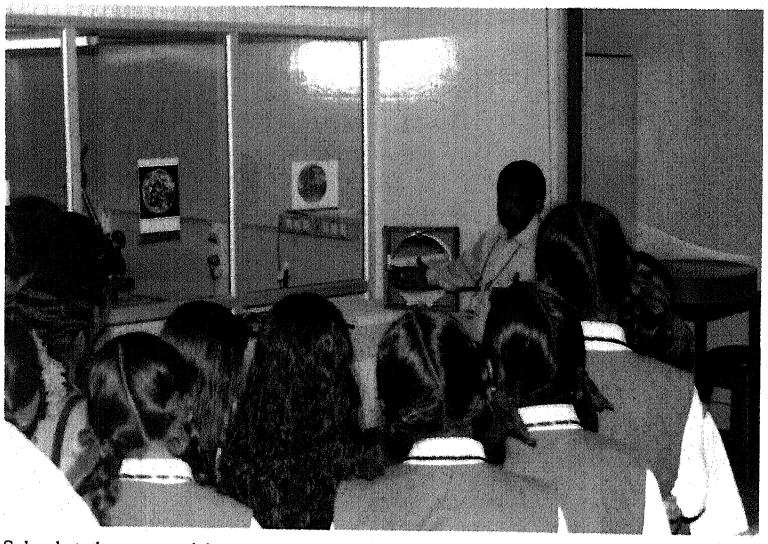
J.P. Lancelot gave lectures at the M.P. Birla Institute of Fundamental Research, Bangalore, for their course on Astronomy and Astrophysics.

K. Sundara Raman delivered two special lectures on the topics "Importance of Basic Science Education and Research" and "Study on Sun" on 2 August 2004 at Anna Science Centre Planetarium, Trichy for the benefit of local public and students of schools and colleges.

K. Sundara Raman addressed a group of M.Sc. (Physics) students belonging to various colleges at Anna Science Centre, Trichy on 3 August 2004 for a detailed discussion on the importance of dissertation work that forms a part of the curriculum in the universities at PG level.

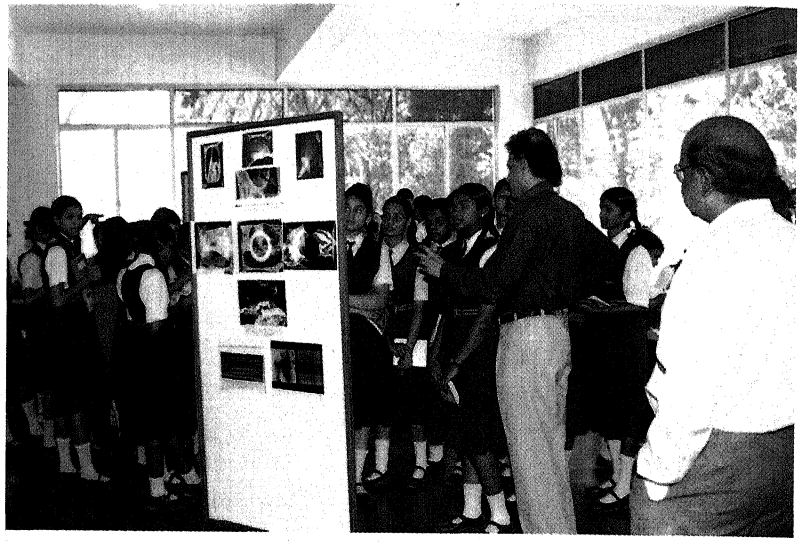
National Science Day

An open house day was observed on 28th February 2005 to celebrate the National Science Day. About 400 students and their teachers from various schools and colleges in Bangalore spent a good part of the day on the Bangalore campus of IIA. S.P.Bagare had arranged a special science exhibition at the ICNAPP lounge, assisted by Murali Das and Malini, to highlight the scientific achievements of the Institute. Models of telescopes and a collection of large posters on work at IIA, and on popular astronomy topics, were on display. The sunspot viewing was arranged with the help of the Mechanical lab and was organized by Ebenezer. At the Photonics division, Lancelot arranged the



School students on a visit to the Photonics Laboratory on the National Science Day

viewing of optics work in progress, as well as a few demonstrations of some fascinating optical effects. Special talks were given by S.P.Bagare on Glimpses of the solar system and the special status of planet Earth,and by R.Ramesh on the Celestial radio sources. A 15-minute movie on the history of IIA was screened. These programmes were repeated during the day. The visiting students



National Science Day, February 28, 2005

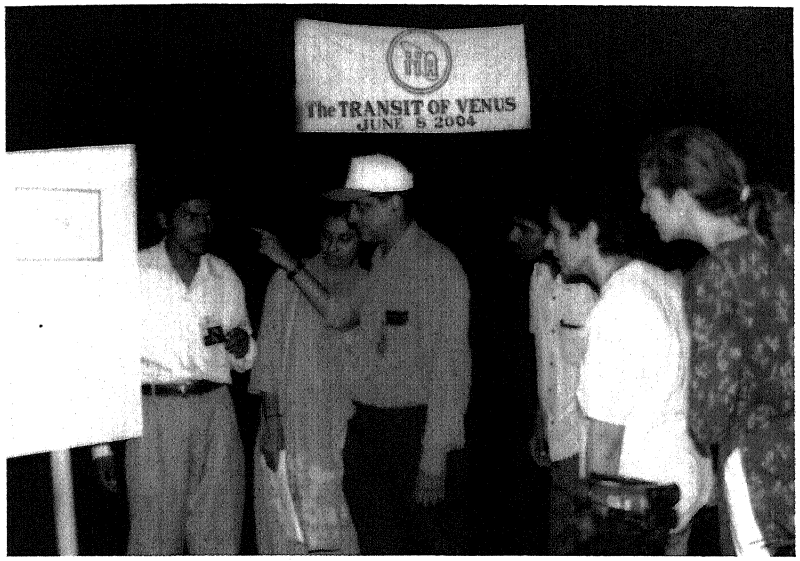
and teachers freely interacted with the members of staff and students of the Institute.

The Transit of Venus 2004

A rare celestial event, namely the transit of the planet Venus took place on June 8, 2004. The planet passed in front of the Sun as viewed from the Earth.

As seen from the Earth, transits of only Mercury and Venus are possible. On the average there are 13 transits of the planet Mercury in a century. As the orbit of Venus is much bigger than that of Mercury, transit of Venus is even rarer. At the same time, Venus has an angular diameter bigger than that of Mercury. Such an event, though not as exciting as a total solar eclipse or a comet is of interest in its own right.

A transit is difficult to observe as the planets are small- Venus has an angular diameter of about 1 arc min (6052 km mean radius) compared to 31.5 arc



Thousands of visitors to the Institute at its Koramangala Campus had a glimpse of the Transit of Venus on June 8, 2004

min (mean radius 695950 km) of the Sun and so will appear as a small dot against the bright disc of the Sun. It can be distinguishable from a sunspot only because of its regular shape and the movement across. The event was going to be visible from India, in fact throughout Asia. As the smaller disk of Venus moves in front of the Sun's, the transit is marked by four contacts; these phases are given below for New Delhi (IST): h m s

Ingress, exterior contact 10 46 09.8 (Ist contact)
Ingress, interior contact 11 05 04.5 (IInd contact)
Least angular distance 13 48 02.5
Egress, interior contact 16 31 36.3 (IIIrd contact)
Egress, exterior contact 16 50 39.4 (IVth contact)

The Venus transits are very rare, about 12 in a millenium. The last one happened a good 122 years ago, on December 6th, 1882. As Venus passes in between us and the Sun a line-up takes place every 1.6 years. But the transit does not happen since the orbit of Venus is at 3.4 degrees to that of the Earth and each time a line-up takes place, Venus is either above or below the disk of the Sun (the so called inferior conjunction). However, when the line-up occurs at a place where the orbits cross each other the transit will happen. The crossing line corresponds to the 7th of June and 8th of December. Such a line-up was to be on June 8th, 2004. Being so close to the orbit crossing line, Venus would transit across the Sun, through its south side. The next transits are due in June 2012 and Dec. 2117. The transits have interestingly a 243 year repetition, with two transits in December 8 years apart, followed 121.5 years later by two June transits 8 years apart. That tells why the June 2004 transit was such a rare one. No living person among us had seen one ever. There have been 6 events since the invention of the telescope. The first ever viewing of a transit with an equipment was on Dec. 4, 1639 by Gassendi.

In these times, a Venus transit is not all that important so far as serious research is concerned. It still is worth an attention in more ways than one. As a public interest event its educational value is immense where the media and the internet have an important role to play.

1. During the second and the third contact, it is possible to notice what has been termed as 'black drop effect'. This mysterious effect happens at those crucial times when the disk of Venus appears a bit deformed, clinging to the limb of the Sun by a thin column or thread. The breaking of this thread marks the 2nd contact. The 3rd contact happens in exactly the reverse order. This effect is a result of seeing effects due to the turbulent atmosphere of the Earth. 2. There is a likelihood of the Sun showing up with sunspots. And if Venus happens to pass in front of or close to one, it will be an exciting sight. 3. A few hours before or after the transit, Venus will still be close to the Sun separated by only a few degrees. The Sunlight's refraction through the atmosphere of the planet will light it up and a ring around the tiny but dark disk of Venus can be seen. This may be possible if the bright disk of the Sun is blocked for only the planet to be in the field of view of a suitable equipment.

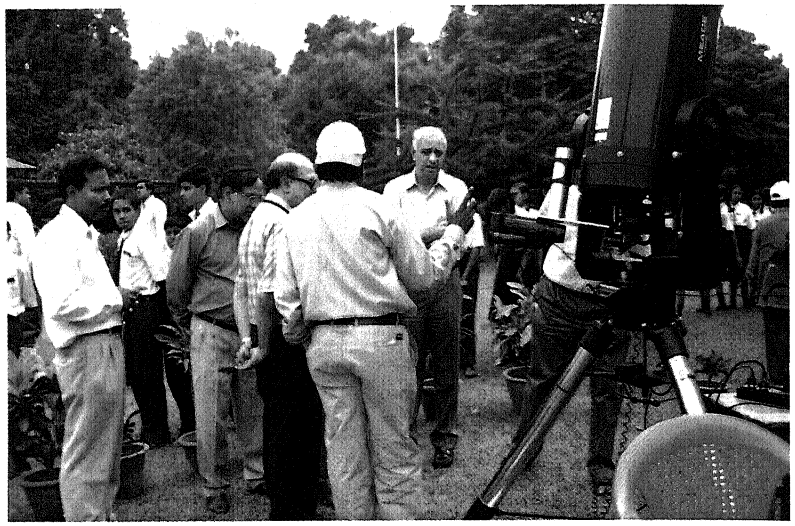
Observations planned from the Kodaikanal Observatory, for the event of 8th June 2004, weather permitting, were as follows:

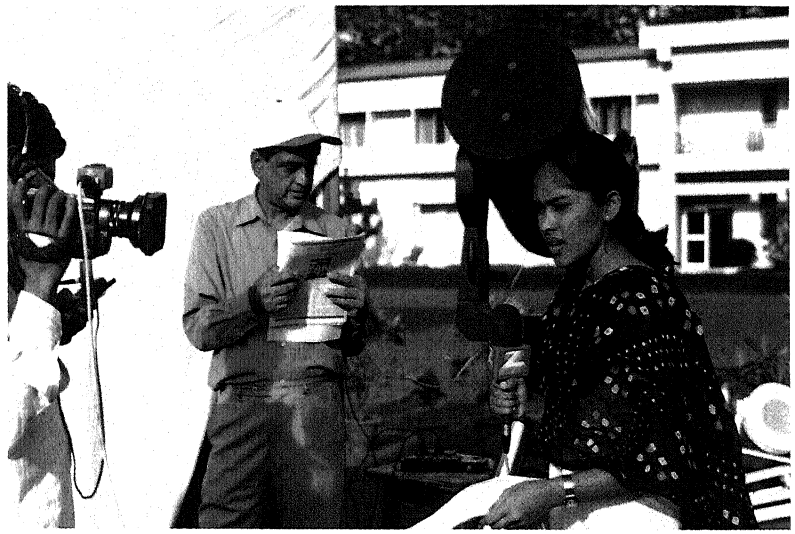
a. Photographic recording of broad band (white light) frames, at about once in 30 minutes, of the full solar disk during the transit. Multiple frames were planned during ingress and egress. The timing of the circumstances of the event were recorded based on the GPS facility available at the Observatory.

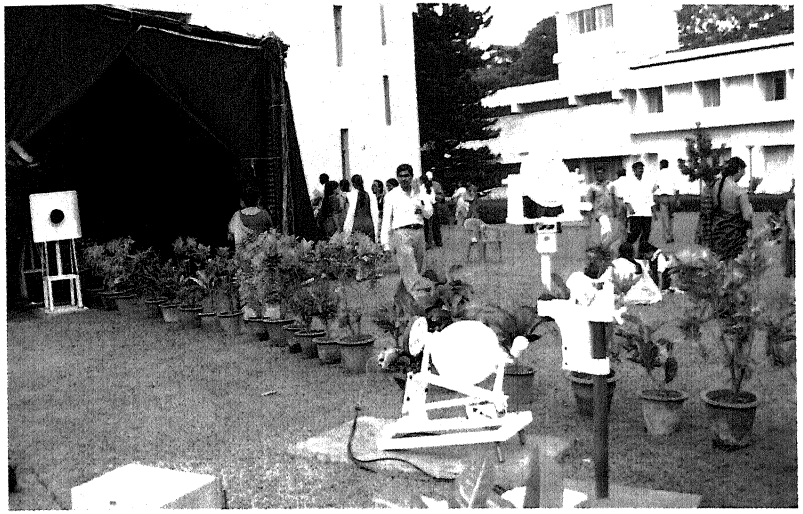
b. Narrow band full disk imaging in the Chromospheric lines, the Calcium K and/or the Hydrogen alpha, close to the timings of the frames in (a) above.

c. CCD camera recording of select regions of the Franhaufer spectrum in order to look for possible spectral signatures of the atmosphere of Venus silhouetted against the solar disk.

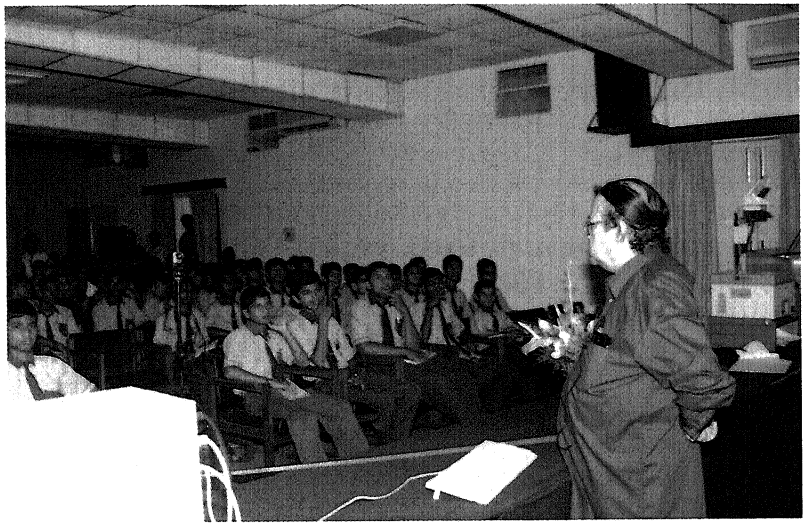
The transit was witnessed by thousands of visitors from all walks of life including school children from near and far. At the Koramangala campus an arrangement was made to view a 30 cm image of the Sun on a screen in a tent formed with a 20 cm coelostat system very ably installed by F Gabriel and his associates from the VBO. The event began at 10:45:31 hrs. The sky was generally cloudy throughout the day but in between the event was possible to be watched whenever the cloudcover got thinner or clear up for a while. Venus appeared against the bright image of the Sun as a dark round spot, 1/30 its diameter transitting across it in over 6 hours. This apart, there was also installed a 35 cm Maede telescope attached with a video camera to directly record the entire event and project it through a multimedia facility. This was specialized to the transit by J P A Samson and his team. Inside the auditorium, C Sivaram conducted a nonstop lecture and question answer session all through the 6 hr transit for the benefit of the general public whose enthusiasm was never failing. Towards the latter part of the day, the clouds got thicker much to the disappointment of the scientists and the visitors alike as they could not watch the grand egress of the planet at about 16:30 hrs onwards. The event received wide publicity in the print and electronic media while a news channel had stationed an outdoor broadcasting van exclusively to cover the transit-watch live from the IIA campus.







The Transit of Venus was arranged to be viewed on a screen kept in a tent.



Transit of Venus : Prof. C. Sivaram lectures before general public.

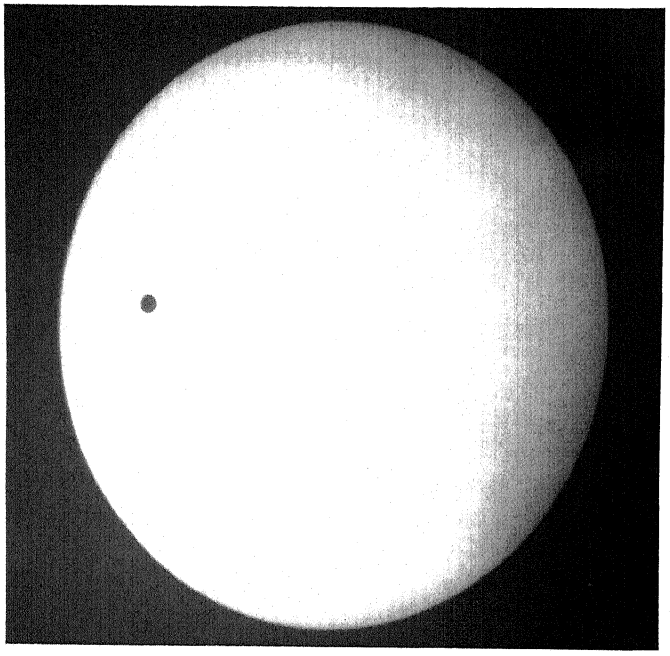
We carried out observations at the Kodaikanal Observatory during the rare astronomical event of the transit of Venus on 08 June 2004.

All the solar optical observational facilities of the Kodaikanal Observatory were geared for a campaign mode of observations for the rare astronomical event; the 15 cm telescope for photoheliograms, the Solar Tower Telescope for high resolution imaging with a CCD, and the Spectro facility for Hydrogen alpha imaging using a large format CCD. Despite the presence of passing clouds, a significant number of the broadband and narrowband images of the event were obtained intermittently. Unfortunately, the ingress and egress periods were cloudy and could not be recorded. More than 40 H-alpha images were obtained and these can be used for studying the effect of the atmosphere of Venus on the background chromospheric radiation. At least ten good broadband images were recorded. The observations were carried out by Michael and Hariharan at the 15 cm telescope, Bagare & Gupta assisted by Devendran and Hari at the STT, and by Aleem, Ravi, Suryanarayana, Selvendran and Kumaravel, assisted by Devendran at Spectro.

At Kodaikanal, the day started off with a drizzle and overcast skies and remained cloudy throughout the day but for gaps through passing clouds for short durations. Over a thousand people from all walks of life, particularly from Mother Teresa University and other educational institutions in and around Kodaikanal visited the Observatory to get a glimpse of the transit, availing the special arrangement made for public viewing. Film personality Charu Hasan and the Vice Chancellor of the Mother Teresa university were among the visitors besides the IIA scientists Prof B. V. Sreekantan, Prof V. K. Gaur, and Prof J. H. Sastri from Bangalore.

The planet Venus was seen beautifully silhouetted against the solar disk, appearing like a lovely bindi on the Sun. Every one who witnessed the large image here was exhuberant !

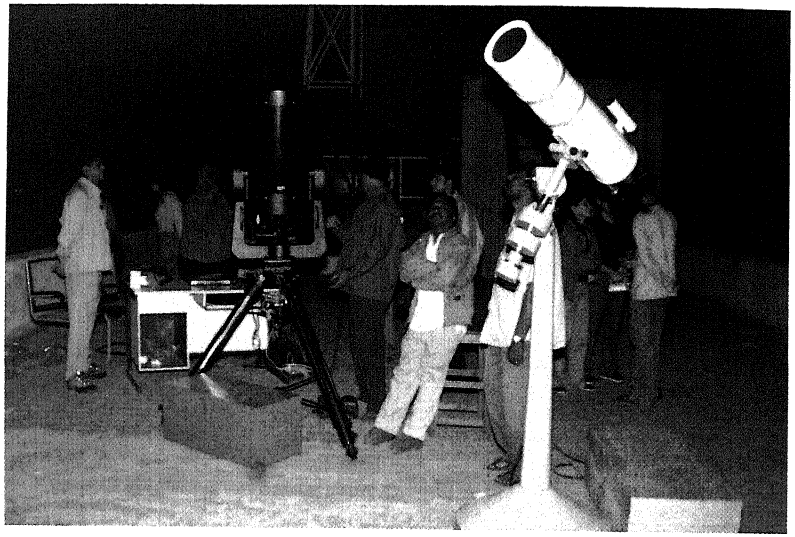
Over 35 digital frames of the full Sun and close up view of the planet were recorded with the 34 cm image of the Sun. Venus was a spectacular one cm sharp and dark disk on the solar image at the Solar Tower Telescope. The



above photograph was taken at 12:20:40 IST by Dr S.P.Bagare, Dr S.S.Gupta, and the observing team at the Kodaikanal Observatory. A large number of digital frames were obtained successfully in the chromospheric Hydrogen alpha line. A few frames were also obtained in the Calcium K line. Four 20 cm diameter images of the Sun with Venus in transit were photographically recorded with the historical 15 cm telescope white light facility at the Observatory.

In addition to the above, a useful number of spectra in the Hydrogen alpha, the Sodium D1 & D2, and the Calcium K lines were obtained using special CCD cameras.

Comet C/2004 Q2 (Machholz) : The comet discovered on Aug 27, 2004 by D. E. Machholz with a 15 cm reflecting telescope has been given the official name C/2004 Q2. This is his 10th comet discovery. Its orbit is rather large. It was at its closest to the Earth on Jan 5, 2005, at about 50 million km and was getting closer to the Sun while moving in its orbit. It got brighter as it approached its perihelion, due on the 25th Jan 2005.



Watching Comet C 2004 Q2 Machholoz through 35 cm Meade and 15 cm Carl Zeiss Telescopes

This comet was monitored closely by professional as well as amateur astronomers alike all over the world. On Jan 25, 2005 it reached its perihelion, already close to its brightest at a visual magnitude of about +4. This value meant it to be surely a naked eye object, even though about half as bright as the Andromeda galaxy (to the naked eye).

In the second week of January 2005 the comet was in the constellation of Taurus. The second week of January was the darkest period -the New Moon on the 10th- and it passed in front of the Pleiades, on the evening of 8 Jan 2005, from an apparent distance less than the Moon's diameter. As far back as a fortnight ago, the comet was described as an impressive sight and some observers noted that despite the moonlight interference the comet Machholz

was visually spectacular, the coma very condensed, bright and large with a visible dust tail.

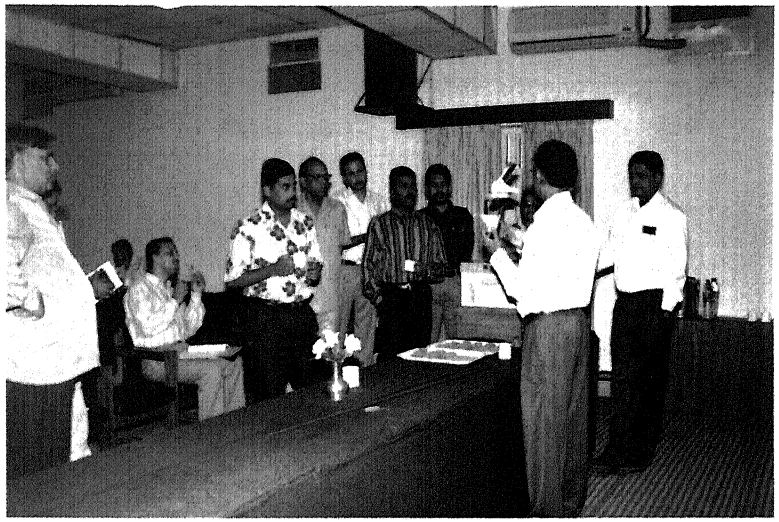
A group of scientists of the Indian Institute of Astrophysics had been monitoring the comet from the Vainu Bappu Observatory. Through the CCD imaging, the idea was to see any active regions and study dust scattering. At the Koramangala campus, Comet Machholz watch was organized on several nights during 7-15 Jan 2005. The 35 cm Meade and the 15 cm Carl Zeiss were installed atop the Annexe Building. About 500 visitors and students visited the campus and watched the comet.

A false colour CCD image of the comet Machholz (C/2004 Q2) taken through the 102 cm Carl Zeiss Telescope of the Vainu Bappu Observatory, Kavalur at 13 41 UT, Jan. 6, 2005 was made available on our website

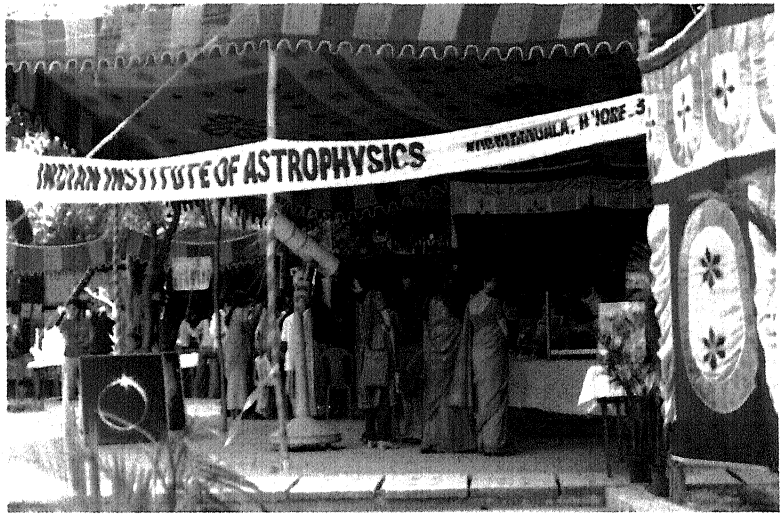
The IIA Almanac and the Greeting Card : A six-sheet calendar of the Institute was brought out featuring astronomical objects taken through the Vainu Bappu Telescope at Kavalur and the Himalayan Chandra Telescope at Hanle. Also released in December 2004 was a greeting card featuring the great Orion Nebula. These carried the famous logo of the International Year of Physics 2005, in celebration of the 100th anniversary of the miraculous year 1905 in which Albert Einstein published four monumental papers which provided the basis for fundamental developments in physics- the theory of relativity, quantum theory and Brownian motion.

Exhibition : IIA organized an exhibition on Dec 9, 2004 as a part of the Kala Vanijya Vignanotsava 2004 of the Jyoti Nivas PUC College in Koramangala with colourful displays on astronomical objects and the laboratories of the Institute.

A.K. Saxena was the chief guest at the Kala Vanijya Vignanotsava 2004.



Visit by DST Scientists on a field trip to IIA on August 19, 2004. Prof. M. Parthasarathy talks about IIA and its programmes



IIA organized exhibition for the Kala Vanijya Vignanotsav 2004 on December 9, 2004at Jyoti Nivas PUC College.

Marigold *(Tagetes spp.)*

14. Personnel

Academic / Scientific / Technical Staff :

Acting Director : J.H. Sastri

Distinguished Professor : Ramanath Cowsik (till 31-08-2004)

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

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, A.V. Raveendran, P.M.S. Namboodiri

Associate Professor II : Jayant Murthy

Associate Professor : P. Bhattacharjee, S.G.V. Mallik, K.N. Nagendra, K.R. Subramanian, Sunetra Giridhar, S. Surendra Gupta, K.E. Rangarajan, S.K. Saha,

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

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, B.A. Varghese,

Scientist : K.M. Hiremath

Research Scientist : R.T. Gangadhara, Arun Mangalam

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

Senior Technical Officer : J.P.A. Samson

Engineer C : V. Arumugam, 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, L. Yeswanth,

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

Technical Officer : M. Mohd.Abbas, S. Muthukrishnan, K. Rangaswamy, R. Muraleedharan Nair, 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

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

Adjunct Scientist : B.S. Acharya, P.N. Bhat, N. Krishnan, C.S. Unnikrishnan

Visiting Scientist : R. Vasundhara

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, G. Rajalakshmi, B.S. Ramachandra, B.K. Sahoo, P. Shalima, G.A.S. Sundaram

Project Assistant : D. Suresh

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

Conferences and Meetings attended

G.C. Anupama attended the International Virtual Observatory Association (IVOA)-Interoperability Workshop and the IVOA-Small Projects Meeting held at IUCAA, Pune during September 27 to October 1, 2004 and also the 23rd Astronomical Society of India meeting held during 21-24 Feb 2005.

S.P. Bagare attended a national workshop on Indian initiative for the International Heliospherical Year 2007, held at RAC, Ooty during 10–12 July 2004. He also attended the National workshop on Indian Antarctic Research - - A status review, held at NCAOR, Goa, during 27 29 Oct 2004.

P. Bhattacharjee served in the National Organizing Committee of the meeting on International Conference on Physics & Astrophysics of Quark-Gluon Plasma (ICPA-QGP), SINP, Kolkata, 7–12 February, 2005. DAE High Energy Physics Symposium, Saha Institute of Nuclear Physics (SINP), Kolkata, 29 November – 3 December 2004. He also attended the International Conference on Physics & Astrophysics of Quark-Gluon Plasma (ICPA-QGP), SINP, Kolkata, 7--12 February, 2005.

Christina Birdie attended the review meeting of the Digital Library Project convened by Ministry of Communication and Information Technology at New Delhi, during18 – 19 May 2004. She attended the FORSA annual meeting held at NCRA, Pune in July 2004.

S. Giridhar attended the International conference titled "Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis" conducted at UT at Austin, Texas, USA, during June 17–20, 2004. She was invited to chair a session on "Massive Stars" at the symposium.

S.S. Gupta attended the National Workshop on "Indian Antarctic Research A Status Review", Oct. 27-29, 2004 at the National Center for Antarctic and Ocean Research, Goa.

***R. Mohan, and J. Murthy** presented a paper titled "Preparing for new UV Space Missions" at ASI Meeting, Nainital.

K.N. Nagendra participated in the 19th NIAS Course for Senior Executives, with the theme: "Excellence in Leadership" - during 23rd-29th Jan 2005. In that course: (a) delivered a talk about his professional experiences, and IIA, (b) Chaired one of the 5 Sessions during the Course-work Week.

***G. Rajan, J.Murthy and B.R. Prasad** presented a paper titled "Methods to Study Dark Count and Spatial Resolution of an ICCD" at ASI Meeting, Nainital.

K.B. Ramesh attended the Advanced Techno-Management Programme for Scientists and Technologists held during March 7 to April 16, 2005, at Administrative Staff College of India, Hyderabad.

K.B. Ramesh attended the ASI Meeting held at ARIES, Manora Peak, Naini Tal and presented the following two poster papers. "A Two-Beam Spectropolarimeter for Kodaikanal Tower Telescope" by K. B. Ramesh, K. Nagaraju, K. E. Rangarajan, K. Sankarasubramanian and J. Singh and "Study of modulation and demodulation schemes for a two-beam polarimeter" by K. Nagaraju, K. Sankarasubramanian, K. B. Ramesh, and K. E. Rangarajan.

R. Ramesh attended the IAU Symposium 226 on Coronal & Stellar and mass ejections held during September 13-17, 2005 in Beijing, China. Presented an invited talk on "Low frequency (30-110 MHz) radio imaging observations of solar coronal mass ejections".

B.E. Reddy attended the international conference on "Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis" held in Austin, USA, during 17-19 June, 2004 and submitted a poster on "Lithium Abundance survey of the Galactic Thin disk".

S.K. Saha chaired a scientific session of the conference on Engineering Optics and Spectroscopy, at CSS University, Meerut, UP, 6th April, 2004. Conference on Laser and their Applications in Basic Applied Sciences, during January 10-13, 2005 at Visva-Bharati University, Santiniketan, West Bengal, India. XXX optical Society of India (OSI) Symposium on Optics and Opto-Electronics (SOOP-05), during Jan. 19-21, 2005, at National Physical Laboratory, New Delhi 110012, India.

S.K. Saha served as a International Conference on Super resolution and Photonics to be held at Calcutta during 15-16 February, 2005.

J.H. Sastri participated in the first Annual Meeting of the Asia Oceania Geosciences Society(AOGS) held in Singapore during 5-9 July 2004.

J. H. Sastri presented the paper "Characteristics of an equinoctial ionospheric storm and its implications" at the Ist AOGS Meeting, Singapore, July 5-9, 2004.

P. Shastri attended IAU Symposium 222, The Interplay Among Black Holes, Stars and ISM in Galactic Nuclei, Gramado, Brasil, 1-5 March, 2004 Talk: Gaseous Outflows from Seyferts and Unification; GS75: Meeting to celebrate the 75th Birthday of Prof. Govind Swarup, NCRA, Pune, 22-23 March, 2004. (Participant); International Conference on Evidence for Tori & Winds in AGN, University of Leicester, 13-16 September, 2004, Talk: Gaseous Outflows & Absorption in Obscured Seyferts.

Sujan Sengupta gave a seminar at TIARA Star formation conference held at Academia Sinica, Institute of Astronomy and Astrophysics, Taipei, Taiwan, April 2004, on "Atmosphere of Extra-solar planets"; three colloquiums at Academia Sinica,Institute of Astronomy and Astrophysics, Taipei, Taiwan, 2004 on "Sunyaev Zeldovich effects by multiple scattering"; "Brown Dwarfs : The missing link between stars and planets"; "Astrophysical facilities and activities in India."

A. Subramaniam attended the IVOA meeting of the Virtual observatory held in IUCAA, Pune from 27 September to 01 October 2004.

K.R. Subramanian and **Ebenezer** attended the NSO workshop 22 on Large scale structures and their role in solar activity. Sunspot, NM, USA during October 18 -22, 2004. Gave An oral talk on 109 MHz Observations of Equatorial coronal hole of February 25, 1999.

Invited talks in conferences, seminars

G.C. Anupama gave a talk titled "2m HCT - Remote operations and data archiving" on 30 September 2004 at the IVOA Meeting held at Pune. She also gave a talk on "Report from the Vainu Bappu Observatory and the Indian Astronomical Observatory": on 23 February 2005 at the 23rd Astronomical Society of India Meeting held at Naini Tal and presented three poster papers on "Optical spectroscopy of the classical nova V5114 Sgr 2004" G.C. Anupama & P.S. Parihar ; "Photometric study of type Ia supernova SN 2002hu" D.K. Sahu, G.C. Anupama & T.P. Prabhu and "Post-outburst phase of the McNeil's nebula (V1647 Orionis)" by D.K. Ojha* et al.

S.P. Bagare gave an invited talk titled "Solar Physics in India: the science and the facilities" in a national workshop, held preparatory to Indian participation in the International Heliospherical Year 2007, at RAC, Ooty in July 2004. He gave another joint invited talk titled Observations of unique extended duration shadow band activity during the total solar eclipse of Nov 23, 2003 near Maitri, Antarctica, at the national workshop on Indian Antarctic Research : A status review, at NCAOR, Goa, in Oct 2004.

D. Banerjee gave an invited oral presentation at the SOHO 15 meeting, 6-9 September 2004, St. Andrews, UK; ASI. Nanital, Feb 2005; International solar

workshop at ARIES, Nainital 05-07 April, 2005 ; delivered a public lecture at Kodaikanal during the summer school, 2004.

Pijush Bhattacharjee attended the workshop on "UHE cosmic rays, gamma rays and neutrinos", May 1--20, Kavli Institute for Theoretical Physics (KITP), UCSB, Santa Barbara, USA, 1--20 May 2005. EHE ($E>10^{20}$ eV) particles from Top-Down processes. He also gave a colloquium at Raman Research Institute, 17 December 2004, titled "Neutrino mass, cosmic strings and matter-antimatter asymmetry of the Universe".

S. Giridhar was invited to give a lecture on "Pre-Main Sequence stars and Binarity" at Institute of Astronomy, UNAM, Mexico on June 3, 2004.

N. Kameswara Rao attended the symposium 'Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis' in honor of David L. Lambert, symposium held 17-19 June, 2004 in Austin, Texas. - and gave an invited talk. He attended International Workshop on 'Asteroseismology' held at ARIES, Nainital during 6 -10th Dec 2004. N. Kameswara Rao gave an invited talk Symposium 'Infrared and Optical Astronomy at Mt.Abu observatory: The past Decade and The Future' held at Physical Research Laboratories, Ahmedabad during 15 - 17 th Dec. 2004 - presented an invited talk.

R C Kapoor and **C S Shukre*** gave an invited talk "Emission altitudes in radio pulsars with triple profiles" at the COSPAR Colloquium on 'Spectra and timing of compact x-ray binaries', Jan 17-21, 2005.

A. Mangalam gave an invited talk on "Black Hole Physics with UVIT on ASTROSAT" at the ASTROSAT workshop on "Black Holes" held in May 10-16, at BARC, Mumbai.

Rajat Choudhury gave an invited talk on "Theoretical studies on the excited states of HCN" at the Symposium on Theoretical Chemistry held in BARC, Mumbai (9-12 Dec. 2004).

S.K. Saha gave a talk entitled "Interferometric imaging in Optical Astronomy" in a conference on Engineering Optics and Spectroscopy on 6th April, 2004 at CCS University, Meerut, UP. Laser guide artificial star for high resolution imaging in a conference on Laser and their Applications in Basic Applied Sciences, during January 10-13, 2005 at Visva-Bharati University, Santiniketan, West Bengal, India. "Speckle interferometry at IIA", at the Applied Physics Department, Calcutta University, Calcutta, on 11 January, 2005. Optical interferometry with diluted apertures: a matured technique, at the XXX optical Society of India (OSI) Symposium on Optics and Opto-Electronics (SOOP-05), during 19-21, 2005, at National Physical Laboratory, New Delhi 110012, India. "High resolution imaging with diluted aperture interferometry", at the International Conference on Super resolution and Photonics to be held at Calcutta during 15-16 February, 2005.

A.K. Saxena delivered an invited talk at the 22nd OSI Symposium on "Use of Long Trace Profilometer for Surface Metrology of Unconventional Optics".

C. Sivaram gave an invited talk on "Impact of Einstein's work in Astrophysics and Cosmology" Workshop on Knowledge reconstruction in Physics, Mysore Univ., Feb 2005; "General Theory of Relativity", Symposium on Role of Mathematics in Physical Science, Jan. 2005, Bangalore; Astrochemistry and Astrobiology (2 Lectures), IUCAA workshop on the interstellar medium, Dec. 2004.

A. Subramaniam attended the 23rd meeting of ASI held at Nainital in February and presented two invited talks and three poster papers at the meeting.

K.R. Subramanian gave 4 talks on Basics of Radio astronomy at Birla Institute of fundamental research, Bangalore. K.R.Subramanian gave a talk on Radio sky as a part of world year of physics 2004 at Madura college , Madurai 25th March 2004.

Visits

G.C. Anupama visited the Neils Bohr Institute for Astronomy, Geophysics and Physics at Copenhagen, Denmark during March 12-20 for the preliminary acceptance tests of the HFOSC Autoguider unit being developed by them for use at the 2m HCT.

S.P. Bagare visited NCAOR, Goa in July 2004, in connection with the reshipment of equipment taken for the total solar eclipse expedition to Antarctica during Nov Dec 2003.

B.C. Bhatt visited ARIES, Nainital, 3-5 October, 2004 and gave talks on (a) Interstellar matter and (b) Star formation. He also visited Calicut University; 29-31 October, 2004.

S. Giridhar continues to serve as Principal Investigator for a DST sponsored Indo-Max collaborative program and she visited the Institute of Astronomy UNAM, Mexico during May 15-June 15,2004. Analysis of a sample of hot post-AGB candidates was completed during her stay.

K.N. Nagendra visited Observatoire de Nice, France, for two months during August-September, 2004, to continue ongoing collaboration. Continued the discussions and collaboration on several important problems of polarized line transfer theory with French Scientists ; Istituto Ricerche Solari Locarno, Switzerland, for 3 weeks during October 2004, for the purpose of observations, and work ; Visited La Specola Solare Ticenese, at Locarno in Switzerland, and learnt about the Research activities, and discussed with Senior Scientists ; Visited MET-SVIZERA the Meteorological Observatory at Locarno, Switzerland, and studied the activities there, and discussed with Scientists.

M. Parthasarathy visited the Department of Physics and Astronomy, University of Oklahoma, Norman, USA for several months. He gave four talks on UV-bright stars in Globular clusters, rapidly evolving hot post-AGB stars, binary stars with white dwarf companions and determination of chemical composition of stars from the analysis of high resolution spectra.

R. Ramesh visited Instituto Nacional De Pesquisas Espacias (INPE), Sao Paulo, Brazil during November-December, 2004 in connection with the colloborative work on Phase-I of the Brazilian Decimetre Array project. Interfaced digital & analog receiver systems, developed software for regular observations in the tracking mode, amplitude phase calibration, synthesis and analysis of one-dimensional images.

B.E. Reddy was a visiting scholar at University of Texas, Austin, USA and McDonald Observatory, Fort Davis, USA from April through June, 2004. He was a visiting scientist at ARIES, Nainital, from 02 October to 10 October, 2004. He was a visiting scholar at University of Texas, Austin, USA and McDonald Observatory, Fort Davis, USA from May through July, 2004. He gave a talk Abundance Survey of Galactic Disk: Thin versus thick disks. The 23rd meeting of the ASI, ARIES, Nainital 21-24 Feb 2005. Li abundances in stars. ARIES, Nainital 05 Oct 2004. Abundance Survey of Galactic Disk. ARIES, Nainital 06 Oct 2004.

P. Shastri visited the Astronomy Department, University of Maryland, College Park, USA and gave seminar: Seyferts, their Outflows and Unification, 1st September, 2005. She visited to the Space Telescope Science Institute, USA and gave a seminar: Seyferts, their Outflows and Unification, 2nd September, 2005.

P. Shastri visited the Astronomy Department, University of Texas, Austin, USA, for collaborations with Dr. Beverley Wills, 4-10 September, 2004. Seminar: Seyferts, their Outflows and Unification, 9th September, 2005.

A. Subramaniam gave a talk titled "The bar(s) of the Large Magellanic Cloud", at RRI, September 2004.

Teaching and guidance

Aruna Goswami supervised a summer project student during May -July 2004, titled "Low resolution spectroscopy of carbon stars".

S.P.Bagare gave a course on Solar Physics at the Kodai Summer School in Physics and Astrophysics, held during 7 July 2004, at the Kodaikanal Observatory. The school was jointly organized by the Indian Academy of Sciences and IIA. Bagare was also involved in the selection of students, on an all India basis, for this Summer School. He served as a Member of the Board of Exams for PG Physics, Bangalore University (BUB), and as an External Examiner for M.Sc. Physics of BUB. He further continued to Co-guide two external Ph.D. students registered with the Madurai Kamaraj University. He also served on a Selection Committee for Ph.D. student admissions at IIA during the year 2004.

S. Giridhar continues to serve as Principal Investigator for a DST sponsored Indo-Max collaborative program and she visited the Institute of Astronomy UNAM, Mexico during May 15-June 15,2004. Analysis of a sample of hot post-AGB candidates was completed during her stay.

R.T. Gangadhara participated in the Workshop on Theoretical Plasma Physics, 5-16 July, 2004, International Centre for Theoretical Physics, Trieste, Italy and made an oral presentation on "Emission altitude from relativistic phase shift due to plasma corotaion in pulsars". Since January 2003 he has been guiding Mr. Reji Mathew C. Thomas (JRF, IIA) for his Ph. D. thesis on pulsar radio emission.

S.S. Gupta guided four M.Sc., (Physics) and ten B.Sc., (Physics) students on Solar Physics projects that formed as a partial fulfillment for the award of the degree by the University. As an external examiner conducted Astrophysics practicals examination at IIA, Kodaikanal for the II (30/4/04) and III (27/11/04) semester M.Sc., (Physics) students of the Mother Teresa Womens University, Kodaikanal.

At the Mother Teresa Womens University, Kodaikanal: S.S. Gupta is a member of Board of Studies in M.Sc. Physics (specialization in Astrophysics), member of Board of Examiners in M.Sc. (physics) for a 3-year (2002-05) term; adjunct faculty for a 2-year (2003-05) term and approved supervisor to guide a student for Ph.D., in Physics. He is also a joint supervisor to guide a student for Ph.D. in Physics, of the Gandhigram Rural Institute - Deemed University, Gandhigram.

K.M. Hiremath was invited by the Syndicate of the University of Kerala to be a member of the Board of Adjudicators to evaluate the thesis entitled "Some studies on the Solar Magnetic Field Structure of the Solar Corona and Interplanetary Medium", by Mr. G. Gopkumar. He has evaluated the aforementioned Ph.D thesis and submitted the report. K.M. Hiremath was also made Chairman for conducting the open defense of Ph.D thesis. He was nominated as chairman by the registrar of University of Kerala for conducting the open defense of the above-mentioned thesis. He guided a summer student Venkata Rama Krishna of final year M.Sc (Physics), Bangalore University and he worked on the research problem "Some aspects of the solar core magnetic field".

N. Kameshwar Rao guided one student K. Lakshmi of Bangalore universitry, Physics department for her summer student project entitled 'Spectroscopic study of VBT echelle spectra of high latitude cool RV Tauri star CE Virginis'.

A. Mangalam delivered 6 lectures in Stellar Astrophysics and on Solar Magnetism (including tutorials) at the Kodai Summer School in Physics during July 2004.

A. Mangalam is a part of the Research Education Advancement Programme (REAP) training and research program run by the Bangalore Association for Science Education (BASE), Nehru Planetarium for advanced graduate and undergraduate students, in which IIA is a participating institute. He taught a semester-long undergraduate course (with tutorials) on Electrodynamics from Sept 2004 to February 2005 at the Nehru Planetarium for senior B.Sc, Engg and M.Sc students.

J. Murthy is a perennial visiting lecturer at Bangalore University where he teaches Space Science. He is also an external guide for a PhD student at Bangalore University and is an examiner for two other students. He also is an external examiner for the MSc examinations at Bangalore University. He supervised two students under the REAP program, which is a collaboration between the Nehru Planetarium and IIA, amongst other institutions. Murthy has lectured at several institutions around Bangalore including the Birla Institute of Fundamental Research; the Jawaharlal Nehru Planetarium; Jain College and others.

K.N. Nagendra serving as a main guide to Ms. M. Sampoorna, a regular PhD student of IIA, on a PhD Thesis Project. The Research project is started from August 2004. She has made excellent progress. Serving as Co-Guide for Ms. Ye Ye Oo, of Mandalay University, Myanmar, who is supported by the Govt. of India Fellowship under ICC. She defended her PhD thesis and would be awarded PhD in Physics from Bangalore Univ. in August 2005. Guided two M.Sc. students under the SPSP-Program (the Summer Project Students Program) organized by the BGS. The duration of guidance was 3 months (May 2005-July 2005). K.N. Nagendra continued to hold the position of Visiting Professor at the Observatory of Nice, France, for the 11 th consecutive year. He has continued for the second year as a Technical Specialist and collaborator in a major French CNRS project organized to be conducted at Observatory of Nice, and Observatory of Paris, in France, for a duration of 3 years.

P. Shastri has been resource person for Summer Programme, Bangalore's Nehru Normal and Active Galaxies in 2004. She also lectured in the REAP Programme, Bangalore Planetarium Active Galaxies and Supermassive Blackholes in 2004. Taught the Bangalore University Course in Astronomy: Extragalactic Astronomy, 2004.

C. Sivaram gave 24 lectures of 24 hours lecture course on General Relativity and Cosmology to post graduate and research students of Bangalore University from Jan 2005 - march 2005. He also gave several lectures on astrophysics and cosmology in the refresher course in UGC academic staff college and physics department, Mysore University (Sept 2004); Two lectures on Astrochemistry in ISM and Astrobiology were given at the IUCAA workshop on interstellar medium in Dec. 2004 ; A full - fledged one month course in "Introduction to Astrobiology", (25 Lectures) was conducted at the Birla Institute, during Oct - Nov 2004. Lectures were given to several batches of students in the Introductory courses to Astronomy and Astrophysics at BIFR during April - June, Sept - Nov 2004 (20 Lectures). He guided a summer school student, (Shincy John) for a project on supernovae and pulsar energetics May - July 2004. Guidance was also provided to two students (K. Arun and C. Samartha) for doing a project on (Aspects of black hole energetics) as a partial fulfilment of their M.Sc degree, from Christ College . (Jan - April 2005).

A. Subramaniam taught the JAP course titled "Observational Techniques - optical, IR and UV astronomy", for the students from JAP, RRI, ISRO. The students were also taken to CREST, Hosakote and VBO, Kavalur, as part of the course.

An M.Sc. physics student of St. Josephs College, Trichy was guided by **K. Sundara Raman** in the project Saturn and its atmosphere during October-December 2004.

Involvement with scientific community, national and international programmes and bodies

G.C. Anupama is a Co-PI of the project "Symbiotic binary stars and related objects" approved under the Indo-Polish Exchange Programme. She is Editor of the Bulletin of the Astronomical Society of India since 2004 March ; 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 ; Member of the expert committee constituted by the UGC to review the rectification of the 1.2m telescope of Japal Rangapur Observatory ; Member

of the review committee for the project Virtual Observatory - India, (PI: A.K. Kembhavi, IUCAA), funded by the Ministry of Communications and Information Technology ; Viva voce examiner of the Ph.D. thesis submitted by C.D. Ravikumar to the Cochin University of Science & Technology (CUSAT), Kochi.

S.P. Bagare was elected Leader of the Working Group on Solar Physics, for the proposed Indian participation in the International Heliospherical Year 2007, at a National Workshop held at RAC, Ooty in July 2004.

H.C. Bhatt served as a member of the GTAC (GMRT Time Allocation Committee); Project Scientist in the TAUVEX Project of ISRO; Gave lectures in the IUCAA sponsored workshop on "Interstellar Matter" organised by Bangalore University.

P. Bhattacharjee served as a member of the National Organizing Committee (NOC) of the 16th DAE High Energy Physics (HEP) symposium held at Saha Institute of Nuclear Physics (SINP), Kolkata, during 29 Nov -- 3 Dec 2004. He is 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 have refereed a number of papers for these as well as several other journals.

P. Bhattacharjee gave an IIA Colloquium, 17 August 2004. "Spaghetti in cosmic soup: Neutrino mass, cosmic strings and matter anti-matter asymmetry of the Universe". He gave a talk at IIA at a meeting to felicitate Prof. R. Cowsik on his being elected a foreign associate of US National Academy of Sciences: IIA, 27 August 2004. He also gave a talk titled Nobel Prize in Physics 2004, IIA, 8 October 2004. He gave a talk at a one-day symposium celebrating the "International Year of Physics 2005" on the occasion of the 100th anniversary of the 1905 papers of Einstein. IIA, 14 March 2005. GTR, Cosmology and the cosmological constant.

As vice president of the IAU Commission 45 on Stellar Classification (2003-06). **S. Giridhar** has contributed to the preparation of a proposal for a Joint Discussion for IAU General Assembly GA-2006. This Joint Discussion titled " Exploited Large Surveys for Galactic Astronomy" has been allotted 1.5 days during GA-2006 (16-25 August 2006). **Giridhar** would co-chair SOC along with Christopher Corbally and Coryn Bailer-Jones. Giridhar would also be co-editor of the Proceedings.

R.T. Gangadhara has been working on development of software for data simulation, pipeline, and reduction for ASTROSAT--UVIT. We have made a group of two scientists and three engineers to work on this project. Each one is actively working on different parts of the project.

A. Mangalam served as IIA representative for JEST 2005. He was also involved in the selection of students for the Summer School in 2004 and involved in the oordination of the Astrophysics part of the Kodai Summer School in July 2004. He is representing IIA on the program coordination committee for the Joint Astronomy Program (JAP) since January 2003 and carrying out some of the academic and administrative tasks.

K.N. Nagendra continue to be a Scientific Organising Committee Member of Comm. 36 of IAU, on Stellar Atmospheres, with an elected term of 3 years (2003-06) ; He continues to be a Consulting Specialist for the French CNRS Programme involving Observatoire de Nice, and Observatoire de Paris ; In Dec 2004, he also organized a 3 weeks visit of the Dr. Michele Bianda of Solar Observatory, Locarno, Switzerland for collaboration and discussion with other colleagues. He initiated a new collaboration with him. The follow up collaboration is under progress ; In Feb, 2005, He organized a visit of Prof. J. Poutanen of University of Helsinki, for 1 week, for the purpose of collaboration.

M. Parthasarathy is the Vice President of the IAU Commission 29 on Stellar Spectra for the triennium 2003 - 2006.

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

J. H. Sastri served as a Member of the National Science Steering Committee (NSSC) & as Co-Chair of the working group on 'Space Weather' of CAWSES-India program.

S.K. Saha was invited to become a member of the Project Appraisal & Review Committee (PARC) of a project on Design & Development of Adaptive Optics System for Missile Imaging & Tracking and Long Range Surveillance, by the Director, Instruments Research & Development Establishment (IRDE), Defence Research & Development Organisation (DRDO), Dehra Dun, India. He served as a member of the technical committee of the XXX optical Society of India (OSI) Symposium on Optics and Opto-Electronics (SOOP-05), during Jan. 19-21, 2005, at National Physical Laboratory, New Delhi 110012, India.

A.K. Saxena continues to serve as an expert member of many national scientific project committee's of ISRO, IRDE and BARC.

C. Sivaram was examiner for Bangalore Univ M.Sc final , Astrophysics and practical exam optics etc. (June 2004) Also setting of question papers. A regular newsletter on "Astrobiology" is being brought out for the past one year (June 2004 - April 2005) by C. Sivaram with the assistance of Mr Ajay Sastry. There have been many contributions from abroad. Professors Chela Flores and Messeroti have described it a 'timely initiative'.

Colloquia and talks given by visitors

14 July 2004
Brazilian Decimetric array : Present Status
Jose Hiroki Saito
University of Sao Carlos , Brazil

27 July 2004
Highlights of the conference on "Cosmic abundances as records of stellar evolution and nucleosynthesis" held in Austin, Texas, in honour of Prof. David Lambert. June 17 - 19 , 2004
B. Ishwar Reddy
Indian Institute of Astrophysics, Bangalore

29 July 2004
Kinematics of interstellar clouds: New results from GMRT
Rakesh Mohan
Raman Research Institute , Bangalore

5 August 2004
Search for northern hemishere roAp Stars
V.Girish
ISRO Satellite Centre, Bangalore

10 August 2004
Two suns in the sky: Many extrasolar planets orbiting stars in multiple systems
Deepak Raghavan
Georgia State University, Atalanta, Georgia, USA

7 September 2004
Lensed Quasars
Prasenjit Saha
Queen Mary College, London, UK

5 October 2004
The Chandra X - Ray Observatory
Jonathan McDowell
Harvard - Smithsonian centre for Astrophysics, Cambridge,USA

6 October 2004
Dawn of the space age
Jonathan McDowell
Harvard - Smithsonian centre for Astrophysics, Cambridge,USA

12 October 2004
Pros and cons of a fast solar tachocline
K.Petrovay
Eotvos University, Budapest, Hungary

25 October 2004
Search for microlensing events towards M31
Yogesh C. Joshi
TIFR, Mumbai

23 November 2004
The large synoptic survey telescope
Abhijit Saha
NOAO,Tucson, Arizona, USA

30 November 2004
Astrophysics at INPE, Brazil,
Space weather effects
Udaya Bhaskaram Jayanthi
Instituto Nacional de Pesquisas Espacias (INPE), Sao Jose, Brazil

3 December 2004
Polarization Measurements in solar Prominences
Michele Bianda
Irsol Locarno, Switzerland

16 December 2004
Virtual Observatory :Russian and Ukrainian
Tatyana Dorokhova
Odessa State University Astronomical
Observatory Odessa , Ukraine

11 January 2005
Transition region small - scale dynamics
Luca Teriaca
MPI fur Sonnensystemforshung, Lindau, Germany

12 January 2005
Lithium in metal - poor dwarf stars;
problems for standard primordial nucleosynthesis
David Lambert
University of Texax, Austin, Texas, USA

13 January 2005
Lithium in metal - poor dwarf stars;
problems for standard primordial nucleosynthesis
David Lambert
University of Texax, Austin, Texas, USA

18 January 2005
Introduction to Open MP: Parallelization in shared memory systems
Angom Dilip Singh
Physical Research Laboratoy, Ahmedabad

19 January 2005
Data grouping in distributed systems
Angom Dilip Singh
Physical Research Laboratory, Ahmedabad

15 February 2005
Shocks in the solar Chromosphere
Wolfgang Kalkofen
Harvard - Smithsonian center for Astrophysics
Cambridge, MA02138, USA

17 February 2005
Morphological evolution of galaxies: probing
the Assembly of the Hubble Sequence
Swara Ravindranath
Space Telescope Science Institute,
Baltimore, Maryland

1 March 2005
Recent Results of Helio - and Asteroseismology
J . Christensen - Dalsgaard
Department of Physics and Astronomy,
University of Aarhus, Denmark

8 March 2005
Neutrinos and the cosmic microwave background radiation
Subhendra Mohanty
Physical Research Laboratory, Ahmedabad

16 March 2005
Beginnings of Stochastic Diffusion
T.N.Narsimhan
Materials science and Engineering Enviornmental Science, Policy and
Management
University of California at Berkeley

22 March 2005
The interstellar medium: Abundances, Depletions and Extinction
U.J. Sofia
Whitman College, USA

29 March 2005
Local helioseismology and the magnetohydrodynamics of near - surface
S.P. Rajaguru
W.W. Hansen Experimental Physics Laboratory,
Stanford University, Stanford, CA 94305,USA.

APPENDIXES

Publications

Journals

Anupama, G. C., Sahu, D. K., Jose, J., (2005) A&A, 429, 667.
Type Ia supernova SN 2003du: Optical observations.

*Arellano Ferro A., *Arevalo M.J., *Carlos Lazaro, *Mannuel Rey, *Bramich D.M., Sunetra Giridhar, (2004) Revista Mexicana A&A, 40, No. 2, 209.
CCD photometry of the RR Lyrae stars in NGC 4147.

Aruna Goswami, (2005) MNRAS, 359, 531.
CH stars at high galactic latitudes.

Bhattacharjee, P., *Gupta, N., (2005)
hep-ph/0501191, Physics Letters B., (Submitted).
Probing neutrino mixing angles with ultrahigh energy neutrino telescopes.

Bhattacharjee, P., *Sahu, N., *Yajnik U., (2004) Physical Rev., D70 083534.
B-L cosmic strings and baryogenesis.

Cowsik, R., **Charu Ratnam, *Bhattacharjee, P., *Majumdar, S.,(2005) New Astronomy (Submitted).
Dynamics of dwarf-spheroidals and the dark matter halo of the Galaxy.

Frisch, H., Sampoorna, M, Nagendra, K.N., (2005), A&A, in press.
'Stochastic polarized line formation–I', Zeeman propagation matrix in a magnetic field.

Gangadhara, R.T., (2004), ApJ, 609, 335.
Pulsar radio emission height from curvature radiation.

Gangadhara, R. T., (2005), ApJ, 628, 923.
On the method of estimating emission altitude from relativistic phase shift in pulsars.

Gangadhara, R.T., (2005), Physica Scripta, T116, 117.
Emission altitude from relativistic phase shift due to plasma corotaion in pulsars.

Hiremath, K. M., Suryanarayana, G. S., *Lovely, M. R.,(2005) A&A, in press.
Flares associated with abnormal rotation rates : Longitudinal minimum separation of leading and following sunspots.

Jagdev Singh, *Takashi Sakurai, *Kiyoshi Ichimoto, *Tetsuya Watanabe (2004) ApJL, 617, L81.
Complex nature of line-intensity ratio variations with height above the limb of coronal emission line.

Jagdev Singh, *Takashi Sakurai, *Kiyoshi Ichimoto (2004) Asian J. Phys., 13, 245.
Detection of cooler loop-tops in a coronal structure.

Jagdev Singh, *Takashi Sakurai, *Kiyoshi Ichimoto, *Suzuki, I., *Hagino, M., (2005), Solar Phys., 226, 201.
Spectroscopic studies of solar corona VII. Formation of a coronal loop by evaporation.

* Collaborators from other institutions
** deceased

Kameswara Rao, N., Sriram, S., Jayakumar, K., Gabriel, F., (2005) J.Astrophys. Astr., 26.
High resolution stellar spectroscopy with VBT Echelle spectrometer.

Kameswara Rao, N., Eswar Reddy, B., (2005) M.N.R.A.S. 357, 235.
High resolution spectroscopy of high galactic latitude RV Tauri star CE Virginis.

Kameswara Rao, N., Bacham E. Reddy, David L. Lambert, (2004) M.N.R.A.S. 355, 855.
R Coronae Borealis stars at minimum -UW Cen

Kariyappa, R., Satyanarayanan, A., *Dame, L., (2005) BASI, 33, 19.
Period-brightness relationship in chromospheric bright points.

*Kharb, P., Shastri, P., (2004) Astron. Astrophys., 425, 825.
Optical nuclei of radio-loud AGN and the Fanaroff-Riley divide.

*Lal, D.V., Shastri, P., *Gabuzda, D., (2004) Astr. Astrophys. 425, 99. astro-ph/0406597.
Milliarcsec-scale radio structure of a matched sample of Seyfert 1 and Seyfert 2 galaxies.

*Lin, Chia-Hsien, Banerjee, D., *Doyle, J.G., *O'Shea E., *Foley C.R., (2005) A&A, 434, 751
Coronal oscillations in the vicinity of a sunspot as observed by GIS/CDS.

Maheswar, G., *Manoj, P., Bhatt, H. C., (2004) MNRAS, 355, 1272.
Photometric distances to dark clouds: cometary globule CG 12

Maiti, M., Sujan Sengupta, Parihar, P.S., Anupama, G.C., (2005) ApJ, Lett, 619, L183
Observation of R-band variability of L dwarfs.

*Malaya K. Nayak, Rajat K. Chaudhuri, *Krishnamachari, S. N. L. G., (2005) J. Chem. Phys., 122. 184323.
Theoretical study on the excited states of HCN.

Mangalam A., (2004) Asian J. Physics, 13, 251.
A unified description of anti-dynamo conditions for incompressible flows.

*Manoj, P., Bhatt, H. C., (2005) A&A, 429, 525.
Kinematics of Vega-like stars: Lifetimes and temporal evolution of circumstellar dust disks.

*Mohan, D., *Mishra, S.K., Saha, S.K., (2005) Ind. J. Pure & Appl. Phys., 43, 399.
Adaptive optics and its applications.

Murthy J., *Sahnow, D. J. (2004), ApJ, 615, 315.
Observations of the diffuse FUV background with FUSE.

Murthy J., *Sahnow, D. J, *Henry, R. C. (2004), ApJL, 618, 99L.
Intense diffuse emission from Orion.

Namboodiri, P.M.S., (2004), Asian J. Physics, 13, 215.
Remnants of closely interacting galaxies.

*O'Shea E., Banerjee D., *Doyle J.G., (2005) A&A Lett, 436, L35.
On the widths and ratios of Mg X 624.94 and 609.79 Å lines in polar off-limb regions.

*O'Shea, E., Banerjee D., *Doyle, J.G., (2005) A&A Letters, 436. L43
Blinkers/macro-spicule activity in an off-limb polar region.

*Pandey, A. K., *Upadhyay, K., *Ogura, K., *Sagar, Ram, *Mohan, V., *Mito, H., Bhatt, H. C., Bhatt, B. C. (2005) MNRAS, 358, 1290.
Stellar contents of two young open clusters: NGC 663 and 654.

Pandey, Gajendra; Lambert, David L.; Rao, N. Kameswara; *Gustafsson, Bengt; Ryde, Nils; Yong, David (2004) MNRAS.353..143P
The R Corona Borealis stars: Carbon abundances from forbidden carbon lines.

Pandey, Gajendra; *Lambert, David L.; Rao, Kameswara, N., *Jeffery, C. Simon, (2004) ApJ...602L.113P.
Abundances of Neutron-Capture Elements in the Hot Extreme Helium Stars V1920 Cygni and HD 124448.

*Paniveni U., Krishan V., Jagdev Singh, *Srikanth R., (2005) Solar Phys., in Press.
On the fractal structure of solar supergranulation.

Parthasarathy M., Jain S.K., *Sarkar G., (2005) AJ, 129, 2451.
Polarization measurements of post-asymptotic giant branch candidates and related stars.

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Public Poster

J. Murthy and Mohan have put together a public poster for TAUVEX for an exhibition on Observatories at the Visvesvariah Museum of Technology. This exhibition will travel around the country over the next year.

Popular Articles

Kapoor, R.C. (2004) The Transit and what to look for, Deccan Herald, June 2.

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Sky conditions

Vainu Bappu Observatory, Kavalur

Time Allocation during 2004-05

I. VBT		Total No. of Proposals received	53
	a.	No. of Spectroscopic Proposals	37
	b.	No. of Photometric Proposals	14
	c.	No. of target of opportunity proposals	2
	d.	Total No. of Nights requested	458
	e.	No. of Nights requested for Spectroscopic work	334
	f.	No. of Nights requested for Photometric Work	124

Vainu Bappu Observatory

Year	Month	Spectroscopic Hours	Photometric Hours
2004	April	111	22
	May	26	5
	June	49	0
	July	15	0
	August	62	0
	September	26	3
	October	33	0
	November	92	8
	December	181	13
2005	January	204	28
	February	235	88
	March	158	28
	Total	1192	195

Sky conditions at Indian Astronomical Observatory, Hanle

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2004	April	67	116	240
	May	153	193	217
	June	41	105	210
	July	58	105	217
	August	94	131	248
	September	201	227	270
	October	192	231	310
	November	242	270	330
	December	220	245	341
2005	January	143	202	341
	February	70	105	280
	March	69	139	279
	Total	1550	2069	3273

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
2004	April	12	12	–	24	–	5	19	–	–
	May	4	5	–	14	–	2	11	1	–
	June	8	8	–	17	–	–	12	5	–
	July	3	3	–	17	–	8	7	2	–
	August	9	9	–	17	–	3	11	3	–
	September	8	8	–	15	–	1	9	3	2
	October	2	2	–	10	–	1	3	4	2
	November	7	6	–	11	–	–	4	7	–
	December	21	21	–	26	–	14	10	2	–
2005	January	23	23	–	26	1	9	7	9	–
	February	25	25	–	27	–	5	10	12	–
	March	20	19	–	24	–	4	14	6	–
	Total	142	141	–	228	1	52	117	54	4

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
2004	April	22	2	3	14	1	2	–	–
	May	9	1	1	5	1	1	–	–
	June	7	–	–	5	–	2	–	–
	July	7	–	–	3	–	2	2	–
	August	8	–	1	3	–	2	2	–
	September	11	–	–	6	1	3	1	–
	October	8	–	–	4	2	1	1	–
	November	9	–	–	6	–	2	1	–
	December	18	2	–	12	–	3	1	–
2005	January	20	1	–	14	2	2	1	–
	February	19	1	–	9	3	4	2	–
	March	21	–	2	11	5	2	1	–
	Total	159	7	7	92	15	26	12	–

AUDITORS' REPORT

We have audited the attached Balance Sheet of the "THE INDIAN INSTITUTE OF ASTROPHYSICS", BANGALORE, as at 31st March, 2005, and the Income and Expenditure Account for the year ended on that date, annexed thereto. These Financial statements are the responsibility of the Management of Indian Institute of Astrophysics, Bangalore. Our responsibility is to express an opinion on these Financial Statements based on our Audit.

We have conducted our audit in accordance with Auditing standards generally accepted in India. Those Standards require that we plan and perform the audit to obtain reasonable assurance about whether the Financial Statements are free of material misstatement. An Audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the Financial Statements. An audit also includes assessing the accounting principles used and significant estimates by Management, as well as evaluating the overall Financial Statement presentation.

We believe that our audit provides a reasonable basis for our opinion.

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our Audit.

In our opinion, proper Books of Accounts as required by law have been kept by the Management so far as appears for our examination of such books.

The Balance Sheet and Income and Expenditure Account dealt with by this report are in agreement with the books of account.

In our opinion and to the best of our information and according to explanations given to us, the said accounts read with the schedules & notes thereon give a true and fair view :-

i) In the case of the Balance Sheet, of the state of affairs of the Institute as at 31st March, 2005.

AND

ii) In the case of Income and Expenditure Account of the Surplus under both Plan and Deficit under Non-Plan, for the year ended on that date.

Sd/-
for **B.R.V. GOUD & CO.,**
CHARTERED ACCOUNTS

August 10, 2005

PLAN
RECEIPTS AND PAYMENTS ACCOUNT UNDER PLAN AND OTHERS FOR THE YEAR 31 MARCH 2005

PREVIOUS YEAR Rs.	RECEIPTS	SCHEDULE	AMOUNT Rs.
1,21,12,857	Opening balance		2,68,82,949
14,00,00,000	Grants-in-aid	A	23,30,00,000
9,74,287	Interest on Bank Deposits	B	4,35,298
5,36,27,144	External Funds for the Projects	C	7,55,40,532
3,22,06,889	Advance to Supliers Credits / Adjustments	D	4,01,24,354
23,89,21,177	Total		37,59,83,133

PREVIOUS YEAR Rs.	PAYMENTS	SCHEDULE	AMOUNT Rs.
10,80,75,309	Recurring Expenditure	E	10,79,81,984
5,99,11,544	Non-Recurring Expenditure	F	2,86,05,547
47,40,866	Expenditure out of Grants/ Assistance from other Government Agencies	G	31,47,613
3,93,10,509	Deposits and other payments	H	5,50,52,375
2,68,82,949	Closing balance*	7	18,11,95,614
23,89,21,177	Total		37,59,83,133

*Closing balance of 18,11,95,614/- includes unutilized grants from external projects amounting to Rs. 11,25,19,859/-

NON-PLAN
RECEIPTS AND PAYMENTS ACCOUNT UNDER NON-PLAN AND OTHERS FOR THE YEAR ENDED 31 MARCH, 2005

PREVIOUS YEAR Rs.	RECEIPTS	SCHEDULE	AMOUNT Rs.
6,513	Opening balance		6,822
2,85,00,000	Grants-in-aid	I	2,70,00,000
1,69,112	Recoveries (Net)	J	9,957
47,65,243	Miscellaneous Receipts	K	30,41,703
3,34,40,868	Total		3,00,58,482

PREVIOUS YEAR Rs.	PAYMENTS	SCHEDULE	AMOUNT Rs.
3,20,14,851	Recurring Expenditure	L	2,86,91,026
13,91,453	Advances	M	13,29,780
27,742	Non-Recurring Expenditure	N	32,426
6,822	Closing balance	7	5,250
3,34,40,868	Total		3,00,58,482

Sd/-
SR. FINANCE & ACCOUNTS OFFICER

Sd/-
ADMINISTRATIVE OFFICER

Sd/-
DIRECTOR

Place : Bangalore
Date : 10-08-2005

Sd/-
B.R.V. GOUD & CO
CHARTERED ACCOUNTS

PLAN

INCOME AND EXPENDITURE ACCOUNT UNDER PLAN FOR THE YEAR ENDED 31 MARCH, 2005

PREVIOUS YEAR Rs.	INCOME	SCHEDULE	AMOUNT Rs.
14,99,00,000	Grants-in-aid	8	23,30,00,000
9,74,287	Interest on bank deposits	9	4,35,298
15,08,74,287	Total		23,34,35,298

PREVIOUS YEAR Rs.	EXPENDITURE	SCHEDULE	AMOUNT Rs.
4,54,27,326	Salaries and Allowances	10	5,81,95,191
6,22,62,775	Working Expenses	11	5,02,78,050
8,45,19,116	Deprreciation	5	8,70,07,069
19,22,09,217	Total		19,54,80,310
4,13,34,930	Excess of Income Over expenditure (A-B)		3,79,54,988

NON-PLAN

INCOME AND EXPENDITURE ACCOUNT UNDER NON-PLAN FOR THE YEAR ENDED 31 MARCH, 2005

PREVIOUS YEAR Rs.	INCOME	SCHEDULE	AMOUNT Rs.
2,85,00,000	Grants-in-aid	12	2,70,00,000
24,06,242	Miscellaneous Receipts	13	12,60,084
3,09,06,242	Total		2,82,60,084

PREVIOUS YEAR Rs.	EXPENDITURE	SCHEDULE	AMOUNT Rs.
2,81,40,006	Salaries and Allowances	14	2,46,81,329
30,88,097	Working Expenses	15	30,94,341
5,78,498	Stores & Consumables	16	4,88,923
3,18,06,601	Total		2,82,64,593
9,00,359	Excess of Income Over expenditure (A-B)		4,509

Sd/-
SR. FINANCE & ACCOUNTS OFFICER

Sd/-
ADMINISTRATIVE OFFICER

Sd/-
DIRECTOR

Place : Bangalore
Date : 10-08-2005

Sd/-
B.R.V. GOUD & CO
CHARTERED ACCOUNTS

BALANCE SHEET AS AT 31 MARCH, 2005

PREVIOUS YEAR Rs.	SOURCES OF FUNDS	SCHEDULE	AMOUNT Rs.
54,81,48,799	Capital Funds	1	58,61,03,787
2,38,08,820	General Fund	2	2,38,04,311
6,07,94,446	Unutilised Grants	3	11,25,19,859
10,97,076	Sundry Creditors	4	5,92,18,339
63,38,49,141	Total		78,16,46,296

PREVIOUS YEAR Rs.	APPLICATION OF FUNDS	SCHEDULE	AMOUNT Rs.
52,17,58,324	Fixed Assets	5	47,55,47,431
8,52,01,046	Current Assets, Advances and Deposits	6	12,48,98,001
2,68,89,771	Cash and Bank Balances	7	18,12,00,864
63,38,49,141	Total		78,16,46,296

Sd/-
SR. FINANCE & ACCOUNTS OFFICER

Sd/-
DIRECTOR

Sd/-
ADMINISTRATIVE OFFICER

Sd/-
B.R.V. GOUD & CO
CHARTERED ACCOUNTS

Place : Bangalore
Date : 10-08-2005