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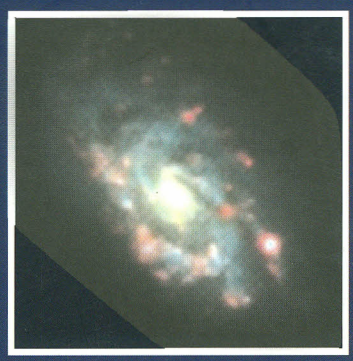

ACADEMIC REPORT 2007 - 08

INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT

2007–08

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Front Cover : B, V, Hα combined image of the infrared bright galaxy NGC 1084 obtained with the HCT

Back Cover (outer) : Enlarged view of NGC 1084

Back Cover (inner) : Sample vintage maps from IIA Archives

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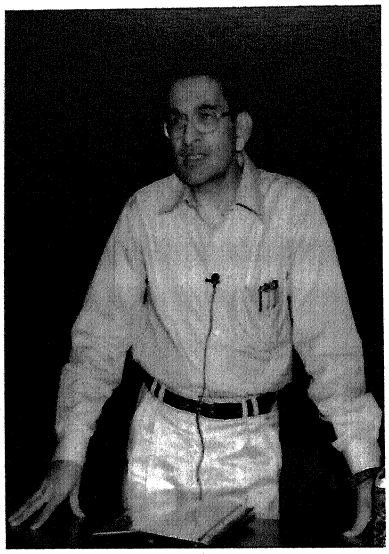
THE YEAR IN REVIEW

The year 2007-08 witnessed the operation of the High Altitude Gamma Ray (HAGAR) telescope array at the Indian Astronomical Observatory (IAO), Hanle. All seven units of this facility have been installed at Hanle and are being operated simultaneously from the central control station. Test runs on the sky show that an angular resolution of 0.2 deg is achieved.Significant progress has been achieved on site characterisation work for the National Large Solar Telescope (NLST) at two locations, namely Hanle and Merak by the Pangong lake. Intensive efforts are being made to characterize the site at Hanle using SDIMM (Solar Differential Image Motion Monitor) and SHABAR (Shadow Band Ranger). The sky radiometer data in visible wavelengths indicate a low content of aerosol particles in the atmosphere at this site. Observations of wind and other meteorological parameters are also being continued. Initial data, acquired from Merak, appear to be promising where the winds flowing along the direction of the water body are mostly laminar. The wind speed is typically a few meters per second. Efforts are on to start observations shortly at Devasthal in Uttaranchal.

Turning to space related programmes, the ultraviolet imaging telescope (UVIT), a payload on the first dedicated Indian space astronomy mission ASTROSAT, is progressing well. All the detector modules have been delivered by Photek, UK to the Canadian Space Agency for developing the detector system. LEOS, ISRO has handed over the engineering model of the mirrors to IIA. A significant development during the current year was the completion of the MGK Menon Laboratory for Space Sciences that is equipped with a state of the art clean room (class 100 to 100000) facility for assembly, testing and calibration of the space payload. The TAUVEX mission, an Indo-Israeli collaboration to observe the ultraviolet sky, is awaiting final calibration prior to its delivery to ISRO for integration with the GSAT-4 spacecraft in preparation for a launch. Its unique positioning in the geostationary zone will enable it to have longer observations near the celestial poles. The Institute is the lead member of a national project to design and fabricate a 20 cm space coronagraph, operating at 530.3 nm and 637.4 nm, which will carry out detailed studies of the solar corona.



Professor Balaram delivering the Founder's Day Lecture

Hon'ble member Shree P. G. Narayanan addressing the Scientists of the Institute

An in-house scientific meeting was held at IIA in April 2007, where a large number of scientists and technical staff presented their contributions. The Institute hosted several workshops, conferences, and schools during the academic year. These included the *Kodai Summer School in Physics* (June 2007), the first *IIA - Penn State School on Astrostatistics* (July 2007), mini-workshop on *Hinode X-Ray Telescope Data Analysis* (July 2007), Kodai-Trieste workshop on *Plasma Astrophysics* (August-September 2007), National meeting on *Infrared Astronomy* (November 2007), National Symposium on *Gamma Ray Astronomy* (November 2007), first Asia-Pacific School on *International Heliophysical Year (IHY)* (December 2007), and National workshop on *Preserving our Scientific Heritage* (January 2008). A new series of schools on *Astronomy and Astrophysics* at VBO, Kavalur was also initiated in May 2007 to attract young researchers to this area as well as to promote excellence in the field. The Institute initiated a Founder's day lecture series on August 10, the birthday of the Founder Director, M. K. Vainu Bappu. The first talk was delivered by Professor Balaram, Director, Indian Institute of Science, Bangalore on *Measuring and Assessing Science.*

The Parliamentary Standing Committee on Science and Technology, Environment and Forests, with the Hon'ble Shree P. G. Narayanan as its Chairman, along with 12 Hon'ble Members belonging to both houses of Parliament visited the Institute on June 25, 2007 and had detailed discussions with scientists at the Institute. They also witnessed a live video conferencing with the staff at the Himalayan Chandra Telescope.

Academic staff members continue to pursue their research vigorously in their respective fields. In solar physics, research is being carried out on the dynamics and heating of the magnetized chromosphere and coronal plasma, condensation in coronal loops, transition region explosive events in coronal holes, derivation of residual rotation rates in the solar activity cycle, molecular rotational lines in sunspot spectra, helioseismology of sunspots, X-ray bright points in the corona, toroidal component of the magnetic flux in the solar convective envelope, and other topics. Results from the dual-beam polarimeter at the Kodaikanal Tower Telescope match with magnetic field measurements from the Solar Optical Telescope (SOT) on the spacecraft Hinode. In the radio band,

studies on correlation of spectral indices with solar activity and pre-flare heating in the solar atmosphere are being carried out. Comet Tempel 1, Comet 17P Holmes and mutual events of the Uranian satellites were observed.

Optical astronomers working in stellar and galactic astronomy are carrying out observations with the Institute's telescopes located at the Vainu Bappu Observatory (VBO), Kavalur and the Indian Astronomical Observatory (IAO), Hanle, Ladakh. In observational astronomy, scientists have focussed their attention on star formation in bright-rimmed clouds and cometary globules, h &-χ Persei clusters, search for CH stars, hydrogen deficient stars, time variability of absorption lines of interstellar medium, young stellar objects, globular cluster, reflection nebulae, planetary nebulae, exploding stars such as novae, supernovae, and activity in galaxies.

The theoretical astrophysical group is engaged in pursuing research on various problems such as Hall-MHD phenomenon in plasma physics, magneto-rotational instability in accretion disks, radiative transfer in magneto-turbulent media, pulsars, stellar dynamics around black holes, extra-solar planets, many-body studies in atomic physics and non-accelerator particle physics.

Turning to the facilities at the observatories, it is a pleasure to note that the Vainu Bappu telescope, VBO, Kavalur, as well as the remote controlled Himalayan Chandra Telescope (HCT), Hanle, Ladakh, are extensively being used by astronomers from within the country and abroad. The detailed concept design for the Hanle Echelle Spectro-polarimeter (HESP) for the HCT was finalized and efforts were initiated to identify a suitable vendor for fabricating the instrument as a technical collaboration. A new secondary mirror is being fabricated for the 1-m telescope at VBO Kavalur. Work on the 1.3-m telescope for the Vainu Bappu Observatory, Kavalur is in progress. The Institute has commenced an expansion of the Gauribidanur Radioheliograph to increase the array size by adding more antennae in order to enhance the sensitivity and angular resolution of the array.

Digitization of the solar data, obtained at Kodaikanal since the dawn of the last century, commenced recently. These data can be used to study the long term variations on the sun of solar irradiance, differential rotation rate, solar activity, tilt angle of sunspots and so on. In order to observe broad band and Ca-K line images of the sun, a twin telescope has been developed in-house and installed at Kodaikanal.

The Computer Centre is being further upgraded to provide facilities for high performance computing. Over 200 computers in the institute are linked by a CAT-6 (1 Gbps) backbone and wireless network. A fast 8 Mbps internet connection allows immediate access to databases around the world. This Centre also hosts a 10 TB disk server, and several clusters. Field station computer centres have been upgraded to 2 Mbps links whereas the CREST campus has a 5 Mbps link. The Library continues to offer state of the art facilities. It has acquired many new books and provides online subscription to a large number of journals and data bases. Recently, it has set up a new archive centre with an impressive collection of historical scientific material.

The Institute has a vibrant graduate studies programme with more than twenty five students. An Integrated Ph.D on Physics and Astrophysics, in collaboration with Indira Gandhi National Open University (IGNOU), and an Integrated M. Tech.-Ph.D (Tech.) on Astronomical Instrumentation in collaboration with the Department of

Applied Optics & Photonics, University of Calcutta, were recently started. The Institute also runs visiting students and trainee programmes. In addition, the Institute hosted a batch of four students from USA under the IRES (International Research Experience for US Graduate Students) programme, sponsored by the US National Science Foundation. A new students hostel 'Bhaskara' is nearing completion.

The Institute pursues a vigorous public outreach programme which includes hosting programmes at the Institute for the general public. Furthermore, new programmes are being planned for the International Year of Astronomy in 2009. As part of this effort, an affordable and sturdy telescope has been designed in house and will be available for distribution to national institutions. National Science Day was observed which included several exhibitions, talks and viewing of the night sky. Welfare activities for SC/ST staff members continue as before and the Hindi cell is functioning efficiently. An annual day function was celebrated with great cheer and enthusiasm.

S. S. Hasan
Director

1 Sun and solar systems

1.1 Solar physics

Coronal observations during the eclipse- Implications to coronal plasma heating

Images of the eastern part of the solar corona in the [Fe XIV] 530.3 nm and [Fe X] 637.4 nm coronal emission lines during the total solar eclipse of March 29, 2006 at Manavgat, Antalya, Turkey were obtained. The images were obtained using 35 cm Meade telescope equipped with peltier cooled 2k x 2k CCD and 0.3 nm pass-band interference filters at the rates of 2.95 s (exposure times of 100 ms) and 2.0 s (exposure times of 300 ms) in the [Fe XIV] and [Fe X] emission lines, respectively. The analysis of the data indicates intensity variations at some locations with a period of about 26 seconds. These results confirm earlier findings of variations in the continuum intensity with periods in the range of 5 to 56 seconds by Singh et al. (1997, Sol. Phys. 170, 235). The authors have found intensity oscillations in the green line emission with a period of about 26 seconds at number of locations in the solar corona. These intensity oscillations may be caused by existence of fast magneto-sonic waves in the solar corona and could be responsible for heating of the plasma in the corona.

(Jagdev Singh, S. S. Hasan, G. R. Gupta, D. Banerjee, S. P. Bagare, R. Srinivasan, S. Muneer & K. P. Raju)

Statistical detection of propagating waves in solar atmosphere

Evidence for waves in the solar atmosphere comes from meaurements of intensities in a wide range of the electromagnetic spectrum including visible, ultraviolet, X-ray and radio waves in addition to Doppler oscillations in visible and ultraviolet light emitted by different solar structures at chromospheric, transition region and coronal temperatures.

Using the temporal series data from SUMER/SOHO oscillations were recorded in the transition region line, (N IV 765Å) and lower coronal (Ne VIII 770Å) line in on-disk polar regions of the sun. The authors have identified the presence of compressional waves in network and internetwork regions of the polar coronal holes. Measurements of the phase delay between these two line pairs reveal that the measured phases tend to line up along diagonal lines corresponding to fixed time delays. From the orientation of the slopes of these diagonal lines, they infer the direction of propagation of these waves. In the present study, they have reported the presence of upward propagating waves in network region and in internet work region; they have reported both upward and downward propagation waves (Figure 1). From estimate of the formation heights of the lines, and using measured time delays, the propagation speed for the line pair has been estimated. The estimated speed indicates that the waves producing these observed phase delays are slow magneto-acoustic waves propagating at speed much less than the sound speed. By comparing with the previous studies, the authors hypothesize that the wave speed increases with height in the solar atmosphere.

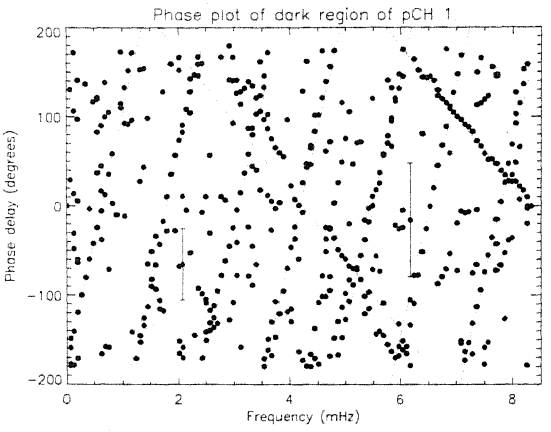


Figure 1: Phase delays measured between the oscillations in the spectroscopic line pair for the dark locations of pCH. The phases in radiant flux oscillations are shown in the grey circle symbols while that in LOS velocities are shown as the black circle symbols. Overplotted on each figure are black parallel lines, corresponding to fixed time delays. The inclined parallel straight lines indicate the presence of both upwardly and downwardly propagating waves. Representative errors are indicated by the error bars.

(G. R. Gupta, E. O'Shea[1], D. Banerjee, M. Popescu* & J. G. Doyle*)*

Evidence for wave harmonics in cool loops

Using temporal series image data from the Coronal Diagnostic Spectrometer (CDS) on SOHO, the authors found presence of oscillations in intensity (radiance) measurements from the transition region OV 629 line with the aim of finding evidence of wave harmonics in cool loops. Using standard Fourier techniques, together with a pre-whitening method, they measure all statistically significant frequencies present in oscillations related to flaring active region loops at the temperature of O V. By measuring

[1]*Collaborators from other institutions

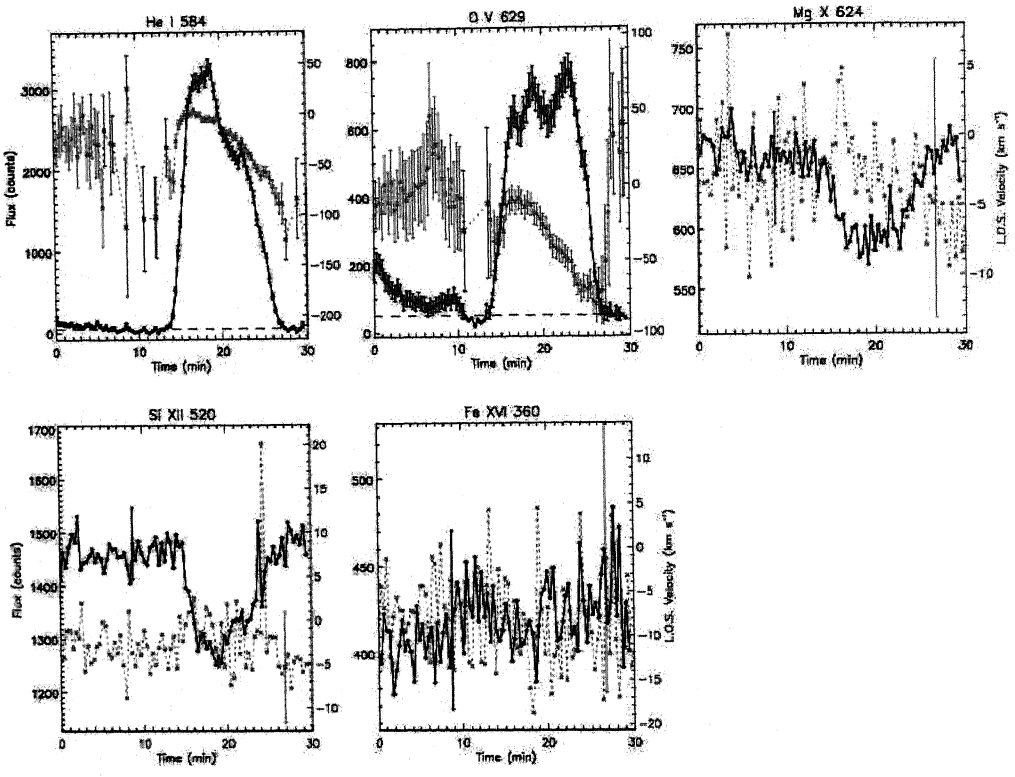


Figure 2: Variation with time of intensity (black lines) and velocity (grey lines) corresponding to pixel 57 of dataset s27152r01.

the distances traveled by three Propagating Disturbances (PDs; see Figure 2), one can estimate their propagation speeds. Evidence is found for harmonics in the measured oscillations suggesting the presence of standing waves in the loops. They find that PDs in cool OV active region loops have sub-sonic velocities of between 12–24 km s^{-1}, suggesting that they are driven either by slow mode (acoustic or slow magnetoacoustic) wave propagation or by bulk flows along the loops triggered by flaring that also produces PDs. They conclude that standing waves are present in flaring cool transition region loops. This evidence comes in the form of oscillations showing harmonic frequencies that match those expected for standing fast kink waves.

(E. O'Shea, A. K. Srivastava*, D. Banerjee, & J. G. Doyle*)*

Plasma condensation in coronal loops

Using temporal series data from the Coronal Diagnostic Spectrometer (CDS) on SOHO, plasma condensation within coronal loops have been reported through the use of spectroscopic analysis. For the cooler lines of He I 584 Å, and O V 629 Å, sharp increases in intensity has been observed, accompanied by large blueshifted velocities. In the case of O V there is a substantial rebound to redshifted velocities when the strong brightening fades. The sharp increase in intensity and blueshifted velocity in the cooler lines is accompanied by a corresponding decrease in the intensity of the coronal lines (Mg X 624 Å, Fe XVI 360 Å, Si XII 520 Å), but with no corresponding change in their velocity values implying an evacuation of plasma. From the Fourier analysis, evidence is found for possible 1st and 2nd harmonics in the He I and O V lines, indicative of standing waves in loops. The authors conclude that they are seeing the first spectroscopic evidence of plasma condensation taking place in coronal loops.

(E. O'Shea, D. Banerjee & J. G. Doyle*)*

Macro-spicule and transition region explosive event in solar coronal hole

Spicules and the higher macro-spicules (jet-like structures seen at the solar limb) are believed to be the dominant mechanism for mass ejection in the higher solar atmosphere outside active regions. But what is

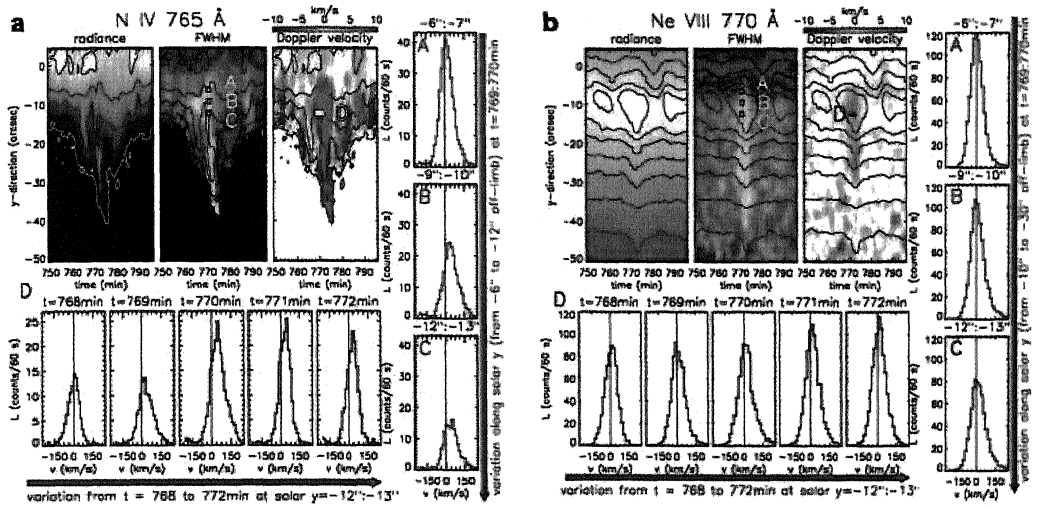


Figure 3: Time series radiance, FWHM and Doppler velocity maps in the N IV line for a macro-spicule seen from t = 750 to 795 min. The overlaid contours show different values of the radiance in logarithmic scale. A, B and C indicate the locations where the spectra examples are shown in the right panels, whereas D is the location along the temporal direction from where spectra are shown in the lower panel

the connection between them and other small-scale structures in the Sun's atmosphere, like for example transition region explosive events, is not known yet. Temporal series spectroheliograms of EUV emission lines from two ions (N IV 765 Åand Ne VIII 770 Å), taken with the SUMER (Solar UV Measurements of Emitted Radiation) spectrograph on SOHO (the Solar and Heliospheric Observatory) was studied. SUMER's good spatial, spectral and temporal resolution enables the most detailed studies of these small-scale structures over a range of transition region temperatures. The present study reveals that a macro-spicule seen off-limb looks similar to a transition region explosive event, especially in the map of the full-width-at-half-maximum (FWHM) (Figure. 3). The macro-spicule seen in the low transition region N IV line ($\sim$ 140,000 K) is also visible in the higher temperature Ne VIII line ($\sim$ 630,000 K). Also, the jet seen on-disk in the N IV line heats and accelerates plasma to the higher Ne VIII temperature, traveling probably along the local (presumably open) magnetic field line.

(M. Popescu, D. Banerjee, J. G. Doyle* & L.D. Xia*)*

Local helioseismology of sunspots

A new set of time-distance helioseismic measurements, using helioseimic data from the Michelson Doppler Imager (MDI) onboard SOHO, that combine surface- and deep- focus geometries for wave-paths that distinguish surface magnetic contributions from those due to deeper perturbations have been carried out. Travel times showing an increased wave speed region extending to depths in the range of 11–18 Mm beneath a large sunspot are detected in deep-focus geometry that largely avoids use of wave field within the spot. Direction (in- or out-going wave) and surface magnetic field (or focus depth) dependent changes in frequency dependence of travel times are shown and identified to be signatures of wave absorption and conversion in near surface layers rather than that of shallowness of sunspot induced perturbations.

(S. P. Rajaguru)

Using waves to infer the magnetic topology of the solar chromosphere

The aim of this work is to examine the hypothesis that the wave propagation time in the solar atmosphere can be used to infer the magnetic topography in the chromosphere as suggested recently (Finsterle et al. 2004, ApJ, 613, L185). The authors did this by using an extension of their earlier 2-D MHD work on the interaction of acoustic waves with a flux sheet. It is well known that these waves undergo mode transformation due to the presence of a magnetic field which is particularly effective at the surface of equipartition between the magnetic and thermal energy density, the $\beta = 1$ surface. This transformation depends sensitively on the angle between the wave vector and the local field direction. At the $\beta^M = 1$ interface, the wave that enters the flux sheet,

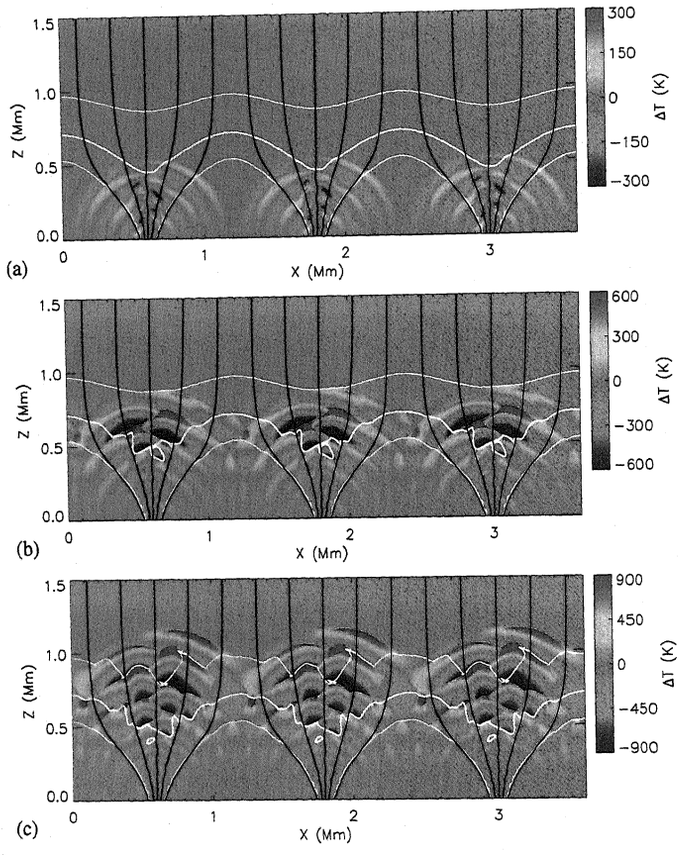


Figure 4: The temperature perturbation, ΔT, (about the initial state) at (a) 75 s, (b) 122 s, and (c) 153 s in a network region consisting of 3 flux tubes. Wave excitation is due to periodic horizontal motion at the lower boundary, with an amplitude of 750 m s^{-1}, and a period of 24 s. The black curves denote the magnetic field lines, and the colour scale shows the temperature perturbation. The white curves denote contours of constant β corresponding to $\beta = 0.1$ (upper curve), 1.0 (thick curve) and 10 (lower curve) (from Hasan & van Ballegoiijen, 2008).

(essentially the fast mode) has a higher phase speed than the incident acoustic wave. A time correlation between wave motions in the non-magnetic and magnetic regions could therefore provide a powerful diagnostic for mapping the magnetic field in the chromospheric network.

(S.S. Hasan & O. Steiner)*

Waves in the solar photosphere

The solar photosphere is a partially ionized medium with collisions between electrons, various metallic ions and neutral hydrogen playing an important role in the momentum and energy transport in the medium. Furthermore, the number of neutral hydrogen atoms could be as large as 10^4 times the number of plasma particles in the lower photosphere. The non-ideal magnetohydrodynamic (MHD) effects, namely Ohm, ambipolar and Hall diffusion, can play an important role in the photosphere. It is demonstrated that Hall is an important non-ideal MHD effect in the solar photosphere and shown that the Hall effect can significantly affect the excitation and propagation of the waves in the medium. It is also demonstrated that the non-ideal Hall-dominated inhomogeneous medium can become parametrically unstable, and it could have important ramifications for the photosphere and chromosphere of the Sun. The analysis hints at the possibility of the solar photosphere becoming parametrically unstable against the linear fluctuations.

(B. P. Pandey, J. Vranjes* & V. Krishan)*

Measurement of solar diameter

The reduction of the measurements of solar diameter over 3 solar cycles from the Kodaikanal white light images have been completed. Reduction of the rest of the measurements is expected to be completed during 2008. The results so far suggest that the solar

diameter shows variations in anti correlation with the sunspot cycle and is of the right magnitude that can explain the observed variation of the surface temperature of the sun with sunspot cycle.

(K. R. Sivaraman, S. S. Gupta & A. V. Ananth)

Zonal velocity bands and the solar activity cycle

The authors have derived the residual rotation rates by subtracting the time-averaged rotation rate from that at each epoch from helioseismic data from the GONG project for a full solar cycle (1996 - 2007) at r = 0.98 $R_\odot$ in the solar interior. These show a set of zonal velocity bands moving with faster-and slower-than-average rotation rate.

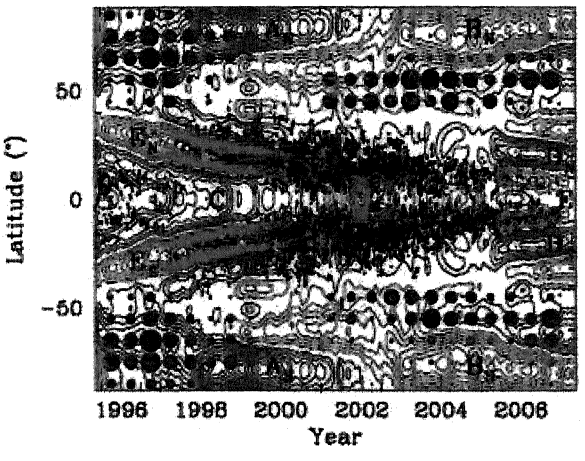


Figure 5: Contours of constant residual rotation velocity, dv j = d W r cos q, at r = 0.98$R_\odot$ obtained from GONG data are shown as a function of time and latitude. The red contours show positive values while the blue contours show negative values. The contour spacing is lms-1 and the zero contour is not shown. Different bands of faster (e.g., B_N , Bs, E, E*N*, Es) and slower (e.g., A_N , As, C, D*N*, Ds) than average rotation velocity are marked in the figure. The markings at low latitudes show the position of sunspots. The filled black circles at high latitudes represent the daily mean number of polar faculae averaged over a period of six months in 10 deg latitude bins from 40 to 90 deg. The area of the circles is proportional to the number of polar faculae.

The zonal velocity bands have two components per hemisphere (see Figure 5) (a) the high-latitude component of alternating slow (blue contours) and fast (red contours) streams (above ~50°) that move poleward (AN or As and Bn or Bs), (b) the low-latitude component of fast (En or Es) and slow (Dn or Ds) streams in the sunspot latitudes that move towards the Equator. En and Es later merge to form a single fast stream E. The 50 deg latitude in the two hemispheres seems to be the boundary that separates the high latitude streams from the low latitude streams. Interestingly, this is also the latitude region where the rotation rate residual is close to zero throughout almost the entire convection zone. In the present study the authors have established that (a) polar faculae and the zonal-flow bands in the region above ~40–50° latitudes have very similar distribution in the spatial and temporal domains, irrespective of whether the zonal velocity band is a fast stream or a slow stream. The switch from fast to slow happens around sunspot minimum (around 1996) when there is no reversal in polarity of the polar magnetic field, while the switch from slow to fast occurs around the sunspot maximum which coincides with field polarity reversal at the poles around 2007. Thus there is one pair of streams (one fast and one slow) during the period of two successive polar-field reversals and both components of the pair are associated with polar fields of the same polarity either positive or negative as the case might be. (b) In the sunspot latitudes, the butterfly pattern coincides with the fast streams (En, Es or E) although part of the sunspot distribution spills over to the slow streams (Dn and Ds) too.

The helioseismic data from GONG and MDI accumulated over the past solar cycle 23 enabled Antia, Chitre, and Gough to study temporal variations in the solar rotational kinetic-energy. It was demonstrated that at high latitudes (>45°) variation in the kinetic energy through the convection zone is correlated with the solar activity, while in the equatorial latitudes (<45°) it is anti correlated except for the upper 10% of the solar radius where both are in phase. The amplitude of temporal variation of the rotational kinetic-energy integrated over the entire convection zone turns out to be ~3 X 10^{38} ergs implying a rate of variation of about 5 X 10^{30} ergs s^{-1} over the solar cycle. From energy conservation it is expected that the torsional kinetic-energy variation is comparable with that in the magnetic energy but with opposite phase. It thus seems that the temporal variation in rotational kinetic energy in the convection zone is related to the solar cycle with its tantalising similarity with the magnetic activity cycle.

(K. R. Sivaraman, H. M. Antia, S. M. Chitre* & V. V. Makarova*)*

Atlas of the H alpha synoptic charts

The authors have prepared very comprehensive two

atlases showing the position of the H-alpha filaments for solar cycles 15-17 (solar rotations 815–1214) and cycles 18-19 (solar rotations 1215–1486) using the solar data from the Kislovodsk Solar Station (Russia) and Kodaikanal data. These atlases provide research material for the study of the dynamics of the organization and migration of uni-polar magnetic regions on the Solar surface that are the visible manifestation of the sunspot cycle processes on the solar surface.

(V. I. Makarov, K. R. Sivaraman, K. S. Tavastsherna* & E. V. Poliakov*)*

Studies of coronal holes using SOHO/CDS data

In continuation with earlier studies, Doppler velocities and spectral linewidths in a coronal hole and the quiet Sun region outside have been obtained using five strong emission lines in the CDS wavelength range whose formation temperatures represent different heights in the solar atmosphere from the lower transition region to the inner corona. It has been found that the Doppler velocities in the coronal hole are generally blue-shifted with respect to the quiet Sun, and the magnitude of the blue-shifts increases with the height. Several localized velocity contours have been found mainly on network brightenings and in the vicinity of coronal hole boundary. Presence of velocity contours on network may represent network outflows while the latter could be due to localized jets probably arising out of magnetic reconnection at the boundary. All spectral lines have larger widths in the coronal hole than in the quiet Sun. Also polar coronal hole have larger linewidths and Doppler velocities than those in the equatorial extension indicative of the different initial conditions of the solar wind flow at these regions.

(K. P. Raju)

Studies of solar activity using Kodaikanal calcium K data

The Calcium K images from Kodaikanal Solar Observatory have been used to study solar activity. The images are dominated by the chromospheric network and plages. While the network is a manifestation of the solar convective scale - supergranulation, plages represent the newly emerged active regions on the solar surface. Programs have been developed to obtain the network and plage indices from the daily images as functions of solar latitude and time. The data covers a period of about 100 years and hence contains information on several solar cycles. The study is expected to give insights on solar activity, solar differential rotation and the interaction between the magnetic field and convection.

(K. P. Raju & Jagdev Singh)

Spectroscopic investigation of sunspot umbral spectra for identification of molecular rotational lines

The identification of molecular rotational lines in FTS spectra of sunspot umbrae, observed by NSO, was carried out for several diatoms of the Beryllium hydride isotopomer lines. Some of the transitions were found to be present in the cooler umbrae. Rotational temperatures were estimated for the well resolved lines only. The values were found to be in the range of 3000 to 4000 K. Estimation of transition probabilities was carried out for several molecules including CS, which is reportedly the first molecule found in interstellar space and is also found in the solar atmosphere. Even though CS is well studied in several astrophysical sources, the significant values of transition probabilities obtained encourage a search for its presence in sunspot umbrae.

(S. P. Bagare, B. Karthikeyan, R. Shanmugavel* & N. Rajamanickam*)*

H alpha spectropolarimetry of active regions close to disk centre

Spectropolarimetric observations were carried out for two relatively simple round sunspots located close to disk centre around H alpha wavelength (6563 Å). The corresponding active region numbers are NOAA 10940 and NOAA 10941 referred to as AR1 and AR2. The vector magnetic field at the photosphere is derived through inversion of Stokes profiles of FeI line at 6569 Åunder Milne-Eddington atmospheric model. The chromospheric fields are derived from H alpha Stokes profiles under weak-field-approximation (WFA). Both the sunspots studied show a typical magnetic topology at the photosphere, meaning, the field strength decreases uniformly in the radial direction from the centre's of the umbrae towards the peripheries of the visible sunspots. Also, the penumbral fields at this height are more inclined with respect to the surface normal while the umbral fields are more or less vertical. AR1 comprises of a sunspot surrounded by opposite polarity magnetic activity and AR2 is more or less an isolated sunspot. This dif-

ference in distribution of the magnetic field at the photosphere causes the difference in magnetic topology above these two sunspots at the chromosphere as evidenced by the vector magnetic field inferred through H alpha Stokes profiles. The field inclinations in the umbral chromosphere above AR1 tend to increase towards the centre of the umbra and it is as large as 70 deg. This is immediately evident in the X-ray images of the same region observed by Hinode/XRT, which shows horizontal loops extending from the umbra of the main sunspot to the surrounding magnetic activities. The field inclinations in the umbral chromosphere above AR2 are almost constant but, larger (50 deg) compared to their photospheric counterparts (close to 0 deg near the centre of the umbra). The larger inclinations above this sunspot is caused due to the regular fanning out of magnetic fields with height. This is clearly shown by the X-ray images of AR2 which exhibit more of open loop structures. The magnetic field strengths at the chromosphere are more or less linear with respect to the photospheric field strengths but, with different proportionality constants viz 0.284 for AR1 and 0.423 for AR2. The authors also find larger velocity gradients in the umbra compared to penumbra at the chromosphere in confirmation with the earlier observations, which may be due to the larger magnetic field gradients in the umbral chromosphere.

(K. Nagaraju, K. Sankarasubramanian & K. E. Rangarajan)*

On the weakening of chromospheric magnetic field in active regions

Simultaneous measurement of line-of-sight (LOS) magnetic and velocity fields at the photosphere and chromosphere are studied. Fe I line at λ6569 and H_α at λ6563 are used respectively for deriving the physical parameters at photospheric and chromospheric heights. The LOS magnetic field obtained through the centre-of-gravity method show a linear relation between photospheric and chromospheric field for field strengths less than 700 G. But in strong field regions, the LOS magnetic field values derived from H_α are much weaker than what one gets from the linear relationship and also from those expected from the extrapolation of the photospheric magnetic field. The properties of magnetic field observed in H_α from the point of view of observed velocity gradients is discussed in detail. The bisector analysis of H_α Stokes I profiles shows larger velocity gradients in those places where strong photospheric magnetic fields are observed. These observations may support the view that the stronger fields diverge faster with height when compared to weaker fields.

(K. Nagaraju, K. Sankarasubramanian & K. E. Rangarajan)*

Magnetic and velocity properties of G-band bright points around a pore

Physical properties of G-band bright points (GBPs) surrounding a pore are studied using observations spanning from photosphere to chromosphere. The magnetic field strengths obtained in these bright points are of the order of 1.2 kG. These GBPs show very little linear polarization and the magnetic field lines are vertical. The observed GBPs show a fill-fraction between 20 to 40%, revealing that they are smaller than the achieved spatial resolution of 0.2arc-sec. The observed GBPs harbour accelerated downflows.

(K. Nagaraju, K. Sankara Subramanian & K. E. Rangarajan)*

Intensity oscillations and heating of the solar corona at the sites of X-Ray bright points from Hinode/XRT observations

The relation of X-ray Bright Points (XBPs) with the underlying photospheric and chromospheric features is an important issue in understanding the origin of the footpoints of XBPs and hence to study the heating of the quiet corona. A 7-hours long time sequence of the soft X-ray images obtained on April 14, 2007 at high temporal resolution using X-Ray Telescope (XRT) on-board the Hinode mission is analysed. The aim is to observe the intensity oscillatory phenomena in X-ray Bright Points (XBPs) of different brightness levels and to bring out the differences, if any, in the period of intensity oscillations. SSW in IDL is used to derive the time series of XBPs and construct the power spectra to determine the period of intensity oscillations associated with XBPs. The authors chose 14 XBPs and 2 background coronal regions from the time series images and derived their light curves (Figure 6). For the first time, power spectrum analysis on XBPs data has been used to determine the periods of intensity oscillations. The power spectra of XBPs show several significant peaks at different frequencies corresponding to a wide variety of time scales which range from a few minutes to hours. The light curves of all the XBPs give the impression that the XBPs can be grouped into three classes depending on emission levels: (i) weak XBPs;

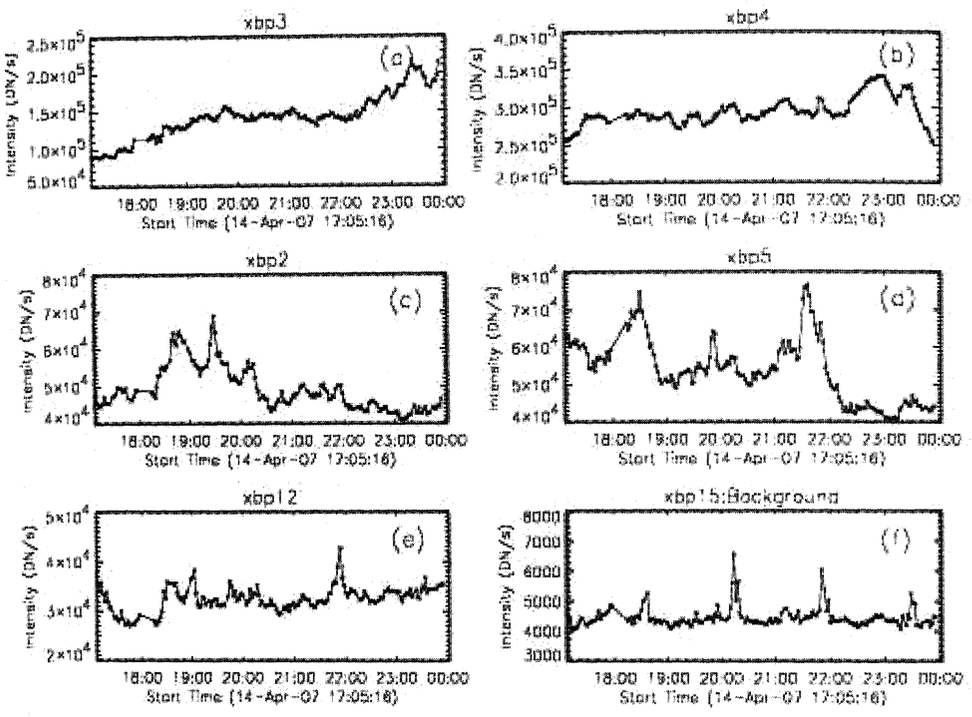


Figure 6: Time series of XBPs and background coronal region (xbp2, xbp3, xbp4, xbp5, xbp12 & xbp15) of April 14, 2007, where (a) xbp3 & (b) xbp4: Class I; (c) xbp2 & (d) xbp5: Class II and (e) xbp12: Class III and (f) xbp15: background coronal region.

(ii) bright XBPs; and (iii) very strong XBPs. The periods of intensity oscillation are consistent in all the XBPs and are independent of their brightness level. The period-brightness relationship can therefore be taken as evidence that the heating mechanisms in all the three groups of XBPs are similar. The different classes of XBPs may be related to the different strengths of the magnetic field with which they have been associated.

(R. Kariyappa & B. A. Varghese)

Prediction of the amplitude of the solar cycle 24

Prediction of the strength of a solar cycle well in advance is important in view of the effects of solar activity on the terrestrial atmosphere and the space environment. A large number of forecasting methods (precursors, spectral analysis, non-linear dynamics, solar system dynamics, etc.) are used to predict the amplitudes of the solar cycles. There have been many predictions for the amplitude of cycle 24, but their range is very wide. The solar cycle 24 prediction panel came out with a consensus statement that it supports the two possible peak amplitudes, 90 ± 10 and 140 ± 20, for the smoothed international sunspot number of this cycle (`http://www.sec.noaa.gov/Solarcycle/sc24/statement_01.HTML`). So far most of the predictions of the solar cycles are based on the sunspot data of previous cycles, *i.e.*, the sunspot number before or at the preceding sunspot minimum of a cycle is correlated with the sunspot number at the maximum of the same cycle.

There exists a statistically significant north-south asymmetry in several solar activity phenomena. Recently, Javaraiah (*MNRAS*, 377, L34, 2007), using Greenwich and Solar Optical Observatory Network (SOON) sunspot group data during the period 1874 – 2005, found that the sums of the areas of the sunspot groups in $0° - 10°$ latitude-interval of the Sun's northern hemisphere and in the time-interval, -1.35 year to $+2.15$ year from the time of the preceding minimum–and in the same latitude interval of the southern hemisphere but 1.0 year to 1.75 year from the time of the maximum–of a sunspot cycle well correlate with the amplitude (maximum of the smoothed monthly sunspot number) of its immediate following cycle. Using these relationships it is possible to predict the amplitude of a sunspot cycle by about 9 – 13 years in advance. The author has predicted 112 ± 13 and 74 ± 10 for the amplitude of the upcoming cycle 24. These predictions are highly

statistically significant (97% correlation) compared to the predictions from any other methods used so far.

(J. Javaraiah)

Search for short-term periodicities in the Sun's surface rotation : a revisit

Temporal variations in the Sun occur on many time scales. The time scales relevant for dynamical process range from minutes (lifetime of small convective elements such as granules) to years/decades/centuries (solar cycles) to billions of years (evolution). Studies on short-term variations in solar activity and solar rotation, and their solar cycle dependence, may greatly help for better understanding the basic process of solar activity cycle and for predicting the level of solar activity. Recently, the authors have improved the analysis described in Javaraiah and Komm (*Solar Phys.* 184, 41, 1999) by using relatively longer and better calibrated daily data of the solar equatorial rotation rate determined from the Mt. Wilson daily Doppler velocity measurements during the period 3 December 1985 – 4 April 1999 and investigated short-term periodicities in the equatorial rotation rate and their dependency on solar cycle. These daily values of the equatorial rotation rate have been binned into a 38 day and 1 year time series. A cosine fit with a period of 1 year was first applied to the 38 day sequence to remove a seasonal trend. The spectral properties of this sequence were then investigated using standard Fourier and maximum entropy methods. The results show the presence of $\sim$ 1.4 year and $\sim$ 250 day periodicities in the surface equatorial rotation rate. Weaker $\sim$ 6 year, $\sim$ 2.2 year and $\sim$ 153 day periodicities are also visible. A Morlet wavelet analysis of the aforesaid data suggests that the $\sim$ 1.4 year periodicity was predominant around both the years 1990 and 1995, i.e. near the maximum and the end of the cycle 22, while the 250 day and the 155 day periodicities occurred mainly around the years 1987 and 1995, respectively. The 2.2 yr periodicity occurred around 1990. The annual time series of the equatorial rotation rate determined from the Doppler velocity data, and also the corresponding time series obtained from the sunspot group data, show that the equatorial rotation rate steeply decreased during the rising phase, with a minimum in correspondence of the maximum, of the solar cycle 22. The aforementioned weak $\sim$ 6 year periodicity is somewhat clearly visible from the former time series, whereas it is not clear from the latter. The authors have also analyzed the Mt. Wilson Doppler data during the period 5 April 1999 – 5 March 2007, which are measured with relatively more stable Mt. Wilson spectrograph instrumentation. No significant variations of any kind are found in the data during 1996 – 2007, leading to suspect the existence of the above periodicities in the data before 1996. However, the temporal behavior of most of the activity phenomena is considerably different during cycles 22 (1986 – 1996) and 23 (after 1997). Hence, during these cycles the temporal behaviour of the rotation may also be considerably different.

(J. Javaraiah, R. K. Ulrich, L. Bertello*, & J. E. Boyden*)*

Initial umbra penumbra ratio of the sunspot groups

For different life spans, during their initial appearance on the surface, the data of 106 (1871-1976) yrs from the Greenwich photoheliographic results are considered for computation of sunspot groups'umbra penumbra ratio. Irrespective of their sizes and for different life spans, preliminary results are : (i) umbra penumbra ratio is strongly inversely correlated with increase in life span, *i.e.*, the sunspot groups with small life spans ($\sim$ 2 days) have high umbra penumbra ratio ($\sim$ 0.40) compared to the sunspot groups with higher life spans ($\sim$ 12 days) that have umbra penumbra ration of $\sim$ 0.20 and, (ii) an empirical relationship between the umbra penumbra ratio and the intensity of the sunspot groups yields the thermal structure : the spot groups that have smaller life spans ($\sim$ 2 days) are hotter ($\sim$ 3400^o K) compared to the spot groups with higher life spans ($\sim$ 12 days) that have lower temperature ($\sim$ 3200^o K).

(K. M. Hiremath)

Toroidal component of the magnetic flux in the solar convective envelope

For different life spans of the bipolar spots, the line of sight component of the magnetic flux is measured from the SOHO/MDI magnetograms during their initial appearance on the surface and toroidal component is separated. Irrespective of their sizes, strength of the measured line of sight component (Figure 7a) of the magnetic field structure varies from $\sim$ 400 G to $\sim$ 250 G for the life span of two and twelve days. Whereas strength of the estimated surface toroidal component (Figure 7b) of the bipolar spots varies from $\sim$ 10 G to $\sim$ 200 G for the life span of two to twelve days. The Parker's (ApJ, 121, 491, 1955) flux

tube model and Hiremath's (A&A, 386, 674, 2002) life span anchoring depth information are used for inferring the toroidal component ($\sim 10^4$ G near base of the convective envelope to $\sim$ 10 G near the surface) of the magnetic flux at different anchoring depths (Figure 7c).

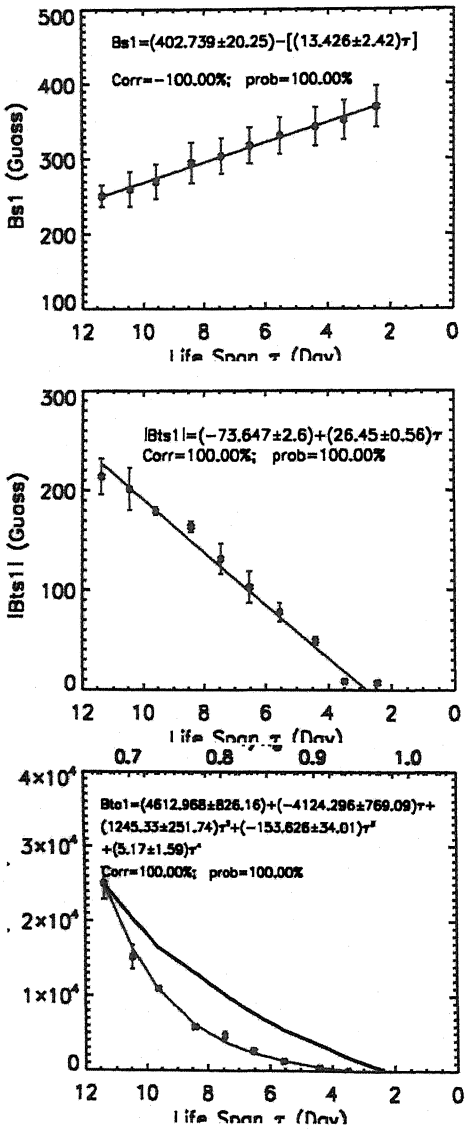


Figure 7: On the surface, magnetic field strength of the bipolar sunspots: measured line of sight (Figure 7a) and estimated toroidal (Figure 7b) components. The inferred (Figure 7c); the blue continuous line is theoretical curve computed from MHD equations of Hiremath (*BASI*, 29, 169, 2001) strength of toroidal component of the magnetic field structure at different anchoring depths in the convective envelope.

(K. M. Hiremath & M. R. Lovely)*

1.2 Solar radio astronomy

Correlation of radio spectral indices with solar activity

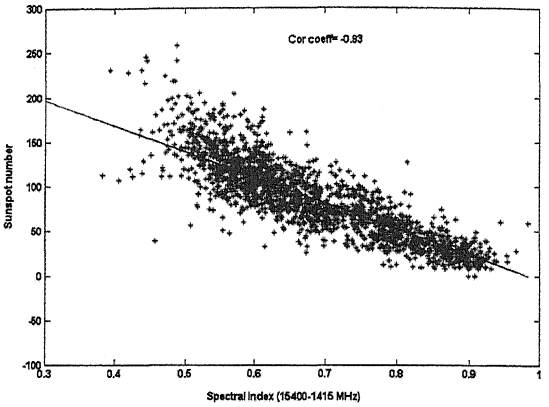


Figure 8: Variation of the sunspot number with the spectral index for the band 15400 - 1415 MHz

Solar activity covers a whole range of phenomena at all levels in the solar atmosphere and time scales ranging from seconds to minutes through months to 11 or 22 years cycles. Solar physicists have tried to quantify the variation of solar activity with time with many indices like Sunspot number, Sunspot area, 2800 MHz radio flux, X-ray, EUV indices, cosmic ray fluxes etc. At radio wavelengths, global solar radio flux at 10.7 cm had been used to quantify the solar activity. The authors have made a study of relation between the radio spectral indices and the sunspot activity. The data used is obtained from the US Air Force Radio Solar Telescope Network (RSTN) which measures the global solar radio flux at 15400, 8800, 4995, 2800, 2695, 1415, 610, 410 and 245 MHz at the same time. These values are adjusted to 1AU. The frequencies in the range 15400 MHz to 1415 MHz cover the chromospheric levels and the frequencies in the range 610 to 245 MHz cover the upper corona. For the present study the authors have used the daily solar radio flux values given by the Penticton observatory and given in the solar geophysical data published by NOAA. For the present study they have used the data for the period 2000 – 2004. The authors have divided the data into 2 bands, 15400 – 1415 MHz and 610 – 245 MHz as the emission mechanism is believed to be different. From the radio flux at different frequencies, the spectral index is calculated using least square fit. The variation of flux density with frequency can be expressed as S is proportional to $f\alpha$, where f is the frequency of observa-

tion and α is the spectral index. From the plot of the log S vs Log f one can determined the spectral index using least square fit. It is found that the spectral indices in the band 15400 – 1415 MHz is well correlated with the sunspot number suggesting that the radio emission is closely associated with sunspot activity. The spectral indices in the band 610 – 245 MHz show only a weak correlation with the sunspot number suggesting the radio emission in the upper corona is not influenced by the sunspots.

(K. R. Subramanian, K. B. Ramesh, E. Ebenezer & K. H. Raveeesh)

Radio observations of pre-flare heating in the solar atmosphere

The solar radio astronomy group of the institute and INPE, Brazil have been involved in the joint analysis of the data obtained with Phase-1 of the Brazilian Decimetre Array (BDA) at 1.6 GHz. One of the interesting results obtained recently was on the radio activity prior to filament eruption/flare activity in the solar atmosphere. There was a SF/C2.5 class H-alpha/GOES flare on December 8, 2004 from NOAA/USAF AR 10709 (N05 W03) during the interval 19:34:44 UT (Figure 9). The peak of the event was around 19:59 UT. There was also a H-alpha filament disappearance from the location (N01 W07) in the interval 19:17-19:42 UT. The authors found that there is a steady increase in the peak radio brightness temperature over a period of about 4 h, due to filament activity prior to its eruption and pre-flare heating.

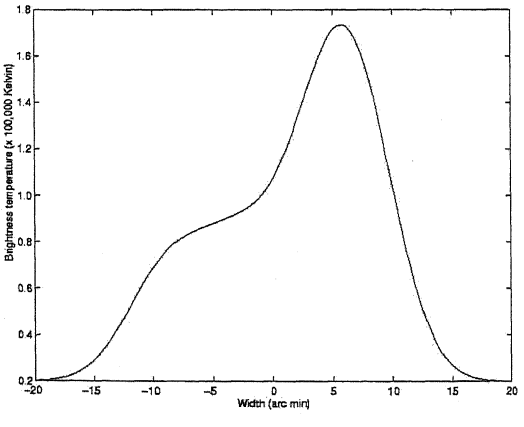


Figure 9: East-West one-dimensional scan of the Sun obtained with BDA on December 8, 2004 around 15:00 UT. Solar east is to the left in the image.

(R. Ramesh, H. S. Sawant et al.)*

1.3 Planetary sciences

Comet Tempel 1

Modeling of non-impact related dust morphology was continued to further investigate the dust emission scenario of this comet. Sequence of images obtained by the High Resolution Instrument (HRI) cameras aboard the Deep Impact Spacecraft show near nuclear changes in dust morphology over a period of a revolution of this comet (Farnham et al. 2007, Icarus 187, 2007). The working model was applied to the series of these published images. Results of the modeling indicate presence of two kinds of active locations on this comet. While the curvature of the dust trajectories in the large field ground based data of 4×10^4 km can only be explained if the maximum grain velocity is 70 m s^{-1}, the evolution of the prominent spiral in the HRI data requires the grains to be three times slower. Further, the activity of the source producing the spiral is found to continue also on the night-side of the nucleus. The dichotomy of the sources found from the present investigation is supported by the findings of Feaga et al.(Icarus, 2007, 190, 345-356) of enhanced emission of CO_2 in the region near the southern pole of comet Tempel 1. They point out that there is preferential sublimation of CO_2 compared to H_2O during the night when the temperature may drop below 200^o K but remains above 110^o K. The sublimation of CO_2 therefore continues.

A quantitative comparison of the intensities of the simulated image and the observed image from the HCT indicates that 80 % of the contribution comes from regions that are south of the nucleus between -20 deg and the south pole. Dust emission in comets is correlated with gaseous emission. The derived locations of the dust sources were used to construct synthetic OH production curve of the comet. This closely follows the production rates of OH at various epochs published by several groups. In particular, the peak occurs around 50 days before perihelion in accordance with the observations.

(R. Vasundhara)

Comet 17P Holmes

Comet 17P Holmes had a massive outburst around 24.07 October, 2007. The comet brightened from a normal magnitude of 17.8 to 3.5 on October 24.55 (IAUC 8886). The comet was observed in the Z band at the HCT on 25 and 26 October. Figure 10 shows the images obtained on these two days. Top and

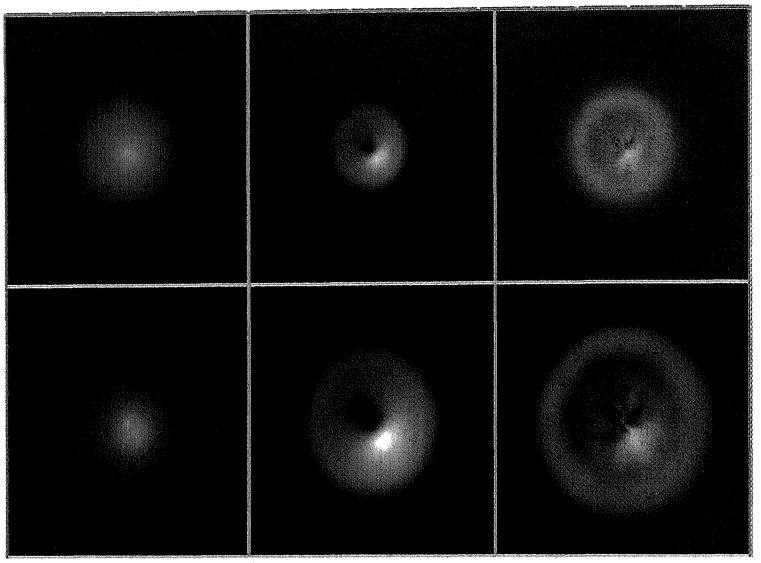


Figure 10: Left panels: original processed images of 25 (above) and 26 October (below) 2007. North is top and East is to the left. The total image field is 3.55 X 10^5 km. The ejected debris is seen in the south-westerly direction. Middle panels: After removing the contribution of the 1/r coma. The outburst plume and the envelope are seen more clearly. Right panels: After application of a digital filter using the "Shift-Rotation" algorithm to delineate finer details. The shell structure in these processed images should be interpreted as the edge of the expanding envelope and is not a real feature.

lower left panels show the original processed images of 25 and 26 October respectively. The ejected debris is seen in the south-westerly direction. The outburst plume and the envelope are seen more clearly in the middle panels after the contribution of the 1/r coma is removed. Further details are delineated by applying a digital filter using the "Shift-Rotation" algorithm. This filter brings out details of the edges of the ejecta where the intensity gradient is maximum. A preliminary analysis indicates a projected velocity of 0.4 - 0.45 km $s^{-}1$. Modeling of the dust features in these images will be carried out to investigate the outburst activity, grain properties and the ejection velocities. Medium resolution spectra obtained on the two dates will be used to investigate the dust and gaseous characteristics of the expanding ejecta debris.

(R. Vasundhara, K. Sasikumar Raja, P. Ramya, S. Muneer, Ravindra Pawase, Aman Preet Kaur & Manjunath hegde)

Mutual events of the Uranian satellites

In 2007-2008, the planet Uranus passed through one of the nodes of its orbit on its equatorial plane for the first time since 1966. For a few years around this time, its satellites eclipsed and occulted each other whenever any two of them were aligned with the Sun or the Earth respectively. Observations of several of these events were carried out during July 2007- December 2007 from VBO and IAO. The analysis of the data is being carried out. The derived light curves will be fitted with model light curves to extract relative astrometric position of the uranian satellites with accuracies of the order of 0.05 arcsec.

(R. Vasundhara, B. C. Bhatt, S. Muneer & D. K. Sahu)

1.4 Solar-terrestrial relationship

Geomagnetic Storm Sudden Commencements (ssc's)

High-time resolution data of 210 Magnetic Meridian (210MM) magnetometer network and Circum-pan Pacific Magnetometer Network (CPMN) are used in studies aimed at enhancing the empirical knowledge of SSCs in the sub-auroral region and thereby enrich comprehension of the physics of SSCs.

The 210 MM magnetometer network extending over both the hemispheres at the specified magnetic longitude has proved valuable in many investigations of the hemisphere differences in the characteristics of geomagnetic disturbances on various time scales. Event-specific evidence has been found for the prevalence of a remarkable summer-winter hemisphere asymmetry in the manifestation of the pre-

liminary reverse impulse (pri) of storm sudden commencements (SSCs) at midlatitudes of the local afternoon sector. The asymmetry is characterized by a larger peak amplitude (by a factor of 3-7 in individual cases) of the pri in the summer hemisphere compared to the winter hemisphere.

The authors are extending the study to find answer(s) to the question as to whether the hemisphere asymmetry of pri is typical or atypical of the midlatitude SSC and under what circumstances it arises.

The authors have examined the possibility that interplanetary (IP) shocks near Earth's orbit that are driven by solar coronal mass ejections (CMEs) could preferentially lead to SSC* with a preliminary reverse impulse (pri) at the dayside dip equator. The authors found, for the first time, that 78 per cent of the CME-driven IP shocks indeed resulted in SSC* at the dayside magnetic equator. This noteworthy relationship of SSC* in the dayside dip equatorial region with CME-related IP shocks persists even when SSC data of the Pacific and south American sectors are examined separately. The significant dependence of the SSC waveform (conventional SSC with just the main positive impulse, mi and SSC* with a negative impulse preceding mi) on the solar source of the causative IP shock is a new facet of solar-terrestrial coupling.

At the moment, there is an acute paucity of information on certain aspects of SSC* near the dayside dip equator which has a direct bearing on the currently incomplete understanding of solar wind-magnetosphere-ionosphere coupling on the time scale of SSCs. As a step in the direction of redressing the situation, they have analyzed the simultaneous observations at dip equatorial stations in the Pacific sector of Circum-pan Pacific Magnetometer Network (CPMN) with reference to a large number of well-identified IP shocks and the SSCs associated with them. Specific aspects studied included the dependence of the amplitude of pri and mi of SSC* (and mi of conventional SSC+) on magnetic local time (MLT) and the properties of the causative IP shock. It is found that the normalized amplitude of pri as well as mi of SSC* assumes high values around local noon and falls off on either side, and this time interval is longer for mi compared to pri. The latter feature arises because mi at dayside dip equator receives contributions from both the shock-induced compression effect (DL field) and the additional perturbation field of polar origin (DP field). The authors also found that the amplitude of pri as well as of mi bears a statistically significant linear relationship to the change in the square root of the dynamic pressure (Pd) of the solar wind across the shock.

(J. H. Sastri, K. Yumoto, J. V. S. V. Rao & A. Ikeda*)*

Plasma-neutral coupling in Earth's upper atmosphere

The day-to-day variability of equatorial upper atmosphere parameters is generally sought in terms of plasma-neutral coupling, and high latitude-low latitude dynamical and electrodynamical couplings. Ground work (identification of magnetospheric substorms of various types and geomagnetic storms with unique features caused by varied structures in the solar wind plasma and interplanetary magnetic field and their solar sources; collection of relevant upper atmosphere data etc) is completed for assessing the combined/individual role of the coupling processes in individual geophysical events. The actual data analysis is due to be initiated.

(J. H. Sastri and collaborators)

Solar forcing on the changing climate

With the concentration of atmospheric carbon dioxide, the influence of solar cycle and activity phenomena is critically examined by considering two important cases of Indian monsoon rainfall and surface temperature of the subcontinent. In the previous academic years, the solar and astronomical forcings on the Indian monsoon rainfall is examined.

The variation of maximum and minimum surface temperature records from 1901–2003 of the Indian subcontinent show that : (i) after 1980 onwards, although there is a strong correlation between the variation of maximum temperature with the variation of concentration of atmospheric carbon dioxide, variations of the minimum temperature and difference between maximum and minimum temperature records (that represents the earth's albedo) vary strongly with the solar activity indices and, (ii) based on ample evidences from the scientific literature and results of this analysis, with reference to the latest IPCC report on the global warming due to anthropogenic greenhouse gases, it is concluded that solar forcing on the earth's climate and the environment cannot be simply underestimated and ignored completely.

(K. M. Hiremath)

2 Stellar and Galactic Astronomy

2.1 Star formation

Kinematic signatures of triggered star formation in bright-rimmed clouds and cometary globules

Bright-rimmed clouds (BRCs) and cometary globules (CGs) are prime examples of triggered star formation. Massive stars or supernovae in OB associations generally provide the star-forming trigger by shocking the ambient dense clouds. The clouds (BRCs and CGs) are accelerated away from the central trigger. Molecular-line radial velocity measurements support such expansion of the cloud system. The plane-of-the-sky transverse motion of the clouds, however, is difficult to measure. If a young star is formed in the cloud due to the trigger, then proper motion of the young stars may be used to study the transverse expansion. The authors are studying the kinematics of the young stars in BRCs and CGs by spectroscopic and proper motion measurements. In the Gum Nebula region of triggered star formation it is found that young stars have proper motions that are directed radially away from the central trigger and are parallel to the cometary tails of the CGs.

(H. C. Bhatt & Rumpa Choudhury)

Understanding the star formation history in h & χ Persei clusters

Young open clusters (age $\sim$ 10 Myr) have a non-zero duration of star formation, resulting in a range of ages for member stars. In some cases, the range is as large as the cluster age itself. In this study, the duration of star formation in h and χ Persei clusters is estimated. Combining the CCD photometry of Slesnick et al. (2002) with the 2MASS data, pre-main sequence (PMS) stars are identified as stars with near infrared excess. The ages of these candidate PMS stars were estimated using PMS isochrones. The authors have identified 24% and 17% of PMS stars in h and χ respectively, within a radius of 7 arcmin. The ages of PMS stars were found to be in the range 1-10 Myr in both the clusters, suggesting the age of the youngest stars as $\sim$ 1 Myr. Thus, both clusters have similar fraction of PMS stars and have experienced very similar duration of star formation. The results suggest that the clusters experienced a major burst of star formation at the turn-off age of 13 Myr, which was followed by smaller bursts till the last 1 Myr. Thus, stars in these clusters have a significant age spread, as large as the turn-off age itself. This has implications on the interpretation of PMS time scales and disk properties of the recently identified PMS stars and stars with active and truncated disks.

(Annapurni Subramaniam, B. Bhavya, Smitha Subramanian & Blesson Mathew)

2.2 Evolved stars

Low-resolution spectroscopy of high Galactic latitude objects: A search for CH stars

Properties of CH stars like iron deficiency and enrichment of carbon and heavy elements can provide valuable inputs to understand nucleosynthesis. In particular, these parameters provide strong observational constraints for theoretical studies of nucleosynthesis of heavy elements at low-metallicity. Accurate identification and spectroscopic characterization of CH stars is therefore very essential. The authors have undertaken a program with a prime objective to search for these objects in a mixed sample of carbon stars taken from Hamburg survey. The spectra of the objects were obtained using OMR at VBO, Kavalur and HFOSC at HCT, IAO, Hanle, during 2005 and 2006. Twenty-one CH stars were detected from a sample of sixty objects based on low-resolution spectral analysis. Estimated effective temperatures, $^{12}C/^{13}C$ isotopic ratios, and their location in the two colour J-H vs H-K plot support their identification with the class of CH stars.

(Aruna Goswami, P. Bama, N. S. Shantikumar & Deepthi Devassy)

The cool suspected R CrB star DY Per

The nature of this cool carbon star suspected to be of R CrB type has been investigated. Although the light curve did suggest similarity with cool R CrB stars the question about hydrogen deficiency was not clear. The nature of the star has been studied from spectra obtained with 11- meter Hobby-Eberly telscope (HET), 2.7 m Harlan Smith telescope of McDonald observatory along with low resolution spectra obtained with 2 m HCT from Hanle. The observations were obtained when the star was at minimum (V = 15-16 mag) as well as at maximum light. The spectra at minimum do show very strong broad lines

of Na I D in emission accompanied by high velocity (-220 km $s^{-}1$) absorption components typical of R CrB stars at minimum. The high velocity absorption components (shell lines) also seem to persist during maximum light as well. The question of hydrogen deficiency is being investigated with the help of the strength of the G-band of CH. The authors used specially computed model at atmospheres for hydrogen deficient cool carbon stars at Upsala to synthesize the spectral region of the G-band. As a comparison the authors also synthesized the G-band region for other cool R CrB stars and HdC stars. DY Per appears to be hydrogen deficient, although questions related to metallicity and abundances of s-process elements are still to be established. This work is in progress

(N. Kameswara Rao, D. L. Lambert, C. A. Prieto*, K. Eriksson* & R. Wahlin*)*

High-resolution spectroscopy of the R Coronae Borealis star V Coronae Australis

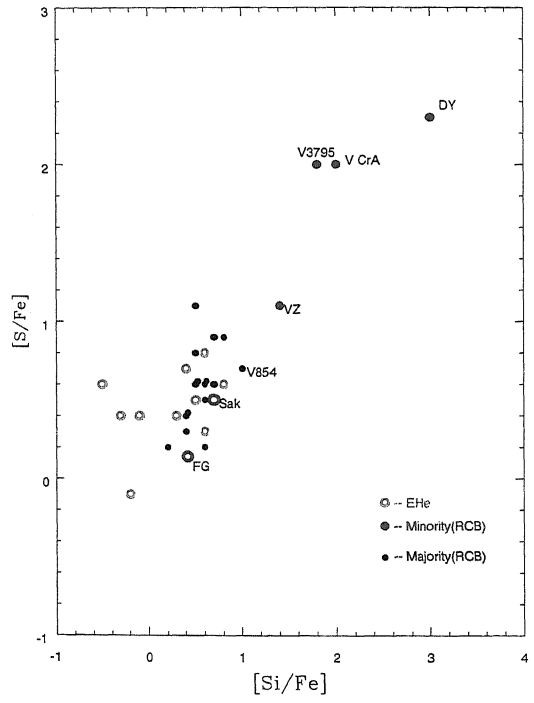


Figure 11: The abundance ratio [Si/Fe] vs [S/Fe] for minority RCBs (red dots, stars identified by name), majority RCBs (blue dots), EHe stars (yellow dots), and the final flash candidates FG Sge and Sakurai's object (unfilled red dots). V CrA is a leading member of minority group.

Optical high-resolution spectra of the R Coronae Borealis star V CrA at light maximum and during minimum light are discussed. Abundance analysis confirms previous results showing that V CrA has the composition of the small subclass of R Coronae Borealis (RCB) stars know as 'minority' RCBs, i.e., the Si/Fe and S/Fe ratios are 100 times their solar values. A notable novel result for RCBs is the detection of the 1-0 Swan system $^{12}C^{13}C$ bandhead indicating that ^{13}C is abundant: spectrum synthesis shows that $^{12}C/^{13}C$ is about 3 to 4. Absorption line profiles are variable at maximum light with some lines showing evidence of splitting by about 10 km s^{-1}. A spectrum obtained as the star was recovering from a deep minimum shows the presence of cool C_2 molecules with a rotational temperature of about 1200K, a temperature suggestive of gas in which carbon is condensing into soot. The presence of rapidly outflowing gas is shown by blue-shifted absorption components of the Na I D and K I 7698 Åresonance lines.

(N. Kameswara Rao & D. L. Lambert)*

Stellar winds of R CrB stars

The spectra at maximum light of warmer R CrB stars (e.g. R CrB, RY Sgr, SU Tau, etc.) show that there is high velocity wind blowing from these stars, particularly the line profiles of O I 7774 A triplet. It also appears that the wind starts mildly from the surface and gets accelerated and heated as it moves outward. The authors have also been monitoring several spectral lines that would be sensitive to the wind behaviour with time. It has been seen in R CrB spectrum the Fe I lines which have higher Landau g factor show variations in strength with time whereas the other lines with same excitation and log gf are stable suggesting possible connection between stellar wind and surface magnetic fields. These aspects are being investigated in RCrB stars with high resolution spectra obtained at 2.7 m telescope at McDonald and 2.3 m telescope at VBT, Kavalur.

(N. Kameswara Rao & D. L. Lambert)*

Fluorine in R Coronae Borealis and extreme helium stars

Neutral fluorine lines are identified in the optical spectra of several R Coronae Borealis stars (RCBs) at maximum light. These lines provide the first measurement of the fluorine abundance in these stars. Fluorine is enriched in some RCBs by factors of 800 to 8000 relative to its likely initial abundance. The over abundances of fluorine are evidence for the syn-

thesis of fluorine. These results are discussed in the light of the scenario that RCBs are formed by accretion of an He white dwarf by a C-O white dwarf. Sakurai's object (V4334 Sgr), a final He-shell flash product, shows no detectable neutral fluorine lines.

(G. Pandey, D. L. Lambert & N. Kameswara Rao)*

Hydrogen deficient binaries

High resolution spectra of hydrogen deficient binaries Upsilon Sgr and KS Per are being accumulated towards a comprehensive study of these systems. Observations from both the 2.3 m telescope at VBT, Kavalur and McDonald's 2.7 m telesope are being obtained.

(N. Kameswara Rao, G. Pandey & D. L. Lambert)*

Dust production around hydrogen deficient stars

It is known that some WC type hot Wolf-Rayet binaries make dust periodically at certain epochs (mostly near periastron) in their orbits. These systems are similar to R CrB stars as they are rich in carbon and helium and are hydrogen deficient. The dust is thought to be produced due to collision of winds from both stars although the process of dust production is not understood. The authors plan to investigate the phenomenon by observing the cool gas that would lead to dust production in such a binary system at the time of periastron passage. The WC star WR 19a was predicted to have such an event in November 2007- January 2008. The presence of cool gas is expected to be observable through the molecular bands of C2, and CN from the lowest energy states (Phillips system of C2). On a few occasions, during November 2007–January 2008, the authors have obtained observations with the high resolution spectrometer Phoenix on 8 m Gemini south. These observations are being reduced and analysed.

(N. Kameswara Rao, D. L. Lambert, A. Gacia-Hernandez*, K. Hinkle*)*

FIP effect in evolved stars

It has been found that some RV Tauri stars and semi-regular variables do surface abundance anomalies related to the first ionization potential of the element. It was suggested that such abundance anomalies are a result of stellar winds controlled by surface magnetic fields. A systematic high resolution spectroscopic survey of RV Tauri and semi-regular variables in the T_{eff} range of 5000 – 4000 K have been undertaken with VBT and Harlan Smith telescopes' echelle spectrometers. Observations of several variables have been obtained in this program. Reductions and analysis are being carried out.

(N. Kameswara Rao, B. E. Reddy & D. L. Lambert)*

21-cm HI emission around evolved stars using GMRT-Y CVn

To understand the mass-loss phenomenon in AGB stars it is proposed to observe the 21-cm emission from circumstellar ejecta around AGB stars using the GMRT. GMRT provides large collecting area and high spatial and spectral resolutions necessary to map the H I emitting gas around these stars. Y CVn, a carbon variable star on AGB has been observed with GMRT during august 2007. Clouds of HI with mild expansion have been detected around the star coincident with the position of detached (from the star) cool infrared dust shell earlier detected by ISO and IRAS. H I clouds seemed to appear only on one side of the star and are very asymmetrically distributed. The data are being analysed. The authors hope to systematically study several AGB stars with the GMRT to arrive at the mass-loss rates and have obtained more time with GMRT for such studies.

(N. Kameswara Rao, Rekesh Mohan & D. L. Lambert)*

High resolution spectroscopy of hot, short period variables

Spectral line profile variations in hot early type short period variables e.g. HR 3117, beta Cephei type variables, Gamma Peg are being studied using VBT Echelle. HR 3117 appears to be a zeta Oph type system.

(K. Jayakumar, N. Kameswara Rao & R. Sriram)

UX Arietis

UX Ari is a bright member of the RS Canum Venaticorum binaries, and is one of the few objects for which extensive *BV* photometry exists. The light variability seen in RS CVn binaries has been attributed to starspots, analogues to sunspots, present on the active component of the binary system. One would expect the starspots, which are presumed to be cooler than the surrounding photosphere, to make the star redder at fainter visual magnitudes, and in

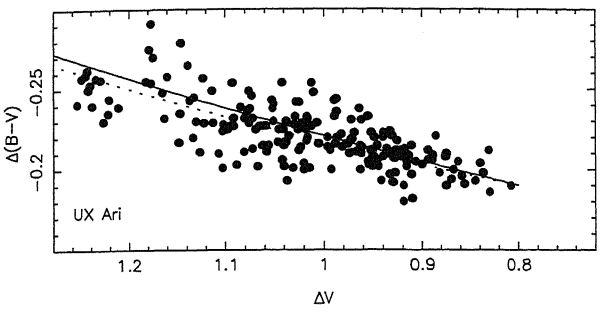


Figure 12: Plot of $\Delta(B-V)$ of UX Ari with respect to 62 Ari against the corresponding ΔV obtained at VBO over 1984–2008 with the 34-cm telescope. The solid and dotted lines represent the expected variation of the composite colour as the brightness of UX Ari varies. In the former case the $(B-V)$ of the active star was assumed to be 1.08 throughout, and in the latter case it was assumed to vary linearly from 1.08 to 1.10 when ΔV varied from 0.8 to 1.25.

fact most RS CVn systems behave as such. The behaviour of UX Ari is unusual in this respect: it becomes bluer when fainter. The $\Delta(B-V)$ against the corresponding ΔV obtained at VBO over 1984–2008 is shown in Figure 12. All the observations were obtained with the same photomultiplier tube and the same set of filters. The figure clearly shows that UX Ari becomes bluer as it becomes fainter, as reported in the literature by several investigators. The $(B-V)$ colour varied by about 0.07 mag when the V magnitude varied by about 0.45. The components of the UX Ari binary system have been assigned the spectral types G5 V and K0 IV. The modelling of BV photometry based on estimation of most probable relative brightnesses of the components shows that UX Ari becomes bluer when it becomes fainter because of the increase in the fractional contribution to the total light in the blue spectral region by the hotter star and that there is no need to invoke the occurrence of faculae, as done by several investigators, to account for the unusual colour variation observed in UX Ari.

(M. J. Rosario, A. V. Raveendran & M. V. Mekkaden)

2.3 Low mass stars

Polarized stars

Literature study suggests that the dust induced polarization is more for late L-spectral classes. Similar kind of trend is also observed in optical and near infrared colours, the objects become more redder for late L-spectral class. Astonishingly, there is a certain jump from late L-dwarfs (J-K$\sim$ 2.0) to early T-dwarfs (J-K$\sim$0.0), within a temperature difference of only 200 K. This is an unresolved L$\longrightarrow$T transition problem. It has been a mystery for long time that how the dusty atmosphere becomes dust free within such short range of temperature. Along with effective temperature, it is considered gravity as the second parameter in the rapid disappearance of condensates in L$\longrightarrow$T transition. The authors computed the expected polarization for different temperature and gravity near L$\longrightarrow$T transition at the central wavelength of R, I , J filters and in R-band as well. Analysis show that polarization has a strong dependence on gravity. The change in polarization due to a difference in gravity by 0.5 dex is nearly the same as change of polarization due the temperature difference of 100 K. For long time, it was presumed that the rapid thinning of dust cloud, which is the main cause behind the L$\longrightarrow$T transition, is due to the effect of decrease in temperature only. Then Golimowski et al. (2004) suggested that, T_{eff} is nearly constant from L7 to T4.5. Burrows et al. (2006) showed that gravity can be a second parameter for this drastic spectral change from L to T dwarf, within a small temperature range. The present polarization study at L$\longrightarrow$T transition supports this idea. The authors also found that the number density of the condensates has a strong dependence on gravity.

(M. Maiti)

Extrasolar planets: analysis of the first detected polarization

Recently, the detection of linear polarization in the blue band from an extrasolar hot giant planet HD 189733b has been reported. The observed peak amplitude of polarization is a few times of 10^{-4}, more than an order of magnitude higher than all theoretical predictions. Rayleigh scattering of H_2 and He may although give rise to a high albedo and hence a planet-star flux ratio of the order of 10^{-4} in the blue band, cannot account for the high polarization unless the planet has an unusually extended atmosphere. Therefore, it is suggested that the high polarization should be attributed to the presence of a thin cloud of sub-micron size dust grains in the upper visible atmosphere which supports the observational finding of an almost featureless transmission spectrum between 550 and 1050 nm with no indication of the expected alkaline absorption features. It is found that the polarimetry observation allows for a small eccentricity of the orbit that is predicted from the time delay of the secondary eclipse of the planet. The estimated

longitude of the ascending node is $16^o \pm 6$ which interestingly coincides with the observationally inferred location of the peak hemisphere-integrated brightness.

(Sujan Sengupta)

Extrasolar planet: polarization from a system of planets

The scattering linear polarization profile of starlight by a system of extrasolar planets has been presented. The polarization is calculated as a function of the orbital period of the outermost planet that has condensates in its atmosphere. It is shown that not only the additional asymmetry caused by the oblateness of the individual planetary surface increases the degree of polarization but also the presence of more than one planet with condensates in their atmosphere makes the polarization of the starlight significantly high. The polarization by the individual planets is calculated as a function of orbital eccentricity, inclination angle, phase angle as well as the epoch of periastron passage and the total observable polarization is calculated as a function of the phase angle of the outermost planet that contributes to the polarization. The model is applied to the extrasolar planetary system of Gl581 which has two planets that should have water condensates in their atmosphere and the third one should be condensate free.

(Sujan Sengupta)

Brown dwarfs

Recent studies have detected linear polarization in L dwarfs in the optical I band. Theoretical models have been developed to explain this polarization. These models predict higher polarization at shorter wavelengths. Linear polarization measurements of 4 brown dwarfs in R and I bands are presented. As predicted by theoretical models a higher degree of polarization in R band is found when compared to polarization in I band for two out of four of these brown dwarfs which suggest dust scattering asymmetry is caused due to oblateness. The detail theoretical models fitting the observation are also presented. One case for variability of linear polarization is found which suggest presence of randomly distributed dust clouds. Another case for the presence of circumstellar disk is also discussed.

(Malay Maiti & Sujan Sengupta)

2.4 Binary system

Plotting orbits of binary stars from the interferometric data

Speckle interferometric technique is being used to decode the diffraction-limited spatial Fourier spectrum and image features of the object, from a series of short-exposure (<20 milliarcsec) images. A large number of specklegrams of several close binary stars (separation <1 arcsec) from the southern hemisphere using the speckle interferometer have been recorded at the Cassegrain focus (f/13) of 2.34 m VBT, VBO, Kavalur, India. Pre-processing of these data followed by power spectrum analysis of a few binary stars are being carried out. The most common binary orbit periods (as estimated from their separations and typical distances) lie between 10 to 30 yrs. Thus at the present stage, a large number of binary systems have completed one or more revolutions under speckle study and speckle data alone can be sufficient to construct the orbits. An algorithm based on standard least square technique with iterative improvement of orbital parameter is being used to plot orbits of close binary stars. The noted advantage of this algorithm is that it does not require any previous knowledge of the period of the system, and hence only speckle measurements are enough to obtain the orbit. However, while plotting the orbits, other interferometric data along with speckle measurements are being considered. Information obtained from the orbits, along with some spectroscopic information will also be used to obtain radial velocity curves of the components of the systems.

(S. K. Saha & D. Takir)*

Binary stars: Am CVn system

Theoretical spectra are constructed for a pair of white dwarf stars in a short period AM CVn system to explore the observational signature probing the thermal state of the mass transferring component and the evolutionary history of the binary system. Spectra were calculated for irradiated and non-irradiated cool, low mass white dwarfs based on the TLUSTY stellar atmosphere code suitably modified. The spectra in the optical to near infrared wavelength band for the white dwarf pair are applied to the first confirmed eclipsing AM CVn system SDSS J0926+3624. For a model in which the emission from a nearly edge on accretion disk is negligible in comparison to the combined photospheric emission from the two white dwarf stars, it is shown that the ther-

mal state of the donor star can be probed at wavelengths greater than about 1.2 μm, independent of irradiation effects. In such a model, the distance of J 0926+3624 is estimated to be about 290 pc.

(Sujan Sengupta, Ronald Taam & Christofar Deloye*)*

2.5 Star clusters

On the frequency distribution of binaries in star clusters

The authors deal with the determination of the number of binaries of various separations, by calculating their birth and death rates. The birth takes place due to star capture and death occurs due to stochastic heating by passing field stars. It shows that for binaries with separation greater than 10^4 AU, the life time is less than 10^10 years and are thus unlikely to survive. The fit with observations is found to be satisfactory.

(S. Chatterjee & H. C. Bhatt)

Comparing observed and simulated globular clusters

The integrated spectra of stellar clusters depend both on stellar and dynamical evolution. A stellar cluster orbiting in the tidal field of its host galaxy loses stars, and therefore the dynamical evolution leads to a change in the stellar mass function of the cluster. Hence, the dynamical evolution changes the integrated spectrum of the cluster.

In order to investigate the dynamical influence on the integrated spectra, N-body simulations of stellar clusters are performed. The NBODY6++ code (Spurzem 1999, JCoAM 109, 407-432) is used, which contains the Cambridge stellar evolution (Hurley et al. 2001, MNRAS 323, 630-650). The BaSeL 2.0 stellar library (Lejeune et al. 1998, A&AS 130, 65-75) is used to transform the stellar parameters into spectra.

The integrated spectra calculated from such a N-body simulation depend on various parameters such as age, metallicity, initial mass, galactocentric distance. Simulation runs with different parameter combinations are performed. The resulting spectra are compared to integrated spectra of Galactic globular clusters.

Such a comparison with observed globular clusters has the potential to estimate the parameters of these objects. Preliminary results show the prospect of metallicity estimation for galactic globular clusters (see Figure 13). Work in progress. For final results more simulation runs are needed, which takes computer time.

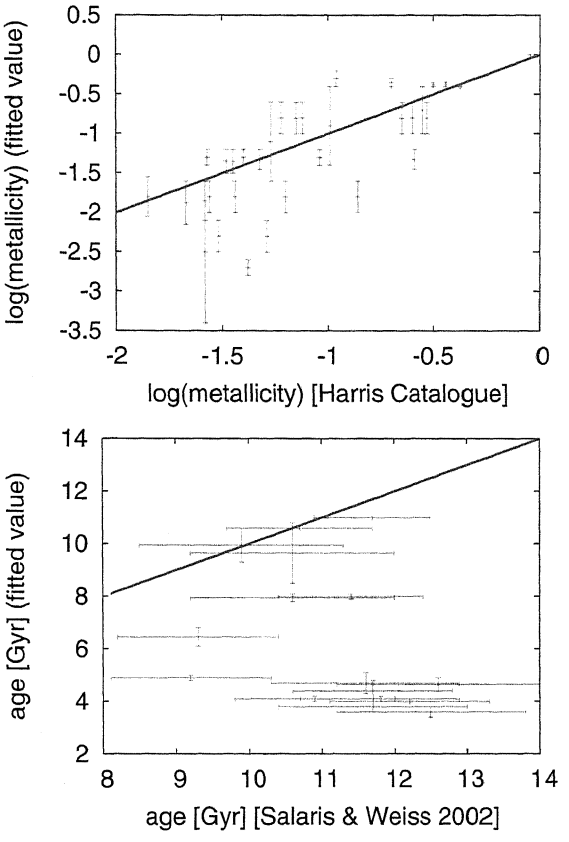


Figure 13: Preliminary results of the metallicity and age estimation of galactic globular clusters. The integrated spectra of Schiavon et al. (2005, ApJS 160, 163-175) are taken and fitted to a grid of synthetic spectra with different ages and metallicities. The metallicities and the ages of the clusters are plotted. In both plots the estimated values are plotted on the y axis, whereas the x axis shows the literature values. For the literature values, the metallicities are taken from the Harris Catalogue, and the ages are taken from Salaris & Weiss (2002, A&A 388, 492-503).

(A. Borch, R. Spurzem & J. Hurley*)*

Be phenomenon in young open clusters: Results from a survey of emission line stars

Emission-line stars in young open clusters are identified to study their properties, as a function of age, spectral type and evolutionary state. 207 open star clusters were observed using slitless spectroscopy method and 157 emission stars were identified in 42 clusters. The authors have found 54 new emission-line stars in 24 open clusters, out of which 19 clusters

are found to house emission stars for the first time. Rich clusters like NGC 7419, NGC 663, h & χ Persei, NGC 2345 are also rich in emission-line stars while other clusters contain a few emission stars. About 20% clusters harbour emission stars. The fraction of clusters housing emission stars is maximum in both the 0–10 and 20–30 Myr age bin ($\sim$ 40% each) and in the other age bins, this fraction ranges between 10% - 25%, up to 80 Myr. Most of them belong to spectral type earlier than B5, even though there are appreciable numbers of late-type emission stars. The authors have used optical colour magnitude diagram (CMD) along with Near-IR Colour-Colour diagram (NIR CCDm) to classify the emission stars into Classical Be (CBe) stars and Herbig Be (HBe) stars. Most of the emission stars in the survey belong to CBe class ($\sim$ 92%) while a few are HBe stars ($\sim$ 6%) and HAe stars ($\sim$1%). The youngest clusters to have CBe stars are IC 1590, NGC 637 and NGC 1624 (all 4 Myr old) while NGC 6756 (125-150 Myr) is the oldest cluster to have CBe stars. The CBe stars are located all along the MS in the optical CMDs of clusters of all ages, which indicates that the Be phenomenon is unlikely due to core contraction near the turn-off. Most of the clusters which contain emission stars are found in Cygnus, Perseus & Monoceros region of the Galaxy, which are locations of active star formation. The distribution of CBe stars as a function of spectral type shows peaks at B1-B2 and B6-B7 spectral types. The Be star fraction (N(Be)/N(B+Be)) is found to be less than 10% for most of the clusters and NGC 2345 is found to have the largest fraction ($\sim$ 26%). The results indicate there could be two mechanisms responsible for the CBe phenomenon. Some are born CBe stars (fast rotators), as indicated by their presence in clusters younger than 10 Myr. Some stars evolve to CBe stars, as indicated by the enhancement in the fraction of clusters with CBe stars in the 20-30 Myr age bin.

(Annapurni Subramaniam, Blesson Mathew & B. C. Bhatt)

CCD photometry of the globular cluster NGC 5466

The authors report the results of CCD V and r photometry of the globular cluster NGC 5466. The difference image analysis technique adopted in this work has resulted in accurate time-series photometry even in crowded regions of the cluster enabling us to discover five probably semi-regular variables. The authors present new photometry of three previously known eclipsing binaries and six SX Phe stars. The light curves of the RR Lyrae stars have been decomposed in their Fourier harmonics and their fundamental physical parameters have been estimated using semi-empirical calibrations. The zero-points of the metallicity, luminosity and temperature scales are discussed and Fourier results are transformed accordingly. The average iron abundance and distance to the Sun derived from individual RR Lyrae stars, indicate values of [Fe/H] = -1.91 $\pm$ 0.19 and D = 16.0 $\pm$ 0.6 kpc, or a true distance modulus of 16.02 $\pm$ 0.09 mag, for the parent cluster. These values are, respectively, in the Zinn & West metallicity scale and in agreement with recent luminosity determinations for the RR Lyrae stars in the Large Magellanic Cloud.

The MV-[Fe/H] relation has been re-calibrated as MV = +(0.18 $\pm$ 0.03)[Fe/H] + (0.85 $\pm$ 0.05) using the mean values derived by the Fourier technique on RR Lyrae stars in a family of clusters. This equation predicts MV = 0.58 mag for [Fe/H] = -1.5, in agreement with the average absolute magnitude of RR Lyrae stars calculated from several independent methods. The MV-[Fe/H] relationship and the value of [Fe/H] have implications on the age of the globular clusters when determined from the magnitude difference between the horizontal branch and the turn-off point (HB-TO method). The above results however would not imply a change in the age of NGC 5466, of 12.5 $\pm$ 0.9 Gyr, estimated from recent isochrone fitting. Based on observations collected at the Indian Astrophysical Observatory, Hanle, India.

(Sunetra Giridhar)

2.6 Nebulae

High resolution mid-IR imaging of dust in reflection nebula OH231.8+4.2

Sub-arcsec resolution, nearly diffraction limited narrow and broad band thermal images of OH231.8+4.2 taken with the 8 m Gemini telescope have been obtained. After deconvolution, the images have an unprecedented pixel limited spatial resolution of 0.09$''$ to resolve the emission distribution. The mid-IR emission peaks at the nebular core of size 1$''$ to and more extended at longer wavelengths. The SEDs of the core and the lobes show significant differences: the core shows featureless 10 μm absorption band whereas the lobes show sharp bottom end features at 10 μm; a larger opacity at the long wavelength wing of 10 μm and at 18 μm band was seen in the

core than in the lobes. The authors present one dimensional radiative transfer models for the core and the lobes and show that these differences could be accounted by the presence of amorphous alumina and crystalline enstatite respectively at the core and lobes along with the silicate dust component. The authors further report that the lobes are older than the core and the core is due to a recent mass-loss from the central Mira. From the investigation, the evolutionary nature of OH231.8+4.2 was suggested as follows: the molecular envelope, disk and the lobes were formed when the progenitor was in its 'first' AGB phase of evolution, whereas the core is due to the recent mass-loss of the progenitor which is at its 'born-again' AGB evolution caused by a late thermal pulse. Dust masses estimated from mid-IR observations and from *IRAS* fluxes show that a large amount of cold dust is present at larger distance which is unseen in mid-IR wavelengths.

(C. Muthu, S. Kwok & K. Volk*)*

Planetary Nebula NGC 6826

The authors have included the FUSE (Far Ultraviolet Spectroscopic Explorer) data along with the IUE, optical and ISO data, in the analysis of the planetary nebula NGC 6826. They have convincingly modelled have convincingly modelled the PN and demonstrated the power of modeling in not only getting the chemical abundances accurately but also the parameters of the central star (e.g. T$-eff$, log g, luminosity and distance). Though the authors could measure the FUSE spectra and also get the corresponding ORFEUS (Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer) spectra, they found that these could be used only to a limited extent. But these spectra show surprising results like the presence of absorption lines of H_2 molecule as well as the typical ISM. These are unexpected as the line of sight has very little extinction.

(R. Surendiranath & S. R. Pottasch)*

2.7 Interstellar Medium

Study of 2175 A interstellar absorption feature

The absorption feature at 2175 A is widely observed in the ISM which implies that its carrier is made of commonly available material in the ISM. The width and the extinction peak of the feature show large variation with line-of-sight (+/- 12%) indicating a large chemical dispersion in the Galaxy, however, the peak value always occurs at 2175A. It is now recognized that the interstellar grain population can include a substantial amount of ultra-small grains with PAH composition and the expected carrier of the 2175 Åfeature is a mixture of PAHs. Ultra-small grain population is also needed to reproduce the far-UV rise in the extinction curve. The observed variation in the width of the feature would result from differences in the PAH mix.

To model the extinction curve, the size distribution function introduced by Weingartner & Draine for silicate and carbonaceous grains is adopted. This includes an ultra-small grain population of size less than 100 A with PAH composition with the sum of two log-normal size distributions. The size distribution of classical graphite and silicate grains of sizes larger than 0.1μm follows the power law. Best fit model for the observed extinction curve is obtained by varying the carbon abundance as one free parameter. A model extinction curve produced for Rv = 3.1 from the program corresponds to a carbon abundance of 6×10^{-5} in the ultra-small grain composition.

(C. Muthu, G. Maheswar, C. Eswaraiah* & A. K. Pandey*)*

Time variability of absorption lines of ISM in the direction of Vela supernova remnant

High resolution spectroscopy with VBT is being carried out for several stars in the direction of the supernova remnant in Vela. Spectra of more than 30 stars have been acquired with good S/N so far to study the interaction of the stellar ejecta with ISM.

(S. Muneer & N. Kameswara Rao)

2.8 Exploding stars

Spectroscopy of novae

Spectroscopic observations of the classical novae V2467 Oph, V5558 Sgr, V709 Cas were obtained, using the HCT, during their immediate postmaximum phase, while nova V2362 Cyg was observed during its late nebular phase. Spectra of the recurrent novae T CrB, RS Oph, CI Aql and U Sco were obtained during their quiescence phase. Quite unlike other novae at quiescence, CI Aql shows the hydrogen Balmer lines in absorption.

(G. C. Anupama)

The dusty Ia supernova SN 2003 hx

The photometric and spectroscopic evolution of the highly reddened supernova SN 2003hx in NGC 2076 was studied. SN 2003hx was observed with the HCT during 8–146 days past B maximum. Template fits to the light curves indicate that the supernova reached a maximum brightness in B band on JD 245 2893 ± 1.0 with an apparent magnitude of 14.92 ± 0.01 mag. The luminosity decline rate is $\Delta m_{15}(B)$ = 1.17 ± 0.12 mag and the absolute B band magnitude is M^B_{max} = -19.20 ± 0.18 mag. Extinction due to the host galaxy is estimated as $E(B-V) \sim 0.6$. The peak bolometric luminosity indicates that $\sim 0.66\ M_\odot$ mass of ^{56}Ni was ejected by the supernova. The spectral evolution indicates the supernova to be a normal type Ia event.

(K. Misra, D. K. Sahu, G. C. Anupama & K. Pandey*)*

The hypernova SN 2007ru: adding to the diversity of Ic SNe

The spectral evolution of the type Ic supernova SN 2007ru during the first 3 months show broad spectral features due to very high expansion velocity, normally seen in hypernovae. The photospheric velocity $\sim$ 8 days after explosion is found to be lower than SN 1998bw, however, at later epochs it is comparable to that of SN 1998bw and higher than other type Ic supernovae. The light curve evolution of SN 2007ru indicates a fast rise time of 8±3 days to B band maximum and post-maximum decline more rapid than other broad-line type Ic supernovae. With an absolute V magnitude of −19.10, SN 2007ru is comparable in brightness with SN 1998bw and lies at the brighter end of the observed type Ic supernovae. The mass of ^{56}Ni is estimated to be $\sim 0.4\ M_\odot$. The fast rise and decline of the light curve and the high expansion velocity suggest that SN 2007ru is an explosion with a high kinetic energy/ejecta mass ratio (E_K/M_{ej}). This adds to the diversity of type Ic supernovae.

(D. K. Sahu, M. Tanaka, G. C. Anupama, U. K. Gurugubelli & K. Nomoto*)*

The Ibn supernova SN 2006jc

The peculiar type Ib/c supernova SN 2006jc was observed with the 2m HCT during days 5–94 since B maximum. This supernova exhibited intermediate width helium emission lines, and weak hydrogen lines, in addition to the supernova features. Multiwavelength observations of this supernova have shown it to be unique in many respects. Early *SWIFT* UVOT observations indicate extremely blue UV-V colours. X-ray emission has also been observed by the *CHANDRA* satellite. On the contrary, SN 2006jc was not detected in the radio. The early X-ray emission and the UV excess are attributed to a strong interaction of the supernova ejecta with the circumstellar material (CSM). The optical spectra show a prominent blue continuum that lasts well into the onset of the nebular phase. Around 75 days since maximum, the steepness of the blue continuum had dropped, while the continuum in the red had brightened, with the overall spectrum taking a "U"-shape. The red excess had disappeared by day 128. Interestingly, the optical light curves showed a sharp decline after day 50, while the near infrared luminosities brightened during the same epoch. The near infrared magnitudes increased from $\sim$ 50 days to $\sim$ 90 days and then declined, coinciding with the increase in the red excess seen in the optical continuum. This red excess is attributed to the formation of a hot dust in the dense swept up CSM.

The He I line widths indicate a velocity of $\sim 2200 - 3000$ km s^{-1}. A narrow P Cygni component is noticed in the He I 3889 Å line, at a velocity of $\sim$ 620 km s^1. A similar component could be present in the 4471 Å line also, at $\sim$ 670 km s^1. Hα is clearly detected in all the spectra. While it is seen in absorption during the early days, it evolves into an emission feature around day 18–20. The progenitor of SN 2006jc was observed to undergo an LBV-like mass loss episode, lasting about 10 days, two years prior to the supernova event. If it is assumed that the helium emission lines seen in the supernova spectra arise in the shell ejected during the LBV-like event, and this shell is helium enriched, then, the observed helium line luminosity may be used to estimate the density and mass of the shell. Assuming the helium emitting region to have a ring-like geometry, based on the observed double peaked helium line profiles, using the observed line fluxes and a distance of 25.6 Mpc, an average density in the range $(0.65-4.4) \times 10^{10}$ cm^{-3} is estimated for a shell with a velocity of 500 km s^{-1}. The corresponding mass range for this shell is $M_{He} = 0.001-0.007\ M_\odot$. If the shell velocity is assumed to be 2500 km s^{-1}, corresponding to the observed widths of the helium emission lines, then the average density lies in the range $(0.6-4.0) \times 10^9$ cm^{-3} and the corresponding mass range is $M_{He} = 0.01 - 0.07\ M_\odot$. The density estimates are consistent with that required for formation

of hot dust.

(G. C. Anupama, D. K. Sahu, U. K. Gurugubelli, T. P. Prabhu, N. Tominaga, M. Tanaka* & K. Nomoto*)*

2.9 The local group

Estimating the depth of the small and large Magellanic clouds using red clump stars

An estimation of depth in the central regions of the disk of Magellanic Clouds using red clump stars as proxies is presented. The data are taken from the BVI photometric data of OGLE II (Optical Gravitational Lensing Experiment) survey. Also, the VI photometric data from MCPS (Magellanic Cloud Photometric Survey) are taken for the SMC disk depth estimation. The observed dispersion in the magnitude distribution of red clump stars is used to estimate the depth. The intrinsic width of red clump stars due to population effects, internal reddening in the regions of Magellanic Clouds, photometric errors and the depth effect contributes to the dispersion in the magnitude distribution. Deconvolving these effects, the resultant dispersion in LMC has a range from 0.05 mag to 0.4 mag (corresponding to a depth (front to back) of 1 kpc to 9 kpc). In the SMC, the dispersion ranges from 0.15 mag to 0.38 mag (corresponding to a depth (front to back) of 4 Kpc to 10 kpc). Both in LMC and SMC, the statistical significance of the value of dispersion corresponding to depth is more than 5Δ, where Δ is the error associated with the estimation of dispersion. The thickness profile of LMC indicates a flaring in the central bar region, which is asymmetric with respect to the optical centre of the LMC. The LMC thickness profile indicates a disturbed structure in the central regions. In SMC, an increase in depth is seen near the optical centre.

(Annapurni Subramaniam & Smitha Subramanian)

Survey of the outer regions of the LMC

The project titled 'Outer limits Survey' was accepted as a survey proposal and was awarded thirty nights of observing time in the Blanco 4.0m telescope at CTIO, La Serena, Chile over a period of three years. Six nights each were also allotted at the 1.0m telescope, for the same project. The fields located at 7, 9, 11 and 12.5 degrees to the north of the Large Magellanic Cloud is reduced and the analysis is in progress. The authors see a reduced disk population as it is moved outward. The age of this population is estimated to be about 8 Gyr, indicating that this is still the disk of the LMC. The authors do not detect any halo population. Detailed analysis is in progress.

(A. Subramaniam)

2.10 Active galaxies

The nuclei of high-energy peaked BL Lacs

The systematics of High-energy peaked BL Lac objects on the parsec-scale has been investigated using Very Long Baseline Interferometric Polarimetry (VLBP) of a sample of X-ray selected BL Lacertae objects. On these scales the radio morphology ("core-jet" with polarized jet components), fractional polarisation of the jets, and position angle of the core polarisation relative to the local jet direction do not differ from the radio-selected low-energy peaked BL Lacs (LBLs), but the fractional polarisation of the nuclei is systematically lower than that of the LBLs, and the magnetic fields in the nuclear jet tend to be parallel to the jet direction, similar to the trend in quasars rather than the trend in LBLs. Systematically lower values of superluminal motion suggest that the Lorentz factors in the HBL jets could be systematically lower. If these jets have helical magnetic fields due to 'winding up' of a seed field due to accretion and black hole rotation, then the relative ratio of their characteristic rotational and outflow velocities could determine the observed magnetic field geometry.

(P. Kharb, D. Gabuzda*, P. Shastri & S. Laurent-Muehleisen*)*

Study of X-ray emission from Seyfert galaxies in the framework of the Unification Scheme

Seyfert galaxies are defined as low luminosity ($M_B > -25$), radio-quiet (F_5GHz/F_B Band < 10) AGN. They are mainly classified into two classes 'Type 1' or 'Type 2' depending on the presence or absence of broad emission lines in their optical spectra, respectively. The Unification Scheme hypothesises that the two subclasses constitute the same parent population and differ only due to the inclination with respect to line-of-sight of anisotropically distributed dusty, molecular material (most probably in the form of 'torus') around the nucleus. In Seyfert galaxies, X-ray emission is believed to arise from the inner part of the accretion disk around the supermassive

black hole at the centre. The typical X-ray spectrum can be modeled as an absorbed power-law plus a Compton reflection component and an Fe Kα emission line. The Unification Scheme predicts that the soft X-ray photons from the AGN will be absorbed by the obscuring 'torus', and therefore Seyferts of type 2 for which the absorbing 'torus' is purportedly in the line of sight, should show effects of such absorption but not Seyferts of type 1 (which are purportedly pole-on). The authors are studying X-ray imaging and spectral properties of a rigorously selected sample of Seyfert galaxies using XMM-Newton and Chandra observations. The preliminary results using EPIC measurements from 2XMM-Newton Serendipitous Survey are broadly consistent with the Seyfert Unification Scheme.

(V. Singh, P. Shastri & Guido Risaliti)*

Investigation of the characteristics of the low-frequency radio emission from Seyfert galaxies

High spatial resolution radio observations of Seyfert galaxies have found the compact nuclear radio emission comprising of linear jet-like or more complex structures which are probably low-power analogues of the larger jets found in radio galaxies but perhaps distorted or stunted by the surrounding interstellar medium (ISM) of the host galaxy. However, the large scale, low surface-brightness structures have been attributed to starbursts as well. In this context, the characteristics of low frequency radio structures in Seyferts are being investigated, using the Giant Metrewave Radio Telescope.

(V. Singh, P. Shastri & Ramana Athreya)*

3 Theoretical Astrophysics and Physics

3.1 Scattering

Scattering of light by a periodic structure in the presence of randomness - Application of statistical detection test

This work involves the detection of periodicities hidden in randomness. The extended matched filter method, developed by the authors, is known to be capable of detecting hidden periodicities, even when conventional methods fail to do so. This work, further explores the strength of the method used by the authors and with the help of statistical tests, gives the bounds within which the matched filter method is capable of distinguishing extremely low amplitude periodicities, hidden behind very large randomness. The bound is found to be $(r_o/\bigwedge) \geq 0.11$, with 95 % confidence, while conventional methods are capable of detection for $(r_o/\bigwedge) \geq 0.33$, where r_o is the coherence length of the wave front, due to scattering by the random part of the inhomogeneity, this method being thus an advance over the conventional ones.

(V. C. Vani & S. Chatterjee)*

3.2 MHD

Kinematic dynamo in partially ionized plasmas

Partially ionized plasmas, by definition, occur next to the fully ionized plasmas. There are several astrophysical situations where one needs to study the dynamics of magnetic flux in partially ionized turbulent plasmas. In a partially ionized plasma the magnetic induction is subjected to the ambipolar diffusion and the Hall effect in addition to the usual resistive dissipation. The study of the kinematic dynamo in a partially ionized turbulent plasma is initiated. The Hall effect arises from the treatment of the electrons and the ions as two separate fluids and the ambipolar diffusion due to the inclusion of neutrals as the third fluid. It is shown that these nonideal effects modify the so called α effect and the turbulent diffusion coefficient β in a rather substantial way. The Hall effect may enhance or quench the dynamo action altogether. The ambipolar diffusion brings in an α which depends on the mean magnetic field. The new correlations embodying the coupling of the charged fluids and the neutral fluid appear in a decisive manner. The turbulence is necessarily magnetohydrodynamic with new spatial and time scales. The nature of the new correlations is demonstrated by taking the Alfvénic turbulence as an example.

(V. Krishan & R. T. Gangadhara)

Cylindrical Hall-MHD waves: A nonlinear solution

The exact nonlinear cylindrical solution for the waves in the incompressible Hall-Magnetohydrodynamics (HMHD), including dissipation, essentially due to the electron-neutral collisions, is obtained in a uniformly rotating weakly ionized plasma such as exists in the photospheric flux tubes. The $\omega - k$ relation of the waves, called here as Hall-MHD waves, demonstrates the dispersive nature of the waves, introduced by the Hall-effect, at large axial and radial wavenumbers. The Hall-MHD waves are in general elliptically polarized. The partially ionized plasma supports lower frequency modes, lowered by the factor δ = ratio of the ion mass density and the neutral particle mass density, as compared to the fully ionized plasma ($\delta = 1$). The relation between the velocty and the magnetic field fluctuations departs significantly from the equipartition found in the Alfvén waves. These short wavelength and arbitrarily large amplitude waves could contribute towards the heating of the solar atmosphere.

(V. Krishan & B. A. Varghese)

Magnetorotational instability in accretion disks

Accretion disks are a basic and an ubiquitous construct of nature. The authors describe their formation, briefly and qualitatively, in diverse astrophysical situations. These systems, though controlled by the gravitational forces, have embedded in them a host of magnetohydrodynamic (MHD) and plasma-physical mechanisms without which many an observed phenomena would be hard to account for. The essential role of the MHD turbulence has been well emphasized. The authors give, here, a critical review of the ways and means of generating it through the magnetorotational instability and in the process correct the erroneous premise on which the local analysis continues to be carried out. The problem is complex and the present level of its understanding leaves much that needs novel techniques to fully capture its

entire range of processes.

(V. Krishan & S. M. Mahajan)*

Spectrum of density fluctuations in the solar wind

The power spectrum of the density fluctuations in the solar wind and its relationship with the spectra of the velocity and the magnetic field fluctuations is investigated. The density fluctuations could behave as a passive scalar and be simply convected by the velocity or the magnetic field fluctuations or they could dynamically participate in the joint production mechanism of all the fluctuations. The spectrum of the density fluctuations can distinguish between these two possibilities. Further the inclusion of the Hall effect near the ion-inertial scale generates different spectra for the velocity and the magnetic fluctuations. Which spectrum would the density fluctuations, behaving as a passive scalar, follow in such a case? The answer leads to the interesting consequence that the electron density fluctuations and the ion density fluctuations have different spectra at spatial scales equal to and smaller than the ion-inertial scale. This result clearly demonstrates the two fluid picture brought in by the Hall effect.

(V. Krishan)

3.3 Radiative transfer

Study of radiative transfer equations in X-rays

Diffuse radiation field is calculated using time-independent transfer equation in plane parallel geometry using discrete space theory of radiative transfer equation in a homogeneous medium with total optical depth 1 and 5. Free-free emission and absorption as well as emission due to electron gas to be operating in the medium are assumed. The three terms n, n^2 and $(\partial n/\partial x_k)$ where n is photon phase density and $x_k = (h\nu/kT_e)$, in Kompaneets' equation and those due to free-free emission are utilized to calculate the change in the photon phase density in a hot electron gas. Two types of incident radiation are considered: (1) isotropic radiation with the modified blackbody radiation I^{MB} and (2) anisotropic radiation which is angle dependent. The emergent radiation at $\tau = 0$ and reflected radiation $\tau = \tau_{max}$ are calculated by using the diffuse radiation from the medium. The emergent and reflected radiation contain the free-free emission and emission from the hot electron gas. Kompaneets equation gives the changes in photon phase densities in different types of media . Although the initial spectrum is angle dependent, the Kompaneets' equation gives a spectrum which is angle independent due to multiple Compton scattering.

(A. Peraiah, M. Srinivasa Rao & B. A. Varghese)*

Parametric study of Compton broadening due to electron scattering

The effects of Compton broadening due to electron scattering in hot stellar atmospheres, quasars, AGN etc have been investigated. A purely electron scattering medium stratified into plane parallel with an input radiation field localized on one side of the slab is assumed. The numerical method adopted to solve the relevant radiative transfer equations is based on the discrete space theory. The solutions are obtained by considering that the electron scattering is relatively unimportant. In another case electron scattering is included and the equations are solved simultaneously.

The Comptonized spectrum depends on three parameters, the optical depth of the medium, the temperature of the thermal electrons and the viewing angle. It is shown that the Compton effect yields redshift and asymmetry in the line. The redshift and the asymmetry increase as the optical depth increases. For higher optical depth, the emergent specific intensities become completely asymmetric in the given direction.

(M. Srinivasa Rao)

Some aspects of polarized line formation in magneto-turbulent media

Observations and numerical simulations of magneto-convection show a highly variable solar magnetic field. Using a statistical approach, the authors analyze the effects of random magnetic fields on Stokes profiles of spectral lines. The micro and macro-turbulent regimes, which provide bounds for more general random fields with finite scales of variations (Frisch et al. 2006, A&A, 453, 1095) are considered. The mean Stokes parameters are obtained in the micro-turbulent regime, by first averaging the Zeeman absorption matrix $\mathbf{\Phi}$ over the probability distribution function $P(\boldsymbol{B})$ of the magnetic field and then solving the concerned radiative transfer equation. In the macro-turbulent regime, the mean solu-

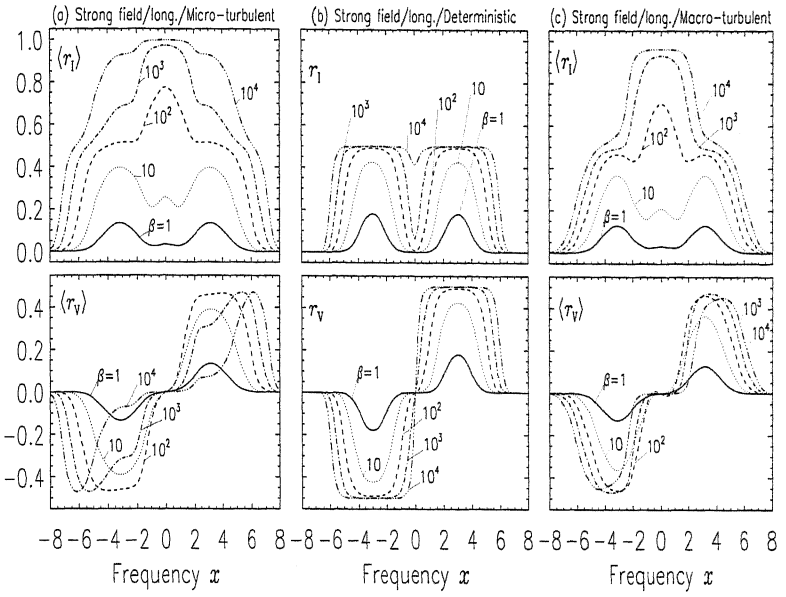


Figure 14: Strong mean field limit. Longitudinal mean field case. Dependence of intensities $\langle r_{I,V} \rangle$ on line strength β. Panel (a): micro-turbulent limit with $\Delta_Z B_0 = 3$, $\gamma_B = 1$. Panel (b): deterministic case with $\Delta_Z B = 3$. Panel (c): macro-turbulent limit with the same model as in panel (a).

tion is obtained by averaging the emergent solution over $P(\boldsymbol{B})$. It is assumed that $\boldsymbol{B}$ has a Gaussian distribution defined by its mean field $\boldsymbol{B}_0$, angular distribution and dispersion (Frisch et al. 2005, A&A, 442, 11). Fluctuations parallel and perpendicular to $\boldsymbol{B}_0$ are considered.

Spectral lines are parameterized by their strength β, which is varied over the range 1 to 10^4. A detailed comparison of micro and macro-turbulent limit with mean field solution shows that differences are important for $\beta \geq 10$. When β increases, the saturation behavior of micro-turbulent profiles are significantly different from that of mean field profiles (see e.g. Figure 14). The Stokes profiles shapes are explained in terms of the non-linear β-dependence of the Unno-Rachkovsky solution using approximate expressions for the mean absorption coefficients. These expressions when inserted in the Unno-Rachkovsky solution can predict Stokes profiles that match with the numerical result to a good approximation.

(M. Sampoorna, H. Frisch & K. N. Nagendra)*

Zeeman line formation in the solar magnetic fields : Studies with empirical probability distribution functions

Numerical simulations of magneto-convection and analysis of solar magnetograms provide probability distribution functions (PDFs) for the magnetic field strength. The effects of these PDFs on Zeeman line formation are explored. The mean Stokes parameters for a Milne-Eddington atmosphere in the limit of optically thin (micro-turbulent) and thick (macro-turbulent) magnetic structures and the dispersion around the mean profiles in the optically thick limit are calculated. Several types of PDFs are considered: (a) Voigt function and stretched exponential type PDFs for fields with fixed direction but fluctuating strength, (b) a cylindrically symmetrical power law for the angular distribution of magnetic fields with given field strength, (c) composite PDFs accounting for randomness in both strength and direction obtained by combining a Voigt function or a stretched exponential with an angular power law. For optically thin structures, explicit expressions are given for the mean values of the Zeeman absorption matrix elements. It is also described how the averaging technique for a normal Zeeman triplet may be generalized to the more common case of anomalous Zeeman splitting patterns.

It is shown that, for magnetic field rms fluctuations of the order of 6 G, consistent with observational data, Stokes I is essentially independent of the shapes of the PDFs but Stokes Q, U and V and also the dispersion around the mean values are quite sensitive to the tail behavior of the PDF (see e.g. Figure 15). It is found that Stokes V is less sensitive to the scale of the magnetic structures than Stokes Q and U. The composite PDF proposed for the fluc-

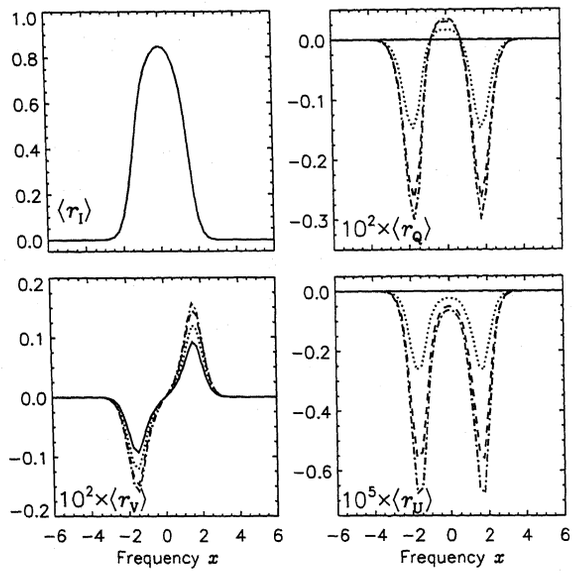


Figure 15: Stokes profiles $\langle r_{I,Q,U,V} \rangle$ for optically thin limit and for limb observation ($\mu = 0.1$). Composite PDF with asymmetric Voigt function corresponding to a mean magnetic field $y_0 = 4.5$. The line types correspond to transition field strength (between isotropic and anisotropic distribution) $y_t = \infty$ (solid), $y_t = 50$ (dotted), $y_t = 10$ (dashed), and $y_t = 5$ (dash-dotted).

tuations of the magnetic field vector has an angular distribution peaked about the vertical direction for strong fields, and is isotropically distributed for weak fields; it can be used to mimic solar surface random fields.

(M. Sampoorna, K. N. Nagendra, H. Frisch & J. O. Stenflo*)*

Hanle-Zeeman redistribution matrix : Solution of the polarized line formation problem

The linearly polarized spectrum of the Sun, known as the "second solar spectrum", contains a wealth of information about the physics of light scattering on atoms. The solution of the polarized line transfer equation is used to interpret the shapes of observed Stokes line profiles. The solar atmosphere with its magnetically active regions harbor a whole range of field strengths (milligauss to kilogauss fields). Hence a general form of the radiative transfer equation that is valid in this entire range has to be formulated and tested. Such a transfer equation has been formulated by Stenflo (1994, Solar magnetic fields, Kluwer).

In a correct treatment of non-LTE line formation in the presence of a magnetic field of arbitrary strength, one has to take into account both the Zeeman absorption matrix and partial frequency redistribution (PRD) effects. Such a treatment requires a redistribution matrix which is valid in all field strength regimes. The required "Hanle-Zeeman" redistribution matrix is only recently derived by Sampoorna et al. (2007a, ApJ, 663, 625; and 2007b, ApJ, 670, 1485). This Hanle-Zeeman redistribution matrix is incorporated into the polarized line transfer equation and the equation is solved by a two stage perturbation method (where polarization is treated as a perturbation to intensity).

To mimic a nearly 90° single scattering event, an unpolarized normally incident beam ($\mu = 0.95$ and $\varphi = 0°$) of radiation is provided at the lower boundary of a optically very thin slab, and the emergent Stokes vector at tangential direction ($\mu = 0.11$). The magnetic field is canopy like having an inclination of 90° and an azimuth of 45° with respect to the normal to the atmosphere. Different line types refer to different values of field strength parameterized through v_B, which is varied from 0.0008 to 2.5 in steps of 5. Clearly Hanle-Zeeman theory allows a smooth transition from scattering dominated weak field Hanle regime to the strong field Zeeman regime.

(M. Sampoorna, K. N. Nagendra & J. O. Stenflo)*

3.4 Pulsars

Mean-field dynamo in partially ionized plasmas

There are several astrophysical situations where one needs to study the dynamics of magnetic flux in partially ionized turbulent plasmas. In a partially ionized plasma the magnetic induction is subjected to the ambipolar diffusion and the Hall effect in addition to the usual resistive dissipation. In this work the study of the kinematic dynamo in a partially ionized turbulent plasma is initiated. The Hall effect arises from the treatment of the electrons and the ions as two separate fluids and the ambipolar diffusion due to the inclusion of neutrals as the third fluid. It is shown that these nonideal effects modify the so called α effect and the turbulent diffusion coefficient β in a rather substantial way. The Hall effect may enhance or quench the dynamo action altogether. The ambipolar diffusion brings in an α which depends on the mean magnetic field. The new correlations embodying the coupling of the charged fluids and the neutral fluid appear in a decisive manner. The turbulence is necessarily magnetohydrodynamic with new spatial and time scales. The nature of the new correlations is demonstrated by taking the

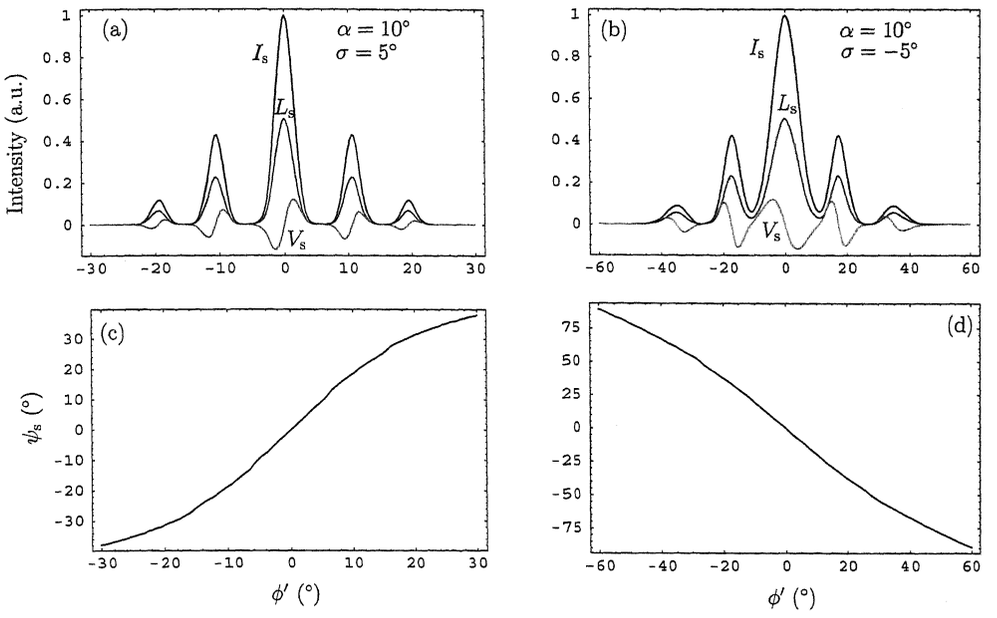


Figure 16: Simulated pulsar profiles. Chosen $P = 1$ s and $\gamma = 400$. For panels (a) and (b) are polarization profiles, and (c) and (d) are polarization angles.

Alfvénic turbulence as an example.

(V. Krishan & R. T. Gangadhara)

Polarization of radiation emitted by relativistic sources in pulsars

The polarization state of the curvature radiation in terms of the Stokes parameters is deduced. The beamed emission from relativistic sources (plasma particles or bunches) constrained to move along the curved trajectories, occurs in the direction of their velocity. To receive it, observer's line-of-sight must align with the velocity within the beaming angle $1/\gamma$, where γ is the Lorentz factor. At any given pulse phase, a distant observer tends to receive the radiation only from the specific heights or regions due to geometric restrictions.

The shape of pulsar profiles indicates that the entire polar cap does not radiate. It is only some selected regions that radiate, which may be organized into a central core emission and coaxial conal emissions, which has an overwhelming support from observations. Hence the radiating region above the polar is assumed to have a central column of emission (core) and a few coaxial conal regions of emission (cones). It is well known that the components of a pulsar profile can be decomposed into individual Gaussians by fitting one to each of the sub-pulse component. For example the components in the pulse profile of PSR 1706-16 and PSR 2351+61 are fitted with appropriate Gaussians by Kramer et al. (1994, A&A, 107, 515). When the line-of-sight crosses the emission region, it encounters a pattern in intensity due to Gaussian modulation in the azimuthal direction. Because of the Gaussian modulation in the azimuthal direction, the intensity becomes nonuniform in the polar directions too. These arguments indicate that a Gaussian like intensity modulation exists in the polar directions too. So, it is assumed that the emission region of a pulse component has an intensity modulation both in the azimuthal and polar directions.

By considering uniform and modulated emissions, a few typical pulse profiles have been simulated. The circular polarization of antisymmetric type is an intrinsic property of curvature radiation, and it survives only when there is modulation or discrete distribution in the emitting sources. Our model predicts a correlation between the polarization angle swing and antisymmetric circular polarization under each component of the pulse profile in the figure.

(R. T. Gangadhara)

3.5 Interacting galaxies

Dynamics

One of the important parameter in a galaxy collision

is the impact parameter. Numerical simulations have been performed to study the structure of the density profiles of the merger remnants of a pair of interacting galaxies for various values of the impact parameter. The initial density distribution of the galaxy corresponds to that of a polytrope of index $n = 4$. The galaxies have equal mass and they undergo merging and non-merging collisions. Merging occurs when the closest approach distance of the galaxies is less than three times its half-mass radius and the merging time increases with distance of closest approach. The density profiles of the merger remnants can be represented by the $r^{1/4}$ law in the inner parts and deviate from it in the outer regions. This is characteristic of tidally distended galaxies. In distant encounters, the galaxies remain almost intact with only negligible change in their masses and internal energies.

(P. M. S. Namboodiri)

3.6 Black holes

Entropies of dark energy and that of black holes

Effects of ambient dark energy on the long term evolution of black hole entropy have been studied. Various facets of the thermodynamic aspects suggest interesting links between these two major unsolved problems.

(C. Sivaram)

Intermediate mass black holes

Several aspects of IMBHs such as their expected luminosity, spectral nature of radiation, etc., are being studied. Scenario for their formation (especially in the early universe) including effects of dynamical friction, gravitational radiation, etc., are being considered.

(C. Sivaram & K. Arun)*

Thermal gravitational waves

High frequency gravitational waves, are often not discussed. Various sources of thermal gravitational radiation, such as newly formed compact objects, gamma ray bursts etc., are being studied. Generation of such radiation in the very early universe and the integrated thermal gravitational radiation background from all the sources also considered. Various possible methods for detection of such radiation is also a topic of study.

(C. Sivaram & K. Arun)*

Stellar dynamics around black holes

The origin of the dichotomy of radio loudness among quasars can be explained using recent findings that the mass of the central super massive black hole (SMBH) in extended radio-loud quasars is systematically a few times that of their counterparts in radio-quiet quasars. This sensitive dependence of radio jet ejection upon SMBH mass probably arises from the blockage of jets by the presence of substantial quantities of gas tidally stripped from stars by the central BH. This disruptive gas, however, will only be available around BHs with masses less than $M_c \simeq 10^8 M_\odot$, for which the tidal disruption radius lies outside the SMBH's event horizon. Consequently, it is found that AGN with $M_{BH} > M_c$ can successfully launch jets with a wide range of powers, thus producing radio-loud quasars. The great majority of jets launched by less massive BHs, however, will be truncated in the vicinity of the SMBH due to mass loading from this tidal debris. This scenario also can naturally explain the remarkable dearth of extended radio structures in quasars showing broad absorption line spectra.

(Gopal-Krishna, A. Mangalam & Wiita*)*

Binary black holes

The super massive short period black hole binary OJ287 was analyzed in detail as a precision testing ground for general relativity and alternative gravity theories. The gravitational radiation energy losses are ten orders larger than that of the binary pulsar. The orbital precession is forty degrees per period. Significant orbit shrinking is already apparent. Einstein gravity for this system is already tested to a few percent. Possible future constraints are being studied

(C. Sivaram)

3.7 Non-accelerator particle physics

Lifetime calculations of some ions of astrophysical interest

Ab initio calculations of the lifetimes of the first two metastable states of ionized Sc and Y have been performed based on the relativistic coupled cluster the-

ory. A knowledge of these quantities is necessary in certain areas of astrophysics, particularly for the study of post-main sequence evolution of the chemically peculiar stars.

(H. S. Nataraj, R. K. Chaudhuri, B. P. Das, B. K. Sahoo & D. Mukherjee*)*

Electric dipole moment of paramagnetic atoms

The relativistic coupled-cluster theory is used to arrive at some new results for the EDMs of paramagnetic atoms. By considering CP violating interactions mediated by the Higgs boson between the electron and the nucleus, a new limit for the scalar-pseudoscalar coupling constant is obtained. This limit can provide useful information about the Higgs particle and also insights into certain models of supersymmetry. In addition, high precision results for the enhancement of the atomic EDMs of rubidium and cesium compared to the EDM of the electron are also obtained. These results could be used in combination with the results of the laser cooled EDM experiments on those two atoms in future to arrive at a new limit for the electron EDM, which would have profound consequences for particle physics and cosmology.

(H. S. Nataraj, R. K. Chaudhuri, B. P. Das, B. K. Sahoo & D. Mukherjee*)*

Many-body theory of ultracold atoms

Quantum phase transitions have important applications in many areas of physics. The density matrix renormalization group method is used to study quantum phase transitions in a mixture containing two species of ultracold bosonic atoms. The previous work is extended to obtain phase separated charge density waves in addition to phase separated superfluids and Mott insulators. This was achieved in the framework of the extended Bose-Hubbard model.

(Tapan Mishra, B. P. Das, B. K. Sahoo & R. V. Pai*)*

3.8 Atomic physics

Development and applications of improved virtual orbital based multi many-body perturbation theory

Multireference Möller-Plesset (MRMP) perturbation theory is modified to use improved virtual orbitals (IVOs) and is applied to study ground state potential energy curves for isomerization and dissociation of the N_2H_2 and C_2H_4 molecules. In contrast to traditional MRMP or *multistate* multi-configuration quasi-degenerate perturbation theory (MCQDPT) where the reference functions are obtained from (often difficult to converge) state averaged multiconfiguration self-consistent field (MCSCF) methods, the reference functions in the present scheme are represented in terms of computationally efficient IVOs. This IVO-MMRMP/MCQDPT which is now a part of GAMESS package, is highly cost effective compared to the state-of-the-art Coupled Cluster method (CCM).

(R. K. Chaudhuri)

Application of relativistic coupled cluster method

The electric quadrupole and magnetic-dipole transition amplitude in $^{199}Hg^+$ and Yb, respectively, are calculated using the Fock space coupled cluster method. This is the most accurate to date and can be very important in the search of physics beyond the standard model.

The branching ratios of the allowed and forbidden radiative transitions among the first few (9) fine structure levels of O VI are studied using the relativistic coupled-cluster theory. Irregular patterns for a number of transitions within n-complexes with $n \leq 4$ has been addressed. In general, the electric quadrupole ($E2$) transition probabilities are greater in magnitude than magnetic dipole ($M1$) transition probabilities, whereas for medium atomic transition frequencies they are of the same order of magnitude. On the other hand if the transitions involved are in between two fine structure components of the same term, then the $M1$ transition probability is more probable than that of $E2$.

(R. K. Chaudhuri & C. Sur)*

4 Experimental Astronomy

4.1 High resolution astronomy

Toward a revival of Stellar Intensity Interferometry

Building on technological developments over the last 35 years, intensity interferometry now appears a feasible option by which to achieve diffraction-limited imaging over a square-kilometer synthetic aperture. Upcoming Atmospheric Cherenkov Telescope projects will consist of up to 100 telescopes, each with 100m2 of light gathering area, and distributed over $\sim 1\ km^2$. These large facilities will offer thousands of baselines from 50 m to more than 1 km and an unprecedented (u, v)-plane coverage. The revival of interest in Intensity Interferometry has recently led to the formation of a IAU working group. The authors presented various ongoing efforts towards implementing modern stellar intensity interferometry.

(S. LeBohec, C. Barbieri*, W. de Witt*, D. Dravins*, P. Feautrier*, C. Foellmi*, A. Glindemann*, J. Hall*, J. Holder*, R. Holmes*, P. Kervella*, D. Kieda*, E. Le Coarer*, S. Lipson*, S. Morel*, P. Nuñez*, A. Ofir*, E. Ribak*, S. K. Saha, M. Schoeller*, B. Zhilyaev* & H. Zinnecker*)*

Using parallel processing hardware and software for adaptive optics experiments

The essential elements of adaptive optics are wavefront sensor, wavefront error computation and control of adaptive mirrors in a such a way that the incoming aberrations are removed in real time. The cycle time required to complete one cycle of wavefront error measurement and control is only a few milliseconds. Earlier solution to this problem is to design fast dedicated hardware using multiple digital signal processors or field programmable gate arrays (FPGA). The availability of many general-purpose processors in a single chip has prompted the authors to investigate the possibility of using these low cost multi core processors for adaptive optics (AO) control. In Shack Hartmann wavefront sensor, computation of centroid in each sub-aperture is independent of the other, hence centroids of many sub-apertures can be computed simultaneously. In the same way, for mirror control, many actuator channels can be controlled simultaneously. Hence, the parallel processing hardware can be exploited for this purpose. It is found that the software required to control multiple processors are not simple. They have studied the problems of multiple threads, and related software. Distributed computing tool box of MATLAB and parallel C are being studied for implementation of parallel algorithms. Hardware and software requirements are identified and purchase procedures are started.

(V.Chinnappan & A. K. Saxena)

4.2 Space astronomy

UVIT

UVIT is one of the five science payloads on ASTROSAT: there are four X-ray telescopes, which observe in soft/hard X-rays, and UVIT observes in ultraviolet and visible bands. Three of the X-ray telescopes and UVIT can observe an object simultaneously. UVIT observes simultaneously in FarUV (1300-1800 A), NearUV(1800-3000 A), and VIS(3500-5500 A); UVIT makes images with an angular resolution of 1.8 arcseconds in a field of 29 arcmin; in addition to a selection of filters for each of the three channels, low resolution (~100) slitless spectroscopy is available for Far UV and Near UV channels. ASTROSAT aims to observe simultaneously in X-rays, UV and visible. UVIT would be used to study time variability of X-ray objects, on time scales ranging from seconds to days, in coordination with the X-ray telescopes, and would observe on its own objects like interacting galaxies, star forming galaxies, globular clusters, hot/evolved stars.

All the detector modules with a very small gap between photo-cathode and MCPs, to minimize lateral drift of photo-electron, have been completed and delivered (by Photek, UK) to Canadian Space Agency who will integrate these with the high voltage units and the control electronics to develop the full detector system. The engineering model of the high voltage units (for the detector modules) too is delivered (by MSSL, UK) to Canadian Space Agency.

Interferogram of spherical mirror taken with ZYGO interferometer in MGK Menon Space Science Laboratoryi: Interferograme in the black and white window is the display used for the alignment of the instrument with the spherical mirror under test. The coloured wavefront map is obtained by difference of two interferograms taken for the spherical mirror, and it shows the stability of the instrument is 0.029 wave PTV and 0.002 wave rms.

An engineering model of UVIT is expected to be ready for tests in the next year. The full payload is expected to be ready in the year 2009.

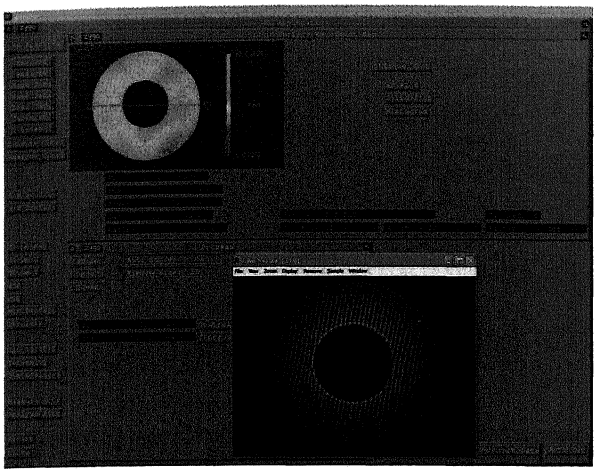


Figure 17: Interferogram of spherical mirror taken with ZYGO interferometer in MGK Menon Space Science Laboratory : Interferogram in the black and white window is the display used for the alignment of the instrument with the spherical mirror under test. The coloured wavefront map is obtained by difference of two interferograms taken for the spherical mirror, and it shows the stability of the instrument is 0.029 wave PTV and 0.002 wave rms.

Science with UVIT: Physical parameters of stars

The authors have started investigating how to derive physical parameters of stars from the observations in various filter bands that would be obtained with the proposed Ultraviolet imaging telescopes (UVIT) on ASTROSAT mission. Using the available UVIT filter transmission functions that were provided in PDR, it is investigated whether the fundamental parameters of stars T_{eff}, log g, metallicity could be obtained independently from the colours of UVIT bands. Phoenix model atmospheres and the synthesized energy distributions in the T_{eff} range 5000 to 12000 K have been used for various range of log g (5.5 to 1.0) and metallicities ranging from twice solar to 10000 times less solar. The sensitivities of the colours for these physical parameters have been investigated along with the effect of reddening (E(B-V)) on the bands. These theoretical indices are being calibrated/and checked with the archival UV observations earlier obtained with IUE satellite. It appears that metallicity effects are strong in UV region and T_{eff} cannot be uniquely be determined from UVIT colours alone. Once T_{eff} is obtained independently other physical parameters can be obtained from UVIT colours including interstellar reddening. SDSS colour R-I would be useful in arriving at T_{eff} irrespective of metallicity. The combinations of using model atmospheres and the observed spectral energy distributions with the estimated spectroscopic metallicities are being investigated for the expected UVIT colours. The work in in progress.

It has also been investigated whether the hydrogen deficient stars could be distinguished with respect to normal stars and how useful UVIT colours would be in this respect. It has been shown from synthetic colours obtained from model atmospheric energy distributions that line blanketing effects dominate the UV spectrum of hydrogen deficient stars and UVIT colours would certainly provide measurable colour differences to distinguish the hydrogen deficient stars in the T_{eff} range 9000K to 18000 K.

(N. Kameswara Rao, N. Naslim & G. Pandey)

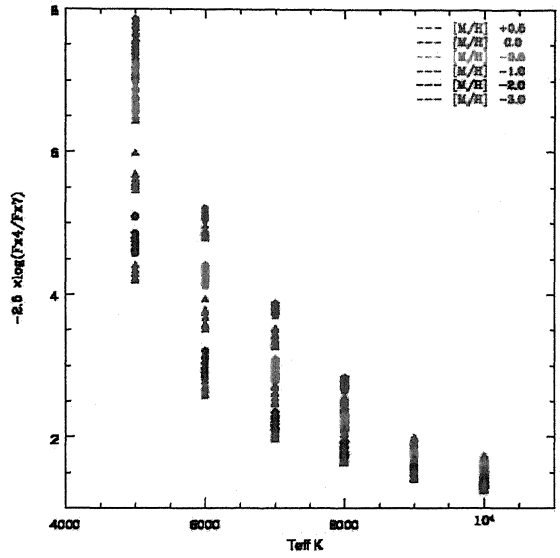


Figure 18: The plot shows UVIT colour (B3-vis1) versus T_{eff} (model). The colour corresponds to the UVIT filters centered at 2400Åand 3500 Å. The plot illustrates the sensitivity of the colour to various metallicities and log g. These colours are computed from the theoretical energy distributions using Phoenix model stellar atmospheres for various metallicities, T_{eff} and log g.

Proposed visible emission line space coronagraph

The occurrence of total solar eclipse provides observations of solar corona with minimum of scattered light in the visible and near IR part of the spectrum, but for short durations to study the intensity oscillations in the solar corona and the coronal magnetic fields. The varying sky transparency and scattered light introduce large amount of uncertainty when studying the high frequency oscillations and magnetic fields in the solar corona. Thus it becomes difficult to believe the results because of the low am-

plitude of the variations in intensity and magnetic fields have large uncertainties. Therefore a coronagraph with these instruments in space, above the earth's atmosphere will provide ideal conditions to study the existence of waves and the strength of magnetic fields. Keeping in view of the above mentioned goals the authors proposed a 20 cm coronagraph to be launched in space by ISRO and take the images of the solar corona in the green (at 530.3 nm) and red (637.4nm) emission lines with the following scientific goals.

(a). To determine the existence and nature of waves in the solar corona by studying the intensity oscillations using the emission lines, Fe xiv at 530.3 nm and Fe x at 637.4 nm, in different type of coronal structures.

(b). The simultaneously obtained images of the active regions in the 530.3 nm and 637.4 nm emission lines, representing plasma at about 1.8 MK and 1.0 MK respectively, will yield clues to the cooling processes involved in the coronal and post flare loops.

(c). High cadence observations will permit to determine the velocity pattern of CMEs (coronal mass ejections) and possibly the origin of solar wind.

(d). Information about the origin and acceleration of CMEs will help to predict space weather and help protect the space programs.

(IIA, USO-PRL, ISAC-ISRO, ARIES, RAC-TIFR)

TAUVEX

IIA is continuing the collaboration with Tel Aviv University and ISRO on the TAUVEX mission, an ultraviolet imaging observatory, which is going to be launched in early 2009.

With the launch of the Indo-Israeli collaborative project TAUVEX (Tel Aviv University UV Explorer) late this year, the astronomical community will have access to a flexible instrument for observations in the mid-UV range 135 – 400 nm. The TAUVEX Core Group at IIA is responsible for the scientific planning of the mission, development of the pipeline and science tools.

Activities over the last year included publication of a special TAUVEX-dedicated BASI issue (BASI, June 2007), with more than 10 papers on science aspects of the mission and some papers based on March 2006 Science Meeting presentations; publication of the essential mission documents on the TAUVEX webpage, such as: *Call for Letters of Intent, Data Agreement and Policies, TAUVEX Observers' Manual, Observational Windows– Straylight Analysis, Pre-Launch Call for Proposals* and *TAUVEX Detectors Guide and Safety.* With the launch date fast closing, the TAUVEX pipeline work has nearly reached the completion, and the set of science tools has been expanded since last year.

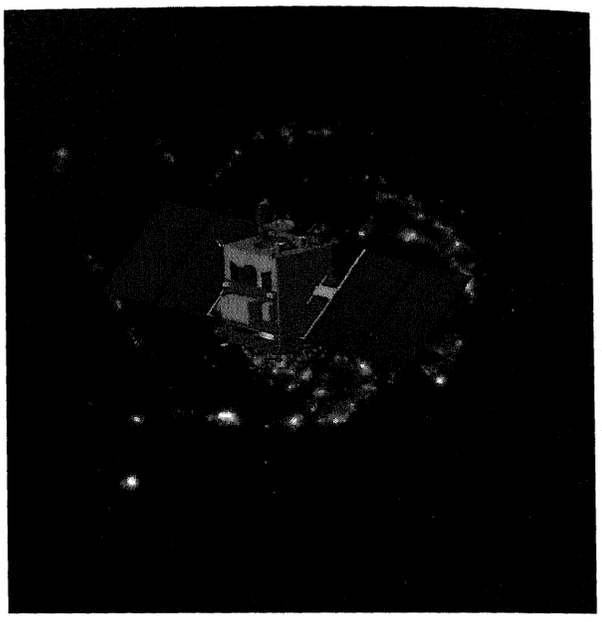


Figure 19: An image of the GSAT-4 spacecraft superimposed on a UV image of the galaxy M101 in which the regions of star birth are seen as bright knots. TAUVEX is the blue box sitting on the front panel of the satellite.

The main task now in progress is the creation of an initial 2-year observational plan, that includes the 3-month long calibration plan, and 4-month long First Science Survey. Special emphasis is being put on the detection and scientific follow up of variable sources. TAUVEX is unique amongst UV missions in obtaining real-time data, crucial for observations of variable sources early in their evolution.

(TAUVEX group)

Interstellar dust studies with TAUVEX

The authors propose to carry out studies on the properties of interstellar dust using TAUVEX. Through the multi-band TAUVEX observations, particularly with the use of filters optimized for extinction observations of the 2175Å feature, combined with optical observations and 2MASS archived data, it will be possible to derive the extinction curve from UV to near-IR for stars located in different regions and environments. The extinction curve is a sensitive indicator of the properties of the interstellar dust and, as such, will allow to trace the properties and evolution

of the interstellar dust as a function of environment.

(G. Maheswar, C. Muthu, N. V. Sujatha, G. Pandey, H. C. Bhatt, N. Kameswara Rao & J. Murthy)*

4.3 Laboratory physics

Spatial light modulator for wave-front sensing and correction

Liquid crystal spatial light modulators have been used for correcting the phase of an aberrated wave-front. A simple and efficient lab model has been demonstrated for wave-front correction. The crux of a wave-front correcting system in an adaptive optics system lies in the speed and the image quality that can be achieved. The speeds and the accuracy of wave-front representation using Zernike polynomials have been improved using a very fast method of computation. This work details the generation and correction of Zernike aberrations imposed on an image using two SLMs. Different Zernike aberrations were produced using the LC2002 Holoeye SLM. Wave-front correction is achieved by imposing phase corrections on the second SLM which is a Meadowlark Optics Hex127 SLM. Both the SLMs were characterized in terms of their nonlinearity and phase retardance for best performance. A complete study of the effect of various aberrations and the images as they look after the imposition of Zernike aberrations has been carried out. The extent of correction has been quantified and the results have been analysed. The possibility of making an efficient adaptive optics system using two SLMs is clearly indicated in the present work. Highly reliable phase correcting ability of the SLM can make the device a very good wave-front corrector in closed loop adaptive optics systems.

(A. Vyas, M. B. Roopashree & B. R. Prasad)

5 Telescopes and Observatories

5.1 Kodaikanal Observatory

Dual-beam polarimeter at Kodaikanal Tower Telescope

Calibration and characterization of a dual-beam polarimeter installed at Kodaikanal Tower Telescope (KTT) for spectropolarimetric observations is presented here. It was found that a slit width of 48 μm is optimum for the spectrograph setup at KTT and corresponding spectral resolution is 32.47 mÅ. It was demonstrated that the precision in polarization measurement can be achieved better than 0.1 % by increasing the exposure time. However, the polarimetric calibration accuracy is limited to 0.35 % for Stokes Q and U parameters and 0.2 % for Stokes V parameter, mainly due to the uncertainty in the retardance of the calibration retarder. A comparison of the magnetic field measurement between the Solar Optical Telescope (SOT) onboard Hinode and KTT for an active region was made and a good match was found after spatial smearing of Hinode/SOT measurements by 5.12 arcsec.

(K. Nagaraju, K. Sankara Subramanian, K. E. Rangarajan, K. B. Ramesh, Jagdev Singh, P. Devendran & Hariharan)*

Precision diurnal tracking drive system for the 24″ solar tower tunnel telescope at Kodaikanal

The coelostat diurnal drive motor at the 24″ Solar tower tunnel telescope developed problems due to ageing and continuous usage. The efficiency of tracking and stability became poor. Hence it was decided to replace the tracking system with a modern, state-of-the-art high tracking accuracy drive system.

After a detailed survey, it has been identified that a siemens AC synchronous servo motor with a built in incremental encoder, would replace the existing motor. This motor has a compatible Simovert master drive with a power rating on 1.1 KW, 380–480 V AC input, and an output frequency with a resolution of 0.1 rpm, for the motor speed setting.

The drive system was mounted on the control rack II, the power and the signal cables were laid from the control rack to the coelostat tower, to provide a 3 phase power to the drive system. The motor was coupled to the coelostat with a newly fabricated bracket, adopter and a pinion. The parameterization of the drive system was set for normal tracking conditions. A dedicated PC has also been installed to provide online monitoring and also enable corrections of the tracking speed.

The drive system was successfully installed and commissioned on 04 August 2007. The drive rate has been configured for precise tracking, with resultant image stability of more than 25 minutes.

(N. Sivaraj, R. Srinivasan & P. U. Kamath)

Digitization of the solar data obtained at Kodaikanal for about 100 years

Broad band images of the sun are being obtained at Kodaikanal using a 15-cm telescope with an average image size of 20-cm since 1904 using photographic emulsion. From this site spectroheliograms of the sun in the Ca-K and H-alpha lines using 30-cm objective and 650-cm focal length have been obtained, since 1907 and 1912 respectively. All these data are available on the photographic plates and films and is preserved well in dry and dust free atmosphere. These data can be used to study the long term variations on the sun; such as variation in solar irradiance with time, variation in rotation rate of the sun, differential rotation rate, solar activity with time, tilt angle of sunspots with time etc. With a view to study these the authors have designed, fabricated and installed two digitizers at Kodaikanal using the recent developed technology. It will also create a archival of large data base in digital form. The salient features of digitizer are:

- 1 m Labsphere with exit port 35 cm; Uniformity of light 1% from centre to limb; Current control to stabilize the intensity of source; Imaging lens : negligible vignetting.
- CCD camera: Format 4K×4K; Pixel size 15 micron; Read out 16 bit 4 port read out @ 500 kHz.
- Temperature of operation -10C (Cryo cooling) Room conditions: Temperature, humidity and dust controlled.

The authors have started digitizing the images of the sun and the figure shows Ca-K and broad band sample images of the sun.

(Jagdev Singh, S. Muneer, F. Gabriel, P. U. Kamath, P. Devendran, S. Pandya & F. George)

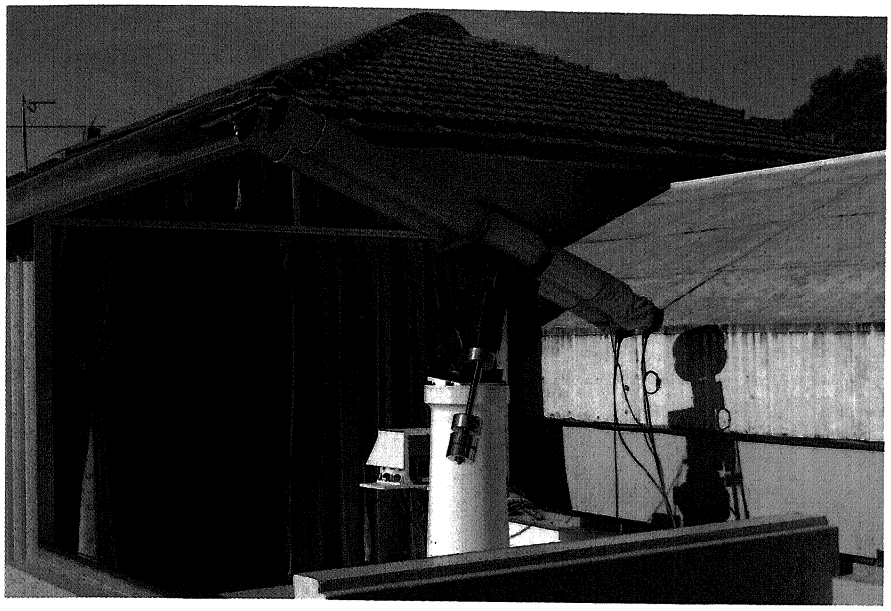


Figure 20: Twin telscope at Spectro in Kodaikanal Observatory.

Twin telescope at Kodaikanal

The authors have been obtaining the images of the sun in continuum, Ca-K and H-alpha lines using the spectrographic emulsions. The special emulsions to record the Ca-K and H-alpha images of the sun have gone out of production due to development of new technology to record digital images using CCD cameras. The digital images have advantages of large dynamic range, photometric accuracy and data analysis to derive scientific results. With a view to obtain broad band and Ca-K line images of the sun the authors have designed, fabricated and installed a TWIN telescope at Kodaikanal. The main features of this telescope are:

- Operation: Semi robotic
  Developed at VBO (IIA)
  Objective = 15 cm lens with 225 cm focal length
  Image scale:=1.25 arcsec/pixel
  Cadence : Full disk images with max spatial resolution and exposure time 0.5 sec. : 6 sec
  Active region with 2×2 binning and ROI of 5.3×5.3 arcmin : 1 sec

- Continuum image: Filter: 10 nm pass band centered around 430 nm
  2K × 2K CCD camera with 13.5 μm pixel size
  Read out 16 bit
  Read out at the rate of 1 MHz
  Temperature of operation: - 40° C (Peltier cooling)

- Ca+K line image: Filter: 0.12 nm pass band centered around 393.37 nm
  2K × 2K CCD camera with 13.5 micron pixel size
  Read out 16 bit at the rate of 1 MHz
  Temperature of operation: - 40° C (Peltier cooling)

(Jagdev singh, S. Muneer, F. Gabriel, K. Ravi, P. Anbazhagan, P.U. Kamath, R. Selvendran, P. Kumaravel, F. George, & P. Devendran)

Digitization of archived analog ionosphere and geomagnetic data of Kodaikanal observatory

Preparatory work for the task of developing a digital database of the analog ionograms and magnetograms meticulously acquired and carefully archived at Kodaikanal Observatory is at an advanced stage, and the actual work is planned to be taken up in 2008–2009 time frame. The need for such a digital base is expressed by the solar-terrestrial scientists who appreciate that the Kodaikanal database is unique for its continuity, quality and, keeping in view the location of Kodaikanal close to the magnetic equator. As such it is a valuable resource for continued studies of 'Space Weather' and 'Space Climatology' of the dip equatorial upper atmosphere and the various cou-

pling processes underlying them under the auspices of programs like CAWSES, IHY and ILWS.

(J. H. Sastri & J. V. S. V. Rao)

5.2 Vainu Bappu Observatory, Kavalur

Automated weather station at VBO

An automated weather station with the following sensors was installed in VBO campus: temperature, relative humidity, soil temperature, rain gauge, solar radiation, barometric pressure, wind direction and wind speed. The weather station is connected to a PC at the computer centre of VBT through RS 232/RS 422/485 interface and hence the weather parameters are available in real time at the observatory. Logger net, a data logger software is installed in the weather station PC and it is programmed in such a way that it collects the data every 10 minutes. The PC is in the local network and efforts are on to put the data on internet.

(S. Muneer, S. Pukalenthi, K. S. Subramanian, A. Mani, K. Ravi & P. Anbazhagan)

Hardware and software updates for the VBT Echelle CCD camera system

The echelle spectrograph in VBT was earlier working with a grade-4 EEV chip. A new camera has been built with a grade-0 CCD chip. The EEV 44-82 forms a matrix of 2048 columns and 4096 rows, with 15 × 15 micron pixels. A new low-noise preamplifier has been built and the camera system has been fine tuned for optimum performance. Software has been implemented to incorporate new features like binning, focus, and continuous acquisition to this camera system. The system has been commissioned at VBT echelle spectrograph and is working satisfactorily.

(R. Srinivasan, K. Anupama, Anbazhagan, K. Ravi & N. Kameshwara Rao)

Communication server for optical telescope

A preliminary version of communication server, which forms a part of distributed controls, is being developed, using java, under linux. The communication server is to communicate with various clients, which form virtual instruments. This scheme has the advantage that the communication with various subsystems is independent of the underlying hardware and provides flexibility in operation in the long run. Simulated clients (act as server also) for telescope, dome, metrology parameters and auto guider were developed using java. User interacts with the server, using a GUI associated with the client. Server maintains a repository or separate log to record telescope, dome, mets and auto guider data and also communication information between server and client. The client and server communicate through TCP/IP based POSIX sockets. Threads are used at both server and client ends, to synchronize the operations. The clients can be Solaris/linux/WIN-NT based clients and some of them can be run remotely over a WAN link.

Though this work is intended as a preliminary version to be tested on 75cm telescope, it could be deployed on other existing telescopes and future telescopes if required.

(V. Arumugam & A. V. Ananth)

5.3 Indian Astronomical Observatory, Hanle

Himalayan Chandra Telescope

HCT entered its fifth year of utilization from the remote control station. The regular preventive maintenance and calibration activities continued through the year to ensure trouble-free operation. In addition, the EOST engineers made a visit, spent extensive time at the site, and tested all the electromechanical aspects as well as some control system aspects. Items requiring further attention for the future were identified, which include the upgradation of the secondary drive, and telescope control computer. The primary mirror was coated early in the year 2000 and will be recoated soon.

Considerable progress was made on the HCT Echelle Spectrometer project during the current year. The concept design was finalized by the AAO-led consortium and reviewed at IIA. The mechanical engineer of AAO visited Hanle in June 2007 as a part of this review to help finalizing the concept of infrastructure needed at the site and transportation of the equipment. The concept design document has been finalized following the review, and a fresh request for proposals issued for detailed design and fabrication. This has received favourable response from vendors.

The upgradation of the HFOSC CCD camera incorporating a better detector array as well as a faster controller is being planned. The existing dewar requires attention since the temperature control is not

functional. An order was placed with UK-STFC for a 4096 × 4096 pixel CCD detector for HCT.

(HCT Team)

Micro-thermal data-acquisition system

Micro-thermal measurements are used to determine the contribution of ground level turbulence in air temperatures to the astronomical seeing. This turbulence varies on the timescale of tenths or hundredths of a second and the temperature variation on these timescales is of the order of a few milli-degrees, which is termed as micro-thermal variation. These measurements are essential in characterizing a site for an observatory. The Fried parameter r_0 is commonly used for measuring astronomical seeing at observatories. An experimental set up with data acquisition system was developed to characterize Himalayan sites.

The principle used here is to excite a balanced Wheatstone bridge by a precision reference voltage to give a null output. The bridge accommodates two differential temperature probes. The probes sense any turbulence/change in temperature through a resistance change. The bridge gives a proportional voltage, corresponding to the change in the differential temperature of the two probes. This voltage is converted through software routine, to its temperature equivalent. The system is designed to resolve a temperature change of about 3.7 milli-degrees. A user friendly GUI has been implemented using LABVIEW, which presents the acquired micro-thermal data, in an elegant graphical form.

(R. Srinivasan, G. Srinivasulu, T.P. Prabhu, K. Dhananjay, M.R. Somasekar, P. Janakiram, G. Indu, Jagadish Kumar & Y. Pavan Kumar Sarma)

Atmospheric CO_2

An indo-french collaborative project on carbon fluxes in India and Central Asia, was recently concluded, with the establishment of India's first ultra-high precision (100 ppb) atmospheric CO_2 concentration measuring laboratory at the site of the Indian Astronomical Observatory in Hanle, Ladakh. This is a fully automated laboratory and has operated without any interruptions since September, 2005, with support from the observatory's engineering staff. The second enduring accomplishment of the project has been the development of inverse modeling algorithms for the abstraction of spatio-temporal distribution of Carbon fluxes from the measured values of CO_2 concentrations by the French collaborators at the Laboratoire des Sciences du Climate et de lEnvironment of CNRS France. The Hanle site is now integrated in the global network of CO_2 concentration for joint analysis of data.

(V. K. Gaur, B. C. Bhatt & Dorje Angchuk)

HAGAR

All the seven units of the HAGAR project have been installed at Hanle and are operated simultaneously from the central control station. The tracking and pointing of the telescopes were tested individually and found to be functioning well. Later all the seven were moved synchronously from the control room at the centre. Pointing models were made for each of the telescopes using over 20 stars centred visually in an auxiliary telescope attached to the mount. After applying the pointing model parameters, the pointing accuracy is 10 arcsec.

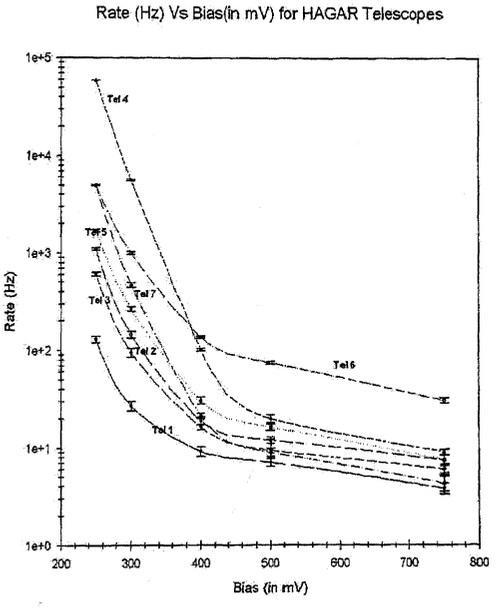


Figure 21: Rate vs Bias curves for the Royal Sum pulses.

All the photo-multiplier tubes are in place at the prime foci. The PMTs (XP2268B) at the focus of each mirror were given high voltage through cables (RG 59) from a CAEN high voltage controller module. The pulse from each photomultiplier was taken out through coaxial cable (LMR) to the base of the telescope from where it was taken to the control room at the centre of the array through another coaxial ca-

ble (RG213). The signal from each PMT is amplified by a factor of ten and sent to a monitoring channel. The high voltages are set for each PMT by adjusting the rate to a desirable value (5 KHZ).

Since each telescope has seven mirrors, it is necessary to ascertain that all the mirrors are aligned parallel to each other and to the optic axis of the telescope. This is done by the bright star scan method where the photomultiplier rates are recorded as a function of time when telescopes are kept fixed and the image of a bright star passes through the focal plane of the mirrors. For a well aligned mirror, the PMT rate is the highest when the telescope points to the star. In practice, 1 or 2 mirrors in each telescope needed realignment.

The signals from the seven PMTs for each telescope are linearly added after amplifying it by a factor of ten to take care of losses in the cables. These added pulses called the Royal Sum pulses which represent the total output from each telescope are sent to a coincidence circuit. The presence of at least 4 such pulses within a short interval of time (100 nanoseconds) signals the impact of Cerenkov radiation over at least part of the HAGAR array is termed an event. Using this as the trigger, the Data Acquisition System (DAQ) is activated. The data recorded for each event are: (a) The relative arrival time of the shower front at each mirror using the TDCs with a resolution of 0.25 nsecs, (b) The pulse height at each mirror using the ADCs, (c) The absolute event arrival time accurate to microseconds using the GPS system. The count rates of all mirrors, royal sums, etc., are recorded every second for monitoring purposes.

It is interesting to get the rate vs bias curves for the royal sum pulses and check them with the one expected from simulations. Figure 21 shows such curves for all the seven telescopes. The steeply falling part of the curve at lower biases and the relatively flat part at higher biases are due to night sky background and Cerenkov light respectively. The differences between the curves are mostly due to different reflectivities and possibly different path lengths for pulses from seven mirrors. The mean of these curves (excepting 6) was compared with what is expected from simulations for two different values of ambient light levels (night sky background). It was seen that there is a fair agreement between the expected and the observed curves, which in turn shows that the predictions of the simulations regarding the energy threshold ($\sim$ 65 GeV) may be attainable with this experimental set up at Hanle. Few more tests and calibrations are necessary before the experiment could be completely started. It is expected that the first observations will take place in summer of 2008.

(Hagar group)

Central power control system for HAGAR array

With all the 7 telescopes of the Hagar array put in synchronized operation, it is essential to switch-on and shutdown any or all telescopes during an emergency from a central command. The location of Tel-7 at the centre is the right choice for the central command, for switching on and off all telescopes, in remote operation. The individual micro-controller and drive interface units can obtain local power in local mode. In remote mode, the central power-control system can energize the selected drive and micro controller units. When any emergency arises the emergency button is pressed and the power supply to all the telescope units is shutdown. Using emergency reset button, one can restore the power supplies to the telescopes, for the normal operation.

(R. Srinivasan, Somasekar, D. Angchuk, D. Babu & Harsha)

5.4 National Large Solar Telescope

Site characterization

Work on site characterization for the National Large Solar Telescope (NLST) at the following places are being carried out:

- **Hanle**: The site characterization efforts were carried out intensively at Hanle, starting May 2007. The SDIMM (Solar Differential Image Motion Monitor) and SHABAR (SHadow BAnd Ranger) equipments obtained on lease from NSO, Tucson, were installed in the vicinity of the Hanle Chandra Telescope. Observations of wind and other meteorological parameters also continued with the weather station located nearby. Analysis of the data was carried out at Bangalore to derive the day-time seeing conditions at the height of the telescope (about 4 meters) and the deduced conditions at various heights of up to about 100 meters above the ground. The necessary reduction and inversion software were adapted and developed for the purpose by the site characterization group at Bangalore. During October

Figure 22: SDIMM and SHABAR equipment with a weather station at Hanle.

Figure 23: Sky radiometer and all sky camera installed in October, 2007.

2007, an all sky camera and a sky radiometer were procured and installed to observe the cloud cover conditions and to monitor the irradiance, the sky brightness, and the aerosol content in the atmosphere at the site. A 15 meter tower for deploying the micro thermal probes was installed by late 2007 at the Mt. Saraswati peak. This location at Hanle has been selected for characterization since the winds here, predominantly from south west, and occasionally from the north east, flow freely without any obstruction.

- **Merak**: The Merak village site located mid-

way on the Indian side of Pangong lake, has been taken up for characterization. An incursion in the lake has been selected since the winds here are laminar most of the time and flow over the water body. The wind speed remains in the range of a few meters per second, not exceeding about 10 m/s, as deduced from the weather station data of over a year so far. These conditions are expected to provide excellent day time seeing since they clear the thermal instabilities caused by ground heating.

- **Devasthal**: The meteorological data of visual cloud cover, daily maxima and minima of temperature, humidity, and wind speed were obtained for the years 1996 – 2000, and studied.

Developmental activities

The SDIMM equipment which was developed and tested at IIA, Bangalore in February 2008, was set up for a brief period at Hanle for comparative studies with the NSO equipment there. Development of basic infrastructure and logistics are in progress at Merak village and at the incursion site.

Highlights of results so far

The visual cloud cover observations for Hanle (1996 – 2003), Devasthal (1997 – 2000), and Merak (2006 – 2007), show that the total yearly sunshine hours for these are in a comparable range varying between 1850 to 2250 hours. Actual irradiance measures for Hanle and Merak show that the yearly clear sunshine (within 5 % of clear sky irradiance) duration is about 1750 hours. Irradiance measurements are to be carried out for Devasthal site.

The observations of wind speed and direction show that Hanle has moderate winds of a few meters per second in the morning hours which favour good seeing. However, the post-noon winds, most of the time from southwest and often crossing 12 to 15 m/s, are not favourable. At Merak, the wind is steady and laminar, within the range of a few m/s to within 10 m/s, and most of the time flowing over the water body. This is expected to be highly favourable for day time seeing conditions. It is observed that the winds are actually channeled between the two mountain ranges adjoining the Pangong lake.

The seeing measurements so far at Hanle show that there are significant spells of good periods at the height of the telescope especially in the morning hours. The SHABAR measurements show that at heights of 10 meters and higher above ground, the seeing is significantly better as it crosses the boundary layer caused by ground heating.

(S. P. Bagare, S. S. Hasan, A. K. Saxena, J. P. A. Samson, T. P. Prabhu, K. E. Rangarajan, R. Srinivasan, Dorje Angchuk, Mohinderpal Singh, T. G. Aditya, Rajendra B. Singh, Sangita Kumari Padhy, Ann Mary Francis, M. Sujatha, K. Ramar, Thubstan Dorje, Dorjai Tsewang, Namgyal Dorjey, Nissar Hussein, & Ugrain Khando)

5.5 CREST, Hosakote

HCT remote operation

The remote operation support for HCT proposals was continued into its fifth year. There was some relief during the current year since a good number of research trainees became available for operational support. As a return, the trainees improve their chance of getting admitted to the Ph.D. programs at different institutions across the country.

(T.P. Prabhu)

MGK Menon Space laboratory

CREST has continued to provide infrastructure support to experimental and development activities such as the activities of laser laboratory, and software development for TAUVEX. A significant development during the current year was the completion of MGK Menon Laboratory for Space Sciences.

The primary purpose of this laboratory is to have state-of-art facility to develop and test/calibrate space instruments for space-based observation platforms. This laboratory has four different classes of clean-rooms (class100000 to class100) as required by different stages of test and integration. This laboratory is designed to meet ISO standards such as ISO 14644-1 and ISO 14644-2 since contamination plays a very critical role in the performance of space-based instruments. Various contamination monitoring equipments are installed as per ISO 14644-2 standards. Molecular contamination is monitored constantly using vacuum reflectometer. Control of contamination is extremely critical as this has a direct bearing on the final performance of space instruments. All the equipment in this laboratory are clean-room compatible and adhere to the ISO standards. A small vacuum tank for component level tests has been commissioned and is operational. A large vacuum tank

Figure 24: Parliamentary committee members visiting MGK Menon laboratory

of the size 1000 mm×5000 mm has been installed for the final test and calibration of instruments prior to launch. A Fizeau interferometer with 18 reference flats have been procured and installed. Other equipments include temperature controlled quartz crystal micro balance, fume hoods, ultra clean storage facilities, ultra clean optical tables and finally test and calibration equipment.

(B. Raghavendra Prasad)

5.6 Visit of Parliamentary Committee for Science & Technology, Environment & Forest

The Parliamentary Standing Committee on Science and Technology, Environment and Forests, with the Hon'ble Shree P. G. Narayanan as its Chairman, along with 12 Hon'ble Members belonging to the Upper and Lower Houses of the Indian Parliament visited the CREST on June 25, 2007. Three officials of the Rajya Sabha Secretariat and representatives of the Department of Science & Technology accompanied them. The Director made a presentation on the activities of the Institute as well as on current initiatives and future projects, which was webcast to the IAO, Hanle. This was followed by a live demonstration of the remote operations of the 2-m.

(K. T. Rajan)

5.7 Radio Telescope, Gauribidanur

A new spectrometer at Gauribidanur observatory for radio spectral observations of the solar corona

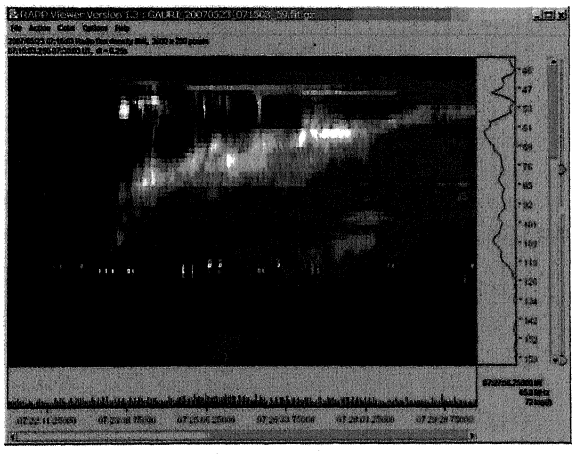


Figure 25: Dynamic spectrum of the type II radio burst of 23 May 2007 observed with the Gauribidanur-Callisto setup.

As a part of the co-ordinated radio spectral observations of the solar corona with near-identical backend receiver systems from various locations around the world during the IHY(2007) and beyond, the CALLISTO (Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory) spectrometer provided by ETH, Zurich has been set-up at the Gauribidanur observatory. A log periodic dipole (LPD) antenna system with gain $\sim$8 dB and VSWR < 2 in the frequency range 30-1100 MHz provided by the solar radio astronomy group of the institute is used as the front end. Figure 25 shows the dynamic spectrum of a type II radio burst from the solar corona observed with the above instrument on 23 May 2007. Interestingly this is the first type II event to be observed during IHY 2007 campaign which started on 19 February 2007. The abscissa and ordinate in the figure are time and frequency (MHz), respectively. The slowly drifting path of intense emission (both in time and frequency), from 96 MHz at 07:23 UT to 58 MHz at 07:28 UT, is the aforementioned type II burst. The two horizontal patches of intense emission around 101 and 46 MHz are due to radio frequency interference. The above instrument, along with other CALLISTO's at different longitudes around the world is expected to provide round-the-clock coverage of the Sun.

(R. Ramesh, C. Kathiravan & C. Monstein)*

Gauribidanur radioheliograph expansion

The Gauribidanur radioheliograph (GRH), operating in the frequency range of 30-120 MHz, obtains two-dimensional images of the solar corona over the radial distance range of $\sim$2 - 1.2 R_s in the solar atmosphere. The spatial and temporal resolution of the array in its existing configuration is $\sim 6' \times 9'$ (at 120 MHz) and $\sim$100 ms, respectively. In order to probe the solar corona in finer detail, it is planned to increase the size (thereby the sensitivity also) of the array. The target spatial resolution is $\sim 1'$ at 120 MHz. The maximum baseline length required to obtain the above resolution is about 10 km. The above work is being carried out in two phases:

- Phase 1: Installation of antennas have been started at the Gauribidanbur radio observatory to extend the present radio heliograph array from 1280 m to 2560 m along the East- West direction with an addition of 128 log periodic dipoles. In the North - South direction the array will be extended to 882m with 64 antennas. This will give a spatial resolution of $\sim 3'$ at 120 MHz. A 4096 channel digital receiver is planned for correlating the IF outputs from the antennas.
- Phase 2: In view of the limitation in the land availability, the array will be populated with antennas in an unfilled manner (i.e. group of antennas spaced 1 km apart), beyond the 3 km distance.

(Radio Astronomy group)

6 Activities at the Bangalore Campus

6.1 Photonics laboratory

1m telescope

A new secondary mirror of zerodur material is being fabricated to replace the existing secondary for the 1m telescope, at VBO Kavalur. A concave secondary with matching eccentricity has already been fabricated and tested with the existing secondary. An elliptical flat mirror was sliced which is to be used in the Hindle's sphere test set-up for testing the convex secondary. The figuring work in the zerodur convex secondary is in progress.

VHRR sun shield panels for INSAT 3D satellites

The polishing of the sunshield panels for INSAT 3D imager and sounder coolers six sets of panels along with the samples have been completed.

An MoU has been signed between ISRO and IIA for the polishing of Eutelsat W2M LNA cooler sun shield panels. These panels are conical in shape and needs special fixtures. Two machines were designed and fabricated in record time and installed at the photonics division. A new polishing strategy was adopted to polish these conical coolers. Three coolers were fabricated and delivered to ISRO. All the the coolers were polished to better than 20 Åsurface roughness value. The photograph shows the W2M conical panel mounted on the polishing machine.

Long trace profilometer: funded by BRNS, DAE

The documentation and the operation manual for the Long Trace Profilometer (LTP), version II (improved version). The instrument is waiting for shipment to RRCAT Indore.

Thin film research

The experimental facility for thin film research at the photonics division has been augmented with the addition of Scanning Electron Microscope (SEM) and Energy Dispersion Spectrometer (EDS). The aim is at developing thin films for NIR detectors and filters and space solar cells. A new design for the 10.5 m Quantum Well Infrared Photo-detector was developed with better performance and improved efficiency. A thin film has to be coated based on this design and performance evaluated. The work has already started on these lines.

Several thin film coatings like, Al, Au, Cu as well as Au-Cu alloy were done on glass substrate using the BC-300 Vacuum Coating plant at Bangalore. The topographical study was carried out with SEM and the compositional study was carried out using EDS. A simulation program is being written for the design of thin film silicon photovoltaic cell for space application.

Vacuum coating

Periodic maintenance work were carried out at the 1.2 m, 2.8 m and 2 m vacuum coating plants at VBO Kavalur and Hanle respectively.

Development of adaptive optics system

A wavefront sensor in an adaptive optics system, measures the phase changes across the telescope pupil of the incident beam. The estimate of these errors is later used in a closed loop correction system to achieve close to diffraction limited optical quality. A new wavefront sensor, based on polarization shearing interferometry technique, using two crossed Babinet Compensators (BC) has been developed and demonstrated. A single interferometric instant record containing shear in two orthogonal directions is exploited to provide complete phase informations of the wavefront under evaluation. Simulations of the interferometric records were carried out for the study of various aberrations in an optical system and the effect of noise, ripple and atmospheric turbulence in the path of the beam. The laboratory experiments using standard Shack Hartmann sensor and this polarization shearing interferometer wavefront sensors in the same optical setup were used for the purpose of establishing the method. The data reduction procedure for the estimation of wavefront errors from a single interferometric record using Fourier technique has been worked out. The actual results obtained from the laboratory experiments for both the sensors have been compared. The method provides a convenient alternative choice for wavefront sensing in an actual adaptive optics system for astronomical observation. The suitability of this new wavefront sensor and the efficacy of the method has been well established.

DALSA CA-D7 1024 T area CCD detector was used for recording of the interferometric records.

Two 15 mm square aperture with 5 degree wedge angle Babinet compensators were used.

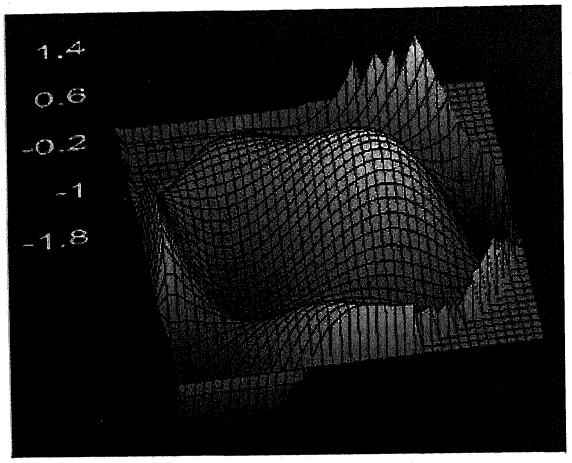


Figure 26: The 2 D wavefront error map (in lambda of the phase plate as computed from the Zernike polynomials)

In view of the National Large Solar Telescope (NLST) project, work has been initiated to build a laboratory model adaptive optics system for solar applications.

(Photonics team)

6.2 Electronics laboratory

SHABAR front-end electronics

A front-end system has been implemented to measure the Fried parameter. This system processes signals falling on a set of photodiodes, arranged in a linear array. The linear array of photodiodes is fixed to an aluminium channel. The aluminium channel is mounted on a tracking system, which always tracks the Sun. The electrical output from photodiodes, will be limited to a BW of 1-900 HZ, using active amplifiers. The output from the amplifiers are sampled in a 1 bit digitizer and correlated in a 15 channel digital correlators, corresponding to the 15 base lines. The measure of correlation, gives an estimation of the Fried parameter. The prototype of the system has been built and is under testing.

(M. S. Sundara Rajan & R. Srinivasan)

6.3 Electrical section

The following activities have been carried out at IIA Bangalore and its field stations:

- **IIA Bangalore**: Bhaskara Science Complex electrical works were checked and supervised. All electrical works for the renovated Directors office block was checked. Two numbers of 500 KVA diesel generator sets are being procured to augment the power supply.

- **Kodaikanal observatory**: Eighteen individual low tension (LT) services for laboratories and 40 office / residential services were merged into one single 22 kilo volt (KV) high tension (HT) bulk supply. The 22 KV / 440 V outdoor switching yard was designed and implemented. Indoor HT breakers and 200 KVA transformer and stabilizer were tested and commissioned. All over head lines were replaced by 2500 m. of under ground cables, improving the reliability of power supply in the campus. A total of 16 UPS units were maintained. To stop the intruding wild bisons, animal safe electric fence was erected around the campus.

- **VBO, Kavalur**: All the earth pits for Vainu Bappu Telescope were renovated. Liquid nitrogen plant was run continuously to supply LN_2 to observations. Animal safe electric fence was continuously maintained to avoid wild elephants entry into the campus.

- **CREST**: Two numbers of 320 KVA DG sets were procured. Factory testing of the units and the distribution boards were conducted. Mounting beds for DG sets and cable routings were done. MGK Menon laboratory's electrical distribution system was tested. All earth resistance values at Hosakote campus were measured and action was taken to improve them.

- **IAO, Hanle**: Two numbers of air-cooled DG sets were sent to Hanle. Performance of 30 KVA peak solar power plants at Hanle were checked and maintained. 5 KVA wind generator was erected and tested at Kavalur before dispatching them to Hanle. DG back up power was provided in head office and all the field stations.

(Electrical section staff)

6.4 Computer centre

The computer facilities at IIA are designed around an individual model where every scientist has their own computer with central facilities intended for support. As such, there are over 200 computers in the Institute, almost all are PCs. These are tied together by a CAT-6 (1 Gbps) backbone and wireless. The link to the outside internet is through an 8 Mbps connection allowing immediate access to databases around the world.

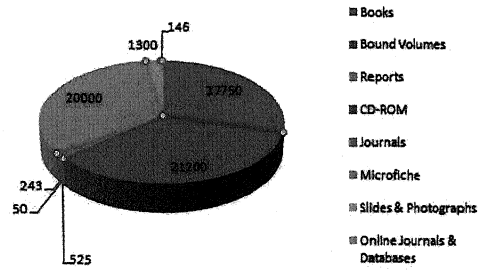
A centralized Computer Centre hosts a number of single user machines where short term visitors and students work. This Centre also hosts a 10 TB disk server which is used for storage for the large amounts of data which will soon come from IIA's space and ground-based observatories. Eight and 16 node clusters are heavily used for the needs of several groups who require access to large amounts of CPU time.

Field stations are all being upgraded to at least 2 Mbps links with a 5 Mbps link at the CREST campus. Plans are underway to link all campuses together to form a virtual campus.

(Computer division)

6.5 Library

Library continues to provide prompt, reliable and easy-to-use access to quality scholarly information regardless of the location of the information or the user. The library holdings of books and journals has increased significantly, and the below diagram depicts the library collection in physical and digital format held in the main and field station libraries currently.



A wide range of print and electronic resources were reviewed or trialed for potential acquisition, including new databases like SPIE Digital Library, Scientific American Digital and New Scientist. Electronic resources were frequently selected to supplement print holdings, identified as being in high demand and to meet the needs of users in dispersed locations like libraries in field stations.

Information service transactions continued through desk, telephone, email, photocopying and extended reference queries, as well as collection loans to other libraries and re-shelving of collection material. The process of weeding the duplicates and unused documents continues as a part of collection re-organization program. The library assisted in the delivery of bibliometric and scientometric analysis of IIA publications required for making policy decisions.

192 Interlibrary loan requests from scientific and technical staff were fulfilled during the period Apr 2007 Mar 2008. Additional journals for display are brought from RRI library regularly.

During 2007- 2008 library has accelerated its digitization program with more contents made available online. Research papers published by IIA scientists totaling 5000 pages were digitized and uploaded in the Open Access Repository of IIA. As the contents in the Open Access Repository grow the usage of the repository also keeps increasing. Wherever the full text is not uploaded due to copyright issues, the metadata is provided for those contents.

A significant upgrade was made to LIBSYS, the library's Integrated Library Management Software to

Figure 27: IIA Archival Gallery, Bangalore.

make it web enabled. This recent version of 5.7.2 has a changed JSP Web OPAC interface and it has enhanced search options through ISBN and Accession Number of the records. Also it has the extended linking facility to the Open Access Repository of IIA up to the full text of contents through multi-media linking.

Library Archives

The library archive was re-arranged with more contents in expanded space. It was re-furnished with wooden floor, AC and de-humidifier to control the moisture. The archival material in original and photocopy form are displayed chronologically in specially designed display units with appropriate illumination.

Some of the dignitaries who visited the archives were Prof. P. Balaram, Director, IISC, Dr.V.Jeyaraj, Curator, Govt. Museum, Chennai, Prof. K. Laxman, Registrar, IGNOU University, Dr. Fegley, Washington University and Mr. Michael Ludgrove, Curator, Royal House of Mysore and they recorded their remarks & appreciation of the display of archival material.

(Library staff)

7 Board of Graduate Studies

The Board of Graduate Studies opened the Ph D admissions throughout the year so that applications can be submitted throughout the year. The selection process was carried out at regular intervals. The first such admission test was conducted on 13 May 2007 followed by a second admission test on November 24 2007. Four students joined IIA in 2007 and one in January 2008. The students who qualified in the JEST written test and those who qualified for JRF through UGC, CSIR exams were also called for interviews.

The Summer Project Student Program was carried out during May 14–July 15, 2007. Applications were received from all over India and 11 students were selected. They were given a series of lectures, covering topics such as Stellar Astronomy, Astronomical Instrumentation, Solar Astronomy, Solar-Radio astronomy, Astronomical space missions, Galactic Astronomy and Cosmology. These students were exposed to IIA facilities through visits to VBO, Kavalur and CREST, Hosakote. They carried out research projects under the supervision of their guides. At the end of the project, they submitted written reports and gave an oral presentation of the project.

Four students from BITS, Pilani have undertaken their projects under the guidance of R. T. Gangadhara, Arun Mangalam, K. E. Rangarajan, and R. Ramesh. The duration of the project is from January 7, 2008 to June 15, 2008.

International Research Experience for US Graduate Students (IRES) Program: sponsored by the National Science Foundation's (NSF's) Office of the International Science and Engineering (OISE). The host institution is identified as the Indian Institute of Astrophysics (IIA) for the next three years. The main goal of the program is to expose potential researchers to an international setting at an early stage in their careers. Students who participate in the program are US citizens, currently registered and in good academic standing in an Astronomy/Astrophysics graduate program in US. The program supports four full-time summer research positions for 8 weeks. During their stay in India, participants will work on a specific research project in close collaboration with scientists from IIA. The first batch of following four students: Natalie Hinkel, Nichilas Moskovitz, Sara Sonnett and Russell Stoneback completed their projects during June–August 2007 under the supervision of R. T. Gangadhara, B. E. Reddy, R. Ramesh and D. Banerjee, respectively.

These students visited the Vainu Bappu Observatory, Kavalur during their stay. The students made presentations of their ongoing research on 26 June 2007. They also presented their projects on 27 July 2007. The program concluded on 3rd August 2007.

(V. Krishan & S. K Saha)

8 Welfare activities for SC/ST staff members

An officer at a senior level of the Institute is functioning as the liaison officer to support the welfare of the SC/ST staff members.

Housing facilities have been extended to many SC/ST staff members 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 March 31, 2008 was 350. As per the orders of the Government, 55 posts in scientific and technical categories were exempted from the reservations. Out of 295 positions, 47 members belong to SC and 29 members belong to ST, forming 15.93% and 9.83% respectively. Apart from this, reservations have been extended to OBCs and physically handicapped persons.

9 Official Language Implementation

This year has been a remarkable year of achievements in connection with the compliance of official language implementation. More emphasis has been given on Section 3/3 of official language Act, as a result cent percent circulars, tender notices, advertisements, forms, mannual, stationary items, rubber stamps, boards etc are prepared bilingual. Administrative and other reports have also been prepared bilingual. These include the Institute's annual report and other administrative reports. Letters received in Hindi are replied in Hindi. Hindi divas was celebrated in the Institute. Two Hindi workshops were conducted for Administrative staff which resulted in a great increase in Hindi correspondence. Reference books, magazines, newspaper in Hindi have been made available to the staff members. Hindi books have been bought for Rs 11161/- Hindi software(Leap Office) has been installed at the CREST campus to enable staff members to get themselves trained. The Dean (Academic) attended the 25th Joint Hindi advisory committee meeting which was held at CSIR, Science Center, Lodhi Garden, New Delhi on 11th August 2007.

10 Publications

10.1 In Journals

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Relativistic unitary coupled-cluster study of electric quadrupole moment and magnetic dipole hyperfine constants of $^{199}Hg^{+}$

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10.3 In Proceedings

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Observational review on global waves

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Some observational aspects of R Coronae Borealis stars

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Less is More? Are radiogalaxies below the Fanaroff-Riley break more polarised on Pc-scales?

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Rangarajan, K. E., Nagaraju, K., *Sankarasubramanian, K. 2007, in Proc. fifth solar polarisation workshop, ASP conf. series
Magnetic and velocity properties of G-band bright points around a pore

Safonova, M., *Rahvar, S., 2007, in Proc. IAU Symp. 238, Black Holes: From Stars to Galaxies Across the Range of Masses, Prague, Czechia. Eds. Vladimir Karas & Giorgio Matt, CUP, p. 439.
Detection of IMBHs from microlensing in globular clusters

Sastri, J. H., 2007, BASI, 35, 549
Physical processes underlying the geomagnetic effects of solar wind dynamic pressure (Pd) variations

Sastri, J. H., *Yumoto, 2007, CAWSES-India Workshop, NARL, Gadanki, 21-23 May 2007
Equatorial geomagnetic effects of sudden magnetospheric compressions

Shastri, P., 2007, BASI, 35, 249.
Active galaxies and their importance: results from imaging them in the UV

Shastri, P., 2008, in The Central Engine of Active Galactic Nuclei, eds. L. C. Ho and J.-M. Wang, ASPC, 373, 435 (San Francisco).
Different angles on active galaxies: Where are we with regard to unification?'

Sivaram, C., *Arun, K., *Samartha, C. A, 2007, in Proc. Intl Symp on cosmology and particle physics, National Taiwan University, November 2007
Phase space constraints on neutrino luminosities

*Thomas, R. M. C., Gangadhara, R. T., 2008, in Proc. first Kodai-Trieste workshop on Plasma Astrophysics, eds S. S. Hasan, R. T. Gangadhara & V. Krishan, Springer, in Press
Polarization of coherent curvature radiation in pulsars

10.4 Book

Sivaram, C., 2008, Rocket dynamics and space flight, Ane Books.

10.5 Book Edited

Hasan, S. S., Gangadhara, R. T., & Krishan, V., Eds, Astrophysics and Space Science Proc., Springer
Turbulence, Dynamos, Accretion Disks, Pulsars and Collective Processes.

10.6 Paper Presentations in Meetings

Saxena, A. K., Celine Joseph, Brijesh Tripathi *Ratna Sircar, 2007, Proc. SENNET 07 Intl conf. on sensors and related networks, December 12–14, 2007, VIT, Vellore
Scheme of a quantum well infrared photodetector (QWIP) for astronomical application

Shastri, P., presented the following papers : in the Indo-Canadian Workshop ASTROSAT Science Planning 2007, October 17-19, 2007, Canadian Space Agency, Montreal, Canada, *Investigations of Active Galaxies with UVIT/ASTROSAT*; in the First IIA-PennState Astrostatistics School, July, 2007, Vainu Bappu Observatory, Kavalur, *Challenges of Modern Empirial Astrophysics*; in the IIA Tutorial on Astronomical Image Processing Software, 21 January, 2008, IIA, Bangalore, *Aperture Synthesis of Radio Emission from Active Galaxies*; *Active Galaxies with UKIRT* in the IIA National meeting on Infrared Astronomy, 12th November 2007; *Active Galaxies with ASTROSAT: Science Questions & Targets for Observation*, ASTROSAT Science Meeting, Delhi University, 17-18 January 2008.

Singh, J., 2007, Mini-workshop on Hinode X-Ray Telescope (XRT) Data Analysis, 3-4 July, 2007
Temperature structure of coronal loops and XRT

Singh, J., 2008, 15th National Space Science Symposium, 26-29 February, 2008
Proposed visible emission line space coronagraph: Payload for ADITYA-1

Subramanian, A., ASTROSAT science meeting: Montreal, Canada, 16-19 October, 2007
Studies of stellar population in the Magellanic Clouds

Subramanian, A., ASTROSAT science meeting: Delhi University, 17-18 January, 2008

UV studies of Magellanic Clouds

Sundara Raman, K., 2007, National conference on IT & ITES, 27 September 2007, during the KNACK FETE07, Kodaikanal Christian College, Kodaikanal
Role of computers in Astrophysics

10.7 Poster Presentations in Meetings

Cowsik, R., Kamat, P. U., *Pendharkar, J. K., Prabhu,T. P., Faseehana Saleem, Srinivasan, R., Srinivasalu, R., Vishwanath, P. R., *Chintnis, V. R., *Acharya, B. S., *Gother, K. S., *Nagesh, B. K., *Upadhya, S. S., 2008, National Space Science Symposium, Feb 2008, Ooty
Status of the High Altitude Gamma Ray (HAGAR) experiment

*Indira, N. K., *Ramonet, M., Bhatt, B. C., Angchuk, D., *Gorka, S., *Royer, A., Gaur, V.K. et. al., 2007, 14th CO2 Expert Meeting, Helsinki, 10-13 September 2007
First analysis of the atmospheric CO_2 measurements at Hanle observatory, Northern India

Muthu, C., 2008, IAU Symp. 251, Organic matter in Space, 18-22 February 2008, Hongkong
A study of 2175 A absorption feature using TAUVEX: An Indo-Israeli UV mission

Rajaguru, S. P., 2008, SDO (Solar Dynamics Observatory) Science Teams Meeting 2008', Napa, CA, March 25 - 28, 2008
Systematics and artefacts in helioseismic travel times over active regions.

Singh, V., Shastri, P., 2008, Conf. Observational evidence for black holes in the Universe, S.N. Bose Centre for Basic Sciences, 10-15 February 2008, Kolkata
X-ray emission from Seyfert galaxies: Surroundings of their supermassive black holes

*Yee Yee Oo, *Phyu Phyu San, Sampoorna, M., Nagendra, K. N., *Ramachandran, G., 2007, Fifth Solar Polarization workshop (SPW5), 17-21 September 2007, Ascona, Switzerland
Scattering phase matrices for polarized radiation in the presence of external magnetic fields: the expressions for higher multipoles of scattering

11 Miscellaneous Activities

11.1 Teaching and Guidance

S. P. Bagare continued to guide students for Ph D program of the Physics Research Centre, Virudhanagar, under the Madurai Kamaraj University. Two co-guided students submitted their Ph D theses during the academic year, to MKU. Two M Sc. students of the Calicut University carried out projects on *Solar optical telescopes and instrumentation* in January 2008.

D. Banerjee is supervising a Ph D student G. Gupta (JAP) . He is also teaching fluids and plasmas for the JAP program. He delivered a series of introductory lectures on the Sun, for the summer school students at Bangalore.

S. Chatterjee gave a ten lecture course on fluid mechanics and MHD at the ARIES, Nainital, 7-16 January, 2008.

B. P. Das is guiding two students H. S. Nataraj and Tapan Mishra.

R. T. Gangadhara guided Natalie Hinkel (Arizona State University at Tempe) for her project on *Modeling the frequency evolution of pulsar profiles using curvature radiation.* She completed the project at IIA during June-August 2007 under IRES.

V. K. Gaur guided S. Mukund, from IIT Kharagpur, on a numerical experiment to obtain the impedance between two points of an elastic medium using the Helmohltz Kirchoffstime reversal theorem.
S. Giridhar & K. E. Rangarajan gave a lecture course on Stellar atmosphere and spectroscopy to the JAP students during January-April, 2008. Giridhar also guided a summer school student R. S. Keerthi Chandra for his project on *Spectroscopic Studies of RV Tau stars* during May 17-July 1, 2007.

S. S. Hasan is supervising the doctoral research of G. Vigeesh, a Ph D student at IIA.

K. M. Hiremath is guiding M. R. Lovely for her Ph.D thesis entitled *Study of dynamics and magnetic field structure of the solar convective envelope using sunspot activity.* Hiremath is also co-guiding a Hungarian student, Ivan Molnar's Ph D thesis entitled *Consideration of the magnetic fields of the solar core* on the basis of Chandrasekhar's equations. Hiremath has also guided Sumangala Rao for her first semester project entitled : *Understanding the long-term variations of the solar activity.* He also guided a student, Juanita Saroj, for her M Sc (Physics) *Revisit of the sunspot butterfly diagram*, at the American College, Madurai, for the year 2007. Hiremath taught a course in Solar Physics for M.Sc (Physics) students as a guest Faculty at the Center for Post Graduate Studies of Sri Bhagawan Mahaveer Jain College, Bangalore.

U. S. Kamath guided a summer project student P. Sangeetha from Periyar University, Salem, for a project *Analysis of optical spectra of MWC 56.*

R. Kariyappa is guiding an M Phil student of Periyar University, Salem and co-guiding S. T. Kumar, Research Scholar, Department of Physics, Bangalore University. He is also appointed as a Member of the Board of Examiners and also as an external examiner for M.Sc. (Physics: Astrophysics) exams of 2007-08 by Bangalore University.

J. P. Lancelot gave lectures at the BIFR for the Astronomy and Astrophysics course. He has submitted his thesis entitled *Wavefront sensing for adaptive optics* for Ph D degree to the Bangalore University.

Malay Maiti has completed his thesis work on *Theory and observation of brown dwarfs* under the supervision of Sujan Sengupta. He has been working on observation of optical variability (in R and I bands) from a few bright brown dwarfs. He will be submitting the thesis to Mangalore University shortly.

K. N. Nagendra guided M. Sampoorna on her Ph D thesis project titled *Polarized formation in turbulent and scattering media*, submitted to IISc. He is also guiding L. S. Anusha, for her Ph D thesis from January 1, 2008.

P. M. S. Namboodiri has been an external examiner for the M.Sc.(Astronomy) examination of Osmania University Hyderabad.

G. Pandey taught spectroscopy for the JAP course on Astronomical Techniques during the first semester, 2007. He also guided a summer project student Devika Kamath in 2007, for her project titled *Exploring the Interstellar Environments towards a B-type Supergiant.*

K. E. Rangarajan taught the course on Stellar At-

mospheres for the Ph D students of ARIES in the month of October, 2007. Ravi Kiran and Baven Dedhia from BITS were also guided by Rangarajan on the projects titled *Identification of G Band bright points* and *SHABAR data analysis* from May 16 to July 16, 2007.

B. E Reddy is guiding a student towards his Ph D. Reddy has also given a course on *Optical astronomical techniques* for IIA/JAP studenst, August - October, 2007. He has also given a series of lectures on astronomical techniques for students at ARIES, Nainital 29 Nov - 4 Dec, 2007.

P. Shastri is supervising the Ph D thesis of Veeresh Singh, IIA Ph D programme. She also supervised Vaishnavi Raghavan (BITS-Pilani), on a summer project titled *Radio-powerful Active Galaxies and Relativistic Beaming'.*

C. Sivaram taught a semester course on general relativity and cosmology, Jan-April, 2008, (25 lectures), to final year M. Sc. Students for Bangalore University, physics department.

A. Subramanian guided Sumangala Rao for her short project titled *Study of young stars in the Small Magellanic Cloud.* She is also guiding Blesson Mathew, Smitha Subramanian and B. Bhavya for their thesis projects. As part of the Graduate Outreach Program she visited the Cochin University of Science and Technology (CUSAT) and presented two talks to the MSc. students of the Physics Department in January 2008. She also coordinated the Ph D entrance exam in this centre.

K. Sundara Raman functioned as the external examiner for 11 M. Phil theses (5 in Astrophysics and 6 in Nanotechnology) and conducted viva voce examinations to these students belonging to the Mother Teresa University during May 2007. He was external examiner for the practical examinations of I and II M. Sc. Physics students as well. He also guidied 6 M. Sc. astrophysics students of the same university, for their dissertation work towards the partial fulfillment of the Master's program during February-March, 2008.

11.2 Invited and contributed talks/ lectures in meetings

G. C. Anupama gave the following talks : *The recurrent nova class of objects* - Invited review given at the International Conference "RS Ophiuchi 2006", 12–14 June 2007, at Keele, U.K.; *One year of monitoring of the 2006 outburst in optical and low radio frequencies*– Oral presentation at the International Conference "RS Ophiuchi 2006", 12–14 June 2007, at Keele, U.K.; *Gamma-Rays from Supernovae* - Invited talk at the National Symposium on Gamma-ray Astronomy 23-24 November 2007, IIA, Bangalore.

S. P. Bagare participated in the CAWSES India WG2 meeting at VSSC, Trivandrum, in December 2007and presented a talk on *The status of solar observational facilities in India.*

D. Banerjee gave a invited review at the IAU Symp. 247, Porlamar, Isla de Margarita (Venezuela) 17 - 22 September 2007. He also gave an invited oral presentation at the SOHO 20 meeting, Gent, Belgium, 27-31 August, 2007.

S. Chatterjee gave a talk titled *Scattering of light by a rough grating: detection of hidden periodicities* at the National Workshop on Light scattering methods in dust modeling, 28-29th November 2007, at the S.N.Bose Centre, Kolkata and *On the frequency distribution of binaries in star clusters* at the NSSS symposium, Ooty, on 28 February, 2008.

B. P. Das gave the following invited lectures :*Relativistic atomic structure calculations using high performance computing*, EU-India grid computing workshop, September 2007, Pune; *Atomic probes of the standard model of particle physics*, International conference on atomic, molecular & optical sciences; *Numerical computations of quantum phase transitions in cold atoms*, 3rd Garuda grid computing partners meet, March 2008, Bangalore.

V. K. Gaur gave an invited lecture on *The Earth's Changing Climate through the Aeons* at the Indian Institute of tropical Meteorology, Pune, held in November 2007, on the Foundation day. He also gave a public lecture at the Annual General Assembly of the Indian Institute of Social Sciences, on *The Universe and Us' at the SNDT University*, Mumbai held in December, 2007. Gaur also delivered the Wadia Medal Award lecture INSA, on *The Himalaya-Tibet Orogen* at the Banaras Hindu University which was held in March, 2008

S. S. Hasan gave the following talks : *New Challenges to Understanding the Structure and Dynamics of the Solar Chromosphere*, August 30, 2007, As-

tronomy Colloquium, TIFR, Mumbai; *Excitement of Modern Solar Astronomy*, September 1, 2007, Lecture series *Vistas in Astronomy*, Nehru Centre, Mumbai; *New Developments in Solar Astronomy*, November 16, 2007, University of Mauritius, Mauritius; *Science with the National Large Solar Telescope*, February 27, 2008, National Space Sciences Symposium, Ooty.

K. M. Hiremath was invited to attend the HELLAS II International Conference, Helioseismology, Asteroseismology and MHD connections, 20-24 August, 2007, Gottingen, Germany. He gave a lecture on *Estimation of magnetic flux in the solar convective envelope from the initial observations of the sunspots.*

U. S. Kamath presented a paper on the *Infrared studies of quiescent novae* at the National meeting on Infrared Astronomy, Bangalore, 12-13 November, 2007.

N. Kameswara Rao attended the International conference on *Hydrogen Deficient Stars* held at Tubingen, Germany from 16-21 September, 2007. He gave an invited keynote review on *Some observational aspects of R Coronae Borealis stars* and also chaired a session. He also attended the Indo-Canadian conference on UVIT (ASTROSAT) science, Montreal, Canada between 16-21 October, 2007 organized by the Canadian Space Agency. He was a member of the SOC and also chaired a session and gave an invited talk on *Hot evolved stars in the Galaxy, globular cluster and other galaxies.* N. K. Rao presented an invited talk on *Science with IIA archives* in the National Workshop on Preserving National Heritage' held at IIA between 21-22 January, 2008.

V. Krishan was invited to give the following talks : *Spectrum of Density Fluctuations in the Solar Wind* during the 4th annual convention of AOGS, (July 31-August 2007) Bangkok, Thailand; *Magnetorotational instability in accretion disks, Solar wind spectra, Kinematic dynamo in partially ionized plasma* during First Kodai-Trieste Workshop on Plasma Astrophysics.

A. Mangalam presented the following talks : *Constraints on Dynamo Action* at First Kodai-Trieste Workshop in Astrophysical Plasmas, 27 August - 7 September 2007 at the Kodaikanal observatory ; *Quasar radio loudness dichotomy and Masses of the Black holes* at *Measuring the spin and mass of Black holes, 18 - 21 December 2007, IUCAA, Pune.*

K. N. Nagendra gave an invited talk entitled *Numerical methods in polarized line formation theory* on 18th September 2007, at the 5th international workshop on Solar Polarization (SPW5) held at Ascona, Switzerland, during 17 - 21 September 2007.

H. S. Nataraj gave an invited talk on *Search for the electric dipole moment of the electron using cold atoms* in the Indo-French Workshop for Young Scientists on Lasers, Quantum Optics and Bio-physics, held during October 29-November 2, 2007, in CNRS campus, Gif-sur-Yvette, near Paris, France.

G. Pandey attended the national meeting on infrared astronomy, 12-13 November, 2007 at Bangalore, and gave a talk on *Measuring fluorine abundance of disk and halo red giants using infrared HF vibration-rotation transitions.*

T. P. Prabhu gave the following invited talks : *Future of optical astronomy in India*, ARIES, Nainital, 26 April 2007; *Star forming regions in the local universe*, Meeting on Infrared Astronomy IIA, Bangalore, 12 May 2007; *Star formation in galaxies*, BASE, Bangalore, 22 May 2007; *Observational facilities in India*, MPIBFR, Bangalore, 17 November 2007; *Observational facilities in India*, BASE, Bangalore, 18 November 2007; *Multiwavelength astronomy from Hanle: National Symposium on Gamma Ray Astronomy*, IIA, Bangalore, 23 November 2007; *Indian Astronomical Observatory, Hanle - Site and facilities* Institute for Astronomy, University of Tokyo, 17 December 2007; *Himalayan Chandra Telescope: Facilities and Science*, 18 December 2007; *Observational facilities in India*, MPIBFR, Bangalore, 21 February 2008; Galaxies (in Kannada), Government High School, Madivala, 29 February 2008

S. P. Rajaguru gave an invited talk on *Magnetic Effects in Helioseismic Signature* at the 'SDO (Solar Dynamics Observatory) Science Teams Meeting 2008', at Napa, CA, USA organized by the Stanford Solar Group, during March 25 - 28, 2008.
M. Safonova attended the 2nd Kolkata conference on 'Observational Evidence for Black Holes in the Universe, 2008, 10-15 Feb., Kolkata. *IMBHs in globular clusters and their detection through microlensing.*

S. K. Saha gave the following invited talk: *Diffraction-limited imaging with single telescope*, at the Institute of Radio Physics & Electronics, Calcutta University, Calcutta, on 13 September, 2007; *Activities at IIA* to the students attended at the National gamma ray

telescope' workshop at IIA, on 23 November, 2007; *Astronomical imaging: conventional versus unconventional* delivered at the symposium of Optical Society of India, on 19 December, 2007, at the Tezpur University, Assam.

M. Sampoorna presented a contributed talks on *Scattering polarization in moderately strong solar magnetic field : The theory of Hanle-Zeeman scattering*, at the fifth international workshop on solar polarization (SPW5) held in Ascona, Switzerland, during September 17-21, 2007.

P. Shastri gave the following invited talks: Yale Center for Astronomy and Astrophysics, Yale University, USA, titled *The AGN Unification Paradigm: Some Empirical Tests*, 16 October, 2007; MIT Kavli Institute, Cambridge, USA, titled *Different Angles on AGN: Some Empirical Tests of the Unification Paradigm*, 22 October, 2007; High Energy Astrophysics Division, Harvard-Smithsonian Center for Astrophysics, Cambridge, USA, titled *Different Angles on AGN: Some Empirical Tests of the Unification Paradigm*, 24 October, 2007; Department of Astronomy, University of California, Berkeley, USA, titled *Different Angles on AGN: Some Empirical Tests of the Unification Paradigm*, 22 October, 2007.

C. Sivaram gave the following invited talks : *Probability of probing new physics in gamma-ray observations* at National Symposium on Gamma Ray Astronomy, November 2007; *The sun in the universe*, at IHY workshop, Kodaikanal, December 2007; *Fifty years of the space age*, valedictory talk at science forum festival, Christ College, October 2007.

K. R. Subramanian gave two invited talks on the radio emission processes in the First Asia Pacific School on IHY, at Kodaikanal.

Sujan Sengupta gave the following talks : *Atmosphere of Brown Dwarfs* : May 2007 at Department of Physics, National Tsing Hua University, Hsinchu, Taiwan; *Polarization - A Potential Tool to Probe Substellar Mass Objects* : January 07, 2008 at CRAL, ENS, Lyon, France; *Polarization - A Potential Tool to Probe Brown Dwarfs and Exoplanets* : January 15, 2008 at Institute of Astronomy, ETH, Zurich, Switzerland; *Polarization - A Potential Tool to Probe Brown Dwarfs and Exoplanets* : February 29, 2008 at Institute of Astronomy and Astrophysics, Academia Sinica, Taipei, Taiwan; *Polarization probes the dusty atmosphere of brown dwarfs* : March 28, 2008 at National Central University, Jhongli City, Taiwan.

P. R. Vishwanath gave a talk on *High Energy Gamma Ray Astronomy* at the Astrophysics Department, University of Delhi, Delhi, 24 September 2007 and another talk on *Gamma Ray Astronomy with HAGAR* at the Winter meeting on Astroparticle Physics, Darjeeling, 18-19 December, 2008.

11.3 Attendance in meetings

G. C. Anupama attended the International Conference on RS Ophiuchi 2006, 12–14 June 2007, at Keele, U.K. She also attended the Virtual Observatory Workshop at IUCAA, Pune and was a member of the SOC; National Symposium on Gamma-ray Astronomy 23-24 November 2007, IIA, Bangalore; National Workshop on Preserving the scientific heritage, 21-22 January, 2008, IIA, Bangalore and was a member of the LOC.

S. P. Bagare attended the Hinode XRT workshop at IIA, Bangalore in July 2007; CAWSES India WG2 meeting at VSSC, Trivandrum, in Dec 2007; National Workshop on Preserving our Scientific Heritage at IIA Bangalore in January 2008; Gamma Ray meeting at IIA in 2008.

B. P. Das attended the following conferences : EU-India grid computing workshop, September 2007, Pune ; International conference on atomic, molecular & optical Sciences and High Peformance Computing, January 2008, Kolkata.

G. R. Gupta attended the national symposium on Gamma Ray Astronomy held at IIA, Bangalore on 23-24 November, 2007. He also attended the RAS National Astronomy Meeting 2008 held at Queen's University, Belfast on 31st March - 4th April 2008.

S. S. Hasan attended the Asia Oceania Geosciences Society (AOGS), July 30 - August 4, 2007, Bangkok, Thailand; International Astronomical Union, Symposium 247, 17-21 September, 2007, Porlamar, Isla de Margarita, Venezuela.

K. M. Hiremath attended the *Mini-workshop on Hinode X-ray telescope*, held at IIA, Bangalore, 3-4, July, 2007 and the *National Symposium on Gamma Ray Astronomy*, held at IIA, Bangalore, 23-24, Nov, 2007.

U. S. Kamath attended the National meeting on Infrared Astronomy, Bangalore, November 12-13, 2007.

N. Kameswara Rao attended the International conference on *Hydrogen Deficient Stars* held at Tubingen, Germany from 16-21 September 2007. He also attended the Indo-Canadian conference on UVIT (ASTROSAT) science, Canada between 16-21 October 2007 organized by the Canadian Space Agency. He was a member of the SOC and also chaired a session and gave an invited talk on *UVIT observations of Hydrogen deficient stars.* N. K. Rao also attended the National Workshop on Preserving National Heritage held at IIA between 21-22 January 2008.

V. Krishan attended the 4th annual convention of AOGS, (July 31-August 2007) Bangkok, Thailand and the First Kodai-Trieste Workshop on Plasma Astrophysics.

C. Muthu attended the IAU Symposium 25 on Organic Matter in Space, 2008, 18-22 February, 2008, Hongkong.

K. N. Nagendra participated and presented an invited talk and a poster at the 5th Solar polarization workshop (SPW5) held at Ascona, Switzerland, during 17 - 21 September 2007.

G. Pandey attended the conference on Hydrogen-Deficient Stars, September 17 - 21, 2007, Tuebingen, Germany.

T. P. Prabhu attended the following meetings : National Meeting on Infrared Astronomy, IIA, 12-13 May 2007 ; National Symposium on Gamma-Ray Astronomy, IIA, 22-23 November 2007 ; First Subaru Conference on Panoramic Views of Galaxy Formation and Evolution, Hayama, Japan, 11-16 December 2007.

M. Safonova attended the 2nd Kolkata conference on Observational Evidence for Black Holes in the Universe, 2008, 10-15 Feb., Kolkata; The IIA–Penn State Astrostatistics School, 2007, 2-7 July, VBO, Kavalur and was part of the organizing comittee; Virtual Observatory Workshop, 2007, October 15 - 19, IUCAA, Pune.

S. K. Saha attended meeting on JEST-2008 preparation, 14 September, 2007, S. N. Bose Institute of Basic Sciences, Kolkata; Symposium of Optical Society of India, during 17-20 December, 2007, Tezpur University, Assam; National gamma ray telescope workshop at IIA, on 23rd November, 2007.

M. Sampoorna participated and presented a contributed talk and a poster in the 5th Solar Polarization Workshop held in Ascona, Switzerland, during September 17 – 21, 2007.

J. H. Sastri participated in the CAWSES-India Workshop held at NARL, Gadanki, during 21-23 May 2007. He also participated in the National Space Science Symposium (NSSS-2008) held at Radio Astronomy Center, TIFR, Ooty, during 26-29 February 2008.

P. Shastri attended the Indo-Canadian Workshop ASTROSAT Science Planning 2007, October 17-19, 2007, Canadian Space Agency, Montreal, Canada; The First IIA-PennState Astrostatistics School, July, 2007, Vainu Bappu Observatory, Kavalur; National meeting on Universalizing the Universe, April 4, 2008; National meeting on Infrared Astronomy, November 12-13, 2007, IIA, Bangalore.

J. Singh attended the mini-workshop on Hinode X-Ray Telescope (XRT) Data Analysis, 3-4 July, 2007 and the 15th National Space Science Symposium, 26-29 February, 2008

A. Subramanian attended the ASTROSAT science meeting at Montreal, Canada 16-19 October 2007; Delhi University 17-18 January 2008

K. R. Subramanian attended the First Asia Pacific School on IHY, 10-22 December, 2007 at Kodaikanal.

Veeresh Singh participated in a conference on *Measuring spin and mass of black holes* held at IUCAA, Pune, 18-20th December 2007. He also participated in a conference on *Observational Evidence for Black Holes in the Universe* organized by S.N. Bose National Centre for Basic Sciences Kolkata, during 10-15th February 2008.

L. Yeswanth attended the Mini-workshop on Hinode X-Ray Telescope (XRT) Data Analysis at IIA, Bangalore, during July 3-4 2007.

11.4 Visits

G. C. Anupama visited the University of Tokyo during 2007 October 31–November 18.

D. Banerjee visited Armagh Observatory, U. K for three weeks during September 2007, under the Royal

Society- British Council joint project grant.

B. C. Bhatt visited TIFR, Mumbai during Sept. 5-26, 2007 for work and discussions on their research work with his collaborators at Deptt. of Astronomy & Astrophysics. He also gave a seminar at TIFR, Mumbai on Sept. 11, 2007 on *IAO-Hanle-Ladakh: 2-m HCT and high altitude field laboratory for science.* He also visited IAO, Leh/Hanle-Ladakh during 22-31 October, 2008, for searching the probable higher sites in and around Hanle-Changthang, suitable for future large telescopes.

B. P. Das visited several institutions and gave the following seminars and talks : Indian Institute of Science Education and Research, Pune, September 2007 *Parity violation in atoms and unification of fundamental forces*; Institute of Physics, Bhubaneswar, December, 2007, *Quantum phase transitions in ultracold atoms*; University of Pune, March 2008, *Quantum phase transitions in ultracold atoms*; Centre for the development of advanced computing, Pune, March 2008.

R. T. Gangadhara visited NCRA (TIFR), Pune during 10-18, January, 2008.

G. R. Gupta visited the Max Planck Institute for solar system research, Lindau, Germany for three weeks during 24 August 2007 – 14 September 2007 under the DAAD-DST project. He also visited Armagh observatory, UK for 5 weeks during 23 March – 28 April 2008 under the Royal Society -British Council Joint project.

S. S. Hasan visited the following institutes : April 29 – May 14 & September 9 – 16, 2007: Kiepenheuer Institute, Freiburg, Germany ; May 15 -June 4, 2007: Harvard Smithsonian Center for Astrophysics, Cambridge, U.S.A.; August 26 – Sept 1, 2007, TIFR, Mumbai; November 14 – 17, 2007; University of Mauritius, Mauritius.

J. Javaraiah visited the University of California, Los Angeles (UCLA), U.S.A. (during 2003 -08) and worked for the Mt. Wilson solar photographic archive digitization and analysis project. This is in collaboration with Roger K. Ulrich.

N. Kameswara Rao spent three months visiting McDonald observatory, University of Texas, Austin working on hydrogen deficient stars and other evolved stars including observing with 2.7 meter Harlan Smith telescope. He visited the Institute Pierre Simon Laplace, Service D'Aeronimie, Paris, France for three days in April 2007 regarding the collaborative project on asteroseismology with Milena Matric. He also visited Pune and GMRT for conducting observations of 21-cm HI around evolved stars from 7th- 9th August 2007; Pune, IUCAA, 8-9th October for a meeting on ASTROSAT science committee. University of Delhi for participating and giving an invited talk at ASTROSAT Science conference 17-19 january 2008 and gave an invited talk on *Measuring metallicity parameters of stars using UVIT filters.*

K. N. Nagendra visited Instituto Ricerche Solari Locarno (IRSOL) at Locarno, Switzerland for nearly three weeks in September - October 2007, to continue the collaboration with M. Bianda and J. O. Stenflo; Visited a technical school SUPSI at Lugano, Switzerland for discussions with the scientists, during visit to Locarno; Visited Observatoire de la Côte d'Azur at Nice, France for one month in October - November 2007, to continue the collaboration with H. Frisch.

H. S. Nataraj visited various laboratories in Institut d'Optique and Laboratoire Kastler Brossel (LKB) laboratories in the physics department of ENS in Paris during Oct. 29 - Nov. 2, 2007.

T. P. Prabhu visited Japan for two weeks in December 2007 through the INSA-JSPS exchange program on Core Collapse Supernovae. He attended the first Subaru Conference on Panoramic Views of Galaxy Formation and Evolution during the first week, and presented a poster paper on Himalayan Sites for Future Facilities in Astronomy. He visited different observatories and instrumentation groups involved in the supernova project, and also gave two talks at the Univesity of Tokyo.

B. E. Reddy visited ARIES, Nainital: 29, Nov - 4 Dec, 2007 and also went as a visiting fellow, Feb 18 - 29 March 2008, McDonald Observatory and University of Texas, Austin, USA.

M. Sampoorna visited Observatoire de la Côte d'Azur at Nice, France for two months in August - September and October - November 2007, to continue the collaboration with H. Frisch ; visited Instituto Ricerche Solari Locarno (IRSOL) at Locarno, Switzerland for nearly three weeks in September - October 2007, to continue the collaboration with M. Bianda and J. O. Stenflo ; visited a technical school SUPSI at

Lugano, Switzerland during her visit to IRSOL for discussions.

P. Shastri visited Yale Center for Astronomy and Astrophysics, Yale University, USA, 15-16 October, 2007; Kavli Institute, Massachussetts Institute of Technology, Cambridge, USA, 22 October, 2007; High Energy Astrophysics Division, Harvard-Smithsonian Center for Astrophysics, Cambridge, USA, 23-24 October, 2007; Department of Astronomy, University of California, Berkeley, USA, 24-25 October, 2007.

Sujan Sengupta visited on sabattical leave, the Theoretical Institute for Advanced Research on Astrophysics at Hsinchu, Taiwan for one year (May 01, 2007- April 30, 2008). He also visited CRAL-ENS, Lyon, France : January 01 - January 18, 2008 for collaboration with France Allard and Issabelle Baraffe. He visited Institute of Astronomy, ETH, Zurich, Switzerland from January 13 - January 16, 2008 for collaboration with Svetlana Berdyugina.

11.5 Involvement with scientific community

G. C. Anupama is the PI of the INSA-JSPS project "Physics of core collapse supernovae"; Editor of the Bulletin of the Astronomical Society of India since 2004 March; Member of the review committee for the project Virtual Observatory India - The Next Generation; Member of the Subject Expert Committee on Physical and Mathematical Sciences for technical evaluation of proposals received under Women Scientist Scheme – (WOS-A).

D. Banerjee received a three year joint research grant for collaborative research between Armagh Observatory, U.K. and Indian Institute of Astrophysics (Bilateral program between Royal Society London and the British Council India). D. Banerjee is the P. I. from India and J. G. Doyle is the P.I. from U. K. principal investigator of joint two year project grant under DST- DAAD (Indo-German bilateral program).

H. C. Bhatt served as chairman, SOC of the ASI and co-convener, special plenary session on *Space Astronomy* at the NSSS-2008.

S. S. Hasan is on the Editorial Board of Solar Physics and the Journal of Astrophysics and Astronomy. Hasan is the Principal investigator of a DST-DAAD International Programme with the Kiepenheuer Institute, Freiburg, Germany on "Dynamics and Heating of the Magnetized Chromosphere"; He is also a member of the IHY International Steering Committee, which has the responsibility of overseeing the operations within IHY. Hasan is on the Membership of the following National Bodies : Chairman, Governing Council, Visheshwara Technological Museum, Bangalore; Governing Body, IUCAA, Pune; Governing Council, ARIES, Nainital; Board of Management, Centre of Theoretical Physics, Jamia Millia Islamia University, Delhi; Governing Council, Poorna Prajna Institute of Scientific Research, Bangalore Governing Body, National Council of Science Museums, Ministry of Culture, Government of India.

R. Kariyappa continues to be a council member for "Karnataka State Council for Science & Technology", Karnataka Government, Indian Institute of Science, Bangalore, for a period of 3-years (2004 - 2007). He continues to serve as co-investigator for SOLARNET Space Mission Project under CNRS, France. He also continues to be as a "Mail-in-Reviewer for NASA" to review three research proposals which have been submitted to NASA for funding.

K. N. Nagendra continued to hold the position of Visiting Professor at the Observatory of Nice, France, for the 14th consecutive year; Continuing for the fifth year as a technical specialist, and collaborator in a major French CNRS project organized to be conducted at Observatory of Nice, and Observatory of Meudon, in France; Re-elected in August 2003 as a Member of the Scientific Organizing Committee of the IAU Commission-36 on Theory of Stellar Atmospheres, for the block period 2006 – 2009, and continuing in that capacity. K.N. Nagendra served as a member of the SOC of the 5th Solar polarization workshop (SPW5) that was held at Ascona, Switzerland, during 17 - 21 September 2007. He is one of the editors for the proceedings of this meeting.

S. K. Saha continues to be the member of the Editorial Board, Asian Journal of Physics. He continues to be the 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', Instruments Research & Development Establishment (IRDE), Defence Research & Development Organisation (DRDO), Dehra Dun, India.

J. H. Sastri served as a Member of the Scientific Advisory Committee of Space Physics Laboratory

(SPL) of VSSC/ISRO, Trivandrum; National Science Steering Committee of CAWSES-India program funded by DOS/ISRO, and also served as a Co-chair of the Working Group 2 (WG2) for 'Space Weather: Science and Applications" of the program; He also served as a member of the editorial board of the Indian Journal of Radio and Space Physics, NISCAIR, New Delhi.

P. Shastri is a Member of the IAU Organising Committee, Division X - Commission 40 - Radio Astronomy (2006-2009). She is also a member of the Board of Studies, Physics Department, St. Agnes College, Mangalore, Karnataka and Member, ASI SOC, 2007-2009.

C. Sivaram brought out four more issues of the Astrobiology Newsletter, 2007 – 2008. He was paper-setter and examiners for Astrophysics for the M.Sc. final exam of Bangalore university. He guided four project students for short term (3 month) projects at IIA. He Supervised the M. Phil dissertation on *Radiation effects in the Solar System on small objects.* Sivaram also refereed several papers, examiner of a Ph D thesis, and evaluation reports of various projects (during the course of the year). He was also the director of the course on *Space Dynamics and Astrophysics* for the second year in succession. Intercollegiate course held during September 2007 – April 2008 and for undergraduate science and engineering students, sponsored by ISRO.

A. Subramanian is the councilor of the ASI for the triennium 2007–2009. She is also member of the expert committee on Physical and Mathematical Sciences for the Women Scientist Scheme of the DST (till June 2007).

11.6 International recognitions

Since 1991, *S. S. Hasan* is an Associate of the Harvard College Observatory, Cambridge, U.S.A.

R. Kariyappa was selected for *Marquis Who's Who in Science and Engineering*, 10th Anniversary (2008-2009) edn, USA.

M. Sampoorna was selected by DST (India), DFG (Deutsche Forschungsgemeinschaft, Germany), and Lindau Foundation for the DST-DFG Award to participate in the 58th Meeting of Nobel Laureates with students/ young researchers to be held on 29th June – 4th July 2008 at Lindau.

The paper entitled *OJ287: New testing Ground for General Relativity and Beyond*, by *C. Sivaram* was awarded Honourable Mention at the 2008 essay competition of the Gravity Research Foundation, Massachusetts (USA).

The paper titled *On the Magneto-convective origin of Light Bridges observed with Hinode* by *P. Sreejith, K. Nagaraju, K., Sankarasubramanian, K. E. Rangarajan* has bagged the first prize of Rs.10,000/- at the Ooty NSSS meeting held in Feb. 2008.

Sujan Sengupta was awarded a visiting associate research fellowship by Theoretical Institute for Advanced Research on Astrophysics of Academia Sinica, Institute for Astronomy and Astrophysics, Taipei, Taiwan.

12 Public Outreach

12.1 Popular talks

S. P. Bagare gave popular lectures on *What is space and why go there ?* at the Cambridge School, Bangalore and on *Introduction to the Physics of the Sun,* at the Nehru Planetarium, in July 2007. He gave a lecture on *Importance of total solar eclipse observations* at the Birla Institute in Bangalore in October 2007.

R. T. Gangadhara gave a seminar on *Radio Pulsars* at Kuvempu University, Shimoga, 6 April 2007.

K. M. Hiremath delivered a lecture on *Physics of the solar interior and sunspot cycle* and interacted with the college teachers of Bangalore Association for Science Education, JN Planetarium, Bangalore, 6th July, 2007. He was also invited to give a lecture at the *State level Seminar on Astrophysics* (22 Sept 2007, Basaweshwara Science College, Bagalkot, Karnataka, India, Hiremath gave a lecture on *The Solar Interior* and interacted with the college teachers and the students.

A. Mangalam gave several lectures on fundamentals of astrophysics to graduate students and research trainees during their orientation program, August 2007. A. Mangalam is a part of the Research Education Advancement Program (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. A. Mangalam taught a semester long course on *Classical Mechanics* with several problem solving sessions. A. Mangalam gave the following talks:*Geometry of space time* to college students at the IIA auditorium, February 29, 2008; *Brighter than a trillion suns: Black holes and Quasars* to school students at the IIA auditorium on February 1, 2008.

C. Muthu gave an invited talk on 5 October, 2007 at the Marudhar Kesari Jain College, Vaniyambadi, titled *Astronomy: why should one care about it ?*

K. N. Nagendra gave a talk given at IIA, on *Radiative Transfer* for a group of mathematics students and faculty of Aurora College, Hyderabad, who visited IIA on 29th Feb 2008.

M. Safonova gave the following popular talks at Burdwan Raj College, Kolkata, February 18, 2008 titled *Astronomy in India - Sky is the limit* at Burdwan Raj College, Kolkata, February 18, 2008; *Light on dark: seeing Dark Matter through gravitational telescopes*, RRI Journal Club, November 2007;*Gravitational lensing*, Lecture during the Summer Course for college students at J.N. Planetarium, May 2007 and during the weekend interactive course, February 2008.

P. Shastri gave the following popular talks : *Galaxies and their Blackholes*, Bangalore Planetarium, on 31 May, 2007; *Galaxies in the Universe*, Physics Department, St. Agnes College, Mangalore, on 13 Sept. 2007. *Galaxies and their Blackholes*, Bangalore Science Forum, National College, Basavanagudi, Bangalore on 5 December, 2007, and in Centre for Learning, Varadenahalli, Magadi Taluk, Karnataka, on 13 March, 2008. *Harnessing Gravity: Shining Black Holes & Growing Galaxies*, National Science Day, IIA, Bangalore, 28 February, 2008.

C. Sivaram gave some special lectures on *2007 physics noble prize, work of J. A. Wheeler* etc. Several lectures were also given in Christ College (as a Chief resource person). Also a two week course in astrophysics was conducted for B Sc students at National college, Bangalore (50 students). More than 20 lectures were given at BIFR during 2007 -08. For the second successive year, a two semester course (intercollegiate) was conducted on Rocket dynamics, space science and astrophysics, at St. Josephs college (Sept. 2007-08). He also gave several popular talks were given in various colleges and organizations (like BEL, 7 March 2008, Mico, Christ College (valedictory address of Science Forum, Oct. 2007), Bharatiya Vidya Bhavan, etc, Lectures were also given at various refresher courses conducted in Bangalore and Mysore universities (Feb. March) etc.

K. R. Subramanian gave a talk on Radio sky to students of Global Academy of Technology, Bangalore on September 22, 2007. He gave two lectures on radio Astronomy to students of certificate course on Rocket and space dynamics conducted by St.Joseph's College, Bangalore in Collaboration with ISRO in January 13, 2008 and January 26, 2008. He gave several lectures on basic radio astronomy to students of certificate course in astronomy conducted by the BIFR, Bangalore during May, October 2007.

K. Sundara Raman delivered a lecture on *Space Weather* to the physics students of Sree Narayana

Womens College, Kollam during September 2007. He gave 2 lectures covering the topics *Sun– Our star* and *Introduction to Astrophysics* to the M.Sc. and M.Phil students of Jamal Mohamed College, Trichy on 25 February 2008. He was the chief guest on the National Science Day 28 February 2008 and inaugurated the science exhibition organized by the schools at Kodaikanal.

P. R. Viswanath wrote a book on *Bhoomiyinda Baaninatta*, an informal history of Astronomy and Astrophysics in kannada , Navakarnataka Publications, 2007 May; *Jnana-Vijanana* – History of Modern Physics being serialized every saturday in Kannada Prabha from October 2007; He also wrote a popular article *Vishwa Hindu, Indu, Mindu* a popular article in Kannada on some aspects of Cosmology, Hosathu (January–Special edition), 2008.

L. Yeswanth gave a talk on *Telescopes*, at Government high school, Madivala, Bangalore on February 27, 2008.

12.2 Popular articles

Rangarajan, K. E., Sun takes centre stage, Deccan Herald, Science & Technology, 17 April, 2007

Sivaram, C., To boldly go where man is poised to go! (to commemorate the 50th anniversary of dawn of space age, sputnik 1) Deccan Herald, Science & Technology, 25 Sept. 2007

Sivaram, C., 300 years after Euler
Deccan Herald Education, Aug. 2007

Sivaram, C., Hail Dark Master, we owe our lives to you
Deccan Herald, 27 Nov. 2007

Sivaram, C., 2008, J. Phy. Ed., 25, 101
What is special about the Planck mass

12.3 IYA09

The United Nations, in response to recommendation from the International Astronomical Union (IAU) has declared the year 2009 as the International Year of Astronomy (IYA 2009) to commemorate the 400th year after Galileo's pioneering and bold experiment to look into the sky with the optical telescope. The IAU considers the IYA celebration as a historic chance for the whole of mankind to look into the question of man's place in the universe and a reiteration that the knowledge about the universe is to be shared by all of mankind to promote the UN's goals of international cooperation.

IIA has already began the preparations for the International Year of Astronomy, 2009. It is planned to develop a 4 inch reflecting telescope, which can be easily replicated in colleges. Mass activity is one of the major aims of IYA 2009, as part of which IIA has started activities promoting a dialogue between scientists, teachers, students, science writers, social scientists, and cultural activists.

(S. Chatterjee)

12.4 Founder's day

The ongoing public outreach program of the institute has seen enthusiastic interactions between the members of the IIA staff and the students and staff from several educational institutions. As a part of the Founder's Day program, public outreach activity was organized, which included a talk by Dr. Vivek Monteiro, of the Nav Nirmiti, entitled, *Sunderstanding* on 9th August at IIA , Bangalore and on 11th August at the VBO. The IIA formally launched the Educational Extension program at the Madivala Government High School, on 4th February, 2008. Several scientists from the institute are visiting the school on a continuing basis, and helping the students with scientific projects.

The eightieth birthday of Dr. M K Vainu Bappu, the Founder Director of the Institute was celebrated on August 10. 2007. Prof P. Balaram, Director, Indian Institute of Science, Bangalore delivered a talk on *Measuring and assessing science.*

(S. Chatterjee)

12.5 Two-element radio interferometer

As a part of the International Heliophysical Year (IHY) and Public Outreach Program of the Indian Institute of Astrophysics, it is proposed to provide hands-on astronomical observing experience to interested science and engineering graduate student community by donating radio antenna and receiver system to their institutions. The host institution is expected to provide a personal computer for data acquisition. The students will be trained to: (i) carry out observations of radio emission from Sun

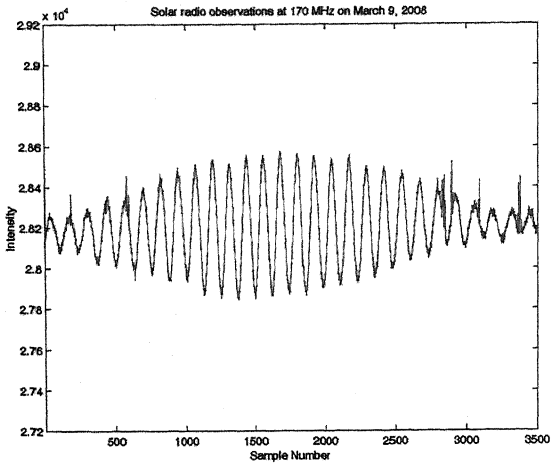


Figure 28: Observations of Sun at 170 MHz with the two-element radio interferometer on 9 March 2008.

and other strong cosmic radio sources with the above set up, and (ii) develop software for deriving quantitative information from the data acquired. The radio frequency (RF) signal reception setup is a simple radio interferometer consisting of two half-wave dipole antennas (tuned to receive RF signal at 170 MHz), separated by ~50 m. A prototype system has been designed and is presently in operation at the Gauribidanur radio observatory. A two-element radio interferometer was set up on the National science day for observations of Sun and other intense celestial radio sources. The signal from it was displayed in an adjoining room where a team of radio astronomers explained the instrument and the radio studies of the Sun. Students from the engineering colleges were excited about this particular experiment and asked many questions. Figure 28 shows the interference fringes obtained with the above set-up on Sun in the meridian transit mode. The total observation duration was about 4 h. The integration time used was 4 s. The overall variation in the observed fringe amplitude is due to the gain variation of the response pattern of the individual antennas as a function of hour angle (Half-power width ~60°).

(R. Ramesh, M. S. Sundara Rajan, C. Kathiravan & Indrajit V. Barve)

12.6 National Science Day

The Ministry of Science & Technology, Govt. of India, chose 'Understanding Planet Earth' as the theme for this year's Science Day which was held on February 28, 2008. Keeping in mind the theme, an exhibition of posters on Water, Air, Ice, Ocean and Space was put up for the visitors. Models of institute's premier telescopes in Kavalur and Hanle were displayed. A special attraction was a desk-top model of the TAUVEX payload and posters describing its science objectives. Children were keen on knowing about weather patterns, global warming, and the phenomenon of La Ni na. The scientist-volunteers were kept on their toes throughout the day responding to the eager queries of the youngsters. Nearly 500 school and college students from Bangalore participated in the festivities on that day.From 9.30 in the morning to 8.30 in the evening IIA had a steady stream of enthusiastic visitors. In the lawns, a coelostat arrangement was put up tracking the Sun in the sky. A large image of the Sun was focussed on a white board kept inside a tent for visitors to see. A quiz programme on sunspots was conducted. Unfortunately, the current period being near the solar minimum, sunspots were hard to come by. The box spectroscope designed by the IIA scientists for easy viewing of the solar spectrum was made available to the children who had a gala time looking through it at the continuous spectrum as well as the Fraunhofer lines. Later in the evening, the sky-watch programme got under way on the terraceof the Main Laboratory Annexe. A 14-inch Meade Telescope was set up for viewing the night sky.

Figure 29: Students watching the sunspots.

A two mirror coelostat system was set up to view the Sun on the science day. A 10 inch image of the Sun was focused on a big screen so that the sunspots could be clearly seen. A CD based spectroscope was made in IIA for the students to look at the Solar Fraunhofer spectrum. College and school students were explained about the sunspot numbers, how the absorption spectrum is formed in the Sun and other

details.

(D. Banerjee & K. E. Rengarajan)

Open days (August 9 & 10, 2007)

An exhibition of posters on the Sun, Space Weather and Solar-terrestrial relationships was set up as a theme exhibition celebrating IHY 2007. A special attraction was the STEREO image of the Sun which could be viewed in 3D using special glasses which were made available to the viewers.

The simple box spectroscope rigged up earlier by the IHY Public Outreach group has now been made available for distribution. The spectroscope can be used to view the spectrum of a terrestrial light source or of the Sun. The visitors to the exhibition had an opportunity to use this spectroscope.

Out in the open, Navnirmiti of Mumbai set up their low-cost no-cost toolswith simple demonstrations on how to measure the Universe with a string and a stone. Among the tools used were the Ball and Mirror Solar Projector, Pinhole Projector and the Sun Card, and the Very Long Focal Convex Lens Projector. The school students were enthralled by the simple experiments.

A continuous film show was also arranged in the auditorium where the film 'Hubble - 15 Years of Discovery', presented by Bob Fosbury on behalf of ESA, was shown.

(D. Banerjee)

13 Conferences, Workshops at IIA

13.1 The National Symposium on Gamma ray Astronomy

The observations in several gamma ray energy regions have shown that a substantial number of the sources cease emission with increase in the energy. Therefore it is possible that Photon Astronomy as one knows it is finding its limit at these energies atleast for several celestial sources. Therefore, experiments in the lower energy region can catch the death knell of quite a few sources. Two such experiments have been undertaken at Hanle in Ladakh: the High Altitude Gamma Ray (HAGAR) experiment which is in the commissioning stage and the Major Atmospheric Cerenkov Experiment (MACE) in its designing stage.

The Indian Institute of Astrophysics hosted a two-day National Symposium on 'Gamma ray Astronomy' aimed at ground-based Gamma ray astronomy, the above mentioned experiments in India, and to motivate young researchers into this field. The symposium was held on 23rd and 24th of November 2007 and had about 135 registered participants.

There were 18 thirty-minute talks in the symposium. The nine talks on the first day were devoted mostly to various aspects of gamma ray astronomy. The last few years have seen the discovery of very high energy gamma ray emission from a variety of sources with major contributions from the HESS and the MAGIC experiments. The phenomenal progress in the field was stressed by several speakers. There were talks on the early Indian experiments at Ooty, Gulmarg, Pachmarhi and Mt Abu and the new experiments HAGAR and MACE at Hanle. The talks on the second day covered other aspects of High Energy Astrophysics like Cosmic Rays, X-ray Astronomy, Neutrino astronomy, Supernovae, Gamma Ray Bursts, Gamma Ray Astronomy at Ultra high energies etc.

A discussion session at the end of the symposium stressed that (a) more multi wavelength efforts are necessary, (b) smaller experiments should choose niche areas to effectively contribute to the field. There were also discussions on how new efforts should be taken to interest young students in astronomy and astrophysics.

13.2 The First IIA-PennState Astrostatistics school

The first IIA-PennState Astrostatistics school was held in the VBO campus of IIA at Kavalur during 2-7th July, 2007. The school was modeled on the Astrostatistics schools of the Center for Astrostatistics, PennState University, USA. The intent of the school was to enable practitioners to meet the two-pronged challenge of modern empirical astrophysics, viz., (a) the compelling need for rigour in the application of state-of-the-art statistical methods, and (b) the recent paradigm shift that involves routine data mining of large multiwavelength data sets, thus necessitating complex automated analytical processes that invoke a very diverse set of statistical techniques.

The school was designed to provide a strong conceptual foundation in modern statistics as well as a repertoire of state-of-the-art statistical tools applicable to astrophysical problems. A heavy emphasis was placed on lab sessions that used the open-source, multi-platform R software environment, which is the current standard in research-level statistical computation. David Hunter, statistician from PennState and R expert, conducted these sessions, which included two new tutorials that were added in this school. The school was distinctive in its involvement of the Indian statistics academia. Thus, in addition to the three faculty from PennState University, five Indian statisticians from ISI Bangalore, Cranes Software, Bangalore, ISI Kolkata, and University of Hyderabad constituted the teaching faculty. The tranquil and isolated venue of the Vainu Bappu Observatory facilitated the intense engagement that was demanded of the school.

The school was open to astrophysics practitioners at all levels that were affiliates of Indian institutions. There were a total of 37 participants in the school, that included 11 from IIA-Bangalore, five from IIA-Kavalur and eight from the university sector, besides those from other astrophysics research institutes all over the country. There were seven faculty, six scientific staff, 21 Ph.D. students and three post-doctoral fellows. The statistics lectures were brought out in the form of Lecture Notes.

13.3 National meeting on Infrared Astronomy

A national meeting on Infrared Astronomy was held on 12-13 November 2007. This meeting was meant to explore the Indian interest in Infrared Astronomy. From the year, 2010 onwards, United Kingdom In-

frared Telescope (UKIRT) plan to share the operational cost against guaranteed observing time at the telescope. Earlier this year, UKIRT invited IIA and India for a partnership for the above purpose. The primary aim of the meeting was to discuss and collate the thrust science areas of Indian infrared astronomy.

The science talks were held on 12th, followed by a business meeting on 13th November. The scientific talks were well attended by the members of the GC II, graduate and project students. 10 outstation participants representing the institutions, ARIES, IUCAA, PRL, TIFR and two universities participated in the meeting. The programme started with a welcome address by the director, IIA, followed by a presentation on the available ground based Infrared facilities and their comparison with UKIRT by Annapurni Subramaniam. A wide variety of scientific projects were presented in 17 talks. This was a good indicator of the strong Indian interest in infrared astronomy and in utilizing the UKIRT for the respective science. The topics presented in the meeting, along with the interests from the participating institutes will be compiled to create a science case for the UKIRT funding proposal. This proposal will be submitted to the DST in due course.

13.4 Tutorial on Radio Aperture Synthesis Data Reductions

A tutorial on reductions of radio aperture synthesis data using the Astronomical Image Processing Software (AIPS) was conducted in IIA on the 18th and 21st January, 2008. The tutorial had introductory lectures by Nimisha Kantharia and Prajval Shastri, and hands-on data reduction sessions using GMRT data that were conducted by Nimisha Kantharia. About 12 participants (including PhD students, post-doctoral fellows and faculty) took part.

13.5 Kodai summer school in physics, 2007

A three week summer school in Physics was conducted during 4-23 June 2007 on the subjects (i) Mathematics to Modern Physics (ii) Optics (iii) Statistical Physics and (iv) Nonlinear Physics at IIA, Kodaikanal. 32 students of final year post graduate and graduate courses from various parts of the country participated. Dr. Rita John, Head of the Department of Physics, Mother Teresa University, Kodaikanal and Dr. K. Sundara Raman delivered evening special lectures in the field of Nanotechnology and Solar Physics respectively to the students and local public. The students were exposed to the solar observations and night sky viewing.

13.6 Mini-Workshop on Hinode X-Ray Telescope (XRT) Data Analysis

Solar-B (Hinode - Sunrise in Japanese) satellite which is a successor to Solar-A (Yohkoh) was launched successfully on September 23, 2006 from Japan. Hinode was developed at ISAS and NAO, Japan, in cooperation with NASA, PPARC and ESA. It has three main instruments, namely, the Solar Optical Telescope (SOT), the soft X-Ray Telescope (XRT) and the EUV Imaging Spectrograph (EIS). Recently, the data from the satellite has been made public for the benefit of researchers working on the Sun. A Mini-Workshop to deal with the data obtained from the Hinode X-Ray Telescope was organized at the Institute (IIA) on July 3 and 4, 2007. There were about 30 participants from IIA, IISc, ISAC/ISRO and CfA (Harvard- Smithsonian Center for Astrophysics, Cambridge, USA). Siraj S Hasan, the Director made the opening remarks followed by introduction of the speakers from CfA. The first talk was an overview of solar and stellar coronae by Vinay Kashyap and Loraine Lundquist (CfA). The next talk given jointly by Monica Bobra and Loraine Lundquist (CfA) was focused on the instruments on Hinode (XRT, EIS, SOT) and the first results obtained from the mission. The interactive data analysis was conducted by Monica Bobra and Loraine Lundquist. They described the methodology of retrieving XRT data from the Virtual Solar Observatory and the XRT website at http://xrt.cfa.harvard.edu, its processing and analysis using the XRT software. They mentioned about acquiring SOT and EIS data. Vinay Kashyap (CfA) gave a one-hour talk on Differential Emission Measure and its use in the Hinode Data. A talk on Predicting Solar Cycle Using a Dynamo Model was presented by Piyali chatterjee (IISc) followed by Jagdev Singh's (IIA) talk on Temperature structure of coronal loops and XRT. Three more talks, Multi wavelength study of coronal loop dynamics as seen from CDS and TRACE by Dipankar Banerjee, Observations of the solar corona at low radio frequencies by R. Ramesh and Solar Physics Research at the ISRO Satellite Center, Bangalore by P. Sreekumar were presented, ending the scientific presentations of the meeting. The interactive data analysis session continued on July 4 afternoon. Finally, a Group Discussion for joint observing programmes/ science projects was organized and the participants took active part in it. As a follow-up, Monica Bobra (CfA)

Figure 30: Group photograph of the IHY school participants.

has prepared a web-page containing many resources at http:/ /xrt.cft.harvard.edu/resources/IHY.

13.7 First Kodai-Trieste workshop on plasma astrophysics

The first Kodai-Trieste Workshop on Plasma Astrophysics was held in the Kodaikanal Observatory, Kodiakanal, during August 27 - September 7, 2007. It was jointly organized by the Indian Institute of Astrophysics, Bangalore and the International Centre for Theoretical Physics, Trieste. The Workshop began in the still pristine precincts of the Kodaikanal Observatory, with a welcome message from director, IIA. The Workshop was designed to provide a strong conceptual foundation of the Plasma Astrophysics to young researchers, and stimulate them to start research activities in the field of Astrophysics. The scientific programme kicked off with sessions on Turbulence, Hydrodynamical turbulence, Solar wind, Astrophysical Dynamos, geodynamo, Pulsars and Quantum Plasmas.

The workshop made for an enthralling experience, both pedagogically, and in terms of the coming together of Plasma Astrophysicists and young researchers. The workshop was concluded to be a success on all accounts.

13.8 International Heliophysical year 2007

The institute organized the first Asia-Pacific School on International Heliophysical Year at its Kodaikanal observatory during December 10-22, 2007. The school was co-sponsored by National Aeronautics and Space Administration, USA and the Asian Office for Aerospace Research and Development, Japan. The overall theme of the IHY school at Kodaikanal was to teach the students how the Sun influences the sphere of 100 AU radius through its electromagnetic and mass emissions and the physical processes involved. And the purpose was to provide an introduction to heliophysics for students who do not have an opportunity to take such a course at their home institution. The school was attended by about 35 students from both India as well as abroad participated in the school. The participants were mainly Ph.D. and post-doctoral research students. As a special case, a few final year M.Sc (Physics) students, with an interest in Solar Physics and who want to pursue it further, were also selected. The school covered a broad spectrum of physical processes in the heliospace like: Sun in the Universe, Solar interior, Solar atmosphere and the heliosphere, Solar eruptions and heliospheric consequences, shocks, flows and obstacles, dynamo processes, Reconnection processes in

Sun and heliosphere, sun-climate, turbulenc:w e in the heliospace, Planetary atmospheres, ionospheres, and magnetospheres, Radio emission processes, Energetic particles in the heliosphere, Elemental abundances in the heliosphere, Space platforms for heliophysical studies, Space weather, Cosmic rays and climate. Speakers were drawn from both India and abroad and there were 45 lectures in total. There were also lab exercises for the students to get experience in observations and data analysis.

13.9 National workshop on Preserving our Scientific Heritage

IIA library with Tata Institute of Fundamental Research, Mumbai and Indian Institute of Science, Bangalore organized a National Workshop on Preserving Our Scientific Heritage in the month of Jan 2008. The workshop was unique as it brought together 100 participants from across disciplines comprising historians, librarians, scientists and policy-makers. The keynote address was given by Ross Bassett (North Carolina State University in Raleigh) on the topic of Archives A historians view. In his role as a consultant to the archives of IITs in India, he mentioned that several issues in archiving were linked directly to the absence of awareness among the policy-makers. The workshop was focused on the following themes, Collection of Heritage Material, Collection Policies & Organization, Setting up of Archives, Preservation and Conservation, Disaster Management, Acidity Management, Storage specifications and copyright issues. The last session of the workshop comprised a panel discussion: (i) copyright issues, (ii)how to develop archives (iii)archival standard, and (iv) the need for a National Science Archives. A significant recommendation made by the participants was the creation of a Forum or an Association of Archives in India that could enable the setting up of standards, modes of information exchange and development of guidelines for the creation of Science archives.

14 National & International Programmes

14.1 Collaborations with other countries

1. Collaboration between IIA and INPE, Brazil: Observations of the Sun and strong radio sources at 1.6 GHz using 5 element interferometer at Cahoreia Paulista, Brazil were continued. A 1444 channel correlator system will be developed at IIA for the final phase of the BDA which will consist of 32 parabolic dishes of 4 m in diameter operating in the band 1.5 - 5 GHz with maximum baselines of 2 km.

2. TAUVEX mission, an Indo-Israeli ultraviolet imaging experiment that will image large parts of the sky in the wavelength region between 140 and 320 nm and is expected to be launched as part of the next GSLV mission (GSAT-4) soon.

3. A radio spectrograph operating from approximately 18-70 MHz is being developed for radio telescope at Gauribidanur under the UN Basic science initiated programme in collaboration with the University of Maryland, and the Naval Research Lab.

14.2 Collaborations with institutes within the country

1. IIA is collaborating with ISRO, Inter University Center for Astronomy and Astrophysics (IUCAA), Physical Research Laboratory (PRL), and Tata Institute of Fundamental Research (TIFR) to develop UltraViolet Imaging Telescope (UVIT), which is one of the payloads on satellite Astrosat.

2. IIA has set up a Gamma Ray Telescope array at IAO, Hanle, in collaboration with TIFR. The telescope design and development (mechanical, civil and control electronics) is implemented by IIA, while the Software for the telescope control and Data Acquisition System are developed by TIFR. The complete array of 7 telescopes is expected to be operational by December 2007 and the preliminary science observations could begin thereafter.

15. Colloquia / Seminar given by visitors

05 April 2007
Strange Quark Stars: From Theory to their Current Standings
Subharthi Ray
Inter-University Centre for Astronomy & Astrophysics, Pune

10 April 2007
Probing Supernovae - Gamma Ray Burst Connection with Neutrinos
Pijushpani Bhattacharjee
Saha Institute of Nuclear Physics, Kolkata

14 June 2007
Anticorrelated Hard X-ray Time Lags in Galactic Blackhole Sources - Evidence for Truncated Accretion Disk Models
Jayant Kumar Pendharkar
Osmania University, Hyderabad

21 June 2007
On-going and Future Instrumentation Efforts at the Anglo-Australian Observatory
Sam Barden
Anglo-Australian Observatory, Epping, Australia

09 July 2007
Low Light Level CCDs: Performance and Issues
Nagaraj Naidu
UK Astronomy Technology Centre, Royal Observatory, Edinburgh, U.K.

10 July 2007
Variability of AGNs on Diverse Time Scales
Alok Gupta
Yunnan Observatory, Kunming, China

24 July 2007
A New Survey of Stars in the Outer Extremities of the Magellanic Clouds
Abhijit Saha
National Optical Astronomy Observatory, Tucson, USA

07 August 2007
Gravity and Higher Dimensions - A Classical Motivation
Naresh Dadhich
Inter-University Centre for Astronomy & Astrophysics

13 August 2007
Piecing Together the X-ray Background: the Bolometric Output from AGN
Ranjan Vasudevan
Institute of Astronomy Cambridge, UK

21 August 2007
Stellar Abundance Anomalies - Always Nucleosynthetic?
David Lambert
University of Texas, Austin, USA

23 August 2007
Compact HII Regions and Massive Star Formation
T.N. Rengarajan
formerly Tata Institute of Fundamental Research, Mumbai

24 August 2007
Observations of Low Frequency Magnetic Field Fluctuations Near the Moon
Thejappa Golla
Department of Astronomy, University of Maryland, USA

04 September 2007
Mass Transfer in Symbiotic Binaries
Joanna Mikolajewska
Nicolaus Copernicus Astronomical Center, Warsaw, Poland

18 September 2007
Deciphering the Universe with Gravitational Wave Astronomy
Bala Iyer
Raman Research Institute, Bangalore

27 September 2007
Dynamics of Warps in Spiral Galaxies
Kanak Saha
Joint Astronomy Programme, Indian Institute of Science, Bangalore

03 October 2007
Transport and Heating in Low Luminosity Accretion Flows
Prateek Sharma
University of California, Berkeley, USA

06 November 2007
Constraining Black Hole Spin with X-ray Spectroscopy
Christopher Reynolds
University of Maryland, College Park, USA

11 October 2007
Radiative Transfer on X-Y Geometry
Annamaneni Peraiah
formerly Indian Institute of Astrophysics

13 November 2007
Polar Plumes as Seen in the Vacuum Ultraviolet
Luca Teriaca
Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany

15 November 2007
Relics from the Dawn of Time: Abundance patterns of Extreme Metal Poor Stars of the Galaxy
Sivarani Thirupathi
Michigan State University, East Lansing, USA

04 December 2007
The Sun's Magnetic Cycle: Current State of our Understanding
Dibyendu Nandi
Montana State University, Bozeman, USA

18 December 2007
Unification of Fundamental Forces and String Theory
Jnanadeva Maharana
Institute of Physics, Bhubaneswar

03 January 2008
The Non-linear Cepheid Period-Luminosity Relation: Implications for H0 and Cepheid Physics
Shashi M. Kanbur
State Univerisity of New York, Oswego, USA

09 January 2008
The 6dF Galaxy Survey: Initial Results and Large-Scale Structure and Galaxy Evolution
Heath Jones
Anglo-Australian Observatory, Epping, Australia

14 January 2008
Multiwavelength Data at the Canadian Astronomy Data Centre
David Schade & Séverin Gaudet
Herzberg Institute of Astrophysics, Victoria, Canada

24 January 2008
Theoretical Studies of Wave Interactions in the Sun
Shravan Hanasoge
Stanford University, Stanford, USA

25 January 2008
Bose-Einstein Condensation: A Quantum Many-body Approach
Barnali Chakrabarty
Lady Brabourne College, Kolkata

29 January 2008
Coronal Mass Ejections from the Sun in 3-D: Early Results from the Coronagraph COR1 aboard STEREO
Nandita Srivastava
Udaipur Solar Observatory, PRL, Udaipur

31 January 2008
Mulitiwavelength Studies of Proto-planetary Nebulae
Bruce Hrivnak
Valparaiso University, Valparaiso, USA

05 February 2008
Characterizing Local Luminous Infrared Galaxies: Towards Understanding their More Distant Cousins
Almudena Alonso-Herrero
Instituto de Estructura de la Materia (CSIC), Madrid, Spain

08 February 2008
Looking for a Pulse: The Search for Radio Emission from Brown Dwarfs and Extrasolar Planets
Gregg Hallinan
National University of Ireland Galway, Galway, Ireland

12 February 2008
The Global Search for Gravitational Waves
Sanjeev Dhurandhar
Inter-University Centre for Astronomy & Astrophysics

18 February 2008
The European Extremely Large Telescope
Colin Cunningham
Royal Observatory, Edinburgh, UK

19 February 2008
Unveiling the Structure of the Circum-nuclear Medium of AGNs through Time-resolved X-ray Spectroscopy
Guido Risaliti
Arcetri Astrophysical Observatory, Florence, Italy

20 February 2008
The Structure of the Solar Internetwork Magnetic Field: Comparison of Numerical Simulations with Hinode Observations
Oskar Steiner
Kiepenheuer-Institut fuer Sonnenphysik, Freiburg, Germany

21 February 2008
Magnetohydro dynamic Shock Flows in Clusters of Galaxies
Yu-Qing Lou
Tsinghua University, Beijing, China

04 March 2008
Astronomical Data: Separating Baby and Bathwater
Rajaram Nityananda
National Centre for Radio Astrophysics, TIFR, Pune

06 March 2008
The Origins and Evolution of Weak Low Ionization Quasar Absorption Systems
Anand Narayanan
Pennsylvania State University, University Park, USA

11 March 2008
Science Using Solar Adaptive Optics: Successes and Future Requirements
Sankarasubramanian Kasiviswanathan
ISRO Satellite Centre, Bangalore

24 March 2008
Rayleigh Scattering System for Palomar 60-inch
Shrinivas Kulkarni
California Institute of Technology, Pasadena, USA

16. Visitors at IIA

3 April - 6 April
Subhrthi Ray
IUCAA, Pune

8 April - 14 April
Pijush Bhattacharjee
SINP, Kolkata

15 April - 30 April
Gopal Krishna
NCRA, TIFR, Pune

28 May - 6 June
H. S. Sawant / J. R. Cecatto
INPE, Brazil

23 July - 28 July
Abhijit Saha
AOAO, Tucson, AZ, USA

6 August - 8 August
N. Dadhich
IUCAA, Pune

23 August - 26 August
G. Thejappa
Dept. of Astronomy, Univ. of Maryland, USA

24 August - 10 September
J. Mikolajewska
N. Copemicus, Astronomical Centre, Warsaw, Poland

1 October - 6 October
Dr. Vikram Athalyle
IISER, Pune

19 October - 24 October
Y. Gupta
NCRA, TIFR, Pune

23 November – 24 November
S.M.Chitre
Univ. of Mumbai, Mumbai.

14 November – 18 November
T.Sivarani
Michigan State University, USA

8 December – 9 December
Arnold Hauslmeier
Karl Franzens University, Graz, Austria

1 January
Ajit Srivastava
Institute of Physics, Bhubaneswar

3 January – 4 January
Sashi Kambur
State Univ. of New York, Oswego, USA

5 January – 11 January
M.Doi, K.Kawabata
N.Tominaga, M.Tanaka
Y.Jhara, Univ. of Tokyo

13 January – 17 January
David Schade
Severin Gaudet
Herzberg Inst. Of Astrophysics, Victoria, Canada.

21 January – 7 February
Bruce Hrivnak
Valparaiso Univ., USA

25 January
Barnali Chakraborty
Lady Brabourne College, Kolkata

26 January – 21 February
Oskar Steiner
Kiepenheuer Institute Fur Sonnenphysik, Germany

28 January – 31 January
Nandita Srivastava
Udaipur Solar Observatory, Udaipur

3 February – 9 February
J.Gerry Doyle
Armagh Observatory, N. Ireland

3 February – 10 February
Almudena Alonso Herrero
Inst.de Estructura de la Materia, Madrid, Spain

7 February – 11 February
Gregg Halliman / Tony Antonova
NUI, Galway, Ireland

11 February – 13 February
S.V. Durandhar
IUCAA, Pune

16 February – 20 February
Guido Risaliti
Arcetri Astrophysical Observatory, Florence, Italy

19 February
Colin Cunningham
Royal Observatory, Edinburg, UK

19 February – 23 February
Yu-Qing Lou
Tsinghua University, Beijing, China

3 March – 5 March
R.Nityananda
NCRA, TIFR, Pune

6 March – 8 March
Anand Narayanan
Pennsylvania State Univ, Univ.Park, USA

17. Staff list 2007 - 2008

Director: S. Sirajul Hasan

17.1 Academic & Scientific members

Senior Professor: B. P. Das, V. Krishan, T. P. Prabhu, N. K. Rao, J. Singh, C. Sivaram, R. Srinivasan

Professor: S. P. Bagare, H. C. Bhatt, S.Giridhar, S. S. Gupta, R.C. Kapoor, J. Murthy, K. N. Nagendra, A. K. Pati, A. V. Raveendran

Associate Professor: G. C. Anupama, S. Chatterjee, R. K.Chaudhuri, S. G. V. Mallik, B. R. Prasad, K. E. Rangarajan, S. K. Saha, P.Shastri, R. Surendiranath

Reader : Annapurni. S, D. Banerjee, R. Kariyappa, M. V. Mekkeden, C. Muthu Mariappan, S. P. K. Rajaguru, K. P. Raju, B. E. Reddy, R. Ramesh, S. Sengupta, F. Sutaria

Scientist - D: B. C. Bhatt, R. T. Gangadhara, A. Goswami, K. M. Hiremath, U.S.Kamath, A. Mangalam, S. Mohin, S. Muneer, P. S. Parihar, K. B. Ramesh, M. S. Rao, D. K.Sahu, A. Satyanarayanan, P. Subramanian, K.Sundararaman

Scientist - C: J. Javaraiah, G. Pandey, C. S. Stalin, B. A.Varghese

Scientist- B: P. Bama, E. Ebenezer, B. S. Nagabhushana, S.Singh

Research Associate: M. Appakutty

Distinguished Professor: R. Cowsik (Vainu Bappu Chair), V. K. Gaur, K. R.Sivaraman, S. N. Tandon

Adjunct Professor: N. D. Hari Dass

Visiting Sr. Professor: J. H. Sastri, P. R.Vishwanath

Visiting Professor: D. C. V. Mallik, K. R. Subramanian

Visiting Associate Professor: P. M. S. Namboodiri, Vasundhara Raju

Post Doctoral / Visiting Fellow: A. Borch, V. Das, P. Gopakumar, C. Kathiravan, M eetu Sethi Luthra, J. Pendarkar, M. Safonova, K. A. P. Singh, N. V. Sujatha, N. Verma

Sr. Research Fellow: R. Chaudhuri, Girijesh R. Gupta, B. K. Erra Reddy, A. M. Karnataki, M. Maiti, B. Mathew, T. Mishra, K. Nagaraju, H. S. Nataraj, A. C. Pradhan, S. Ramya, M. Sampoorna, V. Singh, R. M.Thomas, G. Udaya Kumar, G. Vigeesh

Jr. Research Fellow: Anusha L.S, K. Chandrasekhar, S. Krishna Prasad, Sumangala Rao, M. B. Roopashree, A. Shukla, Smitha Subramanian, A. Vyasa

17.2 Technical staff

Engineer G: A. K. Saxena

Sr. Principal Scientific Officer: A. V. Ananth

Engineer E: V. Chinnappan, G. Srinivasulu, M. S. Sundararajan

Engineer D: S. S. Chandramouli, P. M. M. Kemkar, P. K. Mahesh, R. R. Reddy, Faseehana Saleem, N. Selvavinayagam

Principal Scientific Officer: J. P. Lancelot, J. S. Nathan

Librarian: Christina Bridie

Engineer C: Amit Kumar, Dorje Angchuk, V. Arumugam, S. Kathiravan, S. Nagabhushana, B. R. K. Reddy, M. P. Singh, S. Sriram

Scientific Officer SD: L. Yeshwanth

Scientific Officer: Rhekesh Mohan

Sr. Technical Officer: J. P. A. Samson, A. Selvaraj

Technical Officer B: F. Gabriel, J. V. S. V. Rao, N.Sivaraj, K. S. Subramanian

Sr. Documentation Officer: Sandra Rajiva

Engineer B: P. Anbazhagan, K. Anupama, K. Dhananjay, Sanjiv Gorka, Sonam Jorphail, P. U. Kamath, T. T. Mahay, Vellai Selvi, K. C. Thulasidharen

Technical Officer: A. V. Velayuthan Kutty, K. Rangaswamy, R. Selvendran

Tech. Associate B: K. Jayakumar, K. Kuppuswamy, Narasimhappa, M. Joseph Rosario, G. S. Suryanarayana

Sr. Mech. Asst. C: A. Mani

Tech. Associate: D. Babu, P. Kumaravel, Mallappa, S. Pukalenthi, A. Ramachandra, S. Ramamoorthy, S. Venkateshwara Rao, K. Ravi, M. R. Somashekar, C. V. Sriharsha

Draughtsman E: V. K. Subramanian

Sr. Tech. Asst. B: A. P. Balakrishnan, R. IsmailJabillullah, J. Manoharan, T. K. Muralidas, V. Ponnurangam, A. Muniyandi

Tech.Asst.C: V.Gopinath, M.G.Mohan

Asst. Librarian B: B. S. Mohan, P. Prabahar

Project Consultant: A. Vagiswari

Consultant: Kuldip Chandar, C. Nanje Gowda, B. R. Madhava Rao, Nageshwara Rao.M

Visiting Project Associate: N. Jayavel

17.3 Administrative staff

Administrative Officer: A. J. Ragupathy

Dy. Administrative Officer: S. Rajasekaran

Finance Officer: K. Ramachandran

Accounts Officer: M. P. Parthasarathy

Staff Officer: K. Thiyagarajan

Personnel Officer: A. Narasimharaju

Sr.Asst. Administrative Officer: K. Mohan Kumar

Asst. Administrative Officer: Y. K. R. Iyengar, Ramaiah

Asst. Accounts Officer: G. R. Venugopal

Store Officer: D. Lakshmaiah

Sr. Section Officer: Meena, Pramila Mohan, K. Sutherson

Section Officer: Narasimhamurthy, S. Rajendran, S. B. Ramesh

Hindi Officer: Saroj Ishwaralal

Sr. Office Superintendant: L. Josephine, Uma Maileveloo, P. Alphonse Mary, A. P. Monnappa, M. G. Chandrasekaran Nair, K. Padmavathy, R. M. Paulraj, Malini Rajan

18 Sky conditions

Vainu Bappu Observatory, Kavalur

Year	Month	Spectroscopic Hours	Photometric Hours
2007	April	147	3
	May	98	5
	June	42	8
	July	19	0
	August	27	3
	September	39	0
	October	64	3
	November	133	42
	December	128	15
2008	January	211	73
	February	161	42
	March	99	24
	Total	1168	218

VBT Time Allocation during the period : 1 April 2007 - 31 March 2008

Total No. of proposals received	:	17
Number of spectroscopic proposals	:	15
Number of imaging proposals	:	2
Number of nights allocated for spectroscopy	:	263
Number of nights allocated for imaging	:	27

Sky conditions at Indian Astronomical Observatory, Hanle

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2007	April	119	179	240
	May	82	111	217
	June	78	106	210
	July	50	110	217
	August	53	98	248
	September	113	165	270
	October	229	242	310
	November	275	302	341
	December	205	252	341
2008	January	117	155	341
	February	186	220	290
	March	157	191	279
	Total	1664	2131	3293

Kodaikanal Observatory

Spectro / Photoheliograms and Seeing Conditions at Kodaikanal

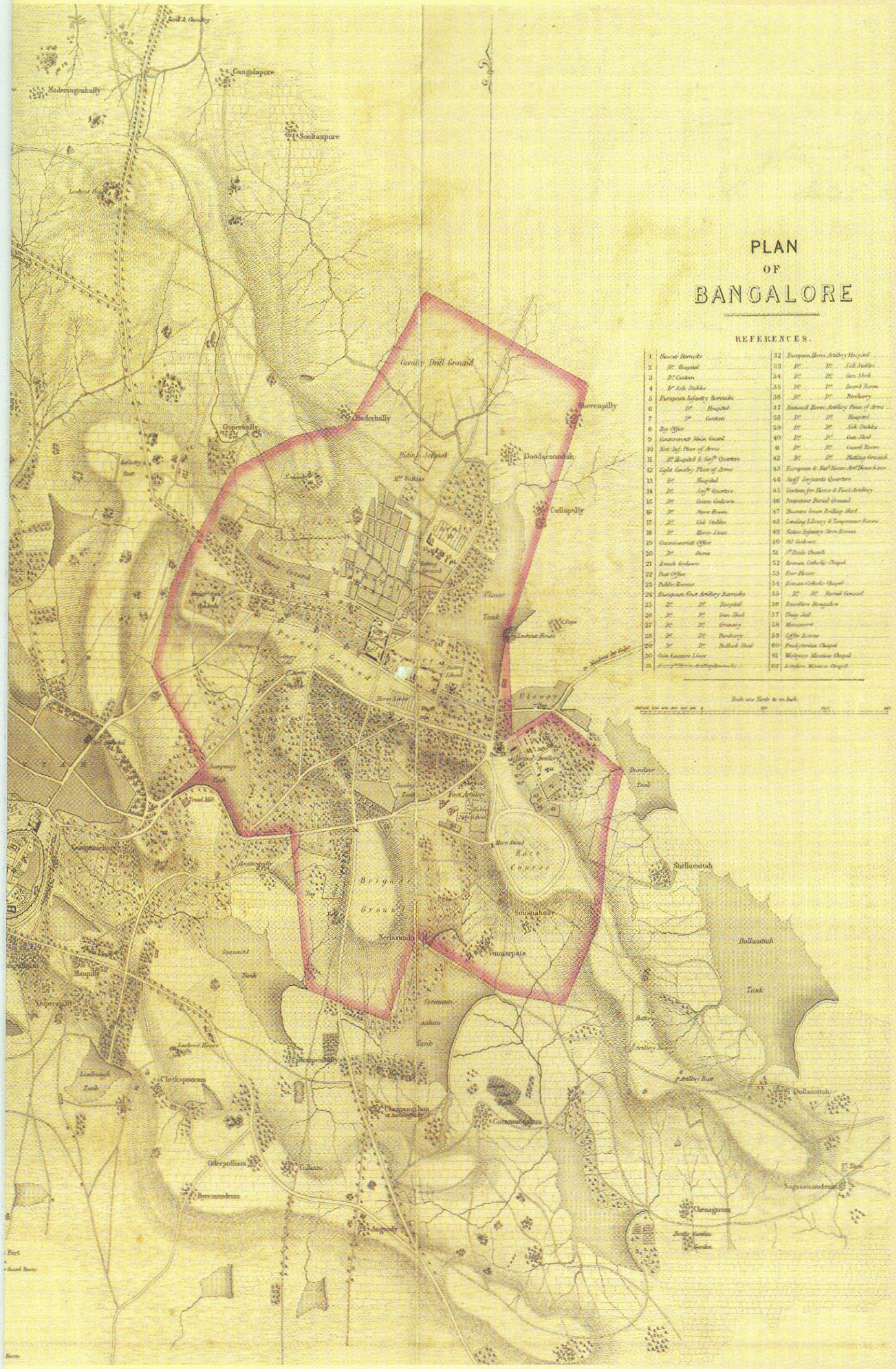
Year	Month	No. of observing days				Seeing Condition*				
		Hα	Kfl	PHGM	FGM	5	4	3	2	1
2007	April	12	12	23	19	0	0	0	23	0
	May	15	15	24	5	0	0	7	17	0
	June	4	10	16	-	0	2	5	9	0
	July	2	2	4	-	0	2	2	0	0
	August	0	3	10	-	0	1	8	1	0
	September	0	3	12	-	0	3	8	1	0
	October	0	3	12	-	0	2	10	0	0
	November	-	-	18	-	0	0	6	12	0
	December	-	-	16	-	0	0	0	16	0
2008	January	-	-	25	-	0	0	4	21	0
	February	-	-	15	-	0	0	0	15	0
	March	-	-	15	-	0	0	1	14	0
	Total	33	48	190	24	0	10	51	129	0

Hα = H-alpha spectro-heliograms; Kfl = Ca-K line spectro-heliograms; PHGM = Photo-heliogram (Ca-k line filter-grams taken on 127 days with about 30 minute intervals)
*(1–Very poor, 2–Poor, 3–Fair, 4–Good, 5–Excellent)

Solar Tower Telescope Observations from April 2007 to March 2008

Year	Month	Seeing (in arcsec)				
		3	3 to 4	4	4 to 5	>5 (poor)
2007	April	9	2	4	-	3
	May	7	3	1	2	1
	June	3	-	5	–	–
	July	4	-	1	–	2
	August	3	1	–	–	–
	September	2	-	1	–	2
	October	8	3	4	3	–
	November	7	-	5	–	5
	December	11	-	6	–	2
2008	January	15	2	1	–	2
	February	14	-	3	–	–
	March	8	1	5	–	6
	Total	91	12	36	5	23

Ca+K Latitude Observations - 109 days; Polarimeter Observations - 29 days,
Spectrographic Observations - 11 days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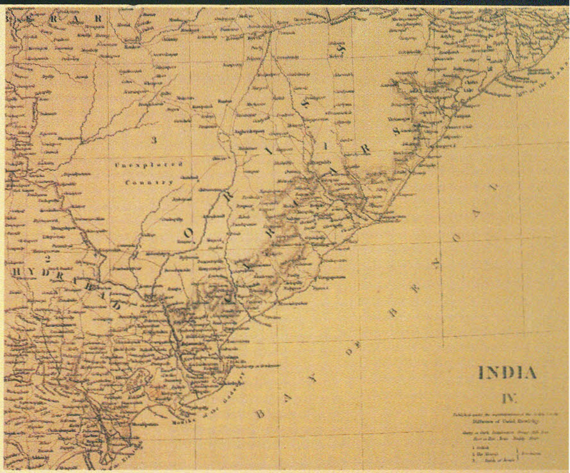
INDIA
IV.


INDIA
III


INDIA
XI