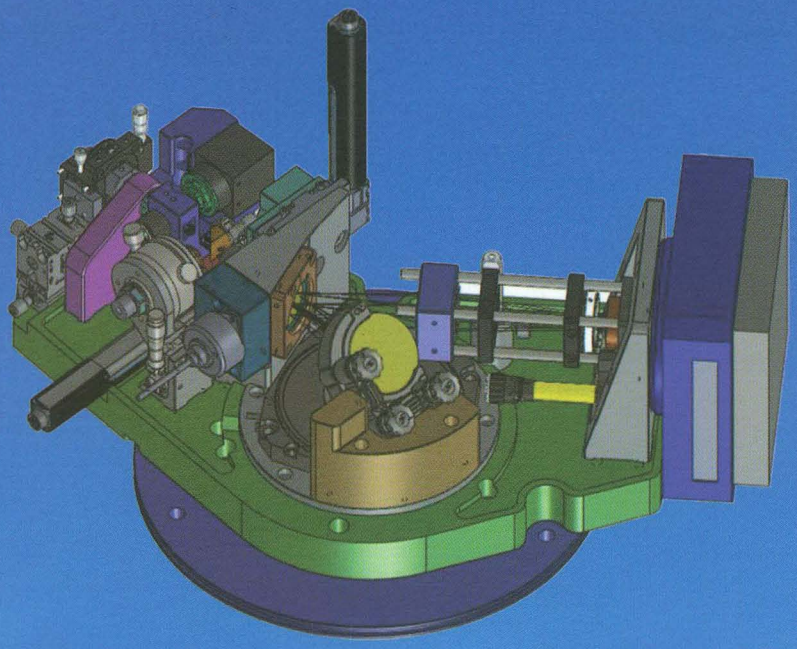
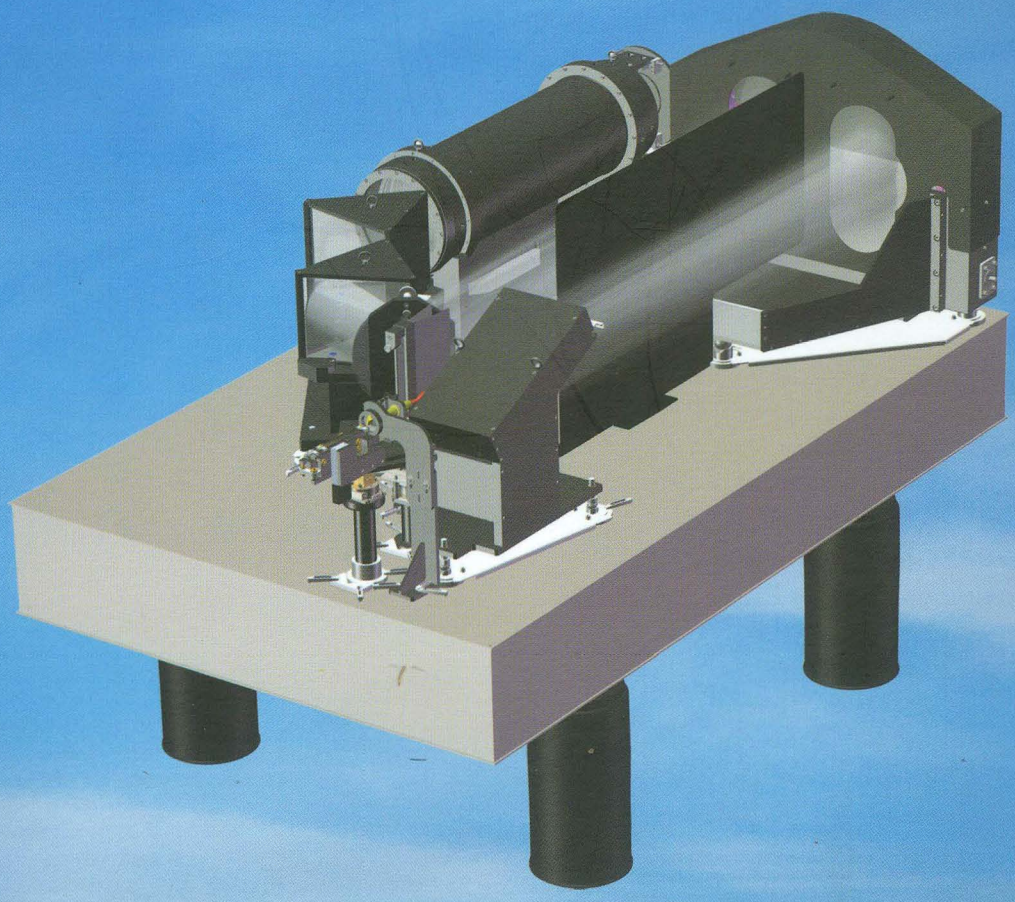


INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT 2011-12



INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT

2011-12

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Cover : A high resolution spectrometer for the Himalayan Chandra Telescope (HCT) is currently under construction with the aim of facilitating many front-line programs that need high spectral resolution and high stability. This instrument is designed to have high efficiency over the full optical spectral range (350-1000nm) in a single exposure. It is being developed in technical collaboration with Industrial Research Limited, New Zealand. The Cassegrain unit will acquire and guide the star on the fibre that feeds the main spectrograph housed in the west wing of the ground floor of the HCT enclosure.

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The Year in Review

It gives me great pleasure once again to present the highlights of IIA's achievements on many fronts in 2011–12. This has indeed been a most productive period during which the Institute has made significant contributions in research, academic and technical activities, human resource development and public outreach. Several new programmes are on the anvil, while earlier ones continue to make excellent progress.

Scientists at the Institute continue their research activities with great vigour in their respective fields. In solar physics, the digitization of over 100 years of solar data on photographic plates from Kodaikanal has made excellent progress. The full series of digitized Ca-K images of the Sun is now available to the scientific community to carry out synoptic studies spanning over 9 solar cycles. An analysis of the combined Greenwich and Solar Optical Observatory Network (SOON) sunspot group data during the period 1977–2011, was carried out and a correlation between the area and change of magnetic flux was established. In another study, high-frequency wave power halos around active regions were studied using observations from the Solar Dynamics Observatory (SDO). From this it was possible to infer possible signatures of magneto-acoustic wave refraction as seen from the observation height dependent changes, which has implications for theories of acoustic wave absorption and mode conversions by the magnetic field. Numerical simulations were carried out to study the acoustic emission from magnetic flux tubes in the solar network. The nature of propagating intensity disturbances in the solar atmosphere was also examined with a view to understand their nature and their contribution to coronal heating, which has important repercussions for coronal seismology. It was found that the observed propagating disturbances are more likely to be signatures of slow magneto-acoustic waves rather than high speed quasi-periodic up flows. The formation, lifetime, temporal evolution and the association with the photospheric magnetic field of several X-ray bright points (XBPs) was studied. Motions in sub-arcsec bright points (BP) associated with the small scale magnetic fields in the lower solar atmosphere that are advected by photospheric granules was also investigated. Other studies included an analysis of the thermal and dynamic properties of the coronal holes and the estimation of the magnetic field in the non-flaring corona through observations of circularly polarized emission from the noise storm continuum source using the radio heliograph and the radio polarimeter at the Gauribidanur observatory of IIA. During a solar eclipse, discrete radio sources on the Sun can be identified with high angular resolution ($\sim$ 10 arcsec) using the diffraction effects at the Moon's sharp limb. Taking advantage of this, an attempt was made to observe compact radio sources in the solar atmosphere from where low-frequency radiation ($<$ 100 MHz) originates. Based on the theory of Stokes vector decomposition for the Hanle effect combined with the Fourier azimuthal expansion of the angle-dependent PRD function, an efficient numerical method was developed of solving the concerned transfer problem in a one-dimensional medium. The authors also derived a suitable form of the laboratory frame PRD matrix for the resonance scattering in subordinate lines in the solar spectrum as well as a technique to solve the angle-dependent PRD polarized radiative transfer problem in multi-dimensional media.

Turning to stellar physics, a spectroscopic study was carried out of several classical Be stars in open clusters in our Galaxy using medium resolution spectra. Ly β fluorescence process is found to be operative in Classical Be stars. The abundances of red giant members for open cluster were determined to improve the understanding of Galactic chemical evolution. Elemental abundances of several post-ABG stars were studied. A warm post-AGB star with strong He I is suggested of being H-deficient and He-rich. The carbon abundance in cool hydrogen-deficient stars (RCB and HdC) were estimated using the molecular C2 Swan bands. Towards understanding the origin of stellar streams the authors have chosen half a dozen streams for the abundance study of member stars. Two dimensional Monte-Carlo radiative transfer models for the disk of the eclipsing binary ϵ Aur were carried out.

The discovery of amplitude and phase modulations typical of the Blazhko effect were reported in 22 RRc and nine RRab type RR Lyrae stars in NGC 5024 (M53). Self-consistent atmospheric models predict a detectable amount of polarization may arise due to the rotation-induced oblateness of the planets. Formation and evolution of pre-stellar cores via gravoturbulent fragmentation were studied. Multiwavelength analysis of the stellar contents associated with in the Sh2-252 HII region have been performed. Polarization measurements of stars in the field of the star forming molecular clouds have been carried out in the optical R band. The photometric and spectroscopic studies of many supernovae were carried out including type Ia supernovae SN 2009an SN 2009ig. Pulsar emission due to perturbation of the field aligned polar cap was studied.

In the area of extragalactic astrophysics, High Altitude Gamma Ray (HAGAR) observations of TeV blazar Mrk 421 were done during a flare phase. The flare is suggested due to a passing of shock in the jet, with the help of multiwavelength data. Six lensed quasars are being monitored from HCT, as part of the COSMOGRAIL (COSmological MOnitoring of GRAvItational Lenses) collaboration, with an average time resolution of 5 days. Study of the three-dimensional structure of the inner Small Magellanic Cloud (SMC) found to be spheroidal or slightly ellipsoidal. Classical Be candidates in the LMC was found to have a new sub class, which is not found in our Galaxy or in the SMC. A study on the recent star formation history of the Magellanic Clouds suggest a shrinking of star formation to the inner regions of these galaxies.

GMRT 1280 MHz radio continuum observations and follow-up optical studies of the disk and nuclear star formation in a sample of low luminosity bulgeless galaxies were performed. Optical spectroscopic and R-band photometric monitoring observations were carried out on a new low luminosity AGN. The electron spectral energy index at high redshift radio galaxies is theoretically estimated to be mostly due to synchrotron losses modified by redshift correction and inverse Compton losses. Magnetic fields correlated on kiloparsec scales seen in disc galaxies were studied.

In the area of atomic and molecular physics, a new experiment was proposed to measure the electric dipole moment (EDM) of atomic Indium arising from time-reversal/CP and parity violations. Relativistic coupled-cluster theory was used to determine the enhancement factor (ratio of atomic EDM to the electron EDM) of this atom. Large scale relativistic coupled-cluster calculations of the electric dipole parity nonserving 6S-5D transition amplitude in singly ionised ytterbium (Yb+) were carried out. An experiment to observe this effect is underway at the Los Alamos National Laboratory, USA. The combined results of experiment and theory has the potential to test the electroweak sector of the Standard Model of particle physics. The 5P(J = 3/2) – 6S (J = 1/2) transition in Indium is of interest in the solar abundance of that element. It is the only indium line that has been observed in the solar spectrum so far. The strength of this line and a number of other lines resulting from transitions between the low lying states of Indium which could perhaps be observed in the future was theoretically determined. The quantum phases of ultracold bosonic atoms in a periodic optical superlattice were analyzed. The calculations for the study were carried out using the decoupling mean field approximation. The Fock space multireference coupled cluster (FS-MRCC) method for the electron detachment process has been applied to determine the magnetic hyperfine constant A_J and nuclear quadrupole moments Q (related to electric hyperfine constant B_J) for the lowest multiplets of $^{33}S^-$, ^{35}Cl and ^{37}Cl with larger basis sets. The ionization potentials, transition energies and oscillator strengths of He I and Li I isoelectronic systems are computed at different plasma environment.

Professor M. G. K. Menon along with Professor S. S. Hasan during the inauguration of the meeting held to commemorate the Silver Jubilee of VBT.

In the area of optical sciences, wavefront sensing issues in large aperture telescope systems were studied using Monte-Carlo and numerical simulations. A low cost turbulence generator for AO (adaptive optics) testing was developed. Measurement and mod-

eling of the influence function was studied in assessing the performance of the continuous MEMS deformable mirror (DM) for adaptive optics applications. Also research on wavefront sensing using Shack Hartmann wavefront sensor as well as interferometric technique using Babinet Compensator is being carried out. Simulations which were performed also show the capabilities of hypertelescopes to image exo-planets, crossing the disk of the well resolved parent star. A Fabry-Perot narrow band imager (NBI) is being built for solar studies at IIA. A constant temperature is required to keep the transmission response of the interference filter stable during the observations. A low-cost, temperature measurement and control system is, therefore, designed and built in the lab.

On the developmental front, integrated tests of the optical system of the 1.3-m telescope and the integrated telescope were carried out. The telescope pier as well as concrete support structure for the steel building and dome was completed in July 2011. The development of a mosaic CCD system for the 1.3 m telescope has been taken up at VBO. The site characterization activities for the NLOT activities continued at Hanle and surrounding regions. BARC, Mumbai is collaborating with IIA in the development of a new gamma ray facility, the Major Atmospheric Cerenkov Experiment (MACE).

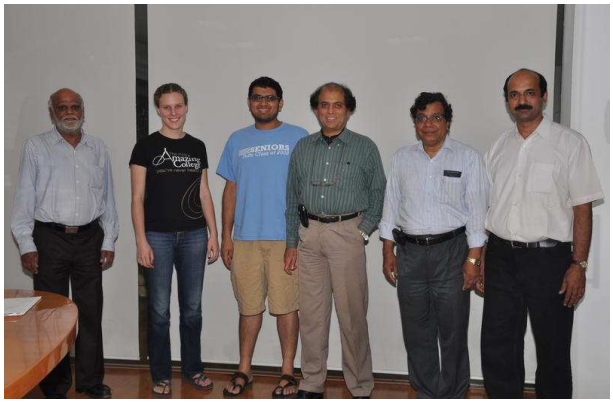
The engineering model of the Ultraviolet Imaging Telescope (UVIT), a payload on India's first dedicated astronomy satellite ASTROSAT, was assembled and tested extensively. Assembly of the flight model commenced in the Class 100 area of the MGK Menon Laboratory at IIA's Hosakote campus. The fabrication of a Visible Emission Line Coronagraph payload on Aditya I to study the solar corona is progressing well. The optical design of the coronagraph was recently prepared and reviewed. A new broad band radio antenna system was commissioned at the Gauribidanur observatory. The antennae were designed and fabricated in house. Expansion of the radioheliograph at the Gauribidanur observatory is also underway.

The Hanle Echelle Spectrograph (HESP), a high resolution spectrograph for the 2-m HCT telescope, is progressing well. The spectrograph design is a compact instrument with large wavelength coverage and high throughput, based on a white pupil concept. A complete wavelength coverage in the range 350 – 1000 nm, will allow measurements of chemical abundances of key elements of stellar evolution.

Turning to new mega facilities, the 2-m National Large Solar Telescope (NLST) project, a unique facility proposed by the Institute for observing the Sun at high resolution, was endorsed by the IIA Governing Council in October 2011. In addition, IIA has played a lead role in co-ordinating India's participation in the the international Thirty Meter Telescope Project, to build and operate the next generation of a ground based mega optical and IR telescope facility. NLST and TMT have been recommended by a national committee for implementation in the 12th five year plan. Development of prototype systems for both the projects is in full swing.

Professor Mushirul Hasan, Director General, National Archives of India, delivered the bicentennial lecture "Is there a Gandhian Legacy?".

Twenty five years have passed since the 2.3-m Vainu Bappu Telescope (VBT) was inaugurated and dedicated to the nation on January 6, 1986 by the late Shri Rajiv Gandhi, then Prime Minister of India. The indigenously built VBT is still the largest optical facility in Asia and continues to be an indispensable facility for research and training in the country. The Institute organized a three-day meeting to commemorate the Silver Jubilee of VBT. The inaugural session was appropriately held on Founder's Day August 10, 2012 as a tribute to Prof. M. K. V. Bappu's vision and dedicated efforts that went in to the realization of this monumental project. Prof. M. G. K. Menon, was the Chief Guest and delivered the Founder's Day lecture entitled "The Founder of



IRES students with Professor S. S. Hasan after their project presentation.

IIA – Vainu Bappu: Many memories and the lessons we can learn from him". He released a specially prepared commemorative volume on VBT and presented mementoes to several dignitaries and groups for their pioneering contributions to the facility. As part of the Silver Jubilee celebrations, another meeting on "Recent Advances in Star Formation: Observations and Theory" was organized at the Bangalore campus during June 28 – July 1, 2011.

The Vainu Bappu Memorial Lecture Award for 2012 was presented to Professor Nigel O. Weiss, FRS from the University of Cambridge, UK. Professor Weiss delivered the fifth Vainu Bappu Lecture on March 9, 2012 entitled "The Chaotic Dynamo in the Sun". Prof. Mushirul Hasan, Director General, National Archives of India, delivered the bicentennial lecture titled "Is there a Gandhian Legacy?", on April 9, 2011. Professor Laurent Gizon, Max Planck Institute for Solar System Research, Lindau, Germany delivered a special lecture on September 30, 2011 on "Seismology of the Sun and Sun-like Stars".

A meeting was organized at IIA, Bangalore (November 2–3, 2011) to bring together solar physicists in the country to discuss ways and means to build greater synergy in science programmes with the planned and upcoming solar facilities. A one day workshop on "Cosmology and Galaxies" was held on November 28, 2011. A two-day brain storming workshop on resource material for day-time astronomy was jointly organized by Vigyan Prasar and Indian Institute of Astrophysics at Bangalore on November 18 – 19, 2011. National Science day was celebrated at IIA on February 28, 2012 in which a large number of students from several schools in Bengaluru participated. The library collections have kept pace with existing academic & technical programs of the Institute and new ones will be added soon. Event related exhibits were organized from time to time using the contents from the Archives. On the occasion of the Silver Jubilee of the Vainu Bappu Telescope at Kavalur, the IIA library organized a photographic exhibition.

With the rising demand for larger memory and higher processing speed, a new data centre was set up at the IIA Bangalore campus. This centre, operational since June 2011, has a new-20 node high performance computing cluster with a peak performance of 5.8 TFlops. The data centre also hosts over 100 years of digitized solar images from the Kodaikanal Solar Observatory and other facilities.

IIA's Ph.D programme along with the recently started Integrated M.Sc-Ph.D programme in Physics and Astrophysics and the Integrated M.Tech-Ph.D (Tech.) programme in Astronomical Instrumentation are progressing well. The second batch of seven students from the integrated programmes completed their Masters degrees. Like previous years, the Institute hosted two students from U.S.A. to carry out research projects with our faculty under the International Research Experience for international students (IRES) programme that is supported by the National Science Foundation of U.S.A. In addition, the Institute continues its Visiting Students and Summer project programmes. Five students were awarded Ph.D degrees and three more have submitted their Ph.D theses on a wide range of topics. Avijeet Prasad, an IIA graduate student, received the prestigious Shyama Prasad Mukherjee Fellowship from the DST. In addition, I would like to felicitate my colleagues who have received awards and honours for their scientific and technical work.

IIA continued its efforts in the implementation of the official language. The IIA Newsletter has been carrying articles in Hindi. In addition to language workshops, the Institute organized a variety of language-based cultural activities with enthusiastic participation by our staff. The Institute continues to play a constructive and important role in building an equitable work environment by safeguarding the interests of SCs and STs as well as women.

Siraj Hasan
Director

Chapter 1

Research

1.1 Solar Physics

Testing Doppler observations by the Helioseismic and Magnetic Imager (HMI) onboard Solar Dynamics Observatory (SDO)

The Helioseismic and the Magnetic Imager (HMI) instrument produces line-of-sight observables (Doppler velocity, magnetic field strength, Fe I linewidth, linedepth, and continuum intensity) as well as vector-magnetic-field maps at the solar surface. The accuracy of the line-of-sight observables is contingent upon the quality of the observables algorithm used to translate HMI filtergrams of an observables sequence into observables quantities. Using one hour of high-cadence imaging spectropolarimetric observation of a sunspot in the Fe I line at 6173 Å through the Interferometric BI-dimensional Spectrometer (IBIS) and the Milne-Eddington inversion of the corresponding Stokes vectors, the accuracy of the observables algorithm currently implemented in the HMI pipeline at Stanford University has been tested: the so-called MDI-like algorithm. This algorithm is also compared to others that may be implemented in the future in an attempt at improving the accuracy of HMI observables: a least-squares fit with a Gaussian profile, a least-squares fit with a Voigt profile, and the use of second Fourier coefficients in the MDI-like algorithm.

(S. Couvidat, S. P. Rajaguru, R. Wachter*, J. Schou*, P. H. Scherrer* & K. Sankarasubramanian*)*

High-frequency wave power halos around active regions: some new results from SDO observations

The authors have studied properties of waves of frequencies above the photospheric acoustic cut-off of 5.3 mHz, around four active regions, through spatial maps of their power estimated using data from

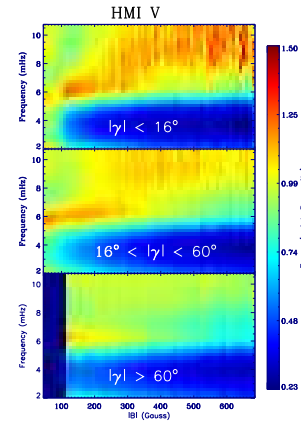


Figure 1.1: Acoustic power normalized to quiet-Sun values, averaged over three different ranges of γ (as marked in the panels), as a function of total magnetic field strength B. These results are from Doppler observations of four active regions (NOAA11092, 11161, 11243, and 11306) made by the HMI onboard SDO. The enhanced power (upto about 50% of quiet-Sun values) in the 7.5 – 10 mHz range and over 300 – 600 G B fields is a new detection attributed to additional wave energy deposition due to the fast magneto-acoustic wave refraction around sunspots.

Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) onboard Solar Dynamics Observatory (SDO). The wavelength channels 1600 Å and 1700 Å from AIA are now known to capture clear oscillation signals due to helioseismic p modes as well as waves propagating up through to the chromosphere. Here they have studied in detail, in comparison with HMI Doppler data, properties of the power maps, especially the so called 'acoustic halos' seen around active regions, as a function of wave frequencies, inclination and strength of magnetic field (derived from the vector field observations by HMI) and observation height. They infer possible signatures of (magneto-)acoustic wave refraction

from the observation height dependent changes, and hence due to changing magnetic strength and geometry, in the dependences of power maps on the photospheric magnetic quantities. An an example result on the high-frequency wave as a function of magnetic field strength and inclination is shown in (Figure 1.1). The implications for theories of p mode absorption and mode conversions by the magnetic field are discussed.

(S. P. Rajaguru)

Omnipresent long period oscillations in open structures

The nature of the propagating intensity disturbances in the solar atmosphere is studied. It is important to understand their nature to estimate their contribution to coronal heating or to proceed for further applications in coronal seismology. Using a three hour imaging sequence from Atmospheric Imaging Assembly (AIA) on board Solar Dynamic Observatory (SDO), oscillations in three different open structures; a fan loop structure off-limb, an on-disk plume like structure, and the plume/interplume regions in the north pole, were studied. Time series at each pixel location in each of these regions was subjected to wavelet analysis. Powermaps in three different period ranges, short (2 min – 5 min), intermediate (5 min – 12 min), and long (12 min – 25 min) were constructed by adding the power in the individual range above the 99% significance level.

Powermaps for the off-limb loop are shown in Figure 1.2 in both 171 Å and 193 Å channels of AIA. The on-disk plume like structure has been explored further using space–time analysis. Spatial damping along this structure has also been investigated. The major findings of this study are listed below.

- The power in long periods is significant up to larger distances along the loop compared to that in the shorter periods. This implies the high frequency oscillations are damped faster.
- Space–time analysis shows faster propagation speeds in hotter channels. Also the amplitude of the oscillation is lower in hotter channel.
- Spatial damping is observed along the loop and the damping lengths are shorter in hotter 193 Å channel. This suggests thermal conduction as a possible mechanism for damping.
- Previous studies indicate that the periodicities observed in active region fan loops are shorter compared to that in polar plume/interplume regions. In the present study long period oscillations are found to be omnipresent at larger heights even in active regions.

All the observed properties can be explained by a simple slow wave model. This suggests the observed propagating disturbances are more likely to be signatures of slow magneto-acoustic waves rather than high speed quasi-periodic up flows.

(S. Krishna Prasad, D. Banerjee, T. Van Doorsselaere & J. Singh)*

Dynamics of Coronal Bright Points as seen by SWAP, AIA, and HMI

X-ray bright points (XBPs) are prominent dynamical features in quiet-Sun and coronal hole regions. These features were first seen in rocket X-ray telescope images and were reported as small X-ray emitters with a spatial size of less than 60 arcsec and lifetime ranging from a few hours to a few days. Bright points are always found to be associated with small, opposite-polarity poles in photospheric magnetograms, which have typical total flux of $10^{19} - 10^{20}$ Mx. XBPs are likely signatures of small loops that connect the opposite polarities of some small-scale bipoles. It is estimated that one third of the bright points lie over ephemeral regions, which are newly emerging regions of magnetic flux, whereas the remaining two thirds lie above canceling magnetic features, which consist of opposite polarity fragments that approach one another and disappear.

The formation, lifetime, temporal evolution and the association with the photospheric magnetic field of several BPs in SWAP, and AIA images are studied. SWAP provides images of the solar corona in an EUV channel centered at 174 Å with a bandpass width of about 15 Å. Full disk AIA (193,211 and 171 channels) images and HMI on board SDO during 13 February, to 15 February 2011 have been used. Ten bright points have been identified and their intensity oscillation properties have been analysed. Figure. 1.3 shows the bright point(BP1) selected to study the complete evolution and dynamics. Multiple connectivities in BPs have been noticed. From the formation stage of the bright point, and throughout its entire lifetime, there is a continuous emergence of new magnetic flux and there is a good overall correlation between the total magnetic flux and emission from the bright points in several UV and EUV. It is observed that the bright points are miniature active regions with multiple connectivities and with sev-

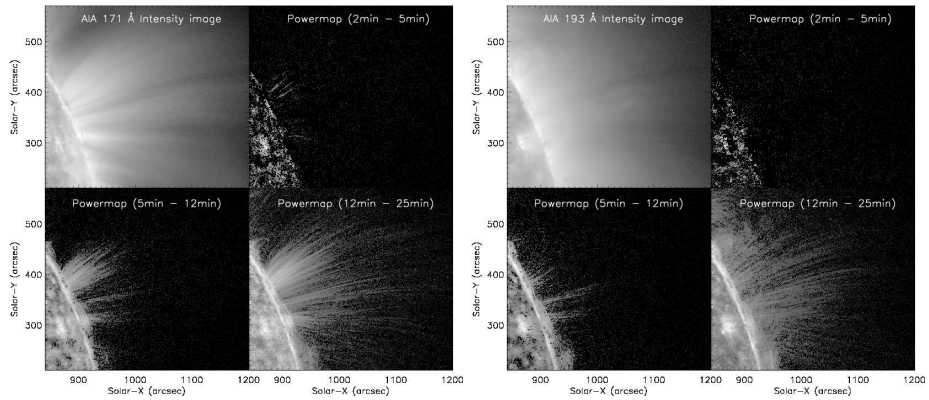


Figure 1.2: Powermaps constructed in three different periodicity ranges for the off-limb loop structure in 171 Å (left) and 193 Å (right) channels of AIA. Top left panels show the original intensity image.

eral loop structures. Another set of important characteristics of BP dynamics are oscillations in intensity. Several studies in EUV and soft X-ray spectral lines have reported a wide range of periodicities. The bright points studied here also show periodic brightenings and the authors have attempted to find the oscillation periods in bright points and their connection to magnetic flux changes. The observed periods are generally long (10-25 minutes) and there is an indication that the intensity oscillations may be generated by repeated magnetic reconnection. Finally the authors have attempted to study whether or not the periodic brightenings of the CBPs can be used for coronal seismology. There are some indications that the period ratio P1/P2 changes during the lifetime of the bright points, which may suggest a scenario of either magnetic-field divergence or density stratification as claimed by Kumar et. al. But it must also be pointed out that a convincing theory has not been found that the period ratio can indeed be used as a tool for inferring the driver of such periodic brightenings. Further statistical work on this is required to come to a conclusion, which will be done in the future.

(K. Chandrashekhar, S. Krishna Prasad, D. Banerjee, B. Ravindra & D. B. Seaton)*

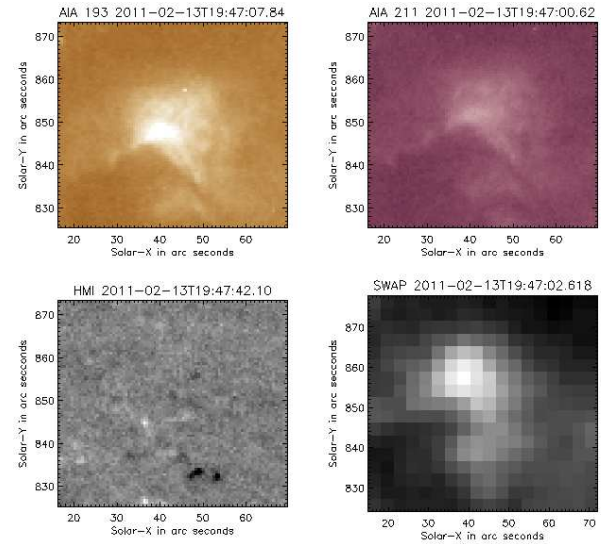


Figure 1.3: BP1 as seen in different channels of AIA (top row), HMI (bottom left) and SWAP (bottom right).

Acoustic emission from flux tubes in the solar network

Numerical simulations of dynamical phenomena in a magnetic flux tube extending vertically through the solar network were carried out. The response of the tube due to the following type of footpoints motions is examined: (a) transversal motions that mimic granular buffeting, and (b) torsional motions that mimic vortex flows. These motions generate slow and fast magneto-acoustic waves in the magnetic flux tube as well as in the ambient medium. The acoustic power is calculated at the boundary of the flux tube by considering three magnetic flux isosurfaces located at radial distance 0.2 Mm, 0.3 Mm and 0.4 Mm from the axis of the flux tube at a height of 1 Mm above the base of the photosphere. The acoustic fluxes are calculated by taking the normal component of velocity on different iso-surfaces of the magnetic flux tube. The authors find that the horizontal excitation results in relatively stronger acoustic emission when compared to the torsional excitation. They also see that the acoustic flux directed normal to the flux-tube boundaries is significantly

lower than the fluxes directed along the magnetic flux-tube.

(G. Vigeesh & S. S. Hasan)*

Scattering expansion method for solving Hanle radiative transfer problem

The resonance scattering is responsible for the generation of a linearly polarized solar spectrum. The magnetic field modifies this linear polarization through the well-known Hanle effect. The shape of the linear polarization profiles of the spectral lines reveals a great deal of information about the anisotropy that prevails in the solar atmosphere. Equally important is the physics of line scattering namely the details of the frequency redistribution during scattering. It is well-known that for a finer analysis of the polarized spectrum, particularly of the strong resonance lines, the angle-dependent partial frequency redistribution (PRD) is necessary.

Based on the theory of Stokes vector decomposition for the Hanle effect combined with the Fourier azimuthal expansion of the angle-dependent PRD function, the authors have formulated an efficient numerical method of solving the concerned transfer problem in one-dimensional media. This iterative method (called as the scattering expansion method, SEM) is based on a series expansion of the polarized source vector in mean number of scatterings. The SEM is shown to be an efficient method to solve angle-dependent PRD problems involving the Hanle effect. The authors show that compared to the earlier methods such as the perturbation methods, the SEM is stable and faster and find that angle-dependent PRD significantly affects the Stokes U parameter (Figure 1.4).

(K. N. Nagendra & M. Sampoorna)

Polarized light scattering on subordinate lines

While it is true that most of the strong lines in the solar spectrum are resonance lines (the lower level being the ground state of the atom), there are several lines that are subordinate (with a broadened lower level) and are polarized. It is quite common in line formation theory to treat scattering in subordinate lines under the assumption of complete frequency redistribution (CRD). The partial frequency redistribution (PRD) in subordinate lines cannot always be approximated by CRD, especially when polarization state of the line radiation is taken into account.

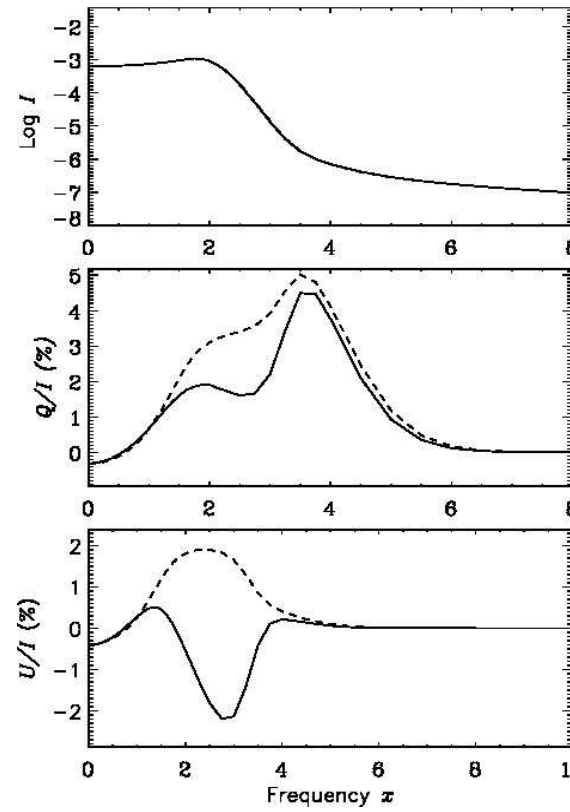


Figure 1.4: Comparison of the emergent linear polarization profiles computed using the angle-dependent (solid line) and the angle-averaged (dashed line) PRD theory.

The authors derive a suitable form of the laboratory frame PRD matrix for the resonance scattering in subordinate lines. They allow for the radiative and collisional broadening of both the upper and lower levels. The elastic collisions both in the upper and lower levels are taken into account. They show that, in situations, when elastic collisions in the lower level can be neglected, the PRD matrix for subordinate lines takes a form that is analogous to the corresponding case of resonance lines. Further, in the case of no-lower-level interactions (i.e., infinitely sharp lower level), the authors recover the PRD matrix for resonance lines.

(M. Sampoorna)

Polarized line transfer in multi-dimensional media with angle-dependent partial frequency redistribution

The solution of polarized radiative transfer (RT) equation with angle-dependent (AD) partial frequency redistribution (PRD) is a challenging problem. Mod-

eling the observed, linearly polarized strong resonance lines in the solar spectrum often requires the solution of the AD line transfer problems in one-dimensional or multi-dimensional (multi-D) geometries. Here, a Fourier decomposition technique to solve AD PRD polarized RT problem in multi-D media is developed to understand the relative importance of the AD PRD effects and the multi-D transfer effects and particularly their combined influence on the line polarization.

Results:(1) An efficient Fourier decomposition technique to handle the AD PRD in multi-D polarized RT is developed. (2) It is proved that the symmetry of the polarized radiation field with respect to the infinite axis, that exists for a non-magnetic 2D medium for the AA PRD (as shown in Anusha, Nagendra & Paletou, 2011b, ApJ, 726, 96) breaks down for the AD PRD. (3) The results of the very first investigations of the effects of the AD PRD on the polarized line formation in multi-D media are presented. It is found that the relative AD PRD effects are prominent in the magnetic case (Hanle effect). It is concluded that the AD PRD effects are important for interpreting the observations of scattering polarization in multi-D structures on the Sun (Figure 1.5).

(L. S. Anusha & K. N. Nagendra)

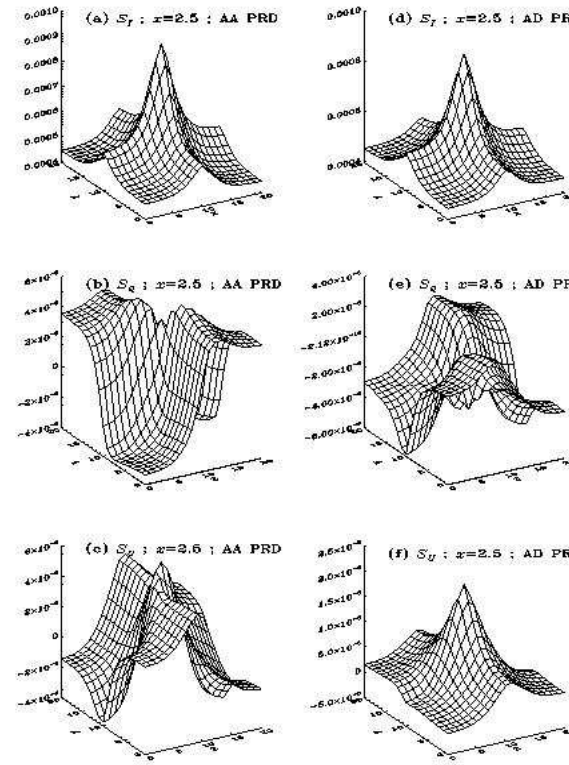


Figure 1.5: Surface plots of the source vector components for the angle-averaged (AA) (left panels) and the angle-dependent (AD) PRD (right panels). The source vector components are plotted as a function of the grid indices along Y and Z directions. Here the value of the magnetic field is given by $(\Gamma, \theta_B, \chi_B) = (1, 90^\circ, 60^\circ)$.

Coronal type II bursts and interplanetary type II bursts: distinct shock drivers

It is largely accepted that the shocks lead to plasma emission in the solar corona that appear as type II bursts and observed in the radio dynamic spectrum as slowly drifting features. Solar radio type II bursts are important because of their role in driving particle acceleration in the Sun that affects terrestrial atmosphere. Therefore it is necessary that the solar source of such particle acceleration is established. The near Earth shocks are often traced to interplanetary type II emission. In order to identify their early signature if any in the Sun, it is often suggested that the coronal type II bursts, especially in the meter wavelength range are caused by the same shock drivers that are also responsible for the interplanetary type II bursts. With a view to establish the same, a study involving two years data (2000 and 2001) of solar radio type II bursts obtained from the archive of solar geophysical data and the coronal mass ejections (CME) from the SOHO LASCO listing and also the interplanetary type II bursts from WIND/WAVES listing is used to understand the correlation if any, between the coronal type II bursts and interplanetary type II bursts. Several issues are addressed. Firstly, statistically it is found that most of the coronal type II emission end within a narrow range of height in the corona. Secondly, a new method has been proposed that enables us to compute the effectiveness of shocks to cause type II emission and helps to estimate the height upto which a given CME would drive the burst. Thirdly, one can observe that a large number of CMEs have been reported for the years 2000 and 2001 but only a small fraction of the same are known to posses kinetic energies that may drive type II emission to significant heights in the sun. A poor correlation was also observed between the occurrence heights and times of coronal type II bursts and interplanetary type II bursts. Considering all these issues alongwith variation in Alfven speed, it has been suggested that most of the coronal type II bursts and interplanetary type II bursts are caused by distinct shock drivers. This scenario is figuratively indicated in Figure 1.6.

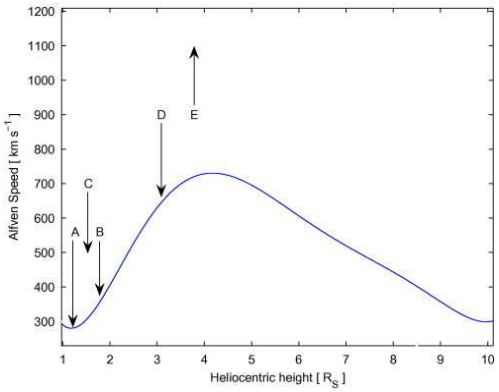


Figure 1.6: The arrow marks A,B,C,D and E in this figure represent the mean start frequency of 120 MHz (1.2 RS), the mean end frequency of 35 MHz (1.7 RS) of coronal type II bursts, the mean CME speed of $\sim$ 500 km s^{-1} associated with the coronal type II emission, the mean height of commencement of a large number of IP type II bursts ($\sim$ 3.0 RS) and the mean CME speed of $\sim$ 1100 km s^{-1} associated with IP type II occurrence in that order..

(G. S. Suryanarayana)

First results on irradiance measurements from LYRA and SWAP

The first and preliminary results of the photometry of Large Yield Radiometer (LYRA) and Sun Watcher using Active Pixel system detector and Image Processing (SWAP) onboard PROBA2 are presented here. To study the day-to-day variations of LYRA irradiance, the authors have compared the LYRA irradiance values (observed Sun as a star) measured in Aluminum filter channel (171 Å– 500 Å) with spatially resolved full-disk integrated intensity values measured with SWAP (174 Å) and Ca II K 1 A index values (ground-based observations from NSO/Sac Peak) for the period from 01 April 2010 to 15 Mar 2011. The authors found that there is a good correlation between these parameters. This indicates that the spatial resolution of SWAP complements the high temporal resolution of LYRA. Hence SWAP can be considered as an additional radiometric channel. Also the K emission index is the integrated intensity (or flux) over a 1 A band centered on the K line and is proportional to the total emission from the chromosphere; this comparison clearly explains that the LYRA irradiance variations are due to the various magnetic features, which are contributing significantly. In addition to this the authors have made an attempt to segregate coronal features from full-disk SWAP images. This will help to understand and determine the actual contribution of the individual coronal feature to LYRA irradiance variations.

(S. T. Kumara, R. Kariyappa, M. Dominique, D. Berghmans*, L. Dame*, J. F. Hochedez* & L. P. Chitta)*

Dynamics of the solar magnetic bright points derived from their horizontal motions

The sub-arcsec bright points (BP) associated with the small scale magnetic fields in the lower solar atmosphere are advected by the evolution of the photospheric granules. The authors measure various quantities related to the horizontal motions of the BPs observed in two wavelengths, including the velocity auto-correlation function. A 1 hr time sequence of wideband Hα observations conducted at the Swedish 1-m Solar Telescope (SST), and a 4 hr Hinode G-band time sequence observed with the Solar Optical telescope are used in this work. The authors follow 97 SST and 212 Hinode BPs with 3800 and 1950 individual velocity measurements respectively. For its high cadence of 5s as compared to 30s for Hinode data, the authors emphasize more on the results from SST data. The BP positional uncertainty achieved by SST is as low as 3 km which is at least seven times better than the previous reported results. The position errors contribute 0.75 km s $^{-1}$ to the variance of the observed velocities. The raw and corrected velocity measurements in both directions, i.e., (vx, vy), have Gaussian distributions with standard deviations of (1.32, 1.22) and (1.00, 0.86)km s $^{-1}$ respectively. The BP motions have correlation times of about 22 – 30s. The authors construct the power spectrum of the horizontal motions as a function of frequency, a quantity that is useful and relevant to the studies of generation of Alfven waves. Photospheric turbulent diffusion at time scales less than 200 s is found to satisfy a power law with an index of 1.59.

(L. P. Chitta, R. Kariyappa, A. A. van Ballegooijen*, L. Rouppe van der Voort* & E. E. DeLuca*)*

Role of magnetic flux emergence in the heating of the solar atmosphere

The authors present examples of multiwavelength observations of magnetic flux emergence events using the Helioseismic and Magnetic Imager (HMI) and the Atmospheric Imaging Assembly (AIA) instruments onboard Solar Dynamics Observatory (SDO).

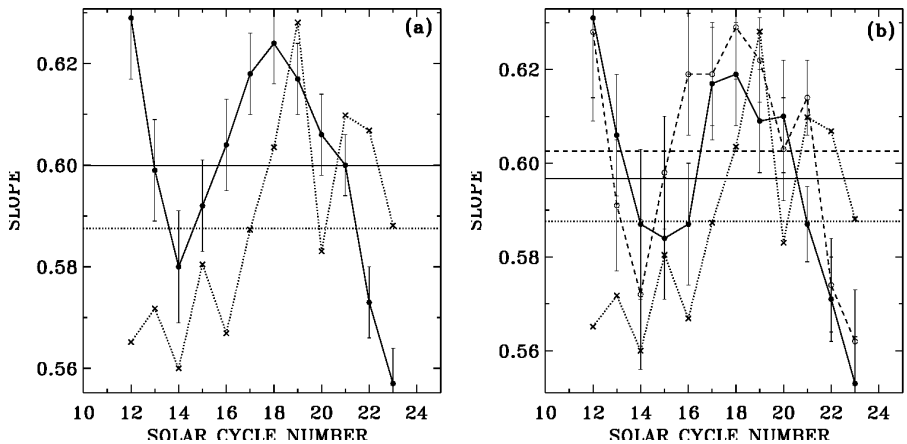


Figure 1.7: Plots of cycle-to-cycle variation in the slope of the linear relationships between $\ln(|D_{n-1,n}|)$ *versus* $\ln(A_{n-1})$ (here n = 2, 3,...,T, T is the life time of the spot group) derived from the data of spot groups in the whole sphere (upper panel) and in the different hemispheres (lower panel): northern hemisphere (open circle-dashed curve) and southern hemisphere (closed circle-solid curve). The cross-dotted curve represents the variation in the amplitudes of the sunspot cycles 12 – 23 (normalized to the scale of the slope). The corresponding values of the mean (over all cycles) are indicated by the horizontal lines of the receptive type.

The emerging flux described in this work appear as a bipolar region at the solar photosphere. The authors study its interaction with the surroundings at different heights in the solar atmosphere and also with the pre-existing (already emerged and detectable flux in the vicinity of new flux emerging regions) flux. Study of such events brings into focus, the importance of initial phase of the flux emergence and show the onset and various phases of atmospheric heating in time which are strongly influenced and dominated by the dynamics of the emerging magnetic field. Work is in progress.

(L. P. Chitta, R. Kariyappa, S. S. Hasan & A. Hanslmeier)*

Sunspot group decay law

The studies on growth and decay of sunspots/sunspot groups (in general active regions) are important for understanding the generation, emergence and evolution of the solar magnetic flux. The authors analysed the combined Greenwich and Solar Optical Observatory Network (SOON) sunspot group data during period 1977 – 2011, and found that there exists a reasonably good correlation and an approximate linear relationship between the logarithmic values of the decay rate (decrease in the area of a spot group between the consecutive days during its life time) and area of the spot group at the first day of the corresponding consecutive days, largely suggesting that a large/small area (magnetic flux) decreases in a faster/slower rate. The slope of the aforementioned linear relationship is found to be varies on a long-time scale of about 90-year, with amplitude of about 0.02 unit (Figure 1.7). In a large number of cycles the slope of the linear relationship is steeper in the northern hemisphere than in the southern hemisphere. However, only in the solar cycles 16 and 21 the differences between the values of the northern and southern hemispheres are found to be somewhat large and statistically significant. The difference in the slopes between northern and southern hemisphere during Cycles 16 and 21, i.e., in a gap of about 5 cycles, may be related to the known 44 – 55 year cycle in solar activity.

(J. Javaraiah)

Long-term variations in the numbers of large and small sunspot groups

Cycle-to-cycle variations: The properties, such as rotation rate, meridional motion, tilt angle, etc., of the sunspots/spot groups depend on the life time/size as well as the age of the spots/spot groups. Studies on these properties of sunspot groups provide information on the subsurface dynamics. Therefore, the studies on the variations in the numbers (counts) of different sizes of sunspots/spot groups are important for understanding the basic mechanism of solar cycle and the relationship of sunspots with other activity

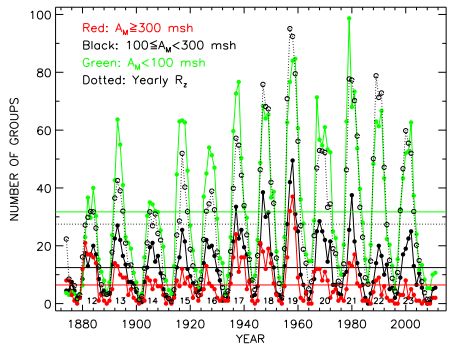


Figure 1.8: Variations in the annual numbers of the small (green curve), large (black curve), and big spot groups (red curve), divided by 3, 2 and 1, respectively, during the period 1874 – 2011 (Note: the data in 1874 and 2011 are incomplete). The open circle-dotted curve represents the values of R_z divided by 2.The horizontal lines represent the respective mean values. Near the maximum of each cycle the corresponding Waldmeier cycle number is mentioned.

indices. The author analysed the combined Greenwich and Solar Optical Observing Network sunspot group data during the period 1874 – 2011 and determined variations in the annual numbers (counts) of the small (maximum area $A_M < 100$ millionth of solar hemisphere, msh), large ($100 \leq A_M < 300$ msh), and big ($A_M \geq 300$ msh) spot groups (Figure 1.8). It is found that the amplitude of an even–numbered cycle in the number of large groups is smaller than that of its immediately following odd–numbered cycle. This is consistent with the well known Gnevyshev and Ohl rule or G-O rule of solar cycles, generally described by using the Zürich Sunspot Number (R_Z). During cycles 12 – 21 the G-O rule holds good for the variation in the number of small groups also, but it is violated by the solar cycle pair (22, 23) as in case of R_Z. This behaviour of the variations in the small groups largely responsible for the anomalous behaviour of R_Z in cycles pair (22, 23). This can be interpreted as the dynamic changes in the shallower layers of the solar convection zone responsible for the anomalous behaviour. It is also found that the amplitude of an odd–numbered cycle of the number of small groups is larger than that of its immediately following even–numbered cycle. This can be called as 'reverse G-O rule'. In the case of the number of the big groups, both the cycle pairs (12,13) and (22,23) violated the G-O rule. The amplitude of the long-term variation in the number of small groups is larger than those of the large and big groups and the period of this variation also seems to be longer than that ($\approx$ 90-year) of the big groups. The long-term trend in the number of small groups implies that the current cycle 24 (and also the next cycle 25) is weak. Variations with the phase of a solar cycle: The author also found that in many solar cycles the positions of the peaks in numbers of the small, large, and big groups are different and considerably differ with respect to the corresponding positions of the R_Z peaks. In the case of solar cycle 23, the corresponding cycles in the numbers of small and large groups are largely symmetric/less asymmetric (Waldmeier effect is weak/absent) with their maxima taking place two years later than that of R_Z. This property might have an impact on the corresponding delay for the occurrence of the maxima of other activity/energetic phenomena. The corresponding cycle of the big groups is more asymmetric (strong Waldmeier effect) with its maximum epoch is same as that of R_Z.

(J. Javaraiah)

EUV network studies

Emission line parameters such as intensity, velocity and width in a polar coronal hole and the nearby quiet Sun region have been obtained from Solar and Heliospheric Observatory (SOHO)/Coronal Diagnostic Spectrometer (CDS) observations. Emission lines originating at different heights in the solar atmosphere from the lower transition region (TR) to the inner corona have been used. The observed region is separated into the network and the cell and the behavior of the quantities were examined in the different regions. It has been found that the network and the cell do not show significant difference in velocities. However the two regions show dramatic difference in linewidths and is more prominent in the coronal hole. The network has always larger width than the cell and the difference tends to reduce towards the corona. Also obtained are the correlations between velocity and width in which an interesting pattern is seen. A mild positive correlation is found between Doppler velocity and width for the lower transition region lines which becomes negative for the inner coronal line. This is probably because of the predominant redshift in the lower TR lines changes sign to blueshift in the upper TR and coronal lines. This is also thought to be related to the wave propagation in the solar atmosphere. The results have implications to the plume-interplume origin of the fast solar wind and coronal heating.

(K. P. Raju & B. J. I. Bromage)*

Synoptic solar studies using Kodaikanal Ca K data

The Ca-K images of the Sun from Kodaikanal have a data span of about 100 years. This covers over 9 solar cycles and hence a good opportunity to study the synoptic solar activity. The Ca-K images are dominated by the chromospheric network and plages which are good indicators of activity. Further, the Ca-K line is a good proxy to the UV irradiance. This is particularly useful in the pre-satellite era where UV measurements are not available. The archival data is now available in the digitized form. Programs have been developed for data reduction and analysis. Some preliminary results on network and plage indices from the Ca-K images have been obtained. Further analysis is underway.

(K. P. Raju, Amareswari & V. Vaddina)*

Model for solar granules

The authors continue to work on modeling of solar granules by considering the equation of continuity, motion, state, energy along with radiative transfer equation. It is assumed that the energy loss is mainly due to radiative losses. The variations of physical variables are taken only along the direction where the gravity acts. The purpose of this model is to explain the sensitivity of radiative losses with the properties on the fluid (like temperature, pressure, density and velocity of the fluid).

(M. Srinivasa Rao & B. S. Nagabhushana)

Tilt angle of the bipolar sunspots during their initial appearance

With simple physical reasonings, it is derived that tilt angle of the bipolar sunspots during their initial appearance on the surface is directly proportional to their life span and square of magnitude of rotation rates. In order to test these derived results, six years of SOHO/MDI magnetograms are used for the analysis. Tilt angle, life span, magnetic fluxes of the leader and the follower, their separation distance of the bipolar sunspots and, rotation rates during their initial appearance on the surface are computed. Consistent with the derived results, following are important findings: (i) As in the previous studies, irrespective of their magnetic fluxes and their separation distance, tilt angle increases with latitude, (ii) Irrespective of their latitudes, tilt angle is directly proportional to the magnetic flux and separation distance between the bipolar spots, (iii) Tilt angle is directly proportional to square of magnitude of rotation rates and the life span of bipolar spot groups and, (iv) On average, life span of the spot groups is a function of latitude.

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

Coronal hole oscillations inferred from the SDO/AIA Data: preliminary results

In recent years, after well known sunspots, evidences are building up that occurrence of solar coronal holes influence the earth's atmosphere and climate. As part of ISRO funded project, the authors plan to study the thermal and dynamic properties of the coronal holes. In the present study, with a high temporal resolution (12 sec) of about two hour duration, data of coronal hole structures in 171 Å, 193 Å and 211 Å taken from SDO/AIA images are considered for examination of oscillations. Total DN counts of whole coronal hole structure in three wavelength bands are computed and the resulting time series are subjected to FFT and wavelet analyses. It is found that significant periods in all the three wavelength bands detected are mainly concentrated around 500 sec as a fundamental mode and its odd (167, 100, 71, 56, 46, 39, 33, 29, 26, 24 seconds) harmonics. In all the three wavelengths, phases of these detected periods are approximately constant suggesting standing oscillations. It is not surprising that property of these detected periods (fundamental with odd harmonics) also suggests that coronal hole tube is closed (narrowed) at one end (in the solar interior) and open at the other end (in the corona). It is conjectured that these standing oscillations are due to Alfven waves. With reasonable assumption of magnetic and density structures of the coronal hole and in order to satisfy the observed fundamental period (near 500 sec), origin of Alfven wave perturbations is estimated to be around $0.6R_{\odot}$.

(K. M. Hiremath & M. Hegde)

Indian summer monsoon rainfall: dancing with the tunes of the Sun

Economy of billions of people of the Indian subcontinent mainly depends upon summer monsoon rainfall whose variability in the past and in future has to be clearly understood. Without giving any physical linkages, overwhelming evidences from the instrumental recorded and paleoclimatic data show that sun indeed influences the Indian summer monsoon

rainfall. In order to unravel the mystery of physical link between the sun and monsoon rainfall and as a part of ISRO funded project, from the coupled cloud-and-rain-related hydrodynamic equations, a single ordinary differential equation for the rate of precipitation is derived. This equation is similar to equation of a forced harmonic oscillator with cloud and rain water mixing ratios as forcing variables. Those internal driving factors are, in turn, parameterized in terms of the combined effect of external forcing arising from sunspot (representing closed solar magnetic field) and coronal hole (representing open solar magnetic field) activities with several well known solar periods (9, 13 and 27 days; 1.3, 5, 11 and 22 years). The equation for the rate of precipitation is numerically solved as an initial value problem. Numerical results show that variability of the simulated rate of precipitation corresponds surprisingly well to actual variability of the Indian Monsoon rainfall (see Figure 1.9) and thus yielding more relevant clues for the physical mechanisms that are so far eluded from statistical correlation analyses alone. A plausible connection has been proposed between cloud and rain water variabilities and solar activity variations on interannual to decadal timescales.

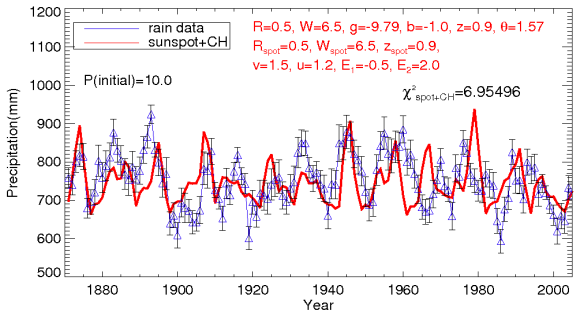


Figure 1.9: For the years 1871-2005, simulated (red continuous curve) annual rate of precipitation with the observed (blue continuous curve with error bars) Indian summer monsoon rainfall.

(K. M. Hiremath, M. Hegde & W. Soon)*

Possible linkages between the Indian summer monsoon rainfall and solar variability and genesis of solar cycle and activity phenomena

The SOHO data is used for the period of 2005–2008 to detect the coronal hole (CH) and different physical parameters (such as heliographic coordinates, area, thermal flux, energy, temperature and strength of magnetic field structure) are extracted. Thus totally the authors have half a solar cycle (2001–2008) CH data set for examining possible linkages of the solar variability with the Indian summer Monsoon rainfall activity, which is the main and ultimate aim of this project. During the period of 2001–2008, as of present report, totally 776 days of CH data are detected and different daily physical parameters are computed. This data set will not only be useful for finding the relationship between Indian Monsoon rainfall but also be used for examining some of the solar problems.

(K. M. Hiremath & M. Hegde)

Low frequency observations of polarized emission from long-lived radio sources in the solar corona

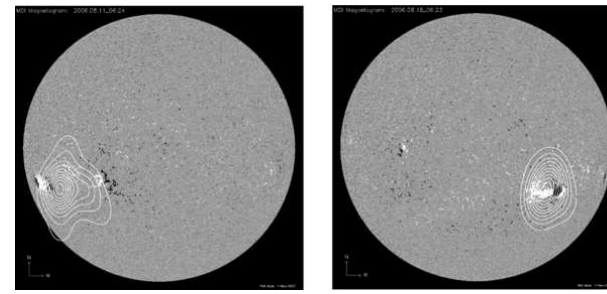


Figure 1.10: Left panel: Composite of the radioheliogram observed with the GRH at 77 MHz on 2006 August 11 around 06:30 UT and SOHO-MDI magnetogram obtained during the same period. The peak radio brightness temperature Tb is 6.3 x 10^7 K, corresponding to the discrete source near the east limb of the Sun. The contour interval is 0.8 x 10^7 K. AR 10904 is the bright active region located to the east of the centroid of the aforementioned radio source. Right panel: same as the image in the left panel, but on 2006 August 18. The peak radio Tb is 7.1 x 10^7 K and the contour interval is 0.6 s 10^7 K. AR 10904 had rotated close to the west limb in this image.

The magnetic field dominates most of the solar corona, playing a crucial role in the formation and evolution of the structures there. Despite its fundamental importance, only a very few direct measurements of the coronal magnetic field are available. Extrapolation of the observed solar surface magnetic field distribution under the assumption that it is potential or force-free is the most widely used technique. In the radio domain, high-resolution circular polarization observations at microwave frequencies (GHz) have been used to measure the field strengths

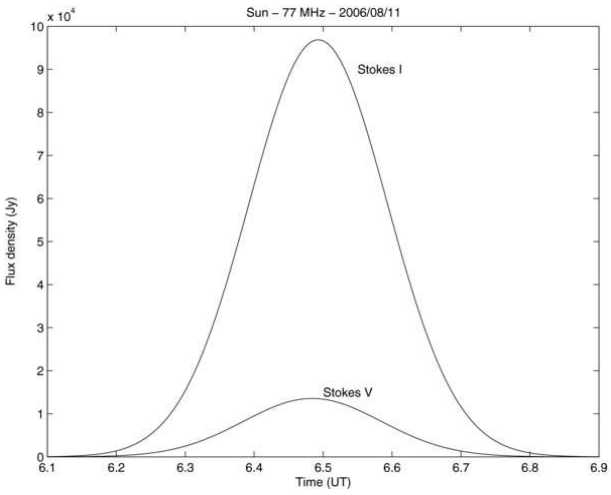


Figure 1.11: East-West one-dimensional Stokes I and V observations of the Sun at 77 MHz around its transit over the local meridian at Gauribidanur on 2006 August 11.

at a radial distance of r > 1.05 solar radii above sunspot regions. Moving to larger radial distances, it is possible to obtain information on coronal magnetic fields through: (i) Faraday rotation observations (at r > 5 solar radii) of microwave signals emitted by transmitters on board artificial satellites and distant background cosmic sources that pass through the solar corona; and (ii) low-frequency observations of circularly polarized radio emission from transient burst emission of various types in the middle corona, i.e., 1.2 – 3 solar radii range. Note that linear polarization, if present at the coronal source region, tends to be obliterated at low radio frequencies because of the differential Faraday rotation of the plane of polarization within the observing bandwidth. Among the different coronal structures observed at low radio frequencies, the noise storm continuum sources are one of the potential candidates for the estimation of the magnetic field, particularly in the middle corona, since they are usually circularly polarized and constitute the most frequently observed type of solar activity. Unlike the transient radio bursts which relate to solar flares, the noise storms primarily relate to non-flaring sunspot active regions and last much longer than flares. The emission consists of occasional short-lived (< 1 sec) narrowband radio enhancements (type I or noise storm bursts), often superimposed on continuous, slowly varying, long-lasting (for hours to days) broadband background emission called type I or noise storm continuum. It is now generally accepted that the radiation is due to fundamental (F) plasma emission and the observed circular polarization results from propagation effects in the presence of a magnetic field. The radio polarization is of the ordinary 'o' mode and corresponds to the magnetic polarity of the leading spot. The authors have established the above possibility by estimating the magnetic field in the non-flaring corona through observations of circularly polarized emission from the noise storm continuum source observed with the radio heliograph and the radio polarimeter at the Gauribidanur observatory. (see Figure 1.10 and Figure 1.11).

(R. Ramesh, C. Kathiravan & A. Satya Narayanan)

High angular resolution radio observations of a coronal mass ejection source region at low frequencies during a solar eclipse

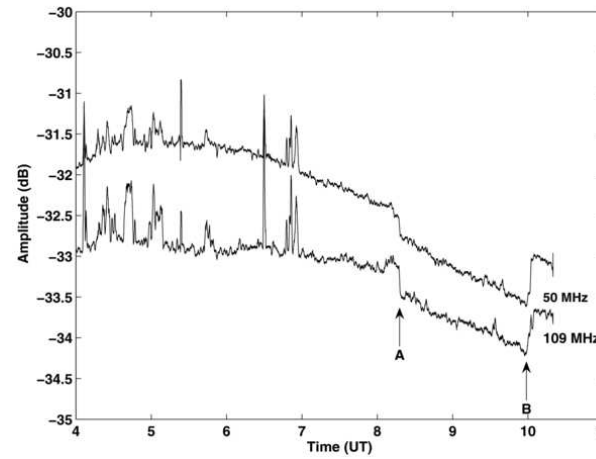


Figure 1.12: Time profile of the radio emission from the solar corona at 50 and 109 MHz observed on 2010 January 15 from the Gauribidanur Observatory. The 'dip' during the time interval 08:17-09:59 UT (indicated by arrows A and B) corresponds to the occultation by the Moon. The integration time used was ∼ 1s.

During a solar eclipse, discrete radio sources on the Sun can be identified with high angular resolution (∼ 10 arcsec) using the diffraction effects at the Moon's sharp limb. Taking advantage of this, the authors have made an attempt to observe small-sized radio sources in the solar atmosphere from where low-frequency radiation (< 100 MHz) originates. Observations during a solar eclipse, particularly at frequencies < 100 MHz, are an useful tool to look for small-sized discrete radio sources in the solar atmosphere since the angular resolution of the corresponding radio antenna arrays has always been relatively low. The authors have carried out radio observations of the solar corona in the frequency range 109-50 MHz

during the annular eclipse of 2010 January 15 from the Gauribidanur Observatory. The radio emission in the above frequency range originates typically in the radial distance range $\sim$ 1.2 - 1.5 solar radii in the 'undisturbed' solar atmosphere. From the observations the authors have found that: (i) the angular size of the smallest observable radio source (associated with a coronal mass ejection in the present case) is $\sim$ 1 arcmin; (ii) the source size does not vary with radial distance; (iii) the peak brightness temperature of the source corresponding to the above size at a typical frequency like 77 MHz is 3 X 10^9 K; and (iv) the coronal magnetic field near the source region is 70 mG. (see Figure 1.12).

(C. Kathiravan, R. Ramesh, Indrajit V. Barve & M. Rajalingam*)*

1.2 Stellar and Galactic Astrophysics

A study of the role of Lyman β fluorescence on OI line strengths in Be stars

The possibility of the Lyβ fluorescence mechanism being operational in classical Be stars and thereby contributing to the strength of the OI 8446 Å line has been recognized for long. However this supposition needs to be quantified by comparing observed and predicted OI line ratios. In the present work, optical and near-infrared spectra of classical Be stars are presented. The observed strengths of the OI 7774, 8446, 11287 and 13165 Å lines which have been theoretically proposed as diagnostics for identifying the excitation mechanism have been analysed. In the present work the authors have considered and examined the effects of Ly β fluorescence, collisional excitation, recombination and continuum fluorescence on these Oi line strengths. From the analysis it appears that the Ly β fluorescence process is indeed operative in Be stars.

(B. Mathew, D. P. K. Banerjee*, A. Subramaniam & N. M. Ashok*)*

Optical spectroscopy of Classical Be stars in open clusters

A spectroscopic study of 150 Classical Be stars in 39 open clusters using medium resolution spectra in the wavelength range 3800 – 9000 Å have been studied. One-third of the sample (48 stars in 18 clusters) has been studied for the first time. All these candidates were identified from an extensive survey of emission stars in young open clusters using slitless spectroscopy (Mathew et al. 2008). This large data set covers CBe stars of various spectral types and ages found in different cluster environments in largely northern open clusters, and is used to study the spectral characteristics of CBe stars in cluster environments. About 80% of CBe stars in the sample have Hα equivalent width in the range -1 to -40 Å. About 86% of the surveyed CBe stars show FeII lines. The prominent FeII lines in the surveyed stars are 4584, 5018, 5169, 5316, 6318, 6384, 7513 and 7712 Å. The authors have identified short- and long-term line profile variability in some candidate stars through repeated observations.

(B. Mathew & A. Subramaniam)*

Observational aspects of Galactic chemical evolution theory

A Ph.D program to undertake the abundances of red giant members for open cluster (OCs) has been initiated to improve the understanding of Galactic chemical evolution. Since the Galactic OCs provide a sample of stars homogeneous in age and chemical composition and their distances are well determined, they were recognized as suitable candidates to study the chemical evolution of Galaxy. The authors have analysed high-dispersion echelle spectra ($R \geq 50,000$) of red giant members for eleven open clusters to derive abundances for many elements. The spread in temperatures and gravities being very small among the red giants, nearly the same stellar lines were employed thereby reducing the random errors. The errors of average abundance for the cluster were generally in 0.02 to 0.07 dex range. Our present sample covers galactocentric distances of 8.3–11.3 kpc and an age range of 0.2–4.2 Gyrs.

The main results of this study are abundances relative to Fe for elements from Na to Eu are equal within measurement uncertainties to published abundances for thin disk giants in the field. This supports the view that field stars come from disrupted open clusters. These eleven clusters support the widely held impression that there is an abundance gradient such that the metallicity [Fe/H] at the solar galactocentric distance decreases outwards at about -0.1 dex per kpc. There is a discrepancy in predicting the shape and slope of the metallicity gradient and evolution using variety of objects (blue supergiant stars, Cepheids and OCS by various authors).

Hence, to improve the understanding on the behaviour of [Fe/H] with Rgc, a program has been initiated to study the abundance pattern of field giants that cover a Rgc range of 5–13 kpc. The authors have started observing the objects with 2m Himalayan Chandra Telescope (HCT) at Indian Astronomical Observatory (IAO), Hanle in Ladak region with a resolution of 1300 using grism 7 that covers a wavelength range of 3800–6840 Å.

(A. B. S. Reddy & S. Giridhar)

Comprehensive abundance analysis of red giants in the open clusters NGC 752, 1817, 2360 and 2506

The authors have analyzed high-dispersion echelle spectra (R $>$ 50 000) of red giant members for four open clusters to derive abundances for many ele-

ments. The spread in temperatures and gravities being very small among the red giants nearly the same stellar lines were employed thereby reducing the random errors. The errors of average abundance for the cluster were generally in the range 0.02–0.07 dex. The present sample covers Galactocentric distances of 8.3–10.5 kpc. The [Fe/H] values are −0.02 ± 0.05 for NGC 752, −0.07 ± 0.06 for NGC 2360, −0.11 ± 0.05 for NGC 1817 and −0.19 ± 0.06 for NGC 2506. Abundances relative to Fe for elements from Na to Eu are equal within measurement uncertainties to published abundances for thin-disc giants in the field. This supports the view that field stars come from disrupted open clusters.

(A. B. S. Reddy, S. Giridhar & D. L. Lambert)*

Chemical composition of a sample of candidate post-asymptotic giant branch stars

Elemental abundances have been derived for a sample of nine IRAS sources with colours similar to those of post-asymptotic giant branch (post-AGB) stars. For IRAS 01259+6823, IRAS 05208-2035, IRAS 04535+3747 and IRAS 08187-1905, this is the first detailed abundance analysis based upon high-resolution spectra. Mild indication of s-processing for IRAS 01259+6823, IRAS 05208-2035 and IRAS 08187-1905 has been found and a more comprehensive study of s-process-enhanced objects IRAS 17279-1119 and IRAS 22223+4327 has been carried out.

A contemporary abundance analysis of the high Galactic latitude supergiants BD+39^o 4926 and HD 107369 has also been made. The former is heavily depleted in refractories and estimated [Zn/H] of −0.7 dex most likely gives initial metallicity of the star. For HD 107369 the abundances of α and Fe-peak elements are similar to those of halo objects and moderate deficiency of s-process elements is seen.

The authors have also compiled the stellar parameters and abundances for post-AGB stars with s-process enhancement, those showing significant depletion of condensable elements and those showing neither. The compilation shows that the s-process-enhanced group contains a very small number of binaries, and observed [α/Fe] are generally similar to thick-disc values. It is likely that they represent AGB evolution of single stars.

The compilation of the depleted group contains a larger fraction of binaries and generally supports the hypothesis of dusty discs surrounding binary post-AGB stars inferred via the shape of their spectral energy distribution and mid-infrared interferometry. However, the conditions for discernible depletion, minimum temperature of 5000 K and initial metallicity larger than −1.0 dex found from our earlier work still serve as useful criteria.

(S. Sumangala Rao, S. Giridhar & D. L. Lambert)*

Is the post-AGB star SAO 40039 mildly hydrogen-deficient ?

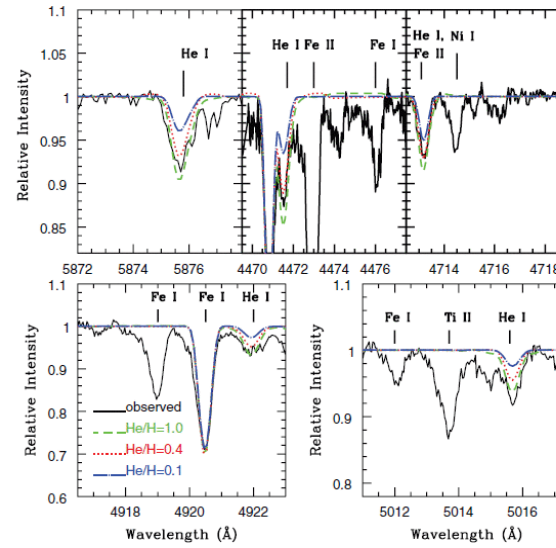


Figure 1.13: The observed and synthesized He I profiles for SAO 40039 using the model with T_{eff} = 8000 K, log g = 1.0 for He/H = 1.0, 0.4 and 0.1.

An LTE abundance analysis has been conducted for SAO 40039, a warm post-AGB star whose spectrum is known to show surprisingly strong He I lines for its effective temperature and has been suspected of being H-deficient and He-rich. High-resolution optical spectra are analyzed using a family of model atmospheres with different He/H ratios. Atmospheric parameters are estimated from the ionization equilibrium set by neutral and singly ionized species of Fe and Mg, the excitation of Fe I and Fe II lines, and the wings of the Paschen lines. On the assumption that the He I lines are of photospheric and not chromospheric origin,a He/H ratio of approximately unity is found by imposing the condition that the adopted He/H ratio of the model atmosphere must equal the ratio derived from the observed He I triplet lines at 5876, 4471, and 4713 Å, and singlet lines at 4922 and 5015 Å. Figure 1.13 shows the agreement between the observed and synthesized He I profiles for these lines for models with He/H of 1.0, 0.4 and

0.1. The detection of mild hydrogen-deficient stars are very important as they provide a link between extreme H-deficient stars and normal stars.

(S. Sumangala Rao, G. Pandey, D. L. Lambert & S. Giridhar)*

Unusually large population of Blazhko variables in the globular cluster NGC 5024 (M53)

The discovery of amplitude and phase modulations typical of the Blazhko effect have been reported in 22 RRc and nine RRab type RR Lyrae stars in NGC 5024 (M53). This brings the confirmed Blazhko variables in this cluster to 23 RRc and 11 RRab stars, which represent 66 and 37 per cent of the total population of RRc and RRab stars in the cluster, respectively, making NGC 5024 the globular cluster with the largest presently known population of Blazhko RRc stars. The authors place a lower limit of 52 per cent on the overall incidence rate of the Blazhko effect among the RR Lyrae population in this cluster. New data have allowed us to refine the pulsation periods. The limitations imposed by the time span and sampling of our data prevent reliable estimations of the modulation periods. The amplitudes of the modulations range between 0.02 and 0.39 mag. The RRab and RRc are neatly separated in the colour-magnitude diagram, and the RRc Blazhko variables are on average redder than their stable counterparts; these two facts may support the hypothesis that the horizontal branch (HB) evolution in this cluster is towards the red and that the Blazhko modulations in the RRc stars are connected with the pulsation mode switch.

(A. Arellano Ferro, D. M. Bramich*, R. Figuera Jaimes*, S. Giridhar & K. Kuppuswamy)*

The globular cluster NGC 6981: variable stars population, physical parameters and astrometry

The results of time-series CCD photometry of the globular cluster NGC 6981 have been reported for which no previous CCD photometry exist. Here they report 11 new RR Lyrae stars, 3 SX Phe. They show that 20 stars previously classified as variables are in fact non-variable and confirm the variability of 29 stars. News ephemerides are provided for all the variables in the cluster. By using the Fourier decomposition of light curves and semi-empirical calibrations available in the literature for RR Lyrae stars, they determined the physical parameters of these stars and hence the mean metallicity and distance of the cluster as [Fe/H]=-1.48 ± 0.03 in the Zinn & West(1984) scale; and 16.73 ± 0.36 kpc.

(R. Figuera Jaimes, A. Arellano Ferro*, D. M. Bramich* & S. Giridhar)*

Exploring the variable stars in the globular cluster NGC 5024 (M53): new RR Lyrae and SX Phoenicis stars

CCD V and I time series photometry of the globular cluster NGC 5024 (M53) is reported. The technique of difference image analysis has been used which enables photometric precisions better than 10 m mag for stars brighter than V 18.5 mag even in the crowded central regions of the cluster. The high photometric precision has resulted in the discovery of two new RR1 stars and 13 SX Phe stars. A detailed identification chart is given for all the variable stars in the field of the images of the cluster. Periodicities were calculated for all RR Lyrae and SX Phe stars and a critical comparison is made with previous determinations.

The light-curve Fourier decomposition of RR0 and RR1 is discussed, and the authors find a mean metallicity of [Fe/H] = -1.92 ± 0.06 in the scale of Zinn & West from 19 RR0 stars. The true distance moduli 16.36 ± 0.05 and 16.28 ± 0.07 and the corresponding distances 18.7 ± 0.4 and 18.0 ± 0.5 kpc are found from the RR0 and RR1 stars, respectively. These values are in agreement with the theoretical period-luminosity relations for RR Lyrae stars in the I band and with recent luminosity determinations for the RR Lyrae stars in the Large Magellanic Cloud (LMC).

The age of 13.25 ± 0.50 Gyr, for NGC 5024, E(B - V) = 0.02 and the above physical parameters of the cluster, as indicated from the RR0 stars, produce a good isochrone fitting to the observed colour-magnitude diagram (CMD).

(A. Arellano Ferro, R. Figuera Jaimes*, S. Giridhar, D. M. Bramich*, J. V. H. Santisteban*, & K. Kuppuswamy)*

Formation and evolution of prestellar cores

Studying the formation and evolution of prestellar cores via gravoturbulent fragmentation of interstellar gas, i.e, the interplay of gravity with turbulence. The authors suggest, turbulence within a molecular

cloud could be injected by shocks triggered by supernovae explosions or powerful radiation emitted by clusters of young stars. Numerical simulations show that the power-spectrum of turbulence so injected is similar to the well-known Kolmogorov spectrum and further, the resulting mass-spectrum of protostellar objects bears a close resemblance with the canonical distribution. Results from the numerical simulations also agree with the ubiquitously observed filamentary structure within molecular clouds.

A semi-analytic investigation of the problem further establishes the importance of physical conditions in a putative star-forming cloud. This investigation has also shown that the canonical distribution of stellar masses can be recovered using the theory of turbulent fragmentation in which case, it is turbulence within molecular clouds must be driven on large spatial scales and must have a power-spectrum steeper than the Kolmogorov-type.

(S. Anathpindika)

Synthetic spectra of AM CVn binary system

Taking into account a range of parameters determined from the evolutionary models and available observational data, the detailed non-LTE spectrum for the primary star and the irradiated donor star in the AM CVn system SDSS J0926+3624 are constructed based on the TLUSTY stellar atmosphere code. The combined spectrum of the primary and the donor stars along with a multi-color blackbody spectrum of the accretion disk that reproduces a detailed numerical model is compared to the SDSS optical spectrum of the system. The photometric flux of the primary star inferred from eclipse observations is compared with the synthetic spectrum. The model fit of the two independent observations provides an upper limit on the distance of the system for different effective temperatures of the primary. In addition, an upper limit on the combined flux of the disk and the donor in the infrared region wherein the contribution of the primary is negligible is also determined. It is shown that the spectrum of a sufficiently cool donor can exhibit emission lines due to irradiation from a hot primary and the emission features should be detectable in the infrared even though the contribution of the flux from the disk dominates. Thus, it is pointed out that infrared observations of the system would provide important information on the thermal state of the donor as well as useful insight on the thermal properties of the primary star and the accretion disk.

(S. Sengupta)

Polarization of directly imaged exoplanets

The atmospheres of the young and self-luminous extrasolar giant planets that have recently been directly imaged are, like the L-dwarfs, dusty. Hence, like the L dwarfs, these planets as well as those likely to be detected in the future, may show detectable amounts of linear polarization in the optical and near-infrared. The required asymmetry in the radiation field over the disk may arise either from the rotation-induced oblateness or from surface inhomogeneities, if present. While it is not possible at present to predict the extent to which the surface inhomogeneity, if any, plays the role in producing net non-zero disk integrated polarization, the role played by rotation-induced oblateness can be estimated providing the minimum possible polarization. Using a self-consistent, spatially homogeneous atmospheric model and a multiple scattering polarization formalism for these kinds of exoplanets, the authors show that detectable amount of polarization may arise due to the rotation-induced oblateness of the planets. The authors also point out that the observed polarization may be even higher if surface inhomogeneities exist and play a significant role. The polarized radiation, when detected, may provide an additional tool to characterize these young planets and a new method to constrain their surface gravity and masses.

(S. Sengupta)

Galactic R Coronae Borealis stars: the C2 Swan bands, the carbon problem, and the $^{12}C/^{13}C$ ratio

For the first time it has been determined, that the carbon abundance in cool hydrogen-deficient stars (RCB and HdC), using the molecular C_2 Swan bands, is independent of the adopted model atmosphere's carbon abundance. The authors also report the $^{12}C/^{13}C$ ratios in these stars. The carbon abundances and the $^{12}C/^{13}C$ ratios in these stars play a key role in understanding their origin and evolution.

(B. P. Hema, G. Pandey & D. L. Lambert)*

Magnetic fields in cometary globules: LBN 437

Polarization measurements of stars in the field of the starforming molecular cloud Gal 96-15 (LBN 437) have been carried out in the optical R band. The polarization vectors give information on the direction of the magnetic field in the cloud. The observed magnetic field appears to be closely related to the elongated morphology of the cloud and the direction of the HH outflows from the young stellar objects in the cloud. From the optical R band photometry and infrared JHK measurements for the stars in the region of the cloud, the distance to Gal 96-15 is derived to be about 360 pc.

(Archana Soam, M. Gopinathan*, H. C. Bhatt)*

Optical and infrared survey of the stellar contents associated with the star-forming complex Sh2-252

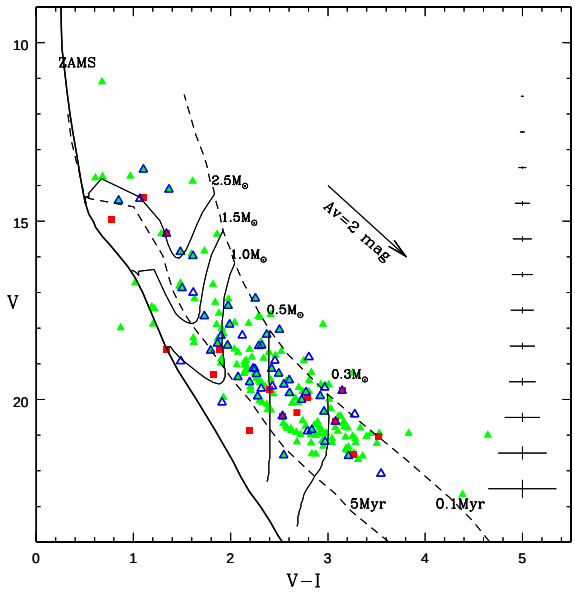


Figure 1.14: $V/(V-I)$ CMD for the candidate YSOs (class 0/I: red squares; Class II: green triangles; $H\alpha$ sources: blue triangles) identified within Sh2-252. The locus of ZAMS (thick solid curve), PMS isochrones (dashed curves) and the evolutionary tracks for various mass bins (thin solid curves) are also shown.

Sh2-252 is an extended HII region ($n_e \sim 9$ cm^{-3}, size ~ 25 pc) ionized by a O6.5 star HD 42088 and is a part of the Gemini OB1 association. Multi-

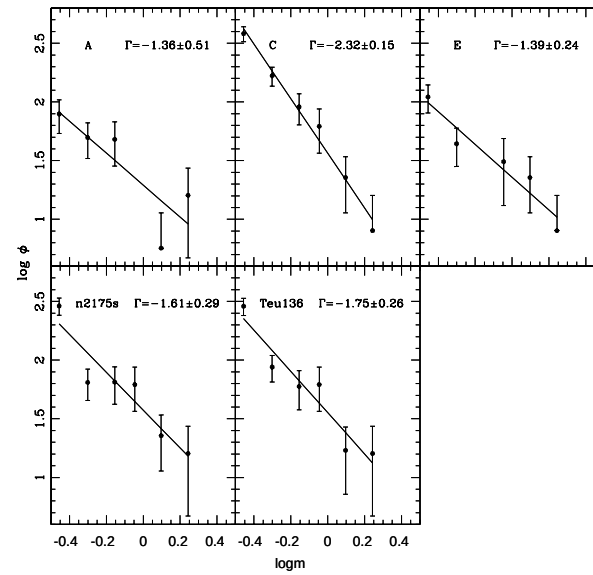


Figure 1.15: MFs obtained for the sub-regions of Sh2-252 after correcting for the field star contamination and data incompleteness. The ϕ represents $N/\mathrm{dlog}\ m$ and the error bars represent $\pm\sqrt{N}$ errors. The value of the slopes obtained are given in each figure.

wavelength anlaysis of the stellar contents associated with this region have been performed using deep optical $UBVRI$ photometry, slit and slitless spectroscopy along with the near-IR data from 2 Mass and mid-IR data from *Spitzer* for an area ~ 1 degree $\times$ 1 degree. The sub-regions of Sh2-252 which includes four compact-H II(CH II) regions, namely A, B, C and E and two clusters NGC 2175s and Teu 136 have been analysed individually. Twelve massive members of spectral class earlier than B6 have been identified spectroscopically and the candidate ionizing sources of the CHII regions are found to be of spectral class earlier than B2V. The stellar surface density distribution in K-band shows 5 prominent embedded clusters associated with the regions A, C, E, NGC 2175s and Teu 136. 61 Hα emission sources are identified using slitless spectroscopy and over 500 young stellar objects (YSOs, Class 0/1/II) are identified based on the MIR colour-colour and SED analysis, resulting in statistically rich number of YSOs in the region. The distribution of the candidate YSOs on the $V/(V-I)$ colour magnitude diagram shows that a majority of them have age spread of 0.1 - 5 Myr and masses in the range of 0.3 - 2.5 $M_\odot$. Within errors, the K-band luminosity functions for the sub-regions are found to be similar and comparable to that of young clusters of age < 5 Myr.

The mass functions of the PMS sample of the individual regions in the mass range of $0.3 - 2.5 M_{\odot}$ are in general, found comparable to the Salpeter value. (Figure 1.14 and Figure 1.15).

(J. Jose, A. K Pandey, K. Ogura*, M. R Samal*, D. K. Ojha*, B. C Bhatt, N. Chauhan*, C. Eswaraiah*, H. Mito* & R. K Yadav*)*

Comparative modelling of the spectra of cool giants

Ability to extract information from the spectra of stars depends on reliable models of stellar atmospheres and appropriate techniques for spectral synthesis. Various model codes and strategies for the analysis of stellar spectra are available today. The authors aimed to compare the results of deriving stellar parameters using different atmosphere models and different analysis strategies. The results from the different groups are presented as well as an additional experiment comparing the synthetic spectra produced by various codes for a given set of stellar parameters. Similarities and differences of the results are discussed. Several valid approaches to analyze a given spectrum of a star result in quite a wide range of solutions. The main causes for the differences in parameters derived by different groups seem to lie in the physical input data and in the details of the analysis method. This clearly shows how far from a definitive abundance analysis the authors still are.

(T.Lebzelter & A. Goswami with 25 coauthors)*

Spectroscopic studies of FHLC stars

The sample of candidate faint high latitude carbon (FHLC) stars chosen from the Hamburg/ESO survey is a potential source to search for objects of rare types. Medium resolution spectral analyses of about 300 objects from this sample have been carried out. The objects are classified into different groups of carbon stars based on a set of spectral criteria. One important finding is the object HE 1015-2050, that is found to belong to the rare class of hydrogen-deficient carbon (HdC). This star is at high Galactic latitude, in metal-poor environment and cooler as expected from similar members of the sample. Apart from U Aquarii, HE 1015-2050 is the only example, till now, of a Galactic cool HdC star that is characterized by strong spectral features of light s-process element Sr, and weak features of heavy s-process elements such as Ba. Understanding the formation mechanism of this object, with its enhanced carbon and hydrogen-deficiency, together with anomalous s-process spectral features, remains an important issue.

(Aruna Goswami, K. Drisya & N. S. Shantikumar)

BVRI polarimetry of carbon stars at high Galactic latitude

BVRI polarimetry is carried out for a sample of faint high latitude carbon stars from Hamburg/ESO survey; the sample also contains a number of classical CH stars and two subgiant CH stars. Some recent spectroscopic studies have suggested that carbon-enhanced metal-poor (CEMP) stars and CH stars represent the same class of objects. However, multiple lines of evidence are desirable to ascertain this classification. The polarimetric observations have been used to explore polarimetric confirmation of such a classification. The polarimetric estimates are found to be $\leq 1\%$ for this sample of stars and are found to exhibit a rather random behaviour with respect to the inverse of the effective wavelength of observations. While the spectroscopic studies indicate a similar formation mechanism for these objects, polarimetric characteristics point at presence of circumstellar envelopes that are likely to be of similar composition.

(Aruna Goswami & K. Drisya)

Carbon in the early Galaxy and in the primordial Halos

There has been a lot of interest in carbon, since the discovery of many carbon rich stars among the old and metal poor stars. Similar enhancements in carbon abundances were also observed in the high redshift intergalactic medium (IGM). The origin is quite unclear (AGBs, massive star wind, faint SN). An extensive study has been done based on 300,000 stars from SDSS-DR7 database. The carbon abundance and the full kinematics of the samples were derived to study the origin. The study indicates that there is carbon production in the early galaxy, through massive stars, either during the wind or through faint SNs. The authors also find supporting evidence based on their study of carbon abundance in Bootes Dwarf galaxy. Similar galaxies are thought to be the first galaxies formed in the Universe and building blocks of our Galaxy halo. Enhanced carbon abundances have been found in the stars of this galaxy as well. This has a lot of implications on the early chemical evolution ,feedback and critical metallicity

for the first low mass star formation and so on.

(T. Sivarani et al.)

Origin of r-process in Carbon enhanced metal poor stars

One of the outstanding problems in the study of Carbon enhanced metal poor stars is that, about 60% of them have s-process rich composition along with high Eu enhancements. Since Eu is mainly produced by r-process during an SN explosion, the formation scenarios and the relative abundances of r+s versus s-only rich carbon stars seem to be puzzling. The authors have proposed for VLT-UVES observations in the far blue end of the spectra for a new r+s star, to study other r-process elements, in order to derive abundances of r-process elements other than Eu. This will confirm whether the anomaly is in deriving Eu-abundances or the enhancement is seen in all the r-process elements. Accurate abundances have been derived for 39 elements, including 19 neutron-capture elements. Both the parametric method and AGB model of Bisterzo et al. (2010) successfully reproduced the two values of the s-process intrinsic index in HE1405-0822, i.e. [Pb/hs] = 0.54 and [hs/ls] = 1.21. This strongly supported the reliability of the methods adopted in this work for calculating the s-process. The simulation results showed that the former AGB companion should be a star with low initial mass, i.e. about $\leq 2\,M_{\odot}$. This is supported by the observed negative [Sr/Fe] = −0.99, which means a marginal effects of the ^{22}Ne neutron source in the former AGB companion with low initial mass.

However, the authors could not reproduce the r-process pattern (including Eu, Gd, Tb, Dy and Er) in HE1405-0822 with a superposition of scaled solar r-process pattern (assuming the main r-process pattern is universal). This means that the origin of r-process elements are more complicated. Similar study of more number of CEMP-s and CEMP-r+s stars will throw some light on the origin of r-process, i.e. a special "s/r" neutron-capture process which should be a single process with features in-between or a superposition of the s- and r-process, or a probably unlikely scenario, a stable triple stellar system.

(T. Sivarani et al.)

Exoplanet research

As part of SDSS-III MARVELS survey, the authors have discovered short-period (P = 2.430420 ± 0.000006 days) companion to the F-type main sequence star TYC 2930-00872-1. A long-term trend in the radial velocity data also suggests the presence of a tertiary stellar companion with P > 2000 days. High-resolution spectroscopy of the host star yields Teff = 6427±33 K, log g = 4.52±0.14, and [Fe/H]= −0.04±0.05. These parameters, combined with the broad-band spectral energy distribution and a parallax, allow us to infer a mass and radius of the host star of M1 = 1.21± 0.08 M⊙ and R1 = 1.09 +0.15 −0.13 R⊙. The minimum mass of the inner companion is below the hydrogen burning limit, however the true mass is likely to be substantially higher.

The authors are able to exclude transits of the inner companion with high condense. Further, the host star spectrum exhibits a clear signature of Ca H and K core emission indicating stellar activity, but a lack of photometric variability and small v sin i suggest the primary's spin axis is oriented in a pole-on configuration. The rotational period of the primary estimated through an activity-rotation relation matches the orbital period of the inner companion to within 1.5σ, suggesting that the primary and inner companion are tidally locked. If the inner companion's orbital angular momentum vector is aligned with the stellar spin axis as expected through tidal evolution, then it has a stellar mass of 0.3 − 0.4 M⊙. Direct imaging limits the existence of stellar companions to projected separations < 30 AU. No set of spectral lines and no significant ux contribution to the spectral energy distribution from either companions are detected, which places individual upper mass limits of M1,2≤ 1.0 M⊙, provided they are not stellar remnants. If the tertiary is not a stellar remnant, then it is likely it has a mass of 0.5 - 0.6 M⊙, and its orbit is likely significantly inclined from that of the secondary, suggesting that the Kozai-Lidov mechanism may have driven the dynamical evolution of this system

(T. Sivarani et al.)

Recurrent novae: T Pyxidis

The recurrent nova T Pyxidis underwent its long overdue outburst in April 2011. Spectroscopic monitoring of the event began immediately using the 2.3m VBT, the 2m HCT and IUCAA's IGO telescope. The spectroscopic evolution is very similar to that of the hybrid classical novae. Photopolarimetric observations have also been obtained using the IGO telescope. Intrinsic polarization has been detected. In addition, T Pyx has also been observed in the ra-

dio using the GMRT. However, the source was not detected in the low frequency radio region. Detailed analysis of all the data are under progress.

(G. C. Anupama, G. Selvakumar, A. N. Ramaprakash, V. Mohan*, N. G. Kantharia*, M. F. Bode*, S. P. S. Eyres*, A. Evans* & T. J. O'Brien*)*

Type Ia Supernovae: SN 2009an and SN 2009ig

The photometric and spectroscopic data of the type Ia supernova SN 2009an obtained during -6 days to $\sim$ +150 days from the B-maximum, and that of SN 2009ig from -9.3 and +185 days were analysed. Based on their Δm_{15}(B), these two SNe are found to marginally deviate from "normal" type Ia events. SN 2009an has an initial decline rate that is faster, with $\Delta m_{15}(B) = 1.52 \pm 0.12$ and absolute B magnitude $M_B = -18.84$, whereas SN 2009ig is a slowly declining object with $\Delta m_{15}(B) = 0.95 \pm 0.10$ and $M_B = -19.43$. The mass of ^{56}Ni ejected varies by almost a factor of two for these two objects, with the estimates being $\sim 0.4 M_\odot$ for SN 2009an and ~ 0.8 $M_\odot$ for SN 2009ig.

The pre-maximum and early post-maximum spectral evolution of SN 2009an is very similar to the transitional type Ia SN 2004eo. High velocity features in Ca II NIR triplet are seen during the early phases. Similar to the other few objects belonging to this class, SN 2009an exhibits a higher value (~ 0.4) of the Si II line ratio RSi II. The velocity gradient of the Si II 6355 Å line in the post-maximum epoch ($\dot{v}$ = 60 km s^{-1}) is just at the boundary between the low velocity gradient and high velocity gradient groups.

The early spectra of SN 2009ig are similar to the spectra of SN 1999aa and SN 1999ac, with prominent lines due to doubly ionized Fe III $\lambda\lambda$ 4404, 5129 and Si III λ4560. The lines due to S II $\lambda\lambda$5654, before B maximum shows high velocity features in Si II λ 6355 line, the high velocity component of Ca II NIR triplet is seen till 4 days before B maximum. The expansion velocity of SN 2009ig inferred from Si II λ 6355 line during the pre-maximum phase is among the highest ever observed. The expansion velocity during post-maximum phase is found to be $\sim$ 13,000 km sec^{-1}, which is higher than the velocity observed in other type Ia supernovae during similar epoch. Based on the low value of velocity gradient (22.0$\pm$2.9 km sec^{-1} day^{-1}) in the post-maximum phase SN 2009ig belongs to the low velocity gradient group. SN2009ig also shows NaI D absorption features that appear to be intrinsic to the supernova. These features are blue shifted by $\approx$ 100 km s^{-1}, an amount similar to that seen in a few other type Ia supernovae. These absorption features are speculated to arise in a pre-SN circumstellar material, providing evidence for a single degenerate progenitor.

(D. K. Sahu, G. C. Anupama & P. Anto)*

Infrared study of low mass K- and G-type giants

Connection between Li-enhancement and IR excess in K giants is one of the important aspects to study and to understand anomalously high Li K giants as well as their contribution to Galactic Li evolution. In this direction the authors have investigated the apparent correlation between Li enhancement and infrared (IR) excess among K giants. For this purpose, the authors have made use of far-IR colors of a sample of 2000 giants with and without Li enhancement. Study shows only a small fraction, just 1% (o 20), of K giants have IR-excess suggesting IR-excess among the K giants is a rare phenomenon similar to Li enhancement. Results suggest two groups of Li-rich K giants: group that overlap with the luminosity bump and the group that overlap with the red clump in the HR diagram. In the case of former most of the Li-rich K giants have IR excess and in the later case none of the Li-rich K giants have IR excess. Results from modeling of dust shells suggest that dust evolutionary time scales are significantly small compared to stellar evolutionary time scales at the bump, and from bump to the tip of RGB. The location of Li-rich K giants in the HR diagram and IRAS color-color diagram with dust shell evolutionary models suggest the following: a) enhancement of Li at the bump is associated with mass loss and hence IR excess; b) absence of Li-rich K giants and/or K giants with IR excess well beyond the bump region imply the phenomenon is transient. With regard to the Li-rich K giants at the clump, an alternate Li production site during post bump evolution, probably at core-He flash, which may not be accompanied with mass loss is proposed.

(Y. B. Kumar, C. Muthumariappan & B. E. Reddy)

Theoretical study of irradiation effects in close binaries

The effect of irradiation is studied in a close binary system when primary component has an extended atmosphere and secondary component is a

point source. The irradiation effects are calculated on the atmosphere of the primary component when secondary component is moving in a circular orbit. In treating the reflection effect theoretically the total radiation which is the sum of the radiation of (1) the effect of irradiation on the primary component is calculated by using one dimensional rod model (2) self radiation of the primary component is calculated by using solution of the radiative transfer equation in spherical symmetry. The radiation field is estimated by using formal solution of radiative transfer equation along the line of sight observer at infinity.

It is found that the radiation field changes on the primary component when the angle of incidence changes and it also makes the irradiation effect more than the self radiation of the primary component. The contour maps show that the radiative interaction makes the outer surface of the primary star warm when its companion illuminates the radiation. On the formation of spectral lines the reflection effect is studied and found that the flux in the lines increases at all frequency points and the cores of the lines received more flux than the wings and equivalent widths changes accordingly.

(M. Srinivasa Rao & B. A. Varghese)

2D Monte Carlo radiative transfer modeling of disk shaped secondary of Epsilon Aurigae

The authors present two dimensional Monte-Carlo radiative transfer models for the disk of the eclipsing binary ϵ Aur by fitting its spectral energy distribution from optical to the far-IR wavelengths. They also report new observations of ϵ Aur made by AKARI in its five mid and far-IR photometric bands and were used to construct our SED. The disk is optically thick and has flared disk geometry containing gas and dust with a gas to dust mass ratio of 100. The primary of the binary has been taken to be a F0Iae-type post-AGB star and the disk is heated by a B5V hot star with a temperature of 15,000 K at the center of the disk. The radius of the disk has been taken to be 3.8 AU for the authors models as constrained from the IR interferometric imaging observations of the eclipsing disk. The models imply that the disk contains grains which are much bigger than the ISM grains (grain sizes 10μ to 100μ). The grain chemistry of the disk is carbonaceous and the authors' models show that silicate and ISM dust chemistry do not reproduce the slope of the observed SED in the mid-IR to far-IR regions. This implies that the formation of the disk shaped secondary in ϵ Aur system could be the result of accretion of matter and or mass transfer from the primary which is now a F0Iae post-AGB star. It is not a proto-planetary disk. The disk is seen nearly edge on with an inclination angle larger than 85^o. It is proposed from the radiative transfer modeling that the disk is not solid and has a void of 2AU radius at the center within which no grains are present making the region nearly transparent. The disk is not massive, its mass is derived to be less than 0.005 $M_\odot$.

(C. Muthumariappan & M. Parthasarathy)*

Radiative transfer models of 21 and 30 micron features in five C rich PPNe

The 21 and 30 micron emission features are the strongest dust emission features detected in the C rich PPNs which together account 20% of the total IR flux. The carriers of these features must fulfill the atomic abundance budget of the stellar photosphere. The authors have performed 1D radiative transfer models for five C rich PPNs which show strong emission features at 21 and 30 micron; namely IRAS 07134+1005, IRAS 16594-4656,IRAS 19500-1709,IRAS 22272+5435 and IRAS 23304+6147 using DUSTY. Taking FeO and MgS respectively are the carriers of the 21 and 30 micron features, the authors have derived the atomic abundance of Fe, Mg and S locked up in the circumstellar grains. These values are compared with the available photospheric abundance measurements of these elements in the literature and discuss their consistency.

(C. Muthumariappan & B. E. Reddy)

Influence of polar cap current on pulsar polarization

The pulsar dipole field gets perturbed due to field aligned polar cap current. Since the emission from a relativistic sources is beamed in the direction of field line tangents, the perturbed field geometry affects the polarization state of the emitted radiation. Due to the effect of polar cap current induced perturbation the intensity (I_s) components and the polarization angle (ψ_s) inflection point get shifted to trailing and leading sides, respectively as shown in Figure 1.16. Note that the shifts get reversed in the case of sight line with negative σ. The phase shifts of the intensity peaks in the cases of $\sigma_\phi = 0.1$ and 0.4 are found to be $0^\circ.54$ and $7^\circ.22$, respectively. The increase in phase shift of intensity peaks with increasing σ_ϕ is due to an induced asymmetry in the

curvature of source trajectory about the maximum source density. Circular polarization V_s is antisymmetric for the steeper modulation ($\sigma_\phi = 0.1$), and changes sign from negative to positive. The positive circular becomes stronger than the negative circular due to the selective enhancement of emission caused by the perturbation.

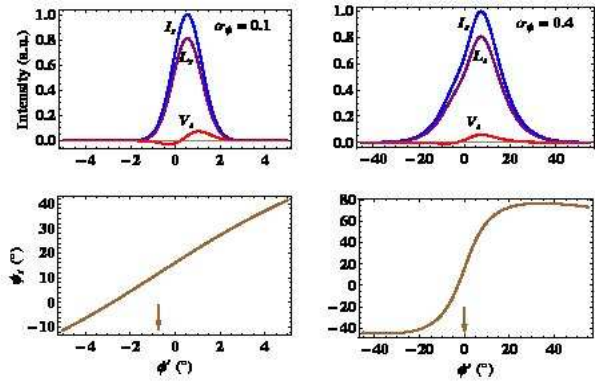


Figure 1.16: Simulated polarization profiles: upper panels - total intensity I_S, linear polarization L_S, and circular polarization V_S; lower panels polarization angle ψ_S. Here $\alpha = 30°$, sight line impact angle $\sigma = 5°$, emission altitude $r_n = 0.1$, period $P = 1$ s, Lorentz factor $\gamma = 400$ and observational frequency $\nu = 600$ MHz. Arrows mark the inflection points.

(D. Kumar & R. T. Gangadhara)

Chemical tagging of Galactic streams

The phase space of the Galaxy's disk, as observed near the Sun, contains a substructure within the larger structures known as the thin and the thick disk. Substructures include open clusters and moving groups. Moving groups are considered to be members of a common space motion and a common chemical composition and originating from a dissolving open cluster. While some of the well known moving groups do share a common composition (e.g., the HR 1614 group) suggesting they come from a tidally-disrupted open cluster, other groups contain stars having very different compositions, a result demanding an origin more complex than disruption of an open cluster. The term 'stream' is now applied to some entities in Galactic phase space. Examples in the thin disk include the Hercules stream and the Hyades stream or supercluster. For streams in the thin disk, a likely explanation involves dynamical interactions of disk stars with the central bar. Other possibilities arise for streams belonging to the thick disk including accretion from external galaxies.

Towards understanding the origin of the streams the authors have chosen half a dozen streams for the abundance study of member stars. As a part of this exercise abundance results of 21 elements of 18 and 26 member stars of Arcturus moving group and the newly identified stream, respectively were obtained. Results show both the streams are metal-poor and very old (10−14 Gyrs) with overlapping kinematics and abundances with the background thick disk component. The authors have made an attempt, through the elemental abundances and age determinations, to disentangle the group origins from the three main competing scenarios: a) dispersal of open clusters, b) dynamical perturbation due to spiral arms or/and bar, c) external origin such as tidal debris of accreting satellites. Large range in metallicity and the abundance trends clearly rule out the first possibility of cluster dispersal scenario. However, elemental abundances of member stars are very similar to the thick disk and they are indistinguishable. They have discussed the results in the context of their being subgroups of the thick disk component and their origin scenarios: external versus dynamical perturbation.

(P. Ramya, B. E. Reddy & D. L. Lambert)*

1.3 Extragalactic Astrophysics and Cosmology

The three dimensional structure of the Small Magellanic Cloud

The three-dimensional structure of the inner Small Magellanic Cloud (SMC) is investigated using the red clump(RC) stars and the RR Lyrae stars (RRLS), which represent the intermediate-age and the old stellar populations of a galaxy. The V- and I- band photometric data from the OGLE III catalog are used for the study. The north eastern part of the SMC is found to be closer to us and the line-of-sight depth (front to back distance) across the SMC is found to be large (∼14 kpc) from the analysis of both populations. The similarity in their depth distribution suggests that both of these populations occupy a similar volume of the SMC. The surface density distribution and the radial density profile of the RC stars suggest that they are more likely to be distributed in a nearly spheroidal system. The tidal radius estimated for the SMC system is ∼7-12 kpc. Based on all of the above results the observed structure of the SMC, in which both the RC stars and

RRLS are distributed, is approximated as a triaxial ellipsoid. The authors estimated the axes ratio, inclination of the longest axis with the line of sight (i), and the position angle (ϕ) of the longest axis of the ellipsoid on the sky from the analysis of the RRLS. The analysis of the RC stars with the assumption that they are extended up to a dept h of 3.5 times the sigma (width of dereddened I_0 magnitude distribution, corrected for intrinsic spread and observational errors) was also found to give similar axes ratio and orientation angles. The above estimated parameters depend on the data coverage of the SMC. Using the RRLS with equal coverage in all three axes (data within 3° in X-, Y-, and Z-axes), the authors estimated an axes ratio of 1:1.33:1.61 with i = 2. 6 and (ϕ) = 70.2. The tidal radius estimates and the recent observational studies suggest that the full extent of the SMC in the XY plane is of the order of the front to back distance estimated along the line of sight. These results suggest that the structure of the SMC is spheroidal or slightly ellipsoidal. The authors propose that the SMC experienced a merger with another dwarf galaxy at 4–5 Gyr ago, and the merger process was completed in another 2-3 Gyr. This resulted in a spheroidal distribution comprising stars older than 2 Gyr. See Figure 1.17.

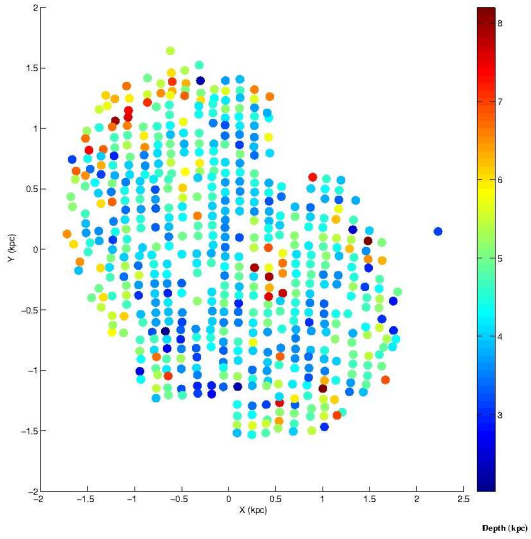


Figure 1.17: Two dimensional plot of the line of sight depth of the sub-regions in the SMC obtained from the analysis of red clump stars.

(S. Subramanian & A. Subramaniam)

The recent star formation history of the Large and Small Magellanic Clouds

The Large and Small Magellanic Clouds (LMC & SMC), along with the components of the bridge and the stream, comprise the Magellanic system. This system moves in the gravitational potential of the Galaxy. It is obvious that the structure, kinematics, and evolution of the clouds and the Galaxy are modified by their interactions. The new proper motion estimates suggest that this interaction is restricted to a recent past. Recent interactions between the LMC, the SMC and the Milky Way (MW) can be understood by studying their recent star formation history. The authors have traced the age of the last star formation event (LSFE) in the inner LMC & SMC using the photometric data in V and I passbands from the Optical Gravitational Lensing Experiment (OGLEIII) and the Magellanic Cloud Photometric Survey (MCPS). The spatial distribution of the age of the LSFE shows that the star formation has shrunk to within the central regions in the last 100 Myr in both the galaxies. The authors propose that the HI gas in the LMC has been pulled to the north of the LMC in the last 200 Myr because of the gravitational attraction of our Galaxy at the time of perigalactic passage. The shifted HI gas was preferentially compressed in the north during the time interval 200-40 Myr and in the northeast in the last 40 Myr, owing to the motion of the LMC in the Galactic halo. The recent star formation in the SMC is due to the combined gravitational effect of the LMC and the perigalactic passage. Figure 1.18.

(G. Indu & A. Subramaniam)

Near infrared and spectroscopic study of candidate Be stars in the Magellanic Clouds

Mennickent et al. (2002, A&A 393, 887) and Sabogal et al. (2005, MNRAS,361,1055) identified a large number of Classical Be (CBe) candidates ($\sim$ 3500) in the L&SMC based on their photometric variability using the OGLE II database. They classified these stars into four different groups based on the appearance of their variability. In order to refine and understand the nature of these large number of stars, the authors have studied the infrared properties of the sample as well as the spectroscopic properties of a subsample. The authors have cross-correlated the optical sample with the IRSF catalog to obtain the J, H, K_s magnitudes of all the four types of stars ($\sim$ 2500) in the L&SMC. Spectra of 119 stars belonging

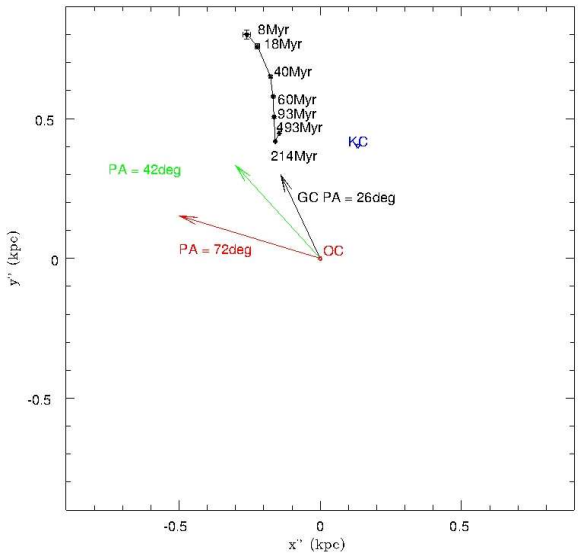


Figure 1.18: Northward propagation of star formation in the LMC due to its interaction with the Milky Way (MW). The direction of the velocity vector of the LMC is shown at a position angle of 72^o, and the line of interaction of the MW and the LMC at a position angle of 26^o. KC is the HI kinematic center, and OC is the optical center of the LMC. (Indu G., Subramaniam A., 2011, A&A, 535, A115)

to the types 1, 2 and 3 were analysed to study their spectral properties. Majority of the stars showed presence of emission lines in the spectra and were found to belong to early spectral type. Among the four types, the type 4 stars is the dominant group, with ~ 60 and $\sim 65\%$ of the total sample in the LMC and the SMC respectively. The NIR colour-colour diagrams suggest that the type 4 stars in the LMC have a subclass, which is not found in our Galaxy or in the SMC. This subclass is $\sim 18\%$ of the type 4 sample. The main type 4 sample which is $\sim 49\%$ of the total sample has NIR properties similar to the Galactic CBe stars and the SMC type 4 stars. Though the new subclass of type 4 stars have high E(B-V) ~ 0.75, they are not located close to regions with high reddening. Spectroscopic studies are necessary to understand these interesting new class of objects. The type 3 stars ($\sim 6\%$ & 7.3% in the L& SMC) are found to have large H_α EW in the SMC and some are found to have large NIR excess. This small fraction of stars are unlikely to be CBe stars. 3 stars among the type 3 stars in the LMC are found to be Double Periodic Variables. The type 2 stars are found in larger fraction in the SMC ($\sim 14.5\%$), when compared to the LMC ($\sim 6\%$). The spectroscopic and the NIR properties suggest that these could be CBe stars. The type 1 stars are relatively more in the LMC ($\sim 24\%$) when compared to the SMC ($\sim 13\%$). The SMC type 1 stars have large Hα EW and this class has properties similar to CBe stars. The spectroscopic sample of type 1 stars which show H_α in emission and confirmed as CBe stars are more abundant in the SMC by a factor of 2.6. If the effect of metallicity is to cause more CBe stars in the SMC, when compared to the LMC, then type 1, type 2 and type 4 stars follow this rule, with an enhancement of 2.6, 2.4 and 1.3 respectively.

(K. T. Paul, A. Subramaniam, B. Mathew*, R. E. Mennickent* & B. Sabogal*)*

Star formation and bulge evolution of disk dominated, bulgeless galaxies

The authors present GMRT 1280 MHz radio continuum observations and follow-up optical studies of the disk and nuclear star formation in a sample of low luminosity bulgeless galaxies. The main aim was to understand bulge formation and overall disk evolution in these late type spirals. It was found that these galaxies have weak radio emission unless interacting with nearby galaxies. In two galaxies of the sample, extended radio emission was detected; the others had patchy disk emission. For the radio strong galaxies, NGC 3445 and NGC 4027, the authors did follow-up Hα imaging and nuclear spectroscopy with the HCT. The Hα emission is mainly associated with the strong spiral arms. The nuclear spectra indicate ongoing nuclear star formation in NGC 3445 and NGC 4027 which may be associated with nuclear star clusters. No obvious signs of AGN activity were detected. Both galaxies appear to be in the process of forming bulges. It is therefore concluded that tidal interactions are an important means of bulge formation and disk evolution in bulgeless galaxies; without such triggers these galaxies appear to be low in star formation and overall disk evolution.

(M. Das, C. Sengupta, S. Ramya & K. Misra*)*

Multiwavelength study of TeV blazar Mrk421 during giant flare

The nearby (z = 0.031) TeV blazar Mrk 421 belongs to a sub-class of the active galactic nuclei (AGN) which are know as high-energy peaked blazars (HBL). The spectral energy distribution (SED) of these blazars show two humps. This is believed that the first hump

is caused by synchrotron radiation from electron population gyrating in magnetic fields of jet. This radiation peaks at infrared to X-rays. The second hump peaks around GeV energies and origin of this hump is not very clear. This hump may be produced by interaction of electrons with photon in leptonic models or proton with photon field or magnetic filed in hadronic models. Mrk 421 was reported to be in a high state of flux activity since November, 2009. This source was observed in bright state using High Altitude GAmma Ray (HAGAR) telescope array at energies above 250 GeV during February 13 - 19, 2010. The emission reached a peak on February 17, with a maximum flux of ~ 7 Crab units, indicating a flare. A weak correlation between X-rays and VHE gamma rays have been found with a time lag of ~ 1 day, Figure 1.19.

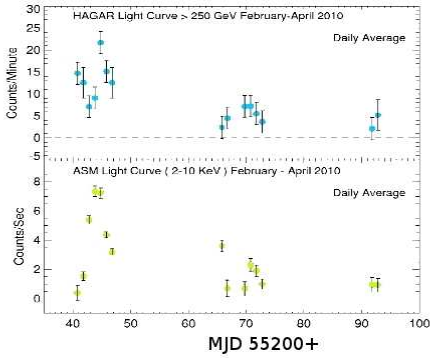


Figure 1.19: A weak correlation between X-rays and VHE gamma rays have been found with a time lag of $\sim$ 1 day.

The optical, X-ray and gamma-ray archival data were also used to obtain the SEDs and light curves. The observed multiwavelength SEDs during February 13 – 19, 2010 indicate changes in the physical conditions such as magnetic field, Doppler factor and particle energies in the emission zone. The multiwavelength flare during February 16 – 17, 2010 and changes in physical conditions of the emission zone are explained as an effect of a passing shock in the jet. Figure 1.20, illustrates the change that the SED undergoes during the four different states of the source.
(A. Shukla et.al, on behalf of HAGAR collaboration)

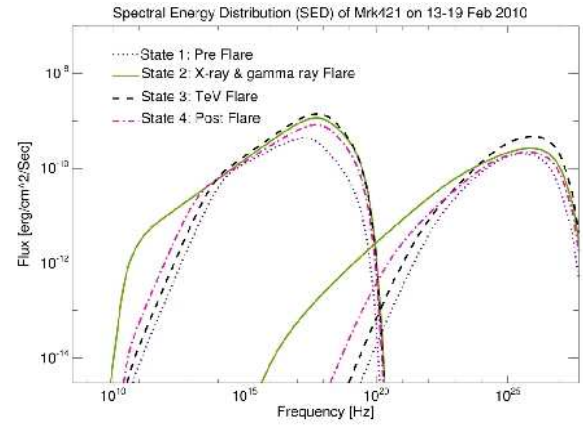


Figure 1.20: Figure illustrates the change that the SED undergoes during the four different states of the source.

SDSS archival study of black hole masses in LSB galaxies

A large sample of LSB galaxies from the SDSS data set has been studies. The authors are in the process of removing the stellar contribution and isolating the emission lines. Using the fluxes of the emission lines the authors will determine whether there are AGN in these galaxies. For those with AGN, the emission lines will be used to classify the AGN type and derive the black hole masses. The black hole masses have already been estimated in four LSB galaxies (Ramya et al. 2011) and found the masses to be relatively low compared to bright galaxies.

(S. Subramanian, M. Das, T. Sivarani, S. Ramya & T. P. Prabhu)

Mass of the black hole in the Seyfert 1.5 galaxy H 0507+164 from reverberation mapping

One of the many methods available to estimate the mass of the super massive black hole (SMBH) in an Active Galactic Nuclei (AGN) is using the reverberation mapping technique. As of now such reverberation mapping estimates of SMBH masses are available for three dozen AGN. Optical spectroscopic and R-band photometric monitoring observations were carried out on a new low luminosity AGN, the X-ray source and the Seyfert 1.5 galaxy H 0507+164 using the 2m HCT. From cross-correlation analysis of the continuum and Hβ line variations, a black hole mass of $9.62^{+0.33}_{-3.73} \times 10^6 M_\odot$ was found for this source.

(C. S. Stalin, S. Jeyakumar, R. Coziol*, R. S. Pawase* & S. S. Thakur*)*

Radio study of LSB galaxies

This is an ongoing project in which the authors are doing continuum and HI imaging of a sample of 7 LSB galaxies. The continuum is done at 325/244, 610, 1280 MHz. The HI studies are being analyzed. The main result of this work is that LSB galaxies can also host AGN activity and some may even have radio jets.

(M. Das, A. Mishra, N. Kantharia*, S. Srivatsav* & S. Vogel*)*

Particle injection spectra in high $-z$ radio galaxies

The authors examined the question of the relativistic electrons in high-redshift radio galaxies are injected with very steep energy spectra. Based on theoretical arguments the authors argue that the electron spectral energy index at high redshift is mostly due to synchrotron losses modified by redshift correction and inverse Compton losses. They discount the possibility of the first order Fermi acceleration process being solely responsible for the steep spectra. They are able to find empirical and observational support for this result by using RM measurements that is a tracer of ambient electron density.

(A. Mangalam, Gopal-Krishna & M. Mhaskey*)*

Models for X-ray & optical light curves from black hole systems

The authors considered the analysis of light curves from active galactic nuclei, comparing a wide variety of time series analysis techniques that have been used in the literature. They have been able to derive useful properties from light curves by programming, testing and applying implementations of the following time series techniques: wavelets, periodograms, Lomb-Scargle periodograms, structure functions, maximum likelihood estimator and multiharmonic analysis of variance. They discuss a unified noise model used in these analyses in order to confirm a detection with consistency and to rule out spurious detections. The only model that can be cleanly analysed assumes that they arise from orbital signatures some location between a few and 100 gravitational radii around the central black hole; adopting such a model places a lower limit on the masses of black holes. The authors are building theoretical models for signatures of relativistic flow near the innermost stable circular orbit and also for jet based models of helical flow to explain the QPO activity.

(P. Mohan, A. Mangalam, A. C. Gupta & P. J. Wiita*)*

Quasi-linear model of the Galactic dynamo

The authors are working on magnetic fields correlated on kiloparsec scales seen in disc galaxies. The origin could be due to amplification of small scale seed fields by a turbulent dynamo. Helicity conservation imposes constraints on dynamo action and one can study the minimal field strength of the large scale magnetic field that could arise despite the constraint. The calculation of helicity is technically complicated because of open boundaries and the usual form for the MHD invariant needs to be modified to take this into account. A general formalism has been developed to calculate the field strength using a quasi-linear dynamo model. As a first step, a galactic disk dynamo model has been built analytically while making the usual assumptions of shear and the α effect. They find quadrupolar solutions that are matched to a force-free field with $D \sim 10$. The general approach to solving the quasi-linear dynamo using the full set of relative helicity boundary conditions are described. They are on integrating the Helicity dynamics assuming a steady state structure that is calculated for saturation. Given the structure of the solution, the helicity of the small scale and large scale is calculated in terms of an amplitude ratio. They can then solve for the trajectory to saturation and investigate if there is a fixed point.

(A. Prasad & A. Mangalam)

Cosmological evolution of magnetic fields in the spherical collapse of density perturbation

The authors considered the evolution of the field under self- similar collapse of a density perturbation and show that one can achieve several e-foldings of growth taking into account just the peculiar velocity and collapse factor. The model places useful limits for seed fields for the virialized proto-galaxy.

(R. Gopal & A. Mangalam)

Dynamics of ellipsoidal collapse in a cosmological setting

The authors applied non-linear theory to spherically symmetric inhomogeneities in cosmological collapse.

The density run, turnaround time and corresponding energy are discussed. Further, an evolution of a rotating oblate ellipsoid is studied in terms of initial conditions of spin acquired from tidal torques, ellipticity and kinetic to potential energy ratio. The collapse pattern of spherical model and ellipsoidal collapse model are compared for same initial parameters. Astrophysically interesting cases for collapse redshifts of z = 4-6 are calculated.

(S. R. Nesar & A. Mangalam)*

Monitoring of gravitationally lensed quasars

Getting an accurate estimate of Hubble Constant (H_0) to within an accuracy of a few per cent is a great challenge in modern astrophysics as it provides key insights in various questions in cosmology. Gravitational lens time delays are one of the methods of finding H_0. This method relies on measuring accurate time delays between the photometric flux variations in lensed quasars images. The time delays thus measured will be converted to H_0 by proper modelling of the lensing galaxy. Despite the apparent simplicity of the method, time delays are extremely difficult to measure due to the longer time scales needed to accumulate high quality photometric data and to the small angular separation of the lensed quasars on the plane of the sky. A total of 6 lensed quasars are being monitored from HCT, as part of the COSMOGRAIL (COSmological MOnitoring of GRAvItational Lenses) collaboration, with an average time resolution of 5 days. Analysis of the data acquired from HCT is in progress.

(S. Rathna Kumar, C. S. Stalin, M. Tewes, T. P. Prabhu, F. Courbin* & G. Meylan*)*

Estimators for non-Gaussianity in the CMB and residual foreground contamination

The numbers of hot and cold spots of the CMB temperature fluctuations are introduced as new statistical probes for extracting non-Gaussian deviations. A numerical technique for calculating them for any given random field, based on geometric methods, was developed, and applied to simulated CMB data. The non-Gaussian deviation shapes of the hot and cold spots counts for various types of primordial non-Gaussian CMB fluctuations which are predicted by popular early universe scenarios were calculated. Further, the issue of whether the cleaned CMB data provided by the WMAP satellite contains residual contamination from our galaxy and point sources which can bias the cosmological information inferred was investigated. Using a method that looks at various correlations of the cleaned data with the foreground fields, it is found that the cleaned WMAP data does indeed contain statistically significant amount of contamination.

(P. Chingangbam & T. Qureshi)*

1.4 Atomic and Molecular Physics

Non accelerator particle physics

(a) The authors have proposed a new experiment to measure the electric dipole moment (EDM) of atomic Indium arising from time-reversal/CP and parity violations. They have used the relativistic coupled-cluster theory to determine the enhancement factor (ratio of atomic EDM to the electron EDM) of this atom. The strong electron correlation effects for this property were calculated to high accuracy. The result for the enhancement factor can be combined with the measurement of the EDM of atomic indium when it is available to obtain new limits for the electron EDM and the coupling constant of a quark-electron CP violating interaction. These limits will have important implications for physics beyond the standard model and matter-antimatter asymmetry in the universe.

(R. Pandey, B. P. Das & B. K. Sahoo*)*

(b) The authors have performed large scale relativistic coupled-cluster calculations of the electric dipole parity nonserving 6S-5D transition amplitude in singly ionised ytterbium (Yb+). The experiment to observe this effect is underway at the Los Alamos National Laboratory, USA. The combined results of experiment and theory has the potential to test the electroweak sector of the Standard Model of particle physics.

(B. K. Sahoo & B. P. Das)*

Atomic astrophysics

The 5P(J = 3/2) – 6S (J = 1/2) transition in indium is of interest in the solar abundance of that element. It is the only indium line that has been observed in the solar spectrum so far. The authors have theoretically determined the strength of this line and a number of other lines resulting from transitions between the low lying states of indium which could perhaps be observed in the future. This work takes into account the interplay of relativistic and many-body effects via the relativistic coupled cluster theory.

(B. K. Sahoo & B. P. Das)*

Ultracold atoms

The quantum phases of ultracold bosonic atoms in a periodic optical superlattice have been analyzed. In addition to the coventional Mott insulator and superfluid phases, unconventional Mott insulator phases were also obtained. It was also found that one of the latter kinds of Mott insulator co-exists with the superfluid phase at an incommensurate density. The calculations for the study were carried out using the decoupling mean field approximation.

(Arya Dhar, Manpreet Singh, B. P. Das, Tapan Mishra & R. V. Pai*)*

Fock space multireference coupled cluster calculations of the hyperfine structure of isoelectronic $^{33}S^-$ and $^{35,37}Cl$

Owing to its flexibility and possible systematic improvement, the Fock space multireference coupled cluster (FS-MRCC) method remains a very important tool for the computation of energy differences of spectroscopic interest. In this work, the FS-MRCC method for the electron detachment process has been applied to determine the magnetic hyperfine constant A_J and nuclear quadrupole moments Q (related to electric hyperfine constant B_J) for the lowest multiplets of $^{33}S^-$, ^{35}Cl and ^{37}Cl with larger basis sets. In addition, the authors also report $^2P_{3/2}([Ne]3s^23p^5) \rightarrow {}^2P_{1/2}([Ne]3s^23p^5)$ magnetic dipole transition matrix element and electron affinity of ^{35}Cl (i.e., ionization energy of Cl^-). Calculated properties are in very good agreement with the available new standard or reference values.

(Madhulita Das, Rajat K. Chaudhuri, Sudip Chattopadhyay & Uttam Sinha Mahapatra*)*

Application of relativistic coupled cluster method to study the plasma effect in He I and Li I isoelectronic systems

The ionization potentials, transition energies and oscillator strengths of He I and Li I isoelectronic systems are computed at different plasma environment with the coupled-cluster theory to examine the parametric dependence of these properties on plasma density and/or temperature. The ionization and transition energies as well as the oscillator strengths are found to be very sensitive to the plasma environment. It is found that the spectral lines corresponding to $\Delta n = 0$ transitions for Li-like C^{+3} and Al^{+10} are *blue* shifted, whereas the lines associated to $\Delta n \neq 0$ are *red* shifted (n is the principal quantum number). As of now, no prior FS-MRCC studies are available on the spectral lines of Li and Li-like ions

subjected to the plasma environment.

(Madhulita Das, Rajat K. Chaudhuri, Sudip Chattopadhyay & Uttam Sinha Mahapatra*)*

Application of an efficient multireference approach to free-base porphin and metalloporphyrins: ground, excited, and positive ion states

The improved virtual orbital-complete active space configuration interaction (IVO-CASCI) method is applied to determine the geometries of the ground state of free-base porphin and its metal derivatives, magnesium and zinc porphyrins. The vertical excitation energies and ionization potentials are computed at these optimized geometries using an IVO-based version of multireference Möller-Plesset (IVO-MRMP) perturbation theory. The geometries and excitation energies obtained from the IVO-CASCI and IVO-MRMP methods agree well with experiment and with other correlated many-body methods. The authors also provide the ground state vibrational frequencies for free-base porphin and Mg-porphyrin. All frequencies are real in contrast to self-consistent field (SCF) treatments which yield an imaginary frequency. To our knowledge, *no prior* experimental and theoretical data are available for these excited state geometries of magnesium and zinc porphyrins. Given that the IVO-CASCI and IVO-MRMP computed geometries and excitation energies agree favorably with experiment and with available theoretical data, the predicted excited state geometries of the authors should be equally accurate.

(Rajat K. Chaudhuri, Karl F. Freed, Sudip Chattopadhyay* & Uttam Sinha Mahapatra*)*

1.5 Optical Sciences & Astronomical Instrumentation

On wavefront sensing issues in large aperture telescope systems

Narrow field Infra-Red Adaptive Optics System (NFIRAOS) is a facility Multi Conjugate Adaptive Optics (MCAO) system for the Thirty Meter Telescope (TMT) observatory. The vertical density profile of the sodium layer is not uniform and the mean altitude and width of the sodium layer fluctuates in time. Extremely large telescopes are highly sensitive to these continuous variations in the sodium layer profile. The design of the NFIRAOS consists of a Moderate Order Radial (MOR) Truth Wavefront Sensor (TWFS, 12 X 12 Natural Guide Star (NGS) based) which is intended to detect the bias in the LGS based wavefront reconstruction which has occurred due to uncertainties and temporal variations in the sodium layer profile. The SHWS spots for the TWFS are seeing-limited since the WFS operates in the 0.6-0.8 micron spectral pass band and the LGS adaptive optics system only provides sufficient wavefront correction for reasonable Strehl ratios in the near infrared and also, each subaperture sees an effective telescope diameter lesser than 2m which by itself is much larger than the average Fried parameter of the TMT site (Mauna Kea) and hence the SH spots can be expected to be of various sizes and irregular shapes. Hence, it becomes important to know the impact of SHWS spot size variations on the TWFS wavefront reconstructions. A large part of the wavefront reconstruction error occurs from inaccurate centroiding of the SH spots which in turn determines the local wavefront slopes. Monte Carlo simulations run on all the centroiding algorithms for 10,000 sample spots, for each of the spot size cases (0.8 to 1.9 FWHM, in steps of 0.1) show that MFC, IWCoG, IARN and IWC outperform CoG and WCoG in terms of the centroid estimation error (CEE). The absolute CEE in the case of MFC and IWCoG is nearly the same at signal level better than 500 photons per subaperture per frame. Although MFC performs better than CoG, WCoG and IWC; IWCoG and IARN perform better than MFC in the case of changing spot size. The degree of curvature in the plot of CEE against the spot size (FWHM) in the case of MFC method increases with reducing signal level and the variation in the CEE seems to be increasing exponentially with reducing signal level in the case of MFC. The stability of the performance of IARN and IWCoG is nearly same at different spot sizes. IARN as expected performs better than IWCoG in terms of the centroid estimation error due to the removal of the problems associated with IWCoG including error saturation and non-uniform convergence of iterations. Inconsistency in the wavefront reconstruction accuracy with a SHWS based adaptive optics system depends on the time varying centroiding error and a possible mismatch of the wavefront distortion points with the wavefront sensing locations. This instability severely limits the performance of an adaptive optics system while imaging variable sources requiring an exposure time much greater than the rate of fluctuations in the wavefront reconstruction accuracy. It was shown through numerical simulations that these fluctuations can be minimized and high wavefront reconstruction accuracy can be maintained consistently for a 1-2m class telescope by using a dither based SHWS, which is intelligent enough to move across the telescope aperture region of interest so as to significantly improve the consistency of the wavefront reconstruction. Further numerical analysis is performed to analyse the possibility of using such a sensor in the case of large telescopes. The investigations suggest that for the case of very large telescopes, multiple dither sensors would do a better job than a simple single dither sensor.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Low cost turbulence generator for AO testing

Laboratory testing of a ground based telescope adaptive optics system requires building turbulence generators, which closely emulate the turbulence statistics of the atmosphere. The authors demonstrated the making of a simple, low cost ATG that can be built using domestic tools. The developed ATG was tested and characterized using a microlens array and a CCD camera (Pulnix TM 1325CL, with pixels of size 6.4μ). The design of the ATG consists of a DC axial fan from NMB-MAT (3610KL-05W-B50, obtained from an old CPU), a hairdryer (Model: OzOMAXTM BR-309 Bharat Light Machine, Delhi) and a facial steamer (Crescent Plastics, India), all of them enclosed in a cardboard box. The hair dryer and the fan were made to stand facing each other such that the hot air from the hair dryer and the cold air from the fan are mixed near the beam path region of the ATG. The facial steamer was placed under the beam path and in line with the hair dryer and fan. The ATG was tested using PSF measure-

ments and a Shack Hartmann wavefront sensor. The -1/3 power law dependence of the centroid variance on the beam size shows that the generated turbulence follows Kolmogorov statistics. The experimental results confirmed that a partial control over the turbulence strength can be obtained by an appropriate choice of the applied fan voltage and hair dryer speed. The obtained Fried parameter range suggests that this ATG can be used for testing AO systems for telescopes in the range, 0.7 m $\leq$ D $\leq$ 2.8 m. Repeatability tests show a greater stability in statistics if left alone for 30 s to stabilize.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Modeling the influence function of a deformable mirror

Measurement and modeling of the influence function plays a vital role in assessing the performance of the continuous MEMS deformable mirror (DM) for adaptive optics applications. The influence function is represented in terms of Zernike polynomials and shown that the dominant modes for representation of central actuators of the DM are different from those for the edge actuators. A novel and effective method of modeling the influence function for all the DM actuators is proposed using the 2D sinc-squared function.The authors used a Shack Hartmann Sensor to measure the influence function of a multi-DM from Boston Micromachines. It is indicated that the behavior of the edge actuators and penultimate actuators is not the same as that of the central actuator which is made clear with the domination of different Zernike modes in each of the cases. The inter-actuator coupling coefficient increases as the poke voltage increases. The most affected actuator is the nearest neighbor and the next nearest neighbor is affected a little too. There is asymmetry in the inter-actuator coupling coefficient in different directions. Actuator modeling is better with sinc-squared function due to the requirement of circular aperture for representation in terms of Zernike polynomials. The current analysis will gain more significance when the DM is used in an optical layout for wavefront correction accommodating the modeled influence function.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Wavefront correction using MEMS deformable mirror

A MEMS Deformable Mirror (DM) from Boston micromachines is used for the wavefront correction. This DM consists of 140 electrostatic actuators arranged in 12 X 12 grid with four corners fixed. The distortions to wavefronts are also induced by the same kind of DM. A 15 mW He-Ne laser is used as the source of light. The laser is spatially filtered using 40X microscopic objective and 5μ pinhole. The spatially filtered beam is collimated using a 15 cm focal length converging lens. This collimated beam is made to incident on the first DM (DM1). Different kind of distortions can be encoded to the collimated beam using this DM. The authors have particularly imposed different Zernike aberration on to the beam. This plane where the wavefront is distorted was imaged onto the second DM (DM2) using 4f geometry. They have used two 12.5 cm focal length converging lens in the 4f geometry retaining unit magnification. The plane of first DM which introduces wavefront distortion was sensed using a Shack Hartmann Sensor (SHS) using relay optics. The SHS is also at the conjugate plane of DM2 since the DM2 is in the conjugate plane of DM1. As a first step the authors have recorded the reference focal spot pattern of SHS with 0V applied to all the actuators of both the DMs. Then different Zernike aberrations were introduced using DM1 by applying different voltages to its actuators. The fitting voltages were calculated using the actuator voltage to DM surface displacement plot provided by the manufacturers. At this stage all the actuators of DM2 are at 0V. The focal spot pattern of this phase distorted wavefront was captured using the CCD camera of SHS. The centroid positions of reference focal spot pattern and focal spot pattern corresponding to aberrated wavefront are calculated using simple Center of Gravity (CoG) algorithm since the light levels are good in the experiments. In fact the authors placed neutral density filter to cut down the intensity of the light beam just immediately after the source to avoid saturation of CCD pixels. The displacement of centroid positions of aberrated wavefront with respect to centroids of reference spots provide the local slopes of the aberrated wavefront across each subaperture of the SHS. These local slopes in 'x' and 'y' direction is given as input to the wavefront reconstruction algorithm. Vector Matrix Multiply (VMM) technique was used to obtain the least square solution. In this way the wavefront shape is determined. Then 0V was applied to all actuators of first DM. The same

Zernike aberration is imposed on the second DM and the wavefront was again measured. This is to make sure that both the DMs are aligned properly. The maximum voltage applied on DMs was restricted to 40V to avoid the crosstalk between subapertures of SHS. If the alignment is good then the authors will find same Region of Interest yields good reconstruction accuracy for both the cases. Finally the aberration is applied on the DM1 and the conjugate of the aberration on DM2. It was found the resultant wavefronts are flat confirming the wavefront correction capabilities of MEMS DM. To quantify the correction of the distorted zernikes, the parameters were averaged like maximum displacement of the focal spot along x-axis when distortion is addressed on DM1 and DM2 and compared with the maximum displacement after correction. The percentage improvement is the statistic is calculated as follows. (Average value of the statistic before correction - Average value of the statistic after correction) X 100n Average value of the statistic before correction Similarly the authors have quantified the correction by calculating the mean displacement, standard deviation of the displacement along x and y direction. The results confirm wavefront compensation upto 70 percentage.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Wind speed measurement technique - experimental verification

Real-time wind velocity measurement is exceedingly essential to update the design metrics of the adaptive optics system periodically to improve the dynamic performance. A Shack Hartmann Wavefront Sensor (SHWS), which is generally used in astronomical telescope adaptive optics systems for wavefront sensing, can be simultaneously used for wind velocity estimation and this means of wind speed estimation needs special attention due to the ease of its implementation. The technique of wind measurement from the calculation of the two dimensional cross-correlation function was evaluated experimentally. Adopting the peak technique, it was found that the identification of the peak can be made accurate by using the computation cost effective 3-point parabolic interpolation technique, which is shown to behave close to the 3-point Gaussian interpolation. Also, it is shown that the time interval chosen for the calculation of the cross-correlation plays a vital role in optimal performance. For small time interval case, the interpolation techniques do not yield correct results. In this case, it is shown that the iteratively weighted center of gravity algorithm is more suitable.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Noise reduction in imaging systems involving the MEMS deformable mirror

The frames captured with a compact, high-resolution, monochrome progressive scan CCD camera, of a continuous facesheet micro-electro-mechanical systems (MEMS) deformable mirror (DM), include unwanted diffractive, background and readout noises; which significantly reduces the quality of imaging in many applications. Processing these images before passing them on to meet later experimental objectives can improve its performance greatly. A sequence of steps involving image intensity weighted noise removal and other smoothing techniques were proposed to minimize the noise and improve the phase production and correction capabilities of the DM.

(M. B. Roopashree, Akondi Vyas & B. Raghavendra Prasad)

Detection of periodicities, hidden behind randomness

A periodic structure, hidden behind roughness, cannot be detected from ordinary intensity measurements of scattered light. This happens because, intensity peaks created due to scattering from periodic parts are broadened by the randomness and overlap with each other. With the help of the “augmented matched filter methods, developed by the authors for this purpose, it is shown that the hidden periodicity can be detected, which the conventional methods would not allow. In the recent work, the success of this method has been demonstrated in various cases of randomness, for different types of correlation functions and also developed suitable statistical tests for these detections.

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

On the X-ray attenuation coefficient of mixtures

The X-ray attenuation coefficient of substances, are known to consist of two parts, (1) due to Compton scattering, (2) due to photoelectric effect. The former, in its complete relativistic form is given by the

Klein-Nishina formula, which is generally used in the non-relativistic limit. The photoelectric effect part is found to follow, (Zeffx/Ey), where Zeff is the effective atomic number of the substance and E is the energy of the photon. Quite intriguingly, there is no standard value assigned for the exponents x, y. Our theoretical and experimental studies show for correct interpretation of data (a) the full Klein-Nishina formula has to be used, (b) the exponent y has to be fixed at y = 3.0669 (c) a fixed value for x cannot be assigned. These results are of importance in the inversion of the Dual Energy Computed Tomography (DECT) data, which is pointed out.

(R. R. Haghighi, S.Chatterjee, A. Vyas, P. Kumar* & S. Thulkar*)*

Aperture synthesis at optical wavelengths

Optical stellar interferometers have demonstrated milli-arcsecond resolution with few apertures spaced tens of meters apart. Results from the area of stellar angular diameters with implications for emergent fluxes, effective temperatures, luminosities and structure of the stellar atmosphere, dust and gas envelopes, binary star orbits with impact on cluster distances and stellar masses, relative sizes of emission-line stars and emission region, stellar rotation, limb-darkening, and astrometry have been published. However, in order to obtain snapshot images, many-apertures would be required, for a better sampling of the incoming wavefront. The coherent imaging thus achievable improves the sensitivity with respect to the incoherent combination of successive fringed exposures, heretofore achieved in the form of optical aperture synthesis. For efficient use of a multi-aperture imaging interferometer, this can be done with pupil densification, a technique also called hypertelescope imaging. When equipped with a coronagraph, this can be used for imaging of exoplanet transits across a resolved star. The capabilities of such a technique can be envisaged through a simulated image carried out recently by Surya et al.

(S. K. Saha)

Hypertelescope approach: A novel method for imaging of stellar objects aperture synthesis at optical wavelengths

The diffraction limited phase retrieval of a degraded image is an important subject that is being implemented in other branches of physics too, for example, electron microscopy, wavefront sensing, and crystallography. A third-order moment (Bispectrum) analysis yields the phase allowing the object to be fully reconstructed. This can be extended from the single aperture speckle interferometry to the multi-aperture long baseline interferometry as well. However, in order to obtain snapshot images of the astronomical sources, many aperture optical array with arbitrarily diluted apertures is required to be built, what is known as Hypertelescope approach. A major challenge for building such a system is the development of adaptive phasing system. Modified wave sensing techniques such as dispersed speckle analysis are planned to be used with these systems. But development and installation of such advanced methods are not available at present. In such a scenario, speckle mode observations with Hypertelescope becomes a viable alternative. A study of speckle techniques with such systems is thus of great interest. This work is aimed to describe some of these techniques and methods.

(S. K. Saha)

Imaging exoplanet transits with hypertelescopes

Optical stellar interferometers have demonstrated milli-arcsecond resolution with few apertures spaced hundreds of meters apart. To obtain rich direct images, many apertures will be needed, for a better sampling of the incoming wavefront. The coherent imaging thus achievable improves the sensitivity with respect to the incoherent combination of successive fringed exposures, heretofore achieved in the form of optical aperture synthesis. For efficient use of highly diluted apertures, this can be done with pupil densification, a technique also called 'Hypertelescope imaging'. One of the major applications of Hypertelescopes will be in imaging of exo-planet transits across a resolved star. Our simulations show the capabilities of Hypertelescopes to image exo-planets, crossing the disk of the well resolved parent star.

(A. Surya, S. K. Saha, & A. Labeyrie)*

Tomographic speckle imaging: laboratory experiments with aperture masking

Speckle imaging based on triple correlation is a very efficient image reconstruction technique which is used to retrieve Fourier phase of object imaged in the presence of atmospheric turbulence. The authors have developed both Direct Bispectrum and

Radon transform based Tomographic speckle masking (TSM) algorithms to process speckle frames. The latter is a much computationally efficient technique because it works with 1-dimensional image projections. Tomographic speckle imaging provides good image recovery like Direct Bispectrum, but with a large improvement in computational time and memory requirements. The authors have developed a laboratory setup to simulate Aperture masking Interferometry in Fizeau mode combination with 5-20 subapertures. The authors describe the results from TSM algorithm with the images obtained with this aperture masking setup and also compare its computational requirements and reconstruction quality with direct bispectrum technique.

(A. Surya, K. V. Suneeth, S. K. Saha, & J. P. Lancelot)

Finite element analysis of a lightweighted solar telescope mirror

The primary mirror heating of a solar telescope is a complex and challenging problem for optical engineers. The thermal performance of the telescope mirror needs to be accurately predicted under real observing conditions. From the view point of thermal management alone, the lightweighted mirrors offer significant advantages over heavy, monolithic mirrors. Besides, a significant reduction in overall weight, the temperature of a lightweighted mirror stabilizes rather quickly, thus reducing the detrimental effect of mirror seeing on image quality. Unlike solid mirror, the pocketed cell structure created by the lightweighting process leads to material inhomogeneities within the mirror blank. The most conspicuous fallout of the different cell geometries and side wall structure is the appearance of the thermal footprints on the reflecting optical surface of the mirror. Finite element methods have been used to study the geometry induced temperature inhomogeneities on the surface of a 2-m class lightweighted solar telescope mirror. The heat transfer model solved using finite element software realistically takes into account the mirror heating caused by a smooth and gradual increase of the solar flux during the day and convective and radiative cooling during the night. A simple physics-based model is used as an input to simulate typical ambient temperature conditions that may exist at the observatory site. The results show the temperature distribution of the optical surface clearly mimicking the underlying geometrical cell structure of the telescope mirror.

(R. K. Banyal & B. Ravindra)

Development of a temperature controller for the order-sorting interference filters

A Fabry-Perot narrow band imager (NBI) is being built for solar studies at IIA. The NBI has an order sorting pre-filter that selects an optical beam within desired wavelength band. A constant temperature is required to keep the transmission response of the interference filter stable during the observations. A low-cost, temperature measurement and control system is, therefore, designed and built in the lab. The temperature sensing is done with a digital thermometer and thermostat IC DS1621 from *Maxim*. Digital input/output pins of the PC printer port are utilized to create a simple 2-wire serial interface for the sensor. Maximum resolution of the sensor is 0.125°C and the temperature range is -55°C to +125°C. An easy to implement, inexpensive and open source approach can be used to modify and develop different suits of temperature control modules required to meet specific experimental needs in general physics laboratories.

(R. K. Banyal & B. Ravindra)

Development of lunar scintillometer for measuring ground-layer turbulence

Lunar Scintillometer is (LuSci) a linear array of photo diodes which measure the intensity fluctuations in the moon caused by lower layers of Earth's atmosphere. These photodiodes are placed at specific distances from each other in order that they may sample a range of as many different baselines as possible. Covariances of the signals from 15 pairs (baselines) are computed. The measured covariances are normalized and are then related to the distribution of atmospheric refractive index constant, along the line of sight, thereafter fitted to get a turbulence profile. The work completed so far include: hardware design (electronic circuit, Al fabricated mechanical enclosure for the sensors, PCB, webcamera adapter etc) and software (GUI for telescope control, 8-channel data acquisition system, LabVIEW interface for web camera). Inversion algorithm is to be developed and instrument needs to be assembled and tested in the lab.

(R. K. Banyal & P. Parihar)

Status of 75cm Telescope, VBO, Kavalur

The newly modified 75cm telescope at Kavalur was used from January – March 2011 to obtain actual star co-ordinate information for about 500 bright stars. This data was utilized by A. V. Raveendran to develop a telescope modeling program for 75cm Telescope. This is a C application developed under linux and uses GTK (graphics Tool Kit) for graphical user Interface. The modeling program provides the corrected star position from the Almanac positions. The program incorporates corrections for: Propermotion (secularly increasing); Aberration for stellar objects (periodic, 20 arcsec); Precession(secularly increasing); Nutation (periodic, 20 arcsec max); Annual parallax for stellar objects/horizontal parallax for solar objects (periodic, < 1 arcsec); Diurnal aberration (periodic,< 0.3 arcsec); Refraction (around 60 arcsec at 45 degree zenith angle); Telescope pointing errors; a)Model functions b)Local zero points Apart from telescope modeling, there is a facility available for database creation required for modeling. There is also a provision for obtaining rate of change of RA and DEC for each telescope position. This would help adjusting the tracking rate if required. Currently efforts are on to test the modeling program and fine tune the model if necessary. A new guide camera based on L 3 sensor has been procured from e2v U.K. and is undergoing testing. The telescope is being tested for tracking and guiding performance at various telescope positions.

(A. V. Ananth, V. Arumugam, P. Anbazgan & A. Ramchandran)

Development of 2k X 4K CCD camera for 75cm Telescope

A CCD camera based on IIA controller for the 2k X 4k sensor is undergoing testing at the 75cm Telescope. The software for the same based on C/C++ under linux has been developed. The system has some issues related to noise problems because of operating environment particularly telescope and dome drives. Efforts are on to minimize the same. This system has also limitation relating to rate of image data acquisition. Presently, it takes about 3 minutes for image frame of 2k X 4k. In order to overcome the speed limitation, efforts are on to develop a camera based on SDSU (San Diego State university) CCD controllers. A new Dewar is also being developed for the inverted mode of operation for the above sensor incorporating several new features: a. A kapton disk to provide good electrical insulation and good thermal conduction between liquid nitrogen container and the cold finger that is connected to the sensor.

b. Mylar sheet insulation between the outer body and the inner liquid nitrogen container for reducing radiation losses. c. A centre filling option for reducing the losses and increasing the hold time in the inverted mode.

(A. V. Ananth, V. Arumugam, K. Anupama. K. Sagaynathan & A. Ramachandran)

1.6 Publications

In Journals

*Aihara, H., Sivarani, T., 179 coauthors listed alphabetically, 2011, ApJS, 193, 29
The Eighth Data Release of the Sloan Digital Sky Survey: First Data from SDSS-III

Anathpindika, S., Bhatt, H. C., 2011, MNRAS, 412, 921
On the Interaction of a Thin, Supersonic Shell with a Molecular Cloud

Anathpindika, S, 2011, Astronomy & Geophysics, 52, No.4, 4.16
India's Tryst with Modern Astronomy

*Antokhina, E. A., Srinivasa Rao, M., *Parthasarathy, M., 2011, New Astronomy, 16, No. 3, 177
Light Curve Analysis of Hipparcos Data for the Massive O-type Eclipsing Binary UW CMa

Anusha, L. S., Nagendra, K. N., 2011, ApJ, 739, 40
Polarized Line Formation in Multi-dimensional Media.IV. A Fourier Decomposition Technique to Formulate the Transfer Equation with Angle-Dependent Partial Frequency Redistribution

Anusha, L. S., Nagendra, K. N., 2012, ApJ, 746, 84
Polarized Line Formation in Multi-Dimensional Media. V. Effects of Angle-Dependent Partial Frequency Redistribution

*Arellano Ferro, A., *Bramich, D. M., *Figuera J. R., Giridhar, S., Kuppuswamy, K., 2012, MNRAS, 420, 1333
The Unusually Large Population of Blazhko Variables in the Globular Cluster

*Arellano Ferro, A., *Figuera Jaimes, R., Giridhar, S., *Bramich, D. M., *Hernndez Santisteban, J. V., Kuppuswamy, K., 2011, MNRAS, 416, 2265
Exploring the Variable Stars in the Globular Cluster NGC 5024 (M53): New RR Lyrae and SX Phoenicis Stars

*Babu, S. S., *Chaubey, J. P., *Moorthy, K. K., *Gogoi, M. M., *Kompalli, S. K., *Sreekanth, V., Bagare, S. P., Bhatt, B. C., Gaur, V. K., Prabhu, T. P., Singh, N. S., 2011, JGRD, 11624201
High Altitude (4520 m amsl) Measurements of Black Carbon Aerosols over Western Trans-Himalayas: Seasonal Heterogeneity and Source Apportionment

*Bayanna, A. R., *Mathew, S. K., *Sankarasubramanian, K. *Venkatakrishnan, P. Singh, J., Prasad B. R., 2011, Experimental Astronomy, 29, No. 3, 145
Issues with External Occultation of a Coronagraph

*Beers, T. C., *Carollo, D., *Ivezić, Ž., *An, D., *Chiba, M., *Norris, J. E., *Freeman, K. C., *Lee, Y. S., *Munn, J. A., *Re Fiorentin, P., Sivarani, T., *Wilhelm, R., *Yanny, B., *York, D. G., 2012, ApJ, 746, 34
The Case for the Dual Halo of the Milky Way

Bhatt, H. C., 2011, Pramana, 77, 19
Disks Around Young Stellar Objects

*Bilham, Roger., Gaur, V. K., 2011, Current Science, 101, No. 10, 1275
Historical and Future Seismicity near Jaitapur, India

*Britto, R. J., *Acharya, B. S., Anupama, G. C., *Bhatt, N., *Bhattacharjee, P., *Bhattacharya, S., Chitnis, V. R., Cowsik, R., Dorji, N., *Duhan, S. K., *Gothe, K. S., Kamath, P. U., *Koul, R., *Manoharan, J., Mahesh, P. K., *Mitra, A., *Nagesh, B. K., *Parmar, N. K., Prabhu, T. P., *Rannot, R. C., *Rao, S. K., *Saha, L., Saleem, F., Saxena, A. K., *Sharma, S. K., Shukla, A., *Singh, B. B., Srinivasan, R., Srinivasulu, G., *Sudersanan, P. V., *Tickoo, A. K., Tsewang, D., *Upadhya, S. S., Vishwanath, P. R *Yadav, K. K.,2011, Astrophysics and Space Sciences Transactions, Vol. 7, pp. 501-505
Observations with the High Altitude GAmma-Ray (HAGAR) Telescope Array in the Indian Himalayas

*Cano, Z. et al. (including D. K. Sahu and G. C. Anupama), 2011, MNRAS, 413, 669
A Tale of two GRB-SNe at a Common Redshift of z = 0.54

*Carollo, D., *Beers, T. C., *Bovy, J., Sivarani, T., *Norris, J. E., *Freeman, K. C., *Aoki, W., *Lee, Y. S., *Kennedy, C. R. 2012, ApJ, 744, 195
Carbon-Enhanced Metal-Poor Stars in the Inner and Outer Halo Components of the Milky Way

Chatterjee, S., Vyas, A., *Haghighi, R., Kumar*, P., 2011, J. Biomedical Physics and Engineering, 1, No 1, 22
The Energy Dependence of the Photoelectric Attenuation Coefficient of Substances

*Chattopadhyay, S., Chaudhuri, R. K., *Freed, K. F., 2011, Phys. Chem. Chem. Phys., 13, 7514
A Preliminary Prediction of Electronic Structure of Organic Radicaloid Anions via an Efficient and Economic Multireference Gradient Approach

*Chattopadhyay, S., Chaudhuri, R. K., *Freed, K. F., 2011, J. Phys. Chem. A, 115, 3665
Geometry Optimization of Radicaloid Systems Using Improved Virtual Orbital- Complete Active Space Configuration Interaction (IVO-CASCI) Analytical Gradient Method

*Chattopadhyay, S., Chaudhuri, R. K., *Mahapatra, U. S., 2011, Chem. Phys. Chem., 12, 2791
Ab Initio Multireference Investigation of Disjoint Diradicals: Singlet versus Triplet Ground States

*Chattopadhyay, S., *Mahapatra, U. S., Chaudhuri, R. K., 2012, Theo. Chem. Acc., (in press)
State-Specific Complete Active Space Multireference Perturbation Approach for Multireference Situations: Illustrating the Bond Breaking in Hydrogen Halides

Chaudhuri, R. K., *Freed, K. F., *Chattopadhyay, S., *Mahapatra, U. S., 2011, J. Chem. Phys., 135, 084118
Application of an Efficient Multireference Approach to Free-Base Porphin and Metalloporphyrins: Ground, Excited, and Positive Ion States

*Chauhan, N., *Ogura, K., *Pandey, A. K., *Samal, M. R., Bhatt, B. C., 2011, PASJ, 63, 795
Stars at the Tip of Peculiar Elephant Trunk-Like Clouds in IC 1848E: A Possible Third Mechanism of Triggered Star Formation

Chingangbam, P., *Qureshi, T., 2012, Prog. Theor. Phys., 127, 3
Ghost Interference and Quantum Erasure

Chitta, L. P., *Jain, R., Kariyappa, R., *Jefferies, S. M., 2011, ApJ, 744, 98
Observational Evidence of the Interaction of Acoustic Waves and Small-Scale Magnetic Fields

*Couvidat, S., Rajaguru, S. P., *Wachter, R., *Sankarasubramanian, K., *Schou, J., *Scherrer, P. H., 2012, Solar Phys., 278, 217
Testing Doppler Observations by the Helioseismic and Magnetic Imager (HMI) onboard Solar Dynamics Observatory (SDO)

*da Silva, R., *Milone, A. C., Reddy, B. E., 2011, A&A, 526, 71
Homogeneous Photospheric Parameters and C Abundances in G and K Nearby Stars with and without Planets

*Das, M., Chaudhuri, R. K., *Chattopadhyay, S., *Mahapatra, U. S., *Mukherjee, P. K., 2011 J. Phys. B., 44, 165701
Application of Relativistic Coupled Cluster Linear Response Theory to Helium like Ions Embedded in Plasma Environment

*Das, M., *Das, M., Chaudhuri, R. K., *Chattopadhyay, S., 2012, Phys. Rev. A., 85, 042506
Application of Relativistic Fock-Space Coupled-Cluster Theory to Study Li and Li-Like Ions in Plasma

*Das, M., Chaudhuri, R. K., *Chattopadhyay, S., *Mahapatra, U. S 2011, Phys. Rev. A, 84, 042512
Fock Space Multireference Coupled Cluster Calculations of the Hyperfine Structure of Iso-Electronic $^{33}S^{-}$ and $^{35,37}Cl$

Das, M., *Sengupta, C., Ramya, S., *Misra, K., 2012, MNRAS, in press, (2012arXiv1205.1936)
Star Formation in Bulgeless late Type Galaxies: Clues to their Evolution

Dhar, A., Singh, M., *Rai, R. V., Das, B. P., 2011, Physical Rev. A, Vol. 84, No. 3, 033631
Mean-field Analysis of Quantum Phase Transitions in a Periodic Optical Superlattice

*Eisenstein, D. J., and 243 colleagues including Sivarani, T., 2011, AJ, 142, 72
SDSS-III: Massive Spectroscopic Surveys of the Distant Universe, the Milky Way, and Extra-Solar Planetary Systems

*Garca-Hernndez, A. D., Rao, N. K., *Lambert, D. L., ApJ, 739, 37
Dust around R Coronae Borealis Stars. I. Spitzer/ Infrared Spectrograph Observations

*Golovin, A., *Galvez-Ortiz, M. C., *Hernan-Obispo, M., *Andreev, M., *Barnes, J. R., *Montes, D., *Pavlenko, E., *Pandey, J. C., *Martinez-Arnaiz, R., *Medhi, B. J., Parihar, P. S., *Henden, A *Sergeev, A., *Zaitsev, S. V., *Karpov, N., 2012, MNRAS, 421, 132
FR Cnc Revisited: Photometry, Polarimetry and Spectroscopy

*Gopal-Krishna, *Goyal, A., *Joshi, S., *Karthick, C., *Sagar, R., *Wiita, P. J., Anupama, G. C., Sahu, D. K., 2011, MNRAS, 416, 101
Rapid Optical Variability of TeV Blazars

*Gopal-Krishna, *Mhaskey M., Mangalam, A., 2012, ApJ, 744, 31
Are the Relativistic Electrons in High-Redshift Radio Galaxies Injected with Very Steep Energy Spectra ?

*Gudennavar, S. B., *Bubbly, S. G., *Preethi, K., Murthy, J. 2012, ApJS, 199, 8
A Compilation of Interstellar Column Densities

*Gupta, A. C., *Krichbaum, T. P., *Wiita, P. J., *Rani, B., *Sokolovsky, K. V., Mohan, P., Mangalam, A., et al., MNRAS, 425, 1357
Multi-Wavelenth IDV of the BL Lac S 0716+714

*Haghighi, R. R., Chatterjee, S., Vyas, A., *Kumar, P., *Thulkar, S., 2011, Medical Physics 38, 5270
X-ray Attenuation Coefficient for Mixtures: Inputs for Dual Energy CT

*Hansen, C. J., *Nordström, B., *Bonifacio, P., *Spite, M., *Andersen, J., *Beers, T. C., *Cayrel, R., *Spite, F., *Molaro, P., *Barbuy, B., *Depagne, E., *François, P., *Hill, V *Plez, B., Sivarani, T., 2011, A&A, 527, A65
First Stars. XIII. Two Extremely Metal-Poor RR Lyrae Stars

Hema, B. P., Pandey, G., *Lambert, D. L., 2012, ApJ, 747, 102
The Galactic R Coronae Borealis Stars: The C2 Swan Bands, the Carbon Problem, and the $^{12}C/^{13}C$ Ratio

Hiremath, K. M., 2012, Planetary & Space Sci., 63, 8
Magnetic Field Structure of Mercury

Hiremath, K. M., *Lovely, M. R., 2012, New Astronomy, 17, 392
Toroidal Magnetic Field Structure of the Solar Convective Envelope Inferred from the Initial Observations of the Sunspots

*Hsieh, H. H., *Yang, Bin., *Haghighipour, N., et al., Bhatt, B. C., Sahu, D. K ., 2012, ApJ, 748, No. 1 , L15
Discovery of Main-Belt Comet P/2006 VW139 by Pan-STARRS1

Indu, G., Subramaniam, A., 2011, A&A, 535, A115
Recent Star Formation History of the Large and Small Magellanic Clouds

*Jain, R. K., Chingangbam, P., *Sriramkumar, L., 2011, Nucl. Phys. B 852, 366
Reheating in Tachyonic Inflationary Models: Effects on the Large Scale Curvature Perturbations

Javaraiah, J., 2012, Ap&SS, 338, 217
Solar Cycle Variations in the Growth and Decay of Sunspot Groups

Javaraiah, J., *Rozelot, J.P., *Luca Bertello, 2012, *Adv. Astron.*, 2012, id. 470631
The Solar Cycle

Jose, J., *Pandey, A. K., *Ogura, K., *Samal, M. R., *Ojha, D. K., Bhatt, B. C., *Chauhan, N., *Eswaraiah, C., *Mito, H., *Yadav, R. K., 2012, MNRAS, in press
Optical and Infrared Survey of the Stellar Contents Associated with the Star-Forming Complex Sh2-252

Kapoor, R. C., 2011, J. Astr. History and Heritage, Vol. 14, 93
Madras Observatory and the Discovery of C/1831 A1 (The Great Comet of 1831)

*Kennedy, C. R., Sivarani, T., *Beers, T. C., *Lee, Y. S., *Placco, V. M.,*Rossi, S., *Christlieb, N., *Herwig, F., *Plez, B., 2011, AJ, 141, 102
[O/Fe] Estimates for Carbon-Enhanced Metal-Poor Stars from Near-Infrared Spectroscopy

Kumar, D., Gangadhara, R. T., 2012, ApJ, 745, 157
Relativistic Model on Pulsar Radio Emission and Polarization

Kumar, Y. B, Reddy, B. E, Lambert*, D. L., 2011, ApJ Lett., 730, 12
Origin of Lithium Enrichment in K Giants

Kumara, S. T., Kariyappa, R., *Dominique, M., *Berghmans, D., *Dame, L., *Hochedez, J. F., *Doddamani, V. H., *Chitta, L. P., 2012, Advances in Astronomy, Vol. 2012, 1
Preliminary Results on Irradiance Measurements from Lyra and Swap

*Lai, D. K., *Lee, Y. S., *Bolte, M., *Lucatello, S., *Beers, T. C., *Johnson, J. A., Sivarani, T., *Rock-

osi, C. M. 2011, ApJ, 738, 51
The [Fe/H], [C/Fe], and [α/Fe] Distributions of the Boötes I Dwarf Spheroidal Galaxy

*Lal, D. V., Shastri, P., *Gabuzda, D. C., 2011, ApJ, 731, 68
Seyfert Galaxies: Nuclear Radio Structure and Unification

*Lee, Y. S., *Beers, T. C., *Allende Prieto, C., *Lai, D. K., *Rockosi, C. M., *Morrison, H. L., *Johnson, J. A., *An, D., Sivarani, T., *Yanny, B., 2011, AJ, 141, 90
The SEGUE Stellar Parameter Pipeline. V. Estimation of Alpha-Element Abundance Ratios from Low-Resolution SDSS/SEGUE Stellar Spectra

*Mahesh, P., *Catherine, J. K., *Gahalaut, V. K., *Kundu, B., *Ambikapathy, A., *Bansal, A., *Premkishore, L *Narsaiah, M., *Ghavri, S., *Chadha, R. K., *Choudhary, P., *Singh, D. K., *Singh, S. K., Kumar, S .,Bhatt, B. C.,*Tiwari, R. P., *Kumar, A., *Kumar, A., *Bhu, H., *Kalita, S.,2012, Gondwana Research (in press)
Rigid Indian plate: Constraints Nagarajan, from GPS measurements

*Marley, M. S., Sengupta, S., 2011, MNRAS, 417, 2874
Probing the Physical Prpoerties of Directly Imaged Exoplanets through Polarization

*Mathew, B., *Banerjee, D. P. K., Subramaniam, A., *Ashok, N. M., 2012, in press
A Study of the Role of Lyman β Fluorescence on OI Line Strengths in Be Stars

*Mathew, B., *Banerjee, D. P. K., *Ashok, N. M., Subramaniam, A., *Bhavya, B., *Joshi, V., 2012, Research in A&A, 12, 167
Studies of a Possible New Herbig Ae/Be star in the Open Cluster NGC 7380
*Mathew, B., Subramaniam, A., 2011, BASI, 39, 517
Optical Spectroscopy of Classical Be Stars in Open Clusters

*Meech, K. J., Bhatt, B. C., Sahu, D. K., and 194 coauthors, 2011, ApJ 734, No. 1, L1
EPOXI: Comet 103P/Hartley 2 Observations from a Worldwide Campaign

*Mitra, S., *Priestley, K., *Acton, C., Gaur, V. K., 2011, J. Asian Earth Sci., 42, 1243
Anomalous Surface Wave Dispersion and the Enigma of "Continental-Like" Structure for the Bay of Bengal

Mohan P., Mangalam A., *Chand H., *Gupta, A. C., JAA, 2011, 32, 117
Re-Analysis of QPO in 3C273 Light Curve

*Moorthy, K. K., *Sreekanth, V., *Chaubey, J. P., *Gogoi, M. M., *Babu, S. S., *Kompalli, S. K., Bagare, S. P., Bhatt, B. C., Gaur, V. K., Prabhu, T. P., Singh, N. S., 2011, JGRD, 116, D20212
Fine and Ultrafine Particles at a Near-Free Tropospheric Environment over the High-Altitude Station Hanle in the Trans-Himalaya: New Particle Formation and Size Distribution

Murthy, J., *Henry, R. C., *Holberg, J. B. 2012, ApJS, 199, 11
Voyager Observations of the Diffuse Far-Ultraviolet Radiation Field

Muthumariappan, C., *Parthasarathy, M., 2012, MNRAS (in press)
2D Monte-Carlo Radiative Transfer Modeling of the Disk Shaped Secondary of Epsilon Aurigae

Nagendra, K. N., Sampoorna, M., 2011, A&A, 535, A88
Spectral Line Polarization with Angle-Dependent Partial Frequency Redistribution. IV. Scattering Expansion Method for the Hanle Effect

*Ojha, D. K., *Samal, M. R., *Pandey, A. K., Bhatt, B. C., *Ghosh, S. K., *Sharma, S., *Tamura, M., *Mohan, V., *Zinchenko, I.,2011, ApJ, 738, No. 2, 156
Star Formation Activity in the Galactic H II Complex S255-S257

*Palacios, A., *Parthasarathy, M., Bharat Kumar, Y., *Jasniewicz, G.,2012, A&A, 538, A68
Weak G-Band Stars on the H-R Diagram: Clues to the Origin of the Li Anomaly

*Paul, K. T. Subramaniam, A., *Mathew, B., *Mennickent, R. E., *Sabogal, B., 2012, MNRAS, 421, 3622
Study of Candidate Be Stars in the Magellanic Clouds Using Near-Infrared Photometry and Optical Spectroscopy

*Placco, V. M., *Kennedy, C. R., *Beers, T. C.,

*Christlieb, N., *Rossi, S., Sivarani, T., *Lee, Y. S., *Reimers, D., *Wisotzki, L. 2011. AJ. 142, 188
Searches for Metal-Poor Stars from the Hamburg/ESO Survey Using the CH G Band

*Pottasch, S. R., Surendiranath, R., *Bernard-Salas, J.,2011, A&A, 531, A23
Abundances in Planetary Nebulae: NGC 1535, NGC 6629, He2-108, and Tc1

Pradhan, A. C., Murthy, J., *Pathak, A., 2011, ApJ, 743, 80
Observations of Far-Ultraviolet Diffuse Emission from the Small Magellanic Cloud

Raju, K. P., *Chandrasekhar, T., *Ashok, N. M., 2011, ApJ, 736, No. 2, 164
Analysis of Coronal Green Line Profiles: Evidence of Excess Blueshifts

Ramesh, K. B., *Lakshmi, N. B., 2012, Solar Physics, 276, 395
The Amplitude of Sunspot Minimum as a Favorable Precursor for the Prediction of the Amplitude of the Next Solar Maximum and the Limit of the Waldmeier Effect

Ramesh, R., Kathiravan, C., Barve, Indrajit V., *Rajalingam, M., 2012, ApJ, 744, No. 2 , 165
High Angular Resolution Radio Observations of a Coronal Mass Ejection Source Region at Low Frequencies during a Solar Eclipse

Ramesh, R., Kathiravan, C., Satya Narayanan, A.,2011, ApJ, Vol. 734, No. 1, 39
Low-Frequency Observations of Polarized Emission from Long-lived Non-thermal Radio Sources in the Solar Corona

Ramya, S., Prabhu, T. P., Das, M., 2011, MNRAS, 418, 789
Active Galactic Nucleus Activity and Black Hole Masses in Low Surface Brightness Galaxies

Rao, N. K., *Thakur, P., 2011, J. Astr. History and Heritage, 14, 136
Aspects of Observational Astronomy in India: The Vidyasankara Temple at Sringeri

Rao, N. K., *Thakur, P., *Mallinathpur, Y., 2011, J. Astr. History and Heritage, 14(3), 211
The Astronomical Significance of 'Nilurallu', The Megalithic Stone Alignment at Murardoddiin Andhra Pradesh, India

Rao, N. K., Vagiswari, A., Birdie, C., 2011, Cur. Sci. 100, 1575
Early Pioneers of Telescopic Astronomy in India: G. V. Juggarow and his Observatory

Ravindra, B., *Gosain, S.,2012, Advances in Astronomy, Vol. 2012, Article ID 735879
Rapid Disappearance of Penumbra-Like Features near a Flaring Polarity Inversion Line: the Hinode Observations

Ravindra, B., *Venkatakrishnan, P., *Tiwari, Sanjiv Kumar, *Bhattacharyya, R., 2011, ApJ, 740, 19
Evolution of Currents of Opposite Signs in the Flare-Productive Solar Active Region NOAA 10930

Ravindra, B., *Yoshimura, Keiji, *Dasso, Sergio, 2011, ApJ, 743, 33
Evolution of Spinning and Braiding Helicity Fluxes in Solar Active Region NOAA 10930

Reddy, A. B. S., Giridhar, S., *Lambert, D. L., 2012, MNRAS, 419, 1350
Comprehensive Abundance Analysis of Red Giants in the Open Clusters NGC 752, 1817, 2360 and 2506

Roopashree, M., Vyas, A., Prasad, B. R., Int. J. on Recent Trends in Engineering & Technology, 2011, 6, 2011, 52
Wind Speed Measurement from Shack Hartmann Wavefront Sensor Data: An Experimental Review of Cross-Correlation Peak Detection

Roopashree, M. B., Vyas, A., Prasad, B. R., 2012, Intl J. Control System and Instrumentation, 3, 10
A Novel Model of Influence Function: Calibration of a Continuous Membrane Deformable Mirror

*Sahoo, B. K., Das, B. P.,2011, Physical Review A, Vol. 84, No. 1, 012501
Transition Properties of Low-Lying States in Atomic Indium

*Sahoo, B. K., Das, B. P., 2011, Physical Review A, Vol. 84, No. 1, 010502(R) *Parity Nonconservation in Ytterbium Ion*

*Sahoo, B. K., *Pandey, R. K., Das, B. P., 2011, Phys. Rev. A, Rapid Communication 84, 030502
The Search for a Permanent Electric Dipole Moment

Using Atomic Indium

Sampoorna, M., 2011, A&A, 532, A52
Spectral Line Polarization with Angle-Dependent Partial Frequency Redistribution. III. Single Scattering Approximation for the Hanle Effect

Sampoorna, M., 2012, ApJ, 745, 189
Polarized Partial Frequency Redistribution in Subordinate Lines I. Resonance Scattering with Collisions

Sengupta, S., *Taam, R. E., 2011, ApJ, 739, 34
Theoretical Spectra of the AM Canum Venaticorum Binary System SDSS J0926+3624 : Effects of Irradiation onto the Donor Star

Shantikumar, S. N., 2011, J. Atmos.& Solar-Terres. Physics, 73, 2305
Variability of Sunspot Cycle QBO and Total Ozone Over High Altitude Western Himalayan Regions

Shukla, A., *Chitnis, V. R., Vishwanath, P. R., *Acharya, B. S., Anupama, G. C., *Bhattacharjee, P., *Britto, R. J., Prabhu, T. P., Saha, L., Singh, B. B., 2012, A&A, 541, 140
Multiwavelength Study of TeV Blazar Mrk421 during Giant Flare

Singh, J., Ravindra, B., 2012, BASI, 40, 77
Twin Telescope Observations of the Sun at Kodaikanal Observatory

Singh, J., Ravindra, B., *Raju, S., *Pichaimani, K., *Priyal, M., *Gopalan P., *Thambaje, K., Amareswari, 2012, RAA, 12, 201
Determination of the Chromospheric Quiet Network Element Area Index and its Variation between 2008 and 2011

Singh, V., Shastri, P., *Athreya, R., 2011, JAA, 32, 497
Seyfert Galaxies: Radio Continuum Emission Properties and the Unification Scheme

Singh, V., Shastri, P., *Risaliti, G.,2011, A&A, 533, A128
Measuring the Level of Nuclear Activity in Seyfert Galaxies and the Unification Scheme

Singh, V., *Risaliti, G., *Braito, V., Shastri, P., 2012, MNRAS, 419, 2089
Suzaku X-ray spectral study of the Compton-thick Seyfert galaxy NGC 5135

Sivaram, C., *Arun, K., *Nagaraja, R., 2011, Astrophysics and Space Science, 333, 1
A Critique on Drexler dark matter

Sivaram, C., *Arun, K., *Nagaraja, R., 2011, Astrophysics and Space Science, 335, 599
Dieterici Gas as a Unified Model for Dark Matter and Dark Energy

Sivaram, C., *Arun, K., 2012, A&SS, 337, 169
Enigmatic Aspects of Entropy Inside the Black Hole: what do Falling Comoving Observers See ?

Sivaram, C., Arun, K., 2012, A&SS, 337, 767
Some Aspects of Rotational and Magnetic Energies for a Hierarchy of Celestial Objects

Sivaram, C., Arun, K., 2012, A&SS, 338, 1
Some Unique Constants Associated with Extremal Black Holes

*Smolinski, J. P., *Lee, Y. S., *Beers, T. C., An, D., *Bickerton, S. J., *Johnson, J. A., *Loomis, C. P., * Rockosi, C. M., Sivarani,T., *Yanny, B., 2011, AJ, 141, 89
The SEGUE Stellar Parameter Pipeline. IV. Validation with an Extended Sample of Galactic Globular and Open Clusters

Smitha, H. N., Nagendra, K. N., Sampoorna, M., *Stenflo, J. O., 2011, A&A, 535, A35
Radiative Transfer with J-State Interference in a Two-Term Atom. Partial Frequency Redistribution in the Non-Magnetic Case

Smitha, H. N., Nagendra, K. N., *Stenflo, J. O., *Bianda, M., Sampoorna, M., *Ramelli, R., Anusha, L. S., 2012, A&A, 541, 24
J-State Interference Signatures in the Second Solar Spectrum. Modeling the Cr I *Triplet at 5204-5208 Å*

*Subramanian, P., Shukla, A., *Becker, P. A., 2012, MNRAS, 423, 1707
TeV Blazar Variability: the Firehose Instability ?

Subramanian, S., Subramaniam, A., 2012, ApJ, 744, 128
The Three-Dimensional Structure of the Small Magellanic Cloud

*Sujatha, E. R., *Rajamanickam, V., Kumaravel, P., *Saranathan, E., 2011 Arabian Journal of Geosciences
Landslide Susceptibility Analysis using Probabilistic Likelihood Ratio Model- a Geospatial-Based Study

*Sujatha, E. R., Kumaravel, P., *Rajamanickam, V. G., 2011, J. Mountain Sci., 8, 505
GIS Based Landslide Susceptibility Mapping of Tevan karai Ar Sub-Watershed, Kodaikkanal, India Using Binary Logistic Regression Analysis

*Sujatha, E. R., Kumaravel, P., *Rajamanickam, V. G., 2012, J. Indian Soc. Remote Sensing (in press)
Landslide Susceptibility Mapping Using Remotely Sensed Data through Conditional Probability Analysis Using Seed Cell and Point Sampling Techniques

Sumangala Rao, S., Pandey, G., *Lambert, D. L., Giridhar, S., 2011, ApJ, 737L, 7
Is the Post-AGB Star SAO 40039 Mildly Hydrogen-Deficient?

Sumangala Rao, S., Giridhar, S., *Lambert, D. L., 2012, MNRAS, 419, 1254
Chemical Composition of a Sample of Candidate Post-Asymptotic Giant Branch Stars

Suryanarayana, G. S., 2012, New Astronomy, 17, 117
Coronal Type II Bursts and Interplanetary Type II Bursts : Distinct Shock Drivers

*Taricco, C., *Bhandari, N., *Colombetti, P., *Romero, A., *Vivaldo, G., Sinha, N., *Jenniskens, P *Shaddad, M. H.,2012, Mem.S.A.It.Suppl., Vol. 19, 402
Almahata Sitta Meteorite: Gamma - Activity Measurements at Monte dei Cappuccini Laboratory in Torino

*Vani, V. C., Chatterjee, S., 2011, Pramana, 77, 611
Detection of Periodic Structure, Embedded in Surface Roughness, for Various Correlation Functions

Vigeesh, G., *Fedun, V., Hasan, S. S., *Erdelyi, R., 2012, Astrophys. J., 755, 18 [arXiv:1109.6471]
3D simulations of magnetohydrodynamic (MHD) waves in the magnetized solar atmosphere

In Proceedings

Anupama, G. C., Kamath, U. S., Gurugubelli, U. K., *Mikolajewska, J., 2012, BaltA, 21, 172
Spectroscopic Monitoring of the Symbiotic Star BX Monocerotis

*Arora, S., Sahu, D. K., Anupama, G. C., 2011, ASPC, 451, 275
SN2007rw- A Type IIL Supernova

*Britto, R. J., *Acharya, B. S., Anupama, G. C., *Bhattacharjee, P., *Chitnis, V. R., Cowsik, R., Dorji, N., *Duhan, S. K., *Gothe, K. S., Kamath, P. U., Mahesh, P. K.,Manoharan,J., *Nagesh, B. K., *Parmar, N. K., Prabhu, T. P., *Rao, S. K., *Saha, L., Saleem,F., *Saxena, A. K., *Sharma, S. K., Shukla, A., *Singh, B. B., Srinivasan, R., Srinivasulu,G., *Sudersanan, P.V., Tsewang,D., *Upadhya,S.S., Vishwanath, P. R.,2011, SF2A-2011: Proc. "Annual meeting of the French Society of Astronomy and Astrophysics,", eds G. Alecian et al. pp.535-538
Data Analysis Method for the Search of Point Sources of Gamma Rays with the HAGAR Telescope Array

*Britto, R. J., *Acharya, B. S., Anupama, G. C., *Bhatt, N., *Bhattacharjee, P., *Bhattacharya,S., Chitnis, V. R., Cowsik, R., Dorji, N., *Duhan, S. K., *Gothe, K. S., Kamath, P. U., *Koul, R., Mahesh, P. K., Manoharan, J., *Mitra, A., *Nagesh, B. K., *Parmar, N. K., Prabhu,T.P., *Rannot, R. C., *Rao, S. K., *Saha, L.,Saleem, F., Saxena, A. K., *Sharma, S. K., Shukla, A., *Singh, B. B., Srinivasan, R., Srinivasulu, G., *Sudersanan, P.V., *Tickoo, A. K., Tsewang,D., *Upadhya, S. S., Vishwanath, P. R.,*Yadav, K. K.,2011, SF2A-2011: Proc. "Annual meeting of the French Society of Astronomy and Astrophysics," eds. G. Alecian et al., pp. 539–543
Status of the Himalayan Gamma-Ray Observatory (HIGRO) and Observation with HAGAR at very High Energies

*Britto, R. J., *Acharya, B. S., ... Shukla, A., *Singh, B. B,... Vishwanath, P. R., *Yadav, K. K., 2011ASTRA...7..501B
Observations with the High Altitude GAmma-Ray (HAGAR) Telescope Array in the Indian Himalayas

Dhara, S. K., *Paul, J., Ravindra, B., Banyal, R. K., 2011, " XXXVI OSI Symposium on Frontiers in Optics and Photonics", IIT, New Delhi, December 3–5, 260
Performance Evaluation of a Visible Wavelength Range Fabry-Perot Interferometer

*Figuera Jaimes, R. *, *Arellano Ferro, A., *Bramich, D. M. *, Giridhar, S., 2011, XIII Latin American Re-

gional IAU Meeting (eds. W. J. Henney & S. Torres-Peimbert) Revista Mexicana de Astronoma y Astrofsica (Serie de Conferencias) Vol. 40, pp. 235–236 (2011)
The Globular Cluster NGC 6981: Variable Stars Population, Physical Parameters and Astrometry

Giridhar, S., 2011, "29th ASI Meeting", Raipur, eds P. Khare & C. H. Ishwara-Chandra, ASICS3, 39
The Progress in the Study of Post-AGB Stars

Goswami, A., 2011, "29th ASI Meeting", Raipur, eds P. Khare & C. H. Ishwara-Chandra, ASICS3, 45
Stellar Yields and Galactic Chemical Evolution

Goswami, A.,*Wako Aoki, 2012 in ASPCS (in press)
Contribution of HdC Stars to the Galactic Enrichment: The Sr-Rich HdC Star HE 1015-2050
Hasan, S. S. 2012 , in "Magnetic Fields from the Photosphere to the Corona", (eds) T. Rimmele & A. Tritschler, ASP Conf. Ser., 143, (in press)
India's National Large Solar Telescope

Hasan, S. S., 2011, "First Asia-Pacific Solar Physics Meeting", eds Arnab Rai Choudhuri & Dipankar Banerjee, ASICS2, 37
National Large Solar Telescope of India

Hasan, S. S., *Arnab Rai Choudhuri, Rajaguru, S. P., 2011, "First Asia-Pacific Solar Physics Meeting", eds Arnab Rai Choudhuri & Dipankar Banerjee, ASICS2, 367
Solar Physics in India: developments from the Nineteenth Century to the Present Era

Hiremath, K. M., 2012, "3rd International Conference on Current Developments in Atomic, Molecular, Optical and Nano Physics with Applications", December 14-16, 2011, New Delhi, eds M. Mohan, (in press)
Seismology of the Sun : Inference of Thermal, Dynamic and Magnetic Field Structures of the Interior

*Joseph, C., Saxena, A. K., 2011, "International Conference on Trends in Optics and Photonics"., December 7-9, 2011, Calcutta, eds A. Ghosh & D. Choudhury, pp. 25–30
Performance of 10.5μm Quantum Well Infrared Photodetector for Astronomical applications

Kariyappa, R., *DeLuca, E. E., 2011, PASP Conf., Leon Golub, in press
Coronal Rotation from XBPs Observed with Hinode/XRT Hinode-5 Science Meeting

*Mathew, B., Subramaniam, A., 2011, "29th ASI Meeting", Raipur, eds P. Khare & C.H. Ishwara-Chandra, ASICS3, 75
Study of Emission Line Stars in Young Open Clusters

Muthumariappan, C., Appakutty, M., Jayakumar, K., *Parthasarathy, M., 2012, "Proc. IAU Symposium 283, Planetary Nebulae: An Eye to the Future", IAC, Tenerife, Spain from July 25–29, 2011 (in press)
Optical and Infrared Study of Enigmatic Post-AGB Primary and Disk Shaped Secondary in Epsilon Aurigae

Muthumariappan, C., Reddy, B. E., 2012, "Proc. IAU Symposium 283, Planetary Nebulae: An eye to the future", IAC, Tenerife, Spain, July 25–29, 2011 (in press)
Radiative Transfer Models of 21 and 30 Micron Features in Five C Rich PPNe

*Paul, K. T., Subramaniam, A., *Mathew, B., *Mennickent, R. E., *Sabogal, B., 2011, in Proc. IAU, 272, 294
Photometric and Spectroscopic Study of Candidate Be Stars in the Magellanic Clouds; Active OB Stars: Structure, Evolution, Mass Loss, and Critical Limits

Rajaguru, S. P., 2011, " First Asia-Pacific Solar Physics Meeting", eds Arnab Rai Choudhuri & Dipankar Banerjee, ASICS2, 181
Sunspot Seismology: Accounting for Magnetohydrodynamic Wave Processes using Imaging Spectropolarimetry

Ramesh, R., 2011, "First Asia-Pacific Solar Physics Meeting", eds Arnab Rai Choudhuri & Dipankar Banerjee, ASICS2, 55
Low Frequency Solar Radio astronomy ai IIA

Ravindra, B., Banyal, R. K., 2011, "First Asia-Pacific Solar Physics Meeting", eds A. R. Choudhuri & D. Banerjee, ASICS2, 47
A Dual Fabry-Perot Based Narrow Band Imager for the National Large Solar Telescope

Roopashree, M. B., Akondi, V., Budihal, R. P., 2011, "Adaptive Optics: Methods, Analysis and Applications", OSA Technical Digest (CD), Toronto, Canada, July 10, 2011

Grid Size Optimization for Atmospheric Turbulence Phase Screen Simulations

Roopashree, M. B., Akondi, V., Budihal, R. P., 2011, "Adaptive Optics: Methods, Analysis and Applications", OSA Technical Digest (CD), Toronto, Canada, July 10, 2011
Automated ROI Selection and Calibration of a Microlens Array using a MEMS CDM

Roopashree, M. B., Vyas, A., *Krishnan, A. S., Sriram, R., *Shankar Sai, S., Budihal, R. P., 2011,"Adaptive Optics: Methods, Analysis and Applications", OSA Technical Digest (CD), Toronto, Canada, July 10, 2011
Towards Low Cost Turbulence Generator for AO Testing: Utility, Control and Stability

Roopashree, M. B., Vyas, A., Prasad, B. R., 2011, AIP Conference Proceedings, Vol. 1391, "Optics: Phenomena, Materials, Devices, and Charecterization: Optics 2011: International Conference on Light", 23–25 May 2011, Calicut, Kerala, Ed. P. Predeep et al., pp. 312–314
Experimental Evaluation of Centroiding Algorithms at Different Light Intensity and Noise Levels

Roopashree, M. B., Vyas, A., Prasad, B. R., 2011, AIP Conference Proceedings, Vol. 1391, "Optics: Phenomena, Materials, Devices, and Characterization: Optics 2011: International Conference on Light", 23–25, May 2011, Calicut, Kerala, Ed. P. Predeep et al., pp. 347–349
Intensity Weighted Noise Reduction in MEMS Based Deformable Mirror Images

Roopashree, M. B., Vyas, A.,Prasad, B. R., 2011, AIP Conference Proceedings, Vol. 1391, "Optics: Phenomena, Materials, Devices, and Charecterization: Optics 2011: International Conference on Light", 23–25 May, 2011, Calicut, Kerala, ed. P. Predeep et al., pp. 453–455
Influence Function Measurement of Continuous Membrane Deformable Mirror Actuators Using Shack Hartmann Sensor

Sankarasubramanian, K. *Ramadevi, M. C., *Bug, M., *Umapath, C. N., *Seetha, S., *Sreekumar, P., *Kumar.,2011, "First Asia-Pacific Solar Physics Meeting", eds Arnab Rai Choudhuri and Dipankar Banerjee, ASICS2, pp. 63–69
SoLEXS - A Low Energy X-ray Spectrometer for Solar Coronal Studies

Sengupta, S., *Marley, M. S., 2011, "Chandrasekhar Centenary Conference", Pramana J. Phys. 77, 157
Multiple Scattering Polarization - Application of Chandrasekhar's Formalisms to the Atmospheres of Brown Dwarfs and Extra-Solar Planets

Singh, J., Ravindra, B., 2011, "First Asia-Pacific Solar Physics Meeting," eds A. R. Choudhuri & D. Banerjee, ASICS2, 19
Optical Observational Programs at the Indian Institute of Astrophysics

Sivaram, C., *Arun, K., 2011, Open Astronomy Journal, Vol. 4, pp. 57-63
New Class of Dark Matter Objects and their Detection

Sivaram, C., *Arun, K.,2012, Open Astronomy Journal, Vol. 5, pp. 7–11
Primordial Rotation of the Universe, Hydrodynamics, Vortices and Angular Momenta of Celestial Objects

Subramanian, S., Subramaniam, A., 2012, "29th ASI Meeting", Raipur, eds P. Khare & C. H. Ishwara-Chandra, ASICS3, 144
The 3D Structure of the Small Magellanic Cloud

Sundara Raman, K., 2011, Intl Conf. in 'Astronomy and Astrophysics', Univ. Delhi, December 13–16, 2011 (in press)
Solar Spectroscopy at Kodaikanal Observatory

*Thomas, R. M. C., *Gupta, Y., Gangadhara, R. T., 2011, AIPC, Vol. 1357, pp 297–298, AIP
A Model for Simulating Realistic Profiles of Pulsars

Vyas, A., *Ellerbroek, B., Roopashree, M. B., *Andersen, D. R., Budihal, R. P., 2011, in "Adaptive Optics: Methods, Analysis and Applications", OSA Technical Digest (CD), Toronto, Canada, July 10, 2011
Evaluation of the Performance of Centroiding Algorithms with varying Spot Size: Case of WFS Calibration for the TMT NFIRAOS

Vyas, A., Roopashree, M. B., Prasad, B. R.,2011, "Advances in Power Electronics and Instrumentation Engineering: Second International Conference", PEIE 2011, Nagpur, ed. V. V. Das et al., pp. 13-18
Efficient Minimization of Servo Lag Error in Adaptive Optics using Data Stream Mining

Vyas, A., Roopashree, M. B., Prasad, B. R., 2011 in "Adaptive Optics: Methods, Analysis and Applications", OSA Technical Digest (CD), Toronto, Canada, July 10, 2011
Multi-dither Shack Hartmann Sensor for Large Telescopes: A Numerical Performance Evaluation

In Books

Saha, S. K., 2011, "Trends in Optics and Photonics", eds A. Ghosh & D. Choudhury, 12
Aperture Synthesis at Optical Wavelengths
Saha, S. K., 2011, "Proc. Frontiers of Optics", eds B. P. Pal & A Sharma
Hypertelescope Approach: A Novel Method for Imaging of Stellar Objects

Surya, A., Saha, S. K., *Labeyrie, A., 2011, "Proc. Frontiers of Optics", eds B. P. Pal & A Sharma
Imaging Exoplanet Transits with Hypertelescopes

Vyas, A., Roopashree, M. B., Raghavendra Prasad, B., 2012, in "Adaptive Optics", ed. Robert K. Tyson, pp. 168–196, Jan-2012.
Advanced Methods for Improving the Efficiency of a Shack Hartmann Wavefront Sensor

Technical Reports, Monographs & Circulars

Reddy, B. E., and TMT India team, 2012, March
India's Participation in the Thirty Meter Telescope Project- A concise report for DST

Reddy, B.E., and TMT India team, 2012, March
Memorandum for Expenditure and Finance Committee - Detailed Budget Projections over the Construction period of the TMT project and running ITCC Nodal Office

Sahu, D. K., Anupama, G. C., *Pandey, S. B. 2012, GCN Circular No., 13185, 1
GRB 120326A: HCT Optical Observations

Vasantharaju, N., Dorjey, Namgyal, Ravindra, B., Prabhu, K., Rangarajan, K. E., Prabhu Ramkumar, B., *Sankarasubramanian, K., 2012, IIA technical report series
Solar G-Band Observations at Merak, Leh/Ladakh

Paper Presentation in Meetings

Giridhar, S., 2011, "Intermational workshop on Stellar Spectral Libraries", Delhi, 5–9 December
The Stellar Parametrization using Artificial Neural Network

Indu, G., 2011, "ASI meeting", Raipur, February 23; " Recent Advances in Star Formation Conference", IIA, June 28
Recent Star Formation History of the Large and Small Magellanic Clouds

Kariyappa, R., "Hinode 5 Science Meeting", Boston, USA, 10–15 October, 2011
Coronal Rotation Determination from XBPs

Poster Presentations in Meetings

Anathpindika, S., 2011, National Astronomy Meeting, UK
A Numerical Study of Triggered Star-Formation

Dhara, S. K., *Paul, J., Ravindra, B., R. K. Banyal, 2011, "OSI", 2011, New Delhi.
Performance Evaluation of a Visible Wavelength Range Fabry-Perot Interferometer

Javaraiah, J., 2011, "Solar dynamics and magnetism from the interior to the Atmosphere", October 31 – November 4, 2011, Bechtel Conference Center, Stanford University, USA
A Comparison of Solar Cycle Variations in the Equatorial Rotation Rates of the Sun's Surface and Sunspot Groups

Kumar, Y. B., Reddy, B. E., 2011, "29th ASI Meeting", eds P. Khare and C.H. Ishwara-Chandra, 23–25 February, 2011, ASICS3, 115
Lithium anomaly in K giants: Connection with RGB luminosity bump

Ramya, P., Reddy, B. E. 2011, "29th ASI Meeting", Raipur, , eds P. Khare and C.H. Ishwara-Chandra, 23–25 February, 2011, ASICS3, 120
Arcturus Stream: A case Study

Reddy A. B. S., Giridhar S., *Lambert, D. L., 2011, "Recent Advances in Star formation: Observations and theory", 28 June – 01 July, 2011 at IIA, Bangalore, 197
Chemical abundances of open clusters: NGC 752, NGC 1817, NGC 2360 and NGC 2506";

Reddy A. B. S., Giridhar S., *Lambert, D. L., 2011, "29th ASI Meeting", 2011, Pt. Ravishankar Shukla University, Raipur, 23–25 February, ASICS3, 133.
Comprehensive abundance analysis of four Open Clusters

Subramanian S., 2011," XXIII Canary Islands Winter School of Astrophysics on Secular Evolution of Galaxies" Puerto de La Cruz, Tenerife, Spain, November 14–25
The structure and evolution of the Magellanic Clouds

*Tripathy, S. C., *Jain, K., Ravindra, B., *Baldner, C., *Basu, S., *Bogart, R., *Haber, D. A., *Hill, F., *Gonzalez Hernandez, I., *Komm R., *Rabello-Soares, M. C., 2011, "SDO workshop", Squaw Valley, CA, USA. on May 1–5, 2011
Local Helio Seismology of Sunspots: Comparison between Active Region NOAA 11092 and 11093

Chapter 2

Facilities

2.1 Photonics Laboratory

Adaptive Optics experimentation

As part of Adaptive Optics development program, research on wavefront sensing using Shack Hartmann wavefront sensor as well as interferometric technique using Babinet Compensator is being done. In order to understand Adaptive Optics technology, it is essential to understand the propagation of light through atmospheric turbulence. The authors have attempted to understand this behavior by simulating the environment both numerically and experimentally. Results of such simulation studies will be brought out in a publication. The effects of light propagation through the turbulent atmosphere, and its impact on the Shack Hartmann wavefront sensor are extensively dealt with. The authors have simulated the atmospheric turbulence in the laboratory and its effect on the Shack Hartmann wavefront sensor was measured and studied. The Fried's parameter from the laboratory data was calculated.

(Narsi Reddy, J. P. Lancelot & Suneeth)

Parallel work was pursued on refining the interferometric method of wavefront sensing using Babinet Compensators. Artificial turbulent medium was created in the laboratory. Using Matlab, theoretical simulations were carried out to find the value of Fried's parameter.

(Amita Mohanti & J. P. Lancelot)

As part of the developmental work, it was proposed to develop a wavefront sensing method for extended sources. It was planned to use the Shack Hartmann Wavefront sensor for this purpose. The authors have simulated the Shack Hartmann patterns for extended sources without and with the presence of Kolmogorov turbulence. They have developed a cross-correlation technique for processing such Shack Hartmann patterns from extended objects. In this technique the coordinates of maxima of mutual correlation functions of sub-apertures of a current and reference Hartmann pattern are found instead of centroid coordinates for point sources. Secondly a model has been simulated in the laboratory for extended source and simulated Kolmogorov turbulence is introduced in the optical path. The phase and hence the wavefront has been reconstructed from Shack Hartmann patterns using the above developed technique.

(S. Behera & J. P. Lancelot)

Thin film research activities:

Lyman (alpha) filter design: As part of the thin film research program Lyman band pass filter which has great astronomical applications for solar studies has been designed. The theoretical design consists of six layers of dielectric coating of MgF2 and Aluminium on MgF2 substrate. The design is being further fine tuned to improve the transmission performance of this filter. The fabrication of the prototype will begin after attending to minor problems at the BC 300 Box coater.

(Mohammad Faisal & A. K. Saxena)

Vacuum coating plant

1.5 m coating plant at VBO, Kavalur: The performance of the 1.5 m vacuum coating plant at VBO has been improved to a greater extent with the automation of the operation process. Coordinated with M/s. Orion Automation, for the motorization of the air admittance valve. Now the air can be admitted with a click of a button from the control console. Several trial coatings were taken through manual mode as well as auto mode to check the performance of the system. Now the plant is ready to take up the jobs.

2.5 m coating plant at Hanle: The mainte-

Figure 2.1: Left: The process of removal of the existing aluminium coating on HAGAR mirror. Right: Loading of the HAGAR mirror into 2.5 m vacuum coating chamber at Hanle.

nance work on the 2.5 m vacuum coating plant at Hanle, was undertaken during July–August, 2011 by the optics team in coordination with IAO staff. After solving the initial hurdles like, water flow and electrical problems, the test run was done with test plates. To ensure the performance of the coating plant two HAGAR mirrors were recoated during this time. The process of removing the existing aluminium coating on one of the HAGAR mirrors and the loading of the mirror into the vacuum chamber is shown in the Figure 2.1). An excellent coating could be got on the two 0.9m HAGAR primary mirrors.

(Nirmalkumar, Gopinath, Tse Wang & J. P. Lancelot)

2.2 Kodaikanal Observatory

Solar Tower Telescope

Observations for various scientific programs continued at the Observatory, including observations by Ph.D. students. The facility was often used for testing of various optical components and instruments under development for other facilities including NLST. Observations for M.Sc. and M.Phil. projects, guided by members of staff at the Observatory, were also carried out at the telescope. Some of the members of staff, led by K. Sundararaman, continued to serve on the Board of Studies, Board of Exams, and to teach for the Graduate program of the Physics Department of the Mother Teresa University, with which IIA has been having an MOU.

Augmentation of the polarimeter

Figure 2.2: Rotation stages of the polarimeter at Solar Tower Telescope.

The following upgradation work was carried out during the year: A mechanical mount was made to attach the motorized rotation stages to the polarimeter setup at the Tower Telescope. Programs were written using the Newport control software and Andor CCD macros for rotating the wave plates at the same time controlling the automatic exposures of the CCD during the observation. The polarizer and a retarder wave plate are set up in rotation stages which are controlled by motors enclosed in black cylinders as seen in Figure 2.2)

A cubic polarizing beam displacer, another non-motorized rotation stage containing compensating polarizer and spectrograph slit form the other parts

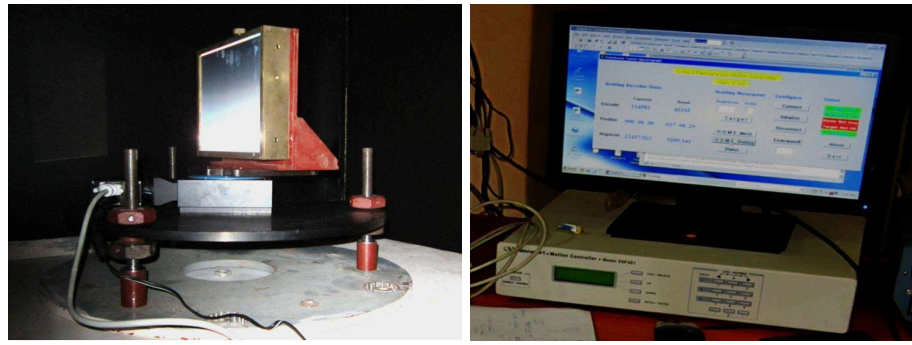


Figure 2.3: (a) The grating system with new mount, and (b) C-863 Labview control panel.

of the current polarimeter setup.

(P. U. Kamath, V. K. Subramanian, R. Prabhu, & F. George)

Augmentation of the main spectrograph grating drive

The old HS-50 stepper motor driven grating positioning system was upgraded to a fully automated system with high precision rotation stage from Physik Instrumente, Germany. PI Rotary stage was used in this mount to provide fine rotary movement of the grating with zero back-lash. A new mechanical mount was designed, fabricated and installed providing for high precision leveling of the grating. With the given Incremental Encoder resolution, the rotation stage can be precisely positioned within ± 0.5 Å. The program uses Native Commands to control the stage. The first level program was released to observers in February 2012, and is in use at the telescope. (Figure 2.3).

(N. Sivaraj, K. Ravi, & P.U. Kamath).

Synoptic observations

The broad band full-disk observations of the Sun continued with the 15 cm telescope. The twin telescope, in use since 2008, was used to continue the Ca K and broad band dull disk synoptic observations. The digital images obtained so far have now been placed at the archival centre of the Institute at Bangalore for general use and studies. Further, one of the two 40 cm DFM telescopes was moved out of the Kodaikanal Observatory and installed at the Merak site in Ladakh, and is being used to obtain G-band filtergrams.

(R. Selvendran, P. Kumaravel, B. Ravindra, K. Prabhu, N.Vasanth Raju, P. Michael, D. Loganathan & G. Hariharan)

WARM telescope

The mechanical system (Coelostat) of the WARM (White light Active Region Monitor) telescope has been installed and tested for accurate functioning in terms of tracking the Sun and positioning of the image. While the positioning is achieved to an accuracy of better than 10 arcsec (with the currently available 17 bit absolute encoder) the tracking performance is better than an arcsec over several hours. The mechanical system, electronics and software are indigenously developed, installed and maintained. Initial alignment of the optics is completed. Detector system (PCO high speed camera) has been installed and tested for its performance. Several components of the optical system, telescope housing, and a sliding dome were fabricated in-house. Planning and design of WARM-building were done in-house.

(K. B. Ramesh, P. U. Kamat, K. C. Thulasidharen, R. Ramachandra Reddy, K. Sundara Raman, K. Sagayanathan, F. George, N. Thimmaiah, C. V. Sriharsha & S. Ganesan)

Digitization programme

The program continued during the year with digitization of the 106 years of white light images, consisting of about 32,000 plates, being completed. Work is in progress with two special digitizer units with large format CCDs Figure 2.4(left), to digitize the Calcium K and the Hydrogen alpha data set which also comprise of comparable number of plates each. The initial calibrations of the Ca-K and white light images have also been completed. Figure 2.4 (right) shows the calibrated Ca-K image which is available

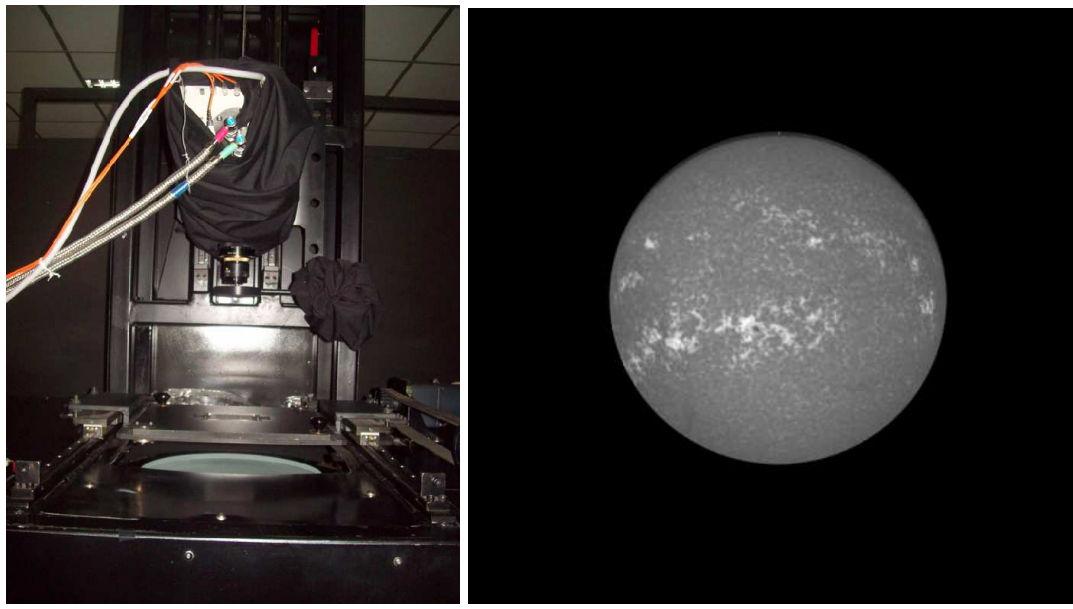


Figure 2.4: (Left) The high resolution digitizer with light table and CCD camera (Right) Sample calcium K filtergram digitized and calibrated.

Figure 2.5: Screenshot of data archival portal at IIA.

in the data archive hosted in the Institute data center located in Bangalore.

The thumbnail images of all the raw and calibrated data are available through the website http://kso.iisp.res.in. Daily images are available through a search engine developed in-house at IIA using Java and database. The website shows raw and calibrated jpeg images starting from 1904 to till date. The final data products will be available for the scientific community through this web portal in near future. Figure 2.5 shows the screenshot of the Data archival portal (http://kso.iiap.res.in/data).

(D. Banerjee, B. Ravindra, M. Priya, K. Amareswari, T. G. Priya, A. A. Nazia, A. Banu, K. Fathima & S. Kamesh)

Sky conditions: Kodaikanal

		No. of observations			Seeing conditions*				
Year	Month	Ca K(TT)	WL(TT)	PHGM	5	4	3	2	1
2011	April	27	27	28	-	2	15	8	3
	May	30	30	30	-	2	15	13	-
	June	19	19	22	-	-	30	17	2
	July	17	17	21	-	-	9	10	2
	Aug	10	10	20	-	-	9	10	1
	Sep	2	22	26	-	1	19	5	1
	Oct	12	14	24	-	6	8	3	7
	Nov	21	24	16	-	6	5	3	2
	Dec	20	20	22	1	6	10	2	4
2012	Jan	31	31	30	-	-	22	6	2
	Feb	28	28	28	-	8	08	10	-
	Mar	29	29	31	-	5	20	6	-
		225	248	237	-	123	97	25	3

CaK: CaK filtergrams taken by twin telescope.
WL: Whitelight filtergrams observed by twin telescope.
PHGM: Photoheliograms observed through 6 inch telescope
*Seeing conditions (1-very poor, 2-poor, 3-fair, 4-good, 5-excellent)

2.3 Vainu Bappu Observatory

1.3 metre telescope project

Telescope: The assembly and test of the mount in the shop of M/s DFM had been carried out during the previous year along with some modifications to the hydraulics control system of the drives. Thereafter the telescope parts were sent for painting and the full telescope was assembled (without optics) by the end of 2010. The primary and secondary mirrors were aluminised by early 2011. During the current year the tests of the optical system and the integrated telescope were carried out.

Figure 2.6: The optics test setup with primary at left in its cell and flat mirror at right. The secondary mirror in its ring mount is hidden behind the persons in the picture.

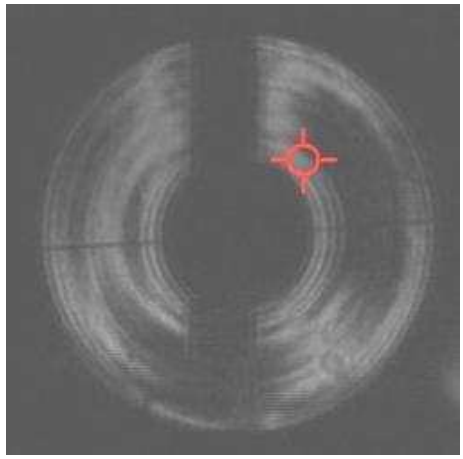


Figure 2.7: Ronchi gram of the integrated system.

The vendor agreed for carrying out integrated bench tests of the optical system though this was not in the original contract. There was some delay in making the mounts and fixtures required for mounting the large optics and the final interferometric testing was only possible after the vendor obtained a large (150 cm diameter) flat mirror on loan.

The integrated tests of the optical system were carried out in the last week of May 2011. A. K. Saxena and A. K. Pati visited the facilities of DFM to conduct these tests Figure 2.6. The Ronchi tests of the primary mirror as well as interferometric tests of the primary-secondary configuration showed that the optical system met the specifications Figure 2.7 and Figure 2.8.

(A. K. Saxena & A. K. Pati)

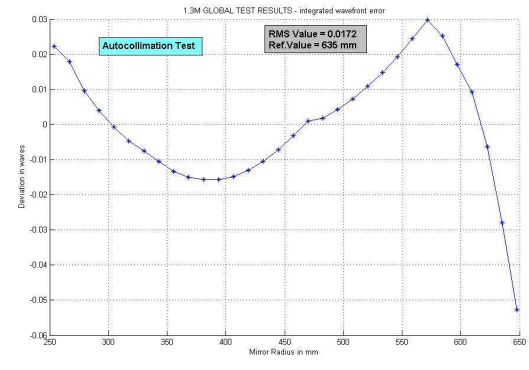


Figure 2.8: Global wavefront error of the system (3 surfaces, double pass).

Figure 2.9: Telescope with optics assembled outside the vendor facility during night tests.

After the bench tests of the optics, the telescope

Figure 2.10: left: Determining the true N-S centerline on the top slab of the pier (May 2011). center: Completed pier and ground floor (September 2011). right: grouting of base plates for erection of steel building and dome at right (December 2011)

Figure 2.11: Left: Enclosure structure as on 26th March 2012. Note the tall crane used to carry the heavier members to the height of 15 meters. center: Dome assembly at factory. Right: Dome wheel assemblies on the circular rail.

was fully assembled with optics in the DFM shop. Since the telescope mount is a new, custom made design, tests of the telescope were carried out during four nights end-August 2011. The tests were aimed at checking functional specifications of the control system, fine tuning of parameters relating to the hydrostatic bearings, trial assembly of the entire telescope and a preliminary assessment of the telescope imaging performance. The final performance checks would be performed at site at VBO during acceptance testing (Figure 2.9).

(A. K. Pati)

Telescope building

Most of the detailed design of the telescope pier and other concrete foundations had been completed in the previous year and the civil construction had started in September 2010. The telescope pier as well as concrete support structure for the steel building and dome was completed by July 2011. During the casting of the top slab of the pier, considerable effort went into ensuring the reference level measurements and the orientation of the centerline with respect to the north-south direction. The Figure 2.10 shows the measurements of the centre line with respect to the N-S direction using solar transit and the status of the structure before commencement of the steel structure.

(A. K. Pati)

Steel enclosure and dome

The design of the 1.3m telescope building utilises a steel structure around the telescope pier as the support for the rotating dome. This is a radical departure from the conventional concrete cylinder which has large enclosed volumes giving rise to adverse thermal effects. The design is an extension of the concept used for the tower built for the DIMM telescope which was completed in 2009. The Figure 2.12 shows the elevation section of the enclosure structure and dome.

The detailed engineering design of the steel telescope building and the rotating dome with bi-parting

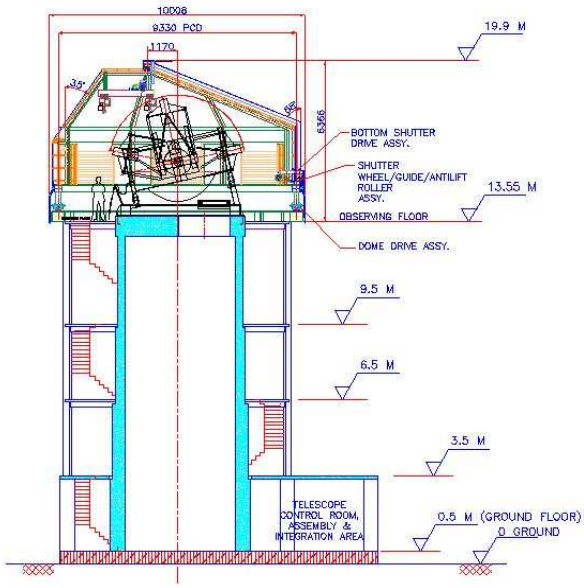


Figure 2.12: Schematic section of telescope enclosure and dome. The telescope is shown mounted atop the hallow pier. The telescope mirror can be lowered down through the pier for aluminising

shutters was completed and ready for manufacturing by May 2011. The manufacturing contract was finalised by end of September 2011 and work started in early October at the vendor's facility in Bangalore. The structural sections of the steel enclosure were made at the factory and transported to site for erection of the structure.

By the end of march 2012, the main enclosure structure was in place, including the top circular beam on which the dome will rotate on a rail. The intermediate floors of the building will consist of steel gratings support by transverse members. The entire structure is isolated from the telescope pier. The outer octagonal structure above the ground floor will be enclosed using panels for the most part with steel mesh. This will ensure flow of air through the structure.

The steel dome is a more complex assembly. It is basically a hexagonal structure rotating on a circular rail that is mounted on the top of the enclosure. The dome will be driven via friction wheels located at two diametrically opposite points. The dome structure including the wheel assemblies was fabricated and erected at the vendor facility for trial movements; it is to be dismantled and sent to the site at VBO for erection atop the enclosure structure. (Figure 2.11).

Many alternative designs for the dome and shutter drives were studied. The final choice for the dome drive uses induction motors. The shutters will be driven by DC motors operating on solar power. This eliminates the need for bus bars for transferring power to the rotating dome. The shutter drive has been designed by VBO engineers based on trials at the 30-inch telescope.

(A. K. Pati, P. U. Kamath, P. M. M Kemkar, V. K. Subramanium, R. R Reddy, S. Suresh & K. Ravi)

Development of Mosaic CCD System for 1.3 m Telescope

The development of a mosaic CCD system for the 1.3 m telescope has been taken up at VBO. Two CCD sensors (model 44-82 from M/s E2V) of size 2 kilopixels X 4 kilopixels with a pixel size of 15 microns, would be butted together to form the imager. At the cassegrain focus of the telescope, each pixel will sample 0.3 arcsec. An ARC Gen III CCD controller has been acquired and tested successfully. The sensor along with the interface boards would be housed in a modified version of the liquid nitrogen cooled dewar developed at IIA. The front section of the dewar will be modified to accommodate the larger mosaic sensor and new electronics interface boards. The mounting flange will be matched to the instrument mounting interface of the telescope.

The CCD controller has a 4 channel video board ARC47 and a clock board ARC32 providing a maximum of 24 clock signals, with a voltage range of $\pm$ 13 Volts. The clock board can be configured as 2 X 12 clock signals as upper and lower sections to enable clocking of Mosaic CCD chips simultaneously. The Video board has analog DCS chains for four inputs with programmable gain setting. ARC64 and ARC22 forms the backbone of the system providing full duplex fibre optic communication upto 250 MHz, with Motorola DSP563XX family processors. The temperature and shutter control is provided by ARC50 utility board, which has a DSP56001 Processor. The power supply ARC81 for the controller is housed as a separate unit. The controller would be mounted as close to the dewar as possible, to minimize noise.

The work involved is the configuration of the controller which includes programming of waveforms, low level DSP code for all operations. The application program OWL provided by ARC Inc is being used as the acquisition software.

The controller was configured for a single 2K X 4K E2V 44-82 CCD sensor housed in an existing CCD dewar (with the existing internal hardware in-

terface). A low noise performance of 10 e rms at 130 KHz was obtained for the setup with a readout time of 98 seconds for a single readout. The setup was optimized for dynamic range, speed and noise performance. It is estimated that the proposed Mosaic CCD System can be operated at a minimum speed of 175 KHz with reasonable read noise performance.

The new interface boards to be mounted inside the mosaic dewar are being procured. The modifications to the existing dewar design (to accommodate the mosaic) are underway. After fabrication of the modified section of the dewar, tests of vacuum integrity and hold time of the liquid nitrogen will be carried out. The method of assembling the mosaic of two sensors has already been tried out and the final assembly of the science imager will be done once the dewar is ready. The test phase described above will be repeated for the mosaic.

(A. K. Pati, P. Anbazhagan, K. Ravi & K. Sagaya nathan)

An Imaging Polarimeter for the 1.3 m Telescope at VBO

Possible optical schemes have been explored for a Dual-Beam Imaging Polarimeter (DBIP) for measuring the optical linear polarization of extended sources. A true imaging polarimeter for extended sources is rare and likely not available on 1 to 2 metre aperture telescopes.

In imaging polarimetry, where the exposures normally last several minutes, the undesirable effects due to atmospheric seeing and scintillations would be negligible, and the main factor which would limit the accuracy of measurements is the transparency variation. For measurement accuracies which are essentially photon-limited, it is essential to record both the extraordinary (e-) and ordinary (o-) beams emerging from the analyser.

The 1.3 m telescope operated at f/8 has a corrected field of 30 arcmin. With a plate scale of 20 arcsec per mm, the linear size of this field at the focal plane is 90 mm. Though ideally it would be nice to carry out imaging polarimetry over the full field, for practical reasons we have started with the feasibility for a field of 20 arcmin (60 mm) and for this field size, at a distance of about 150-200 mm from focal plane the unvignetted beam has a diameter around 85-mm.

The modulator of the polarization state of the incoming beam, a half-wave retarder, is usually the first optical element in a polarimeter, and will have to be kept at a distance similar to the above because of design considerations. Super achromatic half-wave retarders of Pancharatnam design for the spectral range 300-1100 nm with clear apertures as large as 85-mm diameter can be obtained.

There are four main standard designs of analysers which split the incoming beam into two mutually orthogonal linear polarized beams, the ordinary and extraordinary beams: (1) Foster prisms, (2) Thomson prisms, (3) Beam-displacement prisms and (4) Wollaston prisms.

In the case of Foster prisms the two output beams are separated by 90 deg, while Thomson prisms produce output beams separated by an angle of 45 deg. For recording the emergent beams from these prisms simultaneously in the imaging mode we need two independent CCDs, which may make the instrument bulkier but also technically more complicated. Further, Foster prisms with clear apertures bigger than 12 mm are not available; the same may be true for Thomson prisms.

In the case of beam-displacement prisms and Wollaston prisms the emergent beams deviate nearly equally about the incident beam direction. In order to avoid any overlap between the ordinary and extraordinary images of 20 arcmin diameter their centers should be separated by 60-mm at the focal plane of the telescope.

A beam-displacement prism made of Calcite, which has a large difference between the refractive indices of the ordinary and extraordinary rays, the maximum possible angular separation between the two beams inside the prism is only about 6.5 deg. A displacement of 60-mm at the focal plane would require a Calcite block of unimaginable size. Even at a distance of 250-mm the angle of divergence between the beams that is needed for avoiding their overlap is around 13.5 deg.

Large Wollaston prisms of clear aperture around 90-mm that are made of Quartz can be obtained, but the maximum possible divergence is only 45 arcmin. Wollaston prisms made of Calcite can give divergences around the above value (several degrees). Since Calcite crystals are naturally occurring and not grown in the laboratory it is not possible to obtain prisms of clear aperture around 90-mm. Only prisms of 40-45-mm clear apertures may be possible. With such prisms only fields around 7 arcmin can be imaged.

Lithium niobate (LiNbO3) Wollaston prisms also will give divergence large enough to resolve 20 arcmin field, and prisms with clear apertures around 90-mm may be obtainable. But because of the large

variations in refractive indices of the ordinary and extraordinary rays, imaging can be done in only very narrow spectral bands without significant dispersion.

Based on the availability of analysers an optical design has been pursued with a Wollaston prism of about 40-mm clear aperture which would image a field of 7 arcmin without overlapping (of 0- and e-beams). Figure 2.13 shows the schematic diagram.

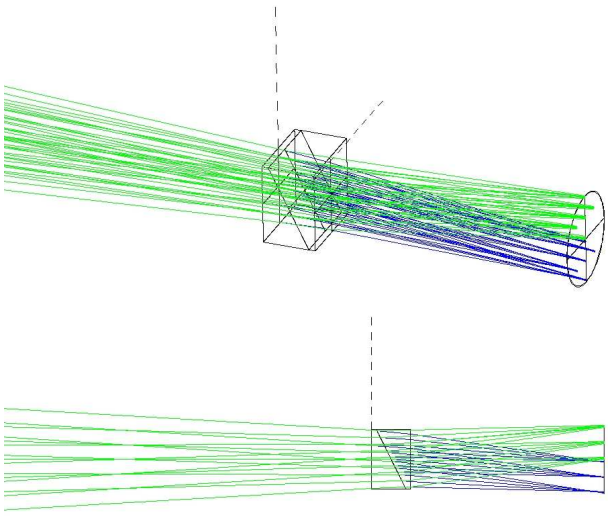


Figure 2.13: The figure shows the schematic diagram.

The instrument configuration details are:

- Wollaston prism size (max available): 40 mm clear aperture, 10 deg divergence 40 mm clear aperture corresponds to about 7 arcmin field at about -148 mm, from the focal plane.
- Calcite Wollaston is placed at, -148 mm, from the focal plane (converging beam)
- o and e images are formed at, +5.6 mm, from the focal plane with no overlap.
- Image size (o+e) 46.24 mm ; Image size (o) 22.5 mm (green) ; Image size (e) 22.5 mm (blue)

With proper design it is possible to accommodate two such prisms, obtaining two fields of 7 arcmin each, utilizing fully a square-format CCD. In this configuration the line joining the axes of the prisms would be perpendicular to the direction of divergence of the emergent beams, almost one-fourth of the available field can be covered. Re-imaging optics for better focus may be needed.

However, a large Wollaston prism made of Quartz having a grid mask at the focal plane may be another possibility. Note that, if the Quartz Wollaston prism is about 150-mm from the focal plane (converging beam), the image strips will be of about 40 arcsec. With a properly designed mask it would be possible to cover half of the available field. Effective field coverage would be smaller than this for an extended object because of diffraction effects near the edges of the masking slots.

This instrument will be designed and developed fully in-house, following the above studies the authors will carry out laboratory studies of the design configuration. It is proposed to procure the critical elements in 2012-13 and start the laboratory instrument setup. The elements will be used in the final instrument to be used at the 1.3 m telescope.

A.V Raveendran and Muneer have participated in technical discussions.

(G. Pandey, A. K. Pati & H. C. Bhatt)

The central data server with 10 terabytes of storage was procured and installed at the observatory. Data from instrument computers at all the telescopes will be archived daily on this server. The server will also hold all the data archives of the VBO (backed up nightly over the years on tapes and optical discs). The data headers of all the data is being examined to arrive at a uniform set of header keywords. This is required to enable online access of the data. The server will eventually hold the online archive once all the data has uniform headers. Towards this end, programs to automate conversion of all the old data have to be developed. The server will be located in the old ISRO building now handed over to the IIA.

The VBO LAN has been extended to cover the 1.3m telescope building and the ISRO building.

(P. Anbazhagan, S. V. Rao & A. K Pati)

CCD imaging detector for spectroscopy with the UAGS spectrograph on the 1 metre Zeiss telescope

The Photometrics CCD used with UAGS spectrograph is over 10 years old and problems have been occurring frequently. The cosmetic quality of the CCD chip has also deteriorated over the years. The 1 metre Zeiss telescope is used for a considerable fraction ($> 60\%$) of the time for spectroscopic studies.

A CCD detector from M/s Princeton instruments, which is compact and light (less than 2.5 Kg) and has a 400 X 1340 mm array of 20 micron pixels was procured. Taking an average seeing of 1.5 arcseconds, a slit width of 100 microns will match 2 pixels on the CCD with the given focal reduction in the spectro-

graph. The reduced overall array size allows deeper cooling, even with thermoelectric coolers, and hence low dark noise during long spectroscopy exposures. The detector can be cooled using air or liquid circulation. The detector has been extensively tested since November 2011 at the telescope, and it is found that with the liquid cooler, a temperature of -80 C can be maintained even in the summer. The advantage of this CCD is that humidity condensation has never been seen on the window (even while the relative humidity was 90%). The readout noise is 4.47 electrons with gain at 1.043 e/ADU. The buildup of dark current is around 0.2 counts per minute of exposure. The stability of the gain (pixel to pixel) is very good and the variation obtained from tests is 5.8 % which is the best among all CCD systems at VBO. M.Tech project students were involved in the analysis of the test data taken with the CCD.

(A. K Pati, C. Muthumariappan, P. Anbazhagan & K. Jayakumar)

The new 320KVA DG set

Specifications: The new radiator cooled 320KVA DG set has been installed in Kavalur: with Cummins Engine Model no: - NTA855-G2 developing 380BHP at 1500 RPM; Coupled with 380KVA Stamford alternator mounted on a iron channel base frame; With a set of AVM pads; Heavy duty air cleaner with acoustics skid; Mounted fuel tank; Residential silencers with bellows; Starting batteries with connecting leads; Powercom with DG set control; AMF control panel with double breaker.

(R. V. Selvi, OSD electrical staff, P. Anbazhagan & C. Muthumariappan)

Sky Conditions

Month	Spectroscopic Hours	Photometric Hours
April 2011	101	4
May	140	33
June	41	0
July	0	0
August	0	0
September	38	0
October	36	0
November	96	3
December	79	2
January 2012	170	24
February	171	31
March	201	05
Total	1073	102

2.4 Indian Astronomical Observatory

Himalayan Chandra Telescope (HCT)

The Himalayan Chandra Telescope is in continuous use by astronomers since 2003. It has continued to be one of the most productive telescopes of the country. There are already over 105 research papers published in the refereed journals using data collected with this telescope.

To keep the telescope in good health, monthly preventive maintenance and an extensive annual maintenance is being carried out regularly. During monthly preventive maintenence inspection, cleaning of components of telescope and instruments were carried out. Various calibrations and look up tables were updated. Annual maintenance of the HCT was carried out during September 2011. The engineers at IAO and HCT core astronomers participated in the maintenance activities.

The point-to-point communication link between CREST, Hoskote and IAO, Hanle, used for remote operation of the telescope, had some problem during October 2011, which was satisfactorily attended to with help from ISRO. When this link was down, observations were carried out by engineers and support staff at Hanle in service mode. The hardware of the satellite communication system is old and obsolete. Since it has been difficult to service the system and obtain spares, upgradation of the system is planned and system specifications have been drawn up obtaining expert advice from ISRO.

A clean room of dimension 7.5 ft $\times$ 10 ft and clean class 10000/ISO-7 has been established in collaboration with TIFR, Mumbai, within Vacuum Coating Plant at Hanle. The clean room has window mounted pressurising module with 5 micron prefilter. The motor blower assembly and HEPA filter is fitted outside the room on window to measure pressure difference and a recirculatory module with 5 micron prefilter, motor blower assembly and HEPA filter Unit is installed on Castor Wheel trolley inside the room. A 4 ft aircurtain is fitted on the entry of the room above the door. A clean room table of dimension 3 ft $\times$ 6 ft is procured and placed in the room to facilitate for working on instruments.

Solar power generators at Hanle are working since 1998 without any upgradation. The battery banks are near the end of their life, and an order for supply of new banks has been placed with M/s Union Batteries, Pune. The batteries were ready to be transported to Hanle, and are awaiting the opening of roads in May 2012.

(HCT Team)

Site Characterization for National Large Optical Telescope (NLOT)

The site characterization activities for the NLOT activities continued at Hanle and surrounding regions. The weather station loaned to the NLOT team was installed at Kalaktartar to the south of Hanle after its return. The old weather station at Kalak Tartar was shifted to Raindong to the north of Hanle. The two weather stations, together with the one at Hanle, provide valuable data to understand microclimatic conditions and hence the relative advantages of the three sites. Two new weather stations with higher masts have been procured to reduce the effect of ground heating, and will be deployed at Hanle and Kalaktartar during the summer of 2012.

The need for having a continuous seeing monitor to characterize Hanle site for the proposed National Large Optical Telescope (NLOT) was felt for quite some time. A Differential Image Motion Monitor (DIMM) was developed for this purpose at CREST/IIA and installed at Hanle during June–July, 2011. Pedestal and dome for this telescope were designed and built locally by the engineers at IAO. The seeing monitor is collecting data on all clear nights. Figure 2.14.

Figure 2.14: Differential Image Motion Monitor.

(NLOT Team)

High Altitude Gamma Ray (HAGAR) Observatory

The HAGAR is being operated jointly by IIA and TIFR. The utilization has continued during the year, with targets including supernova remnants and active galactic nuclei. SINP, Kolkata has also joined in utilization. The development activities continued with improvements to the pointing model of the telescope, alignment of primary mirrors, and data acquisition system. One research paper on the flaring state of blazar Mkn 421 has been published and has been reported elsewhere in this annual report. Additional full papers on pointing model and simulations have been submitted.

BARC, Mumbai is collaborating with IIA in the development of next generation facility, Major Atmospheric Cerenkov Experiment (MACE). The fabrication of the telescope has progressed. Infrastructure development at site has commenced, with the completion of the foundation for the telescope base, and control room. Procurement of satellite communication link hardware and solar power generators is progressing.

BARC, IIA, SINP and TIFR scientists working in the field have been regularly meeting for discussions and collaborations under the banner, Himalayan Gamma Ray Observatory (HiGRO).

(HiGRO Team)

High Altitude Aerosol Observatory

Under the Aerosol Radiative Forcing over India (ARFI) project of ISRO-GBP, a high altitude aerosol observatory was set-up at Hanle by Space Physics Laboratory (SPL), ISRO, Tiruvananthapuram, jointly with IIA, in 2009, with a view to characterizing aerosols in the pristine, free-tropospheric environment; study the concentration of black carbon (BC) over there and its possible impacts on snow/ glaciers; formation of new particles from the precursors under favourable conditions and above all to quantify the aerosol-cloud interactions. Aerosol studies are important to astronomers for understanding extinction of starlight and night sky brightness. The following instruments of SPL are operating at Hanle since August 2009: (i)Multi Wavelength solar Radiometer (MWR) for columnar spectral aerosol optical depth (AOD) measurements at 10 channels from UV to near IR and water vapour. (ii) A specially configured Aethalometer for continuous measurements of BC. (iii) Scanning Mobility Particle Sizer + Counter number size distribution measurements of particles in the nanometer size range and identifying new particle formation bursts, their dynamics, and other relevant parameters. (iv) Calibrated radiation instruments to characterize the incoming short-wave and long wave radiations.The data from these instruments is supplemented by the weather stations operated by IIA. The first year data has been fully analysed and shows that seasonal and annual mean BC at Hanle are significantly lower than corresponding values reported at other Himalayan stations, while they are quite higher than reported at pristine antarctic environments. Diurnal variations were weak in general, except during spring and summer. The region is affected by advection from west and southwest asia, whereas contribution from Indo-Gangetic plain remained very low during spring and summer.

The number-size distribution of aerosols at the pristine location permitted identification of formation of ultra-fine particles from precursor gases possibly transported from valleys. The time of formation was forenoon hours when abundant ultraviolet radiation was available, progressively moving to later hours from summer to winter, while the efficiency decreased as the temperature dropped. The number concentration increased generally when Asian airmass prevailed, whereas in August it increased with airmass from Indian origin as well.

(ARFI-Hanle team)

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh

A. Night hours

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2011	April	136	171	240
	May	86	145	217
	June	93	133	210
	July	92	147	217
	August	73	130	248
	September	161	184	270
	October	217	270	310
	November	259	297	330
	December	255	301	341
2012	January	167	243	321
	February	61	124	280
	March	77	147	341
	Total	1679	2292	3293

B. No. of Nights

Year	Month	Photometric nights (night)	Spectroscopic nights (night)	Total (night)
2011	April	16	23	30
	May	13	24	31
	June	14	19	30
	July	14	23	31
	August	10	18	31
	September	19	21	30
	October	24	29	31
	November	26	28	30
	December	25	29	31
2012	January	19	23	31
	February	9	13	28
	March	11	19	31
	Total	200	269	366

2.5 Gauribidanur Radio Observatory

Gauribidanur RAdio Spectrograph System (GRASS)

The term 'Geospace' represents collectively the upper region of the Earth's atmosphere (few 100 - 1000 km above the surface of the Earth), the ionosphere and the magnetosphere. Systematic recording of the various physical parameters in the above regions of the space provide information on the 'geospace climate' or the 'Space Weather'. The latter has gained importance in the recent years because of the threat posed (by the sudden changes in the 'Space Weather') to the technological systems deployed in space as well as to the communication and power transmission, etc. on the ground. Correlative analyses using multi-frequency observations and in-situ measurements show that the transient energy releases viz. flares, different classes of radio bursts, mass ejections, etc. on the solar atmosphere significantly alter the 'Space Weather'. Therefore, prediction and forecasting of various forms of solar activities has become very important. Since many forms of energetic eruptions in the solar atmosphere have direct consequences on the 'Space Weather', a study of radio waves from the Sun (considered to be sensitive indicators of the transient energy releases) is expected to provide useful information in this regard. The high frequency radio waves originate deeper in the solar atmosphere than the low frequency waves as the atmosphere is made of tenuous plasma and its density decreases radially outward. Therefore in order to understand the transient activities that take place at different heights in the corona, a thorough scan of the corona over a broad range of radio frequencies is necessary. To accomplish the above a new broad band radio antenna system was recently commissioned at the Gauribdianur observatory. The antennas were designed and fabricated in house. Since the sensitivity of any radio antenna system depends on the total aperture area, the new array was built with a large collecting area as compared to the conventional single antenna radio spectrograph systems for spectral observations of the solar corona. See Figure 2.15.

Gauribidanur RadioHeliograph (GRH)

The following activities related to the ongoing expansion of the radioheliograph at the Gauribidanur observatory are presently underway :

(1) Development of software for calibration and analysis of data obtained with Phase-I of the GRH expansion programme; (2) Trial observations with the 4096 channel digital back end receiver, designed and fabricated inhouse, for correlating the signal from each of the 64 antenna groups in Phase-I of the GRH expansion programme with every other group; (3) Testing of the prototype two-channel correlator system based on FPGA technique which will be used for the digital back-end receiver system in the Phase-II of the GRH expansion programme. The raw voltages from each antenna were digitized seperately and correlated offline. The advantage of this method is that it is possible to obtain spectral information over the entire bandwidth of the signal that is correlated. (4) Testing of the prototype optic fibre cable link for use in Phase-III of the GRH expansion programme. The maximum baseline in the latter will be about 10 km and the use of standard RF coaxial cables for signal transmission will lead to larger attenutation of signal strength. Figure 2.16.

(Radio Astronomy Group)

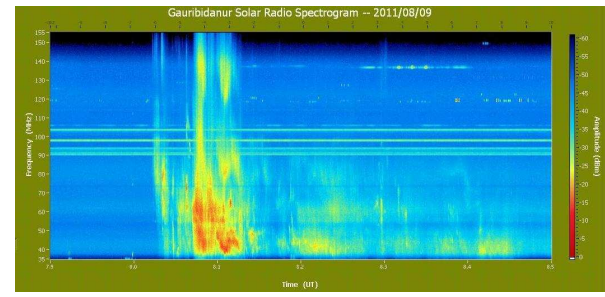


Figure 2.15: Dynamic spectrum of the transient radio emission from the Sun observed with the GRASS in the frequency range 35-155 MHz. The horizontal lines of intense emission over the 90-110 MHz band are due to radio frequency inteference (RFI) related to FM transmission from Bangalore. The intermittent emission around 120 and 140 MHz are also due to RFI, All-India Radio broadcast.

2.6 Library

Collection Development and Management

The library collections are beginning to keep pace with existing academic & technical programs of the Institute and are anticipating forthcoming ones. Both print and electronic books have been enhanced to include 261 titles in print and 8606 titles in electronic format. The collection of e-journals accessed through

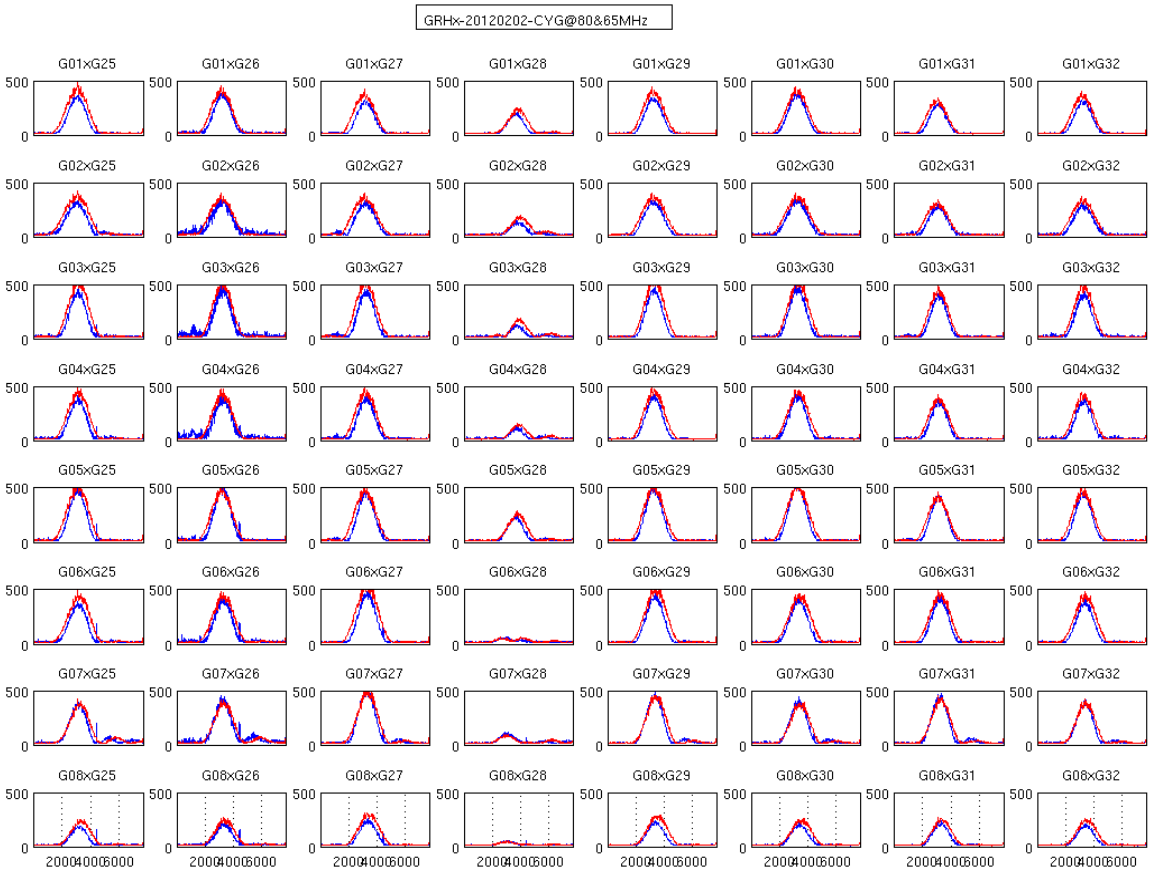


Figure 2.16: The response of different antenna groups in Phase-I of the GRH expansion programme obtained from observations of Cygnus A (3c405) during its transit over the GRH.

NKRC, already strong, is further enhanced during the year to include subject collections of Elsevier-Science Direct, Cambridge University Press and Taylor & Francis journals. Currently IIA Library has access to 3950 titles of journals offered by 19 publishers electronically. The library committee, and faculty participation in selecting books to add to the collection continued strong.

IIA library is already in the mode of replacing existing print resources with their virtual counterparts, hence adding the access to archival files of journals has been accelerated. Nature Archive back files from 1987-1996 is acquired which is electronically accessible in IIA campus and all the field stations.

National Knowledge Resource Consortium

As a coordinating member of the NKRC, Christina Birdie presented an analysis of the E-Resources requirements and usage pattern of all the DST Libraries during the NKRC joint meeting held at Goa, between 17-20 October, 2011. The analysis of the usage pattern of e-journals accessed at IIA, indicates the maximum utilization of the resources subscribed through Consortium as well as a justification of the enhanced requirement from IIA faculty & students.Figure 2.17.

(The use of E-journals and downloads are enhanced in the years 2010-11, when IIA joined the NKRC as a member, compared to earlier years with access to lesser journals.)

Document Delivery Services

Seventy three Inter-library loan requests from IIA faculty and students were fulfilled as they are not

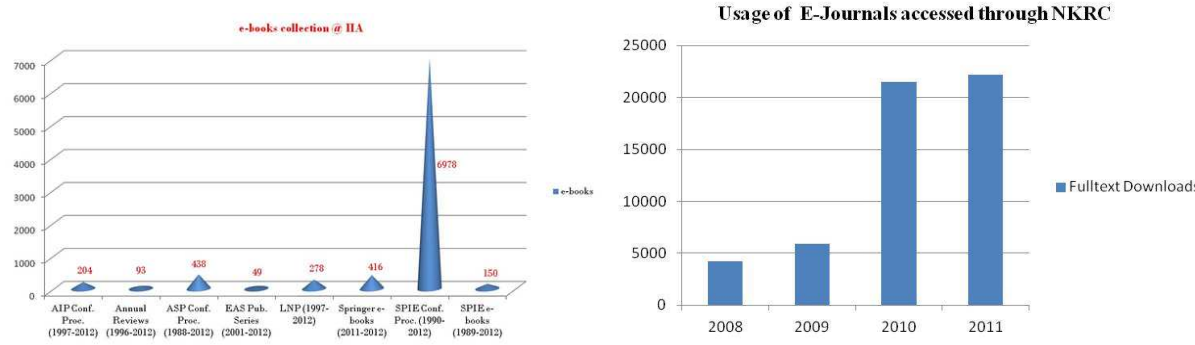


Figure 2.17: Left: E-books collection at IIA. Right: Usage of E-Journals accessed through NKRC at IIA

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Figure 2.18: Visitors and dignitaries at IIA Archives & Exhibition.

held in the IIA collections. More than 60 requests from other libraries and individuals were catered to from our collections as part of the document delivery service.

Bibliometric Analysis

The library assisted in the compilation of bibliometric and scientometric analysis of IIA publications required for making policy decisions time to time, and as input to the DST report.

Open Access Repository (OAR)

IIA Library dynamically maintains the OAR by adding more and more research publications of IIA. The Repository's main page has a new feature, which highlights 'Recent Submissions' of research papers to the repository to alert the users. The library also has facilitated the IIA users, with information on copyright submission guidelines in the OAR webpage for uploading papers in the repository. VBT News and IIA Newsletter are the recently added collections in the repository.

Outreach & Extended Service

Library continues to support Open Access Week and Preservation Week by designing and distributing 'Bookmarks' with contents and tips relevant to preservation and Open Access.

Exhibits & Display

Event related exhibits are organized using the contents from the Archives from time to time. On the occasion of the Commemoration of 25 years of the Vainu Bappu Telescope at Kavalur, IIA library organized a photographic exhibition. Library brought out a flier titled 'Commemorating 25 years of the Vainu Bappu Telescope', with a glimpse of exhibits displayed in the exhibition. Figure 2.18.

Archives

Many visitors and dignitaries visited the archives during the year. Prof. M. G. K. Menon, Honorary Fellow, IIA and Prof. J. V. Narlikar, Member, IIA Governing Council visited the archives, and commended the archives display and contents. The

members of the Scientific Advisory Committee of IIA, gave valuable comments when they visited the archives.Figure 2.18

Library Training Program

Library continues to offer two year library trainee programme, and the trainees are trained in all the sections of the library and especially in the digitization procedure.

(Librarian)

2.7 Computational Facilities

With the rising demand for larger memory, higher processing a new data centre was built in IIA Bangalore campus. The data center is operational since June 2011. The data center is hosting a new-20 node high performance computing cluster with a peak performance of around 5.8 TFlops. Based on Xeon X5675 processors, this new HPC cluster supports 24 logical processing cores and 96 GB DDR3 memory per node. Interconnect is through Infiniband QDR (40 Gb/s). A GPU computing server based on nVidia Fermi C2070 GPU cards, with a peak floating point performance of 2.6 TFlops is also operational. A data processing server with dual AMD Opteron 6176SE 12-core processor and 32GB DDR3 memory is available for memory intensive data processing requirements. A New 3.3 GHz x 16 processor AMD server with 128 GB memory (for memory intensive computing) is also available in the data center. On the storage front, 38 TB IP- SAN disk server is now operational and will be upgraded to 96 TB in the near future. The 20-node cluster has an associated storage module of 48 TB raw disk space. These are new additions, alongside the existing 10TB IBM disk server.

The new data centre (see Figure 2.19) is presently hosting 100+ years of digitized solar images from Kodaikanal Solar Observatory. In-house software development have also provided a common interface to provide access to these data. Data archiving, various software tool development, database management and website development is part of regular activities within data center. The Data center will host other data resources from other observatories also in near future. The IIA Data center also hosts several other servers like ERP server, ftp server, mail server, web server and project related servers like Aditya, UVIT, Tauvex etc.

Internet bandwidth has been upgraded recently

Figure 2.19: The data centre at IIA.

to 40 Mbps. Additional internet link from National Knowledge Network (NKN) is functional now and it offers a total bandwidth of 1 Gbps, shared by various research institutes in Bangalore. Institutes LAN has been upgraded to a new 1 Gbps high speed network infrastructure. Field stations at Gauribidanur, CREST and Kodaikanal are now part of the main campus LAN via MPLS network.

(Dipankar Banerjee)

2.8 Upgrade of Infrastucture

New Telephone Exchange

Figure 2.20: The IP based EPABX.

An Internet Protocol (IP) based EPABX from M/s MITEL for the Bangalore campus has been commissioned with the capability of 350 intercom telephones. One incoming PRI line from BSNL has been added to this system in addition to the existing land lines. With the addition of PRI line, all

intercom lines are mapped as BSNL land lines and the numbering scheme is matched with existing intercom numbers. Therefore all intercom lines appear as direct telephone lines to individuals from BSNL. A call billing software has also been installed to monitor the usage of outgoing/incoming calls, if needed. The MITEL exchange network capabilities are explored to integrate other field station telephone exchanges to it. With integration, all field station calls are routed on existing (VPN) computer network to the respective telephone exchange and such calls become intercom calls. The authors have successfully integrated the Hosakote campus exchange and it is under test. Similarly other field station exchanges will be integrated in due course of time. The present EPABX is server based and capable of connecting video phones, conducting audio conferences and also video conferences with additional equipment. Figure 2.20.

(G. Srinivasalu)

2.9 Upcoming Facilities

2.9.1 High Resolution Spectrometer for the 2m HCT

A high resolution spectrometer giving a resolution of R$\sim$ 60,000 is being developed for the 2m HCT at Indian Astronomical Observatory, Hanle. This fiber-fed spectrometer will be situated at the ground floor of the HCT building in a special thermally controlled enclosure. Following the sanction of the project by DST the design and building of the high resolution spectrometer has been progressing. This project would be executed as technical collaboration with Industrial Research Laboratory, New Zealand through an Agreement.

The optics design: The optical design meeting the technical specifications of the spectrometer has been finalized in November 2011. The design is such that the spectrometer can be accommodated in very limited space available at the west wing of the HCT building. The Cassegrain module containing atmospheric dispersion corrector, the pin hole plate guide camera, fiber input assembly and beam splitters for the selection of calibration sources will be placed at specified port of the instrument cube of the 2m HCT.

The spectrometer comprising of slit, image slicer, collimator, cross-disperser prisms camera and detector will be housed in specially design spectrometer enclosure. A 4K x 4K CCD system using e2V chip (CCD 231-84) with graded AR coating has been chosen to record the spectrum.

Optical components such as Echelle grating, calibration sources has been procured. The opto-mechanical design would be finalised in May 2012. The fabrication of various sub-assemblies would be undertaken during 2012-2013.

(HESP team)

2.9.2 UltraViolet Imaging Telescope (UVIT)

Figure 2.21: A picture of WF testing of the telescope is shown.

Figure 2.22: A picture of the assembled Near UV/VIS telescope is shown.

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. The instrument is configured as two similar Cassegrain telescopes of $\sim$ 375 mm diameter. One of the two telescopes observes in FarUV (1300 – 1800 Å), while the other observes in NearUV(2000-3000 Å) and VIS (3200 – 5500 Å). Images are made simultaneously in all the three channels with an an-

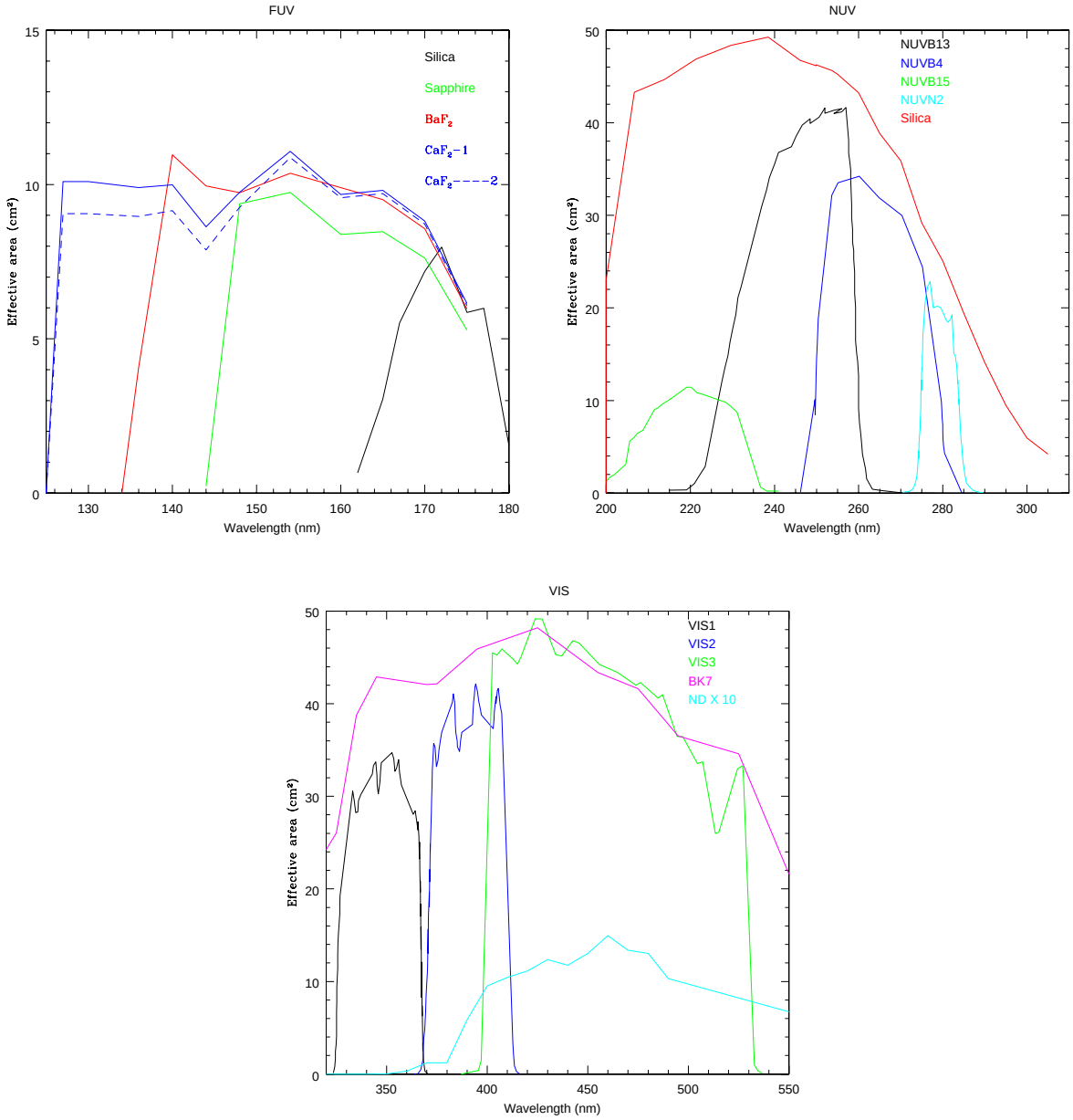

Figure 2.23: Effective apertures are shown for all the filters.

gular resolution of $\sim$ 1.8 arcsec in a field of $\sim$ 28 arcmin. In addition to a selection of filters for each of the three channels, low resolution ($\sim$ 100) slitless spectroscopy is available for FarUV and NearUV 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.

Present Status:

In the last year the engineering model was assembled and tested extensively for vibrations and thermo-vacuum characteristics at ISAC, ISRO. The results of these tests were extensively discussed and analysed in the Critical Design Review by a committee appointed by ISRO. The committee made suggestions for some changes for the flight model and additional analysis. After this one could go ahead with assembly of the flight model.

Assembly of the flight model started in this year

in Class 100 area of MGKM Laboratory at CREST campus of the institute. First, the telescope for NearNUV and VIS channels was taken up as it is more complex and less susceptible to any contaminations. The assembly started with mounting of the primary mirror – this is the most demanding optomehanical operation as no mechanical stresses should transfer from the mechanical parts to the mirror and at the same time mounting of the mirror should be rigid enough to stand strong vibrations of the launch. The mounting of this mirror is done in several minor steps, and after each step a check is made to ensure that surface of the mirror is not deformed due to any stresses. Figure 2.21 shows testing of the telescpe with an interferometer. After many trials (and replacement of the primary mirror) the mirrors and the beam-splitter (which separates the NearUV and the VIS radiation) were aligned such that centres of the two fields are within 30 arcsec of the axis of the telescope. After this, the telescope was fully assembled with detectors and filter-wheels (the assembled telescope is shown in Figure 2.22).

The next most important step was to adjust the axial position and inclination of the detector to get optimal focus in the full field of 28 arcmin for all the filters in the two channels; collimated beam was obtained by a pin-hole source, illuminated by a monochromator, placed at the focus of a telescope of $\sim$ 375 mm aperture. These adjustments were done and the point spread function is found to have FWHM $<1.5''$. The telescope for FUV shall be assembled and tested in the next year. The effective apertures of the instrument are estimated from the calibrations of the individual components, and the results for each filter are shown in Figure 2.23. The assembly would be completed at CREST by July 2012, and after this,the payload would be transferred to ISAC for environmental tests and integration with the spacecraft. As per the present status, the launch of ASTROSAT should take place in early part of the year 2013.

(UVIT team)

2.10 New Initiatives

2.10.1 National Large Solar Telescope

IIA has proposed a 2-m aperture, state-of-the-art National Large Solar Telescope (NLST) for carrying out observations of the solar atmosphere with high spatial and spectral resolution. A comprehensive site characterization programme, that commenced in 2007, has identified a superb site in the Himalayan region at an altitude of 4500-m that has extremely low water vapor content and is unaffected by monsoons. With an innovative optical design, NLST is an on-axis Gregorian telescope with a low number of optical elements to reduce the number of reflections and yield a high throughput with low polarization. In addition, it is equipped with a high order adaptive optics to produce close to diffraction limited performance. To control atmospheric and thermal perturbations of the obsevations, the telescope will function with a fully open dome, to achieve its full potential atop a 25 m tower. Given its design, NLST can also operate at night, without compromising its solar performance. This project is led by the Indian Institute of Astrophysics and has national and international partners. Its geographical location fills the longitudinal gap between Japan and Europe allowing continuous coverage of the Sun with major solar telescopes around the globe. NLST will be a unique research tool for the country and the world.

Current status

- **Comprehensive Site Characterization Report**: It was realized at the very outset that the search for the most suitable site having excellent day time seeing, and other related atmospheric conditions, is critical for the realization of the proposed 2-m class National Large Solar Telescope (NLST) in India. Concerted efforts on selection of prospective sites for detailed characterization started at the Indian Institute of Astrophysics in mid-2006. The site survey report presents the final results of the five years of extensive work carried out during 2006-2011, in an attempt to characterize three candidate sites: Devasthal, Hanle, and Merak. The report finds that Merak by the shore of the Pangong lake in J & K is the best site for the location of NLST;

- **Detailed Project Report**: A detailed project report was prepared and submitted to the DST and IIA Governing Council in 2011;

- **Environmental Impact Assessment & Feasibility Studies**: A multi-disciplinary team conducted studies to assess the environmental impact of building the telescope at Merak. The reports conclude that the proposed site in the Ladakh region has no adverse environmental impact and is feasible, from geotechnical engi-

neering considerations, for the construction of NLST.

- **Vendor identification**: A Request for Proposal was floated as a global tender inviting interested firms to design, manafacture and install NLST at the designated site with participation by Indian companies wherever possible. An evaluation by an Expert Committee found that the technical bid submitted by MT Mechatronics, Germany which had earlier built the 1.5-m GREGOR German solar telescope in Tenerife, was suitable to execute the project.

- **Endorsement by the IIA Governing Council**: The IIA Governing Council during its meeting on October 28, 2011, approved the project and recommended it for funding.

- **Endorsement by the Mega Project Committee on Astronomy**: A meeting was convened at the DST on November 21, 2011 to examine various astronomy mega projects submitted for funding during the 12th five year plan. The Committee endorsed the NLST project for implementation in the 12th five year plan.

(S. S. Hasan & NLST Team)

Site Characterization Program

Observations for the comprehensive site characterization programme completed six years of operation, involving Solar Differential Motion Monitors & Shadow Band Rangers, Sky radiometer, Automated Weather Stations, All Sky Cameras, and Micro Thermal Devices, at the three selected stations Hanle, Merak, and Devasthal. Monitoring of the observations, procurement, preliminary analysis, and archival of data was continued from the project lab at Bangalore, though with significantly reduced scale of operations at Devasthal and Hanle. During the year of this report, it was decided to include evaluation of the sky brightness at Hanle and Merak, using the sky radiometer data already obtained for significant periods. This evaluation at the high altitude sites was considered necessary to complete the comprehensive survey by examining their suitability for coronagraphic observations, especially in view of the ground support that would be needed for the Indian space coronagraphic mission, Aditya. A radiative transfer code RSTAR6B.PACK specially developed by Nakajima et al. of the University of Tokyo for the Prede sky radiometer was adapted and used to estimate the sky brightness in millionths of the Sun. Further, a major effort during the year was the preparation of a detailed Site Survey Report, which constituted a key input for the Detailed Project Report for NLST, submitted by the end of the year 2011. Highlights of the results presented in the report are given below:

Annual Sunshine Hours: The values derived from a few years of observations are as follows; Devasthal $\sim$ 1200 to 1500, Hanle $\sim$ 1900 to 2250, and Merak $\sim$ 1800 to 2150. At Devasthal, the period June to September is severely affected by the monsoon each year.

Daytime seeing: It is seen from the SDIMM results at a height of 6 m that Merak has a large number of continuous spells with excellent conditions of seeing. Hanle has good to excellent periods with a good number of continuous blocks. At Devasthal, there are short spells of good seeing but the numbers of good period blocks are rather limited. The SHABAR results for Hanle and Merak for 16, 26, and 36 m were studied. It emerges that the optimal height for NLST is 28 m for Merak while it is 36 m for Hanle. Suitability for near IR observations: The estimates of Precipitable Water Vapour Content (PWVC) shows that both Hanle and Merak are well suited for near IR observations due to the highly dry conditions (PWVC $<$ 5 mm) prevailing at the high altitudes for most parts of the year, whereas Devasthal has a duration of about 2 months which is suited for this purpose.

Sky brightness for coronagraphic skies: The sky brightness values were evaluated for Hanle and Merak. The annual hours for which the sky brightness at Hanle remains within 25 $\pm$ 10 millionths at 0.8 solar radii, at 1020 nm, is in the range of 470 to 610. A similar value is expected for Merak, considering the random sample days studied. Both Hanle and Merak are well suited for coronagraphic studies. Aerosol optical properties: The yearly average aerosol optical depth at 500 nm is 0.050 $\pm$ 0.001 at Hanle, which is comparable to those observed at Nam Co in the Tibetan plateau and Dome C in Antarctica. This shows the high level of sky transparency in the region.

Meteorological parameters: The wind speeds exhibit a behavior of being very low at Devasthal for most of the time, moderate and laminar with mild gusts for practically whole day at Merak almost throughout the year, and mild to moderate in forenoon but significantly heavy in the afternoons at Hanle. Merak therefore has the ideal conditions of

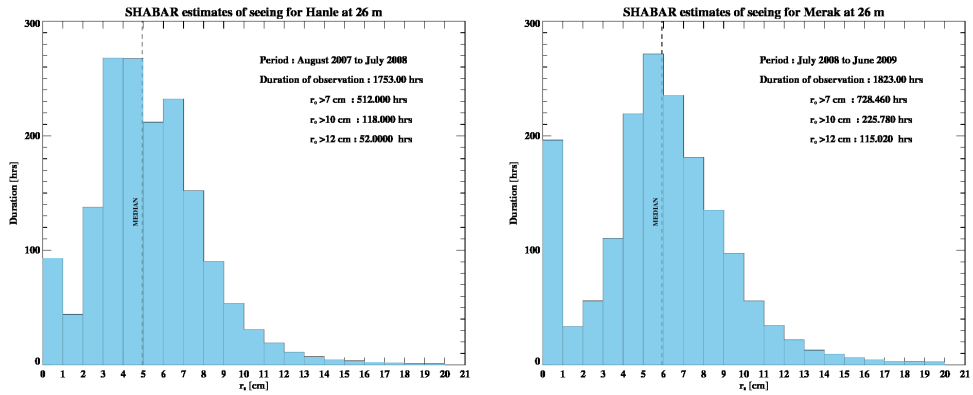

Figure 2.24: Histograms of distribution of r0 at height of 26 m at Hanle and Merak sites, from SHABAR results.

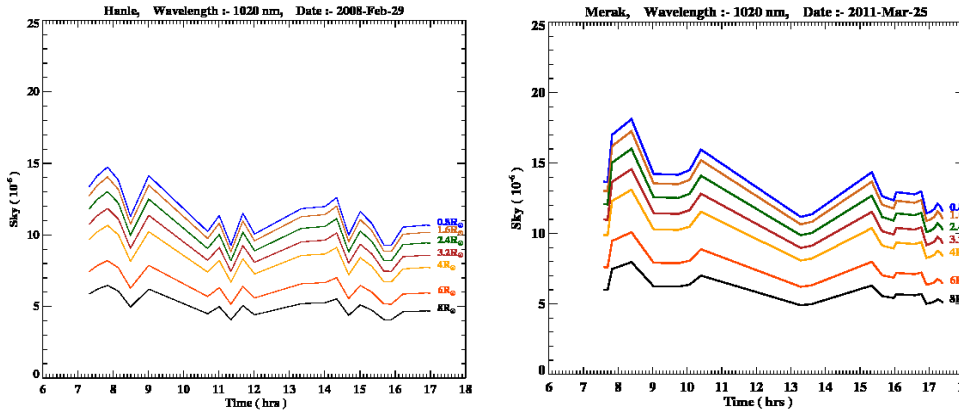

Figure 2.25: Sky brightness at Hanle and Merak in millionths of Sun at 1020 nm for 0.8 to 8 solar radii.

wind speeds which favour good seeing. The direction of flow is also favorable, being over the water body for most part of the day.

Thermal inversion layer: It is found that the heights of the near ground boundary layer of thermal stratification are in the range of 10 - 12 m for both the land sites Devasthal and Hanle, and 6 - 9 m for the lake site Merak. Figures 2.24 and Figures 2.25.

Major findings: The findings which emerge from the above extensive characterization are as follows: Merak is a world class site, best suited for the installation of a large solar telescope for optical and near IR observations (advantage of high altitude desert). It also provides significant periods of coronagraphic skies (high transparency). The laminar winds with mild gusts throughout the day provide periods of outstanding seeing. The site has a combination of the excellent sky conditions found at two of the finalist sites for ATST, in terms of 2 hour blocks of r0 $>$ 7 cm at Big Bear and r0 $>$ 12 cm at Haleakala. A height of 26 to 30 m is desirable for NLST. Hanle is next best with good to excellent seeing conditions, providing significant durations of good periods of r0 $>$ 7 and 12 cm, at heights of 30 to 36 m. It is marginally better suited than Merak for near IR studies and is practically comparable for coronagraphic quality of skies. Post noon hours are more windy than desirable, but there are 3 to 4 months when the high windiness starts later in the day. A height of 36 m is essential at Hanle. Devasthal has periods of good seeing in very short spells but not in blocks of 30 min to 2 hours, which are essential for a large solar facility. The winds are extremely low in speed and not sufficient to flush the thermals. The tall trees and the land terrain in the direction of wind do not seem to favor the day sky conditions. The site has a limited scope for solar observations in the near IR. The value of annual sunshine hours is low (1280 $\pm$ 150), which is caused by a severe monsoon period between June and September each year.

(S. P. Bagare, S. S. Hasan, T. P. Prabhu, Rajen-

dra B. Singh, Sangita K. Padhy, Namgyal Dorjey, N. Vasantharaju, K. Prabhu, Angchuk Dorje, Dorjai Tsewang, Jorphail Sonam, M. Tashithsering, R. Norboo, S. Tundup, D. Tseten, Ramkumar Prabhu, & Wahab Uddin)*

Aerosol optical properties over Hanle

These studies are being carried out using the data from sky radiometer observations, which form an integral part of the site characterization efforts for NLST. The observations were obtained at Hanle for a total period of over three years during October 2007 to December 2010. Preliminary results of aerosol optical depth (AOD), single scattering albedo, and volume size distribution of aerosols, which demonstrated the pristine nature of the site, were published earlier in 2010. During the year of this report, a detailed analysis and study of the entire data set was carried out to examine the seasonality and inter year variations of the parameters. One of the main findings is that relatively high values of mean AOD during spring are observed and this supports the hypothesis of heating of the middle-upper troposphere during the pre-monsoon period. A collaborative effort with the Space Physics Laboratory resulted in the installation of a Sequential Mobility Particle Sizer + Counter of GRIMM Aerosol tek GmbH, Germany at the site during the latter part of 2009. A device for in-situ measurement of black carbon(BC) and other constituents was also installed thereafter. Observations with these instruments in conjunction with some of the observations of the site characterization programme have resulted in studies of fine and ultra fine particles in the near-free tropospheric environment of the site. New particle formation and size distribution were also studied. Further, first ever measurement of black carbon over the western part of trans-Himalayas was studied and it was found that the seasonal and annual BC at Hanle are significantly lower than the corresponding values reported for other Himalayan stations, while they are higher than those reported from the South Pole and other Antarctic environments. Observations over the station Merak are being carried out for nearly past two years and these are being analyzed for detailed study. Preliminary results indicate the low AOD values which are typical of those found in some of the excellent astronomical sites in the world such as Hawaii, Dome C in Antarctica, and in the neighbouring Tibetan plateau.

(S. P. Bagare, S. S. Ningombam, Rajendra B. Singh, Sangita, K. Padhy, T. P. Prabhu, V. K. Gaur, K.

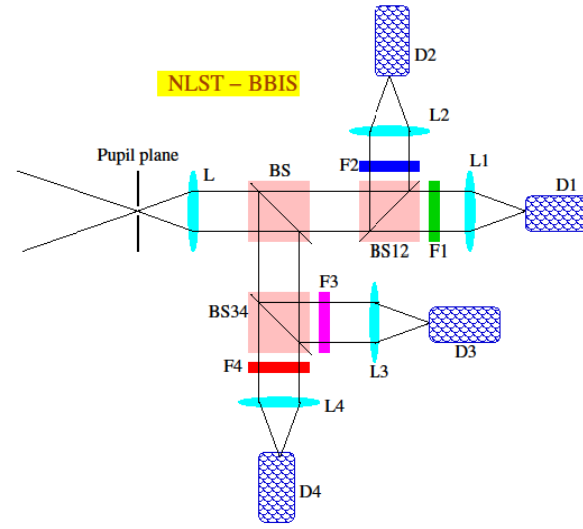

Figure 2.26: Concept design of NLST Broad Band Imaging System. L denotes lens, BS - Beam splitter, F - filter, D - CCD.

Krishna Moorthy, S. Suresh Babu et al.)*

Concept design of Broad Band Imaging System (BBIS) for NLST

The BBIS will be one of the focal plane instruments operated at the back-end of NLST. The prime objective of the BBIS is to record images at the highest possible spatial and temporal resolution at a number of specified wavelengths in the range from 390 nm to 1083 nm. This will be accomplished with an optical design that preserves the Strehl-ratio of the imaging provided by the telescope, and that has a high optical throughput at all considered wavelengths. In addition, the BBIS will provide high-quality imaging through filters with relatively broad pass bands to optimize throughput and stress high cadence and short exposure times to effectively freeze the atmospheric turbulence that allow image reconstruction using speckle interferometric methods for improving image quality beyond what is provided by the telescope AO system. Simultaneous images obtained in four channels are expected to pave way for the studies on the small-scale dynamics in the solar atmosphere. Figure 2.26

(K. B. Ramesh, K. E. Rangarajan & the NLST team)

Solar G-band observations at Merak

G-band observations are important for the study of

dynamics of magnetic features in the solar photosphere and they are carried out using large telescopes, larger than 30 cm. A 40 cm DFM telescope was installed at one of the good sites Merak in the district of Leh/Ladakh. A back-end instrument was designed, fabricated and installed, which involves a band-pass filter at G-band wavelength (430.5nm) to carry out observations of the solar photosphere on a regular basis. The authors report the installation of the telescope and the solar observations made with this back-end instrument. The details about the instrument used, data calibration and comparison with similar data obtained from space are presented. They also discuss how the system can be improved for better quality images in the near future.

(N. Vasantharaju, N. Dorjey, B. Ravindra, K. E. Rangarajan, K. Prabhu, B. P. Ramkumar & K. Sankarasubramanian)*

Development of Narrow Band Imager for solar observations with NLST

The Narrow Band Imager (NBI) is one of the back-end instruments for the proposed 2-m class National Large Solar Telescope (NLST). From January 2011 we started building a small prototype version of the narrow band imager for a smaller telescope which can provide the images of the active region and Dopplergrams at various heights in the solar atmosphere. The instrument design is optimized for photospheric observations of the Fe I 5374 Å line and chromospheric observations of the 6563 Å line. The Fabry-Perot (FP) etalon is the heart of the NBI system. It is also retrofitted with customized order sorting filters to eliminate undesirable wavelength bands. The entire system will be kept in a collimated beam to get the maximum spectral resolution. In the first stage, we tested the FP in the laboratory for its performance. The obtained bandpass is 237 mÅand the free spectral range (FSR) is 5 Å. In Figure, the transmission profile of the FP and a Gaussian fit to extract the bandpass is shown. The measured transmission profile over the instrument's scanning range is also shown in Figure. A comparison of the measured values with vendor specifications was also carried out. The reflectivity of the FP was found to have reduced from 95% to 86% since the elapse of 15 years when it was originally purchased. (Dhara, S. K., Paul, J., Ravindra, B. and Banyal, R. K., 2011, *Frontiers in Optics and Photonics*, 260). Interference based order sorting filters are temperature sensitive. With the temperature change, the peak wavelength of the filters will shift from its specified value. In order to get a stable wavepass response during the observations, a temperature controlled oven was designed and developed to enclose the filters. Figure shows the image of the oven. The performance of the order sorting filters was verified in regulated temperature conditions. The optical design of the NBI, shown in Figure, was made with a ray tracing software (Zemax software). Final integration and assembling various optical components and electronics is in progress. The instrument will be deployed for scientific observations of the sun shortly. Figure 2.27 and Figure 2.28.

(B. Ravindra, Ravinder Kumar Banyal & Sajal Kumar Dhara)

Prototype spectropolarimeter development for NLST

A prototype spectropolarimeter is being developed for NLST. As a start, rotation stages for accurately Rotating the waveplates in the polarimeter in an automatic mode have been procured and tested in Kodaikanal Tower telescope facility. LABVIEW Programs have been written to control the rotation stage. Spectropolarimetric observations have been carried out for calibration purposes using Andor CCD macros. Now the operations are in an automatic mode which allows faster temporal cadence.Figure 2.29.

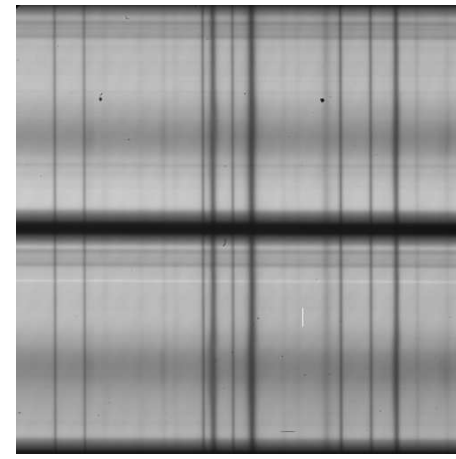

Figure 2.29: A typical spectropolarimetric observations of the magnetically sensitive 6302 ÅFe doublet line wavelength region taken with the newly automated polarimeter at the Kodaikanal tower telescope can be seen in this figure. The Fe lines seen here are considerably broadened across the faint Sunspot region. The central dark patch denotes the separation between the two beams which are orthogonally polarized to each other.

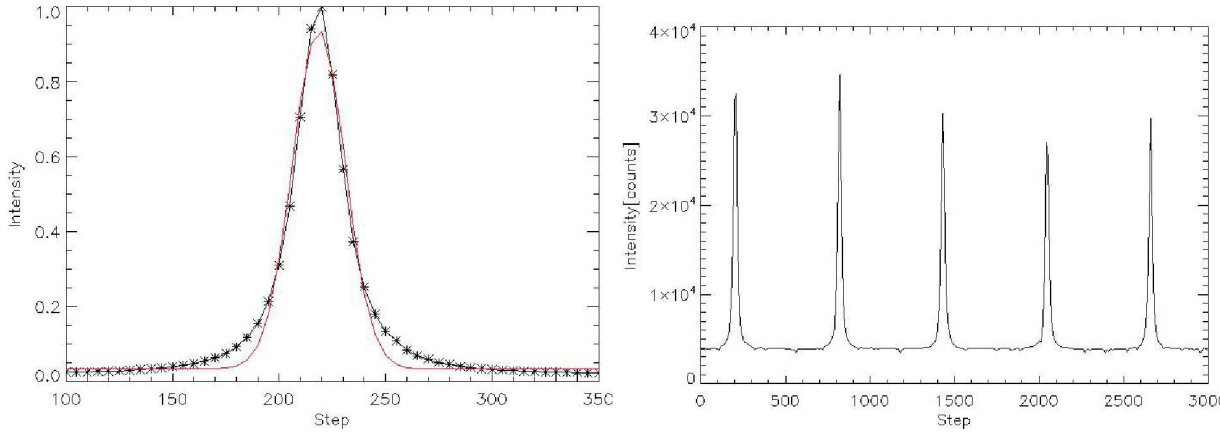

Figure 2.27: Left: The average intensity profile of one transmission peak (black curve). A Gaussian fit to the measured intensity profile (red curve). The wavelength is shown in discrete steps of the CS-100 controller. Right: A transmission profile of the Fabry-Perot etalon. The X-axis is shown in terms of discrete steps of the CS-100 controller.

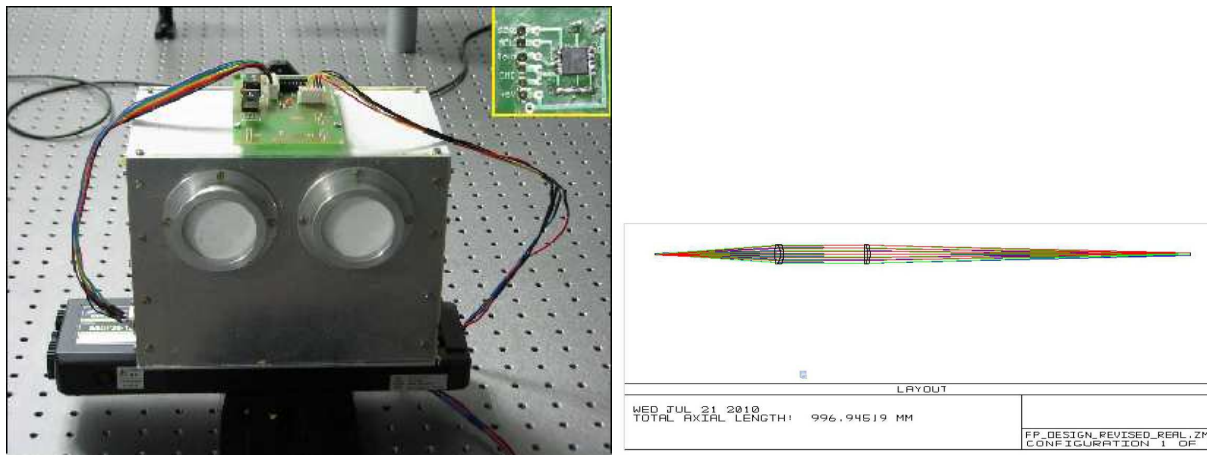

Figure 2.28: Left: A picture of the dual window filter oven and the temperature controller unit. The whole unit has been kept on the translational stage for selecting one window at a time during the solar observations. Right: The optical ray tracing obtained from Zeemax software.

(R. Prabhu, K. E. Rangarajan, K. Prabhu & Vasantha Raju)

2.10.2 Thirty Meter Telescope Project

Progress on the proposal: The Thirty Meter Telescope Project is an international consortium of institutes in Canada, China, Japan, India, and USA to build and operate the next generation ground based mega optical and IR telescope facility. India joined the project as an observer in 2010, since then it is participating in all the activities of the consortium. Design phase of the project is over, and the project is scheduled to begin telescope construction In mid 2014 at the site at Mauna Kea, Hawaii. Technology capability and demonstration of critical systems are underway in the partner countries and expected to be completed by end of 2013. In response to NSF (USA) solicitation request TMT project submitted a proposal for NSF's participation in the project. NSF will make its decision by July, 2012 or by mid August. Proposals for construction fund are at different levels with the respective governments in the partner countries.

In India, 2011–12 was an eventful year for the TMT India. Significant progress has been accomplished both at the policy and at the ground level. In November 2011, TMT project proposal was reviewed at megaprojects review meeting held at the Department of Science and Technology (DST), New Delhi. Followed by the review, DST and DAE decided to jointly set-up the India TMT coordina-

tion Center (ITCC), as an extramural large national project, anchored at IIA, Bangalore. The ITCC will be jointly implemented by the coordinating institutes IIA, Bangalore, IUCAA, Pune and ARIES, Nainital, and the interested institutes/universities and scientists in the country. To this effect, in March, 2012, an office memorandum has been issued by the DST with a set of guidelines for the ITCC. For this DST has provided seed funds towards technology demonstrations and partnership development. In April 2012, Detailed Project Report and a memorandum for Expenditure and Finance Committee (EFC) were submitted to DST for approvals for India's participation at 10% level in the project.

Progress on the work packages: As we have noted in the previous IIA annual reports TMT-India chose to provide some of the high technology and flagship systems as its in-kind contributions to the project which include a fraction of required mirror segments (about 125 out of total 574), M1 controls (Edge sensors, Actuators, segment support assembly) and software. Manufacturing of prototypes of improved versions of Edge Sensors and Actuators are underway at General Optics Asia Ltd, Puduchery and Avasarala Industries Ltd, Bangalore, respectively. First batch of prototypes will be available by September, 2012. SSA will control the segment passively in in-plane degrees and Actuators with the aid of Edge sensors control the segment in out-of-plane degrees (piston, tip and tilt). Each segment will have 3 actuators and 12 edge sensors and one SSA to actively maintain the surface figure. One of the critical components in the SSA is the moving frame that was fabricated at Avasarala and sent to the TMT project. Improved design of SSA and the technical review are completed at JPL and vendor selection prototype is underway at TMT-India. Dr. Parihar (IIA) and Mr. Mahesh (IIA) visited TMT Office and Jet Propulsion Laboratory (JPL) in Pasadena to participate in the design review of M1 controls. Also, they worked on the controls at JPL. However, desired progress couldn't be made in the case of segment polishing. The authors are working on strategies to implement one of the proven polishing techniques (e.g. Stress Mirror Polishing or SMP) to mass produce polished segments in India for the TMT project.

At IIA, TMT-India is developing electronics controls for actuators.Figure 2.30. This can be used to test the manufactured actuators at the industry. Smitha Subramaniam has been appointed as a post doctoral fellow to work on science related problems, and Kinjalsah and Sorjit Roy to work on electronics and mechanics, respectively. Smitha is developing a

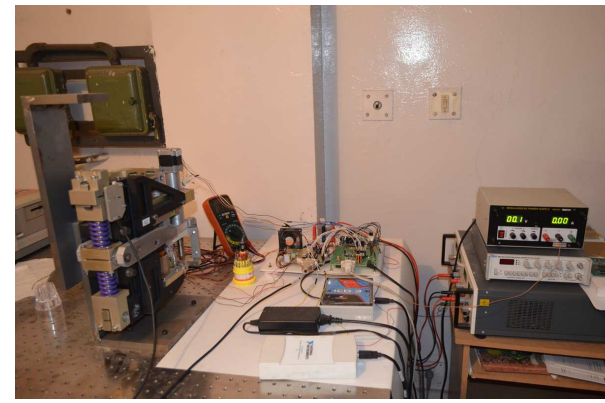

Figure 2.30: Developing actuator controls at IIA.

Laser Guide Star Catalogue (LGSC) for TMT Adaptive Optics facility.

(B. E. Reddy & TMT-India Group)

2.10.3 ADITYA 1

The fabrication of visible emission line coronagraph payload to study the solar corona involves the development of a number of components indigenously after a large amount of research and detailed study. First of all the optical design of the coronagraph has been generated and discussed in a number of review committee meetings. Finally it has been optimised after incorporating the suggestions made by the PDR review committee. It has lead to reduction of one folding mirror and reduction of the size of one of the dichroic filter. The thermal and structural analysis of the payload is being studied. Some of the aspects of realisation of the payload is discussed here.

Fabrication and specifications of optical components:

Specifications of M1 mirror are most critical and stringent. Micro roughness of the mirror should be around 1-2 Å to keep the scattered light from the M1 mirror to a level less than or similar to coronal level in order to get useful data. A small mirror of 50 mm size was fabricated and super polished using recently developed techniques at LEOS (ISRO), Bangalore. The profilo-meter measurements on this mirror indicate that the achieved micro-roughness of the mirror is around 2 Å. Further work is being done to improve the technique.

Further, the fabrication of M2 mirror involves decision on the selection of material for the mirror. It

can be either zerodur or Stainless steel(SS). An aperture hole equal to the size of 1.05 times the diameter of the sun is made at the centre of the mirror without any chipping at the edges to avoid scatter sources. Even smallscale chipping leads to a large amount of scattering from the edge of the mirror. Mirrors using the zerodur glass and SS were fabricated at LEOS(ISRO), Bangalore. In case of zerodur glass, even after very careful drilling of hole it created chipping at the edges. Grinding and polishing of the mirror after drilling the hole did decrease the chipping size but still remained. Therefore, SS material was used for making the M2 mirror.

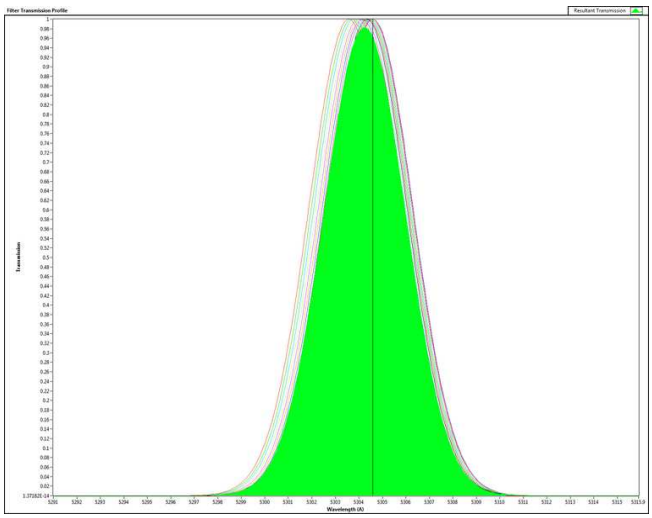

Figure 2.31: Number of curves show the shift in the transmission of the filter as a function of the incident angle of the beam. The curve enclosing the area shown in green represents the average curve of the transmission through the filter.

There have been some doubts about the magnitude of variation in peak intensity, shift in central wavelength and FWHM of the pass band of the narrow band interference filters (IF) of 4 Å across the FOV when kept in the converging beam. Detailed simulations were done to determine the variation in the transmission curve as a function of field of view (FOV) which varies from 0.28 to 0.4 degrees for emission line observations and 0.28 to 0.8 degrees for continuum observations. These parameters do not change in case of continuum channel as the FWHM of this filter is 20 Å.

Assuming the central wavelength as 5304.5 Å, of the green emission line in vacuum, effective refractive index(RI) of filter as 1.6 and transmission profile is Gaussian with 4 Å FWHM, the shift in central wavelength has been computed, peak transmission at

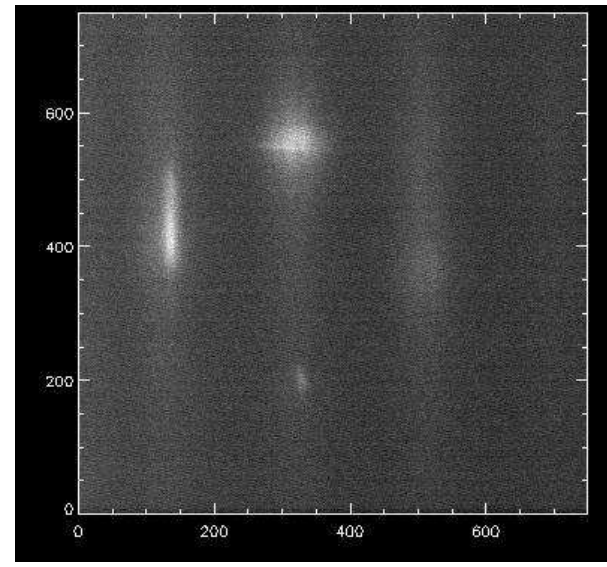

Figure 2.32: The multi-slit spectra in the green emission line at 530.3 nm obtained during the total solar eclipse of July 11, 2010 from Easter Island covering a field of view (FOV) up to about 2 solar radii. The use of narrow band interference filter of about 0.3 nm FWHM permits to record 3 spectra due to three slits each separated by about 1.1 solar radii. Emission lines are seen against the weak background continuum.

5304.5 Å , and FWHM of resultant profiles for different FOV. The converging beam with the f-ratio f/16 at the filter makes incident angle from -1.8 to $+$ 1.8 degrees at zero FOV and from -1.4 to 2.2 degrees at the FOV of 0.4 degrees. For the incident angle of 2.2 degrees the peak transmission of the filter shifts by 1.55 Åbut the average of transmission profiles at all angles yields the resultant transmission curve of the filter at different FOV's. The observations in the emission lines are planned at the FOV between 0.28 to 0.40 degrees. Computations indicate that peak transmission at the 5304.5 Å varies by about 0.8 % from the FOV of 0.28 to 0.40, central wavelength shifts by 24 m Å and FWHM varies by 20 m Å from 4.10 to 4.12 Å. These are marginal variations and will have negligible effect on the scientific objectives.

The Figure 2.31 below shows the effective transmission profile determined by averaging all the shifted Gaussian profiles as a function of incident angle for the zero degree FOV. The peak transmission shifts to the lower wavelength and decreases. The FWHM of the filter also increases.

The observations are proposed to be made in the FOV of 0.28 to 0.4 degrees. The Table above shows transmission at 5304. 5 Å decreases from 0.96 at

0.280 - FOV to 0.95 at 0.40 FOV. The central wavelength and FWHM also differ by 0.02 Å between 0.280 to 0.40 FOV. These are marginal variations and will not affect the scientific objectives over the required FOV.

Similarly the variations in these parameters for the red line filter are also marginal over the required FOV and the affect will be negligible on the results.

The multi-slit spectra obtained during the total solar eclipse of July 11, 2010 covering a FOV of 0.50 degrees using the red and green emission line narrow pass band filters with FWHM of about 3 Å is shown below Figure 2.32. The analysis of the spectra indicates a negligible change in the FWHM and shift of the central peak of the transmission curve of the filter at different FOV's up to 0.50 degrees. It is not possible to access to change in the peak intensity as the intensity along slit varies in the solar corona. These observational results confirm the simulations done for the green and red line narrow band filters.

Scattering and detector studies:

Simulations and computations have been made to study the scattering components due to the primary mirror in the instruments. The details of the experiments are being worked out to determine the component of the scattered light from the combination of M1 & M2 mirror and of the whole system after the fabrication of the instrument.

Two detectors, the CCD chip made by SCL, Chandigarh and the other CMOS detector made by Fairchild have been short listed after a detailed survey and studies of many available detectors for the coronagraph. Experiments have been planned and are being conducted at SAC (ISRO), Ahmedabad to determine the capability of these two detectors to detect a small signal in the presence of large back ground and variation of the order of couple of percent, in the small signal with time. Final choice of the detector for the payload will be made after the results of these experiments.

(Team - ADITYA)

Chapter 3

Students Program and Teaching Activities

3.1 Academic Programs

IIA conducts three different academic programmes leading to Ph.D degree. They are: (i) Ph.D programme jointly with Pondicherry University (PU); (ii) Integrated M.Sc-Ph.D programme in Physics and Astrophysics jointly with the Indira Gandhi National Open University (IGNOU); and (iii) Integrated M.Tech-Ph.D (Tech.) programme in Astronomical Instrumentation jointly with Calcutta University (CU). The procedure for admission to these programmes is through the IIA Screening Test (IIAST) conducted by IIA at several centers (at present 15) across the country every year during December. For the selection of students for 2011-2012, advertisement was given in leading national newspapers inviting applications from motivated and academically bright students. Posters of the advertisement was also sent to colleges / universities across the country. Based on the performance in the national level screening test (IIAST) conducted during December 2011 students were called for personal interview at IIA, Bangalore in January 2012. Those who could not attend the interview were asked to appear for personal interview in June 2012. Candidates who qualify through either of the following national level screening tests: (i) Graduate Aptitude Test in Engineering (GATE) examination scoring high percentile, (ii) UGC-CSIR / NET examination for Junior Research Fellowship (JRF), and (iii) Joint Entrance Screening Test (JEST) scoring high percentile, are also called for the personal interview for all these aforementioned programmes in June at IIA, Bangalore. In addition to the above students selected by the Indian Institute of Science (IISc) under the Joint Astronomy Program (JAP) are also considered for the Ph.D programme in the institute.

The break-up of students who were selected for the different programmes in June 2011 is as follows:
(i) Ph.D programme in collaboration with PU (3 out of 58 candidates short-listed for interview) (ii) IIA-IGNOU Integrated M.Sc-Ph.D programme (5 out of 32 candidates short-listed for interview) (iii) IIA-CU Integrated M.Tech-Ph.D (Tech.) programme (5 out of 30 candidates short-listed for interview)
The number of students who joined the different programmes are:
(i) Ph.D programme (2 students - selected under the JAP programme) (ii) IIA-IGNOU Integrated M.Sc-Ph.D programme (2 students) (iii) IIA-CU Integrated M.Tech-Ph.D (Tech.) programme (3 students)
The break-up of students who were selected for the different programmes in January 2012 is as follows:
(i) Ph.D programme in collaboration with PU (5 out of 24 candidates short-listed for the interview) (ii) IIA-IGNOU Integrated M.Sc-Ph.D programme (6 out of 31 candidates short-listed for the interview) (iii) IIA-CU Integrated M.Tech-Ph.D (Tech.) programme (4 out of 34 candidates short-listed for interview)
Two students selected for the Ph.D programme have joined in January 2012.
The following staff members taught courses (theory classes and practicals) to i the students of the above three catgories as well as the Joint Astronomy Program: C. S. Stalin, K. N. Nagendra, K. E. Rangarajan, F. K. Sutaria, V. Krishan, S. P. Rajaguru, S. K. Saha, U. S. Kamath, J. P. Lancelot, B. Ravindra, R. Banyal, A. Satya Narayanan, A. Mangalam, B. P. Das, M. S. Sundara Rajan, C. Pravabati, P. R. Vishwanath, Mousumi Das, K. Anupama, G. Srinivasalu, J. Murthy, S. Giridhar, G. Pandey, G. C. Anupama, R. K. Chaudhuri, and R. Ramesh.

Achievements: (i) Avijeet Prasad, a student

from the 1st batch of IIA-IGNOU Integrated M.Sc-PhD stream has received the presitigious Shyama Prasad Mukherjee Fellowship from the DST. (ii) Vaidehi Sharan Paliya from the 3rd batch of the same stream received 87th rank (UGC-JRF) in the CSIR-NET examination.

Special Programs: An interaction meeting with the students was arranged when Prof. G. S. Agarwal visited IIA on July 25, 2011.

3.1.1 Visiting internship programme

The visiting students internship programme is conducted by the Indian Institute of Astrophysics (IIA) with the aim to promote scientific research interest in college and university students. Students selected for this programme work on specific projects that form a part of the ongoing research at IIA. Based on the nature of the project, the students will be asked to work at either the main campus of IIA in Bangalore or its field stations. Students carrying out their Ph.D in universities, and would like to visit IIA for collaboration are also encouraged to apply for this programme. During 2011-2012 nine students did their projects under the guidence of the various acdemic staff members.

3.1.2 Summer internship programme

Nine students did their projects under the guidence of the various acdemic staff members under the summer internship programme.

(Board of Graduate Studies)

3.1.3 Summer School in Physics and Astrophysics

The summer school in Physics and Astrophysics, coordinated by the Board of Graduate Studies, is an yearly activity of the Indian Institute of Astrophysics (IIA). The main aim of the school is to introduce students of B.Sc, M.Sc, B.E./B.Tech. degree courses to the field of Astronomy and Astrophysics and secondly to motivate them to take up a career in Astronomy and Astrophysics. For the year 2011, the school was held at the Kodaikanal Observatory, during 16 - 27 May, 2011.

Twenty four students participated in the school, of which nine students each did a short term project for a duration of six weeks during June - July 2011, under the guidance of an IIA faculty in Bangalore. During the second week of July they also made presentations on the results of their project work. The programme during the period 16 27 May 2011, in Kodaikanal consisted of series of lectures including Physics and Astrophysics mostly by the faculties of IIA. The areas on which lectures were given include Introductory Astronomy (Mousumi Das), Galactic Astronomy (Mousumi Das), Classical Physics (Pravabati C), Stellar Structure and Evolution (Firoza Sutaria), Radiative processes (K. E. Rangarajan), Solar Physics (K. Sundara Raman), Extragalactic Astronomy (C. S. Stalin), Astronomical photometry including data analysis (C. S. Stalin), Astronomical Spectroscopy including data analysis (Uday Kumar), Xray and Gamma ray Astronomy (P. R. Vishwanath), Radio Astronomy (R. Ramesh), Relativistic Astrophysics and Cosmology (Arun Mangalam) and Magneto Hydrodynamics (A. Satya Narayanan). G. Govindaraj, Dept Physics, Pondicherry Univ., gave two interesting evening lectures titled "Exploration and Excitement in Quantum Physics with Mathematica.

Local arrangements of the school were efficiently done by the staff of the Kodaikanal Observatory under the guidance of K. Sundara Raman and the school was coordinated by C. S. Stalin.

(C. S. Stalin)

3.1.4 International Research Experience for US Graduate Students (IRES)

Under the International Research Experience for US Graduate Students (IRES) program, sponsored by the National Science Foundation of USA, IIA hosted the following students during the summer (June - August) of 2011: Brandon Patel (Rutgers University, USA) and Meredith Rawls (New Mexico State University, USA). Brandon Patel was guided by G. C. Anupama on "SN2010at: is it a Peculiar Type-Ia Supernova ?" and Meredith Rawls wwas guided by M. Srinivasa Rao on "Light Curve Solutions of Eclipsing Binaries in the Large Magellanic Cloud".

The IRES program, which is for graduate students of the United States to study astrophysics in India, is administered by the National Solar Observatory, Tucson, USA, and is currently co-ordinated by Kiran Jain from NSO, herself an alumnus of IIA. The program aims to expose potential researchers to an international setting at an early stage in their careers. After completing an initial three year period of successful running, this program received a positive review and continued funding from the NSF and

Figure 3.1: Participants of the summer school.

2011 is the fifth year of the program at IIA. The students associate with a faculty member at IIA for a research project, and also undertake visits to IIA's observatories and field stations. Cultural and social events are interleaved too. The program covers the students travel and stay and allows them to extend their return date in order to be a tourist in India at the end of the research period.

3.1.5 Ph.D Awarded

Veeresh Singh was awarded the Ph.D degree for his thesis titled "Multi-Wavelength Studies of Active Galaxies" which was submitted to the Calicut University on August 18, 2010. He carried out the above work under the guidance of P. Shastri.

Rumpa Choudhury was awarded the Ph.D degree for her thesis titled "Studies of Young Stellar Objects and their Environment" which was submitted to the Calicut University on January 31, 2011. She carried out the above work under the guidance of H. C. Bhatt.

Smitha Subramanian was awarded the Ph.D degree for her thesis titled "Stellar Populations in the Magellanic Clouds" which was submitted to the Calicut University on August 17, 2011. She carried out the above work under the guidance of Annapurni Subramaniam.

S. Ramya was awarded the Ph.D degree for her thesis titled "A Comprehensive Study of Star Formation in Blue Compact Dwarf Galaxies" which was submitted to the Bangalore University on November 10, 2010. She carried out the above work under the guidance of T. P. Prabhu.

Abhay Karnataki a JAP student was awarded the Ph.D degree for his thesis titled "Studies of Diffuse

Ultraviolet Radiation" which was submitted to the Indian Institute of Science on September 23, 2010. He carried out the above work under the guidance of Jayant Murthy.

3.1.6 Completion of Ph. D Thesis

The following students submitted their thesis:
Bharat Kumar Yerra submitted his thesis titled "Study of Li-Rich K Gaints" to the Calicut University on 18 August, 2011. The research was done under the supervision of B. Eswar Reddy.

L. S. Anusha submitted her thesis titled "Advanced Numerical Methods for Polaraized Line Formation Theory" to the Mangalore University on 16 April, 2012. The research was done under the supervision of K. N. Nagendra.

A. Vyas a JAP student submitted his thesis titled "Advanced Wavefront Sensing Algorithms in Astronomical Adaptive Optical Systems" to the Indian Institute of Science on 8 February 2012. The research was done under the supervision of B. Raghavendra Prasad.

3.1.7 Completion of M. Sc

Shubham Srivastav under the guidance of R.Ramesh completed his post-MSc. thesis titled "Microcontroller based data acquisition system for Two-Element Radio Interferometer" to the School of Sciences, IGNOU, for his M.Sc degree in Physics and Astrophyscis, in June 2011.

3.1.8 Completion of M.Tech

The following students from the 2nd batch of the above programme have completed their M.Tech. degree under the IIA-CU integrated M.Tech-Ph. D programme.

Tarun Kumar Sharma under the guidance of P.S. Parihar and Ravinder Kumar Banyal submitted his M.Tech thesis titled "Development of Automated Extinction Monitor for the NLOT Site Survey" to the University of Calcutta on July 2011.

Kishore Pulpalli under the guidance of C. Kathiravan submitted his M.Tech thesis titled "Design of a Broad Band Antenna System (40 to 500 MHz) for the Spectral Observations of Solar Corona" to the University of Calcutta on July 2011.

Narsi Reddy Anugu under the guidance of J. P. Lancelot submitted his M.Tech thesis titled "Development of Closed loop Adaptive Optics System at Laboratory" to the University of Calcutta on July 2011.

Jyotirmay Paul under the guidance of B. Ravindra and Ravinder Kumar Banyal submitted his M.Tech thesis titled "Computer Control and Automation for Scanning Fabry-Perot based narrow Band Imaging System" to the University of Calcutta on July 2011.

Soumi Paul under the guidance of T. P. Prabhu submitted her M.Tech thesis titled "Remote Operations and Automation of the All Sky Camera for a Continuous Record of the Sky" to the University of Calcutta on July 2011.

Amita Mohanty under the guidance of J. P. Lancelot submitted her M.Tech thesis titled "Wavefront Reconstruction Using Polarization Sheraing Interferometer" to the University of Calcutta on July 2011.

3.2 Research Guidance

R. Banyal:

- Yogesh Singh for a summer project in IIA on "Development of 2-wire communication interface for thermal control system using a DS1621 band gap-based temperature sensor" and Danda Avinash on "Design of mechanical mount and drive system for scanning cloud monitor".
- Avinash Surendran for his IIA MTech project on "The lunar scintillometer".
- Tarun Sharama (IIA Ph.D) on "Develpment of automatic extinction monitor".
- Sajal Kumar Dara (IIA Ph.D) on the "Develpment of Fabry-Perot based narrow band imager for solar studies".

P. Chingangbam:

- Manogna Sastry, on the topic "Inflation model building", 4 semester, 2011.

B. P. Das:

- Arya Dhar, a senior research Fellow, on "Novel quantum phases of ultracold atoms in optical superlattices".

- Manpreet Singh, a junior research Fellow, on "Theoretical studies of mixtures of ultracold atoms in optical superlattices".

R. T. Gangadhara:

- Dinesh Kumar for his Ph.D thesis project on "Polarization of pulsar radio waves" since August 2009.

S. Giridhar:

- Sumangala Rao for her Ph.D. on "RV Tau stars and related objects".
- A. B. Sudhakar Reddy for his Ph.D. thesis project since February 2010.

A. Goswami:

- K. Drisya for her Ph.D.thesis titled "Studies on Carbon-enhanced metal-poor stars".

U. S. Kamath:

- E. Viswanathan, a summer student from Bishop Herber College, Trichy, on "Optical Spectroscopy of V838 Monocerotis".
- Sayan Bag, INSPIRE, Vivekananda College, Thakurpur, (Calcutta University), "A study of optical spectra of nova V2491 Cyg 2008 No. 2" (co-guides : T. P. Prabhu & G. C. Anupama).

R. Kariyappa:

- Guided L. P. Chitta for his thesis on "Fine scale Features of the Sun".
- Co-Guide for S. T. Kumara for his Ph.D. thesis on "Understand the solar variability from spatially resolved images" at the Department of Physics, Bangalore University, since 2008.

J. P. Lancelot:

- Supervised two M.Tech students; Narsi Reddy and Amita Mohanty on their project work on "Adaptive Optics developmental work".
- Guiding S. Behera; M.Tech student in his project work based on "Solar adaptive optics".

A. Mangalam:

- Prashanth Mohan in the field of "Blackhole astrophysics" towards Ph.D. under IIA-IGNOU I-Ph.D. programme.
- Avijeet Prasad on the topic of "Force free fields and magnetic helicity" towards Ph.D. under IIA-IGNOU I-Ph.D. programme.
- M.Sc. thesis of S. R. Nesar an INSPIRE student from BITS Pilani (Goa campus).

J. Murthy:

- K. Preethi from Christ University for her Ph.D. thesis on "Morphology of interstellar medium using multi-wavelength observations."
- Sowmya Kulkarni from Christ University for her Ph.D. thesis on "Scattering from dust around Eta Car."
- U. Haris from Christ University for his Ph.D. thesis on "Depletion studies in the interstellar medium
- S. Ravichandran from Christ University for his Ph.D. thesis on "Three dimensional mapping of interstellar extinction in Milky Way Galaxy".

C. Muthumariappan:

- Jerin Jose, Aparna Raj, Amita Mathew, M.Sc. students at Christ University, Bangalore on the topic on "Spectroscopic studies of variable stars."

K. N. Nagendra:

- L. S. Anusha submitted her Ph.D. thesis "Advanced numerical methods for polarized radiative transfer: Astrophysical applications" on April 16, 2012 to the Mangalore University.
- H. N. Smitha, a regular Ph.D. student on her PhD thesis titled "Application of polarized line formation theory to the second solar spectrum."
- K. Sowmya, a regular Ph.D. student on her PhD thesis on "Scattering polarization as a tool to diagnose the magnetic structuring of the chromosphere, transition region, and corona."
- A co-guide to H. D. Supriya, a regular Ph.D. student, on her PhD thesis on "Exploration of the depth dependent magnetic fields in the solar atmosphere through polarimetric studies".

G. Pandey:

- B. P. Hema a Ph.D. student for her thesis on "Observational studies of hydrogen deficient stars."

T. P. Prabhu & G. C. Anupama:

- Amit Shukla on his Ph.D. thesis titled on "Radiation mechanisms of very high energy gamma ray sources".

S. P. Rajaguru:

- C. R. Sangeetha for Ph.D. under the IIA-PU Ph.D. programme on "Magneto-convective Processes on the Sun and Sun-like Stars".

K. P. Raju:

- Vivek Vaddina, a summer student from Avanthi's Research and Technological Academy, Vizianagaram, Andhra Pradesh on "Solar activity studies from Kodaikanal archival data."

K. E. Rangarajan

- M. V. Muthamma and Jerin John, M.Sc students of Christ University for their projects on "Calcium line formation in Sun".

B. Ravindra:

- Sajal Kumar Dhara for his M.Tech-Ph.D. thesis titled "A Multi-Wavelength Study of Large Scale Magnetic Inhomogeneities in the Solar Atmosphere" with R. K. Banyal as a co-guide.

B. E. Reddy:

- Y. B. Kumar who defended his thesis on "Study of Li-rich K giants" on 28 April, 2012.
- Is guiding P. Ramya a Ph.D student for her thesis titled "Study of galactic streams."

S. K. Saha:

- Arun Surya, an IIA-CU Integrated M. Tech.-Ph.D. (Tech.) student, Arun Surya, since October, 2009 for his Ph.D. (Tech.) thesis.

A. K. Saxena:

- Celine Joseph, an FIP student from Jyoti Nivas College, Bangalore has submitted her thesis on "Design and Development of 10.5 μm Quantum well infrared Photo-detector (QWIP) for astronomical Applications" to Mangalore University.

C. S. Stalin:

- S. Rathna Kumar's thesis on "Determination of H_0 through monitoring of gravitationally lensed quasars".
- Vaidehi Sharan Paliya, M.Sc., on her project "Multiband monitoring of variability in active galaxies: the case of Narrow Line Seyfert 1 galaxies".

T. Sivarani:

- Anantha Chanumolus an MTech-PhD student for her thesis on "High resolution fibre fed Echelle spectrograph: calibration and characterisation for precise radial velocity and chemical abundances."

A. Subramaniam:

- Smitha Subramanian - Ph.D. - "Stellar population in the Magellanic Clouds."
- Indu, G. - Ph.D. - "Structure and Kinematics of the Large and Small Magellanic Clouds."
- Samyaday Choudhury - Ph.D. - "Evolved stars in the Magellanic Clouds."
- Paul K.T. (Christ University) - Ph.D. - "Study of Classical Be stars in our Galaxy and the Magellanic Clouds."
- Bhavya B. (Cochin University) - Ph.D. - "Duration of star formation in young open clusters."
- Anumol, C. G. (Christ University) - M. Phil. - "Simulation of UVIT images."
- Raja Chakraborty (IIT, Kanpur) - Summer student - "Infrared excess of red clump stars in the LMC."

K. Sundara Raman

- Guided 2 M.Sc. students of Mother Terasa Womens University, Kodaikanal in their dissertation work during November 2011-February 2012 on "Solar Physics".
- Guided 2 B.Sc. (Physics) students of American College, Madurai in the topic on "Solar Physics".

3.3 Pedagogical lectures & courses taught outside IIA

G. C. Anupama:

- "Observations of Transients Using the 2m HCT"- 4 April 2011, HIA, Victoria, Canada.

S. Chatterjee:

- Course of five lectures on "ISM and spectroscopy", Physics Dept of Mohan Lal Sukhadia University, Udaipur, on 22 – 23, March, 2012 for the M.Sc. students with Astrophysics specialization.

P. K. Mahesh:

- Representated IIA at the Bhopal centre of the IIAST 2011 and delivered a talk on "IIA and its activities" to the students and faculty of the Physics Dept, Barkatullah University, Bhopal, December 10, 2011.

A. Goswami:

- "HE 1015-2050: Discovery of a Hydrogen-deficient carbon star at high Galactic latitude", IIA, Bangalore, 14 July, 2011
- "CEMP stars and the Galactic chemical evolution", Dept Physics, Gauhati University, 10–11 August, 2011
- "Spectroscopic charaterization of FHLC stars and a newly found HdC star", Intl workshop on 'Stellar spectral libraries', Delhi University, 5–9 December, 2011
- "Circumstellar envelopes of Late-type stars" " Dust in Astrophysics" - 2012, Dept of Physics, Assam University 31 January – 2 February 2012

C. S. Stalin:

- Gave talks on Stellar Physics and Galactic and Extragalactic Astronomy in Mysore University during the three day seminar on "Some Aspects of Physics and Astrophysics" sponsored by Karnataka State Science and Technology Association held during 3–5 November, 2011
- "Compact Objects" at Calicut University, Calicut, as part of the "National Seminar on Astrophysics" held during the period 13–14 March, 2012

S. Subramanian:

- "Introduction to Magellanic Clouds", 27 January, 2012 for Ph.d students, Christ University, Bangalore

Chapter 4

Scientific Conferences, Workshops & Lectures at IIA

4.1 In-house Scientific Meeting at IIA

Winners of Outstanding Research Paper Award, L.S. Anusha, R. Ramesh and A. Goswami with S. S. Hasan, Director, IIA.

The In-House Scientific Meeting was held at IIA on 18th April, 2011. There were 22 scientific talks and 8 posters, covering areas of solar physics, stars, galaxies, theoretical astrophysics, fundamental physics and astronomical instrumentation. The winners of the outstanding Research paper award for the year 2011 were L. S. Anusha et al., A. Goswami et al.and R. Ramesh et al. The details of the papers are as follows:

Anusha, L.S., Nagendra, K. N., 2011, *Polarized Line Formation in Multi-Dimensional Media. I. Decomposition of Stokes Parameters in Arbitrary Geometries,* ApJ, 726, 6.

Goswami, Aruna, Karinkuzhi, Drisya, Shantikumar, N. S., *HE 1015-2050: Discovery of a HydrogenDeficient Carbon Star at High Galactic Latitude,* 2010, ApJ Lett., 723, 238.

R. Ramesh , C. Kathiravan , Indrajit V. Barve , G. K. Beeharry and G. N. Rajasekara, *Radio Observations of Weak Energy Releases in the Solar Corona,* Astrophys. J. Lett.,719,41

(*T. Sivarani)*

4.2 Recent advances in star formation: Observations and theory

The first of the two meetings to mark the silver jubilee of the Vainu Bappu Telescope (VBT), titled "Recent Advances in Star Formation: Observations and Theory" was organized at the Bangalore campus between the 28th June and 1st July. This meeting brought together leading researchers in the area of observational and theoretical star-formation from within, and outside India. The director, Siraj Hasan, and the Dean of the faculty, Harish Bhatt, gave relentless support for the organization of the meeting.

A team comprising of S. Anathpindika, M. Das, and P. Parihar led by A. Subramaniam organised the conference. The conference was principally funded by the Indian Institute of Astrophysics, and some partial financial supprt was extended by the Department of Science & Technology.

The theory of star-formation, as is perhaps well-known, presents a paradox; while on the one-hand the physical processes leading to stellar birth are much better understood now, the physical properties of star-forming regions, hitherto less-known, are

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Deirdre Coffey from the Dublin Institute of Advanced Studies presenting an evening talk titled, "Disks and jets in young stars: Observations and unsolved problems", as part of the conference

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only being unraveled over the last few years through a number of detailed observational surveys at a number of wavelengths. The enormous volume of data available today has therefore significantly advanced our understanding of the subject. The data collated from the Herschel and Spitzer space observatories in the recent past, and the anticipation of the ALMA telescope has provided an impetus to the global star-formation community which has catapulted in to a number of conferences dedicated to various aspects of the subject. Encouraged by these activities on the global scale, we decided to have one here, at the IIA.

The conference was conducted over a span of 4 days, comprising of 7 sessions with each dedicated to a certain aspect of star-formation. The scientific remit of this meeting, attended by 60 researchers including a substantial number of research students, extended over several, if not all areas of research on the subject of starformation. Close to a dozen posters were also presented and viewed alongside the main conference proceedings that extended over 7 sessions during which, 29 oral presentations were made. The customary evening guest lecture, on this occasion, was delivered by one of our overseas participants, Dr. Deirdre Coffey, on molecular outflows and jets from young stellar objects.

Subjects discussed at the meeting thus, included early stages of stellar birth starting prestellar cores; jets and outflows, accretion disks and formation of dwarfs were also discussed. In this regard, new results about young star-forming regions from the Herschel space telescope were also presented. Episodes of stellar birth triggered by ionising radiation though, received extensive attention at the meeting and a number of star-formation sites in the vicinity of HI bubbles were discussed in a sequence of talks. Also discussed in the meeting were topics related to the

shock-induced assembly of gas in the dense phase where stars were likely to form. Besides the regions of isolated star-formation, clusters of stars and their properties and extending further, to the star-formation history in galactic disks including our own Galaxy, were also discussed in considerable detail in number of talks. The subject of extra-Galactic star-formation also included those galaxies that exhibit a unusually low rate of star-formation in contrast to some others, replete with star-forming regions. The conference concluded with presentations on the future prospects for Astronomy in India. Oral presentations delivered at this conference will soon be published by the Astronomical Society of India in one of its dedicated conference series.

(*Sumedh Anathpindika)*

4.3 Vainu Bappu Telescope Silver Jubilee Meeting

A meeting to commemorate the Silver Jubilee of the Vainu Bappu Telescope was held during 10 - 12, August 2011. The 2.3 metre telescope was built over the years 1978 to 1985 and was dedicated as the Vainu Bappu Telescope by the late Shri Rajiv Gandhi on the 6th of January 1986. Twenty five years have passed and the VBT still remains the largest optical facility in the country.

Siraj Hasan presenting a model of the VBT as a memento to M. G. K. Menon.

The dream of late M. K.Vainu Bappu, of an optical telescope of sizeable aperture in India had its origins soon after he took charge as the Director of the Kodaikanal Observatory. The Indian Institute of Astrophysics itself was formed to embark on new initiatives in optical astronomy. The founding Governing Council of the Institute, led by M. G. K. Menon gave unstinting support and guidance to Vainu Bappu to commence building the 90 inch telescope as it was referred to in those days. The telescope project was exemplary in demonstrating the synergy of national laboratories and private industry in building a state of the art facility with comparatively meagre resources.

Yemuna Bappu, M. G. K. Menon, S. S. Hasan and Indu Menon at the exhibition held at the Library at IIA, Bangalore.

The meeting was inaugurated by S. S. Hasan, Director, IIA. The chief guest for the event was M. G. K. Menon. Menon was the founder chairman of the Governing council of the Institute in 1971 and he held this position for two decades. The founders day of the Institute is celebrated on the 10th of August every year, as it is the birthday of the founder director M. K. Vainu Bappu. The meeting started with Menon and Hasan garlanding the bust of Bappu. A commemorative volume on VBT, which was specially prepared for the occasion was released by Menon. This volume was distributed to all the participants of the meeting. Menon delivered the founder's day lecture titled The Founder of IIA - Vainu Bappu: Many Memories and the Lessons we can Learn from Him. In his talk, Menon remembered his association with Bappu, a truly great man of visions and dreams for the country, from the first time he met him in the late 1950s He recalled the days when Bappu gave lectures on Astronomy and Astrophysics at the invitation of Vikam Sarabhai at the Physical Research Laboratory and how much he learned from these lectures. He talked about similarities between Vainu Bappu and Homi Bhabha, their meetings and discussions, as well as the admiration of Bappu for Homi

Participants at the VBT observing floor, Kavalur

Bhabha. He also pointed out the responsibility of the younger generation to carry forward Bappu's vision for optical astronomy in the country.

After the lecture, a model of the VBT was presented as a memento to Menon. Mementos were also presented to several dignitaries who contributed to the making of the VBT. The mementos for Bappu and Bhattacharyya were received by Mrs.Yemuna Bappu and Mrs.Indira Bhattacharyya respectively. A. P. Jayarajan, A. K. Saxena, B. N. Karkera (on behalf of the BARC team), B. Mallikanadh, S. C. Tapde, A. K. Pati (on behalf of the IIA team), representative from Tata Consulting Engineers (TCE) and W a l c h a n d n a g a r Industries also received mementos After the inaugural session, the meeting had scientific sessions with talks highlighting the science done with the VBT over the years, as well as sessions recalling technical and historical aspects of the VBT project itself. Wide range of topics, including solar system science, young stellar objects, eruptive variables, stellar abundances, star clusters, galaxies and AGN, were presented in 20 talks spread over six sessions. One session was dedicated to the making of the VBT, which had 4 talks. The first two days of the meeting had evening lectures. David Lambert (Dept of Astronomy, University of Texas, Austin, USA) gave a talk titled In my Craft or Sullen Art on the evening of August 10th, followed by a talk titled Chance and Accident in Astronomy by J.V. Narlikar on the evening of August 11th, 2011. Menon releasing the commemorative volume on VBT.

The participants travelled to the Vainu Bappu Observatory, Kavalur on the third day. Two sessions were held on the observing floor of the VBT. The first session was titled 'Reminiscences of the VBT Project', which had three talks. The second session was titled 'Future Perspectives', which had 4 talks. The meeting was attended by several scientists who have used the telescope and those who were involved in the making of the telescope, with the number of participants touching 150. The meeting provided a heartening get together for people who were associated with the building of the telescope. New generation of young astronomers could take a glimpse of the struggle and success in the making of a indigenous telescope and the researchers had an atmosphere for fruitful, detailed discussions and future collaboration.

(Annapurni Subramaniam)

4.4 Science with Planned and Upcoming Solar Facilities in the Country

P. Venkatakrishnan presented an overview of 'Science with MAST'.

A meeting was conducted at IIA, Bangalore (November 2-3, 2011) to bring together solar physicists in the country to discuss ways and means to build greater synergy in the science programmes with the planned and upcoming solar facilities such as National Large Solar Telescope (NLST), Aditya I, Muti-Aperture Solar Telescope (MAST) and other existing facilities. The talks were structured as follows: each session began with an overview of the facility along with the planned post focus instrumentation followed by presentations on specific science objectives. The lectures and the inaugural programme were open to all. Nearly 50 scientists from various National Institutes and Universities participated in the meeting. A web conference facility enabled USO scientists to listen and view the lectures and ask questions remotely. Different methods to enhance student participation in the projects were explored.

(K. E. Rangarajan)

4.5 Mini Workshop on Cosmology and Galaxies

A one day workshop on "Cosmology and Galaxies" was held on 28 November, 2011, as part of the activities of the theoretical astrophysics group at IIA. The workshop brought together researchers whose work focused on the closely related areas of cosmology and the study of galaxy formation and their properties, from three research institutes in Bangalore, namely, Raman Research Institute, Indian Institute of Science and IIA. There were also a few participants from other parts of India and one speaker from the Korea Institute for Advanced

Mousumi Das speaking on the black hole masses for low luminosity galaxies which deviate strongly from the M-σ relation.

Study, Seoul, South Korea. The workshop had four sessions. The first session focused on some of the big questions in cosmology, namely, issues related to the nature of dark energy and the epoch of reionization.Changbom Park spoke about how to use the topology of the Large-Scale Structure of the universe to constrain the dark energy equation of state. Tarun Deep Saini spoke on constraining distance-redshift relation using BBO/DECIGO observations. Ravi Subrahmanyan described how to probe the reionization epoch from redshifted 21-cm observations.The second session had Biman Nath talking about properties of the galactic wind and the intergalactic medium, followed by Chanda J. Jog who explained how to deduce the prolate-shaped dark matter halo in the outer Galaxy from flaring HI gas. Then Prateek Sharma spoke about the role of hot Gas in massive dark matter halos. The third session focused on specific issues related to properties of

Members of the Scientific Advisory Committee (SAC) with the Director of IIA (from left to right): George Joseph, N. Kumar, Nigel O. Weiss, S. S. Hasan, Michael Dopita, Dimitar Sasselov and S. Ananthakrishnan

galaxies. Sivarani Tirupathi described the origin of carbon in early galaxies, Mousumi Das talked about AGN activity and black hole masses in low luminosity galaxies and Amit Shukla talked about multiwavelength study of TeV blazar Mrk421 during a giant flare. The fourth and last session focused again on cosmology. Shiv Sethi posed the question: can a heavy charged lepton be a candidate for dark matter in the universe? He explained why it is worthwhile to pursue this question further. Then Rajesh Gopal described the effect of primordial magnetic fields on the collapse of baryonic region in the early universe. Finally, Pravabati Chingangbam showed that the WMAP data of the CMB contains a small amount of residual foreground contamination which can bias the estimation of primordial non-Gaussianity. The workshop got enthusiastic response from astrophysicists in Bangalore, as was evident from the considerably large participation. It was a pleasure to see lively discussions and exchange of ideas after every talk. It ended on the optimistic note that there will be continued sharing of new research findings and avenues for future collaborations.

(Pravabati Chingangbam)

4.6 Second Visit of the IIA Scientific Advisory Committee

The Scientific Advisory Committee (SAC) visited the Institute for the second time from March 5 through March 9, 2012. Its previous visit was in March 2010. The composition of the Committee is as follows: Nigel O. Weiss, FRS (Chair), Michael Dopita, Dimitar Sasselov, N. Kumar, George Joseph and S. Ananthakrishnan. Several individual and group presentations were scheduled in order to give the Committee a flavor of multifarious prgrammes and facilities of the Institute. In addition, interactive sessions were held with individual scientists and various groups.

The sessions on March 5 included a Report by the Director, Overview of Academic Activities (Dean), Graduate Studies & Training Programmes (Chair, BGS), followed by presentations on new programmes: the proposed National Large Solar Telescope, and the Visible Emission-Line Coronagraph on board Aditya-1. Discussions on the new programmes continued through the second day, with presentations on the UltraViolet Imaging Telescope, Hanle Echelle Spectrometer, update on Indian participation in the

Thirty Meter Telescope Project, and a proposal to participate in the GALEX project. This was followed by an overview of activities of the four Group Committees, and visits to the new computer centre, various laboratories, the library and archives.

On March 7, there were presentations on two other facilities: the Gauribidanur Radioheliograph, and the Indian Astronomical Observatory, Hanle. Four young scientists made presentations on their research and development activities: R.K. Banyal (Development of Adaptive Optics), P. Chingangbam (Probing the Statistical Properties of the CMB), G. Pandey (Studies on Hydrogen-Deficient Stars), and A. Goswami (Studies on Carbon-Enhanced Metal-Poor Stars and Galactic Chemical Evolution).

The Committee was also apprised of the activities of the administration and new civil works that include the I.Ph.D. laboratories, additional rooms for students on campus and the guest house cum conference centre at Kodaikanal, that is nearing completion..

The SAC had interactive sessions on March 7, with students, post-doctoral fellows, and several individuals and groups. There was also a photography session organized with staff and with students that afternoon. Finally, The Committee visited the CREST campus on March 8, and in particular, the M. G. K. Menon Laboratory for Space Sciences where the flight model of UltraViolet Imaging Telescope is undergoing final calibration and integration.

(T. P. Prabhu)

4.7 Lectures at IIA

Vainu Bappu Memorial Lecture

The Vainu Bappu Memorial Lecture Award for the year 2012 was awarded to Professor Nigel O. Weiss, FRS, University of Cambridge, Cambridge, UK. This was the 5th time the VBM Lecture was awarded, and it was held on the evening of the 9th of March, 2012 in the Auditorium on campus at IIA, Bangalore. Following a high tea in the West Lawns of the Institute, the event started with Siraj S. Hasan, director of IIA, introducing Nigel Weiss, reading out the award citation and handing over the roll of honour and a bouquet to Weiss. Weiss titled his lecture as 'The Chaotic Dynamo in the Sun', in which he gave a masterly account of what we have learnt so far on the origins of cyclic magnetic activity of the Sun as controlled by a non-linear magnetohydrodynamic dynamo operating within it.

Professor Nigel O. Weiss

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Weiss focussed on the progress in modeling the nonlinear dynamical behaviour of the solar dynamo, and especially the longer time scale modulation of it, as revealed by, for example, the 17th century grand minimum called Maunder minimum. He discussed how proxy data allow the record to be extended back for almost 10,000 years, and the chaotic nature of such modulations. He related the transitions from periodic oscillations to chaotically modulated cycles to those seen in idealized nonlinear model calculations, and explained that such transitions are an intrinsic feature of these dynamos. He reasoned that future behaviour cannot be readily predicted. Pointing out that the Sun's activity has been abnormally high for the past 60 years, he noted that the feeble start of the current cycle might suggest that this episode is coming to an end.

Nigel Weiss is Emeritus Professor of Mathematical Astrophysics in the Department of Applied Mathematics and Theoretical Physics (DAMTP) at the University of Cambridge, and a Fellow of Clare College. He is a Fellow of the Royal Society (1992) and a former President and Gold Medallist of the Royal Astronomical Society. He obtained his Ph D in geophysics under Sir Edward Bullard but his research has focused on solar and stellar magnetic fields, on magnetoconvection and on nonlinear dynamics. Much of his work has involved numerical computation, studying idealized model systems that have grown increasingly complex as computers became more powerful. Lately, Weiss has focussed his research on furthering the understanding of peculiar variations in the solar cycle properties in terms of chaotic dynamics. Weiss has mentored a large number of Ph D students and several of them have es-

tablished themselves as leaders in the fields of astrophysical fluid dynamics. Weiss has visited the Indian Institute of Astrophysics several times and has served as Chair of the Institute's Scientifc Advisory Committee.

(*S. P. Rajaguru)*

Special Lectures

March 2012
N. O. Weiss
University of Cambridge, Cambridge, UK
The Chaotic Dynamo in the Sun

31 October 2011
A. Mangalam, G. C. Anupama, P. Chinganbam
Indian Institute of Astrophysics, Bangalore
Discussion on 2011 Physics Nobel Prize

30 September 2011
Vidyanand Nanjundiah
Indian Institute of Science, Bangalore, India
The biological roots of altruism

30 September 2011
Laurent Gizon
MPI for Solar System Research, Germany
Seismology of the Sun and Sun-like Stars

15 September 2011
N. Mukunda
Indian Institute of Science, Bangalore, India
Truth, beauty and the meaning of understanding nature

25 July 2011
Prof. G. S. Agarwal
Oklahoma State University, U.S.A.
Quantum Interference between Independent Photons

28 June 2011
Deirdre Coffey
DIAS, Dublin
Disks and jets in young stars: observations and unsolved problems

08 April 2011
Mushirul Hasan
National Archives of India, New Delhi, India
Is there a Gandhian Legacy ?

Colloquia

6 March 2012
Dimitar Sasselov
Harvard -Smithsonian CfA, Cambridge, MA 02138
Stellar and Planetary Theory: New Insights from the Kepler Mission

31 January 2012
Sourav Pal
National Chemical Laboratory, Pune
Predictive Theories for Structure and Dynamics of Molecules

08 November 2011
Changbom Park
Center for Advanced Computation, KIAS, S. Korea
How Are Galaxy Properties Related With their Environment ?

21 June 2011
Girjesh Gupta
Indian Institute of Astrophysics, Bangalore, India
On the Nature of Propagating MHD Waves in the Solar Atmosphere

14 June 2011
Uma Gorti
NASA Ames/SETI, US
Gas Emission Lines from Protoplanetary Disks

12 April 2011
Sudhir Vempati
Centre for High Energy Physics, IISc, Bangalore
From Tiny Scales to Large Scales: What is the LHC going to tell us ?

Seminars

30 March 2012
Bharat Kumar Yerra
Indian Institute of Astrophysics, Bangalore
Study of Li-rich K Giants

21 March 2012
Sudhakar Panda
Harish-Chandra Research Institute, Allahabad
Inflation and Quintessence from String theory

14 March 2012
Per Kjaergaard Rasmussen
Copenhagen University, Denmark

The SONG Project

13 March 2012
Smitha Subramanian
Indian Institute of Astrophysics, Bangalore
Stellar Populations in the Magellanic Clouds

24 February 2012
Sumati Surya
Raman Research Institute, Bangalore
Phenomenology from Quantum Gravity – a brief introduction to causal set theory

22 February 2012
Koji Kawabata
Hiroshima Astrophysical Science Center, Hiroshima University, Japan
Transient Object Studies with Hiroshima 'Kanata' 1.5-m Telescope

17 February 2012
Keiichi Maeda
Inst. for the Physics and Mathematics of the Universe, Univ. Tokyo, Japan
Studying nearby Type Ia Supernovae for future cosmological applications

08 February 2012
Preeti Kharb
Rochester Institute of Technology, Rochester, USA
A Multi-wavelength, Multi-scale Study of Jets in Radio-Powerful AGNs: Clues to Jet formation and Challenges to Unification

07 February 2012
Arnold Hanslmeier
Institut fur Physik, Universitat Graz, Austria
Solar convection in the ascending solar activity phase

25 January 2012
M. B. Roopashree
Indian Institute of Astrophysics, Bangalore
Wavefront correction using MEMS deformable mirror

25 January 2012
Amit Shukla
Indian Institute of Astrophysics, Bangalore
Multiwavelength studies of selected TeV Blazars

24 January 2012
Shravan Hanasoge
Princeton University, USA

The Rapidly Rotating Solar Convection Zone

20 January 2012
Steven Tomczyk
High Altitude Observatory/NCAR
Colorado, USA
Observation of Alfven waves in the Solar Corona

09 January 2012
Trinh X. Thuan
University of Virginia, Charlottesville, VA
Blue Compact Dwarf and Green Pea Galaxies: Laboratories for star formation studies in a nearly primordial environment

04 January 2012
Kartik Sheth
NRAO, Charlottesville, VA
ALMA: A Revolutionary Telescope For Transformational Science, Technology and Computing

02 January 2012
Luca Baiotti
Osaka University, Japan
Binary neutron-star simulations and short gamma-ray bursts

19 December 2011
Dominik Utz
Institute of Physics, Univ. Graz, Austria
Dynamics of magnetic bright points as observed by Hinode/SOT

16 December 2011
Birgit Lemmerer
IGAM, Institute of Physics, Univ. Graz, Austria
Segmentation Algorithms applied to Data from Simulations and Observations - First Results and Outlook

12 December 2011
Manjari Bagchi
West Virginia University, Morgantown, WV 26506 USA
What do the orbital and stellar properties of millisecond pulsars in globular clusters tell us ?

05 December 2011
Neha Choksi
Mumbai, India
A talk about an artist's work and a materially bound search for absence

24 November 2011 Shiv Sethi

RRI, Bangalore
Primordial magnetic fields in cosmological context

09 November 2011
Y. Schekinov
South-Federal University, Rostov, Russia
Mixing of metals in low-surface brightness galaxies and all that

08 November 2011
G. Thejappa
University of Maryland, College Park, USA
Emission Patterns of Solar Type III Radio Bursts: Stereoscopic Observations

01 November 2011
Gaspar Bakos
Princeton University, USA
Searching for planets with HATNet and HATSouth

10 October 2011
N. Kameswara Rao
Indian Institute of Astrophysics, Bangalore
Megalithic stone alignments: A fast disappearing astronomical heritage

12 September 2011
Varun Bhalerao
Caltech, USA
NuSTAR: Unveiling the Hard X-ray Universe

26 August 2011
Sujit Sarkar
Poornaprajna Instit. Scientific Res., Bangalore
Perfect Entanglement Transport in Quantum Spin Chain Systems

25 August 2011
Arunima Banerjee
Indian Institute of Science, Bangalore
Vertical Structure of Disk Galaxies and their Dark Matter Halos

24 August 2011
Sridharan Rengaswamy
European Southern Observatory, Chile
The Very Large Telescope Interferometer

18 August 2011
Rumpa Choudhury
Indian Institute of Astrophysics, Bangalore
Studies of Young Stellar Objects and Their Evironment

17 August 2011
L. N. Hazra
Department of Applied Optics and Photonics, University of Calcutta, Calcutta
Optical system design: A prophylactic strategy for global synthesis

02 August 2011
Suchetana Chatterjee
Yale University, USA
Cosmological evolution of supermassive black holes

01 August 2011
Meridith Rawls
New Mexico State University, USA
Light Curve Solutions of Eclipsing Binaries in the Large Magellanic Cloud

01 August 2011
Brandon Patel
Rutgers University, USA
SN2010a: is it a Peculiar Type-Ia Supernova ?

01 August 2011
Ritaban Chatterjee
Yale University, USA
The AGN/X-Ray binary connection

21 July 2011
Durgesh Tripathi
IUCAA, Pune
Heating of solar active regions

14 July 2011
Aruna Goswami
Indian Institute of Astrophysics, Bangalore
HE 1015-2050: Discovery of a hydrogen-deficient carbon star at high Galactic latitude

11 July 2011
Kinsuk Acharyya
S. N. Bose National Centre for Basic Sciences, Kolkata, India
How Molecules form in the Star Forming Regions ?

07 July 2011
M. Shiva Kumar
Universit Pierre et Marie Curie, Paris
A study of magnetic helicity in forced and decaying 3D-MHD turbulence

06 July 2011
Kanak Saha

Humboldt fellow, MPE, Garching, Germany
Dynamical evolution of a low mass classical bulge in barred galaxies

23 June 2011
L. S. Anusha
Indian Institute of Astrophysics, Bangalore
Polarized line formation in multi-dimensional media with partial frequency redistribution

22 June 2011
N. M. Ashok
PRL, Ahmedabad, India
Infrared studies of recent outbursts of recurrent novae

20 June 2011
Jens Kauffmann
Jet Propulsion Laboratory, Los Angeles, CA
How the structure of Dense Cores and Molecular Clouds influences the Formation of Stars

17 June 2011
Meredith Rawls
New Mexico State Univ., New Mexico, USA
Refined neutron star mass determinations for six eclipsing X-ray pulsar binaries

17 June 2011
Brandon Patel
Rutgers University, USA
Analysis of a state changing supersoft X-ray source in the Andromeda Galaxy (M31)

14 June 2011
H. D. Supriya
Indian Institute of Astrophysics, Bangalore
Study of novae rate in Local Group Galaxies

14 June 2011
K. Sowmya
Indian Institute of Astrophysics, Bangalore
The planetary nebula associated with the classical nova V458 Vul

14 June 2011
C. R. Sangeetha
Indian Institute of Astrophysics, Bangalore
Development of atmospheric turbulence simulator

06 May 2011
V. Ramesh Kumar
Inst. of Physics, Chinese Acad. of Sciences, Beijing
Soliton and its dynamics in Bose-Einstein condensates

04 May 2011
Sanhita Joshi
NCRA, Pune, India
The first polarization maps with the GMRT

28 April 2011
A. B. Sudhakara Reddy
Indian Institute of Astrophysics, Bangalore
Observational aspects of Galaxy formation theory

11 April 2011
Ananda Hota
Institute of Astronomy & Astrophysics, Taiwan
Panchromatic snapshots of Galaxy evolution: infall, merger and feedback processes

28 March 2011
R. Phani Murali Krishna
Indian Institute of Tropical Meteorology, Pune,
High Performance Computing (HPC) and its applications in atmospheric sciences and physics

28 March 2011
Priyam Das
IISER, Kolkata
Investigation of various nonlinear excitations of Bose-Einstein condensates

18 March 2011
John Hutchings
Herzberg Institute of Astrophysics, Victoria, Canada
Isolating QSO types with the combined GALEX-SDSS database

16 March 2011
John Hutchings
Herzberg Institute of Astrophysics, Victoria, Canada
An overview of plans to upgrade the CFHT to 10m

08 March 2011
Rajesh Gopal
Bose Institute, Kolkata
Magnetic field effects in galaxy clusters

Chapter 5

Outreach Activities

5.1 Resource Material for Daytime Astronomy

A two-day brain storming workshop on resource material for day-time astronomy was jointly organized by Vigyan Prasar and Indian Institute of Astrophysics at Bangalore from 18-19 November 2011. One of the main objectives of the workshop was to bring together several groups, organisations and renowned individuals who work at forefront of science popularization and education programmes in the country. Over the years these individuals and organizations have developed innovative teaching aids and activities for communicating astronomy to school children and general public. Opinions and ideas were sought to develop innovative resource material for daytime astronomy.

V. S. S. Shastri, a renowned science educator from Kolar explaining the distinct instruments used for astronomical measurements in Jantar Mantar through paper models.

Astronomy is a powerful tool to fascinate and engage the imaginations of young minds. Scientific concepts and ideas in astronomy are communicated through innovative models, role plays, hands-on activities, popular lectures and interactive sky watch programmes. While the night sky has its own charm, the daytime astronomy is particularly useful for serving many pedagogical and social purposes. The obvious advantages being the leisurely access of the sun to everyone and at all places. Many activities can be easily planned and carried out during the school hours. That way astronomy learning can be an integral part of regular school curriculum. For various reasons, parents in India, do not quite encourage children, especially girls, to participate, e.g. in a public outreach or a sky-watch programmes organized at night. The daytime astronomy is an effective way to compensate those limitations by facilitating the direct involvement and participation of girls and the underprivileged students. Also several simple, no/low-cost experiments can be performed with self-constructed equipments to teach non-trivial concepts in physics and mathematics. No sophisticated equipment is really needed and children can begin performing experiments with the sun in early primary school.

Paper models exhibited by a school teacher during the workshop.

About 60 people from different parts of the country participated in the workshop. There were as many as 20 presentations by different speakers cov-

ering well over 100 different activities and teaching aids for daytime astronomy. A diverse range of topics such as Low-cost Heliostat for Observations of Transit of Venus, Astronomy through Role Models, Solar Analemma, Experiments with Selfconstructed Equipment, Safe Projection Techniques for the Sun, Astronomy through Vigyan Sabha, Sun-related Quantitative Observations with Simple Equipment, Scientific Experiments during TOV-2012, Venus Transit 2012: Plans for Masses and Students etc. were covered in detail. After each presentation, the suitability of the material was evaluated by audience. It was proposed to develop and mass-produce a set of simple and low-cost activities for children to study the Sun, which would serve as vehicles for learning science by doing and discovering. These recommendations were made based on the written feedback on various talks, discussions, comments and many live demos conducted during the workshop. Discussions were also focused on the observations and mass participation of the upcoming Venus transit in June 2012 which is going to be the last transit of Venus for this century. The ultimate goal is to build the same level public awareness and excitement that was seen during various solar eclipses in last decade and also during the celebration of International Year of Astronomy 2009. In order to maximise the reach of these materials and foster effective long term collaborations, participants also agreed to share resources and ideas without any copyrights or proprietary claim.

(Ravinder K. Banyal, Prajval Shastri and S. Chatterjee)

5.2 National Science Day

National Science 2012 was celebrated at IIA on 28 February 2012. Altogether 124 students from six schools in Bangalore participated. The schools from KOramangala that participated were Baby Mona School, Chinmaya School, National Public School, Seema School and Govt. High School from Madivala and MSR Vidyaniketan from Mathikere. The programmes started with a drawing competition in the morning for the students. After the competition, the students were taken around the campus by student volunteers of IIA to locations where various experiments and displays were setup.

They were 1. Observing the sun with the 3 inch telescope. 2. Radio observations of the sun. 3. A Visit to the Photonics Laboratory. 4. Various Scientific experiments in Optics etc. 5. An exhibition of posters and models.

Sujan Sengupta delivering a popular lecture titled *Search for another Earth.*

After going around the above, the students assembled at the auditorium and a quiz competition was conducted in which the students participated enthusiastically.

Following the quiz competition, there was the prize distribution to the winners in the drawing and quiz competitions. First prize for the drawing competition was won by Sneha of 9th standard, Chinmaya School, Koramangala and the second prize was won by Sneha Majumdar of 8th standard, National Public School and third prize was won by Amar of 8th standard of Baby Mona School, Koramangala. Pavithra of 9th standard, MSR Vidyaniketan, Mathikere, Mahin Mundra of 8th standard, National Public School, Koramangala and Harish of 9th standard, Govt. School, Madivala won the consolation prizes. In the quiz competition, National Public School won the first prize and Chinmaya School won the runner up prize.

The forenoon programme ended with a talk titled 'History of Astronomy: A Glimpse', which was delivered by Gajendra Pandey.

The second part of the programme started at 4.30 pm with a play titled 'Heavens Abolished' presented by students of IIA. This is based on Bertolt Brechts play 'Galileo'.

This was followed by a popular lecture by Sujan Sengupta titled *Search for Another Earth*

Following the lecture, a skywatch programme was arranged at the roof top outreach telescope of the IIA in which a large number of public participated. The

The sky-watch programme at the IIA's roof top outreach telescope

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Sneha from Chinmaya School, Koramangala, Bangalore won the first prize for the drawing and painting competition

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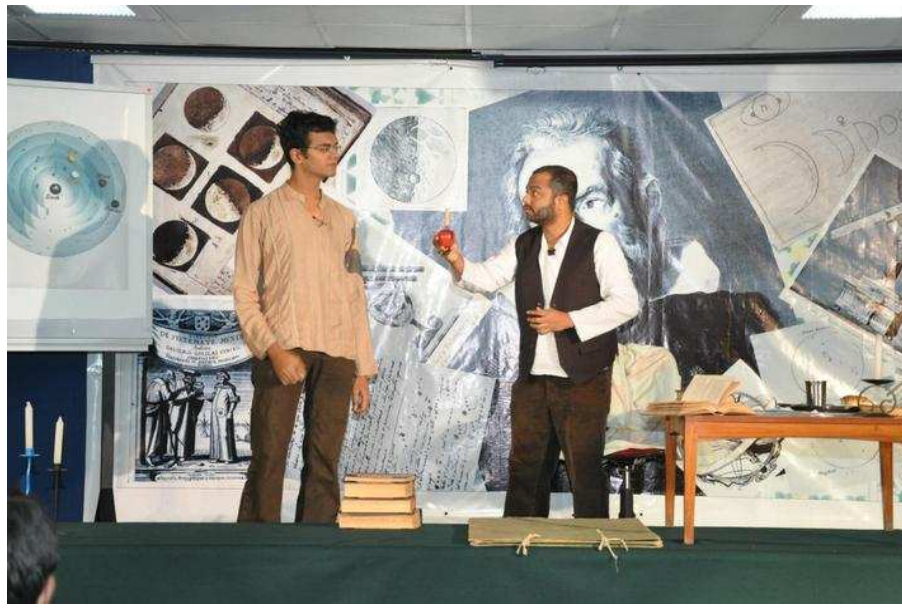

Scene from a play 'Heavens Abolished' staged by the IIA students on the National Science Day

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skywatch programme was co-ordinated by Padmakar Parihar and Kuppuswamy.

Students and staff of IIA volunteered and made the programme a grand success. They were also helped by the volunteers from the Bangalore Astronomical Society.

The volunteers from the IIA were: P. U. Kamath, S. S. Chandramouli, S. Amit Kumar, N. Satyabhama, P. K. Mahesh, C. Kathiravan, J. P. Lancelot, R. K. Banyal, P. M. M. Kemkar, Manoharan, T. K. Muralidas, Annapurni S., G. Pandey, S. Chatterjee, Sujan K. Sengupta, P. S. Parihar, K. Kuppuswamy, B. C. Bhatt, S. P. Bagare, Arya Dhar, Avijeet Prasad, Samyaday Choudhury, Srinivasa Prasanna, Mousumi Das, Avinash Surendran, Prashanth Mohan, Nesar Nayak, Shubham Srivastav, Vaidehi Sharan Paliya, Joby, P. K., Rathna Kumar, S., Supriya, H. D., Sowmya, K., Sangeetha, C. R, Ramya, P, Chandrasekhar, Indu, Sajal Kumar, A. G. Sreejith.

(P. K. Mahesh)

Scientific exhibitions organized

An exhibition on 'Areas of research activities at the Indian Institute of Astrophysics' was organized at the PG center of Physics, Baseveshwar Science College, Bagalkot, during 14 – 15 October, 2011, as part of the National UGC seminar on Astronomy and Astrophysics for college and university lecturers in Physics. Students from UG and PG Departments of Physics in the region, and the participants of the Seminar, visited the exhibition and interacted with the faculty members of IIA, S. P. Bagare, S. K. Saha, and B. C. Bhatt.

The exhibits and video presentations were organized by T. K. Murali. Local organization was extended by the members of Physics faculty, R. L. Deshpande and R. H. Fattepur. An Astrophysics quiz and a theme painting competition were held as part of the activities during the Seminar. Faculty members of IIA participated as judges.

(S. P. Bagare)

5.3 Popular Lectures, Radio Talks, Interviews & Films

S. P. Bagare:

- "Physics of the Sun and the Solar System",National Seminar on "Astronomy and Astrophysics", Mysore, November 3–5, 2011.

R. Banyal:

- "Large Optical Telescopes: Challenges & Opportunities", 15 June, 2011, IIA, Bangalore.
- "Optical Telescopes: Past, Present and Future,", 14 October, 2011, IIA, Bangalore.

Figure 5.1: (left) Students of PG Physics interacting with S. P. Bagare at the National UGC seminar (right) Students at the exhibition organized by IIA at Bagalkot

- "Scientific temper and critical thinking: Major challenges," 29 Decemebr, 2011, IIA, Bangalore.

S. Chatterjee:

- "Scientific temper, building newer platforms": NISCAIR - Vigyan Prasar's National workshop on 'Revisiting Scientific Temper-Science and Nation Building: revisiting the Nehruvian agenda', Palampur, 15 – 17 June, 2011.
- "P.C.Ray, the chemist and catalyst for social action"- DST workshop on 'Multidisciplinary Perspectives on Science, Technology, Society.' NIAS, Bangalore, 15 August, 2011.
- "Akshayananda Bose: A Centenary Tribute: from Romance with Magnetism to Cryogenic brass- tacks". - Asiatic Society , Kolkata, 22 September, 2011.
- "On Education: Quality and Affordability"- Malleswaram Ladies Association, Girl's High School, 23 December, 2011.
- "Scientific temper, building newer platforms"- 'International Conf. Science Communication for Scientific Temper', NISCAIR and Vigyan Prasar, New Delhi, 10 -12 January, 2012.
- "Universalizing the Universe for universalizing quality education"- National Workshop on 'Daytime Astronomy in Preparation for the Transit of Venus', Mumbai, 1 - 2 March, 2012.
- "Discovery of Helium, Astronomy's Gift to Chemistry", Bangalore Science Forum, National College, Bangalore, 25 May, 2011.
- Contributed as technical expert and adviser for the Vigyan Prasar's production of the films: "The Darwin Puzzle", "The Life and Times of P.C. Ray", "Life and science of J.C. Bose" "Life and Science of K. S. Krishnan" and "S. Chandrasekhar"; Bhrath Gyan Vigyan Samithi, Karnataka, Nav Nirmeeti and Vigyan Prasar's film on Day time astronomy, "Sooraj Zammen Par".

P. K. Mahesh:

- "Telescopes", in Kannada, Sriram Vidya Kendra Kalladka,18 January, 2012, sponsored by the DST and Government of Karnataka and coordinated by the Karnataka Rajya Vijnana Parishat.

B. Ravindra and K. B. Ramesh:

- TV-9 arranged an interview and discussions with B. Ravindra and K. B. Ramesh on the "Lunar Eclipse", June 15, 2011.

M. Sampoorna:

- Interviewed by Geeta Rao, the Head of "The Education Times", Bangalore, regarding the "Nobel Laureates meeting with students" held annually at Lindau, Germany, organized by Lindau Foundation, DFG, Germany and DST, India. The interview appeared in "The Education Times", Bangalore Edition, on February 6, 2012.

A. Subramaniam:

- Inaugural talk for the annual day of the school "Nucleus", Ottapalam, Kerala, 10 December 2011.
- Science day lecture at the Christ University, September 2011.

K. Sundara Raman:

- "Application of Electronics and Electrical Engineering in the field of Astrophysics", Sastra University, Thanjavur, August 8, 2011.
- "Space Weather - Sun Earth Connections", Regional Meteorological Centre, Chennai, October 11, 2011.
- "Role of Engineers in Astronomy and Astrophysics", Mahendra Engineering College, Mallasamudram, Salem.

5.4 Popular Books & Articles

R. Banyal:

- "Myths, Superstitions and Propaganda in Scientific Age", International Conference on Science Communication for Scientific Temper, p. 325-333, NISCAIR, New Delhi, 10-12 January, 2012.

D. C. V. Mallik & S. Chatterjee:

- "Kariamanikkam Srinivasa Krishnan: his Life and Work", Orient Blackswan, 2011

B. Ravindra:

- "Exploring Our Nearest Star: The Sun", appeared in "Signatures", Newsletter, Indian Society of Remote Sensing, Ahmedabad, November–Decmber, 2011, Vol. 23, No. 4.

K. Sundara Raman:

- "Sun – Our Fascinating Star", Science Park, 2011, Vol.6, Issue 1, pp. 14–20.

Chapter 6

Miscellaneous Activities by IIA Staff

6.1 Invited & Contributed Talks

S. Anathpindika:

- "A Brief Review of Recent Developments in Indian Astronomy" at meeting on 'National Astronomy Meeting', April 2011, RAS, London.
- "The Contagion of Star-Formation" at the meeting on 'Recent Advances in Star Formation', IIA, Bangalore, June 2011.
- "Towards Understanding the Formation of Stars: An Application of Numerical Hydrodynamics", October 2011, TIFR, Mumbai.

G. C. Anupama:

- "Recurrent Novae: What do we know about them ?" at the IAU Symposium 281 'Binary Paths to Type Ia Supernovae', 11–15 July, 2011, Padova, Italy.
- "Classification of Nova Spectra" at the 'International Workshop on Stellar Spectral Libraries', 5–9 December, 2011, New Delhi.

R. Banyal:

- "Development of Lunar Scintillometer for Probing the Ground Layer Turbulence", at 'Indo-US meeting on Adaptive optics with Moderate-Sized Telescopes' 22–25 August, 2011, IUCAA, Pune.
- "Myths, Superstitions and Propaganda in Scientific Age", at the 'Intl Conference on Science Communication for Scientific Temper', NISCAIR, New Delhi, 10–12 January, 2012.

P. Chingangbam:

- "Cosmology and non-Gaussianity" at the workshop on 'High Energy Physics Phenomenology', Mahabaleshwar, 2–7 January, 2012.
- "Residual foreground contamination and non-Gaussianity in the CMB." Workshop on 'Astro-Cosmo @ Trivandrum', IISER, Trivandrum, 18 November, 2011.
- "Betti numbers as new probe of non-Gaussianity in the CMB" Indo-UK meeting: 'Confronting particle-cosmology with Planck and LHC', at IUCAA, Pune, 10–12 August, 2011.
- "Topological probes of non-Gaussianity in the CMB" 'Cosmic web morphology and topology', held at Nicolaus Copernicus Astrophysical Center, Warsaw, Poland, 12–17 July, 2011.
- Gave contributed talks at Intl Conf. on 'Gravity and Cosmology', Goa, 15–19 December, 2011, titled "Residual foreground contamination in the WMAP data"; "Geometric and topological properties of the CMB", Centre for High Energy Physics, IISc, Bangalore, 22 September, 2011.

B. P. Das:

- "Quantum Phase Transitions in Ultracold Atoms". International Conf. on 'Recent Adavances in Many Electron Theory', Puri, 3 December, 2011.
- "The Role of Relativistic Many-Body Theory in the Determination of the Electric Dipole Moment of the Electron" Asia Pacific Conference on Theoretical and Computational Chemistry, Rotorua, New Zealand, 11 December, 2011.
- "Electric Dipole Moment of the Electron as a Probe of the Standard Model" held at 'National Conference on the Advances in Physics', IIT Roorkee, 29 February, 2012.

M. Das:

- "Star Formation in Bulgeless Late Type Spiral Galaxies" at the meeting on 'Recent Advances in Star Formation', IIA, Bangalore, 28 June–1 July, 2011.
- "AGN Activity and Black Hole Masses in Low Luminosity Galaxies", at 'Mini Workshop on Cosmology and Galaxies', IIA. 28 November, 2011.
- "Nuclear Activity in Low Luminosity Galaxies", 21 October 2011,Tshichu University, Taiwan and 1 November, 2011, National Central University ; "Bulge-Disk Evolution in Interacting Bulgeless Galaxies", at Conference on 'Galaxy Mergers in an Evolving Universe' (Hualien, Taiwan), 25 October.

S. Girdhar:

- "Yellow Supergiants; Probes of Galactic Evolution" at the meeting on 'Recent Advances in Star Formation', IIA, Bangalore, 28 June–1 July, 2011.

A. Goswami:

- "HE 1015-2050: Discovery of a Hydrogen-Deficient Carbon Star at High Galactic latitude" IIA, Bangalore, 14 July, 2011. Talk given on receiving 'The Outstanding Research Paper award for the year 2010'
- "CEMP Stars and the Galactic Chemical Evolution" Dept of Physics, Gauhati University, August 10–11, 2011.
- "Spectroscopic Charaterization of FHLC Stars and a Newly Found HdC star". International workshop on Stellar Spectral libraries, Delhi University, 5–9 December, 2011.
- "Circumstellar Envelopes of Late-type stars" "Dust in Astrophysics – 2012", Physics Dept, Assam University, 31 January–2 February, 2012.
- "Studies on Carbon-Enhanced Metal-Poor stars and Galactic chemical Evolution". Scientific Advisory Committee Meeting, IIA, Bangalore, 5–9 March, 2012.

S. S. Hasan:

- "Solar Research in India", Invited talk at the 5th Central European Solar Physics Meeting, Bad Gleichenberg, Austria, October 8–11, 2011.

K. M. Hiremath:

- "Seismology of the Sun : Inference of Thermal, Dynamic and Magnetic Field Structures of the Interior", 14–16 December, 2011, New Delhi, 3rd International Conference on 'Current Developments in Atomic, Molecular, Optical and Nano Physics with Applications'.
- "Eternal Fire in the Sky: Observations and Inferences since Galileo", 'One Day seminar on Astrophysics', 21 October, 2011, Rajarajeswari College of Engineering, Bangalore.

J. Jose:

- "Young Stellar Population in the Star Forming Complex Sh2-252" at the meeting on 'Recent Advances in Star Formation', IIA, 28 June–1 July, 2011.

A. Mangalam:

- "Supermassive Black Holes", 4 November 2011 and "Magnetic Universe", 6 November 2011, at the KSTA sponsored conference on 'Astronomy & Astrophysics', Mysore University, Mysore.

P. Mohan:

- "Short Timescale Variability in Active Galactic Nuclei", 13 September, 2011 at NAO, China.

K. N. Nagendra:

- "Spectroscopy as a Window to the Universe", Univ. Mysore, Mysore, 26–30 December, 2011.

G. Pandey:

- "Imaging Polarimeter on 1.3 m Telescope" at the Workshop on 'Recent Advances in Star Formation', 28 June–1 July 2011.
- "Surface Composition of H-Deficient Stars–Clues to their Origins", August 10–12, 2011, meeting on 'Commemorating 25 years of Vainu Bappu Telescope', Bangalore, August 10–12, 2011.

T.P. Prabhu:

- "Astronomy from High Altitudes", 27 April 2011, MIT, Manipal, 'Symposium on Space Astronomy'.
- "The World of Galaxies", 28 April 2011, MIT, Manipal, 'Symposium on Space Astronomy'.

- "The World of Galaxies", 25 May 2011, JN Planetarium, Bangalore.
- "Indian Astronomical Observatory", Hanle, 7 June 2011, Saha Institute of Nuclear Physics, Kolkata.
- "Extragalactic Star Formation Rate: Estimates at different wavelengths", 30 June 2011, Workshop on 'Star Formation', IIA, Bangalore.
- "Scientific Studies at High Altitudes in Ladakh", 16 September 2011, CMMACS, Bangalore, Workshop on Exploring New Ideas in Science.
- "Observational Facilities in India", 5 November 2011, MP Birla Institute of Fundamental Research, Bangalore.
- "Science with Himalayan Chandra Telescope", 7 November 2011, SN Bose National Centre for Basic Sciences, Kolkata, First Kolkata Workshop on 'Role of Small Telescopes in Astronomical Research'.

S. P. Rajaguru:

- "How to Probe the Solar Tachocline ? Helioseismic Wave path Geometries and Sensitivities" at the L5 and NGHI2 meeting, NM, USA, 21–22 April, 2011.

K. E. Rangarajan:

- "Chromospheric Observations with NLST", meeting on 'Science with Planned and Upcoming Solar Facilities in the Country', IIA, 2–3 Nov., 2011.

B. Ravindra:

- "Solar Atmospheric Studies using Narrow Band Imager", 2–3 November, 2011 at meeting on 'Upcoming Solar Facilities in the Country', IIA, Bangalore.

B. E. Reddy:

- "Overview of India's Participation in the TMT project: a Few Relevances to Star Formation", given at 'Recent Advances in Star Formation: Observations and Theory', 28 June–01 July, 2011, Bangalore.
- "Galactic Disk Population Studies with ELTs" 29 August, 2011, Ischia, Naples, Italy.
- "Li in K Giants: Recent Observational Results" 5 September, 2011, Observatoire de Paris, Paris.
- "India's Participation in the TMT project" given at 'Mega-Projects in Astronomy – A review', 21 November, 2011, New Delhi.

S. K. Saha:

- "Aperture Synthesis", Dept of Applied Optics & Photonics, Calcutta University, 8 July, 2011.
- "High resolution imaging by means of Speckle interferometry at IIA" meeting on 'Commemorating 25 years of Vainu Bappu Telescope', Bangalore, August 10–12, 2011.
- "Interferometry at Optical Wavebands" at Indo-US meeting on 'Adaptive optics with moderate-sized Telescopes' 22 August, 2011, IUCAA, Pune.
- "Technological Evolution of Observational Astronomy" at UGC sponsored seminar on 'Astrophysics' at Basaveshwar Science College, Bagalkot, 15 October, 2011.
- "Evolution of Observational Astronomy in India", at the East Calcutta Girls School, on 30 November, 2011.
- "Hypertelescope Approach: A Novel Method for Imaging of Stellar Objects", at the Conf. on 'Frontiers on Optics' held at IIT-D, during 3–5 December, 2011.
- "Aperture Synthesis at Optical Wavelengths", at 'International Conf. on Trends in Optics & Photonics (ICONTOP)', Kolkata, during 7–9 December, 2011.
- 'Lasers in Astronomy' at the DST-SERC School on 'Laser and its Application', University of Calcutta, Kolkata on 6 January, 2012.
- "Image Retrieval of Turbulence affected Stellar Objects and its Interface with Medical Image Analysis", 26 March, 2012, IIT, Kharagpur.

M. Sampoorna:

- "Vector magnetic field diagnostics using Hanle effect", at 'Meeting on Science with Planned and Upcoming Solar Facilities in the Country', IIA, Bangalore, 2–3 November, 2011.

S. Sengupta:

- "Scattering Polarization of Extra-solar Planets", International Conference on 'Astronomy and Cosmology', Tribhuvan University, Kathmandu, Nepal, 21 March, 2011.

T. Sivarani:

- "Near field Cosmology", S. N. Bose centre, Kolkata, at meeting on 'Role of Small Telescopes in Modern Astronomy Research', November 7–8, 2011.

C. Stalin:

- "Stellar Physics and Galactic and Extragalactic Astronomy" seminar on 'Some Aspects of Physics and Astrophysics', Mysore University, Mysore, 3-5 November 2011.
- "Compact Objects" at Calicut University, Calicut, as part of the "National Seminar on Astrophysics", 13–14 March, 2012

A. Subramaniam:

- "Structure of the Small Magellanic" Physics Department, University of Heidelberg, Germany
- "Upcoming Indian facility: UVIT on ASTROSAT" conference on "Recent advances in star formation", held at IIA, 28 June–01 July, 2011
- "Understanding the convective core of Intermediate stars", Silver Jubilee meeting of the VBT, 10–12 August, 2012, at IIA
- "Probing the geography, history and chemistry of nearby Galaxies with Future Telescopes" DST-JSPS and CPS school in Japan, 24 September–01 October, 2011
- "Structure and evolution of the Magellanic CLouds" Colloquium at the Physics Department, University of Tasmania, 30 October 2011
- "Classical Be stars in the our Galaxy and in the Magellanic Clouds" 'Stellar spectral libraries', 5–9 December 2011, Delhi
- "UVIT on ASTROSAT" 9 January, 2012, IIST, Trivandrum
- "Evolution of circumstellar disk of pre-main sequence stars" conference on "Dust in Astrophysics", 31 January – 02 February, 2012, Silchar, Assam

K. Sundara Raman:

- "Space Weather– Sun Earth Relations" at the 'Intl Conf.on Astrophysics and Cosmology' 13 March, Tribhuvan University, Nepal.

6.2 Lectures, Colloquia etc.

S. Chatterjee:

- "X-ray Attenuation Coefficient of Mixtures: inputs for Dual Energy Computed Tomography" given at the 'Supercomputer Education and Research Centre', IISc, on 27 December, 2011.
- "Dust in Astrophysics: growth Process, Complexity Immersed in Diversity." 'National Seminar on Dust in Astrophysics', Assam University , Silchar, January 31–February 2, 2012.
- "Dust in Astrophysics: growth Process, Complexity Immersed in Diversity". at the IUCAA - Cochin University of Science and Technology joint workshop on 'Astronomy and Astrophysics', Catholicate College, Patanamthitta, Kerala on 23 February, 2012.

B. P. Das:

- "The Role of Many-Body Theory in Probing the Standard Model of Particle Physics", Institute of Physics, Bhubaneswar, 12 June, 2012.
- "Theory of the Electric Dipole Moments of Atoms", KVI, Groningen, Netherlands, 2 October, 2011.
- "Quantum Phases of Ultracold Atoms in an Optical Superlattice", Institute for Theoretical Physics, University of Utrecht, Netherlands, 5 October, 2011.
- "The Electric Dipole Moment of the Electron", University of Canterbury, Christchurch, New Zealand, 16 December, 2011.
- "Quantum Phase Transitions of Ultracold Bosonic Atoms in an Optical Superlattice", University of Cambridge, Cambridge, UK, 26 March, 2012.

M. Das:

- "Nuclear activity in Low Luminosity Galaxies", IISc, Bangalore, September, 2011.

S. S. Hasan:

- "India's National Large Solar Telescope", Distinguished Lecture delivered at the 8th Annual AOGS Meeting, Tapei, Taiwan, August 8–12, 2011

- "National Large Solar Telescope", Colloquium in the Workshop 'Physics of the Solar Transition Region and Corona', IUCAA, Pune, September 5–7, 2011

- "National Large Solar Telescope of India", 2nd ATST - EAST Workshop in Solar Physics on *Magnetic Fields fro the Photosphere to the Corona*, November 9–11, 2011, Washington DC, U.S.A.

- "New Astronomy Facilities in India", Inaugural Address at the 2nd International Conference on *Trends in Optics & Photonics*, Kolkata, December 7, 2011

- "Opportnities and Challenges for Astronomy Research in India", Keynote address at the Centenary Meeting of the Physics Dept., Aligarh Muslim University, March 21, 2012

A. K. Pati:

- "UV Imaging Telescope on ASTROSAT", Dept. of Physics and Astronomy, Texas A & M university, 7 June, 2011.

- "Exploring the Universe" and "Telescopes and instruments", KIIT university, Bhubaneswar, 20 August, 2011.

S. Sengupta:

- "Cloudy atmosphere of brown dwarfs : Theory vs. Observation", Institute of Astronomy & Astrophysics, Academia Sinica, Taiwan, 20 May, 2011.

- "Worlds outside our own world - In search of another earth", Institute of Astronomy & Astrophysics, Academia Sinica, Taiwan, 13 June, 2011.

- "Physics and Astrophysics of Substellar Mass Object", IISc, Bangalore, 26 July, 2011.

A. Subramaniam:

- "Understanding our neighbours: the Magellanic Clouds", 20 Sept. 2011, IISc., Bangalore.

6.3 National/Intl meetings attended

"Recent Advances in Star-formation", IIA, Bangalore, 28 June–1 July, 2011 was attended by S. Anathpindika, G. C. Anupama, M. Das, A. Goswami, S. Giridhar, J. Jose, G. Pandey, T. P. Prabhu, B. E. Reddy, S. Subramanian, A. Subramaniam.

"Commemorating 25 years of Vainu Bappu Telescope", IIA, Bangalore, 10–12 August, 2011, was attended by K. N. Nagendra, G. Pandey, A. B. S. Reddy, S. K. Saha, A. Subramaniam.

"Meeting on Science with Planned and Upcoming Solar" Facilities in the Country", IIA, Bangalore, 2–3 November, 2011 was attended by S. P. Bagare, K. N. Nagendra, M. Sampoorna.

XXIII Canary Islands Winter School of Astrophysics on "Secular Evolution of Galaxies", Puerto de La Cruz, Tenerife, Spain during 14–25 November, 2011 was attended by G. Indu and S. Subramanian.

International Workshop on "Stellar Spectral Libraries", 5–9 December, 2011 was attended by G. C. Anupama, A. Goswami, S. Giridhar, A. Subramaniam.

National meeting on "Dust in Astrophysics", 31 January–02 February 2012 was attended by A. Goswami, A. subramaniam.

S. Anathpindika:

- "National Astronomy Meeting", Royal Astronomical Society, London, April 2011.

- "Far Infrared Astronomy", Royal Astronomical Society, London, September 2011.

G. C. Anupama:

- IAU Symposium 281 "Binary Paths to Type Ia Supernovae", 2011 July 4-8, Padova, Italy.

- Asiago Meeting on "Symbiotics Stars", 2011 July 10-11, Asiago, Italy.

P. Chingangbam:

- "High Energy Physics Phenomenology", Mahabaleshwar, 2-7 January, 2012.

- International Workshop on "Dark Energy", 21–23 December, 2011, Centre for Theoretical Physics, Jamia Millia Islamia, Delhi.

- International Conference on "Gravity and Cosmology", Goa, 15–19 December, 2011.
- Workshop on "Astro-Cosmo" at Trivandrum, IISER Trivandrum, 18 November, 2011.
- "Cosmic Web Morphology and Topology", Nicolaus Copernicus Astrophysical Center, Warsaw, Poland, 12–17 July, 2011.
- Indo-UK meeting on "Confronting Particle-Cosmology with PLANCK and LHC", at IUCAA, Pune, 10–12 August, 2011.

M. Das:

- "Galaxy Mergers in an Evolving Universe", Hualien, Taiwan, 25–29 October, 2012.
- "Indian Science Congress", Bhubaneswar, 3-7 January, 2012.
- "Mini Workshop on Cosmology and Galaxies", IIA, 28 November, 2011.
- "Mini-symposium on "Dark Matter and Neutrinos" at CHEP, IISc. Bangalore, 16–17 August, 2011.

A. Goswami:

- "The 3rd Subaru international conf.," and "1st NAOJ Symposium on Galactic archaeology: Near field cosmology and the formation of the Milky Way", 1–4 November 2011, Shuzenji, Japan.
- "Science and Technology for Inclusive Innovation-Role of Women" '99th Indian Science Congress,& 1st women Science Congress', 3–7 January, 2012, Bhubaneswar.

S. S. Hasan:

- "Seismology of the Earth and Stars", Princeton Center for Theoretical Sciences; Princeton University, NJ, USA, May 4 – 6, 2011.
- "8th Annual Meeting of the AOGS", Taipei, Taiwan, August 7 – 9, 2011
- "5th Central European Solar Physics Meeting", Bad Gleichenberg, Austria, October 8 – 11, 2011.
- "2nd ATST - EAST Workshop in Solar Physics on Magnetic Fields from the Photosphere to the Corona", Washington DC, U.S.A., November 9 – 11, 2011.
- "Mega-projects in Astronomy", DST, New Delhi, November 21, 2011.
- "Looking Within: Interdisciplinary Approaches to Consciousness", NIAS, Bangalore, January 5 – 7, 2012.

K. M. Hiremath:

- "3rd Intl Conf. on Current Developments in Atomic, Molecular, Optical and Nano Physics with Applications", 14–16 December, 2011, New Delhi.
- "InIl Conf. on Futuristic Science and Technology in Frontier areas and Annual Conf. Indian JSPS Alumni Association", 5–6 August, 2011, Thiruvananthapuram, Kerala.

J. Javaraiah:

- "Solar Dynamics and Magnetism from the Interior to the Atmosphere", October 31–November 4, 2011, Bechtel Conference Center, Stanford University, Stanford, CA, USA.

R. Kariyappa:

- "International workshop on Smallscale Solar Magnetic Fields", Bad Gleichenberg, Austria, 28–29 April, 2011.
- "Hinode 5 Science Meeting", Boston, USA, 10–15 October, 2011.

S. Krishnaprasad:

- "Workshop on Physics of the Transition Region and Corona", IUCAA, Pune, during 5–7 September, 2011.
- " Heliophysics Summer School", Boulder, Colorado, 27 July–3 August, 2011.
- "Fifth Coronal Loops Workshop", Palma de Mallorca, Spain, 29 June–2 July, 2011.

P. Mohan:

- "Beijing International Summer School: The Physics and Evolution of AGNs", 3–9 September, 2011, Beijing, China.

C. Muthumariappan:

- IAU Symposium 283, "Planetary Nebulae: An Eye to the future", IAC, Tenerife, Spain, 25–29 July, 2011.

T. P. Prabhu:

- "Symposium on Space Astronomy", 27–28 April, 2011, Manipal Institute of Technology, Manipal, Chief Guest
- "First Kolkata Workshop on Role of Small Telescopes in Astronomical Research", 7–8 November, 2011, SN Bose National Centre for Basic Sciences, Kolkata

S. P. Rajaguru:

- "L5 Mission Consortium (of NASA) and NGHI2 meeting" Sunspot, NM, 21–22 April 2011.
- "LWS/SDO Science Workshop" during 1–6 May, 2011, Lake Tahoe, CA, Stanford University, Stanford CA, USA.
- "LWS/SDO-3/SOHO-26/GONG-2011 Workshop' during 26 October–3 November 2011, Stanford University, Stanford CA, USA.

B. E. Reddy:

- "Feeding the Giants: ELTS in the era of Surveys", 28 August–02 September, 2011, Ischia, Naples, Italy

S. K. Saha:

- Indo-US meeting on "Adaptive Optics with Moderate-Sized Telescopes" during 22-24 August, 2011, at IUCAA, Pune.
- Conf. on "Frontiers on Optics held at IIT-D", during 3–5 December, 2011 and also, Chaired a scientific session at the same Symposium on December 3, 2011.
- "International Conference on Trends in Optics & Photonics (ICONTOP)", Kolkata, during 7–9 December, 2011.

A. Subramaniam:

- DST-JSPS and CPS school on "Planetary Sciences", as resource person, Japan, 24 September – 01 October, 2011
- ASTROSAT capacity building worshop, 9 January 2012, IIST, Trivandrum

Individual Collaborations

S. Anathpindika:

- James Di Francesco, National Research Council, Herzberg Institute of Astrophysics, Canada
  Topic: "The formation and evolution of prestellar core"
- Jonathan Rawlings, University College London, UK Topic: "A study of the chemical evolution of prestellar cores"
- Centre for Development of Advanced computing, C-DAC, Bangalore
  Topic : "High performance computing"

L. S. Anusha:

- J. O. Stenflo, ETH, Zurich, Switzerland; M. Bianda, IRSOL, Locarno, Switzerland; R. Ramelli, IRSOL, Locarno, Switzerland
  Topic: "Modeling the observations of the second solar spectrum"
- S. K. Solanki, MPS, Katlenburg-Lindau, Germany; A. Feller, MPS, Katlenburg-Lindau, Germany; J. Hirzberger, MPS, Katlenburg-Lindau, Germany
  Topic: "Statistical properties and evolution of the small scale magnetic structures using SUNRISE data"

P. Chingangbam:

- Changbom Park, Korea Institute for Advanced Study, Seoul, South Korea; Rien van de Weygaert, Kapteyn Institute, University of Groningen, Groningen, Netherlands; K. P. Yogendran, IISER, Mohali, Punjab
  Topic: "Statistical properties of the CMB"
- Tabish Qureshi, Centre for Theoretical Physics, Jamia Millia Islamia, New Delhi
  Topic: "Quantum entanglement"

M. Das:

- P. Majumdar and P. Bhattacharjee, SINP, Kolkata; C. Sengupta, CSIC, Spain; K. Misra, STScI, USA; S. Ramya, IAP, Paris S. Mathur, Ohio State University, USA; N. Kantharia, NCRA, Poona; A. Mishra, Univ. Gorakhpur, Gorakhpur; D. Iono, NRO, Nobeyama; I-Chenn Chen and Chorng-Yuan Hwang, National Central University, Taiwan; R. Harsha, RRI, Bangalore
  Topic : "Dark Matter"

R. T. Gangadhara:

- Collaborating with Gupta Y., (NCRA, Pune) and Han J. L. (National Astronomical Observatories, China)
  Topic : "Radio Pulsar"

K. M. Hiremath:

- J. B. Gurman, NASA Goddard Space Flight Center, Greenbelt, MD, USA
  Topic : "Dynamic and Thermal Properties of the Solar Coronal Holes"
- W. Soon, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA
  Topic :"Indian Summer Monsoon Rainfall: Dancing With Tunes of the Sun"

J. Jose:

- J. Serena Kim (Steward Observatory, Arizona); William Sherry (NOAO, Arizona); Michale R Meyer (ETH, Zurich)
  Topic: Young stellar population and star formation in the W3/W4 star forming complex
- J. Serena Kim (Steward Observatory, Arizona); Manash R Samal (LAM, France); Arjan Bik (MPIA, Germany)
  Topic:Star formation within the dark filamentary structures of Sh2-252
- Anil K. Pandey (ARIES, Nainital); D. K. Ojha (TIFR, Mumbai); Neelam Chauhan (NCU, Taiwan); K. Ogura (Kiso, Japan)
  Topic: "Multi-Wavelength Studies on Galactic Star Forming Regions"

C. Muthumariappan:

- Sun Kwok (University of Hong Kong), K. Volk (Gemini Observatory (south))
  Topic: Mid-IR imaging of proto PNe
- Raghvendra Sahai (Jet Propulsion Laboratory)
  Topic: Optical spectroscopy of Proto PNe
- M. Parthasarathy (ARIES, NOAJ), B. E. Reddy (IIA)
  Topic: Radiative transfer modeling of dust in proto PNe

K. N. Nagendra:

- J. O. Stenflo, ETH Zentrum, Zurich, Switzerland.
  Topic: "The theory and application of partial frequency redistribution for a two-term atom"
- H. Frisch, Observatoire de la Cote d'Azur, France.
  Topic: "Modeling the forward Hanle scattering signatures in Ca I 4227 line"
- M. Bianda, IRSOL, Locarno, Switzerland.
  Topic: "Observations of the J-state interference signatures in the Second Solar Spectrum with ZIMPOL-III"
- R. Ramelli, IRSOL, Locarno, Switzerland.
  Topic: "Observations of the J-state interference signatures in the Second Solar Spectrum with ZIMPOL-III"
- R. Holzreuter, MPI fur Sonnensystemforschung, Germany.
  Topic: "Modeling the forward Hanle scattering signatures in Ca I 4227 line"

T. P. Prabhu:

- K. Krishnamoorthy, S. Suresh Babu, Mukunda M. Gogoi, Sreekanth V., D. P. Vajja, and P. P. Pramod, SPL, VSSC, Trivandrum; Tushar P. Prabhu, Bhuvan C. Bhatt, S. P. Bagare, N. Shantikumar Singh, and V. K. Gaur, IIA, Bangalore
  Topic: Aerosol Characterization and Assessment of the Radiative impacts from the High-altitude trans-Himalayan site in Hanle, Ladakh

S. P. Rajaguru:

- Oskar Steiner (Kiepenheuer Institut fur Sonnenphysik, Freiburg, Germany), and Vigeesh Gangadharan (IIA and New Mexico State University, Las Cruces, NM, USA)
  Topic: "Magneto-convective Simulations of small-scale magnetic fields in stellar atmospheres". S. Couvidat, J. Schou, Xudong Sun, K. Hayashi, and P.H. Scherrer, Solar Observatories Group, Stanford University, Stanford CA, USA, and Hannah Schunker, Max-Planck Institute for Solar System Research, Katlenburg-Lindau, Germany.
  Topic: "Local Helioseismology"

K. P. Raju:

- B. J. I. Bromage, Jeremiah Horrocks Institute, University of Central Lancashire, Preston, UK.
  Topic :The EUV network studies using SOHO data:

M. Sampoorna:

- H. Frisch, Observatoire de la Cote d'Azur, France.
  Topic: "Modeling the forward Hanle scattering signatures in Ca I 4227 line"
- J. O. Stenflo, ETH Zentrum, Zurich, Switzerland.
  Topic: "The theory and application of partial frequency redistribution for a two-term atom"
- M. Bianda, IRSOL, Locarno, Switzerland.
  Topic: "Observations of the linear polarization in Cr I triplet with ZIMPOL-III"
- R. Ramelli, IRSOL, Locarno, Switzerland.
  Topic: "Observations of the linear polarization in Cr I triplet with ZIMPOL-III"
- R. Holzreuter, MPI fur Sonnensystemforschung, Germany.
  Topic: "Modeling the forward Hanle scattering signatures in Ca I 4227 line"

T. Sivarani:

- SDSS-III MARVELS (Multi-object APO (Apache Point Observatory) Radial Velocity Exoplanet Large-area Survey) survey P.I Jian Ge - University of Florida
- Co-I on "A Survey for Unrecognized Carbon-Enhanced Metal-Poor Stars in the Galaxy - Gemini-NOAO" (P.I. T.C Beers)
- Co-I on "Survey of detecting metal poor Carbon enhanced stars - SOAR telescope" (P.I. Vinicius Placco)
- Co-I on "C,N,O in the early Galaxy - VLT Xshooter Copengagen GTO" (P. I. Brigitta Nordstrom)

C. S. Stalin:

- S. Jeyakumar, Departamento de Astronomia, Universidad de Guanajuato, Mexico
  Topic:
  "Reverberation mapping of AGN"
- R. Srianand, IUCAA, Pune, India and P. Petitjean, Institut d'astrophysique de Paris, Paris, France
  Topic: "Quasars in CFHTLS"
- F. Courbin and G. Meylan, Ecole Polytechnique Federale de Lausanne, Geneva, Switzerland
  Topic: "Monitoring of gravitationally lensed quasars"

A. Subramaniam:

- Indo- Australian AISTF project with Dr. Andrew Cole, University of Tasmania, Australia
- Ronald Mennickent, University of Concepcion, Chile.
  Topic: Be stars in the Magellanic Clouds
- B. Mathew, D. P. K. Banerjee, N. M. Ashok, PRL, Ahmedabad.
  Topic: "Classical Be stars in our Galaxy" Mathew B., Banerjee, D.P.K., Ashok, N.M., PRL, Ahmedabad

Externally Funded Projects

G. C. Anupama:

- "Properties of Supernovae in the Nearby Universe", (2010–2012) DST-JSPS funded under the India-Japan Cooperative Science Program.

L. S. Anusha:

- "Statistical Properties and Evolution of the Small Scale Magnetic Structures using SUNRISE Data",funded by MPS, Katlenburg-Lindau, Germany

R. K. Chaudhuri:

- Relativistic Study of the Excited/Ionized States of Heavy Atoms Using Coupled Cluster based Linear Response Theory [DST (SERC)].

S. Giridhar:

- PI of Indo-Mexico project on "Variability in the Atmospheres of the Sun and Stars. funded by DST.
- PI of the project on "Design and Fabrication of High resolution Spectrometer for 2m HCT at Hanle". Supported by DST, and is in collaboration with Industrial Research Laboratory, New Zealand.

A. Goswami:

- "Determination and Modelling of Chemical Compositions of Metal-Poor Stars and Observational Constraints for Galactic Chemical Evolution" sponsored by DST.

K. M. Hiremath:

- PI to the project titled "Possible Linkages between the Indian Summer Monsoon Rainfall and Solar Variability and, Genesis of Solar Cycle and Activity Phenomena"funded by ISRO.

R. Kariyappa:

- PI from India, for a joint research proposal on "Photospheric Triggered Waves and the Heating of the Chromosphere" which is sponsered by DST under Indo-Austrian Cooperation Program for a period of two years (2011 - 2013).
- Submitted a research proposal to NASA on "Observational Evidence for Heating of Solar Corona at the Sites of Bright Points from Hinode & SDO" in collaboration with Solar Physics Research Group at NASA/MSFC.

K. N. Nagendra:

- PI for the Indo-Swiss Joint research program on "Observations and Analysis of the Second Solar Spectrum" which is being funded by DST, India and EPFL, Switzerland.

T. P. Prabhu:

- "Aerosol Characterization and Assessment of the Radiative impacts from the High-altitude trans-Himalayan site in Hanle, Ladakh" funded by ISRO

B. E. Reddy:

- India's Participation in the TMT project on "Development of Technology and Demonstration", DST

C. S. Stalin:

- "Interstellar and Intergalactic Medium at high redshift: Reservoir for galaxy formation", funded by CEFIPRA/IFCPAR, for the period September, 2010 – August, 2013.

T. Sivarani:

- Project Manager for "Hanle Echelle Spectrograph" funded by DST

A. Subramaniam:

- The Project "From the Magellanic Clouds to the Milky Way: A New Understanding of Galaxy Structure and Interactions Based on Kinematics of 5000 Star" has been approved as the Indo-Australian collaborative project, under AISTF and is in collaboration with Dr. Andrew Cole, University of Tasmania, Australia.

Visitors hosted at IIA

G. C. Anupama:

- K. Maeda, IPMU, Tokyo, Japan,
- K. Kawabata, Hiroshima University, Hiroshima, Japan

P. Chingangbam:

- Sudhakar Panda, Harish-Chandra Research Institute, Allahabad, 18–25 March, 2012.
- Minu Joy, Alphonsa College, Pala, Kerala, 26 - 29 November, 2011.
- Changbom Park, Korea Institute for Advancd Study, Seoul, South Korea. 1–28 November, 2011.
- Anjan Ananda Sen, Centre for Theoretical Physics, Jamia Millia Islamia, Delhi, 4–8 July, 2011.

M. Das:

- Kartik Sheth, National Radio Observatory, USA, January 2–5, 2012.
- Alka Mishra, University of Gorakhpur, Gorakhpur.
- Arunima Banerjee, IISc., Bangalore, August 2011.

K. N. Nagendra:

- Hosted Helene Frisch, Observatoire de la Cote d'Azur, Nice, France, from November 21 – December 19, 2011, to continue the ongoing collaboration.

T. P. Prabhu:

- P. K. Rasmussen, Project Manager, SONG Project, Copenhagen University Observatory, Niels Bohr Institute, Copenhagen, 13–21 March, 2012.

C. S. Stalin:

- Ananda Hota, Institute of Astronomy & Astrophysics, Academia Sinica, Taiwan, for a week in April 2011
- S. Jeyakumar, Departamento de Astronomia, Universidad de Guanajuato, Mexico, 5 – 16 December, 2011

T. Sivarani:

- Luca Baiotti from Osaka University, 1–2 January, 2012.

6.4 Involvement with the Scientific Community

S. Anathpindika:

- Associated with the Committee of International Affairs, Royal Astronomical Society, UK

G. C. Anupama:

- Chair, Time Allocation Committee, IUCAA Ghirawali Observatory, IUCAA, Pune (2009-2012)
- Member: Subject Expert Committee on Physical and Mathematical Sciences for technical evaluation of proposals received under Women Scientist Scheme – (WOS-A), DST (2009-2011); Project Review and Steering Group of the Virtual Observatory India – The Next Generation project (Phase II); Core Member, TMT-India and Co-Chair, TMT-Science Advisory Committee.
- Co-Chair, Scientific Organising Committee, IAU Symposium 281 'Binary Paths to Type Ia Supernovae', 2011 July 4–8, Padova, Italy.

S. P. Bagare:

- Member: Conference Advisory Committee for the 'National Conference on Optics 2011' held during 23–25 May 2011 at Calicut and organized jointly by NIT, Calicut and OSI.

S. Chatterjee:

- Thesis examiner for Assam University, Assam and Mohan Lal Sukhadia University, Udaipur.

H. C. Bhatt:

- Member: Program Advisory Committee on "Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics" of the DST; RRI-JNU Academic Committee.

S. Giridhar:

- Editorial Board member: Journal of Astrophysics & Astronomy.

S. S. Hasan:

- Principal Investigator of the National Large Solar Telescope Project
- Chairman, Executive Council, Visheshwara Technological Museum, Bangalore
- Membership of the following Governing Councils: ARIES, Nainital; Institute of Plasma Research, Gandhinagar; National Council of Science Museums;
- Member: ISRO Expert Panel to select payloads for the Indian Mission to Mars; Board of Management, Centre for Theoretical Physics, Jamia Millia Islamia University, New Delhi; Academic Advisory Council of ITM University, Gurgaon; Advisory Council for Einstein Bhavana, Visva-Bharati University, Shantiniketan; National Commission for History of Science, INSA, New Delhi; Selection Committee for the D.C.Pavate Memorial Visiting Fellowships to Cambridge University;
- Associate of the Harvard College Observatory, Cambridge, U.S.A. since 1991.
- President of the following Associations: Oxford and Cambridge Society of Bangalore; Alexander von Humboldt Association of Bangalore.
- Co-investigator of a DST-Austria International Programme with the Institute of Astronomy, Graz, Austria on "Photospheric triggered waves and the Heating of the Chromosphere"
- Member: Organizing Committee of IAU Commission 10; International Committee of the Royal Astronomical Society, U.K..

P. K. Mahesh:

- Served as an extrenal expert in the assessment of staff members and participated in meetings

related to administartive matters pertaining to staff members of the Visweswaraiah Industrial and Technological Museum, Bangalore.

A. Mangalam:

- Editorial Board member: Bulletin ASI.
- IIA coordinator for JEST 2012.

A. K. Pati:

- Member: ASTROSAT Science Working Group (formed by ISRO)

T. P. Prabhu:

- Member: Scientific Advisory Committee, Space Physics Laboratory (ISRO/VSSC) Thiruvananthapuram; Project Management Board, 3.6m Devasthal Optical Telescope Project, ARIES, Nainital; Departmental Research Committee and Member, Advisory Committee on Telescope Project, SNBNCBS, Kolka; Selection Committee, SINP, Kolkata.

S. P. Rajaguru:

- Editor: IIA Newsletter.

B. E. Reddy:

- Member: TMT proposal Development team; TMT board of Directors.
- Member and convenor: TMT Work Package proposal screening and technical review committees.
- Coordinator: India's participation in the TMT project.

S. K. Saha:

- Editorial Board member: Asian Journal of Physics; Journal of Optics.
- Member: Doctoral committee of a senior PhD student, working Indian. Institute of Space Science and Technology (IIST), Trivendrum and attended its second meeting in August, 2011.
- Member: Special Board of Studies for Astrophysics, Pondicherry University and attended two meetings held in July and September, 2011.
- Member: Pondicherry University Board of School of Physical, Chemical, and Applied Sciences and attended a meeting in January, 2012.
- Acted as an advisory board member for the International Conference on Trends in Optics and Photonics (IConTOP) held during 7-9 December, 2011, at Kolkata.
- Served as a technical committee member for the Conference on Frontiers of Optics held during 3–4 December, 2011, at IIT-D, New Delhi.

T. Sivarani:

- Member: SDSS-III; Science working group NCFHT: "Next generation Canada French Hawaii Telescope".
- Co-Editor - IIA Newsletter.

A. Subramaniam:

- Associate editor: Bulletin of Astronomical Society of India.
- Member: Science working group, ASTROSAT; Calibration team of UVIT, IIA.

K. Sundara Raman:

- Member: Board of Studies and Adjunct Faculty of Mother Teresa University, Kodaikanal.
- Functioned as External Examiner and conducted the Viva Voce and Practical Examinations for M.Sc. and M.Phil (Physics) during April 2012 at Mother Teresa Womens University, Kodaikanal.

6.5 Visits

S. Anathpindika:

- University college London, UK, September 2011

G. C. Anupama:

- Herzberg Institute of Astrophysics, Victoria, Canada, 2-4 April, 2011
- Mauna Kea Observatories, Hawaii, U.S.A, 10 January, 2012

L. S. Anusha:

- Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany for two months, during January 9, 2012 to March 9, 2012.

M. Das:

- Tshichu university and National central University on October 21, 2011 and November 01, 2011.

A. Goswami:

- IUCAA, Pune, April 27 – 30, 2011
- NECRD, Guwahati, August 9 – 11 , 2011
- Department of Physics, Gauhati University, Guwahati, August 10 – 11, 2011

S. S. Hasan:

- Harvard Smithsonian Centre for Astrophysics, Cambridge, USA: May 7 - 14, 2011;
- Paris Observatory, Meudon, France: May 16-23, 2011, Oct. 1-4, 2011 and Nov. 14-16, 2011;
- Department of Applied Mathematics and Theoretical Physics, Cambridge, U.K.: May 24-26, 2011:;
- University of Graz, Austria as part of an Indo-Austria Exchange Programme: Oct. 5-7, 2011;
- University of Vienna, Austria: October 12, 2011.

R. Kariyappa:

- Institute for Physics, University of Graz, Austria, from 26 April – 10 May, 2011.
- Royal Observatory of Belgium under PROBA2 from 10 – 28 May, 2011.
- LATMOS/CNRS, France to work with Dr. Luc dame from 28 May – 5 June, 2011.
- Institute for Astronomy (IFA), University of Hawaii, USA during 15 Oct. – 1 Nov., 2011

A. K. Pati:

- DFM Engineering, Longmont, USA, 22-28 May, 2011 and 28 August–5 September 2011.
- NOAO, Tucson, USA, 31 May – 3 June, 2011.
- Dept. of Physics and Astronomy, Texas A & M University, USA, 4 – 7 June, 2011.
- Observatoire de Paris - Meudon, France, 8 – 11 June, 2011.

T. P. Prabhu:

- SINP, Kolkata 7-8 June 2011
- SPL, Thiruvananthapuram, 22 – 24 Sept. 2011
- MG University, Kottayam, 13 – 14 October 2011
- SNBNCBS, Kolkata 7 – 9 November 2011
- NCRA, Pune 10 – 11 November 2011
- ARIES, Nainital, 19 – 21 November 2011

B. Ravindra:

- Visted Indian Institute of Science Education and Research, Kolkata, West Bengal during 24 May – 2 June, 2011.

S. P. Rajaguru:

- Kiepenheuer Institut fur Sonnenphysik, Freiburg, Germany during 15 June – 15 August, 2011.
- Solar Observatories Group, Stanford University, Stanford CA, USA during April 23 – 30, 2011 and during Oct. 26 - Nov. 5, 2011.

B. E. Reddy:

- Observatoire de Paris, Meudon, Paris: 4 – 8 September, 2011.
- TMT Project Office, Pasadena, USA: 7 – 14 October, 2011 and 25 December, 2011 - 4 January, 2012.

C. S. Stalin:

- IUCAA, Pune, India, 03 March, 2012.
- ARIES, Nainital, India, December 26, 2011 – January 02, 2012.
- Calicut University, Calicut, March 13 – 14, 2012.
- Mysore University, Mysore, Nov. 3 – 5, 2011.

T. Sivarani:

- S. N. Bose National Centre for Basic Sciences, Kolkata, November 7 – 8, 2011.

A. Subramaniam:

- Visited University of Heidelberg, Germany,01 – 02 April 2011.
- University of Tasmania, Australia 26 October – 01 November 2011.

6.6 Awards and Recognition

C. Sivaram:

- The essay on "Hydrodynamics, Horizon, Holography and Black Hole Entropy" was selected for Honorable Mention by the GRF, Massachusetts, USA for 2011.

Sujan Sengupta:

- Awarded a visiting Associate Professor position for three months by Institute of Astronomy & Astrophysics, Academia Sinica, Taiwan.

Akondi Vyas:

- Recipient of the 2011 Robert S. Hilbert Memorial Student Travel Grant, given by the OSA Foundation for the Imaging and Applied Optics: OSA Optics and Photonics Congress. Akondi presented two papers, "Evaluation of the performance of centroiding algorithms with varying spot size: case of WFS calibration for the TMT NFIRAOS" and "Multi-dither Shack Hartmann sensor for large telescopes: A numerical performance evaluation", at Adaptive Optics: Methods, Analysis and Applications (AO) which took place July 10 – 14 in, Canada.

Vyas Akondi was the recipient of the 2011 Robert S. Hilbert Memorial Student Travel Grant, given by the OSA Foundation.)

A. B. S. Reddy:

- Awarded NICXII travel grant to participate in the "XII International Symposium on Nuclei in the Cosmos", (5–10 August, 2012 in Cairns, Australia). He also received an IAU grant to participate in the XXVIII IAU General Assembly (20–31 August, 2012 in Beijing, China).

K. N. Nagendra:

- Received the "Indira Gandhi Shiromani Award and Certificate of Excellence", given by the India International Friendship Society, New Delhi, for "Outstanding individual achievements and distinguished services to the Nation". There was a seminar on "Economic Growth and National Integration".

K. N. Nagendra receiving the award from Dr G. V. G. Krishnamurthy, former Chief Election Commissioner, on December 17, 2011 at a ceremony held at New Delhi.

S. Anathpindika:

- Received a visiting fellowship of the University College, London.

Kodaikanal flower show competition

Garden at Kodaikanal Observatory which won the prizes at the Horticultural flower show.

The flower show summer festival at Kodaikanal during May 2011 organized by the Tamil Nadu Government Horticulture Department in which IIA bagged

45 prizes in total, out of which two are rolling cups for the main Garden and rose Garden, one shield for well maintained campus, besides 25 first prizes and 17 other prizes for the cut flowers.

6.7 Welfare of SC/ST Staff

A senior officer of the institute has been functioning as the liaison officer to support the welfare of the SC/ST staff members. Special consideration as per norms during recruitment and regular assessment has been provided to these categories of employees. As of the end of the year, members belonging to the SC, ST and OBC categories constitute 15.84%, 10.56%, 2.97% respectively of the total staff strength. In addition, reservations continue to be extended to OBCs and physically disabled persons. Proactive efforts are continuously made towards their welfare. Facilities and mechanisms have been provided for special administrative as well as technical training of staff from the historically disadvantaged categories.

6.8 Official Language Implementation

Achievements

- Official Language Implementation Committee: Four meetings were conducted in 2011-2012 in the Institute and the reports were sent to the Dept. of Science & Technology, New Delhi.
- Hindi Workshop: In order to speed up the implementation of Official Language in the Institute and to improve the staff member's capacity for doing official work in hindi, three Hindi Workshops were conducted for the employees working in Administration, on 15 June, 2011, 24 August, 2011, and 22 March, 2012. Concerned reports have been sent to the DSt New Delhi.
- Incentive Scheme: Under this scheme, two "One word scheme" competitions for the employees working in Administration, were conducted on 24 August, 2011 and 27 February, 2012 at the Institute. Winners were awarded with cash prize.
- Hindi Training Program: Shri. Y. Yarappa & Shri. K. Shankaranarayanan secured 92% & 94% marks respectively and passed the Hindi Typing Exam conducted during the month of July, 2011 & January, 2012 by the Hindi Teaching Scheme, Bangalore.
- Hindi Day/Fortnight Celebration: The institute celebrated Hindi Fortnight from 1st September, 2011 to 14th September, 2011. During the occasion six competitions were conducted in the Institute viz. "Hindi Cross-word" & "Hindi Debate" on 2 September 2011 , "Hindi Song" & "Picture Narration" on 9 September, 2011, "Hindi Visual-Quiz" on 12 September, 2011. "Hindi Essay Writing" on 13 September 2011.
- 14 September, 2011 was celebrated as "Hindi Day" in the Institute. S. S. Hasan, Director as chairman of the OLIC has conducted the function. He addressed the audience and said that it is the moral responsibility of all staff members to accomplish official work in simple hindi, so that others could understand. Gajendra Pandey read the Home Minister's message on Hindi Day. The function was concluded with a vote of thanks by S. Rajanatesan.
- Hindi Day/Fortnight celebrations in field station: On this occasion two hindi competitions were conducted viz. Hindi Administrative Glossary and Hindi Visual-Quiz on 15 & 16 September, 2011 respectively at VBO, IIA, Kavalur. Winners were distributed with cash awards.

(S. Rajnatesan, Hindi Cell)

Hindi Day was celebrated at the Institute on 14 September 2011. Various competitions were held and prizes distributed. The winners are (Standing : Left to Right) N. K.Pramila, S. Rajanatesan, S. Dhananjaya, K. Shankaranarayanan, L. Josephine, Y. Yarappa, Malini Rajan, D. Lakshmaiah, K. Bhaskaran & K. G. Erappa. (Sitting : Left to Right) M. P. Parthsarathy, P. Kumaresan, S. S. Hasan, T. P. Prabhu & N. Narasimharaju.

Chapter 7

People

7.1 Staff List 2011 – 2012

Director: S. S. Hasan

7.1.1 Academic & Scientific Staff

Senior Professor: H. C. Bhat, B. P. Das, T. P. Prabhu, C. Sivaram

Professor: G. C. Anupama, S. P. Bagare, S. Giridhar, J. Murthy, K. N. Nagendra, A. K. Pati, K. E. Rangarajan, A. V. Raveendran, S. K. Saha

Associate Professor: S. Annapurni, D. Banerjee, S. Chatterjee, R. K. Chaudhuri, R. T. Gangadhara, K. M. Hiremath, R. Kariyappa, A. Mangalam, S. G. V. Mallik, B. R. Prasad, K. P. Raju, K. B. Ramesh, R. Ramesh, B. E. Reddy, D. K. Sahu, A. Satyanarayanan, S. K. Sengupta, P. Shastri

Reader: M. Das, J. Javaraiah, C. Muthumariappan, G. Pandey, C. Pravabati, S. P. Rajaguru, T. Sivarani, C. S. Stalin, F. Sutaria

Scientist D: B. C. Bhatt, A. Goswami, U. S. Kamath, S. Muneer, P. S. Parihar, M. S. Rao, K. Sundara Raman, B. A. Varghese

Scientist C: R. K. Banyal, E. E. Chellasamy, B. S. Nagabhushana, B. Ravindra, N. S. Singh

Scientific Officer SD: R. Mohan, L. Yeshwanth

Scientist B: P. Bama, N., G. S. Suryanarayana

Fellow: C. Kathiravan

Research Associate: M. Appakutty, G. Selvakumar

Adjunct Professor: A. R. Choudhuri

Adjunct Scientist: D. Tripathi, K. Sankarasubramanian

Honorary Professor: V. K. Gaur, P. R. Vishwanath

Visiting Professor: J. Singh, S. N. Tandon

Visiting Scientist: M. Safanova

Post Doctoral/Visiting Fellow: S. V. Anathpindika, R. Gopal, J. Jose, S. Raut, J. Roy

Chandrasekhar Post-Doctoral Fellow M. Sampoorna

Ph. D. Fellow: L. S. Anusha, R. Chowdary, G. R. Gupta, A. C. Pradhan, S. Ramya, V. Singh, S. Subramaniam, G. Udaya Kumar, A. Vyas, B. K. Yerra Reddy

Sr. Research Fellow: K. Chandrashekar, L. P. Chitta, S. Choudhury, A. Dhar, K. Drisya, B. P. Hema, S. Indu, D. Kumar, S. R. Kumar, S. K. Prasad, M. Prasanth, P. Ramya, S. Rao, A. B. S. Reddy, M. B. Roopashree, A. Shukla, G. Sindhuja, H. N. Smitha

Jr. Research Fellow: C. Anantha, S. R. Antony, S. Arun, S. K. Dhara, M. Honey, A. Prasad, K. Pullapally, K. S. Raja, T. Samanta, C. R. Sangeetha,T. K. Sharma, M. Singh, K. Sowmya, S. Srivastav, H. D. Supriya, N. V. Suresh, G. Vidya

IIA-IGNOU Integrated M.Sc, Ph.D.: P. K. Joby, S. Kumar, S. Nanda, S. Prasanna, M. Sastry,

S. P. Vaidehi

IIA-CU M. Tech-Ph. D: S. Behra, P. G. Deshmukh, K. Hariharan, J. Mathew, A. Mohanty, S. Pal, M. N. Sarpotdar, A. G. Sreejith, A. Surendran

7.1.2 Technical Staff

Engineer G: A. K. Saxena

Sr. Principal Scientific Officer: A. V. Ananth

Engineer F: M. S. Sundararajan

Engineer E: G. Srinivasulu

Engineer D: D. Angchuk, V. Arumugam, S. S. Chandramouli, S. Kathiravan, P. M. M. Kemkar, A. Kumar, P. K. Mahesh, S. Nagabushana, M. V. Ramaswamy, B. R. Reddy, R. R. Reddy, F. Saleem, S. Sriram

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

Librarian: C. Birdie

Engineer C: P. Anbazhagan, K. Dhananjay, T. Dorjai, S. Gorka, S. Jorphail, P. U. Kamath, T. T. Mahay, V. Selvi, K. C. Thulasidharan

Sr. Technical Officer: K. Jayakumar, K. Kuppuswamy, K. Rangaswamy, M. J. Rosario, A. Selvaraj, R. Selvendran

Technical Officer B: J. V. S. V. Rao, N. Sivaraj

Sr. Documentation Officer: S. Rajiva

Engineer B: K. Anupama, A. Ramachandran, K. Ravi

Technical Officer: A. V. V. Kutty

Tech. Associate B: D. Babu, P. Kumaravel, Narasimhappa, S. Pukalenthi, S. Ramamurthy M. R. Somashekar, C. V. Sriharsha

Sr. Mech. Asst. C: A. Mani

Tech. Associate: V. Gopinath, M. G. Mohan, Mallappa, J. Manoharan, S. Ramamoorthy, S. Venkateshwara Rao

Draughtsman E: V. K. Subramanian

Sr. Tech. Asst. B: A. P. Balakrishnan, R. I. Jabillullah, D. Kanakaraj, A. Muniyandi, T. K. Muralidas, M. Nagaraju

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

Driver Mech. E.: Anandaraman

Consultant: K. Chandar

Consultant Engineer: M. Nageshwara Rao, B. S. Nataraju

7.1.3 Administrative Staff

Administrative Officer: P. Kumaresan

Dy. Administrative Officer: S. Rajasekaran

Personnel Officer: A. Narasimharaju

Accounts Officer: M. P. Parthasarathy

Staff Officer: K. Thiyagarajan

Purchase Officer: Y. K. R. Iyengar

Stores Officer: D. Lakshmaiah

Asst. Accounts Officer: G. R. Venugopal

Sr. Section Officer: L. Josephine, Meena, P. Mohan, A. P. Monnappa, K. Sutherson

Section Officer: N. Murthy, K. Padmavathy, S. Rajendran, S. B. Ramesh, Ramaswamy, N. Valsalan

Section Officer (Hindi): S. Rajanatesan

Sr. Office Superintendent: D. Dakshinamoorthy, U. Maileveloo, G. A. Mary, M. G. C. Nair, N. K. Pramila, M. Rajan, N. Sathya Bama, A. Veronica

7.2 Visitors to IIA

Ananda Hota
NCRA-TIFR, Pune
6 – 13 April 2011

Sanhita Joshi
NCRA-TIFR, Pune
1 – 6 May 2011

M. H. Gokhale
205, Sairanga
Kothrud, Pune
11 May, 2011

Alok Gupta
ARIES, Manora Peak
Nainital 263129, India
24 May – 2 June, 2011

Anjan Sen
Center for theoretical physics
Jamia Millia, New Delhi
4 – 8 July, 2011

Kinsuk Acharyya
S. N. Bose Institute
Kolkata
11 – 14 July, 2011

N. M. Ashok
PRL, Ahmedabad
20 – 23 June, 2011

Ritaban Chatterjee
Yale University
New Haven, CT 06511
31 July – 3 August, 2011

Suchetana Chatterjee
Yale University
New Haven, CT 06511
31 July – 2 August, 2011

Sree Ram Valluri
Univ.of Western Ontario
23 – 24 July, 2011

L. N. Hazra
University of Kolkata, Kolkata
13 – 17 August, 2011

Durgesh Tripathi
IUCAA, Pune
21 July, 2011

G. S. Agarwal
Oklahama State Univ.,
USA
25 July, 2011

D. K. Ojha
TIFR, Mumbai
18 August, 2011

A. N. Ramprakash
IUCAA, Pune
18 August, 2011

U. S. Mahapatra
Noulana Azad college
28 September – 14 October,2011

Tapan Mishra
Department of Physics
Georgetown University
Washington, DC 20057, USA
22 September – 1 october

Ashok Mohapatra
NISER
Bhubaneswar
27 September

T. Ajay
IISER, Kolkata
3 – 7 October 2011

Alka Misra
Gorakhpur University
19 October – 31 December 2011

P. Shalima
IUCAA, Pune
28 October – 9 November

Changbom Park
KIAS, Korea
16 November, 2011

Ramakant Yadav
ARIES, Nainital
16 – 19 November, 2011

Neha Choksi
19/A Motiwala Mansion
Pitha Cross Lane, Jambhoomi Marg
Fort, Mumbai - 400001
2 – 5 December 2011

Maheshwar Gopinath
ARIES
Nainital
26 – 27 November, 2011

S. R. Kulkarni
Caltech
Pasadena
CA 91125, USA

S.Jeyakumar
Departamento de Astronomia
Universidad de Guanajuato
Guanajuato, Mexico
6 – 16 December 2011

M. B. Pandge
SRTM University
1 – 30 December 2012

P. K. Mukerjee
Visva Bharti University
West Bengal
26 February – 27 March, 2012