INDIAN INSTITUTE OF ASTROPHYSICS

Academic Report 2012-2013

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Cover : The new 1.3 m aperture optical telescope at the Vainu Bappu Observatory. The first star light through the telescope was seen on 10th March 2013. The telescope has a novel double horseshoe mount. Science observations using this facility will start after acceptance testing. The telescope building and dome are shown on the back cover.

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The Year in Review

It gives me great pleasure to present the highlights of achievements in research and development activities at the IIA in 2012–13. 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 projects are on the anvil, while earlier ones continue to make excellent progress. The personnel of the institute were active in research, teaching, training, development and maintenance of the observatories and outreach activities.

One of the major achievements is first light through the 1.3 m optical telescope at the Vainu Bappu Observatory, Kavalur, which took place on 10th March 2013. This is a 1.3 m aperture Ritchey-Chretien telescope, with a focal ratio of f/10. The telescope installation started from 7th February 2013 with the arrival of the three member team from the vendor company (DFM Engineering) at the site. In the current year the erection of the steel structures of the building as well as the dome was completed by August 2012 followed by the fixing of the aluminium cladding sheets for the building and dome. A large team of institute personnel have been closely associated with the installation of the telescope. This has been a close collaboration of mechanical, electrical, optical engineers located at the VBO, as well as at Bangalore, under the leadership of Prof. Ashok Pati. The team has to its credit, in house development of installation and development of the interfaces between the telescope control electronics and the drives of the telescope dome, in the installation of the mirror supports and loading of the primary mirror in the cell, development of software needed for testing of the new fast CCD camera. Fine tuning of the telescope is in progress and will be ready for science observations soon. My hearty congratulations to the whole team for their valuable contribution to the project and bringing it to the stage of first light.

The institute has interests in various field of astrophysics and the major breakthrough achieved in these areas are summarised in this report. A few highlights are mentioned here. In the area of Solar Physics, the Solar Corona was studied using the observations taken during the total solar eclipse which gave valuable clues to the heating mechanism. Research in the areas of magnetic field in the solar atmosphere, asteroseismology, active regions and polarisation of spectral lines continued. A significant achievement was the development of a theoretical framework to treat scattering polarization from a multiplet of spectral lines that took into account quantum interference effects. This was successfully applied to the linear polarization profiles of the solar Cr I triplet.

In the area of stellar astronomy, high resolution spectral studies using data including those obtained from the 2.3 m telescope were continued. The studies were focussed on the hydrogen-deficient stars, Carbon enhanced metal poor stars, members of star clusters and stellar streams. The nature of star formation molecular clouds including those in the inner Galaxy are studied using observations as well as simulations. The studies of eruptive variables included Novae and Supernovae. Pulsars, binaries and theoretical modelling of various systems, were also performed.

In the area of Extragalactic astronomy, the nearby galaxies were studied using multiwavelength data as well as theoretical modelling. These studies include various types of galaxies, to understand their properties, which include mass of black hole, presence of AGN, structural properties and jets. In Cosmology, new theoretical techniques have been formulated to determine the statistical properties of the cosmic microwave background (CMB) radiation. Furthermore, a novel method has been developed to detect the presence of residual foreground contamination in the cleaned CMB data–this is an important step forward in the extraction of cosmological information from CMB.

In the area of atomic and molecular physics, several investigations are carried out on the singly ionised barium (Ba II), which is of considerable importance in astrophysics. Detailed theoretical studies of the influence of the three- body interactions on the superfluid to Mott insulator transition in ultracold bosonic atoms in optical lattices and superlattices were undertaken. Behaviour of Be I and Na I isoelectronic sequence in the Debye plasma environment were also carried out.

The institute is a major partner in the multiwavelength astronomy mission, ASTROSAT. Significant progress was made in the integration of the Ultra Violet Imaging Telescope (UVIT), one of the instruments on ASTROSAT. Both the telescopes were integrated and was sent to ISRO for environmental tests.

The high resolution spectrometer for the 2 m Himalayan Chandra Telescope (HCT) at Indian Astronomical Observatory (IAO) Hanle is making significant progress with the fabrication of various components and construction of the enclosure in HANLE.

Professor Bhanu Pratap Das handing over a bouquet to Anil Kakodkar, who delivered the Founder's Day lecture on "Management of Mega Science Programmes."

Among the new initiatives, the Indian effort to join the international consortium of TMT is progressing well. For the India TMT, the last year has been an eventful year both in terms of policy and the progress made at the ground level fulfilling our commitments to the project. India TMT hosted two TMT partner wide meetings: a two day science meeting followed by the science advisor committee (SAC) meeting at IUCAA, Pune during 10–14 December 2012, and the TMT board of directors meeting in New Delhi during 21–22 January 2013. India TMT has taken up various critical hardware and software work packages with the Indian Industry. The Indian institutions are involved in the development of science cases as well as with the instrument groups.

The National Large Solar telescope project is making progress with the detailed site characterisation and design of back-end instruments for the planned telescope.

The Aditya-1 mission with the Visible Emission Line space solar Coronagraph has been progressing well. The Preliminary Design Review (PDR) of the optics has been completed and discussions on structure design are in the final stages. In January 2013, it has been decided to enhance the capability of mission by changing the orbit of the satellite from low earth orbit (LEO) to L1–Lagrange point with a bigger satellite capable of taking more weight and volume.

The students program of the institute continues to be very active. The MTech-PhD program in collaboration with the Calcutta University has been getting very good response and the number of students in this stream is increasing. The PhD program continues to produce well trained and qualified graduates. The internship and the summer programs are used to train a large number of undergraduate as well as postgraduate students from various institutions and universities.

Mr Vaidehi Sharan Paliya I-PhD student of IIA who received the University Gold Medal from the Vice Chancellor of the National Law School of India University, Bangalore, on the occasion of IGNOU's 26th convocation, held at Bangalore, on 12th April 2013.

The outreach activity of the institute was spread across the field stations, apart from the Bangalore campus. The teams also participated in various exhibitions, open days as well as visit to schools. The venus tranist of 6th June 2012 was witnessed by a large number of students and public at Bangalore, Kodaikanal and Kavalur.

The founder's day was celebrated with a lecture by the renowned nuclear scientist and former Chairman of the Atomic Energy Commission of India, Dr. Anil Kakodkar. Dr. Kakodkar spoke on "Management of Mega Science Programmes", a topic of relevance and importance to IIA, which has recently assumed leading roles in a few mega-science projects in the country.

The 22nd Bicentennial Lecture was held on the 14th of December, 2012 and it was delivered by Raghavendra Gadagkar, Professor at the Centre for Ecological Sciences, Indian Institute of Science (IISc), Bangalore and JC Bose National Fellow.

I am very happy to mention a few more achievements: Prof. B. P. Das was elected as a Fellow of the American Physical Society (APS). Prof. G. C. Anupama was elected Fellow of the Natioanl Academy of Sciences India. Mr Vaidehi Sharan Paliya I-PhD student of IIA who received the University Gold Medal and MSc. degree from the Vice Chancellor of the National Law School of India University, Bangalore, on the occasion of IGNOU's 26th convocation. Smitha Subramanian received the best thesis presentation award and two posters of students bagged the best poster presentation award in the 30th Astronomical Society of India (ASI) meeting. The details of the highlights mentioned here and more are presented in this report. The lists of publications in refereed journals and conference proceedings as well as in monographs, books and in popular periodicals are included. Also included are the reports on the implementation of the official language and Welfare of SC/ST and physically challenged Staff.

Bhanu Pratap Das
Director (Acting)

Chapter 1

Research

1.1 Solar Physics

Modeling the J-state interference signatures of the Cr I triplet in the second solar spectrum

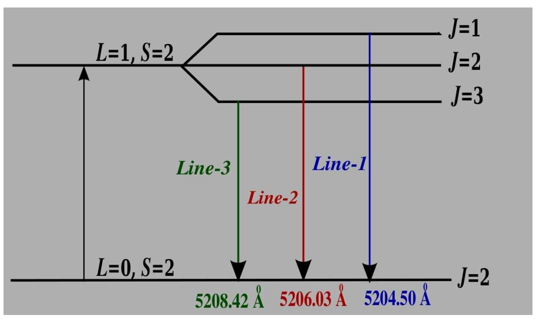

Figure 1.1: The term diagram showing transitions in the Cr I triplet (not to scale)

The scattering polarization in the solar spectrum is traditionally modeled with each spectral line treated separately, but this is generally inadequate for multiplets where J-state interference plays a significant role. The theory of J-state interference was developed in Smitha et al. (2011, ApJ, 733, 4). This theory is now applied to model the Cr I triplet observed in the Sun. The Cr I triplet arises because of the fine structure splitting of the upper level, having an orbital angular momentum $L = 1$, due to its coupling with spin $S = 2$. This is shown in Figure 1.1. To model Cr I triplet the effects of polarized radiative transfer along with J-state interference and partial frequency redistribution are taken into account. The elastic and inelastic collisions are also accounted for. Figure 1.2 shows the comparison between the observed and theoretical profiles. As seen from the figure, an excellent fit to the observed intensity (I) and linearly polarized (Q/I) profile is achieved. To obtain the fit a slight modification of the standard FALF model atmosphere in the deeper layers is found to be necessary. This emphasizes that the I and Q/I spectra provide a much stronger constraint on the model atmosphere than the I spectrum alone. The second solar spectrum is thus not only useful for magnetic field diagnostics, but also for modeling the thermodynamic structure of the Sun's atmosphere. These results are published in Smitha et al. (2012, A&A, 541, A24).

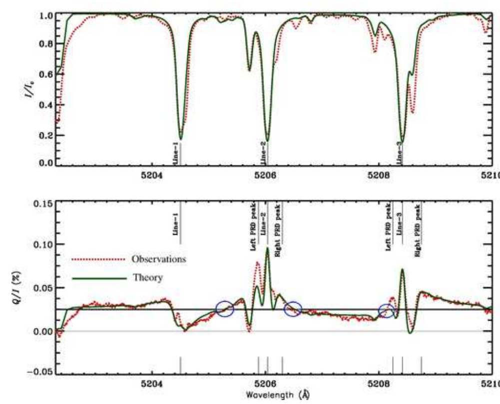

Figure 1.2: Comparison between the limb observations of $(I, Q/I)$ and the theoretical profiles. The centers of the 3 lines and the PRD peak positions are marked with vertical lines. The interference region is marked with circles.

(H. N. Smitha, K. N. Nagendra, J. O Stenflo, M. Bianda*, M. Sampoorna, R. Ramelli*, & L. S. Anusha)*

Polarized subordinate line formation

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,

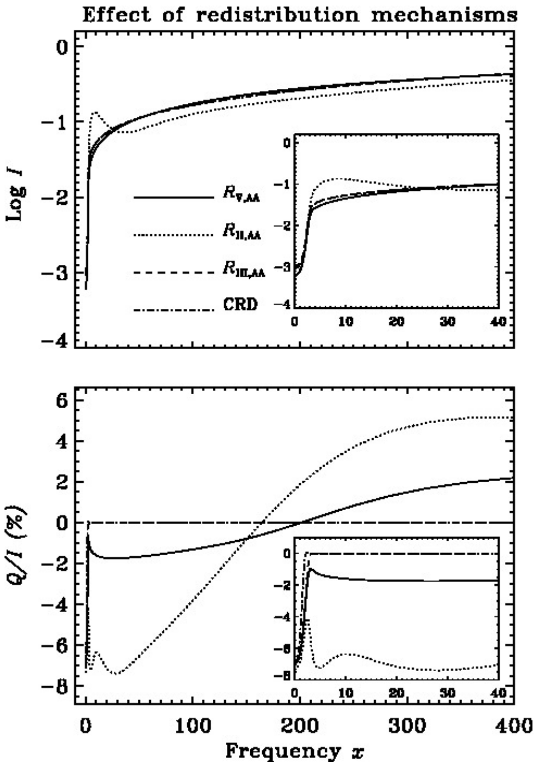

Figure 1.3: Comparison of emergent polarization profiles formed under different redistribution mechanisms.

especially when the polarization state of the line radiation is taken into account. The PRD effects in subordinate lines including scattering polarization is investigated. The line formation is described by a polarized non-LTE line transfer equation based on a two-level atom model. The recently derived subordinate line redistribution matrix (see Sampoorna 2012, ApJ, 745, 189) is used. Polarized approximate lambda iteration methods to solve the concerned transfer problem are devised.

Figure 1.3 shows a comparison of emergent Stokes profiles formed with different redistribution mechanisms. For intensity profiles of subordinate lines CRD is a reasonable approximation (compare solid and dot-dashed lines in the top panel of Figure 1.3). On the other hand, the linear polarization profiles computed with PRD and CRD differ significantly throughout the line profile (compare solid and dot-dashed lines in the bottom panel of Figure 1.3). Thus one can conclude that in the polarized line transfer calculations of subordinate lines, PRD plays as important a role as it does in the case of resonance lines. These results are published in Nagendra & Sampoorna (2012, ApJ, 757, 33).

(K. N. Nagendra & M. Sampoorna)

Angle-dependent Hanle scattering

The polarization of line radiation is caused by resonance scattering on bound atomic levels. A modification of this process by external magnetic fields is called the Hanle effect. Hanle scattering is an important diagnostic tool to study weak solar magnetic fields. Partial frequency redistribution (PRD) is necessary to interpret the linear polarization observed in strong resonance lines. Usually angle-averaged (AA) PRD functions are used to analyze linear polarization. However, it is established that angle-dependent (AD) PRD functions are often necessary to interpret polarization profiles formed in the presence of weak magnetic fields. An efficient decomposition technique, and the numerical method to solve the concerned angle-dependent line transfer problem are developed.

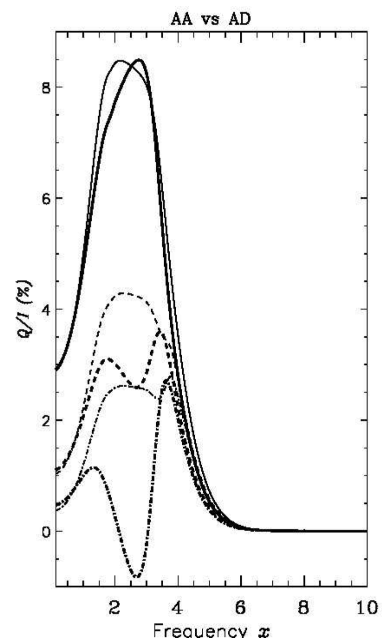

Figure 1.4: Comparison of angle-averaged (thin) and angle-dependent (thick lines) cases. Solid lines: non-magnetic case; dashed lines: deterministic magnetic field; dot-dashed lines: micro-turbulent field.

Figure. 1.4 shows the comparison of linear polarization profiles computed using AA and AD redistribution matrices. From the figure it is clear that the differences between the linear polarization profiles computed with AA and AD functions gets enhanced in the presence of a micro-turbulent magnetic field. This is probably because of the localization of line photons within the micro-turbulent scattering eddies, resulting in a relatively larger number of scatterings. These results are published in Supriya et al.(2013, JQSRT, 119, 67).

(H. D. Supriya, M. Sampoorna, K. N. Nagendra, B. Ravindra & L. S. Anusha)

Polarizing blend lines

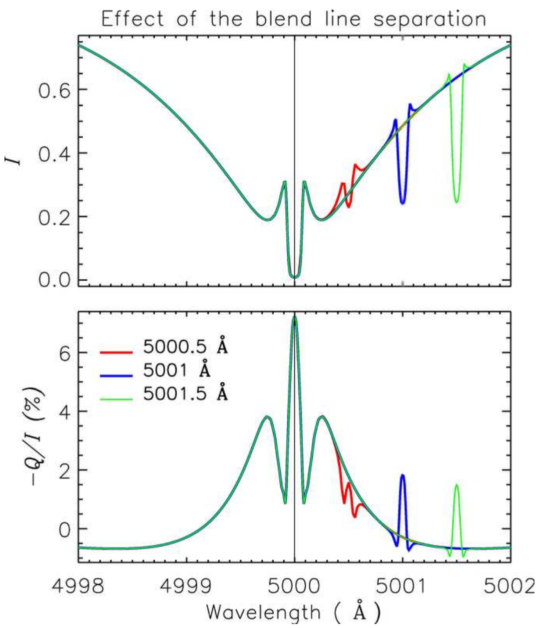

Figure 1.5: Blend line effects on a polarized line. Main line position indicated by a vertical line. The line of sight is represented by $\mu = 0.05$.

Modeling of the second solar spectrum, which is produced by coherent scattering processes on the Sun, requires a proper treatment of the blend lines. This spectrum is characterized by numerous blend lines, both intrinsically polarizing and depolarizing. These blend lines form an integral part of the theoretical analysis and modeling of the polarized spectrum of the Sun. A framework to include these polarizing blend lines in the radiative transfer equation was developed by extending the line source function expression. The influence of blend lines on the polarization of main line of interest was studied, by taking an isothermal slab atmosphere.

Figure. 1.5 shows the effect of wavelength proximity of the blend line to the main line. The position of main line is kept fixed at 5000Å and blend line position (marked in the Q/I panel) is varied. The blend line dominantly affects its own core and nearby wavelengths as it is assumed to be weak.

The dependence of blend line intensity and polarization effects on various parameters like, polarizability factor, blend line strength, the slab thickness, continuum opacity and its polarization, magnetic field, and elastic collision rates have been explored in detail in Sowmya et al. (2012, MNRAS, 423, 2949). Such calculations help in the analysis of the solar spectrum, and solar atmospheric studies.

(K. Sowmya, K. N. Nagendra & M. Sampoorna)

Multi-dimensional radiative transfer to analyze Hanle effect in Ca II K line at 3933 Å

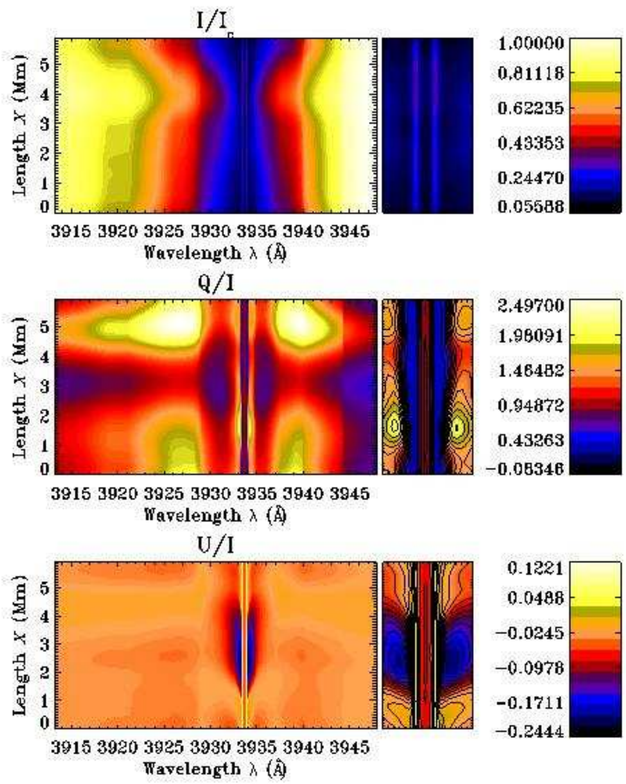

Figure 1.6: Spatial and spectral variation of $I/I_c, Q/I, U/I$ in Ca II K line. The middle panels show the same profiles in a smaller wavelength range between 3932.9 Å to 3934.2 Å .

Radiative transfer (RT) studies of the linearly polarized spectrum of the Sun have generally focused on line formation, with an aim to understand the vertical structure of the solar atmosphere using one-dimensional model atmospheres. Modeling spatial structuring in the observations of the linearly polarized line profiles requires the solution of multi-dimensional (multi-D) polarized RT equation and a model solar atmosphere obtained by magnetohydrodynamical (MHD) simulations of the solar atmosphere. The authors aim, in here, is to analyze the chromospheric resonance line Ca II K at 3933 Åusing multi-D polarized RT with the Hanle effect and partial frequency redistribution in line scattering. They use an atmosphere that is constructed by a two-dimensional snapshot of the three-dimensional MHD simulations of the solar photosphere, combined with columns of an one-dimensional atmosphere in the chromosphere. Here they represent the first application of polarized multi-D RT to explore the chromospheric lines using multi-D MHD atmospheres, with PRD as the line scattering mechanism. See Figure. 1.6.

The authors find that the horizontal inhomogeneities caused by MHD in the lower layers of the atmosphere are responsible for strong spatial inhomogeneities in the wings of the linear polarization profiles, while the use of horizontally homogeneous chromosphere (FALC) produces spatially homogeneous linear polarization in the line core. These results are published in Anusha & Nagendra (2013, ApJ, 767, 108).

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

Analysis of the solar coronal green line profiles from eclipse observations

Analysis of the solar coronal green line profiles reveals information regarding the physical conditions of the solar corona like temperature, density, Doppler velocity, non-thermal velocity etc. This will provide insights to the unresolved problems like the coronal heating and the acceleration of the solar winds. Recent studies have reported excess blueshifts in the coronal line profiles and are interpreted as due to nanoflare heating, type II spicules and nascent solar wind flow. A time series of Fabry-Perot interferograms of the solar corona obtained during the total solar eclipse of 2001 June 21 from Lusaka, Zambia have been analyzed and the spatial behaviour of the coronal green line profiles were examined. Variations in intensity, linewidth, Doppler velocity and line asymmetry were obtained. Several line profiles showed asymmetry indicating the presence of multi-components. Such line profiles were fitted with double Gaussian curves. Majority of them showed excess blueshifts. The secondary component of a typical line profile is found to have a relative intensity about 0.28, Doppler velocity around -30 km s^{-1} and a halfwidth about 0.6 Å.

(K. P. Raju, Maya Prabhakar & T. Chandrasekhar*)*

Synoptic study of the solar EUV network in transition region

The chromospheric network, the bright emission network seen in the chromospheric lines such as Ca-K and H-alpha, outline the supergranulation cells. The solar EUV network is essentially the continuation of the chromospheric network in the transition region. The Coronal Diagnostic Spectrometer(CDS) on board Solar and Heliospheric Observatory (SOHO) provides spectroscopic data from the solar meridian in the EUV range everyday. Using Intensity distribution and statistical modelling, the properties of the EUV network were examined over roughly one solar cycle(1998-2011). Statistical central tendency measures and curve fitting procedures were employed to separate the network and cell areas. The EUV network index is obtained for the O V 630 Å. Further studies are underway.

(K. P. Raju & Aditya Tyagi)*

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 to be developed for data reduction and analysis. Some preliminary results on the network and plage indices were obtained from the Ca-K images and further studies are underway.

(K. P. Raju & Amareswari)

Reflection and refraction of (magneto-)acoustic waves at the magnetic canopy: further evidences from multi-height seismic data from SDO

Recently the authors presented evidences (S. P. Rajaguru et al. 2012, arXiv:1206.5874) that seismic halos around expanding magnetic structures in the lower solar atmosphere are related to the acoustic to magnetoacoustic wave conversions, and associated reflection and refraction of (magneto-)acoustic wave modes, using multi-height data from HMI and AIA (1700 and 1600 Å channels) onboard SDO. The authors have continued this work with detailed analyses of phase and power maps over several heights in combination with a mapping of the magnetic canopy through extrapolation (both potential and non-linear force-free) of the HMI vector magnetic field. They have related these findings to theories of p mode absorption and mode conversions in solar atmospheric magnetic field.

(S. P. Rajaguru, S. Couvidat, Xudong Sun* & Keiji Hayashi*)*

Relating photospheric dynamics with chromospheric UV emissions: a study using SDO data

Analyses of correlations between photospheric p-mode absorptions by magnetic field and upper-photo spheric and lower-chromospheric UV emissions are carried out. Photospheric p -modes and their interactions with magnetic field are measured using the Helioseismic and Magnetic Imager (HMI)/SDO observations of Doppler velocities, line-of-sight magnetic field, the continuum and line-core intensities (using the 6173 Å Fe I line). Chromospheric UV emissions are from the Atmospheric Imaging Assembly (AIA)/SDO observations in the 1700 and 1600 Å UV channels. Photospheric flow dynamical quantities such as amplitudes of horizontal velocities, vertical vorticity and horizontal divergence are derived from the local correlation tracking of magnetic fields and convective granules. Major results obtained are: (i) although vortical or swirl motions at the photospheric layers are preferentially found at strong magnetic field regions, they do not appear to correlate well with the UV emission intensities at the chromospheric layers. This result, in the light of recent findings (in the literature) that swirl motions contribute to energy deposition at coronal layers, implies that such motions propagate largely undamped through the chromospheric layers. (ii) Emissions in the 1700 and 1600 Å AIA UV channels have high correlations with the acoustic absorptions by the magnetic field at the photosphere, pointing to magnetic-field-assisted wave-heating as the cause of these emissions in the lower chromosphere.

(C. R. Sangeetha & S. P. Rajaguru)

Three dimensional numerical simulations of wave propagation in the solar network

Three dimensional numerical simulations of dynamical phenomena in a magnetic flux tube extending vertically through the solar network are underway. Waves are generated in the flux tube through motions of their footpoints which are anchored in the solar photosphere. These motions generate slow and fast magneto-acoustic waves in the magnetic flux tube as well as in the ambient medium. The response of the upper atmosphere to the underlying photospheric motion and the role of the flux tube in channeling the waves is investigated (see Figure. 1.7). The authors compute the energy flux in the various wave modes and examine the observational implications for chromospheric and coronal heating. An important objective of the investigation is to examine the coupling of various modes and to quantitatively identify the regions where mode transformation occurs.

(S. S. Hasan)

Observational signature of magnetic field intensification in the solar atmosphere

The authors use high resolution data from SUNRISE balloon solar telescope to look at the statistics of magnetic flux concentrations in the solar network. The data consist of simultaneous images in Ca II H (396.8 nm), CN (388.0 nm) and Fe I (525.02 nm) along with simultaneous vector magnetograms. They study the morphological characteristics of a large number of Network Bright Points (NBPs) to look for evidence of convective collapse, a theoretical mechanism postulated several years ago for the intensification of magnetic fields in the solar photosphere. The authors look for correlations between strong fields and downflows to isolate the regions where convective intensification may have occurred. An important advantage of this dataset is the large number of NBPs observed with high spatial and spectral resolution providing simultaneous information of their intensity, velocity and magnetic field with a time cadence of a few seconds.

(S. S. Hasan & L. P. Chitta)

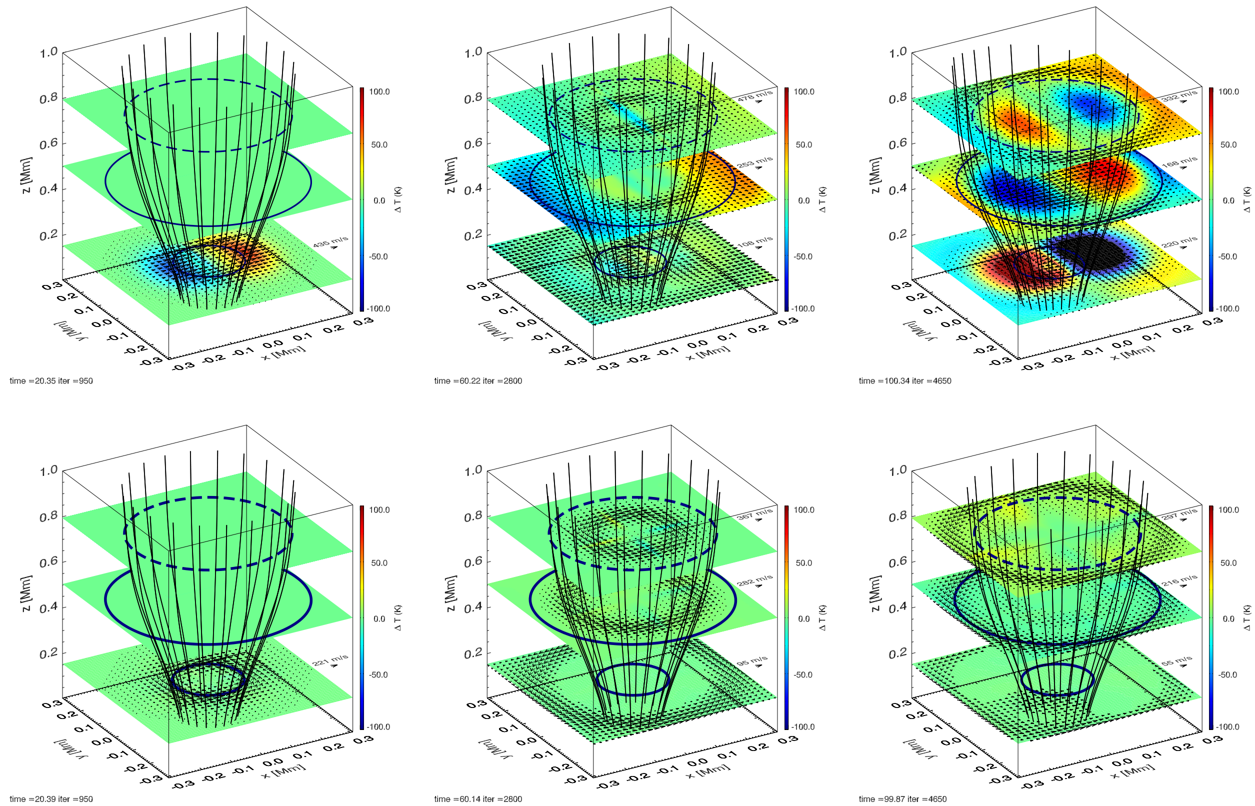

Figure 1.7: Temperature perturbations at t=20 s, 60 s, and 100 s at different heights in the solar atmosphere as a result of a transverse excitation (top) and torsional excitation (bottom) at the footpoints of a magnetic flux tube in the solar network. The blue dashed and dashed-dotted curves depict β=1 & 0.1 levels.

Segmentation of coronal features to understand the solar EUV & UV irradiance variability

The study of solar irradiance variability, which requires a careful tracking and monitoring of active regions (AR), quiet sun (QS), and coronal holes (CH) is of great importance in heliophysics and climate applications. The variablity of solar irradiance for a period of two years (January 2011 – December 2012) is studied, using the Lyman Alpha Radiometer (LYRA) a solar UV radiometer, The Sun Watcher using APS and Image Processing (SWAP, an EUV imager) on board Proba-2, and Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). Spatial Possibilistic Clustering Algorithm (SPoCA) to identify and track the segmented features from the EUV observations of SWAP and AIA is used. The resulting parameters such as the integrated intensity, and fractional area contribution of these features are studied and compared with the LYRA channel 3 irradiance measurements. The authors report the results obtained from SDO/AIA and PROBA2/SWAP images taken from January 2011 to December 2012 and compare the resulting integrated full-disk intensity values with PROBA2/LYRA irradiance values. The authors have determined the contributions of the segmented features to EUV & UV irradiance variations. The variations of the parameters resulting from the segmentation, namely the area, mean intensity, and relative contribution to the solar irradiance, are compared with LYRA irradiance. It is found that the active regions have a great impact on the irradiance fluctuations, whereas the quiet Sun is the greatest contributor to the solar irradiance, up to 60 % and active regions will have contribution only around 10 %. It is also found that the area of the features is highly variable and needs to be accounted in explaining the irradiance variations. It is successfully shown that it is possible to use EUV telescopes in order to measure irradiance fluctuations. This allows us to extract the different features and to quantify the contribution of each part to the total solar irradiance. This study also shows that SPoCA is viable, and that the segmentation of images can be a useful tool.

(S.T. Kumara, R. Kariyappa, J. J. Zender, G. Gabriel*, L. P. Chitta, V. Delouille*, L. Dame* & J. F. Hochedez*)*

Observations and modeling of the emerging extreme-ultraviolet loops in the quiet Sun as seen with the Solar Dynamics Observatory

The authors have used data from the Helioseismic and Magnetic Imager (HMI) and the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO) to study coronal loops at small scales, emerging in the quiet Sun. With HMI line-of-sight magnetograms, they have derive the integrated and unsigned photospheric magnetic flux at the loop footpoints in the photosphere. These loops are bright in the EUV channels of AIA. Using the six AIA EUV filters, they have constructed the differential emission measure (DEM) in the temperature range 5.7 – 6.5 in log T (K) for several hours of observations. The observed DEMs have a peak distribution around log T $\approx$ 6.3, falling rapidly at higher temperatures. For log T $<$ 6.3, DEMs are comparable to their peak values within an order of magnitude. The emission-weighted temperature is calculated, and its time variations are compared with those of magnetic flux. They present two possibilities for explaining the observed DEMs and temperatures variations. (1) Assuming that the observed loops are comprised of hundred thin strands with certain radius and length,the authors tested three time-dependent heating models and compared the resulting DEMs and temperatures with the observed quantities. This modeling used enthalpy-based thermal evolution of loops (EBTEL), a zero-dimensional (0D) hydrodynamic code. The comparisons suggest that a medium-frequency heating model with a population of different heating amplitudes can roughly reproduce the observations. (2) They also consider a loop model with steady heating and non-uniform cross-section of the loop along its length, and find that this model can also reproduce the observed DEMs, provided the loop expansion factor γ 5–10. More observational constraints are required to better understand the nature of coronal heating in the short emerging loops on the quiet Sun.

(L. P. Chitta, R. Kariyappa, A. A. van Ballegooijen, E. E. DeLuca*, S. S. Hasan & A. Hanslmeier*)*

Thermal structure of coronal loops

The physical mechanism responsible for heating the solar corona to multi-million kelvin temperatures is not clearly understood yet. Any improvement in the knowledge of coronal loops, which are regarded as basic building blocks of solar corona, can help us in solving the coronal heating problem. Understanding the thermal structure of coronal loops is crucial for determining the exact plasma heating mechanism. To study this, a portion of the solar corona is observed simultaneously in four forbidden iron emission lines in the visible and near infrared part of the spectrum. These observations were made on several days using a ground based coronagraph, located at Norikura, Japan. Temperature profiles along 18 loop structures observed on 4 different days, were computed using temperature sensitive emission line ratios. Line pairs with closer peak formation temperatures, such as (Fe XIV, Fe XIII) and (Fe XI, Fe X) are chosen since they mostly represent the emission from same plasma volume. The loops which were observed in hotter lines show a negative temperature gradient along the loop whereas that observed in colder lines show a positive temperature gradient. Figure 1.8 displays the temperature profiles along two different loops observed in the hotter (left panel) and colder (right panel) line pairs. The solid line overplotted in each panel represent the linear fit to the data. This implies that the loop tops appear hotter or colder depending on the line pair chosen.

Theoretical models indicate that the temperature along a uniformly heated stable hydrostatic loop gradually increases from its foot point and peaks at the loop top. Also, if the loop is non-uniformly heated with bulk of the energy deposition taking place close to its foot point, then the temperature maximum can occur well below the loop top leading to a negative temperature gradient. But the data chosen in this analysis is based solely on the signal-to-noise and similar kind of loops structures behave differently when observed in different line pairs. Taking the generality of the results into account and the number of loops studied, this behavior seems to be common. To explain this, gradual interaction between different temperature plasma has been proposed. This is possible if the loop structures studied here are multi-stranded and multi-thermal. However, the exact physical mechanism responsible for this interaction remains to be explored. These results were published in ApJ Letters.

(S. Krishna Prasad, J. Singh, & K. Ichimoto)*

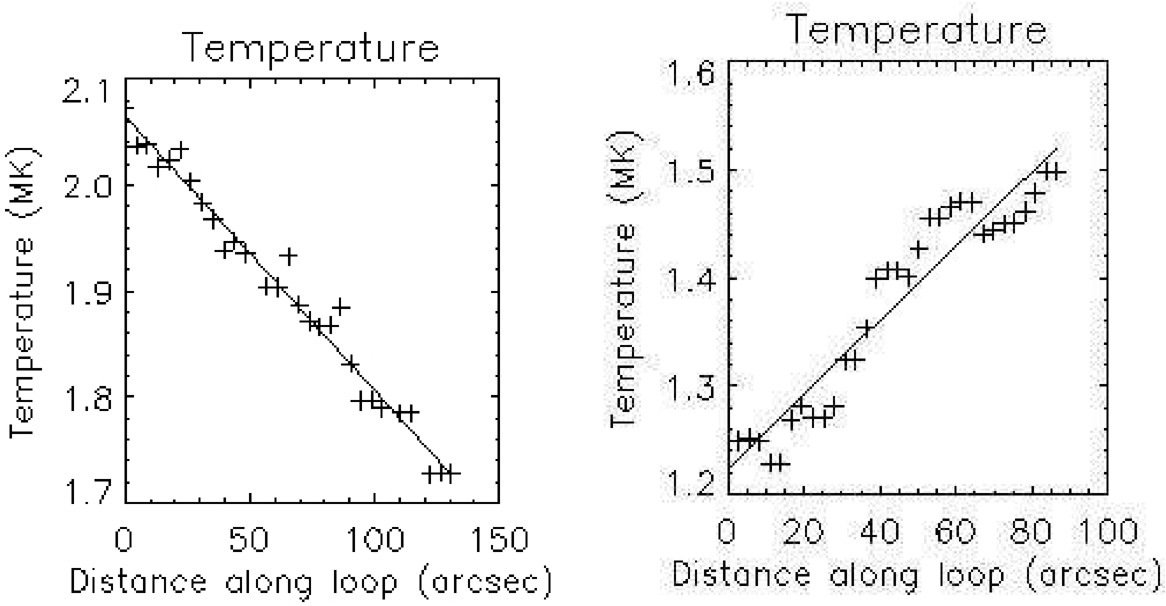

Figure 1.8: Estimated temperature values along two different loop structures using emission line ratios. The solid line overplotted in each panel represent the linear fit to the data.

Depth dependence in the differential rotation of sunspot groups

The author analyzed the Greenwich and Solar Optical Observing Network (SOON) sunspot group data during May/1874 – December/2011 and determined the latitudinal dependencies in the mean rotation rate of the sunspot groups over the whole aforementioned period by averaging the daily values of the rotational velocities (ω) of sunspot groups in 2° latitude intervals and also by fitting the whole period daily data into the equation (differential rotation law) $\omega(\phi) = A + B \sin^2 \phi$, where ϕ is the corresponding heliographic latitude. It is found that a large portion (up to $\approx 30°$ latitude) of the rotational profile that is obtained from the sunspot group data lies between the corresponding profiles at $0.94R_{\odot}$ – $0.98R_{\odot}$ determined from the Global Oscillation Network Group (GONG) measurements, where $R_{\odot}$ represents the Sun's radius. Since the rotation rates of tracers depend on the life times/sizes/age of the tracers, the author also determined the latitudinal dependence in the 'initial rotation rates' (first two days heliographic positions of the sunspot groups are used) of the sunspot groups by classifying the sunspot groups on the basis of their life times: 2 – 3 days, 4 – 5 days, 6 – 8 days, and > 8 days, and found that the portions up to 25° latitude in the profiles of the mean initial rotation rates of the ≤ 8 and >8 days lived sunspot groups are somewhat close to those of the internal rotation at $0.94R_{\odot}$ – $0.96R_{\odot}$ and $0.8R_{\odot}$, respectively (see Figure. 1.9). It is widely believed that magnetic flux, in the form of large flux tubes, emerges to the surface–presumably from near the base of the convection zone (where the dynamo process is believed to be taking place)– and responsible for sunspots and other solar active phenomena. However, according some models the sunspots form just beneath the surface. There are also suggestions/arguments that the sunspot form in different layers throughout the convection zone. The above results largely consistent with these suggestions/arguments, but the same results also support the idea that large magnetic structures might be generated near the base of the solar convection zone, many of the large magnetic structures may be fragmenting or branching into smaller structures while buoyant rising through the solar convection zone, i.e., small magnetic structures may be fragmented or branched parts of the large magnetic structures (as suggested in the author's earlier study). Some scientists argued that the dynamical disconnection of sunspots from their magnetic roots should take place during the final phases of their magnetic structures' buoyant ascent towards the surface.

(J. Javaraiah)

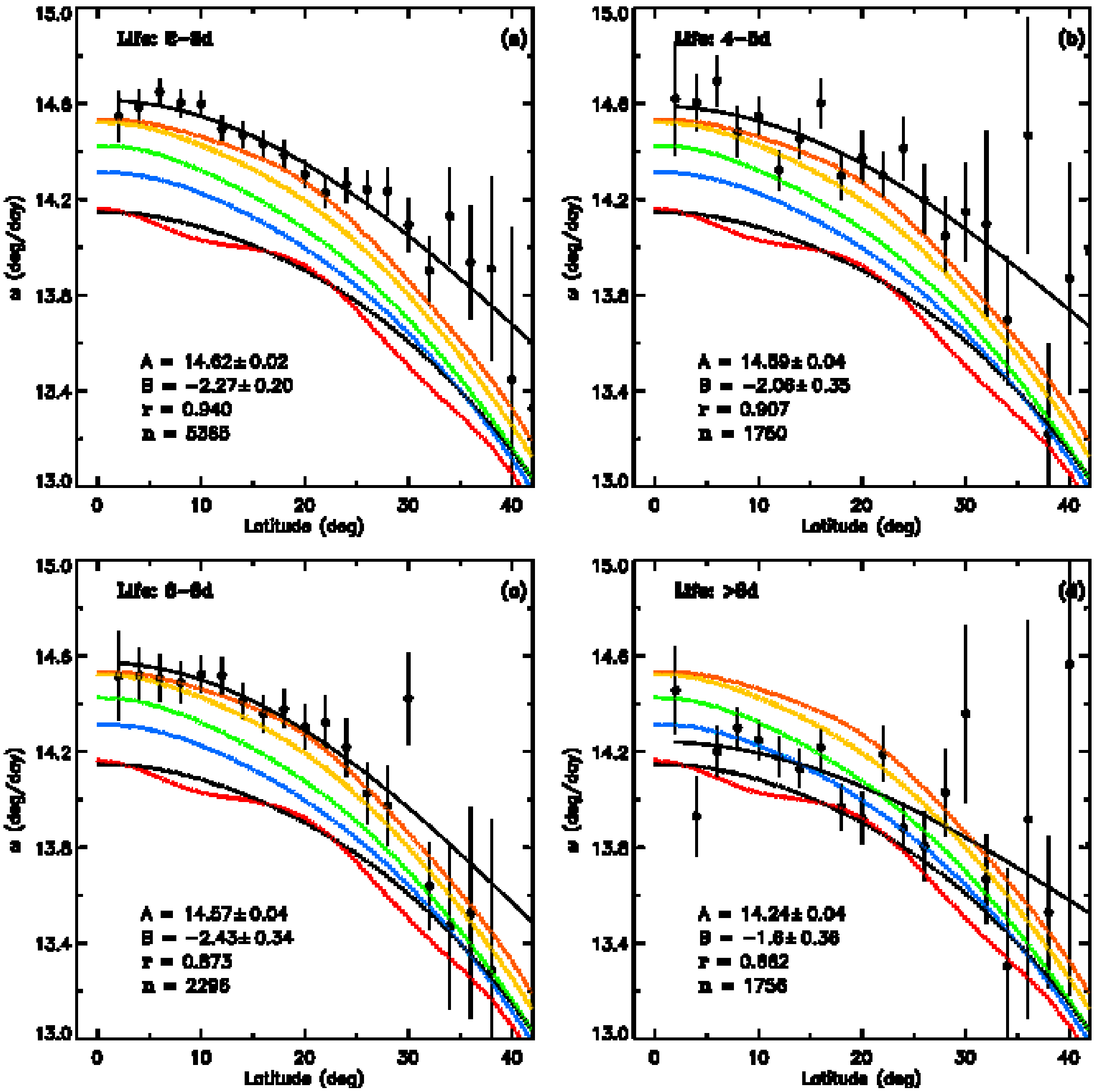

Figure 1.9: The latitudinal dependence of the mean 'initial rotation rates' of the sunspot groups whose life times are in the ranges: (a) 2 – 3 days, (b) 4 – 5 days, (c) 6 – 8 days, and (d) >8 days, determined by averaging the daily rotation rates of sunspot groups obtained from the Greenwich and SOON sunspot group data during May/1874 – December/2011 over 2° latitude intervals, $1^\circ - 3^\circ$, $3^\circ - 5^\circ$, $5^\circ - 7^\circ$,. . . ,$40^\circ - 42^\circ$ (plotted at 2°, 4°, 6°,. . . ,42°). The error bars represent $1s$ level, where s is the standard error. The solid curve represents the corresponding mean profile deduced from the values (also shown) of the coefficients A and B of differential rotation obtained from the total number of daily data (n). The different colored-dotted curves represent the latitudinal dependencies in the mean (over the whole period 1995 – 2009) plasma rotation rates deduced from the GONG data at the different depths: black, blue, green, yellow, light-red, and red colored-dotted curves represent the profiles at depths 0.75 $R_\odot$, 0.80 $R_\odot$, 0.85 $R_\odot$, 0.90 $R_\odot$, 0.95 $R_\odot$, and 1.0 $R_\odot$, respectively.

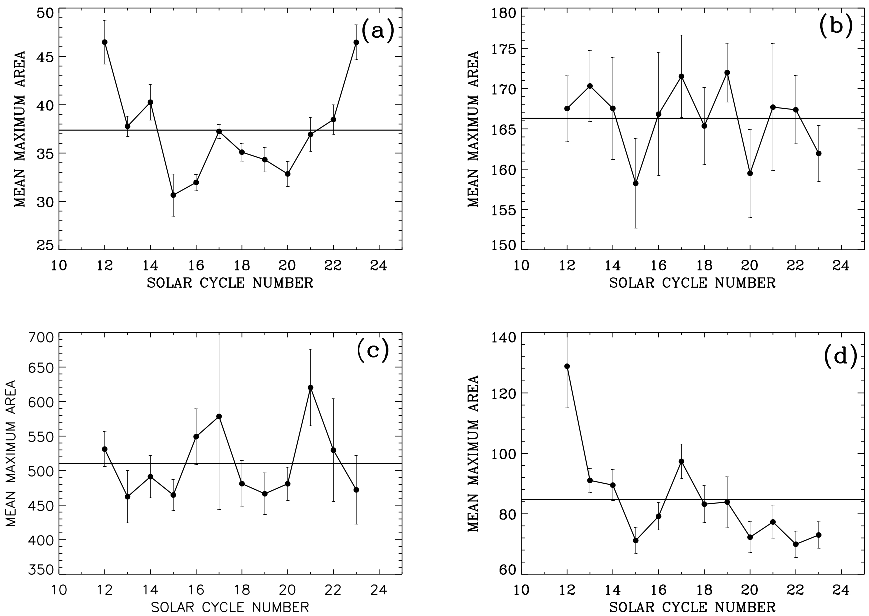

Figure 1.10: Cycle–to–cycle variations in the mean maximum sizes (in msh) of (a) small sunspot groups (SSGs), (b) large sunspot groups (LSGs), (c) big sunspot groups (BSGs), and (d) all sunspot groups, during cycle 12 – 23. The error bars represent the standard error.

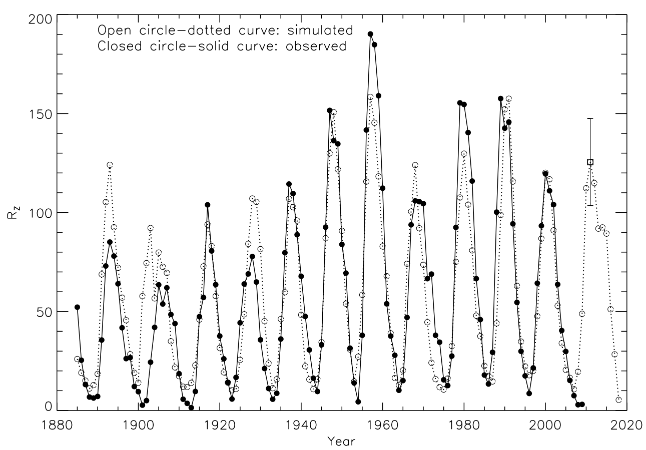

Figure 1.11: Plot of simulated and observed values of R_Z versus time (year). The square at year 2011 represents the maximum of the simulated cycle 24 and the error bar represents the standard deviation of a simulate value.

Long-term temporal variations in the areas of sunspot groups

Recently, the author analyzed the combined Greenwich and SOON sunspot group data during the period 1874 – 2011 and studied 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) sunspot groups. The author extended that analysis and studied variations in the mean maximum sizes (the mean values of maximum areas) of the aforementioned three classes of sunspot groups and also their combination. It is found that there is no significant correlation between the mean maximum size of any class of sunspot groups and the International Sunspot Number (R_Z), probably due to in a given time interval small sunspot groups/sunspots outnumber the large ones. A pattern of an approximate 9-year period cycle is seen in the variations of the mean maximum sizes of the large and the big sunspot groups during a solar cycle. On long-time scales it is found that there exists a strong 130 or more years cycle in the variation of the mean size of the small sunspot groups, whereas there is a hint on the existence of ≈ 44-year cycles in the variations of the mean maximum sizes of the large and the big sunspot groups (see Figure. 1.10). During the decline phase of cycle 23, there was a scarcity in the sunspot groups whose $A_M \leq 37$ msh, which may be related to the slow growth of sunspot groups during this period. During the minimum between cycles 23 and 24 may be due to the presence of a number of small sunspot groups whose $A_M > 37$ was larger than that of whose $A_M \leq 37$, the relatively large size coronal holes were present at low-latitudes and the total solar irradiance was very low.

(J. Javaraiah)

North-south asymmetry in solar activity and solar cycle prediction

Prediction of yearly mean monthly sunspot number: Many attempts have been made to predict a solar cycle (including amplitude, length, etc.) by using old cycles' data with a belief that solar magnetic field persists for a quite sometime. The magnetic fields at different latitudes during different time-intervals of a cycle might contribute (/related) to the activity at the same or different latitudes during its following cycle(s). Recently, the author by using this hypothesis and and by analyzing the combined Greenwich and SOON) sunspot group data during 1874−2006 made 5 - 6 prediction for the amplitudes of solar cycle 24. Now SOON data are available for 5 more years. The author analyzed the extended data and found that there exists a high correlation (88% from 125 data points) between the sum of the areas of the sunspot groups in $0° - 10°$ latitude interval of the southern hemisphere during a Qth year (middle year of 3-year smoothed time-series) and the annual mean smoothed monthly International Sunspot Number (R_Z) of $(Q + 9)$th year, indicating that it is possible to predict the annual mean R_Z by 9-year advance. This relationship yielded the following (also see Figure. 1.11): 125 ± 22 for the amplitude (R_M, *i.e.* the largest R_Z) of solar cycle 24, the maximum of this cycle might have already been taken place in the year 2011 and in 2014 a secondary peak may occur, the rise to maximum may be also steep in this cycle as that of cycle 23, and the next minimum may be also weak similar to the last (between cycles 23 and 24) very weak minimum.

An early prediction for the amplitude of the solar cycle 25: Recently the SOON sunspot data were available for more number of years and the minimum epoch of of cycle 24 is known. Thus, by using the relationship (that was earlier found by the author) between the difference in the sums of the areas of sunspot groups in $0° - 10°$ latitude intervals of the Sun's northern and southern hemispheres–and in the time interval of -1.35 year to $+2.15$ year from the time of preceding minimum of a solar cycle–and the amplitude (R_M) of the cycle, the author predicts that the amplitude (84 ± 10) of solar cycle 25 would be about 16% lower than the value that is predicted for the amplitude (100 ± 10) of solar cycle 24 and by about 30% lower than the observed amplitude of solar cycle 23 (also see Figure. 1.12). However, the author also found a much lower amplitude (66 ± 13) for solar cycle 24. In fact, this low value seems to be more close to reality as per the current trend of sunspot activity and may be having a better physical background. However, this method can be used for prediction of the amplitude of cycle 25 only after the epoch of maximum of cycle 24 known. There is also an indication of the upcoming minimum of the current Gleissberg cycle will take place in solar cycle 25 and the cycle pair (24, 25) will be a part of the current long-term minimum, which may be similar to the recent Modern Minimum (or Dalton Minimum).

(J. Javaraiah)

Dynamic properties of sunspots

Sunspot observations from Kodaikanal Observatory in the form of digitized data were used to study the properties of sunspots with regard to the ratios of the areas of their penumbrae to umbrae. It was found that (a) in regular sunspots, the ratio shows an increase with increasing collective strength of opposite polarity spots and pores in the vicinity, (b) in the presence of mixed polarity pores, implying flux emergence in the region, the increase in relative area of penumbra is the highest, (c) in the presence of flux emergence accompanied by pore sized blob(s) present in it, the penumbra is very significantly enlarged, by up to 50% on average, and (d) in the presence of a light bridge, and also when the umbra is in the process of splitting or is just split, the relative area of penumbra is significantly reduced implying that the penumbra has shrunk from its regular size. Interestingly, the relative area of penumbra in this phase was found to be independent of the ambient magnetic configuration. This study is further taken up with data from SDO. Preliminary results confirm the above results. An extensive study involving a large number of cases was taken up using the high resolution SDO data.

(S. P. Bagare)

Flare duration driven by abnormal rotation rates of bipolar sunspots

The association between the sunspots and flares is well known. But systematic studies of changes in the sunspot motions and the association to flare occurrences have been lacking. This issue was addressed in the paper (Hiremath and Suryanarayana, 2003, A&A

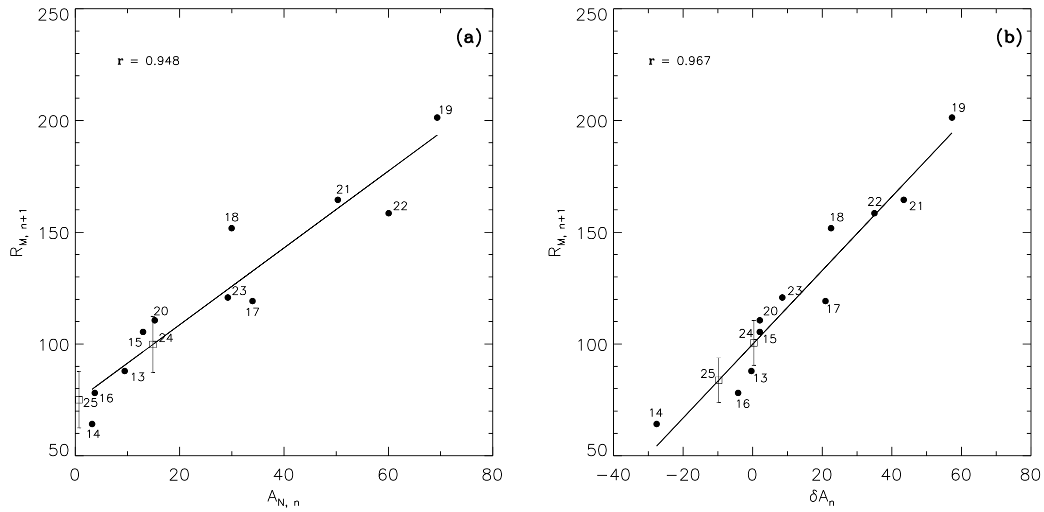

Figure 1.12: Plots of (a) the area sum $A_{\rm N}$ and (b) the north-south difference $\delta A(T^*_{\rm m}) = A_{\rm N} - A_{\rm S}$ during $T^*_{\rm m}$ of cycle n versus $R_{\rm M}$ of cycle $n+1$, where $n = 12, \ldots, 22$ is the Waldmeier cycle number. Near each data point the corresponding value of $n+1$ is shown. The solid lines represent the corresponding linear relationships. The squares represent the predicted values of the amplitudes of cycles 24 and 25. The error bars represent the square-roots of the deviations from the respective solid lines. The value of the corresponding correlation coefficients (r) are also shown.

Lett., 411, 497) in which the authors found that flares occur on the same day or later if sunspots experience abnormal rotation rates. This yielded a strong observational evidence for the connection between the two set of activities. Continuing in this direction such an association is being examined between the abnormal rotation rates of bipolar sunspots and the total flare duration. This is important because among different flare characteristics, the flare duration has a significant bearing on the occurrence of CMEs and particle acceleration which influence the terrestrial atmosphere. For this purpose they have considered sunspot data of Kodaikanal observatory and soft X ray flare data for more than 50 flare events. Further, a computer code is developed to determine the abnormal rotation rates of the sunspots and the flare duration. The preliminary results suggest that with a high statistical significance, a good association exists between the two set of activities

(G. S. Suryanarayana, K. M. Hiremath & S. P. Bagare)

Abnormal rotation rates of bipolar sunspots and energetics of the flares

By using Kodaikanal Observatory white light pictures, in the previous study (Hiremath and Suryanarayana, A&A, 411, L497, 2003) it is discovered that whenever either or both of the leading and following sunspots experience abnormal rotation rates, eventually flares occur. Although, it is found that occurrence of flares are mainly associated with the abnormal rotation rate of the sunspots, it is not clear whether energetics of sunspots due to abnormal rotation rates are also associated with the observed energetics of the flares. Keeping this view in mind, the authors consider one year Kodaikanal data of white light picture of the sunspots and, kinetic energy due to abnormal rotation rates of sunspots is computed and compared with the observed flare energy obtained from the x-ray flares. Preliminary result shows that magnitude of observed flare energy is comparable to the magnitude of kinetic energy attained due to abnormal rotation rates of the sunspots if the sunspots, while rising towards surface, impulsively accelerate around the region of $0.935R_\odot$ (where rotation shear layer exists) that transfer kinetic energy to the ambient plasma resulting in increase of thermal and radiative energy ultimately leading to flares. Present school of thought for explanation of genesis of flares is due to magnetic reconnection of opposite polarity sunspots although there is a lack of observational evidence. In contrast, alternative mechanism-impulsive acceleration and heating of the ambient plasma-due to abnormal rotation rates of the sunspots, proposed in this study, is consistent with the observations.

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

Atmospheric Water Vapor: A Possible Linkage between Solar Activity and Indian Summer Monsoon Rainfall

As part of the ISRO funded project, the authors continued to unravel the possible link between the solar activity and the Indian Monsoon rainfall. In the previous study, equation of precipitation from the coupled cloud hydrodynamic equations that are relevant to the Earth's atmosphere (troposphere) is derived and is numerically solved as an initial value problem. It is found that variability of the simulated rate of precipitation is almost similar to actual variability of the Indian Monsoon rainfall if the forcing variables cloud and rain water mixing ratios are parametrized in terms of the combined effect of external forcing as measured by sunspot and coronal hole activities with several well known solar periods (9, 13 and 27 days; 1.3, 5, 11 and 22 years). As the cloud and rain water mixing ratios depend directly on the ambient atmospheric precipitable water vapor, it is interesting to examine if there is any association between variabilities of atmospheric precipitable water vapor and the combined solar activity from past observations. In order to confirm or reject this reasoning, the authors have used the Smithsonian Astrophysical Observatory (SAO) data of precipitable water vapor for the historical period from 1923 through 1936 and find a strong association (see Figure 1.13) with the combined solar activity that substantiate the author's simulations. They also find that an increase of 0.1% of solar total irradiance from minimum activity to maximum activity increases the atmospheric precipitable water substantially ($\sim$ 200%). In other words, changes in the incoming solar radiation of $\sim$ 1 Watts/m^2 on the Earth's surface from one activity minimum to maximum results in increase of 200% precipitable water in the Earth's atmosphere. The authors strongly feel this is one of the important results that answers the long standing conundrum (that how the sun with nearly 0.1% variation of radiation energy influences strongly on the Earth's climate in general and Indian Monsoon rainfall in particular). Thus substantial increase of atmospheric precipitable water from solar minimum to maximum suggests that sun-climate and hence sun-Monsoon relationship must physically be a non-linear phenomenon.

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

Genesis of magnetic field structure of solar system objects from the catastrophic events

A standard paradigm for explanation of genesis of magnetic field structure of fast rotating solar system bodies such as Earth is a *dynamo mechanism* that requires Coriolis and Lorenz forces of similar orders. On the other hand, slow rotating objects such as Mercury that has a large-scale stationary magnetic field structure does not satisfies the criterion of dynamo mechanism. Further, although Earth and Mars have same rotation rates, dynamo mechanism is ceased to operate for the Mars at the present epoch. Hence, such intriguing questions can not be answered with a simple *dynamo mechanism* alone. For genesis of large scale magnetic field structure of slow rotating objects, can clues be got from the past history of solar system formation? During the early history of solar system formation, different bodies such as planets, natural satellites of the planets and asteroids, experienced heavy bombardments by the comets and space debris that might have completely altered the solar system bodies' internal as well as external physical structures and their dynamics respectively. Due to collision of external objects on the surface of the solar system objects, especially terrestrial planets (Mercury, Venus, Earth, Mass), moons of the planets and asteroids that have solid bodies, created impact craters on their surface and penetrated deep in the interior of the objects if kinetic energy of the impactor is very high. This penetration of impactor in the deep interior might have transferred kinetic and thermal energies that might have altered original thermal structure of the bodies that are inherited during the early solar system formation.

For example, as magnetic diffusivity is roughly inversely proportional to temperature structure of the interior, owing to heavy bombardment, magnitude of magnetic diffusivity might have substantially reduced and hence diffusion time scale of large scale magnetic field structure might have increased. Using this physical scenario, recently Hiremath (Planetary and Space Science, Volume 63, p. 8–14, 2013) came to a conclusion that the planet Mercury might have retained its large-scale magnetic field structure for billions of years. Thus, question remains as to is there any relationship between dynamics, morphology (such as diameter) of the craters due to heavy bombardment of the external objects with other physical parameters (angular velocity, angular momentum, magnetic field structure, etc.,) of the solar system bodies. In order to achieve this aim,

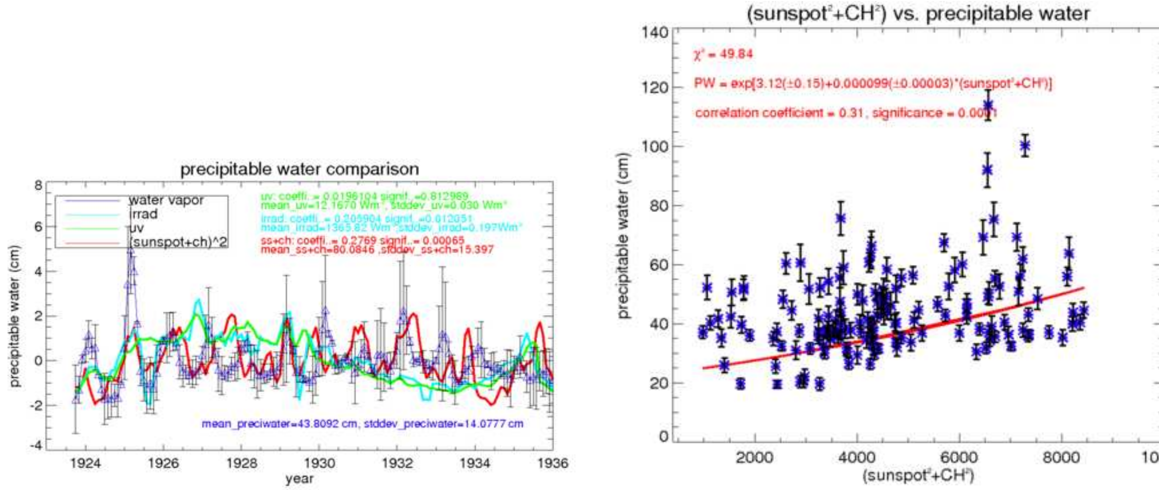

Figure 1.13: Left: The figure illustrates the association between the smoothed, annual-averaged atmospheric precipitable water (blue continuous curve) and three measures of solar activity variations (red: the combined solar activity index, i.e, square of the sum of sunspot and coronal hole data series; green and indigo colors: UV and total irradiance data, respectively, courtesy of Dr. J. Lean) for the years 1923-1936. The respective means and their standard deviations, correlation coefficient and its significance (small value suggests that correlation is not by chance) are over plotted. Whereas the figure on the right illustrates a scatter plot of monthly averaged atmospheric precipitable water and combined solar activity data respectively. In this plot, non-linear least square fit, χ^2, correlation coefficient and its significance are over plotted. The red continuous line represents the non-linear least square fit with a law of the form $Y = e^{(A+BX)}$ (where Y is precipitable water PW, X combined solar activity, A and B are constant coefficients that are determined from the least square fits).

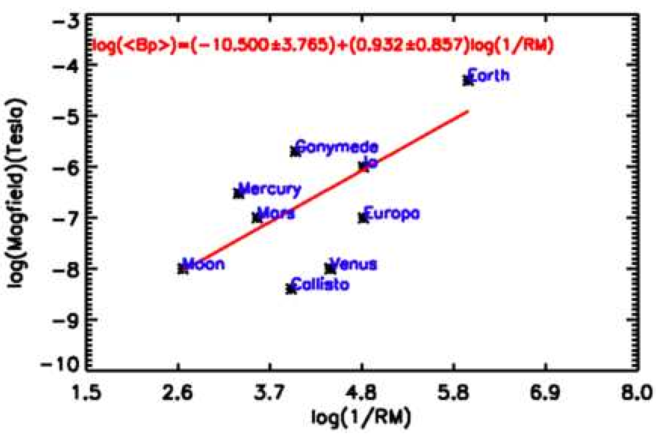

Figure 1.14: The figure illustrates the inverse of intensity of cratering RM versus strength of average dipole magnetic field structure of different solar system bodies. The red continuous line represents a linear least square fit.

available strength of magnetic field structure and, crater data of terrestrial planets (Mercury, Venus, Earth, Mars), Earth's Moon, some of natural satellites of Jupiter (Callisto, Europa, Ganymede and Io) are considered. For each object considered in this study, average crater diameter and crater impact parameter 'RM' (intensity of cratering, defined to be ratio of total cratered area to the total surface area of the object) are computed. Interestingly, preliminary results (see Figure 1.14) show that cratering impact parameter is directly proportional to strength of magnetic field structure. That means heavily cratered objects in the solar system have much reduced strength of magnetic field structure compared to less cratered objects. This result suggests that genesis and diverse intensity of magnetic field structure of terrestrial planets and their satellites and, some of Jupiter's satellites are attributed mainly due to catastrophic events occurred during the early history of solar system formation.

(K. M. Hiremath)

1.2 Stellar and Galactic Astrophysics

Young stellar population and ongoing star formation in the HII complex Sh2-252

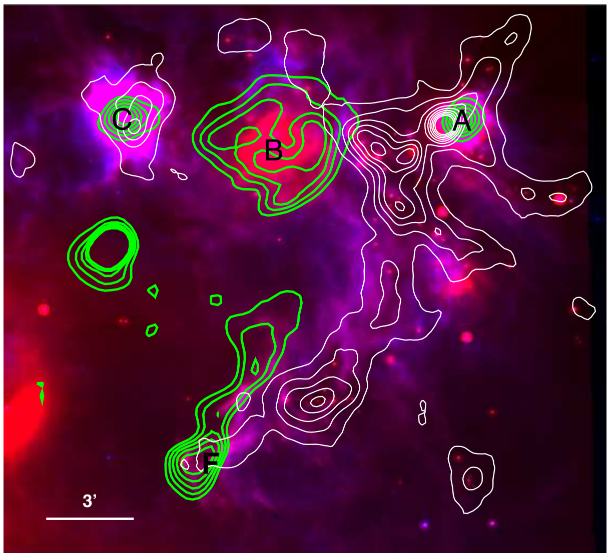

Figure 1.15: Colour composite image of the western half of Sh2-252 made from the 8.0 and 24 μm bands along with the 1.1 mm dust continuum emission map (white) and the low resolution continuum map at 1280 MHz (green). The sub-regions are marked in the figure.

An extensive survey of the star forming complex Sh2-252 has been undertaken with an aim to explore its hidden young stellar objects (YSOs) as well as to understand the structure and formation history. This complex is composed of five embedded clusters associated with the sub-regions A, C, E, NGC 2175s and Teu 136. Using NIR and MIR photometry the authors have identified over 600 YSOs and the spatial distribution of these YSOs shows that they are mostly clustered around the sub-regions in the western half of the complex. The SED and CMD based age analyses shows that the region A is the youngest ($\sim$ 0.5 Myr), the regions B, C and E are of similar evolutionary stage ($\sim$ 1-2 Myr) and the clusters NGC 2175s and Teu 136 are slightly evolved ($\sim$ 2-3 Myr). Morphology of the region in the 1.1 mm map shows a semi-circular shaped molecular shell composed of several clumps and YSOs bordering the western ionization front of Sh2-252. Our analyses suggest that next generation star formation is currently under way along this border and that possibly fragmentation of the matter collected during the expansion of the HII region as one of the major processes responsible for such stars. The authors observed a site of proto-cluster formation at the western outskirts of the complex sandwiched between the two relatively evolved compact HII regions A and B(see Figure 1.15).

(Jessy Jose, A. K Pandey, M. R Samal*)*

Galactic R CrB stars and the final He-shell flash object V4334 Sgr (Sakurai's Object): A comparison

Using the high-resolution optical spectra of H-deficient stars: R Coronae Borealis (RCB) stars and H-deficient carbon (HdC) stars, the C-abundances and the $12^C/13^C$ ratios are determined from C2 bands, which are potential clues to the origin and evolution of these stars. The surface chemical composition studies support the merger scenario (DD-scenario) for the origin of RCB/HdC stars, which involves the merging of a He white dwarf with a CO white dwarf. To compare with the C-abundances and the $12^C/13^C$ ratios determined for the merger products, i.e., RCB/HdC stars, the authors have determined the C-abundance and the $12^C/13^C$ ratio for the final flash (FF) object, V4334 Sgr (Sakurai's Object). The final flash object is a born-again asymptotic giant branch (AGB) star, which became H-deficient by experiencing the final helium shell flash in its post-AGB phase. The carbon abundance in Sakurai's object is 10 times higher than in the RCB star VZ Sgr, which is having the similar stellar parameters like Sakurai's object. On an average, the carbon abundance in the Sakurai's Object is about 10 to 100 times higher than in RCB stars as expected for FF-object. The $12^C/13^C$ ratio in Sakurai's object is 3.4, the equilibrium value, as expected for FF products unlike in RCB/HdC stars which are having high values (20 – 100) of $12^C/13^C$ ratio.

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

Spectroscopic survey for identifying H-deficient stars in the globular cluster: Omega Cen

The H-deficient stars are a rare group of supergiants spanning a range in their effective temperature. The origin and evolution of these stars is not yet clearly understood. Knowing their positions on the HR-diagram is very important in exploring their origin and evolution. The HR-diagram is well studied for the stars in the globular clusters. Hence, to study the origin and evolution of H-deficient stars in detail, the survey was conducted to identify new H-deficient stars in the globular cluster Omega Cen spectroscopically. The stars were selected from the tip of the giant branch with the visual magnitude ranging from ($12 < V < 14.5$). To increase the probability of finding H-deficient stars from the author's sample, the authors have used the J-H and H-K colors, in which the H-deficient stars are distinct from those of the normal giants and the dwarfs. Out of the 1337 bright ($12 < V < 14.5$) red-giants of Omega Cen, about 190 stars were finally selected as the most probable candidates for obtaining the low resolution spectra. The low resolution spectra were obtained from VBT, Kavalur, using the OMR spectrograph. The data were reduced and analyzed to identify the H-deficient stars by examining the strengths of H-alpha and Mg b lines including the strength of (0,0) MgH band. From author's analyses only one star is identified as the H-deficient candidate and from their theoretical predictions about 2 to 3 H-deficient stars are expected in Omega Centauri, which supports their observations.

(B. P. Hema & Gajendra Pandey)

Deriving the M-sigma relation for nuclear black holes in low surface brightness galaxies and void galaxies

The authors have derived the black hole masses in sample of low luminosity galaxies and isolated void galaxies. The nuclear black hole masses of the low surface brightness galaxies lies below the regular M-Sigma relation for bright galaxies. But the isolated void galaxies have masses closer to the M-Sigma correlation.

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

Moving groups in the Galactic disc

The phase space of the Galaxy's disc is known to contain substructures within the larger structures such as the thin and thick discs. Substructures include open clusters, OB associations, star-forming regions and stellar streams. The latter are also often referred to as moving groups. These are groups of gravitationally unbound stars scattered all over the sky with common kinematics. More than a dozen of moving groups such as Hyades, Pleiades, Arcturus, Hercules etc, have been detected in the solar neighbourhood so far. Many are being discovered with the current large stellar surveys, e.g; Radial Velocity Experiment (RAVE), Sloan Digital Sky Survey (SDSS) etc. It is important to understand how such kinematic groups came into existence in the Galaxy. The origin of the groups may lead to finding of evolution sequence of the Galaxy.

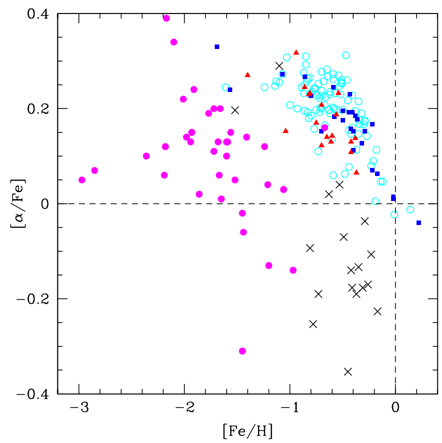

Figure 1.16: The [α/Fe] versus [Fe/H] plot. Red triangles: Arcturus stream, Blue squares: AF06 stream, Cyan open circles: Thick disk, Magenta filled circles: dSph satellite galaxies (Draco, Sculptor, Sextans, Ursa Minor, Carina, Fornax, Leo I), Black crosses: Sgr dSph

In the literature one finds three main scenarios to explain the moving group formation which are: a) disruption and dispersion of open clusters with time. The dispersed cluster members thus form moving groups as they have inherited kinematics from the parent cluster, b) the debris of accreted dwarf satellite galaxies too can form moving groups, c) insitu formation due to dynamical perturbations such as orbital resonance interaction with the non-axisymmetric components in the Galaxy such as the bar and/or the spiral arms. But none of these scenarios explain all the properties of these groups. A study has been undertaken by us to understand and find clues to their origin by way of chemical tagging of stars of kinematically selected samples in some of the well known moving groups. Two moving groups known as AF06 and Arcturus identified by their overdensity in the kinematic plane were chosen. High resolution spectroscopic study of 18 stars from the Arcturus stream and 26 stars from the AF06 stream has been performed. Kinematic properties indicate both the streams belong to thick disk component. Our results show that both streams are metal poor and very old (10-14 Gyr) with large range in metallicity implying their thick disk origin. Results show that neither stream can be interpreted as vestige of open cluster. Alpha element abundance trends are quite similar to thick disk abundance but diffrent from that of dwarf satellite galaxies in the Local group (see Figure 1.16). This may suggest that it is highly unlikely that either stream represents tidal debris from an accreted satellite galaxy. Thus, probably these moving groups owe their origin to insitu dynamical perturbations. However, recent simulations could not reproduce the high rotational lag of these streams using resonance interactions. Insitu formation may also occur due to dynamical perturbations introduced by merging satellite. These results are published in MNRAS. (425, 3188-3200, 2012).

(P. Ramya, Bacham E. Reddy & David L. Lambert)*

Stellar parametrization using Artificial Neural Network

An update on recent methods for automated stellar parametrization is given. Preliminary results of the ongoing program for rapid parametrization of field stars using medium resolution spectra obtained using Vainu Bappu Telescope at VBO, Kavalur, India is presented. Artificial Neural Network for estimating temperature, gravity, metallicity and absolute magnitude of the field stars has been used. The network for each parameter is trained independently using a large number of calibrating stars. The trained network is used for estimating atmospheric parameters of unexplored field stars. The paper appears in ASICS 6, 2013, eds P. Prugniel and H. P Singh.

(S. Giridhar, A. Goswami, A., Kunder, S. Muneer* & G. Selva Kumar)*

Investigation of variable star candidates in the globular cluster NGC 5024 (M53)

The authors have performed a careful investigation of 74 candidate variable stars reported recently for this cluster. While four candidates are new variables three of them are SX Phe type and one is a semi regular (SR) type red giant variable; they also tentatively confirm the presence of true variability in two other candidates. They are unable to investigate four other candidates because they are not in the database. However, it was found that the remaining 54 candidate variable stars are spurious detections where systematic trends in the light curves have been mistaken for true variability. The erroneous detections may have been caused by the adoption of a very low detection threshold used to identify these candidates. The results are published in 2012, MNRAS, 424, 2722.

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

Constraining parameters of globular cluster NGC 1904 from its variable star population

The analysis of 11 nights of V and I time-series observations of the globular cluster NGC 1904 (M 79) is presented. The authors searched for variable stars in this cluster and attempted to refine the periods of known variables, making use of a time baseline spanning almost 8 years. Their data was used to derive the metallicity and distance of NGC 1904. Difference imaging was used to reduce their data to obtain high-precision light curves of variable stars. The authors then estimated the cluster parameters by performing a Fourier decomposition of the light curves of RR Lyrae stars for which a good period estimate was possible. As a result out of 13 stars previously classified as variables, it can be confirmed that 10 are bonafide variables. The authors cannot detect variability in one other within the precision of their data, while there are two which are saturated in their data frames, but they do not find sufficient evidence in the literature to confirm their variability. The authors also detect a new RR Lyrae variable, giving a total number of confirmed variable stars in NGC 1904 of 11. Using the Fourier parameters, they find a cluster metallicity $[Fe/H]ZW = -1.63 \pm 0.14$, or [Fe/H] $UVES = -1.57 \pm 0.18$, and a distance of $13.3 \pm 0.4 kpc$ (using RR0 variables) or 12.9 kpc (using the one RR1 variable in their sample for which Fourier decomposition was possible).The results are published in 2012, A&A, 548, 92.

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

Difference image analysis: extension to a spatially varying photometric scale factor and other considerations

The authors present a general framework for matching the point-spread function (PSF), photometric scaling and sky background between two images, a subject which is commonly referred to as difference image analysis (DIA). They introduce the new concept of a spatially varying photometric scale factor which will be important for DIA applied to wide-field imaging data in order to adapt to transparency and airmass variations across the field-of-view. Furthermore, the authors demonstrate how to separately control the degree of spatial variation of each kernel basis function, the photometric scale factor and the differential sky background. They discuss the common choices for kernel basis functions within their framework, and introduce the mixed-resolution delta basis functions to address the problem of the size of the least-squares problem to be solved when using delta basis functions. They validate and demonstrate the author's algorithm on simulated and real data and also describe a number of useful optimizations that may be capitalized during the construction of the least-squares matrix and which have not been reported previously. Special attention is paid to presenting a clear notation for the DIA equations which are set out in a way that will hopefully encourage developers to tackle the implementation of DIA software. The results are published in 2013, MNRAS, 428, 2275.

(D. M. Bramich, K. Horne*, M. D. Albrow*, Y. Tsapras*, C. Snodgrass*, R. A. Street*, M. Hundertmark*, N. Kains*, A. Arellano Ferro*, R. J.Figuera* & S. Giridhar)*

Comprehensive abundance analysis of red giants in the open clusters NGC 2527, 2682, 2482, 2539, 2335, 2251 and 2266

The authors have analyzed high-resolution echelle spectra of red giant members for seven open clusters in the Galactic anticentre direction to explore their chemical compositions. Cluster membership has been confirmed by radial velocity. The spread in temperatures and gravities being very small among the red giants, nearly the same stellar lines were employed for all stars thereby reducing the abundance errors: the errors of the average abundance for a cluster were generally in the 0.02-0.05 dex range. The present sample covers Galactocentric distances of 8.3-11.3 kpc and an age range of 0.2-4.3 Gyr. A careful comparison of the author's results for the cluster NGC 2682 (M67) to other high-resolution abundance studies in the literature shows general good agreement for almost all elements in common.

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

Comparative modelling of the spectra of cool giants

The 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 aim to compare the results of deriving stellar parameters using different atmosphere models and different analysis strategies. The focus is set on high-resolution spectroscopy of cool giant stars. Spectra representing four cool giant stars were made available to various groups and individuals working in the area of spectral synthesis, asking them to derive stellar parameters from the data provided. The results were discussed at a workshop in Vienna in 2010. Most of the major codes currently used in the astronomical community for analyses of stellar spectra were included in this experiment. In this work 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 resulted 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 one is from a definitive abundance analysis. The results are published in A& A, 547, A108 (2012).

(T.Lebzelter, A. Goswami et al.)*

Polarimetric studies of carbon stars at high Galactic latitude

Very little is known about the polarimetric properties of CH stars and carbon-enhanced metal-poor (CEMP) stars although many of these objects have been studied in detail both photometrically and spectroscopically. The authors aim to derive polarimetric properties for a large sample of CEMP stars and CH stars to fill this gap. Multiband polarimetric observations are conducted in the first run for a sample of twenty nine objects that include twenty two CEMP and CH stars and seven polarization standards. Estimates of polarization are obtained using standard procedures of polarization calculation. Five objects in author's sample do not show any significant polarization over the different colours of BVRI. For the rest of the objects the derived percentage polarization estimates are $\leq 1\%$, and are found to exhibit a random behaviour with respect to the inverse of the effective wavelength of observations. Polarization also does not seem to have any correlation with effective temperatures of the stars. The authors polarimetric estimates indicate presence of circumstellar envelopes around these stars that are spherically symmetric or envelopes with little or no dust. In the plane of differential polarization, defined as the difference between the maximum and the minimum polarizations within the $BVRI$-bands, versus their visual magnitude, the stars appear to confine in a narrow band. The implication of this trend in understanding the nature of the circumstellar environment remains to be determined that requires detailed modelling. The results are published in A&A, 549, A68 (2013).

(Aruna Goswami & Drisya Karinkuzhi)

Subaru/HDS study of HE 1015-2050: spectral evidence of R Coronae Borealis light decline

Hydrogen-deficiency and a sudden optical light decline by about 6 - 8 magnitude are two principal characteristics of RCB stars. The high latitude carbon star HE 1015−2050 was identified as a hydrogen-deficient carbon star by Goswami et al. (2010) from low-resolution spectroscopy. Photometric data of the Catalina Real-Time Transient Survey gathered between Feb 2006 and May 2012, indicate that the object exhibits no variability. However, a high-resolution (R $\sim$ 50000) optical spectrum of this object obtained with the 8.2m Subaru telescope using HDS on the 13th January, 2012, offers sufficient spectral evidences for the object being a cool HdC star of RCB type undergoing light decline. In contrast to the Na I D broad absorption features, seen in the low-resolution spectra on several occasions, the high-resolution spectrum exhibits Na I D_2 and D_1 features in emission. A few emission lines due to Mg I, Sc II, Ti I, Ti II, Fe II and Ba I are also observed in the spectrum of this object for the first time. Such emission features combined with neutral and singly ionized lines of Ca, Ti, Fe, etc. in absorption, are reportedly seen in RCBs spectra in the early stage of decline or during the recovery to maximum. Further, the light decline of RCBs is ascribed to the formation of a cloud of soot that obscures the visible photosphere. Presence of such circumstellar material is evident from the polarimetric observations with an estimated V-band percentage polarization of $\sim$ 1.7% for this object.The results are published in ApJL, 763, L37 (2013).

(Aruna Goswami & Wako Aoki)*

Contribution of HdC stars to the Galactic enrichment: The Sr-rich HdC star HE 1015-2050

A fraction of the five Hydrogen deficient Carbon (HdC) stars and the fifty five HdC stars of R Coronae Borealis (RCB) type known so far in our Galaxy exhibit strong features of light neutron-capture elements such as Sr, Y and Zr usually attributed to the weak component of the s-process. Believed to be in a very short-lived evolutionary phase, their ejecta could have significantly contributed to chemical enrichment in the Galaxy. The origin of these stars have long been disputed and poorly understood due to a lack of statistically significant sample. The authors compare and contrast the abundance patterns of heavy elements observed in HdC stars and Carbon-Enhanced Metal-Poor (CEMP) stars to explore a common origin at least for a subset of these objects. They comment on the unique spectral characteristics of the recently discovered HdC star HE 1015-2050 with an anomalously strong features of Sr in its spectrum. The results are published in ASPC, 458, 127 (2012).

(Aruna Goswami & Wako Aoki)*

Spectroscopic characterization of FHLC stars and a newly found HdC star

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. From medium resolution spectral analyses of about 250 objects from this sample, the object HE 1015−2050, was found to be a hydrogen-deficient carbon (HdC) star. 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. This object, with its enhanced carbon and hydrogen-deficiency, together with anomalous s-process spectral features, poses a challenge as far as the understanding of its formation mechanism is concerned. Possible mechanisms for its formation in the framework of existing scenarios of HdC star formation are discussed. The results are published in ASICS, 6, 189 (2012).

(Aruna Goswami)

Probing the Brown dwarf desert with MARVELS

MARVELS (Multi-object APO Radial Velocity Exoplanet Large-area Survey) is one of the best surveys to date for exploring the "brown dwarf desert", the paucity of 15–80$M_{Jupiter}$ companions to solar-type stars. Large number of short and intermediate period planet system probed by MARVELS are the key to understanding of migration of giant planets after their formation. The discovery of a very low-mass stellar and a brown dwarf companion around a Solar-like star is reported in Ma et al. (2013, AJ, 145, 20). The star is a G0IV sub-giant, which also chromospherically active. The activity could be due to ongoing tidal spin-up of the host star. Another sub-stellar companion around a F type star is presented in Fleming et al. (2012, Aj, 144, 72F). This system also seem to be a binary system with a low mass companion. Planets around binary system is quite useful, since their orbital parameters can distinguish between core accretion and disk fragmentation models of planet formation.

(T. Sivarani on behalf of the SDSS-III MARVELS team)

Origin of CEMP stars

CEMP (Carbon enhanced metal poor) stars are metal poor stars below [Fe/H] < -2.0. Their [C/Fe] ratios are 10–1000 times higher than the sun. CEMP stars have received a lot of attention in the recent years. Their frequency at low metallicity seem to show a large increase. This has been checked by SDSS data and high resolution followup. The high resolution studies (e.g Aoki et al. 2013, AJ 145, 13) indicated that the CEMP stars below [Fe/H] < -3.0 have no s-process (slow neutron capture process elements mainly produced by AGB stars, e.g Sr,Y, Zr, Ba, La,Ce,Pb,Bi) enhancement and proposed a massive star origin to their abundances. Most of CEMP stars in the range -3.0 < [Fe/H] <-2.0, have s-process enhancement. Based on SDSS data, Susmitha & Sivarani (2013), derived Barium abundances for about 30,000 stars and show that 80% of the CEMP stars below [Fe/H] < -3.0 are CEMP-s stars. In an earlier work Carollo et al. (2012), presented that outer halo stars have higher CEMP fraction compared to inner halo of the Galaxy. Abundances and kinematics of inner/outer halo stars show that the outer halo stars may be formed from minor non-dissipative/dry merging events of low mass satellite galaxies similar to the ultra fain dwarfs. Lai et al.(2011, ApJ, 738, 51), found that indeed some of the ultra faint dwarf satellites, (e.g. Bootes dwarf), has 15% CEMP frequency.

(T. Sivarani, A. Susmitha Rani & W. Aoki et al.)*

Magnetoconvection (3-D) simulations of small-scale magnetic fields in stellar atmospheres

The authors have continued their study of stellar photospheric magneto-convective processes using a magnetohydrodynamic simulation code CO5BOLD, which can solve the MHD equations in 2- and 3- spatial dimensions. They have reported on first experiences with real-life applications using the MHD-module of CO5BOLD together with the piecewise parabolic reconstruction scheme and presented preliminary results of stellar magnetic models with Teff = 4000 K to Teff = 5770 K. (see Figure 1.17).

(S. P. Rajaguru & Oskar Steiner)*

Evolution of irradiated clouds

Turbulence plays a crucial role in regulating the star-forming history and shocks are considered to be important sources of turbulence within molecular clouds. The authors prepared high-resolution, 3-d numerical simulations where initially turbulent molecular clouds were irradiated by an external source of ionising radiation. Turbulence introduced by this radiation generated dense filamentary clouds at the junction of these clouds. This is consistent with the observations of typical star-forming clouds. Shown here is a rendered density image of an irradiated star-forming cloud. (see Figure 1.18)

(S. Anathpindika)

Gravoturbulent fragmentation and the origin of the stellar initial mass function

Continuing with the idea of turbulence and turbulence-related fragmentation the effect of the strength of turbulence on the evolution of molecular clouds was examined. The distribution of masses of dense clumps of molecular gas and prestellar cores was derived and shown to be consistent with that deduced via observations of molecular clouds. Shown below is the result from one such calculation. (see Figure 1.19)

(S. Anathpindika)

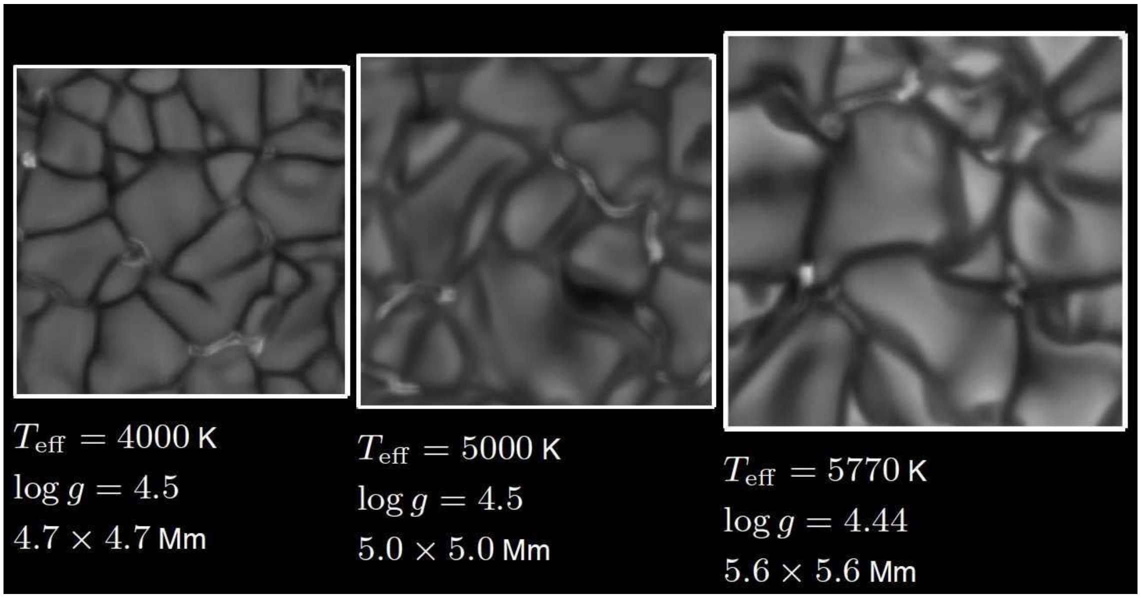

Figure 1.17: Emergent bolometric intensity of models with effective temperature, surface gravity, and field-of-view as indicated. The initial models were supplemented with a homogeneous, vertical magnetic field of 50 G and advanced for 1 to 3 hours using HLLMHD with PP reconstruction.

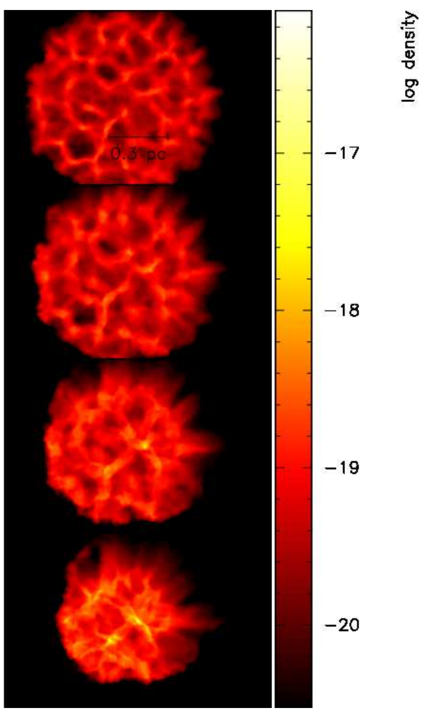

Figure 1.18: Shown here is a rendered density image of a turbulent cloud exposed to a source of strong ionising radiation (source at the bottom left-hand corner). The radiation induced shocks generate turbulence within the cloud that produces dense filamentary structure, potential sites for the formation of prestellar cores. However, actual formation of cores not shown here for want of space.

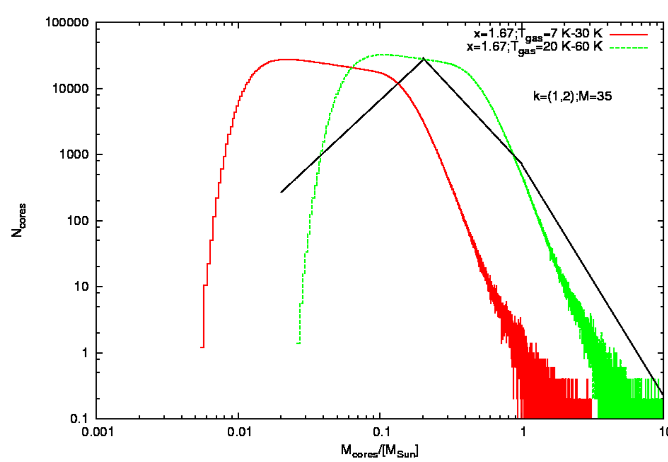

Figure 1.19: Shown here is a sample calculation where relatively higher modes (6,8) are driven by a strongly turbulent velocity field (Mach 35). The result is a distribution of core-masses shown by the histogram and fitted by a power-law.

On the evolution of starless cores

One of the principle questions while studying the formation of stars is the dynamical stability of prestellar cores. Recent observations of young star-forming clouds have shown the existence of cores that show little evidence of star-forming activity. These are the so called starless cores. The authors constructed 3-d hydrodynamic models to examine the formation and stability of such cores. It was shown that a radial inflow of gas can assemble such cores.

(S. Anathpindika & James di'Francesco)*

Evolution of irradiated turbulent clouds and modes of triggered star formation

Gas within molecular clouds (MCs) is turbulent and unevenly distributed. Interstellar shocks such as those driven by strong fluxes of ionizing radiation (IR) profoundly affect MCs. While small dense MCs exposed to a strong flux of IR have been shown to implode due to radiation-driven shocks, a phenomenon called radiation-driven implosion, larger MCs, however, are likely to survive this flux, which, in fact, may produce new star-forming sites within these clouds. This hypothesis has been examined using the smoothed particle hydrodynamics algorithm and simulations are performed for three choices of IR flux spanning the range of fluxes emitted by a typical B-type star to a cluster of OB-type stars. The extent of photoablation depends on the strength of the incident flux and a strong flux of IR severely ablates an MC. Consequently, the first star formation sites appear in the dense shocked layer along the edges of the irradiated cloud. Radiation-induced turbulence readily generates dense filamentary structure within the photoablated cloud although several new star-forming sites also appear in some of the densest regions at the junctions of these filaments. Irrespective of the nature of turbulence, the protostellar mass functions(MFs) derived in this study follow a power-law distribution. When turbulence within the cloud is driven by a relatively strong flux of IR such as that emitted by a massive O-type star or a cluster of such stars, the MF approaches the canonical form due to Salpeter and even turns over for protostellar masses smaller than $0.2M_{\odot}$.

(S. Anathpindika & H. C. Bhatt)

Study of young stellar objects and associated filamentary structures in the inner Galaxy

Star formation processes in the inner Galactic regions are important to understand as it happens in an environment of relatively higher density and metallicity. Relative to the low-mass star formation processes, the high mass star formation mechanism is poorly understood. the authors present a study of star forming regions towards the Galactic center. This region is suggested to be undergoing high mass star formation as revealed by previous studies. The region of their interest is the inner Galactic plane, in the longitude-latitude range, $10^0 < l < 15^0$ and $-1^0 < b < 1^0$. A total number of 1107 Class I and 1566 Class II sources are identified in this Galactic region. With the help of GLIMPSE 5.8 μm & 8 μm images, the authors have identified the presence of 10 major star forming sites in the Galactic mid plane, of which 8 of them are filamentary while 2 are clusterings of Class I & II sources. Most of the Class I sources are found to be aligned along the length of these filamentary structures, while Class II sources have a random distribution. Mass and age distribution of 425 Class I and 241 Class II sources associated with filaments & clusterings are studied using SED analysis. Most of the Class I sources detected have mass $> 8M_{\odot}$, while Class II sources have relatively low mass. Class I sources have ages ≤ 0.5 Myr, while Class II sources have ages in the range $\sim$0.1–3 Myr. Along with the help of high mass star forming tracers, the authors demonstrate that the 10 regions studied here are forming a large number of high-mass stars.

(B. Bhavya, A. Subramaniam & V. C. Kuriakose*)*

Novae

Classical novae (CNe) are interacting binaries in which a white dwarf (WD) accretes gas from a main sequence companion, and the build up leads to a thermonuclear runaway (TNR) in the surface material. This generates a fireball, leading to the visual brightening that allows us to detect these events. This is accompanied by the ejection of around $10^{-4}M\odot$ of material at velocities of 200 to 5000 km s^{-1}. Planetary nebulae (PNe) are the ejected envelopes of evolved stars, which become visible as they expand at a few 10s km s^{-1} to the point where the hot stellar core of the progenitor is able to illuminate them. This core cools to become a WD, and the PN fades away over around 10,000 years. Around 15% of these Central Stars of Planetary Nebulae (CSPN) are believed to be binary in nature. The connection between CNe and PNe is clear – the WD in a nova must have ejected its envelope at some point in the past; alternatively such systems may have had a common envelope phase, also leading to the ejection of a proto–PN. Until 2008 only one CNe had been associated with a PN – GK Per, which underwent a nova eruption in 1901. A PN was detected associated with the nova V458 Vul, following detection of the star's outburst on 2007 August 8, making this only the second example. In an attempt to study the environs of this unique object, V458 Vul was imaged in the HI continuum using the Giant Metre Wave Telescope (GMRT). A shell-like H I structure associated with, and in slightly offset position from, the nova V458 Vul was detected. High spectral resolution observation with the Giant Metre Wave Radio Telescope made it possible to detect the narrow emission line of width 5 km s^{-1}, and to study the detailed kinematics of this broken and expanding shell. Assuming a distance of 13 kpc to the system, as quoted in literature, estimated H I mass of the nebula is about 25 M$\odot$. However, there are some indications that the system is probably closer than 13 kpc. The observed narrow line width of the H I emission suggests that the shell consists of mostly cold gas. The asymmetric morphology and the off-centred stellar system indicates past strong interaction of the mass loss in the asymptotic giant branch phase with the surrounding interstellar medium.

(Nirupam Roy, N. G. Kantharia*, S. P. S. Eyres*, G. C. Anupama, M. F. Bode*, T. P. Prabhu & T. J. O'Brien*)*

Supernovae

Core-collapse supernovae (CCSNe) result from the violent death of massive stars with initial masses greater than 8 M$\odot$. Considerable diversity is observed in the photometric and spectroscopic properties of these objects, leading to their classification into various classes. The observed diversity in the properties of CCSNe is due to the state of the progenitor star's hydrogen and helium envelopes at the time of explosion, and their subclassification can be represented in the form of a sequence - IIP→IIL→IIb→Ib→Ic, which can possibly be interpreted as a sequence of stripping of the H envelope. The studies of the type IIb CCSNe have recently gained greater interest as they provide a link between the hydrogen rich type II (type IIP and type IIL) supernovae and the hydrogen deficient type Ib and Ic objects.

The type IIb supernova SN 2011fu discovered in the galaxy UGC 01626 was monitored in the optical region for a period of 175 days, beginning a few days after the explosion. $UBVRI$ photometry was done using the 2m HCT (IIA), the 1m ST (ARIES) and the 1.3m DFOT (ARIES), while low-resolution spectroscopic observations were done using the 2m HCT. The early-phase light curve showed a decline followed by early rise in all bands, indicating a possible detection of the adiabatic cooling/shock break-out phase. Modelling of the quasi-bolometric light curve suggested that the progenitor had an extended (1×10^{13} cm), low-mass (0.1 M$\odot$) H-rich envelope on top of a dense, compact (2×10^{11} cm), more massive (1.1 M$\odot$) He-rich core. The nickel mass synthesized during the explosion was found to be 0.21 M$\odot$, slightly higher than in other Type IIb SNe.

(Brajesh Kumar, S. B. Pandey*, D. K. Sahu, J. Vinko*, A. S. Moskvitin*, G. C. Anupama, V. K. Bhatt*, A. Ordasi*, A. Nagy*, V. V. Sokolov*, T. N. Sokolova*, V. N. Komarova*, Brijesh Kumar*, Subhash Bose*, Rupak Roy* & Ram Sagar*)*

Optical $UBVRI$ photometry and low resolution spectroscopy of the type IIb supernova SN 2011dh in M 51, covering the first year after the explosion, were made using the 2m HCT. With a peak V band absolute magnitude of $M_V = -17.12 \pm 0.18$ mag, SN2011dh was found to be a marginally faint type IIb event. The early phase light curve evolution of SN 2011dh was found to be very similar to SN 1993J and SN 2008ax, while the decline in the late phase was found to be faster than SN 1993J. The late phase decline in the B band was found to be steeper than in the R and I bands, indicating the possibility of dust formation. Analytical modelling of the bolometric light curve indicated $\sim 0.09\pm$ M$\odot$ of ^{56}Ni was synthesized during the explosion. The nebular spectra of SN 2011dh showed a box shaped emission in the red wing of the [OI] 6300-6363 Å feature, that was attributed to Hα emission from a shock excited circumstellar material. The analysis of nebular spectra indicated that ~ 0.2 M$\odot$ of oxygen was ejected during the explosion. Further, the [CaII]/[OI] line ratio in the nebular phase, of ~ 0.7, indicated a progenitor with a main sequence mass of 10-15 $M_\odot$, consistent with a yellow supergiant in a binary system, as indicated by studies of the HST images of the host galaxy, and hydrodynamic and binary evolutionary models.

(D. K. Sahu, G. C. Anupama & N. K. Chakradhari)*

Role of rotation and polar cap current on pulsar radio emission and polarization

By considering simultaneously the pulsar rotation and polar cap (PC)-current perturbations, for the first time, developed a more realistic curvature radiation model (Kumar, D. & Gangadhara, R. T., 2013, ApJ, arXiv1303.2787). The model explains the wide range in the behavior of polarization properties of

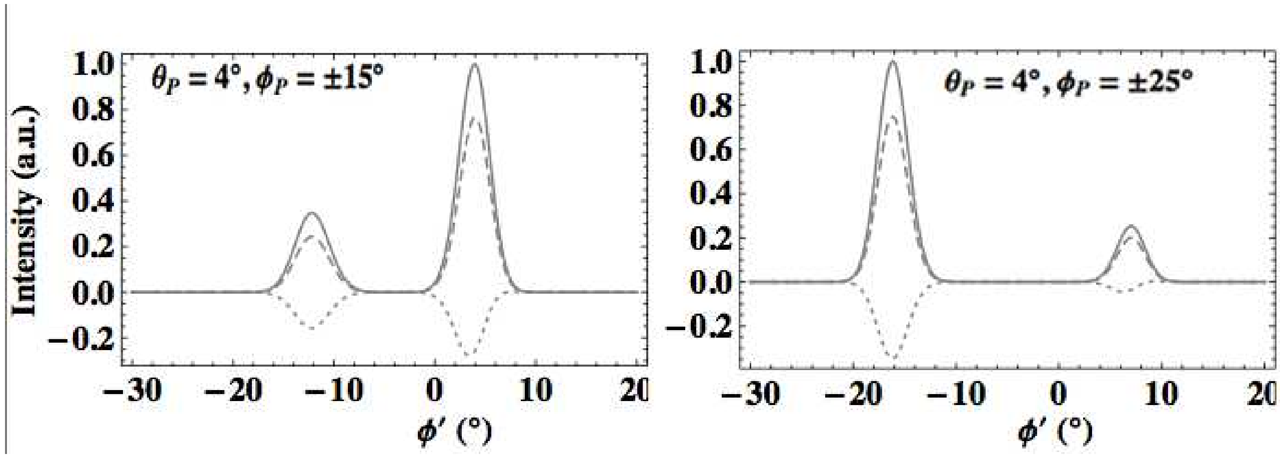

Figure 1.20: Simulated polarization pulse profiles: Intensity (solid line), Linear (dashed line) and Circular (dotted line) polarization.

pulsar radio emission. Because of the perturbations. There arises an asymmetry in the phase shift of intensity components and polarization position angle (PA) inflection point. In pulsar profiles the leading side components can become either stronger or weaker than the corresponding trailing side components of a given cone (see Figure 1.20). This is due to the induced asymmetry in the curvature of source trajectory and the sight line encountered asymmetry in the modulation strength between the two sides. Both the "antisymmetric" and "symmetric"-types circular polarization are possible within the frame work of curvature radiation when the perturbation and modulation are operative. The 'kinky' type distortions in the PPA swing could be due to the incoherent addition of modulated emissions in presence of strong perturbations.

(D. Kumar & R.T. Gangadhara)

Modelling of scattered light from envelopes around N-Tye stars

It is commonly observed that several super giants of O and B type stars and red giants have circumstellar shells, which are formed due to various physical phenomena. High resolution observations are obtained for these emission lines which are formed in these shells. Theoretical model is developed for a spherically symmetric model for the envelope, assumed to be optically thin. The emission line profiles are obtained in the context of circumstellar envelopes by taking required input parameters from Gustafsson et al.(A&A, 318, 535).

Using the above model line profiles are computed for the N-type star R Scl and compared with the observations which are available in the above mentioned article. These line profiles are computed at different radii of the star by considering the expansion velocity and mass loss rate etc. Work is under progress.

(M. S. Rao & Malcolm Gray)*

Radiative transfer modelling of dust in IRAS 18333–2357

The authors report results from their 1-D radiative transfer modelling of dust in the hydrogen-deficient planetary nebula IRAS 18333–2357 located in the globular cluster M22. A spectral energy distribution was constructed from archival UV, optical and IR data including observations from *AKARI* at its 18-, 65-, 90-, 140- and 160-μm photometric bands. An archival *Spitzer* spectrum shows several aromatic infrared bands indicating a carbon-rich dust chemistry in the shell. Their modelling requires a hot central star. The spectral energy distribution is well fit by a model with a density function which includes compression of the nebula by its interaction with the ISM. The model fit of the *AKARI* far-IR fluxes indicates the presence of a significant amount of cold dust down to a temperature of 52K at the outer edge of the nebula, at $13''.77\pm4''.47$ away from the central star. The authors study shows that there exists a large amount of excess emission, over the emission from thermal equilibrium dust, in the mid-IR region with their model values systematically lower than the observations. This excess emission is proposed to have originated from the thermally fluctuating dust grains in the intense UV field of the hot central star. The dust-to-gas mass ratio is found to be quite high with a value of ~0.335. Very likely, in the absence of photo-ionization being the main source of free electron energy for this PN, this energy could be supplied by the photo-electric emission from the very small grain population. The authors propose that the progenitor of this PN had possibly evolved from an early stellar merger case. The hydrogen-deficient nebula was likely to have resulted from a late thermal pulse which occurred in the central star.

(C. Muthumariappan, M. Parthasarathy & Y. Ita*)*

Theoretical model for light curves of X-ray binaries

The simplest model for an X-ray binary could be the system containing one non-degenerate star and one compact star; the former being the normal star and the latter of negligible size but gravitationally effective. The reflection effect thereby can be conveniently neglected. However, the model should take into account the non-spherical surface and the surface variations of temperature and gravity resulting from the tidal distortion. Light changes in such systems have been investigated by taking into consideration the self rotation and tidal effects due to the presence of the secondary component. The total potential of a star is given by the sum of rotational and gravitational potentials.

The theoretical model can be applied to X-ray binaries for explaining their light curves in general. The light curves analysis also provides the information about the binary system like, unseen third body or extendedness of the atmosphere and other orbital parameters of a binary system. Work is under progress.

(M. S. Rao & Diana Kjurkchieva)*

1.3 Extragalactic Astrophysics and Cosmology

Structure of the Large Magellanic Cloud from near infrared magnitudes of red clump stars

The Large Magellanic Cloud (LMC) is a disk galaxy with planar geometry. Koerwer (2009, AJ, 138, 1, hereafter K09) derived the structural parameters using the JH photometric data of red clump (RC) stars from the InfraRed Survey Facility Magellanic Cloud Point Source Catalog (IRSF MCPSC). This study, was unable to identify the warps in the southwestern end of the disk, which is evident in optical studies of the structure of the LMC using the RC stars. In the study of K09, the sample of RC stars have contamination from stars in the other evolutionary phases, such as the asymptotic giant branch (AGB) stars and the details of the method applied for the reddening correction is not clearly mentioned. Again, in the analysis, there is an overlap of sub-regions in the peripheral regions of the disk, which can cause some structural information to be averaged out. These points motivated us to re-estimate the LMC structure using the same NIR data of the RC stars used by K09.

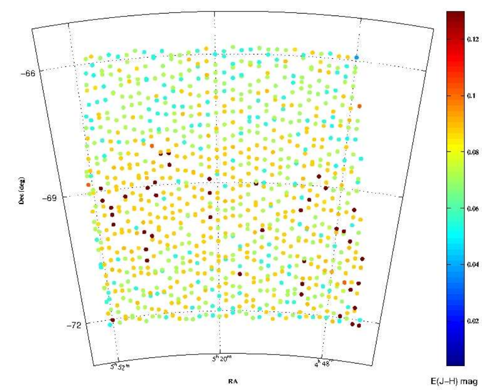

Figure 1.21: The two dimensional plot of reddening, $E(J-H)$.

The observed LMC region is divided into several sub-regions, and stars in each region are cross-identified with the optically identified RC stars to obtain the near infrared magnitudes. The peak values of H magnitude and $(J-H)$ colour of the observed RC distribution are obtained by fitting a profile to the distributions and by taking the average value of magnitude and colour of the RC stars in the bin with largest number. Then the dereddened peak H_0 magnitude of the RC stars in each sub-region is obtained. The right ascension (RA), declination (Dec), and relative distance from the centre of each sub-region are converted into x, y, and z Cartesian coordinates. A weighted least square plane fitting method is applied to this x, y, z data to estimate the structural parameters of the LMC disk. An intrinsic $(J-H)$ colour of 0.40 ± 0.03 mag in the SIRIUS IRSF filter system is estimated for the RC stars in the LMC and a reddening map based on $(J-H)$ colour of the RC stars is presented. An inclination of 25.7 ± 1.6 degrees and a $PA_{lon} = 141.5$ 4.5 degrees were obtained.

The authors estimate a distance modulus, $\mu = 18.47 \pm 0.1$ mag to the LMC. Extra-planar features which are both in front and behind the fitted plane are identified. They match with the optically identified extra-planar features. The bar of the LMC is found to be part of the disk within 500 pc. They find that the inner disk, within ~ 3 degrees, is less inclined and has a larger value of PA_{lon} when compared to the outer disk. (see Figure 1.21).

(S. Subramanian & A. Subramaniam)

The metallicity map of the Large Magellanic Cloud

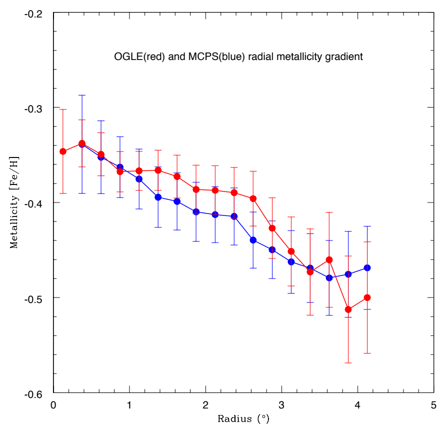

Figure 1.22: OGLE(red) and MCPS(blue) radial metallicity gradient.

A high resolution metallicity map of the LMC has been created using the OGLE III and MCPS photometric data. This is a complete first of its kind map of metallicity upto a radius of (4°- 5°), which will throw light on evolutionary history as well as star formation history of the LMC. The red giant branch is identified in the V, (V-I) colour magnitude diagrams of small sub regions within the galaxy. The slope of the red giant branch in each sub region is estimated, which is an indicator of the mean metallicity of the region. The estimated slope is calibrated to metallicity using spectroscopically derived metallicities of field red giants near the central region (Cole et al.2005) and star clusters (Grocholski et al. 2006) in the LMC . The bar region is found to be more metal rich and homogeneous (due to mixing by bar) as compared to the outer regions. The mean metallicity for the bar region and that of the whole LMC is estimated, which are found to be in agreement with previous results obtained for smaller pockets in the LMC. The mean radial metallicity gradient of the LMC is found to be very shallow till 4°. The eastern and western region have similar gradient in metallicity. The MCPS metallicity map exposes the metallicity trend in the northern and southern region of the LMC which compliments its OGLE III counterpart. A combination of OGLE III and MCPS shows metal poor ring whose location coincides with the accretion of metal poor gas from the SMC over a duration of (1–2) Gyr and in situ star formation. Other specific locations of metal poor regions are also identified from the combined map. At present a better method for calibration of MCPS metallicity map is being carried out. The future plan involves spectroscopic follow up study of identified metal poor regions. (see Figure 1.22).

(Samyaday Choudhury & Annapurni Subramaniam)

Study of faint star clusters in the LMC using Washington Photometry

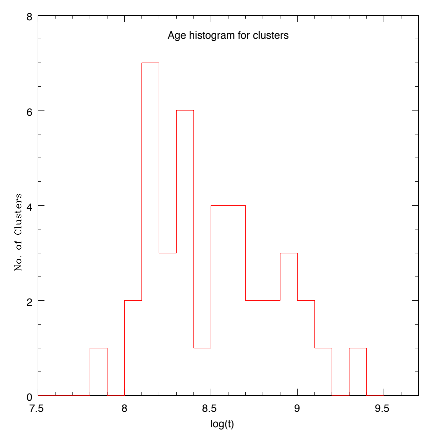

Figure 1.23: Age histogram for true clusters.

In an effort to increase the sample of parametrized clusters in the Large Magellanic Cloud (LMC) a study has been carried out using CCD Washington CT_1 photometry of stars in the field of 50 LMC clusters which are either unstudied or very poorly studied. Observations were taken using the 4.0m Blanco telescope in Chile, operated by CTIO, and are deep enough to identify the turn-off of faint, poorly populated old clusters. Data were downloaded from the SDM archive of the NOAO and reduced at IAFE in Argentina. The data was analysed to estimate the radii, reddenings and ages for these clusters. Out of the given sample, 34 of them can be categorized as true clusters, 10 as possible clusters or asterisms and the rest of the cases are discarded due to insufficient data. The cluster parameters thus estimated are more accurate when compared to previous studies as more reliable data has been used. The ages of the true clusters mostly fall in the range log(t)= 8-9 Gyr. (see Figure 1.23).

(Samyaday Choudhury, Annapurni Subramaniam & Andrés E. Piatti)*

Generation of a near infrared catalog for the Thirty Meter Telescope observations

At first light of Thirty Meter Telescope (TMT), a multi-conjugate adaptive optics (MCAO) system will be available using a laser guide star (LGS) system. Narrow Field Infrared Adaptive Optics System (NFIRAOS) is the TMT's adaptive optics (AO) system for infrared instruments (IRIS and IRMS). Though MCAO will be using LGS system to measure the shape of optical wavefronts and hence to correct the distortions, fainter natural reference stars are required for image position information. The TMT Infra Red Guide Star Catalog (TMT-IRGSC) is a star catalog consisting of point sources with JHK_s magnitudes as faint as 22 mag in J band, covering the entire TMT-observable sky from +90 to -45 degrees declination. The TMT-IRGSC will be a critical resource for TMT operations that enables efficient planning and observing. No catalog currently exists with objects as faint as $J_V ega = 22$ mag over a large enough area of the sky to be useful as a guide star catalog. Hence it is highly essential to develop this catalog by computing the expected near infrared magnitudes of sources using the optical magnitudes. The scope of the present work is to identify the requirements for the generation of this catalog and hence to create a road map for the final production of TMT IRGSC.

In the Phase Ia of TMT IRGSC work, the initial requirements of the catalog are finalised. Also, a methodology to compute the expected J band magnitudes of stellar sources from the optical magnitudes is developed by assuming a black body model for the stars. For the validation of the methodology developed the authors computed the J band magnitudes of sources in three test fields (each of size 1 sq.degree in the sky and these regions have infrared observations along with optical observations) and found that the observed and computed magnitudes match well. The authors do not have sources brighter than 16 mag because those sources are saturated in optical bands. The sources fainter than J_{Vega} 20 mag are also not available because the star/galaxy classification used here is not optimal for fainter sources. Thus the developed methodology is validated for the $J_V ega$ mag range of 16 – 20 mag. Factors which affect the adopted method are identified and methods for improvement are found. These are planned to be carried out in the subsequent phase of the project. (see Figure 1.24).

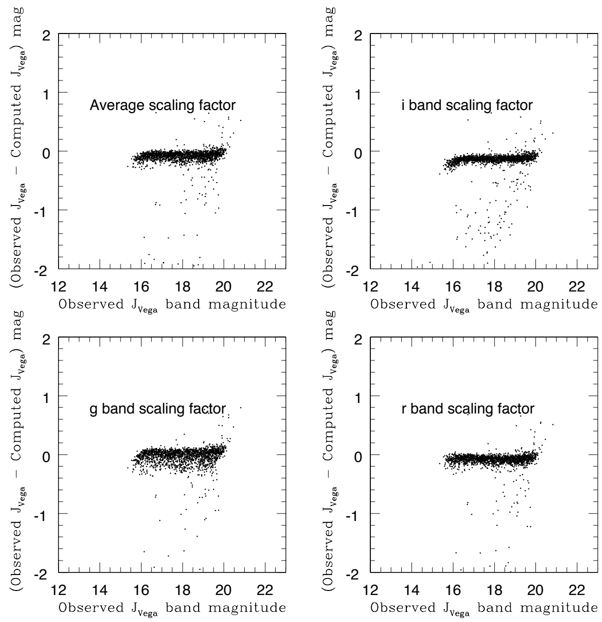

Figure 1.24: For the probable stellar sources in one of the three test fields, the difference between the observed and computed magnitudes are plotted against the observed J_{Vega} magnitude.

(S. Subramanian, A. Subramaniam, L. Simard, K. Gillies*, A. N. Ramaprakash*, G. C. Anupama, C. S. Stalin, S. Ravindranath* & B. E. Reddy)*

Multi-wavelength studies of the LSB galaxy NGC5905 : evidence for tidal disruption of a star by the nuclear black hole

The authors have investigated the tidal disruption event in the low surface brightness galaxy NGC 5905 using archival X-ray, archival Spitzer and GMRT radio observations. The authors find evidence that there was a tidal disruption event and show that an AGN outburst is unlikely.

(H. Raichur, M. Das, A. Alonso-Herrero*, P. Shastri & N. G. Kantharia*)*

Discovery of molecular gas using CO emission from nearby void galaxies with the Nobeyama Radio Telescope

The authors have detected molecular gas in a sample of four out of five void galaxies. These CO millimeter observations were in collaboration with Daisuke Iono and his student Toshiki of Nobeyama Radio telescope in Japan. Further interferometric observations are planned.

(M. Das, Iono, Toshiki)*

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

The authors have extended their work on introducing morphological and topological properties of excursion sets of the CMB as statistics that can determine its non-Gaussian characteristics. 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 the authors infer was investigated. Using a method that looks at various correlations of the cleaned data with the foreground fields, it is confirmed that the cleaned WMAP data does indeed contain statistically significant amount of contamination. The authors have further shown that the residual contamination results in a big fraction of the observed non-Gaussian deviations in the WMAP data.

(P. Chingangbam, Changbom Park, Rien van de Weygaert*)*

VLBA observations of MRK6: probing the jet-lobe connection

The authors have carried out high resolution VLBI observations at 1.6 and 4.9 GHz of the radio jet in the radio-loud Seyfert galaxy, Mrk 6. These observations were able to detect a compact radio core for the first time in this galaxy. They find that the core has an inverted spectral index and a brightness temperature of 1 X 10^8K, suggesting the presence of a relativistic synchrotron jet in Mrk 6. In addition, three distinct radio components which resemble jet elements and/or hot spots, are also detected. These form a part of the north-south 1 kpc jet observed in Mrk 6 by Kukula et al. (1996). The position angles of these typically elongated jet elements point not only to an undulating jet, but also towards a connection between the Active Galactic Nucleus (AGN) and the kpc-scale radio bubbles/lobes that have been detected in this galaxy. It is therefore likely that the lobes are being powered by AGN jets.

(P. Kharb et al., C. O'Dea, S. Baum*, et al.)*

Force-Free Models of Magnetic fields and application to Solar active regions

The author's have made a systematic study of force-free field equation for simple axisymmetric configurations in spherical geometry. The condition of separability of solutions in radial and angular variables leads to two classes of solutions: linear and non-linear force-free fields. They have studied these linear solutions and extended the non-linear solutions to the irreducible rational form $n = p/q$, which is allowed for all cases of odd p and to cases of $q > p$ for even p. They have further calculated their energies and relative helicities for magnetic field configurations in finite and infinite shell geometries. They demonstrate a method here to be used to fit observed magnetograms as well as to provide good exact input fields for testing other numerical codes used in reconstruction on the non-linear force-free fields.

They have further calculated their energies and relative helicities for these magnetic field configurations in finite and infinite shell geometries. In collaboration with B. Ravindra, they apply these solutions to simulate photospheric vector magnetograms obtained using the spectro-polarimeter onboard Hinode. Using the best fit to these magnetograms, they build the full 3D field configurations and calculate the energy and relative helicity for active regions - NOAA AR 10923, 10930 and 10933. For the active region NOAA AR 10930 they have analyzed 5 magnetograms spanning a period of 3 days during which two X class flares occurred which allowed them to find the energies of the active region before and after the flare; their analysis indicates a peak in free energy before the flare events consistent with expectations. The trends thus predicted for the ARs are largely consistent with results mentioned in literature. This method can provide useful reconstruction of the non-linear force-free fields as well as reasonably good input fields for other numerical techniques.

(A. Prasad & A. Mangalam)

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

Variability in active galactic nuclei is observed in ultraviolet to X-ray emission based light curves. This could be attributed to orbital signatures of the plasma that constitutes the accretion flow on the putative disk or in the developing jet close to the inner region of the central black hole. The author's have worked on some theoretical models which build on this view. These models include general relativistic effects such as light bending, aberration effects, gravitational and Doppler redshifts. The novel aspects relate to the treatment of helical flow in cylindrical and conical geometries in the vicinity of a Schwarzschild black hole that leads to amplitude and frequency modulations of simulated light curves as well as the inclusion of beaming effects in these idealized geometries. They present a suite of time series analysis techniques applicable to data with varied properties which can extract detailed information from them for their use in theoretical models.

They 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.

The maximum likelihood estimator is used to determine fit parameters for various parametric models of the Fourier periodogram followed by the selection of the best fit model amongst competing models using the Akaike information criteria. This analysis, when applied to light curves of active galactic nuclei can be used to infer the presence of quasi-periodicity and break or knee frequencies. The extracted information can be used to place constraints on the mass, spin and other properties of the putative central black hole and the region surrounding it through theoretical models involving disk and jet physics.

(A. Mangalam & P. Mohan)

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.

(Rajesh Gopal & A. Mangalam)

1.4 Atomic and Molecular Physics

Atomic astrophysics

The spectrum of singly ionised barium (Ba II) is of considerable importance in astrophysics and has been the subject of many investigations. The authors have performed ab initio relativistic quantum mechanical studies of two spectroscopic properties of this ion; i.e. polarizabilities and hyperfine interactions involving the nuclear electric quadrupole moment and electrons. They started with the mean-field approximation of the wavefunction and systematically took into account correlation effects arising from the instantaneous Coulomb interaction between the electrons. Relativistic effects were included in our work from first principles using a many-electron Dirac Hamiltonian.The interplay of relativistic and correlation effects were treated using the relativistic coupled-cluster theory, which subsumes the residual interaction (difference between the exact electron-electron and the mean-field interactions) to all orders.

The inclusion of electron correlation and relativistic effects in a rigorous manner for Ba II polarizabilities made realistic comparisons between our results and those of experiments possible. These effects were also incorporated in the author's nuclear quadrupole hyperfine studies and in addition special care was taken to determine the wavefunction accurately in the nuclear region. In both cases, the single electron states were sufficiently large and the electronic configurations were able to account for the most important physical effects. The authors were able to make accurate predictions of the nuclear electric quadrupole moments of the two most abundant isotopes of barium by combining their theoretical results for Ba II and experimental hyperfine data for the same ion.

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

Quantum phase transitions in ultracold atoms

The authors have carried out detailed theoretical studies of the influence of the three- body interactions on the superfluid to Mott insulator transition in ultracold bosonic atoms in optical lattices and superlattices. The computations were performed for densities 1, 2 and 3. Density in this context being defined as the ratio of the number of atoms to the total number of sites in the lattice.

Their results convincingly show that the three-body onsite interactions have a significant effect on the superfluid to Mott insulator transition for higher densities. This provides new insights into the behaviour of both the superfluid and Mott insulator phases. The former phase can exist both in terrestrial and astrophysical systems. The authors have also proposed an experiment to unambiguously observe the signature of the three-body interactions in the superfluid to Mott insulator transition.

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

Spectral lines behavior of Be I and Na I isoelectronic sequence in Debye plasma environment

The authors report the plasma screening effect on the first ionization potential and [He]2s^2 ($^1S_0$) $\rightarrow$ [He] 2s2p/2s3p allowed ($^1P_1$) and inter-combination transitions ($^3P_1$) in some selected Be-like ions. In addition, the authors investigate the spectral properties of [Ne]3s ($^2S_{1/2}$) $\rightarrow$ [Ne]np ($^2P_{1/2}$ and $^2P_{3/2}$ for n=3,4) transitions in Ca X and Fe XVI ions (Na I isoelectronic sequence) and [He]3s ($^2S_{1/2}$) $\rightarrow$ [He]np ($^2P_{1/2}$ and $^2P_{3/2}$ for n=2,3) transitions in Li, B II and N IV (Li I isoelectronic sequence) under plasma environment. The *state-of-the-art* relativistic coupled cluster calculations using the Debye model of plasma for electron-nucleus interaction show that (a) the ionization potential decreases sharply with increasing plasma strength and (b) the gap between the [He]2s^2 ($^1S_0$)$\rightarrow$ [He] 2s2p ($^{1,3}P_1$) energy levels increases with increasing plasma potential and nuclear charge. It is found that the [He]2s^2 ($^1S_0$) $\rightarrow$2s3p ($^{1,3}P_1$) transition energy decreases uniformly with increasing plasma potential and nuclear charge. In other words, the spectral lines, associated with 2s-2p (i.e., $\Delta n = 0$, where n corresponds to principle quantum number) transitions in Be I isoelectronic sequence exhibit a blue-shift (except for Be I, B II and the lowest inter-combination line in C III, which exhibit a red-shift) whereas those associated with 2s-3p (i.e., $\Delta n \neq 0$) transitions are red-shifted. Similar trend is observed in Li I and Na I isoelectronic sequences, where spectral lines associated with $\Delta n = 0$ ($\Delta n \neq 0$) are blue-shifted (red-shifted). The effect of Coulomb screening on the spectral lines of ions subjected to plasma is also addressed.

(R. K. Chaudhuri)

Theoretical studies of the ground and excited state structures of stilbene

Optimized geometries are evaluated for the ground and low lying excited states of *cis*-stilbene (*c*S), *trans*-stilbene (*t*S), and 4a,4b-di-hydro-phenanthrene (DHP) from calculations performed with the improved virtual orbital, complete active space configuration interaction (IVO-CASCI) method. The calculations indicate that a non-planar conformer of *trans*-stilbene is the most stable among the isomers. The calculated ground and low lying excited state geometries agree well with experiment and with prior theoretical estimates where available. Our IVO-CASCI based multi-reference Möller-Plesset (MRMP) computations place the ^1B_u state of *trans* stilbene to be $\sim$4.0 eV above the ground X^1A_g state, which is in accord with experiment and with earlier theoretical estimates. The 1^1B_u state of *trans*-stilbene can be represented by the highest occupied molecular orbital (HOMO)$\rightarrow$lowest unoccupied molecular orbital (LUMO) transition (ionic type) from the ground state, whereas its 2^1B_u state is dominated by the HOMO$\rightarrow$ LUMO+1 and HOMO-1$\rightarrow$LUMO transitions (covalent type). Likewise, the 1^1B and 2^1B states of *cis*-stilbene and DHP are also found to be of ionic and covalent types, respectively.

(R. K. Chaudhuri)

1.5 Optical Sciences & Astronomical Instrumentation

Phase conjugation technique for wavefront correction

Adaptive optics is a proven technology that is applied in various fields like astronomical imaging, free space communication, optical microscopy, retinal imaging, optical trapping, laser beam shaping, satellite imaging and in many defense applications. The backbone of an adaptive optics technology is phase conjugation. In the case of astronomical telescopes, wavefront at the telescope aperture can be represented in terms of its amplitude and phase, E(x, y) = A(x, y)e$^{-i\phi(x,y)}$. Multiplying this field by the complex conjugate of its phase term, i.e. by e$^{-i\phi(x,y)}$, compensates the phase distortion, $^{\phi(x,y)}$ or in other words

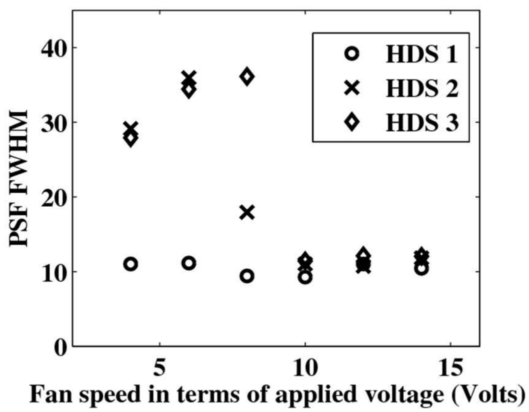

Figure 1.25: Measurement of FWHM of the PSF at different ATG conditions

aberrations present in the optical system. Physically, this represents the correction of the phase aberration, $\phi(x,y)$ using an adaptable optical element or a wavefront corrector. Hence, a wavefront corrector is the phase conjugating optical element in adaptive optics systems. The aberrations in the optical system are measured using wavefront sensors. A digital controller, generally a computer or microcontroller acts like a bridge between the wavefront sensor and corrector. Successful performance of an adaptive optical system depends on many design parameters linked to the wavefront sensor, wavefront corrector and the nature of aberrations to be corrected by the adaptive optics system.

Turbulence in the atmosphere is caused by multiple factors. Boundary layer or ground layer turbulence, which is a consequence of boundary factors like heat convection near the Earth's surface and wind movement affected by local geographic factors, has a prominent role in the overall generated turbulence. The combined effect of this boundary layer turbulence with the turbulence generated at higher altitudes determines the quality of a given site. Atmospheric turbulence can be fundamentally defined by the vertical profiles of refractive index structure constant and wind speed, which can be used to define the derived parameters, namely, Fried parameter, isoplanatic angle and coherence time. These parameters are critical to designing adaptive optical systems for astronomical telescopes. Optimal adaptive optics design parameters are generally obtained using Monte Carlo simulations. These simulations involve simulating phase screens representing the statistics of atmospheric turbulence. This thesis presents a novel method based on statistical interpolation for simulating temporally evolving multi-layered atmospheric turbulence phase screens. Also, there is discussion on the optimal grid size for the simulation of turbulence phase screens.

A low cost atmospheric turbulence generator (ATG) was built using a hair dryer, air cooling fan and facial steamer in a closed enclosure to suit the conditions of a 2m class telescope. The results of the measurement of full-width half maximum (FWHM) of the PSF at different ATG conditions. It can be seen that at a fan voltage of 8V, the turbulence strength can be controlled by changing the hair dryer speed control (HDS). Also, by fixing the hair dryer speed at HDS = 2 or HDS = 3, the turbulence strength can be varied by controlling the fan voltage as shown in (Figure 1.25)

An in-house assembled SHWS made up of a combination of a microlens array and a Pulnix CCD camera was used for wavefront sensing. The performance of the wavefront sensor was tested using deformable mirrors. The deformable mirror was a continuous membrane MEMS mirror from Boston Micromachines. The results of wavefront sensing and correction are shown in (see Figure 1.26). A comparison of two spot centroid location algorithms, center of gravity and weighted center of gravity algorithms was made at different noise conditions.

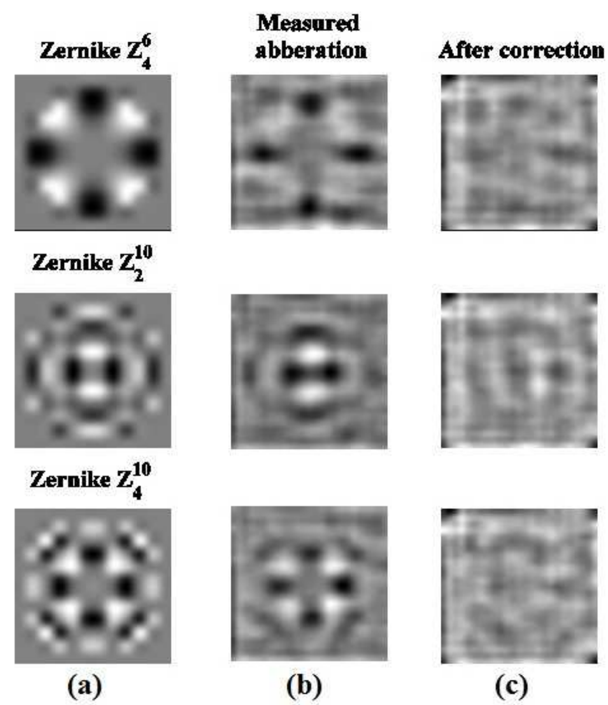

Figure 1.26: (a) Generated aberration (b) measured wavefront (c) wavefront after conjugation

The deformable mirror is mainly characterized by its influence function and interaction matrix. This thesis presents a novel model of representing the influence function, which was measured using the SHWS. SHWS was developed based on a spatial light modulator and was characterized for its performance. Often spatial light modulators exhibit a non-linear phase to gray scale relationship and hence their characterization is of extreme importance. The authors present results of characterization of reflecting and transmitting spatial light modulators using interferometric techniques.

Wind speed at a given site fluctuates over time and hence can have direct effect on the bandwidth of the adaptive optics system. Hence, a continuous monitoring of the wind speed is necessary for optimizing adaptive optics system metrics for good performance. Although many other methods are available for estimating the wind speed, the inevitably present Shack Hartmann wavefront sensor (SHWS) could be used. In the thesis, an advanced correlation based approach was used to estimate wind speed with the SHWS and this method was validated through numerical evaluation and experimental verification. This approach needs precise detection of the temporal correlation peak for accurate estimation of wind speed. It was shown that iteratively weighted center of gravity algorithm can produce good results in comparison with other algorithms (see Figure 1.27).

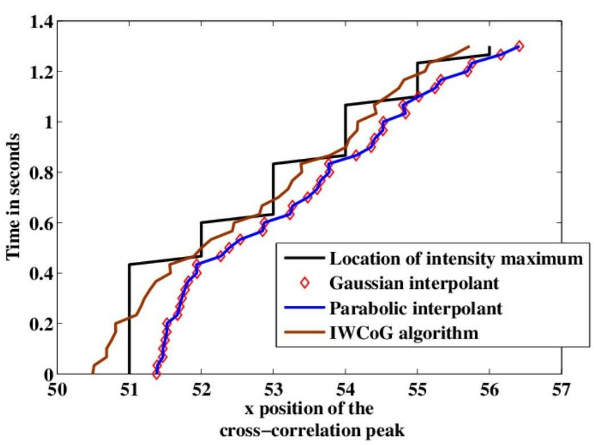

Figure 1.27: Comparison of peak detection methods.

If clean extra-focal and intra-focal pupil images can be obtained, the high sensitivity advantage of the curvature sensor and its simpler optical setup makes it a cost effective alternative for high dynamic range wavefront sensing of low order dominant aberrations. Simulated low order dominant wavefronts were reconstructed by the calculation of Zernike modes using the linearity of the Radon transform after evaluating the extra focal and intra focal images. This method has been used to estimate multiple wavefronts using a mixed modal/zonal approach for wide-field prediction of the spatially-variant point spread function. In this thesis, the performance of the curvature sensor was compared with that of the SHWS for ocular aberrations and low order Kolmogorov phase screens. In summary, this work deals with the simulation of phase screens numerically and in the laboratory, development of a SHWS and demonstration of its usefulness in the measurement of atmospheric wind speed and calibration procedures for spatial light modulators and deformable mirrors.

(M. B. Roopashree & B. Raghavendra Prasad)

2K×4K CCD camera system based on SDSU (ARC) controller

Figure 1.28: A view of the dewar for 2K×4K camera.

A 2K×4K CCD camera system is under development for an image data acquisition system for the 75cm telescope at Kavalur. Though it is intended to be primarily as a back-end, it could be used on any other telescope. This development is in continuation of earlier efforts where the camera system based on a controller was operating as the imaging unit for Echelle spectrograph at VBT, Kavalur and as an optical imager for 2m telescope at Hanle. Some of the limitations of the camera are as under: 1. The image acquisition time for a single frame of 2K×4K was about 3 min 20 sec. This limitation was primarily because the maximum pixel read out rate the controller could achieve was about 42 KHz with a read out noise performance of about six electrons (rms). 2. The Image data acquisition software was based on delphi under Windows-98 /Windows-2000 platform originally. However an image data acquisition software was subsequently developed under red hat linux using GTK mm for Graphical User Interface(GUI) since the operating system was obsolete. 3. The interface board between the PC and the controller was based on ISA platform. This needed a fresh interface based on PCI or USB, since ISA interface is not available currently in most of the conventional PC's. 4. The cabling from the CCD controller mounted on the telescope to the data acquisition computer was based on copper and tended to pick up electrical noise. Hence an optical-fiber link would be a good alternative which provides good noise immunity. The SDSU also called as ARC controllers overcome some of the limitations mentioned above.

Features of SDSU controller: The controller consists of three major boards including a 250 MHZ timing board, a video processing board and the clock board. It also includes a power supply unit required for the board. A PCI interface board is available with drivers for WINDOWS7 and linux operating systems. A fiber optics cable provides the connection between the controller and the interface board on the PC. The video processor can handle 4 channel data and can be used for acquiring data from multiple video channel streams from the CCD sensor.

Highlights of controller: 1.The highest clock speed is 1 MHz but it is expected to be used around 200–250 KHZ to obtain optimal read out noise performance of around 6 electrons. 2.Maximum image data transfer rate of 12.5 M pixels per second. 3.Capable of writing large images directly to system memory using DMA. 4.OWL is a Java and C++ based image acquisition software program that can acquire images from both CCD and IR detector systems. Owl utilizes the ARC_API C++ libraries at its core, with Java only providing GUI, scripting, and control functions. It has been designed to be used for both development and scientific image acquisition. It is possible to modify owl for our camera requirements if necessary. The owl 3.0 image data acquisition software for ARC controller is available for Windows 7 and XP operating systems as well as LINUX for several distributions. It is expected that with this system one can obtain a 2K×4K image frame in a time of about 30 secs, with a read-out noise of approx 6 Electrons.

Present status: The E2V 2K×4K sensor which was originally used in the CCD camera for Echelle spectrograph at VBT is intended to be used as the sensor since the earlier camera is no longer in use. A modified 2.4 litre, centre filling liquid nitrogen dewar is being readied for mounting the sensor (see Figure 1.28). This has a holding time of approximately 24 hours in the normal mode and 12 hours in the inverted mode. A CCD temperature monitoring and control unit using PT-100 and a AD590 is ready and will be used for maintaining the CCD sensor temperature at about –105 degree centigrade. This unit is going to be mounted externally on the dewar. A ESD protection board is getting ready and is to be mounted inside the dewar. This is to ensure safety of the CCD sensor from static charges. This is a four layer board with SMD components and uses SP720 and SP721 for ESD protection. Also all the signals including clock and bias are over voltage protected. This board requires miniature connectors which need to be imported and the board will be tested subsequently. The operation of a 60 mm shutter from Melles Griot has been tested for functioning through the timing board of SDSU controller. The OWL3.0 software has been tested under Windows 7 platform. The entire camera system will be tested in the coming months and is likely to made operational at 75cm telescope in the coming observing season.

(A. V. Ananth, M. R.Somashekar, K. Anupama, K. Sagaynathan, V. Arumugam)

Chapter 2

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Chapter 3

Facilities

3.1 Photonics Laboratory

Adaptive optics experimentation

The developmental activities on wavefront sensing for adaptive optics applications are being continued. The authors have been studying wavefront sensing using Shack Hartmann wavefront sensor and its behavior in the presence of turbulence. The detailed study has been brought out in the publication. Presently, a detailed comparative study on the wavefront reconstruction techniques used in AO is being studied.

(J. P. Lancelot & Narsi Reddy)*

Wavefront sensing technique for extended objects was carried out as part of M.tech project. Shack Hartmann wavefront sensor was used and a portion of the solar image was taken to develop the cross correlation technique. They have simulated in the laboratory a model 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)

Vacuum coating: Periodic maintenance work at the 1.6 m and 2.8 m vacuum coating plants were regularly carried out. About 4 numbers of 8 inch mirrors were aluminized during this period at the 1.6 m coating plant.

The maintenance work on the 2.5 m vacuum coating plant at Hanle, was undertaken during July – August 2012 by the optics team in coordination with IAO staff. This time we have recoated 3 HAGAR mirrors and undertook cleaning of about 10 mirrors.

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

ISRO – Project

As per the MoU between ISAC and IIA, polishing of the sunshield panels for the MET payload for the INSAT – 3DR1 has been completed during this period. The work on INSAT – 3DR2 has been taken up.

(M. G. Mohan, R. Ismail, P. Subramani & J. P. Lancelot)

3.2 Kodaikanal Observatory

Solar Tower Telescope

Observations for select programs continued during the year. The various instruments under development such as prototypes for the proposed National Large Solar Telescope, a spectropolarimeter, a broad band imager, a narrow band imager, and the optical components for each of these were tested, qualified, and calibrated at the STT. Observations for Ph.D. program of Ca K latitudinal spectra were carried out during early part of the year. Many M.Sc. and M.Phil. students from neighbouring Universities used the facility and the observations for their dissertation work under the guidance of staff members at Kodaikanal. These observational programs were carried out under the overall supervision of K. E. Rangarajan, K. Sundararaman, and S. P. Bagare.

A group of 14 international students participating in an advanced study program of the Centre for Space Science and Technology Education in Asia and Pacific, affiliated to the United Nations, and organized in India by the Physical Research Laboratory, Ahmedabad, carried out observations and data reduction at STT, during March 2013. The observations at STT, the analysis, and interpretative studies were guided by K. Sundararaman and K. B. Ramesh.

This visiting student program was co-ordinated by S. P. Bagare.

The work on augmentation of the main spectrograph grating drive to provide an Automated Grating Positioning System was completed during the year. The system was calibrated and made available for observations by N. Sivaraj, K. Ravi, P. U. Kamath, F. George, and S. P. Bagare.

An image motion controller was built and introduced at the STT for automation of the spectropolarimetric observations. The controller allows precise placement of the Sun's image on the spectrograph slit and for scanning to be performed across the region of interest. This requirement was achieved by controlling the tilt of the secondary mirror. This fine image motion controller was developed and installed by K. C. Thulasidharan with observational inputs from K. E. Rangarajan. Detailed testing of the instrument was carried out at the telescope by K. Prabhu, Vasantha Raju, and R. Prabhu.

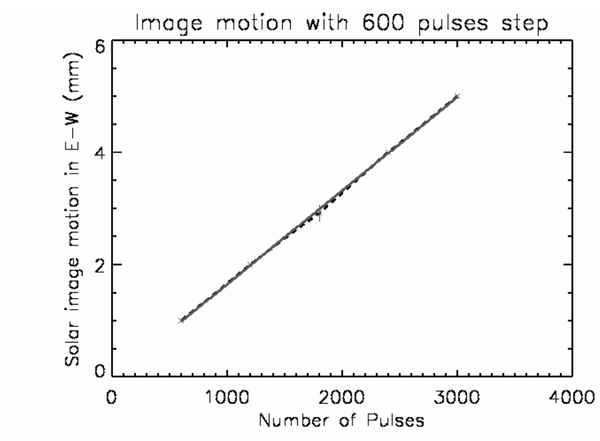

Figure 3.1: Calibration curve. This shows 600 pulses input moves the image by 1 mm with an error of 0.14 mm. This corresponds to an error of nearly 0.5 arcsec which is of the same order of the diffraction limit of the telescope. Seeing and other distortions are usually more than the above error.

Twin telescope

Observations with the 15 cm twin telescope continued during the year, to obtain photospheric broad band images and chromospheric Ca K full disk images using daystar filter, at a cadence of five minutes. The number of images per day varied from about 40 to 120, depending upon the season of the year, observations being obtained regularly by R. Selvendran, and P. Kumaravel. These images have been added to the digitized data archival at Bangalore. Further, observations carried out during the rare event of transit of Venus, which occurred on June 6, 2012, by R. Selvendran and P. Kumaravel, was used for the estimation of stray light contribution from the terrestrial atmosphere, and by the instrumental degradation within the twin telescope. These results will be used by K. Prabhu, B. Ravindra, and K. E. Rangarajan to make corrections to the images obtained with the telescope, in order to enhance the image contrast achieved.

WARM telescope

The white light active region monitor telescope which was nearly completed during the previous year was tested for accuracy of tracking and imaging quality by K. B. Ramesh, assisted by S. Ganesan. Teething problems were faced and efforts were made to overcome the same during this year. It is expected that regular observations will start shortly with the high cadence facility for white light imaging.

GPS observations

Observations were continued with the high precision and high cadence Global Positioning Station, Trimble NetRS system with Met package, installed at the Observatory as a part of the National Network of GPS/Seismograph stations in India. Continuous data recordings were obtained and sent to the National GPS Data Bank in Dehradun. These data are used for studies of the plate tectonics and geodynamics of the Indian sub-continent, and it will also constitute a part of inputs for national disaster management.

Digitization of photographic archival data

Digitization of over a hundred years of solar observational data obtained and archived at the Kodaikanal Observatory on photographic plates and films, continued during the year. In the previous years, digitization of the broad band or white light images, and the chromospheric Calcium K line full disk images, were completed. During the year of this report, calibration of the white light and Ca K data were taken up and completed. Further, the digitization of H-alpha full disk images was carried out for the period 1912–1960, and for the years 1979 and 1980. The entire data and the quick look images for these were uploaded in the digitized data archival in the

The Evershed Hall after renovation.

computer centre at Bangalore. This digitization program was carried out during the year by M. Priya, K. Amareswari, T. G. Priya, A. A. Nazia, and A. Banu, under the overall supervision of B. Ravindra and D. Banerjee.

Restoration of heritage buildings

The over hundred year old Evershed Hall was renovated with care being taken to keep its heritage value intact. The roof was fully refurbished and all the tiles replaced, providing an entirely refreshed look to the building. Rest of the heritage buildings at the Observatory were maintained regularly. Planning of renovation started during the year for rest of the heritage buildings on the Observatory campus. This work was initiated by K. Sundararaman and S. P. Bagare, and was implemented by M. V. Ramaswamy, assisted by F. George and M. I. Basha.

Rehabilitation of the Magnetic dome

The magnetic dome which has been a geomagnetic observatory at Kodaikanal for over fifty years, from 1950 to 2005, and contributed to observations which were regularly published by IIG, Mumbai, and also used by scientists at IIA for Solar Terrestrial Relationship studies, was taken up for rehabilitation. This was pursuant to a proposal by IIG for installation of modern digital magnetometers at Kodaikanal, under a collaborative program. The proposal for renovation was initiated by S. P. Bagare and it is being carried out under the supervision of M. V. Ramaswamy and K. Sundararaman.

(S. P. Bagare)

Sky conditions: Kodaikanal

		No. of observations			**Seeing conditions***				
Year	Month	Ca K(TT)	WL(TT)	PHGM	5	4	3	2	1
2012	April	25	25	26	-	5	17	3	1
	May	28	28	28	-	3	20	4	1
	June	16	16	19	-	-	14	5	-
	July	24	24	24	-	-	12	12	-
	Aug	12	11	15	-	-	2	11	2
	Sep	23	24	20	-	1	10	9	-
	Oct	16	16	18	-	1	13	4	-
	Nov	26	26	28	-	4	16	7	1
	Dec	20	20	23	-	12	4	6	1
2013	Jan	9	24	29	-	13	13	3	-
	Feb	23	23	23	-	3	12	7	1
	Mar	25	25	25	-	7	16	2	-
		247	247	278	-				

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)

3.3 Vainu Bappu Observatory

1.3 metre Telescope Project

Telescope Building & Dome : The telescope pier and concrete foundations of the building had been completed and the erection of the steel building had commenced in the previous year. In the current year the erection of the steel structurals of the building as well as the dome was completed by August 2012. The fixing of the aluminium cladding sheets for the building and dome commenced after that and took well over 3 months.

It should be mentioned that the dome rail as well as dome wheel assemblies were fixed only using temporary weldments and that full welding of these could only be carried out after the building and dome structure were completed.

The installation of the lift support structure and car assembly within the building, the installation of the dome wheel assemblies and the drive assemblies started in September. The tests of dome rotation, correction of the level and circularity of the rail, adjustments of the contact force of the two (friction) drive wheels was done in several iterations before final welding of the rail segments and the dome wheel support structures could be finished by December. A similar process was followed for the shutter drives, for which testing could be carried out only after the outer cladding work of the dome was completed.

Figure 3.2: Steel building and dome structure (August 2012).

The painting of the building structure was hampered considerably by the two monsoons which afflict this part of India. The mechanical fixtures for laying of cables in the building as well as for mounting power distribution panels, lights and power outlets had to be designed, manufactured and fixed before painting. The internal paint work was started during November and progressed from the dome downwards through the building. Painting of the exterior could be taken up only in December, again starting from the dome and progressing downwards.

Figure 3.3: Aluminium cladding work on building and dome (October 2012).

The octagonal building and dome is an unusual design with several new elements; there is natural air flow through the building and the dome shape encloses a minimal air volume. In addition, seven motorized windows in the rotating dome allow for increased airflow, while control of the flow is possible during very windy conditions. There are no bus bars for transferring power or signals to the moving dome. The dome shutters drive motors are powered using solar panels and control is through a radio interface.

The electrical work including cable laying, power distribution, installation of panels and electrical fittings, preparation of the elaborate earthing system and installation of lightning arrestor system, were all carried out during December and January 2013. Since the building is a steel structure, special care had to be taken to isolate the normal electrical earth from that used for the telescope and instrumentation. The lightning arrestor had a separate earth isolated from the rest of the structure. The rocky soil at the observatory gives a high value of earth resistance and some innovation using large diameter cast iron pipes embedded in the earth pits was successfully imple-

Figure 3.4: (left) Inside of the dome (Dec. 2012). One of the dome friction drive wheels is seen on the right. The top of the rectangular telescope pier is in the foreground. Some of the dome wheels and the rail are also seen.(right) The dome hoist of capacity 2 tons will be used for lifting the mirror cell through an opening in the top of the hollow pier.

Figure 3.5: (left) Inside the hollow pier looking upwards. The ladder structure and platform is for installation and maintenance of the oil lines for the hydrostatic bearings of the telescope. The hole at the top of the pier is for lifting or lowering of the mirror cell from ground level. (right) The building/dome after painting in January 2013.

Figure 3.6: B. P. Das (Director, Actg) and T. P. Prabhu (Dean) with A. K. Pati inspecting the site on 13th January 2013. The panels with wire mesh ensure natural airflow through the building. A part of the pier wall is seen at right.

mented to give acceptable values of earthing. These will be monitored regularly to check the efficacy of the design.

The telescope dome/building involved considerable work on the part of the engineering personnel, both at Bangalore and at Kavalur. P. U. Kamath, P. M. M. Kemkar and V. K. Subramanian were continually involved through the design, manufacture and installation. R. R. Reddy and S. Suresh were involved in implementing the civil works, including the pier and ground floor of the building. V. Lokanathan and the workshop staff at VBO were continually engaged in site supervision at all stages of work, in addition to doing smaller fabrication works. K. Ravi played a leading role in specifying the dome and shutter drive systems. The solar powered shutter drives were fully developed at the VBO. The execution of the electrical work was carried out by engineering staff at VBO, led by Vellai Selvi. The electronics section including A. Ramachandran and S. V. Rao participated in the electrical and networking work. P. Anbazhagan, Engineer in-charge, VBO provided all the support for the activities at site, in addition to participating in aspects of the electrical and drive systems

Telescope installation:

The telescope installation started from 7th February 2013 with the arrival of the three member team from the vendor company (DFM Engineering) at site. The telescope mount was specially designed and built for the low latitude of VBO and this was the first telescope of its kind to be installed by the company. The installation was therefore slated to last at least six weeks, with the major portion of the time being for hoisting the telescope parts up to the dome in a pre-defined sequence and testing at various stages of the telescope assembly. This task required the use of a crane that could position the hook above the centre of the dome (about 20 metres above ground) while holding up a load of 5 metric tons during the assembly process. A suitable crane was arranged and available at site for about three weeks during the installation.

The north-south centreline marked on the top of the pier during construction was verified by sighting on the pole star and the sole plates (one each at north and south) on which the telescope structure would be assembled were grouted to the pier. The base frame of the telescope was then hoisted up followed by the two horseshoes and the interconnecting 'D-beams'. These were the largest parts of the telescope mount that were lifted into the dome through the open shutter.

All the parts of the telescope mount were too heavy for the observing floor and the assembly thus had to be done by lifting them in strict sequence with the load coming only on the pier. The assembly process required special jigs and fixtures which would transfer load only on the pier.

The assembly of the two horseshoes and interconnecting D-beams was critical and involved measurements and corrections (using shimming) to ensure that the machined surfaces of the horseshoes form part of a rotating cylinder. This is essential to define a unique polar axis and an orthogonal declination axis between the D-beams. Further, since the assembled structure would rest on the hydrostatic pads at an angle to the horizontal, the design incorporates "thrust" pads to prevent the structure from sliding southwards. The thrust bearing surface on the southern horseshoe therefore needs to be maintained closely perpendicular to the polar axis defined by the centerline of the two horseshoes. This process of checking the alignments involved several iterations and it was repeated as further parts of the telescope tube assembly were loaded onto the structure.

The installation of the hydraulic pump system was carried out parallely to the assembly of the horseshoe structure. The pump is on the ground floor of the building with oil pressure lines as well as the return flow lines installed inside the pier. After placing the horseshoe mount on the hydrostatic pads, the hydrostatic bearing system could be tested, and the oil flow calibrated to ensure smooth movement of the structure on the pads.

Figure 3.7: (left) Lifting out telescope parts from containers 7th February. (middle) Fixing the sole plates on top of the pier 11th February. (right) The base frame was lifted into the dome on 13th February.

Figure 3.8: (left) North horseshoe being lifted into dome. (middle) The 'D-beams' being hoisted up. (right) The horseshoe and D-beam held by fixtures during assembly on top of the pier.

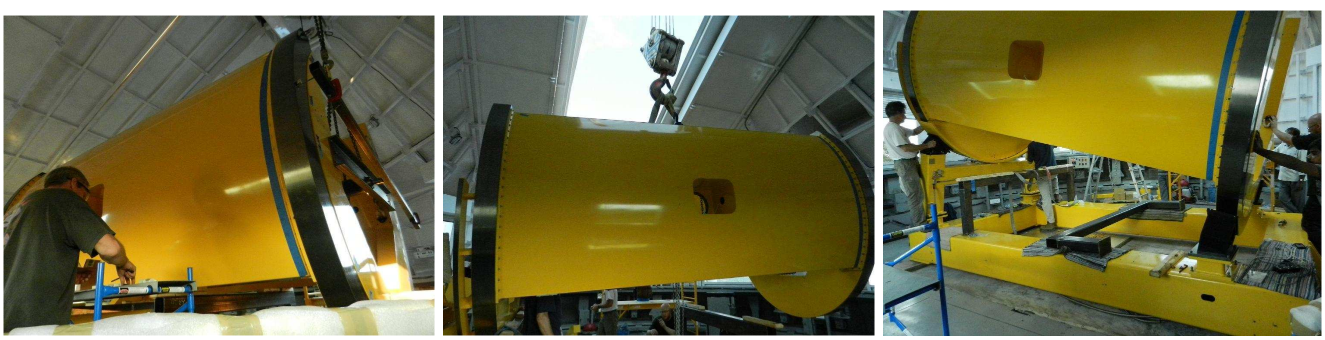

Figure 3.9: (left) Alignment tool mounted on the polar axis at south horseshoe. (middle) Assembled horseshoe mount held up by the external crane prior to positioning on the hydrostatic pads. The tool was for checking perpendicularity of the bearing surface. (right) Mount structure being positioned on bearing pads 18th February.

The elements of the telescope tube assembly were next mounted on the structure, starting with the centre section followed by the tube truss structure, the primary mirror cell, and the top ring holding the secondary mirror assembly. After the addition of each heavy component, the movement of the structure on the bearing system had to be checked for smoothness and adjustments made to the oil flow system.

The mirror cell with the primary mirror inside was to be hoisted up from the ground floor through a hole in the pier. There is a lift table with a "scissors jack" running on rails on the base frame of the mount, that was procured along with the telescope for mounting of the mirror cell to the centre section of the telescope. The dome hoist and lift table were first tested for this task with the mirror cell (without the mirror) and then the cell was lowered back to the ground floor.

The fixing of the mirror supports in the mirror

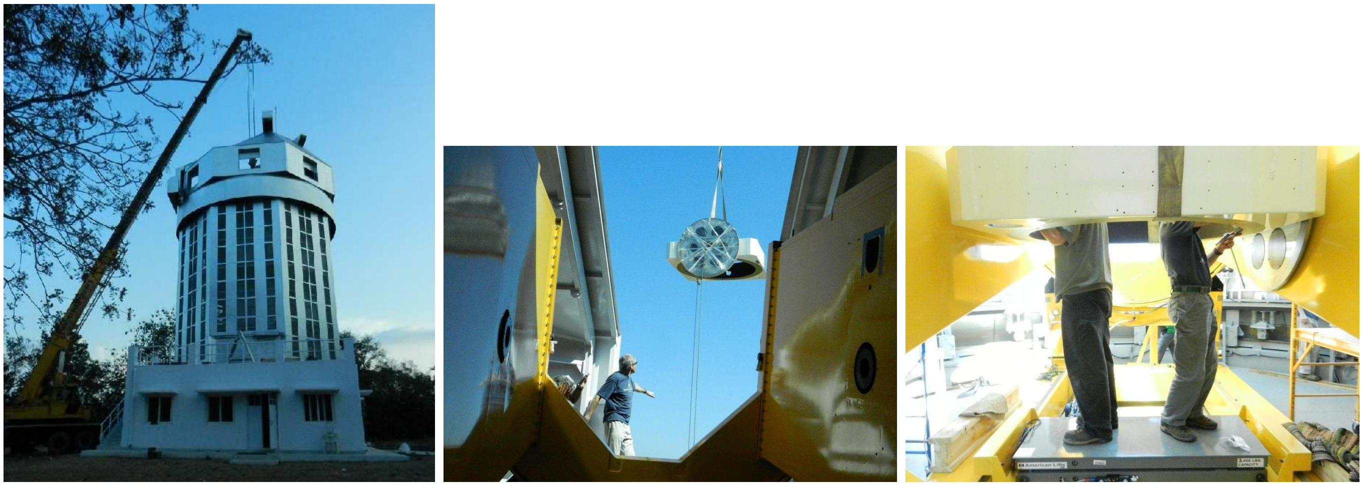

Figure 3.10: (left) External crane positioned during the structure assembly. (middle) Centre section of the tube assembly being hoisted into dome. The bearing mounts defining the declination axis are seen. (right) Centre section being assembled on the declination bearings. A critical operation with little room to manouver!

Figure 3.11: (left) Checking the movement of the mount with centre section. The lift table for mounting/dismounting the mirror cell is seen. (middle) View inside the pier, showing the mirror cell in a test run being lifted from the ground floor using the dome hoist. (right) Fixing mirror supports inside the cell before loading mirror. Both the axial and radial supports were mounted and adjusted on to initial values – 6th March.

Figure 3.12: (left) Mirror mounted in cell, before lifting up through the pier. The blue coating is a peelable protective layer. The cover top is for protection during the lift operation.(middle) The upper truss structure in place. The black invar rods serve as reference for the spacing of the primary and secondary mirrors. (right) Mirror cell being raised using the hydraulic trolley for mounting on the centre section – 8th March.

Figure 3.13: (left) Secondary mirror fixed on the 5 axis mount within the top ring. (right) Top ring being mounted on truss assembly – 9th March.

cell was done on the ground floor. The mirror cell has three fixed and thirty six active axial supports as well as four defining and sixteen active radial supports. The mirror initially rests on the three fixed axial supports, whose height is adjusted to keep the mirror edge at a predetermined depth with respected to the machined flange of the cell. The active axial supports are pre-adjusted before loading the mirror, but do not act till the fixed supports are released (after mounting of the mirror cell on the telescope). Similarly, the centering of the mirror in the cell and positions of the four radial defining supports is also done at this stage, before lifting the mirror and cell to the telescope. The axial supports also act only after mounting the mirror cell to the telescope.

The next step was to mount the secondary mirror on the 5 axis positioning mount held by four spider vanes in the top ring of the telescope. The 5 axis positioner allows remotely controlled translation in X, Y and Z (focus) directions as well as rotation about the X and Y axes. The collimation of the telescope optics after installation is to be done mainly using this positioner system. The top ring was next lifted with the dome hoist and mounted on the upper truss assembly with the telescope 'pointing' north and well into the north horseshoe. Two of the four fixed counterweights at the top ends of the trusses were also mounted at this position; the other two would be mounted as required, when heavy instruments are attached at the telescope focus.

At this stage, all the elements of the telescope were in place. The balance of the telescope about the declination axis was done using the two moveable counterweights. The fixed primary mirror supports were released so that it was 'floating' on the active supports. The centering of the mirror in the cell was also checked. After this, collimation of the optical system was done using a laser at the telescope focus (below the mirror cell) reflecting off a target at the centre of the secondary mirror. The telescope was ready for visual "first light" which occurred on 10th March 2013. Due to the short notice of the event, only a few of the faculty, with the Director, could come for the event.

Following the "first light", a video camera was mounted in place of the eyepiece. First the collimation of the telescope was refined (using the secondary positioner) and preliminary checks on the tracking performance at various positions, as well as observations for making a telescope pointing model were carried out. The tracking adjustments produced reasonably good results and the telescope pointing was also good. However, at some positions (particularly around half an hour west position) oscillations in the star image were seen. These oscillations were of small amplitude (around 1 second of arc) but were distinctly seen in plots of the centroid position of the star.

DFM engineers spent several days in analysing the cause of the problem. It appears this is due to the interaction of the thrust pads with the south bearing surface in some positions. Modifications to the thrust pad mounts were carried out in the observatory workshop but the problem persisted. Any corrective action may need new thrust pads and flow control valves and this can be done only at the DFM shop facility. It was decided that DFM personnel would return as scheduled on 22nd march 2013. They would return to VBO later, after a detailed analysis of the problem and new parts/components as

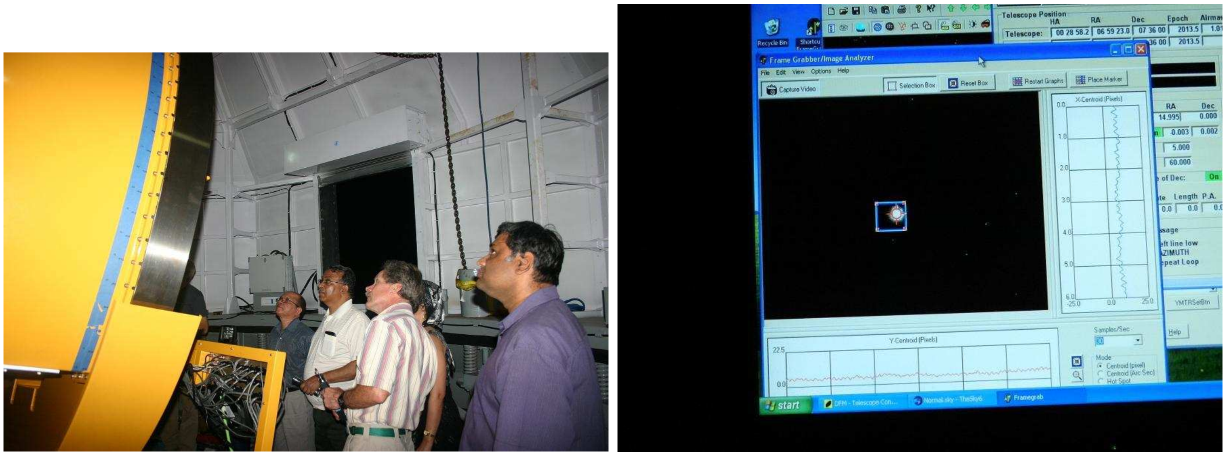

Figure 3.14: (left) H. C. Bhatt, B. P Das, Firoza Sutaria (hidden), Arun Mangalam along with Mark Kelley of DFM Engineering, at “first light”. (right) First test stellar image taken to check collimation, tracking using video camera in place of the eyepiece.

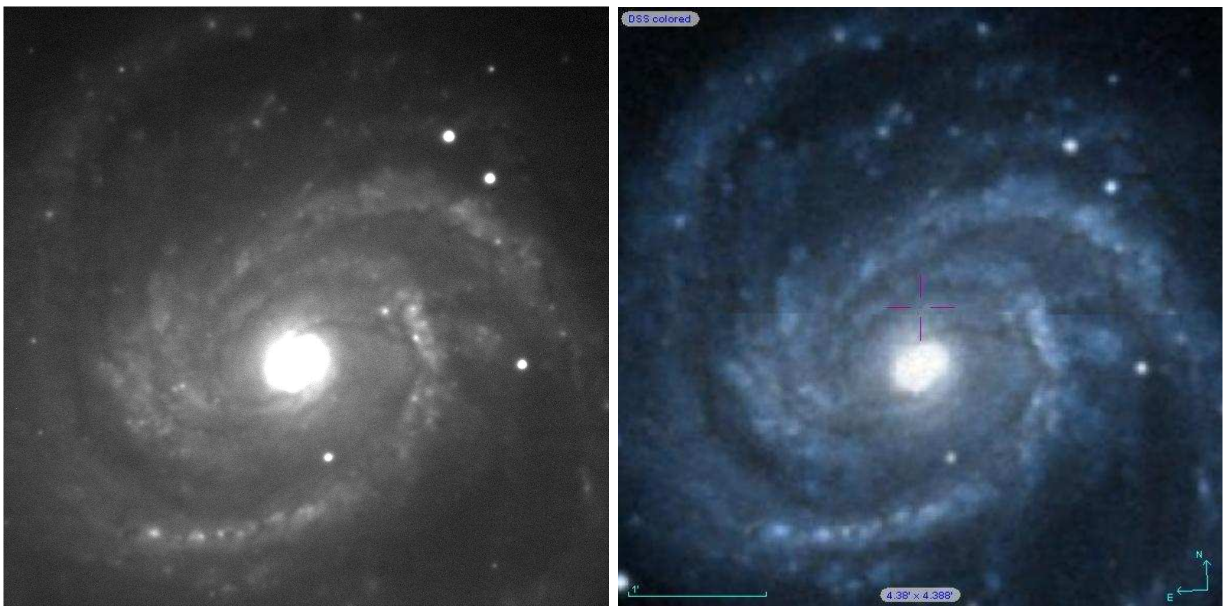

Figure 3.15: (left) Image of the galaxy M100 with exposure of 4 minutes, taken without filters with the 1.3m telescope on 18th March 2013. (right) An image of the same field from the Digital Sky Survey (colour composite) for comparison. The telescope gives well defined stellar images as well as contrast in structures in the extended source (galaxy) image.
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required, to complete the acceptance tests.

The instrument interface unit (IIU) which provides three focal positions with filter changing mechanisms as well as an autoguider, had also been scheduled for tests. The unit was mounted on the telescope two days before the end of the installation run. The testing of this unit will be done with the final telescope acceptance tests. A new CCD camera capable of fast frame readout (upto 10 megahertz) acquired for this telescope, was mounted on a side port of this unit and tests of imaging and tracking by IIA were started from 18th March. It is possible to obtain images in the positions not affected by the oscillations. The initial images show good optical performance of the telescope.

As of the period of this report, we await a resolution of the problem of telescope oscillations. The fast CCD camera is being used to acquire short exposure test images. Stellar tracking performance is also being tested using the rapid frame capture camera; it can read out sub-frames with exposures as short as a few milliseconds continuously (16 bit data). Software has been written at VBO to analyse the shifts in the centroids of stellar images and separate out effects of seeing, oscillations, vibrations etc.Tests with this camera are continuing and the software is being refined.

The institute personnel have been closely associated with the installation of the telescope. P. M. M Kemkar and K. Sagayanathan took turns at being associated with the mechanical installation. P. U. Kamath was associated in some phases. K. Ravi was continually associated with all aspects of the installation and implemented the interfaces between the telescope control electronics and the dome drive system. J. P. Lancelot participated during installation of the mirror supports and loading of the primary mirror in the cell. Vellai Selvi, A. Ramachandran and S.V. Rao provided full support for electrical requirements. The VBO workshop staff led by V. Lokanathan provided both muscle power as well as "quick fix" machining jobs during various aspects of the installation. The Engineer in-Charge VBO, P. Anbazhagan coordinated most of the observatory support for the installation process. He also developed the software required for testing with the new fast CCD camera.

(Ashok Pati)

Controls for 75cm telescope, Kavalur

The controls for 75 cm telescope has been undergoing extensive testing and the telescope is being readied for regular operation. As a part of this, the controls and data acquisition hardware has been shifted from the observing floor to the control room in the ground floor of the 75 cm telescope building. The entire control hardware is placed within two racks. The 75cm telescope control system devices were placed in one console rack and the dome control devices placed in another console rack.(see Figure 3.16)

The telescope control console is the main operator panel equipped with safety controls and indications for telescope limits, secondary focus limits, RA & Dec drive amplifier excess current, focus control drive fault, emergency stop, telescope limit by-pass.

The telescope accessories like secondary focus, instrument control (filter wheel and guide ccd scan), CCD controller and CAS utilities are powered from CAS panelvia solid state relays.

The servo system components like PMAC control cards comprising ACC 8E,Acc 34B, Acc 34AA and RA & Dec drive amplifiers are switched on & off sequentially through relay logic control panel. The telescope safety limit, emergency stop and telescope limit by-pass controls are also equipped through interlock relay logic.

The control console wiring has been completed and telescope performance testing is currently on. The trial observations are being carried out by using 1K×1K CCD camera. Since telescope wiring has considerably changed, the mechanical aspects are also under tuning for optimal performance for positioning, tracking and guiding.

Figure 3.16: A view of the console rack in the 75 cm telescope control room.

(A. Ramachandran, S. Venkateshwara Rao, P. Anbazgan, A. V. Ananth & V. Arumugam)

Sky Conditions

Month	Spectroscopic Hours	Photometric Hours
April 2012	122	2
May	38	0
June	23	6
July	23	0
August	14	0
September	8	0
October	38	0
November	121	9
December	115	14
January 2013	225	35
February	155	45
March	135	34
Total	1017	145

3.4 Indian Astronomical Observatory

Himalayan Chandra Telescope (HCT)

The Himalayan Chandra Telescope (HCT) completed 10 years of utilization through competitive time allocation. 23 proposals received for 2012–Cycle2 (2012 May-August), 23 proposals received for 2012-Cycle3 (2012 September – December) and 26 proposals received for 2013-Cycle1 (2013 January - April). Telescope was over subscribed by a factor 1.5 on an average, while the dark moon period is over subscribed by a factor 2.5-3. HCT proposals cover a wide range of scientific problems, from the observations of nearby solar system objects to the distant quasars. 15 papers based on HCT data have been published in refereed journal during this period.

The telescope is remotely operated from the CREST campus of IIA through a dedicated satellite-based communication link. New communication equipment was procured during the current year to replace the older equipment which has exceeded its expected lifetime. The telescope is fully operated on Solar Photo-Voltaic electric power, and the old battery banks were also replaced during the current year.

The telescope is checked around full moon every month and calibration tables updated to keep the high performance of the telescope. The CCD dewars are evacuated at intervals of once in few months during full moon when the demand for telescope time is low. The dome drives required considerable attention during the year, and new components are being procured to improve the reliability. More detailed preventive maintenance was carried out during the first half of September 2012.

High Altitude Gamma Ray facility

The High Altitude Gamma Ray (HAGAR) facility is operated jointly by the IIA and Tata Institute of Fundamental Research (TIFR), Mumbai. Saha Institute of Nuclear Physics (SINP) is participating with IIA and TIFR in its utilization. The telescope has been in continuous use since 2007 for observations of active galactic nuclei, supernova remnants and gamma-ray emitting binary stars. The first Ph.D. thesis utilizing HAGAR data was submitted by Mr Amit Shukla, IIA, during the current year.

Bhabha Atomic Research Centre (BARC), Mumbai plans to install a 21-m imaging Atmospheric Cerenkov telescope Major Atmospheric Cerenkov Experiment (MACE) near HAGAR. Infrastructure development on the telescope foundation, power generation, and communication link was continued at the site while the telescope is being assembled and tested at Electronics Corporation of India Limited, Hyderabad prior to its shipment to Hanle.

Gamma-ray astronomers of TIFR, BARC, IIA and SINP held discussions on the possibility of participation in the international next generation project, Cerenkov Telescope Array (CTA). Some sites in Ladakh were shortlisted and proposed for the CTA-North facility.

Earth Sciences

IIA has established two GPS stations at Leh and Hanle as a part of National GPS Network. Initially it was funded by Department of Science and Technology, Government of India and later transferred to the Ministry of Earth Sciences with a view to connect all the national GPS stations to Indian National Centre for Ocean Information Service(INCOIS), Hyderabad. INCOIS has installed the VSAT communication equipments at Hanle to facilitate Hanle direct download of data. VSAT equipment for the Leh GPS has reached Leh and will be installed during the next summer.

Space Physics Laboratories, VSSC/ISRO and IIA have collaboratively established an Aerosol Observatory at Hanle. The instruments were shifted from their temporary location to a new hut designed and procured for the observatory.

A new continuous carbon dioxide analyzer, PICARRO was installed at IAO, Hanle inside the CARIBOU building as a part of Carbon Dioxide Observatory operated by IIA, Centre for Mathematical Modeling and Computer Simulation(CMMACS), Bangalore and Laboratoire des Sciences du Climat et de l'Environment (LSCE), France. This analyzer monitors carbon dioxide concentration of the ambient air in addition to molecular concentrations of Methane and Water Vapour in the ambient air. Manual sampling of ambient air is continuing with filling of 1 litre glass flasks periodically for subsequent detailed analysis at LSCE, France. Prof. Michel and Mr. V. Cyrille(LSCE) and Dr. Swathi (CMMACS) visited IAO in July 2012 to coordinate the maintenance of CARIBOU and installation of PICARRO with the participation of scientists and engineers of IIA.

(T. P. Prabhu)

Centre for Research & Education in Science & Technology (CREST)

CREST Campus of IIA houses the remote control station of 2-m HCT, IAO, Hanle. Guest Observers who are allotted time on HCT by the national time allocation committee, utilize this time from CREST with the help of a small group of astronomers supported by research or telescope trainees recruited periodically on a contract basis. Some maintenance and computer upgradation was undertaken during the current year.

Dedication Ceremony of M. G. K. Menon Laboratory for Space Sciences took place on the June 21, 2012. Dr. K. Kasturirangan, Member, Planning Commission and Chairman, IIA Governing Council unveiled a plaque in the presence of S. S. Hasan, Director, IIA.

(T. P. Prabhu)

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh

A. Night hours

Year	Month	Photometric (night hrs)	Spectroscopic (night hrs)	Total (night hrs)
2012	April	100	154	240
	May	129	145	217
	June	102	140	210
	July	81	113	217
	August	18	48	248
	September	118	142	270
	October	193	221	310
	November	198	264	330
	December	184	237	341
2013	January	219	241	321
	February	146	170	270
	March	154	185	341
	Total	1632	2060	3283

B. No. of Nights

Year	Month	Photometric nights (night)	Spectroscopic nights (night)	Total (night)
2012	April	14	20	30
	May	20	22	31
	June	16	21	30
	July	14	17	31
	August	03	7	31
	September	14	18	30
	October	24	26	31
	November	22	28	30
	December	21	24	31
2013	January	23	25	31
	February	16	18	28
	March	19	22	31
	Total	206	248	365

3.5 Gauribidanur Radio Observatory

Whitelight observations of the solar corona close to the photosphere is presently possible only during the solar eclipses. But daily observations of the above region are important since some of the disturbances in the near-Earth space and the terrestrial atmosphere (i.e. the Space Weather phenomena) are primarily due to the transient and energetic eruptions that occur here. At times these eruptions are accompanied by magnetic clouds that propagate outward from the Sun. Satellites are particularly vulnerable as they can be buffeted by these clouds, particularly which propagate in the direction of the Earth. These are called the coronal mass ejections (CMEs) and are the primary candidates of stormy Space Weather. The CMEs travel at speeds in the range ~ 300–3000 km/s and carry a mass of $\sim 10^{15}$ gm. The interest in the disturbances from the Sun has expanded over the years as military and commercial systems have come to depend on systems affected by the Space Weather. The auroras that are observed above the high latitude locations in the Earth are a typical example of the energetic emission from the Sun reaching the near-Earth space.

Observations in the radio band of the electromagnetic spectrum are useful to study these Space Weather events. The emission from the solar corona, particularly in the radio frequency range $\sim$ 120–40 MHz originates typically in the height range $\sim$ 0.1 to 0.8 solar radii above the photosphere, which at present is difficult to observe at other regions in the spectrum. The existing white light coronagraphs wherein the bright light from the photosphere (i.e. the visible disk of the Sun) is artificially occulted (similar to how the Moon's shadow covers the photosphere during a solar eclipse) cannot observe the above height range due to practical difficulties. In view of these and since radio emission from the solar corona in the above height range is rarely observed elsewhere, the institute is operating a low frequency radio telescope at the Gauribidanur radio observatory, about 100 km north of Bangalore. Note that one of the strengths of the institute since 1950s is in radio observations at low frequencies with indigenously designed and constructed low cost radio telescopes. The aforementioned radio telescope named the Gauribidanur RAdio heliograPH (GRAPH) is used for routine observations of the solar corona from $\sim$ 9 AM – 4 PM everyday, and the data obtained is used to address a wide variety of research problems related to the solar corona including the CMEs.

Some of the other advantages in radio observations are that they can be carried out with relatively simple and cost effective facilities. There is no need to block the bright light from the photosphere and so the solar corona above the visible disk as well as the limb of the Sun can be simultaneously observed with the same instrument, even during cloudy sky conditions, as shown in the above GRAPH image. Observations of the solar corona above the visible disk of the Sun are important since the Earth-directed disturbances originate primarily there. Note that even during an eclipse, only the solar corona above the limb of the Sun can be observed.

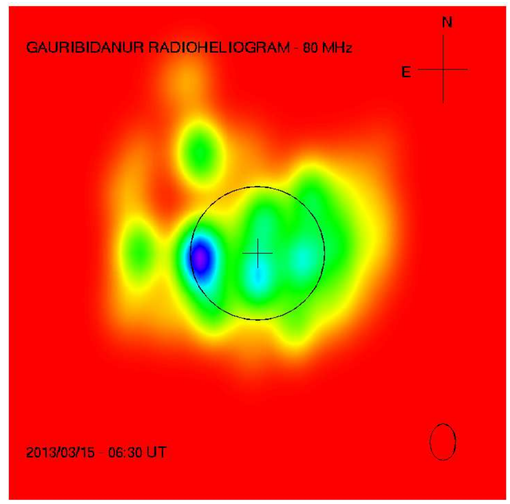


Figure 3.17: Radio image of the solar corona obtained at 80 MHz on 15 March 2013 around 06:30 UT ($\sim$12 Noon IST) during trial observations with Phase-I of the augmentation of the GRAPH. The 'black' circle in the center of the image represents the limb of the visible disk of the Sun (radius = 1 solar radii). The faint emission above the limb in the north-east quadrant corresponds to the onset phase of an Earth-directed CME. The red/blue coloured region close to the east limb indicates the related radio activity on the visible disk of the Sun. The above was an interesting CME since was an increase in the proton and electron flux from the Sun in the aftermath of the event. The associated geomagnetic storm was one of the strongest in the present solar cycle 24. HF radio wave (3–30 MHz) communication in the terrestrial atmosphere was also suppressed. Auroras were observed from high latitude locations.

Taking advantage of the developments particularly in the fields of signal transmission and processing, the radio astronomy group in the institute is presently involved in augmenting the GRAPH with additional antennas and new receiver systems in a phased manner. This is expected to enhance the imaging capability of the GRAPH. The solar corona

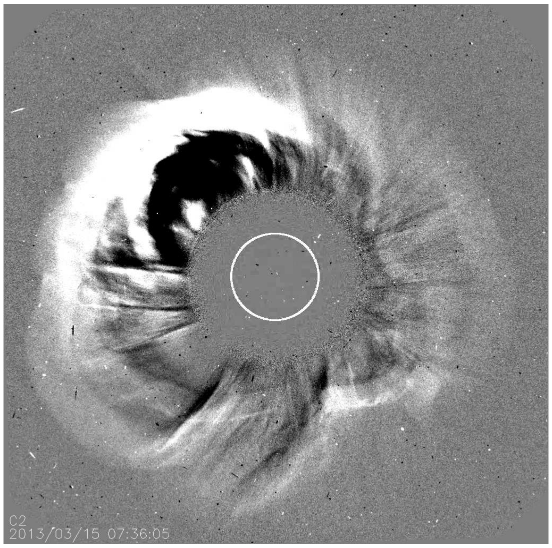


Figure 3.18: Whitelight observations of the CME of 15 March 2013 with the SOHO-LASCO C2 coronagraph, a ESA-NASA joint space mission. The white circle represents the extent of the visible disk of the Sun. The bigger grey colour circular patch is the occulting disk of the coronagraph. In addition to the solar corona above the visible disk of the Sun, it also covers the corona above the limb upto a height of ∼1.5 solar radii. As a result of these restrictions, the CME can be noticed only around 07:36 UT in this image and that too only above the solar limb. Image courtesy of ESA and NASA.

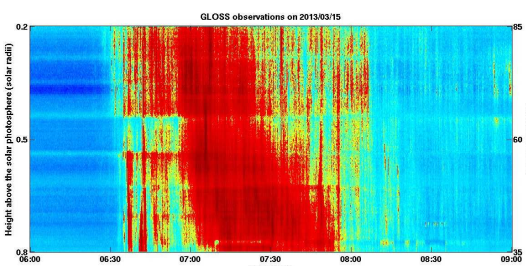


Figure 3.19: GLOSS observations of the transient radio emission associated with the CME of 15 March 2013. The drift of the CME associated radio emission (the bright red patch) during the interval ∼ 07:00 – 07:45 UT can be clearly noticed.

and the disturbances there can be probed in finer detail, particularly from the ground. Presently the Phase-I of the augmentation, where the maximum length of the GRAPH has been increased to ∼ 3 km (from the existing 1.5 km) is nearing completion and trial observations are being carried out.

Gauribidanur LOw-frequency Solar Spectrograph (GLOSS) and a radio polarimeter named the Gauribidanur Radio Interference Polarimeter (GRIP), at the same observatory. These suite of solar observing facilities (heliograph, spectrograph and polarimeter) at radio frequencies are unique to the Gauribidanur observatory. While the data obtained with the GLOSS is used to derive the speed of the propagating disturbances from the Sun, the GRIP provides information on the associated magnetic field. An understanding of the magnetic field in the solar atmosphere is very important since they are the key to understand the energetic eruptions there.

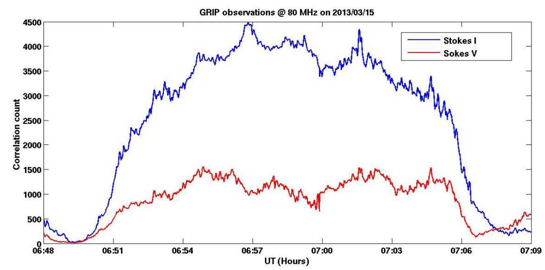


Figure 3.20: GRIP observations of the magnetic field changes associated with the CME of 15 March 2013. The Stokes-V emission, using which the magnetic field strength is derived, will be usually at a very low level. Here it is significant, indicating the level of increased magnetic field activity associated with CME.

Figure 3.21: Aurora associated with the CME of 15 March 2013 seen over Prudhoe Bay, Alaska. Image Courtesy of Greg Syverson and NASA.

(Radio Astronomy Group)

3.6 Library

IIA library's collection saw a major review, especially in relation to the acquisition of e-books replacing the print books. The library has continued the access to e-books collection of Physics & Astronomy, published by Springer and SPIE Digital library along with SPIE e-book collection. The proceedings of IAU collection published by CUP is available electronically from the year 2004, through NKRC consortium along with access to CUP journals. Single titles of books are also acquired electronically on demand. AGU Digital Library consisting of 12 journal titles has been added to the current collection from 2013. The library has acquired new books and additional copies of text books which are required for the course work as per the request of faculty members.

Library Blog: IIA Library has launched its Blog in the month of August 2012 to connect with all the users. This library blog includes the current topics related to the library and information pertaining to IIA staff their Academic interests and General knowledge.

Document Delivery Services: 24 Interlibrary loan requests from IIA faculty and students were fulfilled as they are not held in the IIA collections. More than 40 requests from other libraries and individuals were catered to from the library collections as part of the document delivery service.

Open Access Repository (OAR): M.Sc & M.Tech. theses of IIA regular students are included in Institutional Repository under the "IIAP Master's Theses" collection. The Journal of the Astronomical Society of India(JASI) from Vol.1 to Vol. 10 except Vol.8 has been added to the IR, under ASI publication collection. IIA library has celebrated the "Open Access Week" during October 22–28, 2012 by creating and distributing the poster on "Primary vehicles for delivering OA to research articles" within the campuses of IIA.

Bibliometric Analysis: In addition to the scientometric analysis of IIA research publications as input to Annual Report & DST Report, IIA library has given substantial input for the SAC report, publication data of faculty for the last decade collectively and individually.

Field Station Libraries: The branch libraries at the field stations like Kodaikanal, Kavalur and Hosakote are monitored and maintained from Bangalore, Koramangala Campus Library. Most of the new acquisitions of books & journals in all the field stations are made available electronically for seamless access. Library furniture in Hosakote and Kavalur are upgraded with more shelves and display racks.

Archives: The Indian Institute of Astrophysics, has inherited the pamphlet "Transit of Venus" by Chintamany Ragoonatha Chary the first assistant at the Madras observatory, in English, Kannada and Urdu languages in its archives. The reprinted editions in English and Kannada versions of "Transit of Venus" were brought out by IIA Archives (see Figure 3.22)before the worldwide event of Transit of Venus on June 6, 2012. This Archives publication was officially released by N. Kameswara Rao, former Senior Professor of IIA on the 25th May 2012, after his talk on "Ragoonatha Chary and his Astronomy at Madras Observatory" delivered at IIA.

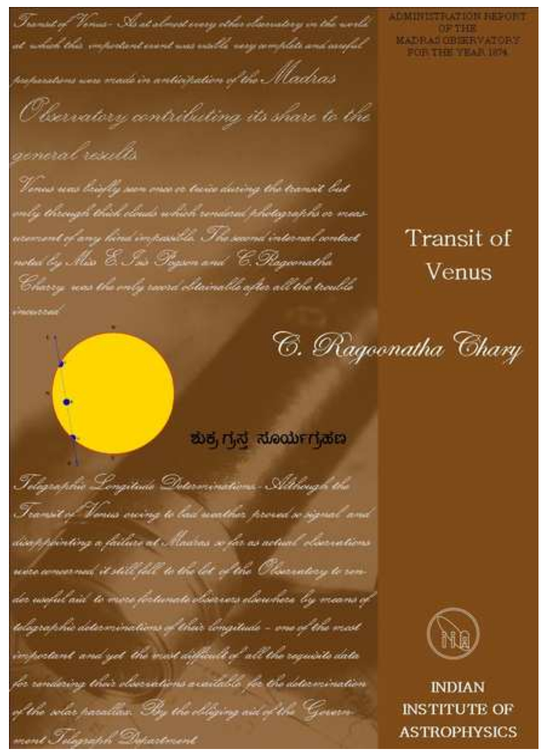


Figure 3.22: Front cover page of reprinted edition in English version of "Transit of Venus."

The collection of photographs in the archives has been revisited and the process of captioning and digitizing them is initiated. The slide collection is also reviewed to identify useful and important ones to be digitized.

Library Training Programme: 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)

3.7 Upcoming Facilities

3.7.1 High Resolution Spectrometer for the 2m HCT

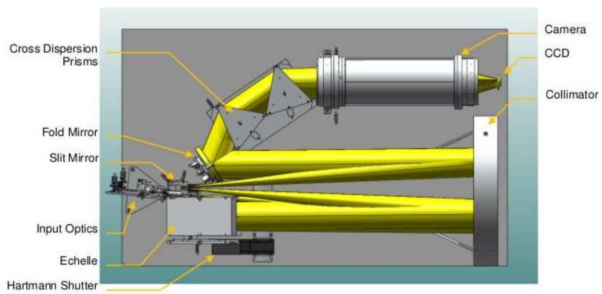


Figure 3.23: The spectrograph unit with its components is shown.

A high resolution spectrometer for the 2m Himalayan Chandra Telescope (HCT) at Indian Astronomical Observatory (IAO) Hanle is being developed to meet the observational requirements of many front-line areas of research, such as extra-solar planets, stellar abundances, asteroseismology, studies of extended envelopes around evolved stars etc.Figure 3.23. The spectrograph design uses white pupil concept, which is used in most modern spectrographs. There are two resolution settings, R $\sim$ 30,000 and 60,000 without and without an image slicer. With a 4K x 4K CCD, the spectrograph is designed to have a continuous spectral coverage over 350-1000nm. The high altitude and low humidity of Hanle site, provide less extinction in blue and low absorption due to water vapor.

The project is largely supported by a DST grant under a fast track scheme IRHPA. It is being executed as technical collaboration with Industrial Research Limited (IRL), New Zealand (recently renamed as Callaghan Innovation Research Limited since February 2013 (CIRL).)

The optics design was completed in November 2011. The full spectrograph design with fabrication drawings and FEA (Finite Element Analysis) has been completed in May 2012. The instrument control (cassegrain unit, spectrograph and calibration unit) and auto guiding, along with the user interface software is being developed at IIA. IIA is also designing and fabricating the thermal enclosure which houses the spectrograph. The thermal enclosure is designed to maintain the temperature of the spectrograph, within 0.5 deg variations over a period of 24 hours.

Update on opto-mechanical fabrication

Mechanical fabrication of cassegrain and calibration units and 95% of spectrograph parts are completed. The glass and mirror blanks and standard optical items have been procured. Optical profiling of all the components (collimator, camera and prisms) are completed. Grinding and polishing of these elements are in progress.

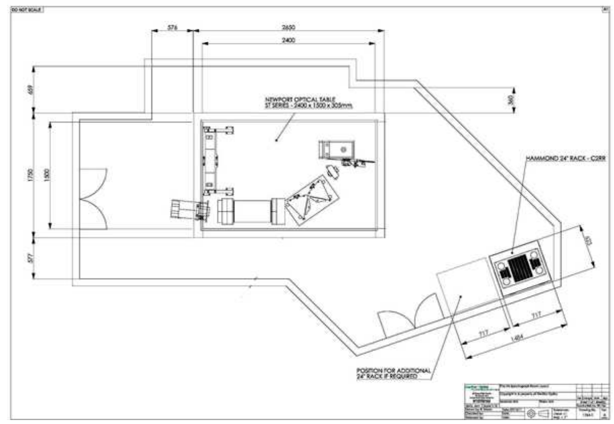


Figure 3.24: The proposed spectrograph layout within the PUF enclosure is shown.

Spectrometer enclosure

At the Hanle site, the spectrograph will be housed in the west wing of the HCT building at the ground floor. The spectrograph needs to be maintained within 0.5 deg (peak to peak), in order to achieve a mechanical stability of 200ms^{-1}.

The ambient temperature at Hanle varies between -28 to $+30^{o}$C over the year. A two layer thermal enclosure concept is planned. An outer layer of 100mm thick PUF layer (Poly Urethene foam) is already installed for the layout design (see Figure 3.24).

Presently we have installed ten thermistor based sensors at different locations within PUF enclosure and a couple outside the PUF enclosure but within HCT building. This temperature data will be useful to optimize the design of the active thermal control and the power requirements.

Spectrometer detector

The spectrometer uses a 4K X 4K chip with pixel size of 15μ in order to cover the full spectral range (3500–10000Å). Further the quantum efficiency (QE) of the

Figure 3.25: The fabrication process of the prism is illustrated in the left column and the right column shows the polishing process for the collimator mirror and one of the camera lens after polishing.

chip must remain high over the full spectral range. The team took advantage of the fixed spectral format of the instrument and proposed to use the graded AR coated CCD chip. E2V technology UK, uses a graded AR coating where the coating thickness is optimized for the wavelength format of the spectrograph at the detector plane. The coating thickness is optimized to the Hanle echelle spectrograph design. Thickness is matched to follow the spectral gradient in the cross-disperser direction as well as the curved pattern of the echelle.(See Figure. 3.27).

To get uniform focus over the full spectral range of 350–1000 nm the design uses a special field flattener that serves as a window of the CCD dewar. A special field flattener with two hyperbolic surfaces made of fused silica has been procured.

(HESP team)

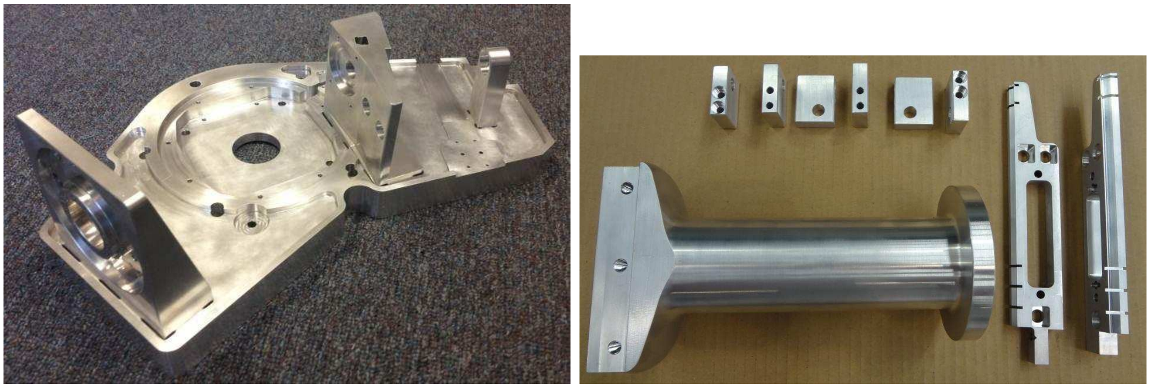


Figure 3.26: The machined mechanical components. On the left is the cassegrain baseplate which will be attached to the HCT instrument cube. On the right, the mechanical parts of the spectrograph input optics and the fold mirror are seen.

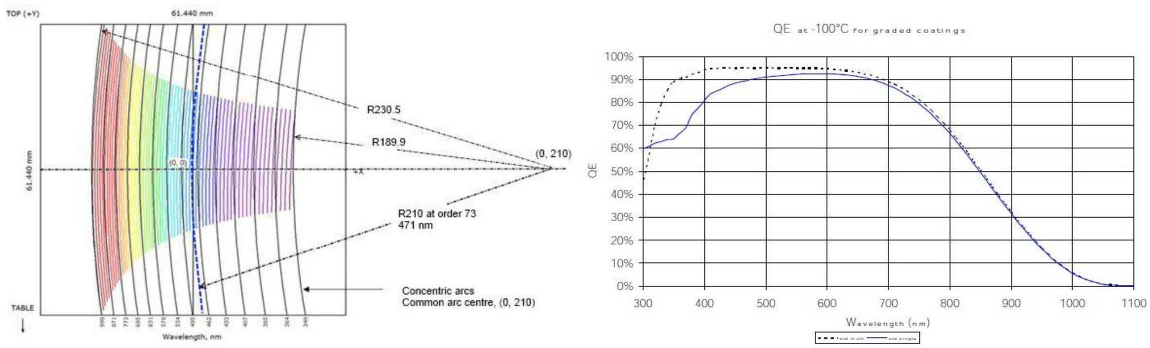


Figure 3.27: Left: The AR coating would follow the location of echelle orders and also the curvature of the order. Right: The enhanced QE due to the AR coating is shown.

3.7.2 UltraViolet Imaging Telescope (UVIT)

UVIT is one of the five science payloads on ASTROSAT, the first Indian satellite devoted fully to astronomy, which is to be launched in the year 2014. ASTROSAT has 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 375 mm diameter. One of the two telescopes observes in FarUV (1300–1800 A), while the other observes in NearUV(2000-3000 A) and VIS (3200-5500 A). Images are made simultaneously in all the three channels with an angular resolution of 1.8 arcseconds in a field of 28 arcmin. In addition to a selection of filters for each of the three channels, low resolution (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:

After completion of all the tests on the Engineering Model and successful completion of Critical design review, the telescope for NearUV and Visible channels was assembled and tested in the last year.

The telescope for FUV was assembled and tested in this year. The spatial resolution in photon-counting mode is found to be ¡ 1.5 for both UV channels. The overall sensitivity of the two UV channel also matches with that calculated from transmission of the individual components which was presented in the report of the last year. There are deviations from linearity in mapping the position from photo-cathode (where the photons are detected) of the detector to the CMOS-imager (where the photon-event is recorded and located). These deviations, called

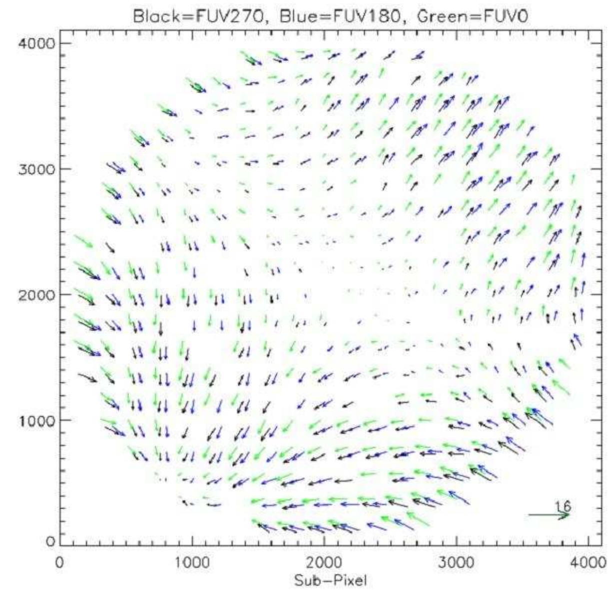


Figure 3.28: Left: Distortion in the FarUV detector is shown. Tail of the arrow represents the corrected position, and head of the arrow indicates the direction in which the measured position is shifted with reference to the corrected position; length of the arrow gives the error in position. Scale on the axes is in units of ≈ 0.4", and scale for the arrows is indicated by an arrow at right-bottom whose length is ≈ 6.4". Right: A picture of UVIT (with the vibration fixture) on the vibration table is shown. The blue tubes, running from top, on the two sides are for purging with clean nitrogen gas to avoid any contaminations.

distortions, have been calibrated for all the three detectors and are shown for FarUV detector in Figure 3.28.

After completion of the two telescopes, the full payload was assembled in Class 100 area of MGK Menon Space Science Laboratory at CREST and transported to ISITE (ISAC), ISRO for vibration tests. The vibration tests were conducted at ISITE during the month of March. Post vibrations checks on the payload showed that all the parts had withstood the vibrations except the detector for the VIS channel. The detector for VIS channel is now under repair. A picture of the payload on vibration machine is shown in Figure **??**. After repair of the detector, the payload would go through thermal-vacuum test before being integrated with the satellite. The repair may be completed by end of May 2013, and the thermal-vacuum tests in July 2013.

(UVIT team)

3.8 New Initiatives

3.8.1 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 observations, the telescope will function with a fully open dome, to achieve its full potential atop a 30 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. The project is currently awaiting formal approval from the Govt. of India.

NLST will be equipped with the following backend instruments:

- Broad Band Imaging System (BBIS)
- Narrow Band Imager (NBI)
- Spectropolarimeter

Prototype development of the backend instruments has commenced at IIA. In the previous annual report details of the NBI instrument were presented. Recently, development of the prototype broad band imaging system and spectropolarimeter for NLST commenced.

(S. S. Hasan & the NLST Team)

Broad Band Imaging System for NLST: The Broad Band Imaging System (BBIS) will be one of the focal plane instruments of the National Large Solar Telescope. The prime objective of this instrument is to obtain high spatial and temporal resolution images of the region of interest on the Sun in the wavelength range from 390 nm to 1083 nm. It will provide filtergrams using broad-band (~1nm) filters while preserving the Strehl ratio provided by the telescope. Furthermore, the BBIS is expected to provide observations that allow image reconstruction to extract wavefront information and achieve a homogeneous image quality over the entire field of view (FOV).

While designing, the BBIS filter transmission is taken into account by the wavelength dependent pre-filter peak transmission. Since the atmospheric transmission decreases with increasing air mass, the photon flux is calculated for four different elevations of the Sun (viz. 90°, 45°, 22.5° and 15°). In order to resolve intensity variations of the order of 1% a signal to noise ratio (SNR) of greater than 100 is needed. From the current photon budget and SNR considerations (right panel of Figure 3.29) it can be seen that this criterion is fulfilled for all wavelength bands.

BBIS is designed to obtain high resolution images of the Sun simultaneously at four wavelengths to probe the morphology of specific features at different depths in the solar atmosphere. In view of the rapid dynamics of the chromosphere, it is essential to observe as many wavelengths simultaneously as possible. BBIS will provide high cadence images to study the time evolution of solar features such as bright points and magnetic elements. High speed detectors would allow speckle reconstruction of features close to the diffraction limit of the telescope.

(K. B. Ramesh, N. Vasanta Raju, R. K. Banyal, K. E. Rangarajan & S. S. Hasan)

Prototype Spectropolarimeter development for NLST: A high resolution spectrograph along with a polarimeter is planned as a backend instrument for NLST. A prototype instrument is under development, which will be deployed on the 50 cm Multi-Application Solar telescope (MAST) at the Udaipur Solar observatory. The instrument will operate in three wavelengths (Fe I 617.3 nm, Fe I 630.3 nm & Ca II 854.2 nm) simultaneously to cover the photospheric and chromospheric layers. Vector magnetic fields will be measured in these layers. The high resolution feature of the spectrograph will allow an accurate measurement of velocities. The broad specifications of the instrument during the prototype and first phase are given in Table 3.1 and the optical design of the spectrograph is presented in Figure 3.30.

The following broad science goals will be pursued: study of sunspots, evolution of polar magnetic fields,

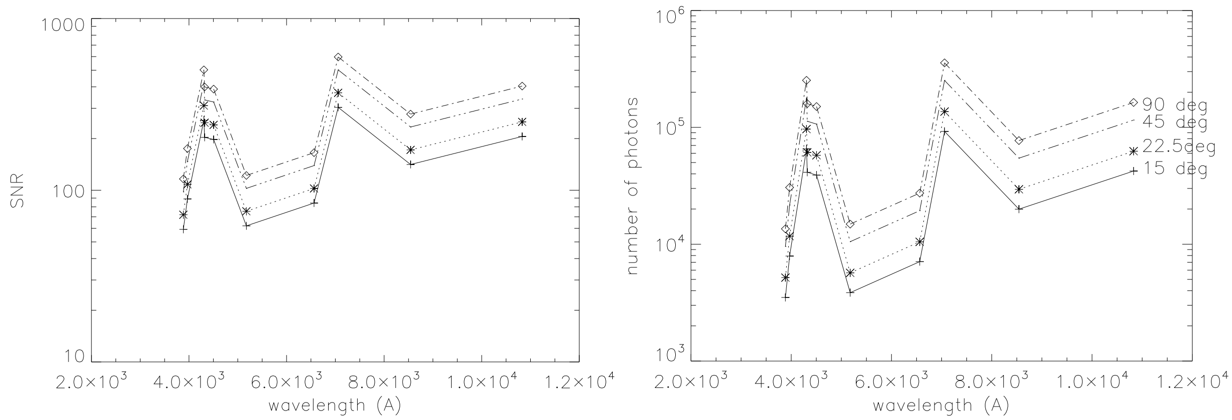


Figure 3.29: Estimated photon numbers N (left) and SNR values $\sqrt{N}$ (right) for the VBI wavelengths for four different elevations of the Sun.

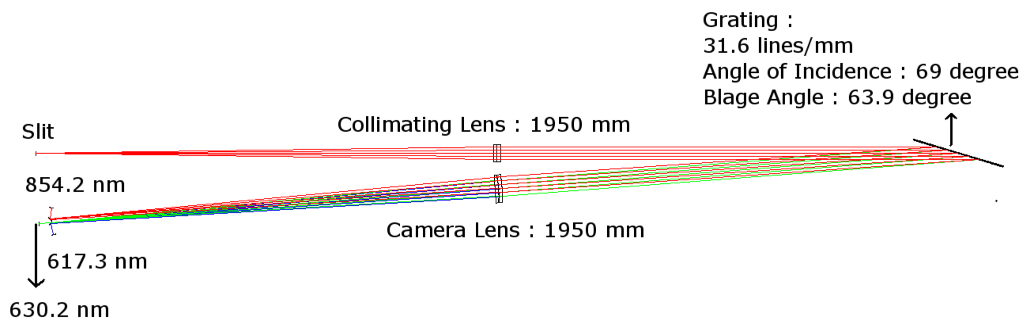


Figure 3.30: Prototype design of the spectrograph.

Table 3.1: Instrument specifications.

Specification	**Requirement**	**Prototype**	**First Phase**
Wavelength range	350 - 1600 nm	350 - 900 nm	350 - 1600 nm
Simultaneous measurements	5 wavelengths	3	5
Spatial resolution	Diffraction limited	Twice telescope	Diffraction limited
FOV	2 arcmin	90 arcsec	2 arcmin
Spectral resolution	10 mÅ	20 mÅ	10 mÅ
Polarimetric sensitivity	10^{-4}	10^{-3}	10^{-4}
Slit scan accuracy	0.06 arcsec	0.3 arcsec	0.06 arcsec

dynamics of active regions, measurements of weak magnetic fields using the Hanle effect, multiwavelength observations to study the magnetic coupling between the photosphere and chromosphere, emerging flux regions and the associated magnetic helicity observations to look for flare eruptions, and off-limb observations of prominences and spicules. The required wavelength resolution for the above studies is: 20 mÅ, with a time cadence of 10 s, field of view of 120" × 120" and polarization accuracy of 10^{-4}. Since MAST has an aperture of 50 cm, observations of solar features would, of course, be at a lower resolution compared to NLST. There is a 5 cm separation between the Ca 854.2 nm (formed in the chromosphere) and the other two Fe I lines (formed in the photosphere). A folding mirror of size 2.5 cm will be kept to observe the 854.2 nm line alone. The 617.3 nm and 630.2 nm lines are separated by a dichroic beam splitter. The collimating and camera lenses have diameters of 10 cm and 15 cm respectively. The approximate time frame for development of the spectropolarimeter is two years.

(K. E. Rangarajan, K. Sankarasubramanian, K. Prabhu & S. S. Hasan)

Site characterization program

A detailed and comprehensive report of the site characterization studies carried out between 2007 and 2011 at the high altitude desert and lake sites Hanle and Merak in Ladakh, and the astronomical site Devasthal in Uttarakhand was submitted by end of 2011. Merak and Hanle turned out to be the finalist sites with Merak having outstanding conditions comparable to those of the finalist sites for ATST in USA. During the year of this report, observations were continued only at Merak using automated weather station, all sky camera, and sky radiometer particularly since observations have already been gathered for a very significant duration at Hanle.

While Merak has outstanding conditions of seeing in the visible, Hanle has good conditions in visible and a marginal advantage for observations in the Near Infra Red (NIR) due to the low amount of precipitable water vapour (PPWV) content over the site. In order to quantify this, computation of the seeing conditions for observations in the NIR was carried out for Hanle for a sample month of August 2007, for various heights up to 34 m above ground. The relation given by Roddier (Progress in Optics XIX 281, 1981) for the wavelength dependence of the Fried's parameter R_0 was used to evaluate the seeing using observational data from Shadow Band Ranger (SHABAR) at 500 nm. The representative results for 800 and 1600, nm are presented for a height of 24 m, in the Figure 3.31. The daily average values of the PPWV less than 5 mm are generally considered suitable for NIR observations. Hanle has longer durations of very low PPWV with eight months having lower than even 2 mm, while three months have averages of over 5 mm. Merak is close behind with daily average PPWV of less than 2 mm for five months, and greater than 5 mm for three months. Therefore, while Merak is an outstanding site for a large solar facility in visible and NIR combined, Hanle is an excellent site for observations from the redward side of visible to near infrared.

(S. P. Bagare, S. S. Hasan, T. P. Prabhu, K. E. Rangarajan, Rajendra B. Singh, Namgyal Dorjey, Angchuk Dorje & Dorjai Tsewang)

Aerosol optical properties of the sites

Observations with a sky radiometer constituted an integral part of the site characterization program at Hanle (Oct 2007 to Dec 2010) and Merak (Jan 2011 to the present). Aerosol optical depth (AOD) measures at these sites show the region to have background like levels of AOD which are comparable to those of some of the best known astronomical sites in the world. During the period of this report the seasonal and diurnal changes of AOD were estimated. An enhancement during spring is observed and these are confirmed using data from Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO). The pathways of the aerosols arriving at the site were studied using back trajectory analysis of Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model and it was found that the airmass arrived predominantly from the Saharan desert region. It was also found, in what is one of the first evidences, that occasional arrival takes place from Gobi and Taklaman deserts in Central Asia. A near absence of arrival of anthropogenic aerosols from the Indo-Gangetic plains was deciphered from the trajectories. Further work on cloud screening of data and carrying out of regular calibrations and health checks of the radiometer were carried out during the year.

(S. P. Bagare, S. S. Ningombam, Rajendra B. Singh, Namgyal Dorjey & Erik Larson)*

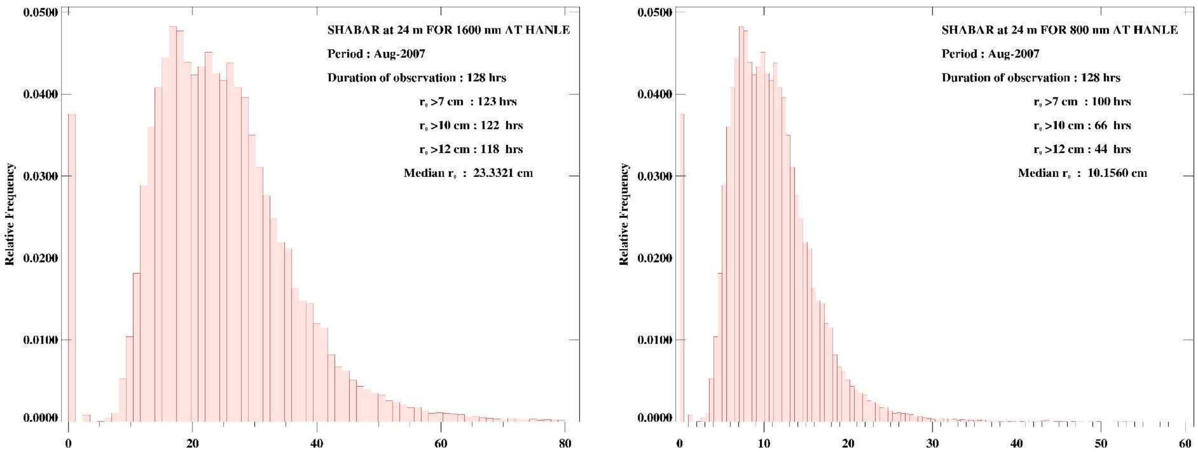


Figure 3.31: Seeing conditions at Hanle in the near infrared at 800 and 1600 nm, at a height of 24 m.

3.8.2 Thirty Meter Telescope Project

Status Report

In 2012–13, the TMT project made a significant progress towards realization of scheduled construction start in mid 2014. In April, TMT crossed an important milestone when it obtained a final land use permit in Hawaii to build the telescope on the summit of Mauna Kea, Hawaii. Also, the National Science Foundation (NSF) entered into a collaborative agreement with the TMT project which is one of the major achievements as many government agencies in the partner countries required US government body to supporting the project. Partners are working to get fund approvals or commitments by the respective funding agencies to meet the schedule. TMT Japan , a 25% partner, in the project had a major break through by getting an approval of its budget of about USD 14M for the year 2013–14 through voting in its parliament "Diet" which is a major boost to the project. The TMT international Observatory (TIO) partnership master agreement is in place and all the partners are ready to sign the document. This agreement will be signed in two stages: one by scientific authorities of the respective partners and next by the financial authorities. A signing ceremony by the scientific authorities is scheduled in Hawaii in July, 2013 at the board of directors meeting. This would signify partners commitments to the project realization. As per India TMT, the academic year 2012-13 has been an eventful year both in terms of policy and the progress made at the ground level fulfilling our commitments to the project. India TMT hosted two TMT partner wide meetings: a two day science meeting followed by the science advisor committee (SAC) meeting at IUCAA, Pune during 10–14 December 2012, and the TMT board of directors meeting in New Delhi during 21–22 January 2013. The science meeting attracted a number of young faculty and students in India. From IIA about 12 members attended the meeting and many of them gave talks. About 30 members from partners countries too attended the meeting. One of the major themes of the meeting was TMT instrumentation and the related science cases. Indian participants identified polarimetry science as a gap in the scientific capabilities of the TMT. The meeting resulted to award India TMT a work package to make a feasibility study. A cohesive group with Asoke Sen (Silcher University, Assam) as a lead and other members drawn from IIA, IUCAA and ARIES has been formed, and which is making progress. In March this year, IIA for India TMT hired a legal firm "Sundaraswamy & Ramadas " based in Bangalore to assist India TMT in its engagements with the partnership.

The 37th TMT board of directors meeting is another important event. This is the second board meeting that happened outside North America. This is one of the rare meetings where the entire board was present including Henry Yang (chair), Ed Stone (co-Chair), Masahiko Hayashi (Director General, NAOJ), Cynthia Atherton (Science Director, Gordon Moore Foundation), Greg Fahlman (Manager, National Research Council, Canada), Suijian Xue (Associate Director, NAOC) and Masanori Iye (programme director, TMT Japan). The meeting was also attended by science attachs of Embassies of respective countries. India TMT was represented by Dr. Ramasami (Secretary, DST, Govt. of India), Ajit Kembhavi (Director, IUCAA), Ramsagar (Director, ARIES), Bhanu Das (Director, IIA), Praveer Asthana (Senior Scientist, DST), Arbinda Mitra (Director, international Division), Rajiv Sharma (Director, Indo-US science forum), Purnaih (DAE), Eswar Reddy, Ramaprakash, and Shashi Pandey.

Eswar Reddy welcomed the board and introduced delegates from India side. After the project report by Gary Sanders (Project Manager), Dr. Ramasami greeted and addressed the board. He affirmed DSTs and Indias commitment to the TMT Project. He emphasized that the collaborative nature of the international partnership is equally as important to India as the scientific capabilities of TMT. He informed the board that TMT has been the one of the top priorities among various international projects. Dr. Ramasami said that the major goal of the project for India is to stimulate young peoples interest in careers in Astronomy. There was a discussion of how the partnership might help with media outreach and communication efforts to increase public awareness and support for the project in India. He has asked Eswar Reddy (Programme Director) to identify any gaps in the timeline and flow of funds for India's participation in the project and to make sure that there is a legal review of the Master Agreement and the proposed legal framework. In the subsequent months, India TMT engaged a legal firm which reviewed the master agreement. The master agreement along with a review report was sent to the DST for its review and approval.

India TMT: India TMT has taken up various critical hardware and software work packages which include providing India's share of 100 segments (total 574), entire set of actuators, Edge sensors, segment support assemblies and a significant part of observatory software. We have taken up prototype development. Significant progress was made in the technology area. GOAL, Puducherry manufactured 12 prototype edge sensors which have been tested at Jet Propulsion Lab (JPL, USA). Avasarala Technologies, Bangalore made first three of 10 prototype actuators which have passed all the functional tests. Two of them have been shipped to JPL for further critical tests. Godrej, Mumbai and Avasarala, Bangalore are working producing 6 sets of SSA each. Initiated developing software modules for the observatory. At India TMT lab, under the guidance of Padmakar Parihar, trainee engineers are working on calibration of edge sensors and developing tools to test actuators functions. (Details of the work are mentioned below. Work on segments are yet to begin.

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

TMT actuators:

In order to achieve very high spatial resolution as well as sensitivity, 492 hexagonal mirror segments of the TMT have to be precisely positioned with respect to each other to form a 30-meter hyperboloid primary mirror. Once mirror segments are aligned based on information from the Alignment and Phasing System, any subsequent deformations due to gravity, thermal changes and wind-induced pressure distributions, will be taken care of by M1 control system (M1CS). The M1CS performs this task, with the help of actuators that move segments in tip, tilt and piston relative to the mirror support structure. These movements are based on error signals generated from edge sensors that are exquisitely sensitive to the relative height and tilt of neighboring segments. The TMT M1CS actuator is a soft actuator primarily controlled by a voice-coil and an extremely accurate position sensor used for feedback. The static weight of the mirror is not supported by the voice-coil, but instead supported by a spring, which off-loads the quasi-static gravitational force. The control system of the TMT actuator contains two loops. The position control loop precisely controls the position of the actuator output shaft and the off-loading loop minimizes the steady state current in the voice coil actuator. Each mirror segment will be driven by three actuators and altogether 1476 actuators are required for the TMT project. The contract to manufacture 10 number of prototype actuators has been given to Avasarala Technology Limited, Bangalore (ATL) and first 3 actuators are expected to be received shortly. Currently we are developing a test station for the M1CS actuator, which will be used to carry out simple functionality tests during the prototype and mass-production of the TMT actuators in India. The final version of the device is aimed to be handy, rugged and works without aid of any external computer. The same device may also be used for any accelerated life tests of actuator at the TMT-INDIA laboratory. The hardware and software of this device is ready and is tested with prototype actuator in ITCC Lab as well as two actuators at Avasarala Technologies Limited, Bangalore. In addition to this, a precision controller is also being developed to control the actuator in close loop. The concept is to implement digital PID control algorithms along with tuning methods, digital filters, limit switches, Snubber and Offloader algorithm in a single SBC board. This will help in the study of actuator performance in close loop & different load conditions. Currently

Figure 3.32: Group photograph of the board members and participants taken at India International Center (venue for the board meeting).

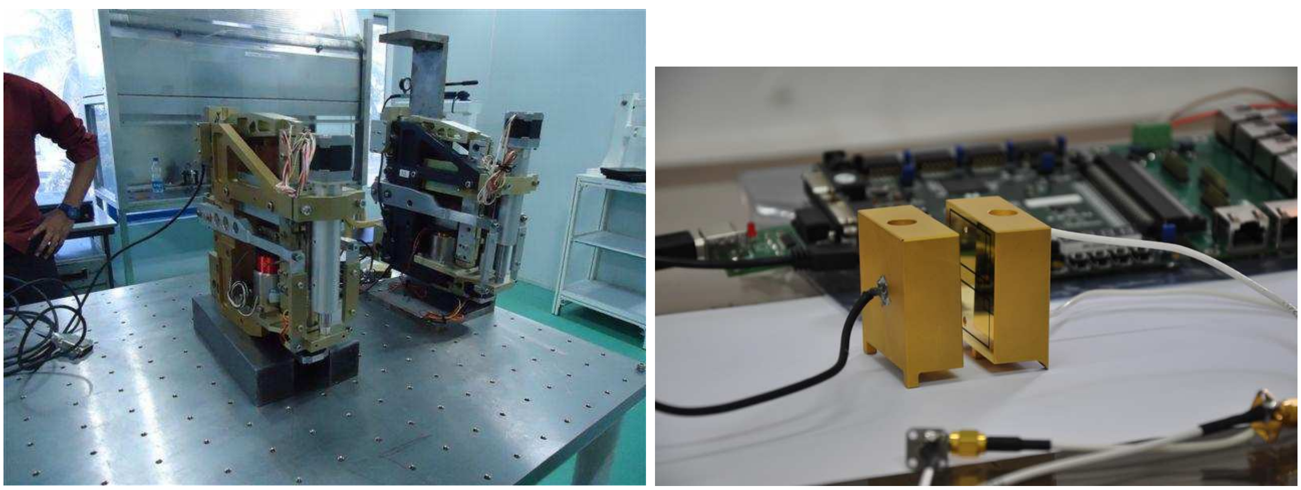


Figure 3.33: (left) Manufactured and assembled actuators in ATL premises. The TMT actuator is seen at right. (right)The edge sensor in the ITCC laboratory. These sensors have been manufactured in India by GOAL.

this controller is in the testing phase and is used with the prototype actuator in ITCC Lab. Further, it is planned to check the performance of the actuator under dynamic load condition and for that a laboratory setup is being created by making use of force inducing devices.

(Prasanna Deshmukh, Kinjal Shah, Maharnab Bhattacharjee, Padmakar Parihar, Eswar Reddy & P. K. Mahesh)*

Edge sensors

The edge sensor is an extremely important component of the Thirty Meter telescope and it is based on capacitive technology, which allows high precision contact-less measurement, on large operational ranges. Each segmented mirror will have 12 edge sensors and in total 3234 sensors are required for the TMT. The capacitance is that of a simple capacitor in air. Each sensor uses a change in the charge on a capacitor to measure a linear combination of a change in the relative height of the two adjacent segments and a change in the dihedral angle between the two adjacent segments. It has got a drive half, mounted on one segment edge and receiver half, mounted on a neighboring segment edge. Each half of the sensor is a rectangular block of glass having extremely low thermal expansion. All sides are polished to relieve stress and coated with 0.5 micron gold over 0.05 micron chromium coating. The work to produce 25 prototype sensors has already been initiated in India and a company named General Optics Asia Limited (GAOL) Puducherry, has given contract to produce 25 number of sensor pair. GOAL has indigenously developed all the processes required to manufacture the sensor and provided 12 sensors which are being independently inspected and tested at TMT headquarter Pasadena as well as in India.In addition to prototype the edge sensors in India, it has been decided to calibrate and test the sensors in ITCC laboratory. The test facility has been created and one round of sensor calibration has been done using, the sensor, related electronics and the software provided by JPL through TMT. Now attempt is being made to carry out all the tests and verify it with the results obtained at JPL. In addition to this, attempts are being made to analyze and test the sensor electronics and suggest any improvement if required.

(Kavitha Bhatt, Faseehana Saleem, Padmakar Parihar, Eswar Reddy & P . K. Mahesh)*

3.8.3 ADITYA-1

Visible Emission Line space solar Coronagraph

The work on the payload VELC has been progressing well. The (Preliminary Design Review) PDR on the optics has been completed and discussions on structure design are in the final stages. Efforts have been made to optimize the mass of the payload. In January 2013, an impression was given to enhance the capability of mission by changing the orbit of the satellite from low earth orbit (LEO) to L1– Lagrange point with a bigger satellite capable of taking more weight and volume. The Indian solar scientists proposed that spectroscopy and spectro-polarimetry may be planned in addition to the imaging of solar corona. There are many missions performing spectroscopy in the UV, EUV and X-ray wavelength range but there is no space base mission having plan to do spectroscopy in the visible emission lines which do not have any blending from other temperature lines. It might be better to perform the spectroscopy 5 emission lines namely, [Fe X] at 637.4 nm, [FeXI] at 789.2 nm, [Fe XIII] at 1074.7 & 1079.8 nm and [Fe XIV] at 530.3 nm simultaneously. These lines represent plasma temperature in the range of 1-2 million degrees and are strong emission lines in the visible part of the coronal spectra. The intensity ratios of [Fe XI]/[Fe X] will yield the thermal and non-thermal structure of the relatively low temperature plasma between 1 – 1.5 million degrees whereas that [Fe XIV]/ [Fe XIII] will provide information about relatively hotter plasma between 1.5 – 2 million degrees. In addition the intensity ratios of the two IR emission lines will yield the density structure in the solar corona. Simultaneous information about temperature, density, velocity and magnetic fields will be of great value to understand the physical and dynamical characteristics of solar corona and make realistic models for the coronal heating processes. The observations in all the emission lines may not be possible because of requirement of large instrument for this purpose and therefore, observations in some of the emission lines only have been planned. Initial design of the instrument has been worked out that will have the facilities to take the images of the solar corona in continuum, spectro-polarimetry in the IR [Fe XIII] emission line at 1074.7 nm and high resolution spectroscopy in the [FeXI] line at 789.2 nm and [Fe XIV] line at 530.3 nm. The final decision about the payload will be taken after various reviews.

The optical design for VELC was initially designed for a detector with pixel size of 13.5 micron and chip size of 2K×2K but the detector for the mission, after number of experiments has been chosen for a better signal to noise ratio is a CMOS chip with 6.5 micron pixel size of 2K×2K format. In view of this, a modification in optical design at the imaging lens in each channel, (keeping design till M4 identical) became necessary. The modified design reduces the image size in all channels to half the previous size, keeping the plate scale per pixel almost same as earlier. The optical layout remains almost same except that specifications of some of the components changes.Figure 3.34

The structure design and optimization of the payload is being done considering various materials and realization. Thermal design is being worked out, especially for the cooling of primary mirror M1 and maintaining the temperature of the detectors at -100 C to obtain the better performance of the detectors. Studies are being made to test and verify the performance of all the optical components and to calibrate the filters.

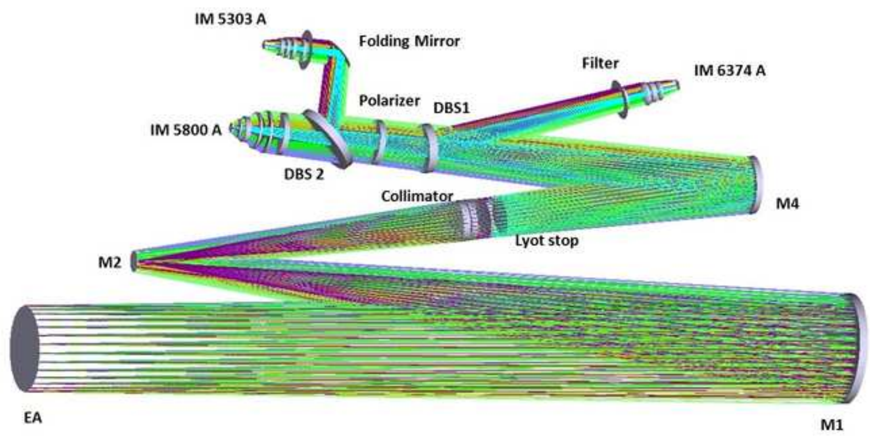


Figure 3.34: Optical lay-out of VELC.

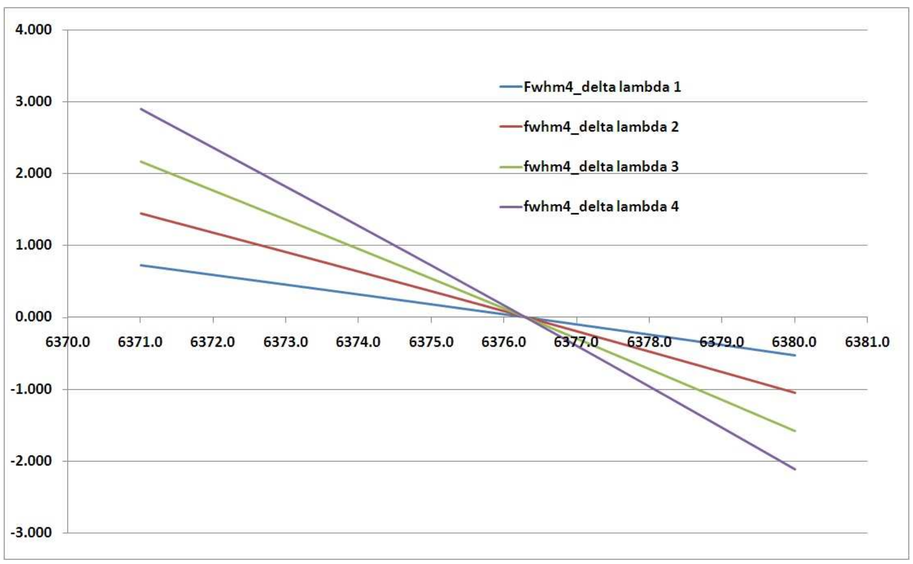


Figure 3.35: The figure shows the results of simulations of intensity ratio as a function of Doppler shift.

Doppler images of the solar corona using VELC on ADITYA mission

It is planned to generate the Doppler images of the solar corona in the red [FeX] emission line at 637.4 nm by taking the images of the solar corona through two narrow pass band filters having peak transmission at different wavelengths; one in the blue side emission line and other in the red side line, alternatively. The line intensity in these two images will vary depending on the shift in the line caused by Doppler velocity. Simulations were done choosing filters with different pass bands and different central wavelength. The figure Figure 3.35 shows the intensity ratio as a function of Doppler velocity for filters with a pass band with a FWHM of 0.4 nm. The wavelength the red line in vacuum is 637.63 nm. Simulations made for the filter with this pass band and central pass band separated by 0.1, 0.2, 0.3 and 0.4 nm are shown in the figure as a function Doppler shift in terms of wavelength. Generally, intensity ratio of two emission lines can be measured reliably up to 100. The curve for filters with separation less than 0.2 nm are slower and do not cover large velocities whereas curve with 0.4 nm separation is steeper. Simulations show that two filters with 0.4 nm pass band having central wavelength of 637.43 and 637.83 nm will be required for making the observations al-

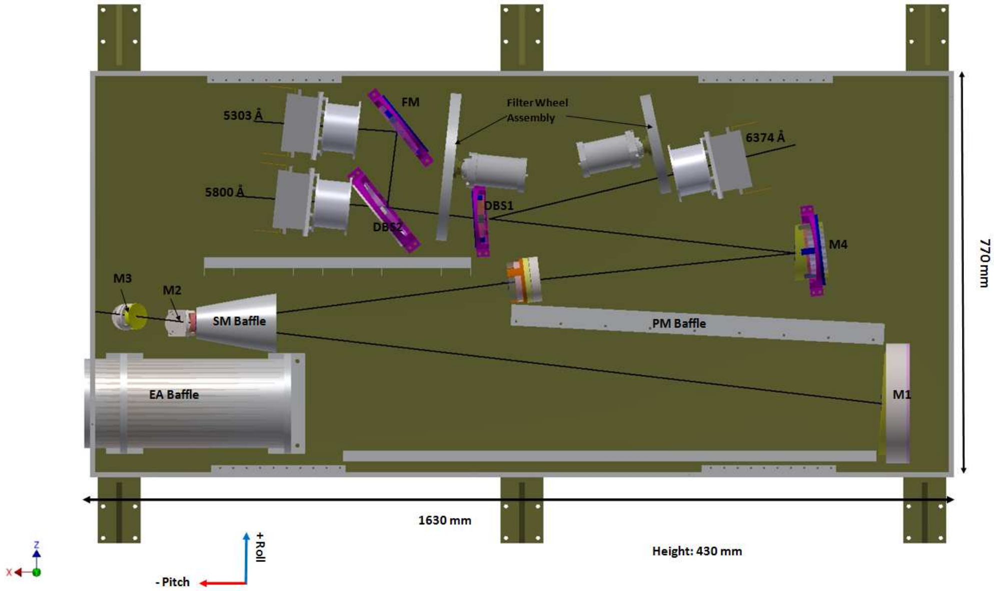


Figure 3.36: Top view of VELC.

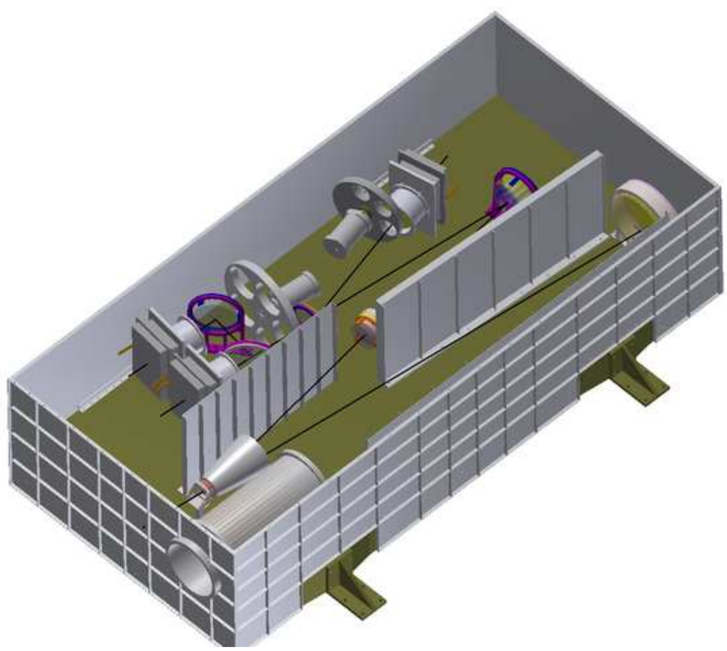


Figure 3.37: Opto-mechanical configuration of VELC.

ternatively and to make Doppler-grams of the solar corona.

The combinations of images of the solar corona in the continuum channel and Doppler images will provide the information about the velocity and direction of CME's, important parameters to study the dynamics of CME's and space weather predictions.

In VELC optical components mounted on an optical bread board, over which all the necessary process electronics are also mounted. Necessary baffles are also placed over this bread board. This entire optics, electronics and other components are covered on all sides with honeycomb panels. The bread board's size is 750mm x1600mm x 100 mm3. In order to make sure that light only from the sun and not from other sources reach the primary mirror, the entrance aperture is projected by 20mm. The overall volume of VELC will be 1630 mm x 770 mm x 430 mm. The total mass of the system is around 137 kg.

The structural design Figure 3.36 is carried out by following both model driven and simulation driven approach. By this, a part is modeled first and immediately it is analyzed to check the conformance of necessary stiffness. Then, based on the observations of the analysis results, the 3D model is edited and simulated again. This process is done continuously, until a balance between the mass and stiffness is struck. Bread board is the major part in the instrument as every other sub-systems are mounted on it. The bread board should be stable, structurally and thermally. To achieve this, quite a few materials were tried and Titanium Alloy (Ti6Al4V) was selected. A complete set of analysis (Modal, Static, Buckling, Frequency Response) was done considering Titanium as the breadboard material. Since there is need to reduce the mass further, currently detailed analysis and discussion is going on to use Aluminum honeycomb with Titanium or CFRP face sheets. The opto-mechanical 3D models Figure 3.37 received from LEOS were fixed at their respective positions as per the optical layout to check for interference, integration clearance. These non-conformances were communicated back to the optical designers and LEOS and issues got resolved from time to time. Again, these opto-mechanics were analyzed with the whole instrument (i.e.) opto-mechanics mounted over the bread board, side covers, baffles etc., integrated and complete analysis was done. Rework/redesign was done wherever needed. All these finite element analysis were carried out considering the load specifications supplied by ISAC.

Selection of detector systems

Asit Patra and his team at SAC, Ahmedabad had conducted experiments suggested by the Dr. Kiran Kumar committee to determine the performance of the short listed two detectors, one the CCD chip made by SCL, Chandigarh and other CMOS detector made by Fairchild and find out the suitability of one of these for the coronagraph payload. Experiments were carried out 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 per cent, in the small signal with time. Figure 3.38 shows that the signal with large background and small variation of less than 1 per cent of 1 Hz frequency was used. The time sequence images were obtained at a frequency 0.33 Hz for 32 seconds. The power spectral analysis of the data indicated that the small amplitude variations of about 0.5 % can be detected with the CMOS detector by binning 4 x 4 pixels. The comparison of data of the CCD and CMOS listed in Figure 3.39 indicates that the performance of CMOS is better as compared to the CCD detector and therefore, it is decided to use the CMOS detector should be used in the coronagraph.

Scatter studies for the VELC for ADITYA-1 mission

Aditya-1 is India's first space solar mission which will carry Visible Emission Line Coronagraph (VELC) in Low Earth Orbital for solar coronal observations. VELC is an internally occulted mirror coronagraph for simultaneous narrow-band imaging of solar corona centered at 5303Å(Fe XIV), and 6374Å(Fe X) emission lines over a Field of View (FOV) of 3Ro (Ro- Solar Radii) and broad-band imaging of solar corona centered at 5800 Åover a FOV of 6Ro. This coronagraph uses internal occulter in order to observe the solar corona from close to the disk (1.05R_o to 3R_o) which will not be feasible with external occulter with the current day technologies. The coronal intensities are on the order of one-millionth of the disk intensities. Due to this, the primary mirror of this instrument which looks at the solar disk light has to be of very high surface quality in order to have low scattered light at the prime focus.

The payload requirement demands scattered light to be less than 5-ppm (parts per million) at final focal plane over the FOV 6R_o in order to have a good signal to noise ratio (SNR) for the projected science goals. In VELC, major contributor to the instrument background is the scattered disk light into the field of view from the primary mirror. The scatter is primarily due to its surface micro roughness. So a detailed study of the scatter light due to the surface micro roughness is critical. Scatter studies will be carried out with the help of theoretical studies (simulations) and by experimental validation.

Primary mirror is the main sub-system which needs to provide low scattered light in the coronagraph since it sees the full disk light. There are two methodologies which will be adapted to estimate the scattered light from the primary mirror: (i) Theoretical estimation of scatter light using existing theoretical models, (ii) Set-up a small (samples up to 50mm) scatterometer in the lab to verify theoretical simulations by making scatter measurements

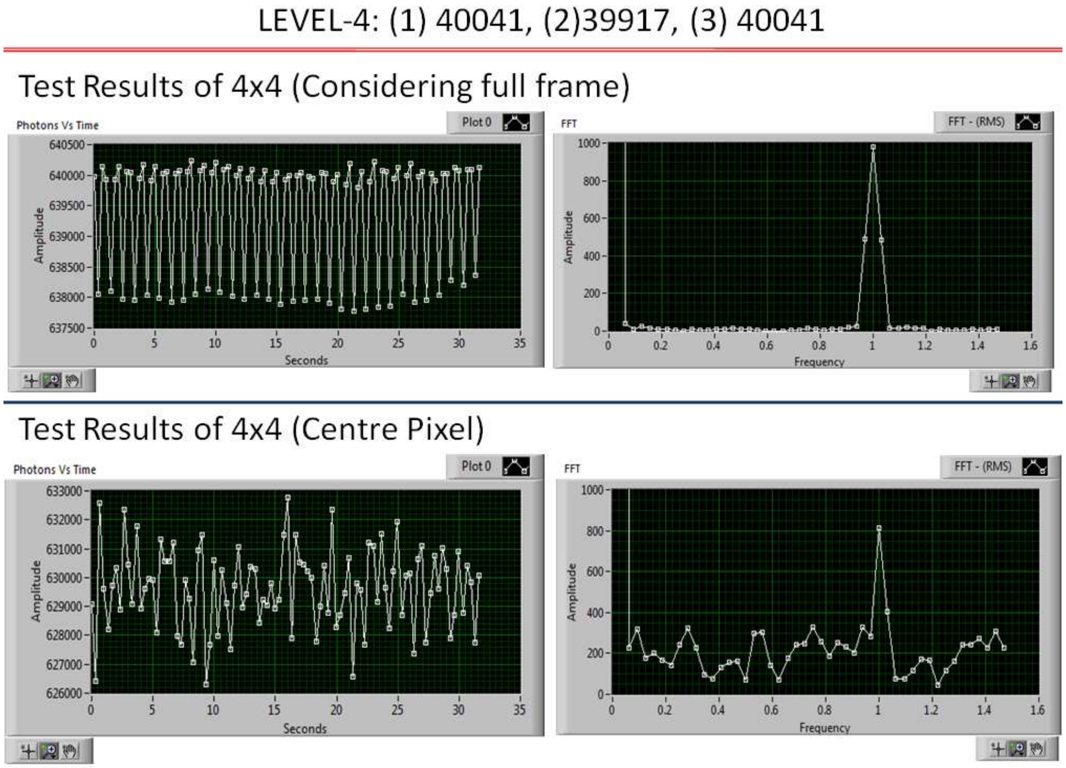


Figure 3.38: The data obtained with the CMOS detector and the FFT of the data are shown here.

on samples and also use the same system for scatter measurements on witness coupons (iii) Estimate angle resolved scattered light using the profilometer data during the figuring of the uncoated mirror as well as after coating and (iv) actual measurement of the angle resolved scattering in the laboratory after the mirror fabrication (including coating) using a 32 arcmin beam, and (v) system level scatter measurements with 32 arcmin beam.

Computation of scattered light resulting from micro roughness of the primary mirror is carried out using ASAP (Advanced System Analysis Program) and ZEMAX. There are multiple models (such as Lambertian, Nonlinear, and Harvey etc.) for scatter estimation. We are primarily focused on the scatter model provided by J. E. Harvey to compute the scattering characteristics of highly polished optical surfaces. Harvey model states that the scatter behaviour of applicable surface types does not depend on the incidence angle alone, but rather upon the angular difference between the scattered and specular rays.

For a coronagraph having a FOV of $1.05R_o$ to $3.0R_o$, the important angle of scattering which would contribute to the final focal plane is from 0.013^o to 1.067^o. Light scattered in other angles either leaves the coronagraph through M2 hole or blocked by the baffles. These angles can be converted into corresponding spatial scales on the mirror surfaces using the standard diffraction equations and that turns out to be from 28.4 μ m to 2.34 mm for the 530.3 nm wavelength and 34.13 μ m to 2.81mm for the 637.4nm. RMS micro roughness of the primary mirror surface should be < 1.5 Å over above mentioned spatial periods.

There are no off-the-shelf angle resolved scatter measuring instruments for the angles of interest of this payload. Hence, a custom build is the only way to proceed. Previous scatter studies for similar coronagraph on-board SOHO (LASCO-C1) can be used as a guideline for the instrument design and development. The method followed in LASCO-C1 coronagraph is to use M1 and M2 mirror in the setup so that the specular beam is taken out of the beam path of interest. In order to minimize scatter due to other sources (like Rayleigh scattering from air molecules, scattering from dust and other contaminants) these experiments need cleaner and controlled environments (preferably inside a clean room). To arrive at the right estimate of the scatter, the illu-

Test Result Summary

It is seen that, When RMS electrons of actual detectable signal is more than four times to the RMS readout noise of the system, FFT shows better results in both the cases. Hence binning requirements for CCD and CMOS for different levels are shown below

Level	sCMOS		CCD	
	Binning requirement to instigate detection	RMS Detectable signal / RMS readout noise	Binning requirement to instigate detection	RMS Detectable signal / RMS readout noise
4 (40K ± 100)	2x2 (1X)	7.6	4x4 (External)	7.56
3 (4K ± 10)	8x8 (10X)	6.3	10x10	4.7
2.5 (2K ± 5)	Data Not taken		16x16	6.05
2 (1K ± 2.5)	10x10 (30X)	3.85	16x16 (Marginally)	3.02
1 (0.4K ± 1)	16x16 (30X)	3.06	Difficult to tune the source	

Requirement of Binning for each levels are identified based on the test results (By considering noise component amplitudes are ≤ 25% of the desired signal)

1. **Level4: 4x4 (sCMOS), 8x8 (CCD, External)**
2. **Level3: 8x8 (sCMOS), 16x16 (CCD)**
3. **Level2.5: 10x10 (sCMOS), 16x16 (CCD)**
4. **Level2: 16x16 (sCMOS), 20x20 (CCD, External)**
5. **Level1: 32x32 (sCMOS)**

Figure 3.39: The comparison of the results obtained from the data obtained with CMOS and CCD detectors with different level of signal.

mination needs to be similar to that of the actual observational condition. In this case, the 32 arcmin size of the illumination (mimicking the disk light) is required to estimate the scatter. While generating such a source care must be taken not to have any optical surfaces from the object to the entrance aperture of the coronagraph. All the optical elements to generate a 32 arcmin source must be placed behind the object (which can be an iris). The distances of this iris must be chosen in such a way that the scattering in the optical element does not reach the entrance aperture, further than the 32 arcmin. The major difficulty comes not in generating the source but in illuminating the full aperture (which is 15cm in this case). To provide a 15cm size beam at the entrance aperture with a 32 arcmin divergence, a space of 16m with clean environment is a must and no-folding is allowed within this distance. The required clean room facilities are available at MGK Menon laboratory of IIA. Efforts are on to develop a standard scatterometer and also the experimental facility to calibrate the coronagraph.

(Jagdev Singh and team VELC)

Chapter 4

Students Program and Teaching Activities

4.1 Academic Programs

4.1.1 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 2012 – 2013 twenty seven students did their projects under the guidance of the various academic staff members.

4.1.2 Summer internship programme

Twenty students did their projects under the guidance of the various academic staff members under the summer internship programme.

4.1.3 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. 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 2012, the school was held at the Kodaikanal Observatory, during 15 – 25 May 2012.

Twenty five students participated in the school, of which ten students each did a short term project for a duration of six week during June – July 2012, under the guidance of an IIA faculty in Bangalore. During the second week of July they also made a presentation on the results of their project work. The programme during the period 15 – 25 May 2012, in Kodaikanal consisted of a series of lectures including Physics and Astrophysics mostly by the faculties of IIA. The areas on which lectures were given included Observational Astronomy (U.S.Kamath), Sun and Solar System (S. P. Bagare), Solar Physics (K. Sundara Raman), Classical Physics (C. Pravabati), Radiative Processes (K. E. Rangarajan), Star formation, Stelllar Structure and Evolution (Firoza Sutaria), Astronomical Techniques and High Energy Astronomy (C. S. Stalin), Galactic Astronomy (Annapurni Subramanian), Magnetic Fields (A. Satya Narayanan), Extragalactic Astronomy (Mousumi Das), Radio Sun and Radio Astronomy (R. Ramesh), Data Reduction (Gajendra Pandey), spectroscopy (R. K. Chaudhuri) Genral Relativity and Cosmology (Arun Mangalam). Lakshminarayan Hazra, Retd. Head & Professor, Department of Applied Optics & Photonics, University of Calcutta gave a interesting evening lectures titles “Astronomical Optics I & II”.

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.

4.1.4 International Research Experience for Students (IRES)

Under the International Research Experience for US Graduate Students (IRES) programme, sponsored by the National Science Foundation of USA, IIA

Figure 4.1: The IRES students with Prof. B. P. Das, Acting Director.

hosted the following students during the summer (June – August) of 2012: 1. Ms. Stephanie L. Fiorenza (CUNY Graduate Center, New York, USA) was guided by T. Sivarani on the project "Search for the primordial population in globular cluster", 2. Ms. April Broaden (Alabama A & M University, Huntsville, USA) was guided by A. Satya Narayanan on the project "MHD waves in twisted flux tubes with flows", 3. Mr. James P. Mason (University of Colorado, Boulder, USA) was guided by Jagdev Singh on the project "Solar coronal studies via spectrographic observations of visible emission lines using 25 cm coronagraph", and 4. Mr. John R. Hodgson II (CSUN, Northridge, USA) was guided by Firoza K Sutaria on the project "Study of transit timing variations in exoplanets".

The IRES programme, 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 programme 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 programme received a positive review and continued funding from the NSF and 2012 is the sixth year of the programme 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 programme 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 research period.

4.1.5 Ph.D. Awarded

Bharat Kumar Yerra was awarded (on 29.06.2012) the Ph.D degree for his thesis titled "Study of Li-Rich K Gaints" submitted to the Calicut University on 18th August 2011. He carried out the above work under the guidance of B. Eswar Reddy.

Akondi Vyas was awarded (on 14.12.2012) the Ph.D degree for his thesis titled "Advanced wavefront sensing algorithms in astronomical adaptive optical systems" which was submitted to the Indian Institute of Science, Bangalore on 8th February 2012. He carried out the work under the guidance of B. Raghavendra Prasad.

4.1.6 Completion of Ph.D. Thesis

The following students submitted their thesis:

Sumangala Rao submitted her thesis titled "Spectroscopic Studies of RV Tau and Related Objects" to the Mangalore University on 25.4.2012. The research was done under the supervision of Sunetra Giridhar.

Amit Shukla submitted his thesis titled "Radiation Mechanisms of VHE *gamma*-ray Sources" to the Pondicherry University on 18.01.2013. The research work was done under the supervision of G.C. Anupama and T.P. Prabhu.

4.1.7 Completion of M.Sc

The following students from the third batch of the above programme have completed their M.Sc degree under the IIA-IGNOU integrated M.Sc-Ph.D programme.

Vaidehi Sharan Paliya under the guidance of C. S. Stalin submitted his thesis titled "Multi-Wavelength Study of Variability in Active Galaxies: The Case of Narrow Line Seyfert I Galaxies", to the School of Inter-disciplinary and Trans-disciplinary Studies, IGNOU, for his M.Sc degree in Physics and Astrophysics, in June 2012.

4.1.8 Completion of M.Tech

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

K. Hariharan under the guidance of R. Ramesh submitted his M.Tech thesis titled "Design of a Circularly Polarized Antenna System for Low Frequency Radio Astronomical Observations" to the University of Calcutta in July 2012.

Avinash Surendran under the guidance of Padmakar S. Parihar and Ravinder Banyal submitted his

M.Tech thesis titled "Development of a Lunar Scintillometer for Measuring ground Layer Turbulence" to the University of Calcutta in July 2012.

Satya Ranjan Behera under the guidance of J. P. Lancelot submitted his M.Tech thesis titled "Wavefront sensing of Extended Sources" to the University of Calcutta in July 2012.

A. G. Sreejith under the guidance of Jayant Murthy submitted his M. Tech thesis titled "High Altitude Balloon Experiments" to the University of Calcutta in July 2012.

4.1.9 Achievement

Vaidehi Sharan Paliya from the 3rd batch of IIA–IGNOU Integrated M.Sc-PhD stream, based upon meritorious performance for award of the University Gold Medal for standing first in the examination held in June 2012, received the gold medal at the 26th convocation held at Bangalore Regional Center of IGNOU.

4.2 Pedagogical lectures & courses taught in IIA

A group of 14 international students participating in an advanced post graduate study program of the Centre for Space Science and Technology Education in Asia and Pacific, affiliated to the United Nations, and organized in India by the Physical Research Laboratory, Ahmedabad, visited IIA during March 14th to 17th, 2013. Lectures were organized at IIA Bangalore, and Jayant Murthy and S. P. Bagare addressed the students on various topics in Astrophysics. The students visited the photonics laboratory where some of the ongoing fabrication techniques were demonstrated to them and explained by J. P. Lancelot. This was followed by a visit to Hosakote campus where the remote operation of HCT was shown and lectures were given by B. C. Bhatt. The students then visited Kodaikanal Observatory where they carried out observations and data reduction at STT, under the guidance of K. Sundararaman and K. B. Ramesh, who also gave lectures on Solar Physics. The entire visiting student program at IIA was coordinated by S. P. Bagare.

4.3 Pedagogical lectures & courses taught outside IIA

S. P. Bagare

- "Our celestial neighbourhood the Sun, the Planets and their Satellites", guest lecture program at a National Workshop co-sponsored by DST and UGC, and held at the Department of Physics, Sri Krishnadevaraya University, Anantapur, during March 2–3, 2013

A. Goswami

- "A cosmic journey from Hydrogen to Iron and beyond", guest lecture program at a National Workshop co-sponsored by DST and UGC, and held at the Department of Physics, Sri Krishnadevaraya University, Anantapur, during March 2–3, 2013

K. M. Hiremath

- taught a course on fundamentals of solar physics to the students of (REAP) Research Education Advancement Programme, January 2013, Jawaharlal Nehru Planetarium, Bangalore

A. Mangalam

- Course on Statistical Mechanics at C-MMACS, Bangalore, at the graduate level, September–October, 2012
- Course on Mechanics at the under-graduate level for REAP conducted by BASE, and Nehru Planetarium for advanced graduate and undergraduate students, in which IIA is a participating institute.

S. K. Saha

- "An Introduction to Astronomical Telescopes & Instrumentation", guest lecture program at a National Workshop co-sponsored by DST and UGC, and held at the Department of Physics, Sri Krishnadevaraya University, Anantapur, during March 2–3, 2013

A. Subramaniam

- Two lectures on "Introduction to CCDs and Data reduction using IRAF," workshop for MSc. students, St. Joseph's College, February 8–13, 2013

Chapter 5

Scientific Conferences, Workshops & Lectures at IIA

Lectures at IIA

Founder's Day Lecture

Figure 5.1: Anil Kakodkar garlanding the bust of Vainu Bppu on the occasion of Founder's Day.

Birthday of Vainu Bappu, the 10th of August, is celebrated every year as the Founder's day at IIA. This year, as has been the custom, all members of IIA gathered in the Library at 10:00 am to remember and reflect on the long-term vision of Vainu Bappu and the progresses made. The Director (Acting) of IIA, Bhanu Pratap Das, led the gathering and garlanded a picture of Bappu. This was followed by a public lecture at 11:00 am. The lecture was by the renowned nuclear physicist and former Chairman of the Atomic Energy Commission of India, Anil Kakodkar. Currently he is DAE Homi Bhabha Chair Professor at the Bhabha Atomic Research Center (BARC).

Kakodkar spoke on "Management of Mega Science Programmes", a topic of relevance and importance to IIA, which has recently assumed leading roles in a few mega-science projects in the country and at the international level. Kakodkar paid tributes to Dr. Vainu Bappu, who pioneered building up major research programmes around indigenously built large size experimental facilities, and stated that the Vainu Bappu Telescope and Vainu Bappu Observatory stood testimony to this visionary effort. He noted that such Mega Science initiatives had implications well beyond the immediate science objectives that trigger them. Kakodkar reasoned that, although many times it is argued that engaging in such efforts causes disproportionate distraction to competitive research, on the whole such initiatives do lead to greater gains not only in terms of greater access to front line research capability both at home and abroad, but also much larger technology spin off benefits for the country. Apart from addressing questions on the cost benefit aspects of large investments made in Mega Science initiatives, he noted that implementing them would be a major challenge, considering the technological complexities and large body of expertise that would be necessary. Kakodkar saw such challenges as those which would bring in opportunities to transform S & T scene in the country. He stressed and concluded that it was necessary to be able to discuss and clearly understand these and related issues from an overall national perspective.

Anil Kakodkar (born on 11th November, 1943) joined the Bhabha Atomic Research Centre (BARC) in 1964, following the one year post graduate training with top rank in Nuclear Science and Technology in the then Atomic Energy Establishment. He became the Director of BARC in the year 1996 and was the Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy, during the years 2000 -2009. Currently he is DAE Homi Bhabha Chair Professor at BARC. Kakodkar holds several important advisory positions in the Government and in corporate bodies that manage sectors like, power, education, societal development and others.

(S. P. Rajaguru)

Bicentennial Public Lecture

The origins of the Indian Institute of Astrophysics is traced back to the year 1786 when the astronomical observations made at Madras by William Petrie, an enlightened officer of the East India Company, led to the setting up of the Madras Observatory. The Bicentennial Public Lectures were instituted in 1987 to commemorate the heritage of 200 years of Astronomy that IIA proudly possesses. The 22nd Lecture in this series was held on the 14th of December, 2012 and it was delivered by Raghavendra Gadagkar, Professor and JC Bose National Fellow at the Centre for Ecological Sciences, Indian Institute of Science (IISc), Bangalore. Professor Gadagkar's lecture was titled 'War and Peace: Conflict and Cooperation in an Insect Society'. The content of his lecture, masterfully and beautifully delivered, derived from the pioneering research that he set up over the past 25 years at the IISc in the area of Animal Behaviour, Ecology and Evolution. The origin and evolution of cooperation in animals, especially in social insects, such as ants, bees and wasps, is a major goal of his research. By identifying and utilizing crucial elements in India's biodiversity, he has added a special Indian flavour to his research.

Figure 5.2: Raghavendra Gadagkar

In his Lecture, Gadagkar elaborated on how some species of insects such as ants, bees and wasps organize themselves into colonies with social organization and integration, division of labour and caste systems that parallel if not better human societies. He then presented his research team's findings on studying the workings of a tropical wasp society, and derived parallels to reflect on how we, the human societies, conduct our affairs. One of the interesting findings by Gadagkar's team was that these wasps were extremely aggressive to, and highly intolerant of, other members of their species which did not belong to their colonies. However, the wasps were highly tolerant of each other and display almost no aggression to colony members even when there was considerable conflict. Gadagkar described and contrasted such war towards foreigners and peace with insiders. He also illustrated his team's research methodology that permitted an understanding of these insect societies.

Figure 5.3: A tropical wasp society, extremely aggressive to, and highly intolerant of, other members of their species which did not belong to their colonies.

Professor Gadagkar obtained B.Sc (Hons) and M.Sc. in Zoology from Bangalore University and Ph.D. in Molecular Biology from the Indian Institute of Science, Bangalore. Gadagkar is now SN Bose Research Professor of the Indian National Science Academy and JC Bose National Fellow at the Centre for Ecological Sciences, Indian Institute of Science, Chairman, Centre for Contemporary Studies, IISc, Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Non-Resident Permanent Fellow of the Wissenschaftskolleg (Institute for Advanced Study) in Berlin and Honorary Professor, Indian Institute of Science Education and Research, Kolkata. He is, or has been, a member of a number of national and international professional scientific bodies and government and non government advisory committees including the Scientific Advisory Committee to the Cabinet, Government of India. As the founder chair of the Centre for Contemporary Studies, Gadagkar has initiated a new experiment that endeavours to engage some of the best practitioners of different disciplines in the human sciences, such as philosophy, sociology, economics, law, literature, poetry, art, music, cinema etc. and aims to forge meaningful interaction between the natural and human sciences with special focus on understanding the diverse research methodologies of different disciplines and create opportunities to rethink the foundations of our own disciplines.

(S. P. Rajaguru)

Colloquia

20 November 2012
Siva Athreya
Indian Statistical Institute, Bangalore
Random processes on fractal like objects

25 September 2012
Rajesh Kochhar
Indian Institute of Science Education and Research, Mohali
Kodaikanal Observatory as a world astronomy heritage site

06 August 2012
G. Rajasekaran
IMSc, Chennai
Standard model, Higgs boson and what next ?

06 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

Seminars

25 March 2013
Subhadeep De
National Physical Laboratory, Delhi
Experiments with mixtures of Bose-condensed rubidium and degenerate fermionic lithium

22 March 2013
Michael Dopita
Australian National University, Australia
Non-thermal electron distributions in HII regions ?

18 March 2013
Michael Dopita
Australian National University, Australia
Close encounters and gas stripping in galaxies

08 March 2013
Rodney Delgado Serrano
Panama Univ. Astronomical Observatory
The evolution of the Hubble sequence: morpho-kinematics of distance galaxies

05 March 2013
L. S. Anusha
MPI for Solar System Research, Germany
Advanced Numerical Methods For Polarized Line Formation Theory

27 February 2013
Bindusar Sahoo
National Institute for Subatomic Physics, Amsterdam
Topologically massive higher-spin gravity

21 February 2013
Sravani Vaddi
Rochester Institute of Technology, New York
Feedback in the local universe: The Relation between star formation and AGN activity in typical elliptical galaxies

15 February 2013
Shriharsh Tendulkar
Caltech, Pasadena, CA 91125
Magnetars: Kinematics, ages and birth places

14 February 2013
Shriharsh Tendulkar
Caltech, Pasadena, CA 91125
Robo-AO: Automated Adaptive Optics for Small Telescopes

14 February 2013
A. K. Sen
Assam University, Silchar
Photopolarimetric Observations of some recent comets

13 February 2013
Pratik Majumdar
Saha Institute of Nuclear Physics, Kolkata

Very High Energy Gamma Ray astronomy : A tool to study the very high energy universe

28 January 2013
Giono Gabriel
University of Lyon, France
Segmentation of Coronal Features to Understand EUV & UV Irradiance Variability

15 January 2013
JinLin Han
National Astronomical Observatories, Beijing, China
Galaxy clusters as tracers of cosmic web

11 January 2013
Rahul Shetty
Univ. Heidelberg, Germany
A non-universal Kennicutt-Schmidt relationship and star formation self-regulation

10 January 2013
Pratika Dayal
Royal Observatory, Institute for Astronomy, Univ. Edinburgh
The earliest galaxies: probing cosmic dawn

09 January 2013
Debanjan Bose
Inter-university Institute for High Energies (IIHE), Brussel, Belgium
Study of AGN and GRBs in Very High Energy Regime

09 January 2013
Manoj Purvankara
Dept Physics & Astronomy, Univ. Rochester, USA
Infrared Spectroscopy of Protostars with Spitzer and Herschel: Probing the earliest stages of stellar birth

08 January 2013
Girjesh Gupta
Max Planck Institute for Solar System Research, Lindau, Germany
Nature of propagating disturbances in the polar coronal hole

04 January 2013
Akondi Vyas
School of Physics Science Centre, North Belfield, Dublin
Detecting lower order aberrations: an analysis of Hartmann Shack, curvature and confocal wavefront sensors

04 January 2013
Bidya Binay Karak
Dept Physics, IISc., Bangalore
Theoretical study of the solar magnetic cycle and its irregularities

02 January 2013
K. Nomoto
Kavli IPMU, Todai Institutes for Advanced Study, Univ. of Tokyo, Tokyo
Progenitors of Type Ia Supernovae

31 December 2012
Shri Kulkarni
Caltech, USA
ULTRASAT: An Ultra-Violet Time Domain Explorer

27 December 2012
Siddharth Savyasachi Malu
School of Basic Sciences, IIT, Indore
A Window into the early history of the Universe

30 November 2012
C. Muthumariappan
IIA, Bangalore
On the nature of IRAS 18333-2357: a very rare and peculiar PN located in the Globular cluster M22

29 November 2012
Natalie Batalha
San Jose State University, USA
Catching Shadows: Kepler

19 November 2012
T. R. Seshadri
Dept Physics and Astrophysics, University of Delhi
Constraining primordial magnetic fields using cosmic microwave background radiation

16 November 2012
G. Thejappa
Department of Astronomy, University of Maryland, College Park, USA
Emission modes of Solar Type I radio bursts

15 November 2012
Shrikanth G. Kanekal
NASA, Goddard Space Flight Center
The dynamics of Relativistic Electrons in the Earth's Van Allen Radiation Belts: current understanding and future prospects

09 November 2012
Kanak Saha
Max-Planck Institute for Extraterrestrial Physics, Garching, Germany
Secular evolution and structure of disk galaxies: impact of dark matter halos

02 November 2012
Petrus C. Martens
Physics and Computer Science Departments, Montana State University, Bozeman, MT, USA
Smithsonian Astrophysical Observatory, Cambridge, MA, USA
Computer Vision for Solar Physics

31 October 2012
Ashok K. Singal
Physical Research laboratory, Ahmedabad
Our large peculiar motion in the universe determined from the radio sky brightness anisotropy at 1.4 GHz

12 October 2012
Subinoy Das
Institute for Theoretical Physics and Cosmology, Aachen, Germany
Mysteries of dark matter, dark energy and their possible connection to the neutrino

27 September 2012
L. N. Hazra
Department of Applied Optics and Photonics, University of Calcutta, Kolkata
Selected topics from contemporary research in applied optics

17 August 2012
Peeyush Prasad
University of Amsterdam, The Netherlands
Amsterdam-ASTRON Radio Transients Facility and Analysis Center, and the search for radio transients using LOFAR

16 August 2012
Sandeep Gautam
Physical Research Laboratory, Ahmedabad
Mixtures of Bose-Einstein condensates

27 July 2012
G. Thejappa
Department of Astronomy, University of Maryland, College Park, USA
Bispectral analysis of a Langmuir wave packets associated with Solar Type III radio bursts

25 July 2012
Debi Prasad Choudhary
California State University, Northridge, USA
The Nature of Sunspot Phenomena - An Observer's View

24 July 2012
Marcel Goossens
Center for Plasma Astrophysics, KU Leuven, Belgium
Coronal Seismology Using Standing and Propagating MHD Waves

24 July 2012
A. Bemporad
INAF-Turin Astrophysical Observatory, Turin, Italy
Solar mass ejections: what we learnt from coronal spectroscopy

23 July 2012
Jorg Buchner
Max Planck Institute for Solar System Research and Georg August University Gottingen, Germany
Magnetic energy release in the laboratory and in astrophysics, the Sun and other stars

13 July 2012
Cristina H. Mandrini
Instituto de Astronomia y Fisica del Espacio, Universidad de Buenos Aires
Combined quantitative study of CMEs – ICMEs

12 July 2012
Marian Karlicky
Astronomical Institute of the Academy of
Sciences of the Czech Republic, Czech Republic
Plasma Processes in the election Beam-return Current System of Solar Flares

11 July 2012
Stanislav Gunar
Astronomical Institute of the Academy of Sciences of the Czech Republic, Czech Republic
Complex modelling of fine structures of the solar quiescent prominences

11 July 2012
Marian Karlicky
Astronomical Institute of the Academy of Sciences of the Czech Republic, Czech Republic
Cascading magnetic reconnection in solar flares

10 July 2012
Petr Heinzel
Astronomical Institute of the Academy of Sciences of the Czech Republic, Czech Republic
Radiative relaxation in solar prominences

04 July 2012
Bhimsen Shivamoggi
Department of Mathematics, University of Central Florida, Orlando. USA
Electron MHD (EMHD) Turbulence

19 June 2012
P. Shalima
IUCAA, Pune
Mid-IR counterparts of X-ray sources in NGC1399

28 May 2012
Vikram Rana
Caltech, Pasadena
The Nuclear Spectroscopic Telescope Array

25 May 2012
N. Kameswara Rao
IIA, Bangalore
Ragoonatha Chary and his Astronomy at Madras Observatory

23 May 2012
Jasjeet Singh Bagla
IISER, Mohali
Forming Galaxies in Dark Matter Haloes

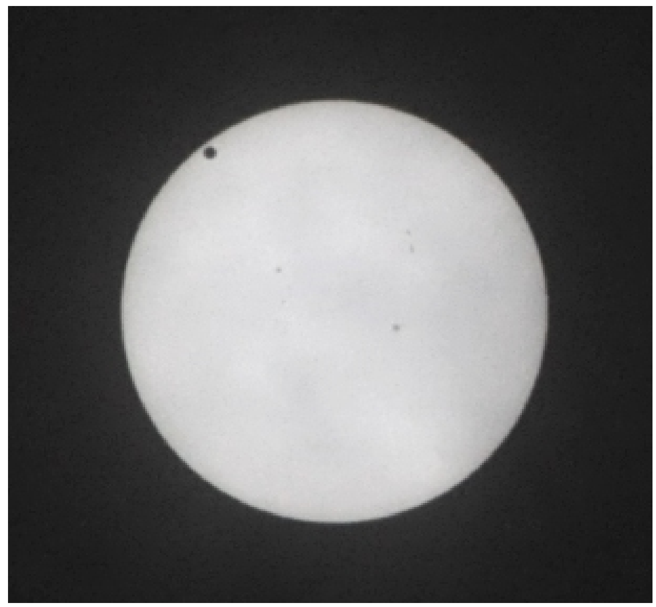
23 April 2012
Ananda Hota
NCRA-TIFR, Pune
Panchromatic Snapshots of Galaxy Evolution: Infall, Merger and Feedback

20 April 2012
Gert de Geyter
Dept. of Physics & Astronomy, University of Ghent, Belgium
Radiative Transfer Simulations: Fitting and Applications

Chapter 6

Outreach Activities

Transit of Venus being observed at the Skywatch Observatory on the terrace of IIA's main building, which houses a 14 inch telescope.



Transit of Venus which occurred on June 6, 2012, viewed from Bangalore

6.1 Transit of Venus

A large number of visitors including school and college students and representatives of several news media channels visited IIA, Bangalore, starting early morning hours to witness and to report the rare astronomical event of transit of Venus across the Sun, on June 6th, 2012. Arrangements were made using two mirror coelostatand a lens system to project a 12 inch image of the Sun on a screen so that the transit may be witnessed live. Arrangements were also made for near-live viewing of the observations from field stations, obtained through internet, at the main auditorium. In addition, a 14 inch Meade telescope was installed on roof top of the Main building for viewing the transit. Special viewing glasses were distributed to the public for safe viewing of the Sun.

A flyer prepared and printed explaining the importance and other details of the transit were also distributed among the visitors. Ravinder K. Banyal gave 30 minute presentations and interactive lectures, in several batches, throughout the day. K. E. Rangarajan, K. B. Ramesh. D. Banerjee, Ebenezer, Ravinder Banyal, B. Ravindra, K. Prabhu, and Rajendra B. Singh, assisted by Murali Das, Periyanayagam and Yogesh, participated in the outreach program. Many Ph.D. student volunteers, including K. Chandrashekhar, B. P. Hema, S. Krishna Prasad, and Sajal Kumar Dhara, participated enthusiastically in explaining the phenomenon to the visiting students and public.

(K. E. Rangarajan & S. P. Bagare)

6.2 National Science Day

National Science day-2013 was celebrated at the Indian Institute of Astrophysics, Bangalore campus, on 28 February 2013. Over 400 students from six schools, in and around Koramangala, namely Baby Mona School, Chinmaya Vidyalaya, Seema School, Govt. High School Madiwala, Christ School and Christ Academy, participated in the programme. The day started with a painting competition. After this event, the students were taken around the campus, by IIA student volunteers, to locations where several experiments and displays were setup. Among them are:

- The projected image of the sun on the screen to show the sunspots.
- A visit to optics laboratory to see the various optical items and demonstrations
- A demonstration of optical and gravitational experiments
- An exhibition of posters and telescope models.

The 4-inch Newtonian telescope distributed by Professor Bhanu Pratap Das to the school teachers.

After going around the optics lab, seeing the experiments, posters and the telescope models the students assembled at the auditorium for a movie show on "Astronomy". This was followed by a talk titled "Our Universe: A short journey from the Earth to Galaxy super clusters" was delivered by Preeti Kharb.

Immediately after the talk, a Quiz competition was held. All the questions for the quiz competitions were shown on the display. There were about 4 rounds of questions and each round consisted of questions.

Soon after the quiz competition, Professor B. P. Das, Acting Director of IIA, distributed prizes to the winners of the painting and quiz competitions. The first prize for the painting competition was bagged by Aishwarya Naik, 7th Std. of Chinmaya Vidyalaya, second prize went to Sebastian Thomas, 8th std student of Christ School and the third prize was bagged by Mohammed Azhar a 10th std student of Govt. School, Madiwala. In the Quiz competition, Christ Academy was the winner and Govt. School, Madiwala was runner up.

School children participating in the painting competition.

In view of bringing awareness among the students and teachers about astronomy, after the prize distribution, a 4-inch Newtonian telescope built by IIA, was given to the schools by the Director. Followed by this, K. B. Ramesh and Bhanu Pratap Das addressed the students stressing upon the importance of science day and the discovery of Raman Effect to the students.

In the evening there was a public Lecture by C. S Stalin on "Thirty Meter Telescope-Bringing Space Closer to Earth". Following the lecture, a sky watch programme was arranged at the roof top with the 14-inch and 12-inch MEADE telescopes of IIA. A large number of people participated in sky watching. This programme was coordinated by Padmakar Parihar.

The student, staff and Faculty of IIA together made the programme a grand success.

The volunteers from the IIA were: P. U. Kamath, P. K. Mahesh, V. K. Subramanian, J. P. Lancelot, T. K. Muralidas, Sandra Rajiva, P. M. M. Kemkar, Periyanayagam, N. Bhaskar, D. Thyagaraja, N. Vasantharaju, B.Prabhu Ramkumar, K. Prabhu, Rajendra Bhaadur Singh, K. B. Ramesh, P. S. Parihar, C. S. Stalin, Preethi Kharab, B. Ravindra, L. C. Pradeep, Sajal Kumar Dhara, K. Chandrasekhar,

The first prize for the painting competition was bagged by Aishwarya Naik, 7th Std. of Chinmaya Vidyalaya.

B. P. Hema, S. Krishna Prasad, M. Prashanth, P. Srinivasa, K. Sowmya, H. D. Supriya, P. Ramya, K. Drisya, S. Avinash, Manpreet Singh, A. G. Sreejith, H. Manjunath, R. K. Sasikumar, Sudhakar Reddy, M. Honey, A. R. Sushmitha, C. Samyaday, H. N. Smitha, Arya Dhar, C. R. Sangeetha, Arun Surya, Tanmoy Samantha, Joice Mathew, Vaibhav Pant, T. Mageshwaran, P. Kishore Kumar, B. S. Mohan

(K. B. Ramesh, B. Ravindra, P. U. Kamath & P. K. Mahesh)

6.3 Activities at the Observatories

Kodaikanal Observatory: Outreach was one of the major activities of the Observatory as it received over a hundred thousand visitors during the year, including students and staff from various Universities, Colleges, and Schools in Southern India. K. Sundararaman, R. Selvendran, P. Kumaravel, attended to the students while G. Hariharan, S. Padmanabhan, and K. Kannan attended to the public at large, predominantly for explanations in Tamil, at the Observatory Museum. Students at the M.Sc. and professional level were shown the major facilities of the Observatory, along with lectures conducted by prior arrangement.

The transit of Venus which occurred on June 6, 2012 drew a large number of visitors to the Observatory, including students from Universities, Colleges, and Schools. Semi-popular and popular lectures were organized and the Observatory Museum was kept open throughout the day. K. Sundararaman and S. P. Bagare co-ordinated the outreach program and gave lectures, assisted by R. Selvendran, P. Kumaravel, S. Ganesan, G. Hariharan, P. Michael, F. George who attended to the visitors at the Museum.

(S. P. Bagare)

Vainu Bappu Observatory, Kavalur: Explanatory talks to visiting students at VBO (IRES students, Oxford College of Science, Christ university).

(Ashok Pati)

The sky watch programme arranged at the Skywatch Observatory on the terrace of IIA's main building, which houses a 14 inch telescope and 12-inch MEADE telescope of IIA, during the National Science Day.

Indian Astronomical Observatory (IAO), Hanle: IAO attracts many visitors, and many visits were permitted to the extent by the limited infrastructure. A special event was organized during the Transit of Venus (ToV) event on June 6, 2012 in collaboration with Vigyan Prasar and Amateur Astronomers Association of Delhi (AAAD), New Delhi. Prior to this event visits to many schools in Leh town were organized to educate students about the event. Vigyan Prasar distributed observational material and telescope kit to different education groups. To cover the event a station was set up at Spituk Gompa in Leh and arrangements were made to provide High Definition live video feed from a telescope to Rajyasabha TV. During the rehearsal sessions on previous night and on the day of ToV event, Rajyasabha TV covered all the events from this station continuously for about 20 hours which included live talks, interviews and panel discussions. In addition, a webcast station was set up near HCT using a small telescope. The data from Hanle was transferred through the HCT satellite link to the CREST campus, where the data was processed and converted from analog to digital and posted on the webcast server placed at the NASA's Sun-earth day portal sunearthday.gsfc.nasa.gov/webcasts/india with a time delay of only a few seconds.

(T. P. Prabhu)

Centre for Research & Education in Science & Technology (CREST), Hosakote : HCT remote control station is a point of attraction at CREST for scientific visitors of IIA as well as laypersons. The centre was visited by many scientists, students, amateur astronomers, and educationists during the period. The remote operation of 2-m HCT was demonstrated through video conferencing facility to all the visitors. HCT group of astronomers gave lectures to organized groups. The organize groups included Amit Smrti Project, Aryabhatta, Bhopal; Jagdish Bose Science Talent Search Programme, SN Bose Institute Kolkata; Astronomy Programme. Birla Institute of Fundamental Research, Bangalore; BASE/REAP programmes Jawahar Lal Nehru Planetarium, Bangalore; Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP, affiliated to United Nations).

National Science Day was celebrated at CREST campus on February 28, 2013. More than 100 students from various schools (New Baldwin International, New Horizon School, Omshree Public school, Citizen school etc.) visited the campus with their teachers. An exhibition was organized to highlight IIA's facilities and research. The day-long activities included a quiz followed by a lecture "Basic Science and Astronomy" by B. C. Bhatt and a small film "Journey to Stars".

(T. P. Prabhu)

6.4 100th Indian Science Congress

The IIA team attended the 100th Indian Science Congress held at Calcutta University, Kolkata, during January 3–7, 2013 and participated in "Pride of India - Frontiers of Science & Technologies Mega Expo". The team set up a stall to showcase facilities and achievements of IIA in the field of Astronomy & Astronomy. A part of this 100 Year Science Congress, 'Vigyan Chalchitra Mela' was organized by Vigyan Prasar, New Delhi and one of the IIA team member participated in the event as a member of organizing committee for this event.

(B. C. Bhat & T. K. Muralidas)

6.5 Popular Lectures, Radio Talks, Interviews & Films

C. Birdie

- "Need for Digital Libraries in Colleges" and "Students and Faculty need Libraries & Librarians in the Age of Internet: Library Vs Internet" at the *Seminar on Digital Libraries: Design & Development*, Dakshina Kannada Kodagu Library Association, Udupi, March 2013

M. Das

- "Galaxies in our Universe" at Madurai American College students, September2012; M.P. Class 12 students, October 2012; science congress, December 2012.

R. T. Gangadhara

- Series of lectures on "Radio Pulsars" at Kuvempu University, Shimoga, Karnataka, February 28 – March 5, 2013

P. Kharb

- "Our Universe: a short journey from the Earth to Galaxy superclusters" National Science Day, 2013

M. Sampoorna

- "Astronomy as a Career – Challenges and Opportunities", Vidya Vardhaka Sangha, First Grade College for Women, Bangalore, December 28, 2012

6.6 Popular Books & Articles

B. C. Bhatt

- Bhartiya Khagol Vedhshala-Hanle, Ladakh, 'Vigyan Pragati', 2012, Vol. 60-61 (12), 16-27p.
- Bhartiya Drishya Prakashiya Khagoliya Prekshan Vedhshalain, IIA-Newsletter, 2012, Vol. 17 (1-4)

K. Sundara Raman

- "Mirattum Suriyan - Thaanguma Boomi" ("Threatening Sun - Whether Earth can withstand"), Tamil daily "Dinamalar" p. 14, 23 April 2012
- "Transit of Venus – About Venus" daily "Dinamalar" p. 12, 10 June 2012

Chapter 7

Miscellaneous Activities by IIA Staff

7.1 Invited & Contributed Talks

S. Anathpindika

- *Applications of computational fluid dynamics to star-formation*, Indian Institute of Science, September 25, 2012

G. C. Anupama

- *An overview of optical astronomy facilities and activities in India*, "India Ground Based Astronomy Workshop", South Africa, 2012, August 5–11, Cape Town, SA
- *Eruptive variables: Novae and supernovae*, "India Ground Based Astronomy Workshop", South Africa, 2012, August 5–11, Cape Town, SA.

S. P. Bagare

- *'Transit of Venus and Related Phenomena* at the DST and UGC sponsored National Workshop for M.Sc. and Ph.D. students of Andhra, at the Sri Krishnadevaraya University, Anantapur, on March 2, 2013
- DST INSPIRE program at Mysore University on January 21, 2013, titled *Fascinating Frontiers of Astronomy & Astrophysics*

P. Chingangbam

- *Residual foreground contamination in the WMAP data*, 5th KIAS Workshop on Cosmology and Structure formation, Seoul, South Korea, 29 October–4 November, 2012
- *Evidence for residual foreground contamination in the WMAP data*, Mini-workshop on Cosmology, APCTP, Postech, Pohang, South Korea, November 9–10, 2012
- *Exploring the statistical nature of the CMB*, Institute for the Early Universe, Seoul, Korea, 24 July, 2012
- *Topology of excursion sets of the CMB*, Korea Institute for Advanced Study, Seoul, Korea, 7 August, 2012 IIT Chennai, 12 September, 2012
- *Geometrical and topological properties of excursion sets of the CMB*, IIT Chennai, 12 September, 2012

*S. Choudhury, A. Subramaniam & Andrés E. Piatti**

- *Study of faint star clusters in the LMC using Washington Photometry*, 30th meeting of the ASI, IISER, Thiruvananthapuram, February 20–22, 2013

B. P. Das

- International Workshop on eEDM with Molecules, Tokyo, 19 May 2012 *Introduction to the theory of electric dipole moments of atoms and molecules*
- CDAC(Garuda)-NKN Partners Meet, Bangalore, 20 July 2012 *God Particle: Computing its footprints in an atom*
- International Conference on Metacomputing, Bhubaneswar, 6 December 2012 *God Particle: Computing its footprints in an atom*
- Infosys Award Function, Homi Bhabha Centre for Science Education, Mumbai, 22 December 2012, *Atomic Clocks and the 2012 Physics Nobel Prize*
- Programme on CP Violation in Elementary Particles and Composite Systems, Mahabaleswar, 21 February 2013 *Introduction to the theory of electric dipole moments of atoms and molecules*

M. Das

- *Investigating AGN - Black hole masses in extreme late type spirals: void and LSB Galaxies* xxx ASI meeting, Thiruvananthapuram, February 20–22, 2013
- *Peering into the dark: the nuclei of low luminosity galaxies*, Saha Institute, May 2012
- *An X-ray and Radio Study of the Seyfert 2 Nucleus in the LSB galaxy NGC 5905*, COSPAR International meeting, July 2012

R. T. Gangadhara

- *Relativistic model on Polarization of Pulsar Radio Emission*, meeting on "Neutron Stars: Inside and Outside" 18–19 October, 2012, SINP, Kolkota

S. Giridhar

- *Applications of spectroscopy to astronomy* INSPIRE winter camp conducted at Pt Ravishankar Shukla University Raipur, during December 25–29, 2012
- *High resolution spectrometer for 2m HCT, Hanle; an update*, xxx ASI meeting,Thiruvananthpuram, February 20–22, 2013
- *HESP: a High Resolution Spectrometer for the 2m HCT*, international workshop "ngCFHT; The Next Generation of the CFHT: A wide field spectroscopic facility for the coming decade, during March 27–29, 2013, Hilo, Hawaii, USA

A. Goswami

- *Metal-Poor stars and First Stars*, "TMT Science and Instrumentation Workshop,"IUCAA, Pune, December 1–12, 2012
- *Carbon-enhanced metal-poor stars: RVs, binarity and origin*, International Workshop on "Current trends in Radia l-Velocity and Exoplanets", Physical Research Laboratory, Ahmedabad, January 21–24, 2013
- *The chemical history of our Galaxy*, NIAS-DST Training Programme for Women Scientists on "Future Challenges to Society - Resources and Development: Scope and challenges," February 11–15, 2013 at National Institute of Advance Studies, Bangalore
- *Nucleosynthesis in stars and stellar evolution*, National workshop on "Transit of Venus and related phenomena," Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, March 2–3, 2013

S. S. Hasan

- August 24, 2012: "India's National Large Solar Telescope", IAU Special Symp. 6, IAU General Assembly;
- November 5, 2012:"New Facilities for Ground Based Solar Astronomy in India", International Symposium on Solar Terrestrial Physics, IISER, Pune
- January 5, 2013: "National Mega Projects in Optical Astronomy", plenary lecture in the Homi Bhabha session on "Mega Science and India" at the Centenary meeting of the Indian Science Congress, Kolkata
- January 21, 2013: "New programmes in Solar Astronomy in India", Indo-UK Seminar on *Solar Atmospheric Wave Studies*, IIA, Bangalore
- February 22, 2013: "India's National Large Solar Telescope", 30th Meeting of the Astronomical Society of India, IISER-TVM & IIST, Thiruvananthapuram
- March 1, 2013: "Challenges for Solar Research", Delhi University

K. M. Hiremath

- *Absence of super Earths in the vicinity of the sun: Clues from exoplanetary data*, and*Clues for genesis of magnetic field structure of Mercury*, 39th COSPAR Scientific assembly, Mysore, July 14–12, 2012

J. Jose

- *Mulit-wavelength analysis of stellar contents in three young clusters*, Frontiers of star formation meeting, ESTEC, Noordwijk, The Netherlands, August 15, 2012
- *Star formation and initial mass function studies in young clusters*, 30th meeting of the ASI, IISER, Thiruvananthapuram, February 20–22, 2013

S. Krishna Prasad

- BUKS 2012 workshop held at Crete, Greece during 4–7 July, 2012 *Oscillations in open loop structures*

- 39th Cospar Scientific assembly held at Mysore, India during 14–22 July, 2012 *Complex variation of line widths in polar corona*
- Indian Institute of Science, Bangalore, on 11 December, 2012 *Propagating intensity disturbances: Slow mode waves or recurring upflows?*

A. Mangalam

- *Orbital signatures from observed light curves of blazars*, 15 December 2012, at University of Guangzhou in Variability of Blazars from Jansky to Fermi, December 13–16, 2012, Guangzhou, China

G. Pandey

- *Studies of hot hydrogen deficient stars*, 39th COSPAR Scientific Assembly, July 14–22, 2012, Mysore
- *Hydrogen deficient stars*, TMT Science and Instrumentation Workshop–2012, December 10–12, 2012, IUCAA, Pune
- *Recent studies on H-deficient stars*, February 21, 2013, Armagh Observatory, Northern Ireland, UK

S. P. Rajaguru

- Chair of Session on 'Sunspots' at the LWS/SDO-5/SOHO-27/GONG-2012 Workshop 'Eclipse on the Coral Sea: Cycle 24 Ascending', Views from SDO/Hinode/GONG held at Palm Cove, Queensland, Australia, during November 12–16, 2012.
- *Clues on the origin of acoustic power halos around sunspots from HMI/SDO and AIA/SDO (1700 and 1600 Å) observations* in the 39 COSPAR Assembly, July 14 – 22, 2012, Mysore, India
- *Small-scale magnetic field dynamics in the photospheres of solar-like K- and M-dwarfs – a preliminary study using CO5BOLD* in the CO5BOLD workshop 2012 , October 1–3, 2012, University of Heidelberg, Germany
- *Seismic halos caused by reflections and refractions of acoustic and fast magneto-acoustic waves at the magnetic canopy: observational evidence*, in the LWS/SDO-5/SOHO-27/GONG-2012 Workshop "Eclipse on the Coral Sea: Cycle 24 Ascending, Views from SDO/Hinode/GONG", held at Palm Cove, Queensland, Australia, during November 12–16, 2012

B. Ravindra

- *Digitization of the Kodaikanal Solar Photographic White Light Images*, 39th COSPAR 2012, July 14–22, 2012, Infosys Campus, Mysore.
- *Oscillations in Large Scale Magnetic Structures*, India-UK seminar on Solar Atmopsheric Wave Studies, January 21–23, 2013, IIA, Bangalore

A. B. S. Reddy

- *Abundance analysis of an extended sample of open clusters: a search for chemical inhomogeneities* in the 30^{th} meeting of the "Astronomical Society of India", held at Thiruvananthapuram, Kerala, February 20–22, 2013

B. E Reddy

- *Lithium in red giants: A nagging problem to stellar models*, October 4, 2012, NAOJ, Tokyo, Japan
- *Lithium in red giants: A nagging problem to stellar models*, October 16, 2012, Hongkong University, Hongkong
- The Thirty Meter Telescope Project: India TMT status, at TMT science meeting, December 10,, 2012, IUCAA, Pune

S. Sengupta

- *Exoplanets : Worlds Outside Our Own World* at DST-INSPIRE Internship Science Camp entitled "Exciting World of Science" held during 10–14, 2012 at Jagadis Bose National Science Talent Search Institute, Kolkata
- *Atmosphere and Habitability of Exoplanets* at International Conference on "Chemical Evolution of Star Forming Region and Origin of Life" held during 10–13 July, 2012 at S. N. Bose National Center for Basic Sciences, Kolkata
- *Spectro-polarimetry of Extrasolar Planets* at International Workshop on Science for the Thirty Meter Telescope held during December 10–12, 2012 at IUCAA, Pune
- *Polarimetry of Extrasolar Planets* at International Workshop on "Current Trends in Radial Velocity and Exoplanets" held during January 21–24, 2013 at Physical Research Laboratory, Ahmedabad

T. Sivarani

- *Planet host star properties,* workshop on "Current trends in radial velocities and exoplanets", PRL, Ahmedabad, January 2013
- *First stars and the Chemical evolution of the early Galaxy*, IISc, Bangalore

H. N. Smitha

- *Quantum interference phenomena in the Second Solar Spectrum*, Observatory of Geneva, November 2, 2012

A. Subramaniam

- *UVIT image simulations of some Globular clusters with compact objects,* 39th COSPAR Scientific Assembly, July 14–22, 2012, Mysore, India
- *UVIT on ASTROSAT - Performance*, 39th COSPAR Scientific Assembly, July 14–22, 2012, Mysore, India
- *In orbit calibration plans for UVIT on ASTROSAT* 39th COSPAR Scientific Assembly, July 14–22, 2012, Mysore, India
- *Understanding our neighbours: Magellanic Clouds,* NCRA, TIFR, Pune, November 5, 2012
- *Report on IIA observatories,* 30th ASI Meeting, February 21–23, 2013, Thiruvananthapuram

S. Subramanian

- *Generation of Infrared Guide star catalogue for the TMT*, December 12, 2012, TMT Science and Instrumentation Workshop, IUCAA, Pune
- Thesis presentation *Stellar Populations in the Magellanic Clouds*, 22 February 2013, 30th ASI Meeting, February 21–23, 2013, Thiruvananthapuram
- *Stellar Populations in the Magellanic Clouds*, meeting on "The Magellanic System – In Perspective", International Center for Radio Astronomy and Research, Perth, Australia, September 13, 2012
- *Stellar Populations in the Magellanic Clouds*, 27 August 2012, MPIA, Heidelberg, Germany
- *Stellar Populations in the Magellanic Clouds*, 22 August 2012, Astronomisches Rechen-Institut, Univ. Heidelberg, Germany

F. Sutaria

- *Timing and spectral studies of Magnetar AXP J1708-4009* 39th COSPAR Scientific Assembly. Held 14-22 July 2012, in Mysore, India. 2012cosp...39.1916S
- *Search for transit timing variations in some Exoplanet systems* 39th COSPAR Scientific Assembly. Held 14-22 July 2012, in Mysore, India. 2012cosp...39.1915S
- *Multi-waveband science with UVIT & X-ray instruments on Astrosat* 39th COSPAR Scientific Assembly. Held 14-22 July 2012, in Mysore, India. 2012cosp...39.1914S
- *Optical and multiwaveband properties of some type-IIn supernovae* IAUS 296: Supernova environmental impacts, 7-11 Jan 2013, Raichak (near kolkata

7.2 Lectures, Colloquia etc.

B. P. Das

- Tohoku University, Sendai, Japan, 7 May 2012 *Parity and Time-Reversal Violations in Atoms*
- Kobayashi Maskawa Institute, Nagoya University, Nagoya, Japan, 15 May 2012 *Atomic Electric Dipole Moments as Probes of CP Violation*
- Tokyo Institute of Technology, Tokyo, Japan, 16 May 2012 *Atomic Electric Dipole Moments as Probes of CP Violation*
- Centre for Mathematical Modelling and Computer Simulation, Bangalore, 18 October 2012 *God Particle: Computing its footprints in an atom*

7.3 National/Intl meetings attended

G. C. Anupama

- DST sponsored South Africa - "India Ground Based Astronomy Workshop", 2012, August 5–11, Cape Town, SA
- "TMT-SAC Meeting", Beijing, China, 2012 September 1–3
- "TMT Science and Instrument Workshop and SAC meeting", 2012 December 10–12, IUCAA, Pune.
- International Workshop on "Radial Velocity Studies", 2013 January 20–22, PRL, Ahmedabad

B. C. Bhatt

- 100th Indian Science Congress held at Calcutta University, Kolkata, during January 3–7, 2013 and participated in "Pride of India - Frontiers of Science & Technologies Mega Expo"
- "NASA Space Festival" at Bharathiar University, Coimbatore (TN) during July 9–14, 2013 organized by BU, Coimbatore.

R. K. Chaudhuri

- Intl conf. on "Electronic Structure and Dynamics of Molecules and Clusters" held in IACS, Kolkata, February 17–20, 2013)

P. Chingangbam

- 5th KIAS Workshop on Cosmology and Structure Formation, 29 October–4 November, 2012, KIAS, Seoul, South Korea.
- IAGRG-27, March 7–9, 2013, H. N. Bahuguna University, Uttarakhand.

M. Das

- 39th COSPAR Scientific Assembly, Mysore, July, 2012.

R. T. Gangadhara

- "Neutron Stars: Inside and Outside" held during 18–19 October, 2012 at SINP, Kolkata.
- "National Science Day meeting" on February 28, 2013 held at Kuvempu University, Shimoga

S. Giridhar

- "ngCFHT; The Next Generation of the CFHT: A wide field spectroscopic facility for the coming decade" conducted at Hilo, Hawaii, USA, during March 27-29, 2013.

A. Goswami

- "TMT Science and Instrumentation Workshop," IUCAA, Pune, December 1–12, 2012
- International Workshop on "Current trends in Radial-Velocity and Exoplanets", Physical Research Laboratory, Ahmedabad, January 21–24, 2013
- NIAS-DST Training Programme for Women Scientists on "Future Challenges to Society - Resources and Development: Scope and challenges," February 11–15, 2013 at National Institute of Advance Studies, Bangalore.
- National workshop on "Transit of Venus and related phenomena" held in Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, March 2–3, 2013

S. S. Hasan

- April 30–May 4, 2012: "Solar Origins of Space Weather and Space Climate", National Solar Observatory, Sunspot NM, U.S.A.
- July 19, 2012: *Space Situational Awareness, Space Weather and Debris Research*, COSPAR, Mysore
- August 22–24, 2012: *Science with Large Solar Telescopes*, IAU Special Symp. No. 6, IAU General Assembly, Beijing, China;
- November 6–9, 2012: International Symposium on Solar Terrestrial Physics, IISER, Pune
- November 12–16, 2012: Eclipse on the Coral Sea: Cycle 24 Ascending (GONG 2012, LWS/SDO-5, and SOHO 27), Palm Cove, Queensland, Australia
- January 21–23, 2013: *Solar Atmospheric Wave Studies*, IIA, Bangalore
- February 20–22, 2013: 30th Meeting of the Astronomical Society of India, IISER-TVM & IIST, Thiruvananthapuram
- March 1–2, 2013: Visitor's Programme, Delhi University, Delhi

B. P. Hema

- XII International Symposium on "Nuclei in the Cosmos (NIC XII)", August 5 – 12 2012, Cairns, Australia

K. M. Hiremath

- 39th COSPAR Scientific assembly, Mysore, July 14–22, 2012

J. Jose

- Frontiers of star formation, ESTEC, Noordwijk, The Netherlands, August 15–18, 2012

R. Kariyappa

- COSPAR meeting, Mysore, July 14 – 21, 2012
- Hinode 6 Science Meeting, University of St. Andrews, St. Andrews, UK during August 13 – 17, 2012

A. Kumar

- SPIE - Space Telescopes and Instrumentation 2012: Ultraviolet to Gamma Ray July 1–6, 2012, Amsterdam, Netherlands

J. P. Lancelot

- Inter Center Experts Committee on "Integrated Lidar System" on December 19, 2012 at VSSC, Thiruvananthapuram

A. K. Pati

- Participated in the "39th COSPAR" assembly held at Mysore during July 2012.
- Co-organiser and member of the SOC of the session on 'Hot stars, Galactic Star Formation and cosmic Star Formation history: Ultraviolet Astrophysics using Space Missions and delivered a talk "UVIT on ASTROSAT: Science Prospects".

S. P. Rajaguru

- 2nd CO5BOLD Workshop 2012, October 1–3, 2012, at the Univ. of Heidelberg, Germany
- LWS/SDO-5/SOHO-27/GONG-2012 Workshop Eclipse on the Coral Sea: Cycle 24 Ascending, Views from SDO/Hinode/GONG held at Palm Cove, Queensland, Australia, during November 12–16, 2012

K. P. Raju

- India-UK Seminar on Solar Atmospheric Wave Studies, January 21–23, 2013, at IIA, Bangalore

A. B. S. Reddy

- 3^{rd} Sardinian Summer School in Astrophysics entitled "Astrochemistry: the astronomer's survival kit", held at Italy, during 30 September–06 October 2012.

M. Sampoorna

- India-UK Seminar on "Solar Atmospheric Wave Studies", held during 21–23 January 2013, at Indian Institute of Astrophysics, Bangalore, India.

T. Sivarani

- International workshop on "Current trends in radial velocities and exoplanets" held at PRL. Ahmedabad, January, 2013

A. Subramaniam

- 39th COSPAR Scientific Assembly, July 14–22, 39th COSPAR Scientific Assembly, Mysore, India

S. Subramanian

- "TMT Science and Instrumentation Workshop", IUCAA, Pune, December 10–12, 2012
- "The Magellanic System - In Perspective", International Center for Radio Astronomy Center, Perth, Australia, September 10–13 2012

F. Sutaria

- 39th COSPAR Scientific Assembly. Held 14-22 July 2012, in Mysore, India.
- IAU symposium 296, Supernova environmental impacts, 7-11 Jan 2013, Raichak (near kolkata)

"30th ASI meeting conducted at Thiruvananthapuram during February 20–22, 2013 " S. Choudhury, M. Das, S. Giridhar, A. Goswami, P. Ramya, A. B. S. Reddy, Jessy Jose, A. Subramaniam, S. Subramanian

7.4 Collaborations across institution

S. Anathpindika

- James di'Francesco, National Research Council, Canada
  Topic : Prestellar cores

G. C. Anupama

- N.G. Kantharia (NCRA), A.N. Ramaprakash (IUCAA), V. Mohan (IUCAA)
  Topic: Observations of novae

- S. B. Pandey (ARIES), K. Misra (ARIES)
  Topic: Observations of supernovae and gamma-ray burst sources

- M. Kasliwal, Carnegie Observatories
  Topic: Follow-up observations of Palomar Transient Factory (PTF) objects

- G. Djorgovski, CALTEC
  Topic: Follow-up observations of Catalina Real Time Survey (CRTS) objects

L. S. Anusha

- J. O. Stenflo, ETH, Zurich, Switzerland; M. Bianda & R. Ramelli, IRSOL, Locarno, Switzerland; H. Frisch, Observatory of Nice, France; R. Holzreuter, ETH Zurich, Switzerland
  Topic: Modeling the observations of the second solar spectrum

- S. K. Solanki, A. Feller, J. Hirzberger, MPS, Katlenburg-Lindau, Germany
  Topic: Statistical properties and evolution of the small scale magnetic structures using SUNRISE data

S. P. Bagare

- Debi Prasad Choudhary, California State University at Northridge, USA
  Topic: Study of dynamic behaviour of sunspot properties using SDO data

- Heimin Wang, Space Weather Research Laboratory, Center for Solar Terrestrial Research, New Jersey Institute of Technology, Newark, USA
  Topic: Studies of transient phenomena using high cadence H-alpha filtergrams from NSO and BBSO

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 and residual contamination in observed data"

S. Choudhury

- Andrés E. Piatti, Instituto de Astronomía y Física del Espacio, Argentina
  Topic: "Study of faint star clusters in the LMC using Washington Photometry"

M. Das

- Prateek Majumdar and Pijushpani Bhattacharjee, SINP, Kolkata
  Topic: Dark Matter

- Chandreyee Sengupta, KASI, Korea
  Topic: Bulgeless Galaxies

- S. Ramya, IAP, Paris
  Topic: AGN in LSB galaxies

- Smita Mathur, Ohio State University, USA
  Topic: Isolated galaxies

- Nimisha Kantharia, NCRA, Poona; Alka Mishra, Univ. Gorakhpur, Gorakhpur
  Topic: LSB galaxies

- Daisuke Iono, NRO, Nobeyama
  Topic: Void galaxies

- Harsha Raichur, RRI, Bangalore; Almudena Herroro Alonso
Topic: Tidal disruption

R. T. Gangadhara

- J. L. Han, NAO, China, 14–20 January 2013

- Y. Gupta, NCRA, Pune, 11–14 February 2013

S. Giridhar

- Armando Arellano Ferro, Institute of Astronomy, UNAM, Mexico
Topic: "A study of variability in stars"

K. M. Hiremath

- 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"

- Manash R. Samal (LAM, France), Arjan Bik, Thomas Henning (MPIA, Germany)
Topic: "Embedded cluster formation within the dark filamentary structures of IRDC"

- 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"

R. Kariyappa

- Luc Dame (LATMOS/CNRS, France)
Topics: "The Space Weather and Ultraviolet Solar Variability (SWUSV) Microsatellite Mission" - ESA
and "EUV & UV Irradiance Variations"

- Joe Zender (ESTEC/ESA, The Netherlands), Gabriel Giono (NAOJ, Japan), V. Delouille (Royal Observatory of Belgium, Belgium)
Topic: "Segmentation of coronal features to understand the EUV & UV solar irradiance variations and their impacts on Earth's climate space weather"

- E. E. DeLuca (CFA/Harvard), A.A. van Ballegooijen (CFA/Harvard), Hanslmeier, A. (University of Graz, Austria)
Topic: "Emerging magnetic flux in Quiet Sun"

- E. E. DeLuca (CFA/Harvard), A.A. van Ballegooijen (CFA/Harvard)
Topic: "Magnetic bright points and their proper motions"

C. Muthumariappan

- M. Parthasarathy (IUCAA, Pune), Y. Ita (NAOJ Japan)
Topic: "AKARI study of circumstellar dust shells"

- Sun Kwok (Hong Kong University), Kevin Volk (StSCI)
Topic: "Mid-IR imaging of proto-PNs"

- Raghvendra Sahai (JPL, Caltech)
Topic: Spectroscopic studies of variable stars with thick dust shells

K. N. Nagendra

- J. O. Stenflo, ETH Zentrum, Zurich, Switzerland.
Topic: "The theory and application of partial frequency redistribution in the regime of Paschen-Back effect"

- H. Frisch, Observatoire de la Cote d'Azur, France.
Topic: "Forward scattering Hanle effect"

- M. Bianda and R. Ramelli, IRSOL, Locarno, Switzerland.
Topic: "Observations of the linear polarization in spectral lines with ZIMPOL-III"

S. P. Rajaguru

- Collaborative research on "Local Helioseismology" with colleagues at the Stanford Solar Group, Hansen Experimental Physics Laboratory, Stanford University, CA, USA, as a team member of the NASA funded Helioseismic and Magnetic Imager (HMI)/Solar Dynamics observatory (SDO) project at Stanford University

- Collaborative project "Magnetoconvection (3-D) simulations of small-scale magnetic fields in solar and stellar atmospheres" is ongoing with Dr. Oskar Steiner at the Kiepenheuer Institut fur Sonnenphysik, Freiburg, Germany

K. P. Raju

- T. Chandrasekhar, Physical Research Laboratory, Ahmedabad, India and Maya Prabhakar, IIA Internship program from Kuvempu University
  Topic:"Analysis of the solar coronal green line profiles from eclipse observations

- Aditya Tyagi, Birla Institute of Technology, Mesra, Ranchi
  Topic: "Synoptic study of the solar EUV network in transition region"

M. S. Rao

- M. D. Gray, Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, M13 9PL, UK
  Topic: "Theoretical modelling of circumstellar envelopes of N type stars"

- D. P. Kjurkchieva, Department of Astronomy, University of Shumen, Bulgaria
  Topic: "Theoretical modelling of X- ray binaries"

M. Sampoorna

- H. Frisch, Observatoire de la Cote d'Azur, France
  Topic: "Forward scattering Hanle effect"

- J. O. Stenflo, ETH Zentrum, Zurich, Switzerland
  Topic: "The theory and application of partial frequency redistribution in the regime of Paschen-Back effect"

- M. Bianda, IRSOL, Locarno, Switzerland
  Topic: "Observations of the linear polarization in spectral lines with ZIMPOL-III"

T. Sivarani

- Jian Ge, University of Florida
  Topic: "SDSS-III MARVELS(Multi-object APO (Apache Point Observatory) Radial Velocity Exoplanet Large-area Survey) survey"

- Timothy Beers, NOAO, Arizona
  Topic: "A survey for unrecognized carbon-enhanced metal-poor stars in the Galaxy"

- Brigitta Nordstrom, J. Anderson, University of Copengagen
  Topic: " C,N,O in the early Galaxy - using VLT Xshooter"

- Wako Aoki, National Astronomical Observatory of Japan
  Topic "High resolution followup of CEMP stars from SDSS"

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

- Mathew B., Banerjee, D.P.K., Ashok, N.M., PRL, Ahmedabad
  Topic: Classical Be stars in our Galaxy

S. Subramanian

- Eva.K.Grebel, Astronomisches Rechen-Institut, University of Heidelberg, Germany
  Topic: "Stellar Populations in the Galactic Bulge"

- Jacco van Loon, Keele University, Keele, UK Topic: "Red Clump stars in the Galactic disc and the Magellanic Clouds"

F. Sutaria

- ARIES - R. Roy, B. Kumar, S.Bose
- TIFR - A. Ray, N. Yadav
- NCRA (TIFR) and RMC, Canada - P. Chandra
- CFA-Harvard - S. Chakraborti, R. Smith,
- U. Chicago - V. Dwarkadas
- Australian Astronomical Observatory: S. Ryder
- Sam Houston State University, TX, USA - Dave Pooley
- Princeton University – Jose Prieto Topic: "Core-collapse supernovae"

Externally Funded Projects

G. C. Anupama

- *A study of supernovae in the nearby Universe – Building blocks for the high redshift Universe* (PIs: G.C. Anupama, IIA & K. Nomoto, Kavli IPMU, Tokyo). DST-JSPS S&T Programme of Cooperation.

L. S. Anusha

- *Statistical properties and evolution of the small scale magnetic structures using SUNRISE data*, MPS, Katlenburg-Lindau, Germany

S. Giridhar

- *HESP: A High Resolution SPectrometer for the 2m HCT,* SERB (DST)

K. M. Hiremath

- *Possible linkages between the Indian Summer Monsoon Rainfall and solar variability and, Genesis of Solar Cycle and Activity Phenomena,* Indian Space Research Organization

T. Sivarani

- Project Manager for "Hanle Echelle Spectrograph" funded by DST

A. Subramaniam

- *From the Magellanic Clouds to the Milky Way: A New Understanding of Galaxy Structure and Interactions Based on Kinematics of 5000 Star* approved as the Indo-Australian collaborative project, under AISTF. This project is in collaboration with Dr. Andrew Cole, University of Tasmania, Australia.

Visitors hosted at IIA

G. C. Anupama

- K. Nomoto (Kavli IPMU, Tokyo. 2013 January 2-6)

S. P. Bagare

- Debi Prasad Choudhary, California State University at Northridge, USA, during June–July 2012
- M. H. Gokhale, former Senior Professor, IIA, during August–September 2012

P. Chingangbam

- Atri Deshamukhya, Silchar University, Assam, June 1–5, 2012

M. Das

- Rahul Shetty, University of Heidelberg, January 2013
- Prateek Majumdar, Saha Institute of Nuclear Physics, November 2012
- Peeyush Prasad, University of Amsterdam, August 2012

R. T. Gangadhara

- J. L. Han, NAO, China, during 14–20 January 2013

P. Kharb

- Sravani Vaddi, Graduate student at the Rochester Institute of Technology, NY, USA, February, 20–21, 2013

K. N. Nagendra

- Petr Heinzel, Marian Karlicky, Stanislav Gunar, Astronomical Institute, Academy of Sciences of the Czech Republic, Ondrejov, Czech Republic, July, 2012

Involvement with the Scientific Community

G. C. Anupama

- Member, TMT-India Core Group.
- Member and Co-Chair, TMT Science Advisory Committee (representing TMT-India).
- Member of the review committee for the project Virtual Observatory India - The Next Generation, (PI: D. Bhattacharya, IUCAA), funded by the Ministry of Communications and Information Technology.
- Member, Time Allocation Committee, IUCAA Ghirawali Observatory, IUCAA.
- Member, GMRT Time Allocation Committee.

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.

C. Birdie

- Nominated as a member by SLA-US to serve in the standing committee of IFLA – Science & Technology division for the year 2013–2017
- Founding member of IOP publishing's Asia Pacific library advisory board
- Member of the panel of librarians and astronomers, of IAU working Group libraries meeting under IAU umbrella, held at Beijing, China between August 20–31, 2012
- Member of the panel debate on "E-Books & Commercialization of Library Services" organized by Informatics, Bangalore, Oct. 17, 2012

S. Giridhar

- OC member of IAU Comm 45 on Spectral classification as past president
- Member of editorial Board of Journal of Astrophysics & Astronomy

S. S. Hasan

- Associate of the Harvard College Observatory, Cambridge, U.S.A. since 1991
- Principal Investigator of the NLST Project
- Chairman, Executive Council, Vishveshwara Technological Museum, Bangalore
- Member, Governing Councils of 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;
- Member, Board of Management, Centre for Theoretical Physics, Jamia Millia Islamia University, New Delhi
- Member, Academic Advisory Council of ITM University, Gurgaon
- Member, Advisory Council for Einstein Bhavana, Visva-Bharati University, Shantiniketan;
- Member, National Commission for History of Science, INSA, New Delhi
- 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
- Member, Editorial Board of Solar Physics
- SOC Co-Chair of the IUSSTF Panel Review on *Space Situational Awareness, Space Weather and Debris Research*, July 19, 2013, COSPAR, Mysore
- SOC Co-Chair of the Intl Symposium on Solar Terrestrial Physics (ISSTP), Nov. 6-9 2012, IISER, Pune
- Member, SOC IAU Symposium 302 *Magnetic fields throughout stellar evolution* , Aug. 25-30, Biarritz, France

K. M. Hiremath

- Reviewed the research proposals from a consortium as invited by the "The French National Research Agency (ANR)"

J. Javaraiah

- Member, Editorial Board of Journal of Astrophysics, Hindawi Publishing Corporation

J. P. L. Lancelot

- Member, Inter-Centre Experts Committee, VSSC, for the "Integrated LIDAR System" of SPL, VSSC, Thiruvananthapuram

K. N. Nagendra

- Member, Indian Physics Association

B. Raghavendra Prasad

- Chairman, Project Review Committee, for the DST center for "Development of fabrication facilities for optoelectronic devices based on molecular, polymeric and composite materials" at IIT, Guwahati
- Member, DST - Expert Advisory Committee (EAC) on "Molecular Electronics, Conducting Polymer Electronics, Non-invasive and other Bio-sensors".
- Member of several DST-TSG - Project Review Committees in the areas of Molecular Electronics, Conducting Polymer Electronics, Non-invasive and other Bio-sensors. He is also the national coordinator of the DST-TSG projects on "Bacteriorhodopsin".

S. P. Rajaguru

- Editor, The quarterly Newsletter of IIA
- Nodal Officer for the Institute's high-speed internet connectivity provided by the National Knowledge Network (NKN) of the National Informatics Center, Dept Information Technology, Govt. of India
- Coordinator, IIA's participation in the Joint Astronomy Programme (JAP) of the Indian Institute of Science, Bangalore

B. E. Reddy

- Member TMT Project board of directors
- Board Member of TMT Project Science Advisory Committee

M. Sampoorna

- Member of the Lindau Alumni, India

T. Sivarani

- Member, SDSS-III;
- Member, Science working group NGCFHT: "Next generation Canada French Hawaii Telescope".

A. Subramaniam

- Associate editor, Bulletin of Astroomical Society of India
- Member, Scientific Advisory Committee, ARIES, Nainital
- Member, Science working group, ASTROSAT
- Member, calibration team of UVIT, IIA
- Member, TMT-INDIA Software group

K. Sundara Raman

- Elected as the Fellow of the Royal Astronomical Society, London during June 2012

7.5 Visits

G. C. Anupama

- South African Astronomical Observatory, Sutherland, and SKA site, South Africa, 2013 August 9–10

P. Chingangbam

- Korea Institute for Advanced Study, Seoul, South Korea, 29 June–10 August, 2012
- IIT Chennai, September 10–14, 2012
- IISER, Mohali, March 1–5, 2013

M. Das

- Saha Institute, Kolkata, May 2012

S. Giridhar

- Institute of Astronomy, UNAM, Mexico, June 4–24, 2012
- Dept of Astronomy, Univ. of Texas at Austin, USA, June 25–July 4, 2012

J. Jose

- Max-Planck Institute for Astronomy, Heidelberg , Germany, August 10–11,2012
- ESTEC, Netherlands, August 12–16,2012

R. Kariyappa

- Institute for Physics, University of Graz, Austria, April 16 – 25, 2012
- ESA/ESTEC, The Netherlands, April 25 – May 10, 2012
- LATMOS/CNRS, France, May 10 – 18, 2012

S. P. Rajaguru

- Kiepenheuer Institut fur Sonnenphysik, Freiburg, Germany, October 3 – 11, 2012

B. E. Reddy

- NAOJ, Tokyo, Japan, October 4–9, 2012
- Hongkong University, October 14–20, 2012

T. Sivarani

- IISER, Mohali, January 2013

H. N. Smitha

- Istituto Ricerche Solari Locarno (IRSOL), Locarno, Switzerland, 6 Sept. 2012 – 4 Nov. 2012
- Observatory of Geneva, Geneva, Switzerland, 2 November 2012

A. Subramaniam

- ARIES, Nainital, as part of the visit of the SAC to ARIES, October 5–8, 2012

S. Subramanian

- Astronomisches Rechen-Institut, University of Heidelberg, Germany, August 6 – 29, 2012

F. Sutaria

- IUCAA, Pune, India, fall, 2012

Awards and Recognition

G. C. Anupama

- Fellow, National Academy of Science, India, Allahabad
- *B. P. Das* was elected Fellow of the American Physical Society (APS) in 2012, following a nomination by the Forum on International Physics. APS fellowship is a distinct honor signifying recognition by one's professional peers, who use the criterion of exceptional contributions to the physics enterprise. The citation for B. P. Das reads: 'For his seminal contributions to the theory of parity and time-reversal violations in atoms in the context of probing the Standard Model of particle physics, and for his leadership in promoting international collaborations in frontier areas of atomic, molecular and optical physics'.

R. T. Gangadhara

- Best Citizens of India Award, 2012
- Rashtriya Gaurav Award, 2012

K. N. Nagendra

- Received "Best Citizen of India" award for 2013, from the International Publishing House, New Delhi

M. S. Rao

- "Rashtriya Gaurav Award" from Indian International Friendship Society (IIFS), New Delhi

A. Susmitha Rani & T. Sivarani

- Best Poster Award "Mining the SDSS database to probe the imprints of the first stars of the Galaxy", 30th ASI Meeting, 2013

S. Subramanian

- Received the "K. D. Abhyankar Best Thesis Presentation Award", presented by Astronomical Society of India during the 30th ASI meeting, Thiruvananthapuram, 20 February – 22 February 2013

Sundara Raman

- Media Guild Academy Award for Academic Excellence by media persons in Chennai on 25th August 2012
- National Award for Teaching Excellence by INDUS FOUNDATION in recognition of the contribution in Higher Education. The award was given in the Indo-American Education Summit 2013 at Hyderabad on February 3, 2013

Welfare of SC/ST Staff & Physically challenged

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 14.38%, 10.27%, 3.76% 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.

Official Language Implementation

- Official Langauge Implementation Committee : Four meetings were conducted in 2012-13 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, two Hindi Workshops were conducted for the employees working in Administration on 20 June, 2012 and 31 August, 2012.

- Incentive Scheme : Under this scheme, one "Administrative Glossary" competition for the employees working in Administration, were conducted on 13 December, 2012 at the Institute. Winners were awarded with cash prize.

- Hindi Day/Fortnight Celebration : The institute celebrated Hindi Fortnight from 1st September, 2012 to 14 September, 2012. During the occasion six competitions were conducted in the institute viz. "Hindi Crossword" competition on 03 September, 2012, "Hindi Speech" competition on 05 September, 2012, "Hindi Easy Writing" competition on 06 September, 2012, "Hindi Song" competition on 07 September, 2012, "Picture Narration" competition on 10 September and "Hindi Visual-Quiz" competition on 12 September, 2012. 14 September, 2012 was celebrated as "Hindi Day" in the institute. Prof. B. P. Das, Acting Director presided over the function. Dr. P. Kumaresan, Administrative Officer gave the welcome speech. Chairman addressed the audience and said that as it is the moral responsibility of all staff members to accomplish official work in hindi, they have to try to do more official work in hindi. Dr. Gajendra Pandey, Reader read the Home Minister's message of Hindi Day. The function was concluded with a vote of thanks by S. Rajanatesan, Section Officer(Hindi). Two hindi competitions were conducted viz. Hindi Administrative Glossary and Hindi Visual-Quiz on 18 & 19 September, 2012 respectively at VBO, IIA, Kavalur. Cash awards were given to the winners.

Chapter 8

People

Staff List 2012 – 2013

Director : S. S. Hasan (up to 30.6.2012)

Director (Acting): B. P. Das (w.e.f. 1.7.2012)

Academic & Scientific Staff

Distinguished Professor: S. S. Hasan

Senior Professor: H. C. Bhat, B. P. Das, J. Murthy, T. P. Prabhu

Professor: G. C. Anupama, S. P. Bagare, S. Giridhar, K. N. Nagendra, A. K. Pati, B. Raghavendra Prasad, K. E. Rangarajan, S. K. Saha

Associate Professor: D. Banerjee, B. C. Bhatt, S. Chatterjee, R. K. Chaudhuri, R. T. Gangadhara, A. Goswami, K. M. Hiremath, R. Kariyappa, S. G. V. Mallik, A. Mangalam, C. Muthumariappan, P. S. Parihar, K. P. Raju, K. B. Ramesh, R. Ramesh, B. E. Reddy, D. K. Sahu, A. Satya Narayanan, S. K. Sengupta, M. Srinivasa Rao, P. Shastri, A. Subramaniam, K. Sundara Raman

Reader: M. Das, J. Javaraiah, P. Kharb, G. Pandey, C. Pravabati, S. P. Rajaguru, M. Sampoorna, T. Sivarani, C. S. Stalin, F. Sutaria

Scientist D: U. S. Kamath, S. Muneer, 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: N. A. Ahmed, N. Dorjey, K. Prabhu, M. Priyal, R. B. Singh, G. S. Suryanarayana

Fellow: C. Kathiravan

Research Associate B: M. Appakutty

Research Associate : G. Selvakumar

Adjunct Scientist: K. Sankarasubramanian, D. Tripathy

Honorary Professor: V. K. Gaur

Visiting Professor: J. Singh, S. N. Tandon

Visiting Scientist: S. Anathpindika, S. G. Bhargavi, M. Safonova

Post Doctoral/Visiting Fellow: R. Gopal, J. Jose, S. Raut, J. Roy, S. Subramanian

Ph. D. Fellow: L. S. Anusha, R. Chowdary, G. R. Gupta, A. C. Pradhan, S. Ramya, V. Singh, 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. Behera, P. G. Deshmukh, K. Hariharan, J. Mathew, A. Mohanty, S. Pal, M. N. Sarpotdar, A. G. Sreejith, A. Surendran

Technical Staff

Sr. Principal Scientific Officer: A. V. Ananth

Engineer F: M. S. Sundararajan

Engineer E: G. Srinivasulu

Librarian: C. Birdie

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

Principal Document Officer: S. Rajiva

Engineer C: P. Anbazhagan, K. Anupama, K. Dhananjay, T. Dorjai, S. Gorka, S. Jorphail, P. U. Kamath, T. T. Mahay, V. S. Narra, A. Parwage, V. Selvi, K. C. Thulasidharan

Sr. Technical Officer: K. Jayakumar, K. Kuppuswamy, K. Rangaswamy, M. J. Rosario, A. Selvaraj, R. Selvendran

Technical Officer B: N. Sivaraj

Engineer B: V. Natarajan, M. F. Nawaz, N. Raj Kumar, A. Ramachandran, K. Ravi, S. Suresh

Technical Officer: A. V. Velayuthan Kutty

Tech. Associate B: D. Babu, P. Kumaravel, J. Manoharan, M. G. Mohan, Narasimhappa, S. Pukalenthi, S. Ramamurthy, M. R. Somashekar, C. V. Sriharsha, S. Venkateshwara Rao

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

Sr. Tech. Asst. C: R. Ismail Jabillulah, T. K. Muralidas

Sr. Mech. Asst. C: A. Mani

Tech. Associate: V. Gopinath, Mallappa

Draughtsman E: V. K. Subramanian

Sr. Tech. Asst. B: D. Kanakaraj, V. Moorthy, A. Muniyandi, M. Nagaraju, K. Sagayanathan

Consultant: K. Chandar

Consultant Engineer: M. Nageswara Rao, B. S. Nataraju

Administrative Staff

Administrative Officer: P. Kumaresan

Principal Staff Officer: K. Thiyagarajan

Personnel Officer: A. Narasimharaju

Accounts Officer: M. P. Parthasarathy (up to 30.9.2012), S. B. Ramesh (w.e.f. 15.1.2013)

Purchase Officer: Y. K. R. Iyengar

Stores Officer: D. Lakshmaiah

Asst. Accounts Officer: G. R. Venugopal

Sr. Section Officer GR II: K. Sutherson

Sr. Section Officer: L. Josephine, Meena, P. Mohan, A. P. Monnappa, N. Murthy, S. Rajendran

Section Officer: D. Dolkar, K. Padmavathy, Ramaswamy, N. Valsalan

Section Officer (Hindi): S. Rajanatesan

Sr. Office Superintendent Gr II: G. A. Mary

Sr. Office Superintendent: D. Dakshinamoorthy, U. Maileveloo, N. K. Pramila, M. Rajan, N. Sathya Bama, A. Veronica