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Chapter 1

The Year In Review

On July 1, 2013, I undertook the enviable job of directing India’s oldest and largest astronomy institution for a 5-year period. The multitude of academic and research activities in this institute reflects the continued growth of astronomy and astrophysics research programs in the country. I am glad to report that during the period of 2013–14, the Institute made important contributions to research, developing and establishing advance research facilities, producing well-trained human resources and in taking science to the public at large. I present here some of the significant achievements of the Institute during this period.

The scope of research in this institute ranges from the Sun and the solar system, stars, our Galaxy, external galaxies and to sources and processes associated with the farthest regions of the observational Universe.

In the field of Solar Physics, properties of small-scale magnetism of solar atmospheres were studied using 3D Magneto-convection simulations. The nature of small-scale vortex motions and their relationship with magnetic fields on the solar photosphere were investigated through detailed statistical analysis. Observational evidences were found supporting the idea that polar jets are likely to be produced by multiple small-scale reconnections occurring at different times in different locations. The interactions among the emerging fields give rise to magnetic reconnections followed by mass ejections with collimated hot plasma flows commonly termed as jets. It is observed that the bright point associated with the first such jet is a part of a sigmoid structure. The dynamical behaviour of a jet in an on-disk coronal hole observed with AIA/SDO is studied in detail. Paschen-Back effect in the hyperfine structure states of an atom in the solar atmosphere and the quantum interference signatures of the Ba II D2 4554 Å line in the second solar spectrum have been investigated. The solar photospheric vector magnetograms are simulated by using linear and nonlinear force-free (NLFF) magnetic fields assuming a simple axisymmetric configurations in spherical geometry. The sunspot whorls are studied by using Big Bear Solar Observatory & Kodaikanal Observatory data. The X-ray Solar Monitor (XSM) on the Indian lunar
mission Chandrayaan-1 provided a unique dataset which was used to derive solar coronal abundances and study its variation as the flare progressed.

In the area of planetary studies, data from the Chandrayaan-1 X-ray Spectrometer (C1XS) experiment, provided for the first time unambiguous evidence of enhanced Sodium from the lunar surface.

In stellar and galactic astrophysics, classical novae Nova Cephei 2013 and Nova Delphini 2013 were observed in the optical and NIR using the 2m Himalayan Chandra Telescope (HCT) and in the radio using the Giant Meterwave Radio Telescope (GMRT). High resolution spectra of Nova Delphini 2013 were also obtained with the 2.3m Vainu Bappu Telescope (VBT). The 2014 outburst of the recurrent nova V745 Sco was monitored spectroscopically using the VBT. Photometric observations were made with the 1.3m JCBT. The recurrent novae T CrB, RS Oph, CI Aql, U Sco and V3890 Sgr continue to be monitored during their quiescence phase as a part of the spectroscopic monitoring programme to study the long term behaviour of these systems. A detailed optical and UV analysis of SN 2012dn was carried out. Properties of newly formed dust grains in the luminous Type IIn Supernova 2010jl were investigated. The optical observations of type Ib supernova iPTF 13bvn obtained with the HCT, were used to compute the bolometric light curve. The hydrodynamical modelling of bolometric light curve shows that the progenitor had a pre-SN mass of \( \sim 3.5 M_\odot \). Therefore, an interacting binary system as the SN progenitor is proposed. From a detailed analysis of multi-wavelength photometry of young clusters, it is found that the star formation process is continuous for the clusters Be 59, NGC 604 and NGC 7510 but the process is episodic for the clusters NGC 1931 and NGC 7261. Extended V and I time-series observations of four globular clusters NGC 7099, NGC 7492, NGC 6333 and NGC 288 yielded high-precision light curves of variable stars which enable search for new variable stars in these clusters and refine periods of known variables. For the first time, low-resolution spectroscopic survey has identified four relatively-hydrogen-deficient (H-deficient) stars in the red giant sample of the globular cluster Omega Cen.

In the area of extra-galactic Astronomy and Cosmology, a few gravitational-lensed quasars were systematically monitored. A sample of 77 Active Galactic Nuclei (AGN) was observed on a total of 262 nights using 1-2m class optical telescopes located in India and the optical flux variations on minute to hour time scales with amplitudes ranging from few hundredths to few tenths of a magnitude were determined. AGN activity and black hole masses in Low Surface Brightness galaxies were investigated by retrieving SDSS spectra of 650 galaxies from a sample of 1200 Low Surface Brightness galaxies provided in various catalogues. Dual-frequency phase-referenced VLBI observations of the Seyfert galaxy KISSR1494 were carried out. A single, slightly resolved radio component at 1.6 GHz is detected, but not at 5 GHz. This implies a spectral index steeper than \(-1.5 \pm 0.5\) for the galaxy. A general relativistic model of jet variability in active galactic nuclei from a helical bulk flow along a funnel shaped magnetic surface anchored to the accretion disk close to the black hole is developed. The neutral atomic Hydrogen (HI) kinematics of the Large Magellanic Cloud is revisited in the light of two new proper motion estimates. The well known arms E, S, W, B and a new stream, Outer Arm, as part of various outer components of the LMC are identified. Results from the largest CaII triplet line metallicity study of Small Magellanic Cloud field red giant stars involv-
ing 3037 objects spread across approximately 37.5 deg$^2$, centered on this galaxy were obtained. A median metallicity of $[\text{Fe/H}]=-0.99\pm0.01$, with clear evidence for an abundance gradient of $-0.075\pm0.011$ dex/degree over the inner 5 degrees was detected.

In the area of theoretical physics, the phases of ultra-cold atoms in lattices formed by lasers in the presence of an additional potential were examined. Multi reference Fock-space coupled cluster has been applied to evaluate the ionization potential (IP), excitation energies (EE), nuclear magnetic hyperfine constant etc. for singly ionized Eka-Lead (Fl II). Similar calculations are also performed for Lead ion (Pb II) to assess the accuracy of the theoretical estimates of Fl ion.

One of the most important activities of the Institute is the graduate student programme. As in previous years, a large number of bright students have joined the Ph.D. and Integrated M.Tech-Ph.D. programmes offered by the Institute. I am happy to report that as many as four students have been awarded the doctoral degree during this period and three students have submitted their thesis towards completion of their Ph.D. A large number of University students also participated in pursuing a variety of summer projects.

A few important instrument facilities for various observatories were designed and developed during this academic year. A full disk solar imaging telescope WARM (White light Active Region Monitor), has been designed and developed in-house to facilitate availability of long-term data products to the solar community. The Kodaikanal digitized images are now archived at the data center of the institute. The archive hosts 41,000 images of the Ca-K spectroheliograms as observed over a period from 1904 to 2007. Design, detailed engineering, manufacture and assembly of “Imager” for testing the 1.3 m telescope to check the image quality and field of view of the telescope was completed. This instrument is planned to be mounted on other telescopes at VBO for similar checks. A new set-up for ground based spectro-polarimetric observations of the solar radio transients in the frequency range 35–85 MHz was recently commissioned at the Gauribidanur radio observatory.

The UVIT instrument which is designed to be the world’s best UV imager, suffered an unexpected setback due to the failure of the visible detector during the final vibration test. Corrective actions are being taken and the payload is expected to be delivered soon to ISRO for integration into ASTROSAT.

Among the new initiative for upcoming facilities, the Thirty Meter Telescope (TMT) project reached some key milestones. On 24th July of 2013, in the meeting of the board of Directors at Hawaii, USA, the scientific authorities of the respective partner countries executed the master agreement agreeing for basic governing principles of the partnership, contributions, observing time etc. With the consent of Department of Science and Technology, I have signed the master agreement representing India TMT which is jointly implemented by Indian Institute of Astrophysics (IIA), Inter University Centre for Astronomy and Astrophysics (IUCAA) and Aryabhatta Research Institute for Observational Sciences (ARIES). Prof. B. Eswar Reddy represented India TMT at the signing ceremony. The overall instrument configuration for ADITYA 1 Visible Emission Line Coronograph (VELC) was finalized and most of the component level designs are completed. Base line Design review is completed for all subsystems including mechanical structure. The preliminary thermal and structural analysis are completed. Considerable effort went into the selection of the detector, configuration of electronic, mechan-
ical and thermal interfaces, optimization of camera electronics and design of on-board data processing schemes. Other projects like the National Large Solar Telescope (NLST) have gained substantial progress during this academic year with activities related to the design and development of prototype focal plane instruments. Besides these upcoming facilities, a high resolution spectrometer (HESP) is being fabricated to enhance observational capabilities for the 2m Himalayan Chandra Telescope (HCT) at Hanle. HESP is currently in an advanced stage with the instrument expected to be installed for trial observations later this year. The new 1.3m telescope established at Kavalur is currently in its final stage of field testing and optimisation.

I am delighted to inform that the Governing Council has elected Professor B.V. Sreekantan to the Honorary Fellowship of the Institute for his illustrious scientific contributions in general and to the Institute in particular as a Member of the Council (1988 – 1992) and subsequently as its Chairman (1992 – 2007). The Institute had the honour of hosting three prestigious lectures: the Vainu Bappu Memorial Lecture - “Conceptual Conundrums in Cosmology” was presented by Professor T. Padmanabhan of IUCAA, Pune on the 5th July, 2013, the IIA Founder’s Day Lecture - “Down Memory Lane - Vainu Bappu’s Dreams Revisited” was delivered by Professor G. Srinivasan on 8th August, 2013 and the 23rd Bicentennial Commemorative Public Lecture - “The Search for a Unified Theory” was delivered by Professor Ashoke Sen on 9th December, 2013.

I am happy to report that Professor Annapurni Subramaniam was elected as Fellow of the Indian Academy of Sciences, Bengaluru and also as Fellow of the National Academy of Sciences, Allahabad. Dr. M. Sampoorna has been awarded the Young Scientist Platinum Jubilee award of NASI (National Academy of Sciences India) for the year 2013 and Mr. A. Prasad has been awarded Shyama Prasad Mukherjee Fellowship for SRF by CSIR. Prof. S.S. Hasan has been elected to the Life Membership of the Clare Hall College, Cambridge.

The public outreach activities of the Institute were spread across all field stations. The National Science Day was celebrated and sky watch for general public was organized.
The 23rd Bicentennial Commemorative Public Lecture entitled “The Search for a Unified Theory” was delivered by Professor Ashoke Sen, FRS on the 9th of December, 2013.

at Bengaluru as well as Kavalur campuses. The Institute has taken several steps for the implementation of the Official Language and the welfare of SC/ST and physically-challenged staff. The list of scientific publications in peer reviewed journals, conference proceedings as well as in monographs, books and popular periodicals are listed in this report.

I would like to place on record the indebtedness of the Institute to Dr K. Kasutirirangan (Member of the Council 1988 - 2007; Chairman: 1-4-2007 to 11-10-2013) and Prof. J.V. Narlikar (Member: 1-4-2007 to 10-1-2014). Their strong support and guidance enabled the Institute to embark on setting up several new astronomical facilities. We warmly welcome Professor P.C. Agrawal, the new Chair of the IIA Governing Council (from 12-10-2013).

Today IIA is playing an important and responsible role in developing many new astronomical facilities catering to the needs of the broader Indian astronomical community, often in close collaboration with other leading institutes in the country. These activities demand optimal use of available scientific and technical expertise. The formation of the IIA Council, the creation of the Systems Engineering Group, the expansion of the Faculty group, conducting comprehensive reviews of ongoing developmental programs, encouraging enhanced activities at field stations and enabling recruitment of essential human resources, are some of the initiatives taken during this period. I truly believe that with several new facilities in the pipeline and some nearing completion, the Institute will continue to enhance its scientific productivity and excel in the field of Astrophysics during the coming years.

P. Sreekumar
Director
Chapter 2

RESEARCH

2.1 The Sun and the Solar System

Frequency-dependent damping in propagating slow magneto-acoustic waves

Enhanced time-distance maps (top) and period-distance maps (bottom) in 171 and 193 channels of AIA, generated from the interplume region.

Polar plume/interplume regions and extended fan loop structures in active regions of the Sun are often found to host outward propagating slow magneto-acoustic waves. Besides their contribution to coronal heating and solar wind acceleration, they are important for their seismological applications. The observed periodicities of these waves range from a few minutes to few tens of minutes and their amplitudes were found to decay rapidly as they travel along the supporting structure. Our recent studies indicate that the observed damping in these waves is frequency dependent. We have used imaging data from SDO/AIA, to study this dependence in detail. For the first time we attempted to deduce a quantitative relation between damping length and frequency of these oscillations by using observational data.

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

Characteristics of polar coronal hole jets

Polar jets and X-ray bright points are prominent dynamical features of coronal hole regions of the Sun. Soft X-ray jets were discovered in Yohkoh/ SXT data. In the coronal hole region the ambient magnetic fields are nearly vertical and often unipolar. The interaction among the emerging fields gives rise to reconnection followed by mass ejections, with collimated hot plasma flows commonly termed as jets. We find observational evidences supporting the idea that polar jets are likely to be produced by multiple small-scale reconnections occurring at different times in different locations and ejecting plasma blobs flowing up and down with a motion very similar to a simple ballistic motion. It was also observed that the bright point associated with the first jet is a part of a sigmoid structure. The time of appearance of the sigmoid and ejection of plasma from the bright
The fine structure of a X-ray bright point and different jets as seen from XRT on Hionde point suggest that the sigmoid is progenitor of the jet.

(K. Chandrashekhar, A. Bemporad*, D. Banerjee, G. R. Gupta* & L. Teriaca*)

The dynamical behaviour of a jet in an on-disk coronal hole observed with AIA/SDO

Over the last two decades, it has become evident that the large-scale ejection of collimated plasma from the lower solar atmosphere into the corona occurs on a regular basis. These events, referred to as EUV, X-ray or coronal plasma jets, are common in coronal holes and at the coronal hole boundaries. These jets are often considered as a potential mechanism for supplying the corona with heated plasma and maintaining the solar wind. We study the properties of the jets in relation to the wave phenomena observed in them and attempt coronal seismology studies to determine coronal magnetic fields and plasma parameters that otherwise cannot be determined by direct methods.

(K. Chandrashekhar, R. J. Morton*, D. Banerjee, G. R. Gupta)

Paschen Back Effect in the hyperfine structure states of an atom

Polarization diagram. $\beta = 0^\circ$ and $\beta = 90^\circ$ represent horizontal and vertical magnetic fields, respectively, with $\beta$ being the angle between the scattered ray and the field vector. The symbols represent the value of field strength in G.

Magnetic field can split the hyperfine structure states ($F$) into magnetic substates. If the magnetic splitting is comparable to or larger than the energy difference between the $F$-states, magnetic field effects are described by the Paschen-Back effect (PBE).
In PBE, the magnetic splitting varies non-linearly with the field strength, leading to level-crossing interference effects. Recently, we have formulated the theory of $F$-state interference in the presence of magnetic fields of arbitrary strengths and derived the partial frequency redistribution (PRD) matrix. We have considered the single-scattering case by taking the example of Na I D$_2$ line at 5889.95 Å. In the PBE regime, the magnetic sub-states belonging to different $F$-states overlap, resulting in the formation of loops in the polarization diagram ($Q/I$ vs. $U/I$; see Figure). The upper loop (near 8 G, see black curve) disappears for wavelengths away from the line center while the lower loop (near 20 G) becomes bigger. When the field is vertical, ‘anti-level crossing’ effect occurs because of the basis transformation of the energy eigenstates in the PBE regime. As a result of this, the $Q/I$ line core value, when considered as a function of field strength, initially decreases and then increases beyond its non-magnetic value. The formulation is useful in exploiting the diagnostic potential of PBE with PRD, complementary to the Zeeman effect, to determine the strengths and geometry of magnetic fields in the solar atmosphere.

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

Rayleigh and Raman scattering polarization in spectral lines

The polarized spectrum of the Sun is formed through the scattering of anisotropic radiation on atoms. Interpretation of this spectrum requires the solution of polarized line transfer in multilevel atomic systems taking account of both the Rayleigh and Raman scattering. If the initial and final states involved in scattering are the same then it is referred to as the Rayleigh scattering, and when they are different it is called Raman scattering. In the case of strong resonance lines, it is necessary to include the realistic scattering mechanism, namely, the partial frequency redistribution (PRD). The theories of polarized line formation in a multilevel atom, formulated in the literature so far, confined themselves to the approximation of complete frequency redistribution, for the sake of mathematical simplicity.
this problem. The proposed theory is applied to a five-level Ca II atom model taking account of multi-level coupling. The second figure shows the emergent linear polarization profiles for this model atom. The linear polarizations of the H and 8662 Å lines are zero (as their polarizability factor is zero). The linear polarization of the IR triplet is basically due to the “multilevel coupling” with the K line.

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

Modeling the quantum interference signatures of the Ba II D2 4554 Å line in the second solar spectrum

A fit to the observed (I,Q/I) profiles using the modified model atmosphere.

The linearly polarized spectrum of the Sun is formed due to coherent scattering processes in which quantum interference phenomena plays a vital role. The Ba II D2 line at 4554 Å is a good example, governed by the F-state interference effects, seen only in the lines of odd isotopes which undergo hyperfine structure splitting. These odd isotopes of Ba constitute only 18% of the total Ba abundance in the Sun, the rest 82% being even isotopes which do not exhibit F-state interferences. It is therefore necessary to account for the contributions from different isotopes to understand the observed linear polarization profiles of this line. We study the radiative transfer model with partial frequency redistribution (PRD) of such observations, while accounting for the interference effects and isotopic composition. The Ba II D2 polarization profile is found to be strongly governed by the PRD mechanism. We also find that the line center polarization is sensitive to the temperature structure of the model atmosphere. To obtain a good fit to the peak at line center of the observed Stokes Q/I profile, a small modification of one of the 1D model atmospheres is needed. A fit to the observed profiles recorded near the solar limb, using this modified model is shown in the figure.

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

Role of solar magnetic carpet in the heating of the quiet atmosphere

In the quiet solar photosphere, the mixed polarity fields form a magnetic carpet, which continuously evolves due to dynamical interaction between the convective motions and magnetic field. This interplay is a viable source to heat the solar atmosphere. In this work, the line-of-sight (LOS) magnetograms obtained from the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO), and the Imaging Magnetograph eXperiment (IMaX) instrument on the Sunrise balloon-borne observatory have been used to study the evolution of the coro-
Horizontal mean of the energy flux plotted as function of height. Left panel: Mean energy flux over an emerging region (ER; red) and a quiet region (QR; blue) observed by HMI. Right panel: Mean energy flux in the IMaX dataset (blue) and Source Model (red) averaged over the entire FOV. As an illustration, a grey striped box is drawn at 2-6 Mm range to compare the energy flux between the two panels at those heights. The energy flux into the corona as predicted by our magnetic carpet simulations is about one order of magnitude smaller than the estimated radiative and conductive losses from the quiet-Sun corona as derived from EUV and X-ray observations.

In coronal heating.

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

Segmentation of solar photospheric magnetic elements

Understanding the role of magnetic field in the EUV and UV solar irradiance variability is an important task in solar physics, particularly a one-to-one spatial correspondence between the different photospheric magnetic features and coronal emission structures. The Spatial possibilistic Clustering Algorithm (SpoCA) has been applied on AIA spatially resolved images and HMI magnetograms to create segmentation maps for Active Regions (ARs), Coronal Holes (CHs) and Quiet Sun (QS). The AIA segmentation maps are then applied on full-disk HMI line-of-sight of magnetograms. The different parameters such as the intensity, the magnetic field and contribution of ARs/CHs/QS features are computed and compared with the full-disk integrated intensity, absolute magnetic field and LYRA EUV and UV irradiance measurements. A one-to-one spatial correspondence between the photospheric magnetic features and coronal features has been determined. It is found that the intensity is related with the strength of the magnetic field associated with AR and QS regions, whereas the intensity of CH is not related to its magnetic field.


On the nature of vortex flows and its relationship to magnetic fields in solar photosphere

Through a detailed statistical analysis of small-scale vortex motions and their relationship with magnetic fields on the solar photosphere,
the following major result has been obtained: small-scale vortex motions, and hence kinetic helicity of flows, found in the converging supergranular flow regions obey a hemispheric rule similar to that found for the current helicity of similar small-scale magnetic field. This implies transfer or decay of magnetic helicity to fluid helicity (kinetic), or vice versa, and it has fundamental implications for processes related to dynamo action. Further diagnostic of this phenomenon is being devised and studied. This work has used the Helioseismic and Magnetic Imager (HMI)/SDO observations of Doppler velocities, line-of-sight magnetic field, the continuum and line-core intensities (in the 6173 Fe I line).

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

Separable solutions of force-free spheres and applications to solar active regions

A systematic study of the linear and non-linear force-free (NLFF) magnetic field equations for simple axisymmetric configurations in spherical geometry was undertaken. New solutions for the NLFF fields are obtained and applied to simulate the solar photospheric vector magnetograms (see Figure). We developed a search strategy, the effectiveness of which is demonstrated through its effective reproduction of known field configurations. The strategy is then used to obtain best-fit to the solar spectropolarimetric data from the Hinode satellite. Based on these fits, we build three-dimensional axisymmetric field configurations and calculate the energy and relative helicity for active regions (ARs) in the Sun. Five magnetograms for AR10930 over three days (during which two X-class flares occurred) are analyzed to study the evolution of free energy and relative helicity during this period. Our analysis shows a distinct peak in these quantities before the flares, consistent with the results in literature. We have also analyzed single-polarity regions AR 10923 and 10933 which are described well using potential fields. This method is thus a useful reconstruction technique for the NLFF fields.

(A. Prasad, A. Mangalam & B. Ravindra)

Spectroscopy of the solar corona using HINODE observations

There have been reports of asymmetries and excess blueshifts in coronal line profiles from
both ground-based and space observations. These are interpreted in terms of nanoflare heating, type II spicules and nascent solar wind flow. Owing to its high spectral and spatial resolutions, EUV Imaging Spectrometer (EIS) on board HINODE observations is useful in the studies of solar corona. The emission line spectra from HINODE/EIS observations have been analysed using the Solar SoftWare (SSW). A series of emission lines from highly ionized atoms from Fe VIII to FeXV are used in the study. The characteristics of emission line profiles from different coronal regions were obtained.

(K. P. Raju)

Studies of chromospheric network using Kodaikanal Ca K data

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

(K. P. Raju)

Synoptic study of the solar EUV network using SOHO/CDS data

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 A.

(K. P. Raju)

Depth dependence of north-south asymmetry in the differential rotation of sunspot groups

The Greenwich (1874-1976) and Solar Optical Observing Network (1977-2011) sunspot group data have been analysed and it was found that the latitude dependence in the mean rotation rate of the sunspot groups well matches with that of Sun’s internal rotation rate at 0.94 - 0.98 solar radius. There is only a slight or no significant difference in the latitude dependencies of the mean rotation rates of sunspot groups in the northern and the southern hemisphere. However, there exists a reasonable difference between the latitude dependencies in the mean initial rotation rates of sunspot groups (determined by using the heliographic positions of the sunspot groups during the first two days of their life times) in the northern and the southern hemisphere. This is mainly due to the initial rotation of the sunspot groups reasonably slower in 10-20 deg latitudes of the northern hemisphere than in the corresponding latitude interval of the southern
The latitudinal dependence of the mean ‘initial rotation rates’ of the sunspot groups whose life times are in the ranges 2-12 days and 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 deg latitude intervals of (a) northern hemisphere and (b) southern hemisphere.

Since the average size of sunspot groups in 10-20 deg latitude interval is large and large sunspot groups initially anchor at deeper layers, the aforesaid result suggests that north-south asymmetry in the solar deferential rotation originate at the Sun’s deeper subsurface layers

(J. Javaraiah)

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

Variations in the number of large to the number of small sunspot groups ratio. The green, black, and red colours represent the small (maximum area $A_{rmM} < 100$ millionth of solar hemisphere, msh), large (100$leA_{rmM} < 300$ msh), and big ($A_{rmM}ge300$ msh) sunspot groups. The dots represent the international sunspot number.

Recently it was found that anomalous behaviour of solar cycle 23 (the violation of even-odd cycle rule by the cycles pair (22, 23)) is mainly due to a large scarcity of small sunspot groups in cycle 23. The combined Greenwich and SOON sunspot group data during the period 1874-2013 are analysed. It is found that the aforementioned scarcity of small sunspot groups in cycle 23 is largely contributed by the southern hemisphere sunspot activity. It is also found that the large to small sunspot groups ratio is larger during the rising phase of the current solar cycle 24 than that of the corresponding phase of cycle 23. This could be a reason for, as found by some authors, that during the rising phase of the current solar cycle 24 the coronal mass ejection (CME) rate was rela-
tively large whereas it is almost certain that
the cycle 24 is weak

\textit{(J. Javaraiah)}

Non-dependence of magnitude of ab-
normal rotation rates of sunspots with
latitude

We continue the study of magnitude of ab-
normal rotation rates of bipolar sunspots us-
ing historical Kodaikanal Observatory photo-
heliographic data and their association with
the durations of flares. In the previous study,
it was found that irrespective of their lati-
tudes, occurrence of flares is strongly asso-
ciated with the occurrence of abnormal ro-
tation rates of sunspots. This gave a strong
hint that magnetic reconnection that is sup-
posed to be sole energy input to the flares
occurs below the observed surface. However,
it is not clear whether occurrences of abnor-
mal rates also depend upon the latitude. To
ascertain the same, in the present study us-
ing Kodaikanal Observatory data, the abnor-
mal rotation rates that are associated with
the flares have been computed. It was found
that magnitudes of abnormal rotation rates
of sunspots is independent of latitude. This
suggests that the sub-surface dynamics re-
ponsible for injecting energy that ultimately
explode as flares might be independent of so-
lar latitudes. The obvious inference is that
the subsurface dynamics, either the magni-
tude of large-scale flows in the convective en-
velope or magnitude of subsurface rotational
shear layer that might play a dominant role
in bringing together raising flux tubes, ap-
ppears to be independent of solar latitude. In
addition, from the Kodaikanal Observatory
data, it was also found that flares are far too
frequently associated with the occurrence of
abnormal rotation rates during the lifespan
of a bipolar sunspot group than with the oc-
currences of non-abnormal rotation rates.

\textit{(G. S. Suryanarayana, K. M. Hiremath, S.
P. Bagare \& M. Hegde)}

Study of sunspot whorls using Big Bear Solar Observatory \& Kodaikanal Ob-
servatory data

Detailed studies of H-alpha chromospheric features have been rather sparse, particularly
since the data are available on original photo-
tographic plates/films at respective observa-
tories. At the Kodaikanal Observatory, full
disk spectroheliogram recording started in
1912 and continued uninterrupted until 2005.
At the Big Bear Solar Observatory, the full
disk observations started in 1969 and have
continued till date. The geographic locations
of these observatories allow mutually com-
plementary observations during common pe-
riods of interest. The total duration of over a
hundred years or nine cycles of solar activity
so far provides a unique data set. In the re-
cent years, both the observatories have taken
up digitization of these data. The BBSO
data have been archived as part of the Global
H-alpha Network. At IIA, the digitization is
nearing completion. A detailed study of the
sunspot associated super penumbral fibril structures was carried out using the above
unique digitized data sets. Also, a feasibility
study was carried out at NJIT, during April-
June 2013, using several sample cases and it
was shown that the two data sets are comple-
mentary for both short and long term stud-
ies of the chromosphere in H-alpha. This is
particularly important in the light of the pro-
posed installation of 20 cm dedicated, narrow
band and high cadence H-alpha telescope be-
ing installed at Kodaikanal. A proposal has
been written for approval by NASA for col-
laborative work in the area.

\textit{(S. P. Bagare, Heimin Wang* \& Debi Prasad
Choudhari*)}
White light Active Region Monitor (WARM)

A full disk solar imaging telescope WARM (White light Active Region Monitor), has been designed and developed in-house to facilitate long-term data products to the solar community. A two-mirror coelostat feeds Sun light to the WARM. An achromat with an effective aperture of 148 mm is used to image the Sun. The f/24 beam produces the Sun’s image of 33 mm in diameter. A non-polarizing beamsplitter diverts the converging beam in to two independent channels. In each channel secondary optical components are used to reimage the full disk on to two individual detectors. In the first channel a PCO2000 CCD is used to image the Sun in 430.5 nm with a pass band of 0.8 nm. In the second channel ANDOR iXON 888 CCD is used with a red filter centered at 630.25 nm. Both the CCDs are mounted on xyzq stages for focus, tilt and position adjustments. WARM is equipped with an optical bread board on to which the dual channel imaging system is set up. This set-up can serve as a test bed for the four-channel broad band imaging system planned for the proposed NLST and as a laboratory too for the development of back-end instruments.

(Hemanth Pruthvi, K. B. Ramesh, N. Vasanthraju* & Technical Team)

Solar imaging with masked apertures

(A) Transfer functions generated for the enclosed masked aperture (placed over 40 cm cassegrain mount telescope). (B) 2D-plot of the transfer functions for the same masked aperture. (C) $r_0$ for one set of observations on is found to be 6.8 cm as the intrinsic g-band contrast (0.192) equals to the rms contrast of deconvolved solar image.

Generally masked apertures reduce incoming photons enabling the high cadence observations near to coherence time of the atmosphere. But the purpose of achieving high-resolution images wouldn’t be served unless the transfer function of such masked apertures are considered beforehand. We have
estimated the short (SE) and long exposure transfer functions (LE), Speckle transfer functions (speckle) and telescope transfer functions (telescope) for the different simulated masked apertures along with the real masked aperture used in the observations performed on 15 October, 2013 at Merak. A comparative study of the transfer functions of different simulated masked apertures under various observing conditions with that of equivalent filled circular apertures indicated that Speckle transfer functions for masked apertures are less sensitive to seeing variations than that of filled apertures. The speckle transfer function for the masked aperture used in the observations is found to be same as short exposure transfer function. We also estimated Fried parameter ($r_0$) from the observed under-sampled data using modified parameter search method. The Fried parameter ($r_0$) for the observed under sampled data with masked aperture is found to vary from 6.2 to 6.8 cm during our observational period.

(N. Vasanthraju*, R. Sridharan* & K. B. Ramesh)

Association between angular momentum and impact due to catastrophic events of the solar system objects

Diverse nature of magnetic field and rotational structures of the solar system bodies is an unsolved mystery. Although the so called dynamo mechanism that needs Coriolis and Lorenz forces of similar orders is supposed to explain the Earth’s magnetic field structure, such a mechanism completely fails to explain large-scale magnetic field structures of some of slow rotating terrestrial planets like Mercury and, fast and slow rotating moons of different planets in the solar system. Considering this deficiency in the dynamo mechanism, the author has proposed that, large-scale magnetic field structure of slow rotating objects can also be maintained if such objects, during the early history of solar system formation, are bombarded by the external objects that might have altered the original internal dynamics and thermal structure.

About 4500 craters data set of all the terrestrial planets and their moons and, moons of Jupiter, Saturn and Uranus that have craters are considered and association between measured impact parameter (measure of intensity of the impact) and angular momentum is examined. It is found that solar system objects that have experienced a very high impact have low angular momentum and vice versa explaining diverse nature of rotational velocities of different solar system solid bodies.

(K. M. Hiremath)
Prototype spectropolarimeter development

India’s National Large Solar Telescope (NLST) of two meter aperture size is proposed to be set up in Ladakh region of Himalayas at a height of around 4300 meters. A high resolution spectrograph along with a polarimeter is planned as one of the backend instruments for NLST. Prototype development of the NLST Spectro-Polarimeter (SP) is proposed to be designed and developed for usage at the back focal plane of the Multi-Application Solar Telescope (MAST) recently installed at the Udaipur Solar Observatory. Design of the prototype SP has been discussed in detail along with the scientific goals. The SP is designed to be operated in three wavelengths to observe photospheric and chromospheric layers of the solar atmosphere simultaneously. Vector magnetic fields will be calculated in these layers. High resolution of the designed SP will provide accurate estimates of velocities. Highly resolved polarized line profiles will allow the user to obtain the height variation of vector magnetic fields when used along with suitable inversion codes.

(K. E. Rangarajan)

Comet ISON

In January 2013, the high-altitude balloon group initiated observations of the comet ISON in preparation for the November 2013 launch of the UV spectrograph to observe it at the time of the perihelion in near UV window. The UV spectra was not obtained, however, in total, the group has observed the comet in January, February, May, September and October 2013, both in imaging and spectroscopic modes using HCT and VBT telescope; providing 370-830 nm coverage. The images are being utilized as part of an international campaign observing the comet from around the globe. From that, one could determine the behavior of morphological evolution as a function of time which is not possible to obtain from a single observatory.

Comet C/2012 (ISON) 2013 October 01, R band 300 sec exposure. The observations were performed in the Keystone mode of the HCT. Distance to the comet is 2.151 AU, where 1AU = 149597871km

The science that can be extracted includes the rotational state of the nucleus, characterization of the nucleus activity, gas and dust properties in the coma, and temporal behavior of the tail structure when the comet is close to the sun. As comet approaches the Sun, its spectra consists of reflected sunlight from dust in the coma and, after crossing the ice line, the emission lines from coma species. The volatile composition of cometary nuclei can be inferred from measurements of the spectral signatures of gases forming the coma. Analysis of comet’s continuum (caused by the reflected sunlight from dust particles in the coma) provides the knowledge about the nature of the comet’s dust. In addition, comet’s images were used for public outreach in the ‘Eyes in ISON’s nation-wide campaign’.

(M. Safonova)
2.2 Stellar and Galactic Astrophysics

Monitoring outburst of classical and recurrent novae

The outburst of the classical and recurrent novae are being monitored to study the temporal evolution of the physical conditions in the outburst ejecta, and its interaction with the circumstellar material. These studies also provide an understanding of the central binary system and the conditions leading to the outburst. The classical novae Nova Cephei 2013 and Nova Delphini 2013 were observed in the optical and NIR using the 2m HCT and in the radio using the GMRT. High resolution spectra of Nova Delphini 2013 was also obtained with the VBT. The 2014 outburst of the recurrent nova V745 Sco was monitored spectroscopically using the VBT. Photometric observations were made with the 1.3m JCBT. The evolution of the low frequency radio flux was studied using the GMRT, and found to be non-thermal similar to RS Ophiuchi. The recurrent novae T CrB, RS Oph, CI Aql, U Sco and V3890 Sgr continue to be monitored during their quiescence phase as a part of the spectroscopic monitoring programme to study the long term behaviour of these systems.


Supernova SN 2012dn: A spectroscopic clone of SN 2006gz

A detailed optical and UV analysis of SN 2012dn is carried out. In optical bands, it is marginally luminous ($M_B^{extmax} = -19.52 \pm 0.15$), however, in the Swift UVOT bands, it is about 1 to 2 magnitudes brighter than normal type Ia supernovae and shows very blue colours in the $(u - v)$ and $(U - B)$ bands. The photometric and spectroscopic behaviour of SN 2012dn is different from those of normal and SN 1991T like objects. With very strong secondary maximum, the light curve in $I$ band peaks after maximum in $B$ band, which is just opposite to the observed trend for normal type Ia events. During late phase light curve decline of SN 2012dn is faster. The contribution of UV bands to the bolometric flux is quite high ($\sim 20\%$). The peak bolometric luminosity indicates that $\sim 0.82 \ M_\odot$ mass of $^{56}$Ni was synthesized in the explosion. Pre-maximum spectra show clear evidence of C,sc ii 6580 AA. The velocity evolution of C,sc ii is peculiar, it is lower than the velocity estimated using the Si,sc ii line. In the pre-maximum phase and close to maximum, to reproduce observed shape of the spectra, the synthetic
spectrum code sc syn++ needs significantly higher blackbody temperature than those required for normal type Ia events. The photospheric velocity evolution and other spectral properties are similar to those of the carbon-rich SN 2006gz.

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

Properties of newly formed dust grains in the luminous Type IIn Supernova 2010jl

 Supernovae have been proposed to be the main production sites of dust grains. However, nature and amount of dust produced by individual supernova is poorly understood. A spectrum of Type IIn supernova 2010jl, covering optical through near-infrared, taken during late phase reveals signatures of newly formed dust. We derive the main population of the dust species as carbon grains at a temperature of $\sim 1,350 - 1,450$K and mass of dust grains to be $\sim (7.5 - 8.5) \times 10^{-4} M_\odot$. We attribute the dust grains to have been formed in a dense cooling shell due to strong SN-circumstellar media interaction.


iPTF 13bvn: The first evidence of a binary progenitor for a Type Ib Supernova

The optical observations of Type Ib supernova iPTF 13bvn obtained with the HCT were used to compute bolometric light curve. The hydrodynamical modelling of bolometric light curve shows that the progenitor had a pre-SN mass of $\sim 3.5 M_\odot$. We propose an interacting binary system as the SN progenitor. The evolutionary calculations self-consistently explain the light-curve shape, the absence of hydrogen, and the pre-SN photometry.


Photometric and spectroscopic studies of star-forming regions within Wolf-Rayet galaxies

 Optical photometric and spectroscopic study of a sample of Wolf-Rayet galaxies was carried out. Their morphologies, colours, star-formation rates (SFRs), metallicities, age of stellar populations and oxygen abundance were estimated by combining broad-band and narrow-band photometry with low-resolution optical spectroscopy. H$\alpha$ images were used to identify star-forming regions within these galaxies and to derive SFR. Our H$\alpha$-based SFR usually agrees with the SFR computed using the far-infrared and the radio-continuum flux. The optical broad-band colours in combination with Starburst99 model were used for estimating the internal reddening and age of the dominant underlying stellar population. For all the star forming regions the age of the most recent star-formation event is found to be 3-6 Myr. Some galaxies show the presence of an important old (400 - 1000 Myr) stellar population indicating that both the current intensity of the starbursts and the star-formation activity have been ongoing for at least a few tens of millions of years in these objects.

(Chrisphin Karthick*, A. R. Lopez-Sanchez*, D. K. Sahu, B. B. Sanwal* & Shuchi Bisht*)
Multi-wavelength photometry of young clusters

Young clusters provide a stellar system where the individual member stars have a range in age (of the order of the cluster age), a range in mass with same initial composition. Study of such a cluster gives insights into the basic star formation processes, time and mass dependent evolution of stars as a whole and finally the dynamics which control the dissipation of material within the cluster as well as the final kinematics within the system. Estimation of fundamental parameters such as reddening, distance, age and membership are necessary before probing the properties of individual cluster members. When the MS stars in the cluster are optically visible, stars in the pre-MS phase require a multi-wavelength analysis based on optical, NIR and MIR to estimate their properties and trace the star formation history of the cluster. In this study we carried out optical photometry of 5 clusters (Be 59, NGC 1931, NGC 6604, NGC 7261 and NGC 7510) with an age range of 1-10Myr by using the Himalayan Chandra telescope (HCT) in combination with NIR data from 2MASS and mid-IR data from WISE. The youngest cluster Be 59, with age $\sim$1Myr, hosts the highest fraction of YSOs. It is found that for Be 59, NGC 604 and NGC 7510 the star formation processes are continuous; while for NGC 1931 and NGC 7261 the star formation is episodic.

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

Properties of small-scale magnetism of Stellar Atmospheres - A study using 3D magnetoconvection simulations

Using a magnetohydrodynamic simulation code CO5BOLD we have obtained preliminary results from simulations for the effective temperature ranging between 4000 K and 6500 K with an initial vertical, homogeneous magnetic field with a strength of 50 Gauss. We find that the field strength of the strongest magnetic flux concentrations increases with decreasing effective temperature at the height where the average Rosseland optical depth is one. Despite of this relation, at the same Bolometric intensity emerging vertically from a single snapshot of each of the four simulation runs. The grey scale of each map ranges from minimal to maximal intensity of each individual map. The snapshots correspond to the models with $T_{\text{eff}} = 4000$ K (top left), $T_{\text{eff}} = 5000$ K (top right), $T_{\text{eff}} = 5770$ K (solar, bottom left), and $T_{\text{eff}} = 6500$ K (bottom right). Note that box sizes increase with increasing effective temperature $T_{\text{eff}}$ in order to accommodate a similar number of granules. Side boundaries are periodic. The length of the bar in the top right of each frame is 10 times the surface pressure scale height.
but assumes super-equipartition in the models hotter than 5000 K. While the Wilson depression of the strongest field concentrations is about one pressure scale height in the coolest model, it is more than four times the pressure scale height in the hottest one. We also find that the relative contribution of the bright filigree to the bolometric luminosity is most significant for the model with effective temperature 5000 K (0.56%) and least significant for that with effective temperature 6500 K (0.12%). This behaviour suggests that the effect of the small-scale magnetic field on the photometric variability is more significant for K dwarf stars than that for F type and M-type stars.

(S. P. Rajaguru, Oskar Steiner*, Rene Salhab* & Bernd Freytag* et al.)

On the relationship between masses of sun-like G stars and their exoplanets

We continued the study of relationship between G stars and their exoplanetary masses. In the previous study, with some constraints on the orbital parameters of exoplanets and by using ad-hoc law of mass loss, initial masses of the host stars during the era of stellar system formation are computed and compared with the present exoplanetary masses. We found the inverse mass relationship between the masses of host stars and their exoplanets. In the present study, with the same data set, a reasonable mass loss correction is applied for both the host stars and their exoplanets. Results clearly support our previous study that there is a universal inverse mass relationship between the host stars and their respective exoplanetary masses. From the empirical inverse mass relationship, initial mass (\(\sim 1.4\, M_\odot\)) of the Sun during solar system formation and present planetary mass (\(\sim 5\, \text{Jupiter mass}\)) in the vicinity of sun are estimated. For existence of present low planetary mass (\(\sim 0.01\, M_J\), where \(M_J\) is mass of Jupiter) in the vicinity of sun, it is conjectured that estimated high planetary mass probably some part might have accreted on to the sun or some part might have been blown off to the space due to stellar radiation during initial stage of solar system formation or part of this missing mass might have migrated outwards from the vicinity of the sun.

(K. M. Hiremath, Shashank Gurumath* & V. Ramasubramanian*)

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

Simulated polarization profiles of pulsars: intensity linear \(L\) and circular \(V\) polarizations and the polarization angle \(\psi\) are plotted as functions of the rotation phase.

Pulsar radio emission is believed to be emitted by the relativistic plasma accelerated along the rotating dipolar field lines. The authors have developed a most general relativistic model for the polarization of coherent curvature radiation by including the pulsar spin, polar cap current perturbation and modulation of radio emitting plasma. Based on the model the authors have simulated pulse profiles for the various combina-
tion physical parameters that prevail in the pulsar magnetosphere. In the Figure, the authors have presented a couple of polarization profiles: $I$ represents the intensity, $L$ and $V$ the linear and circular polarizations, and $\psi$ the polarization angle swing, using magnetic axis inclination angle $\alpha = 10^\circ$ and sight line impact angle $\sigma = \pm 5^\circ$. The rotation induced asymmetry in the curvature of source trajectory, which the sight line encounters, can be asymmetric between the two sides (leading and trailing) of the profile. Hence the peak of intensity profile shifts to the leading side while the inflection point of $\psi$ to later phase (marked by downward arrows). The authors propose that the effect of rotation and PC-current perturbation in the presence of non-uniform source distribution (modulation) along with viewing geometry might be responsible for the most of the observed diverse behaviour of polarization properties of pulsar radio emission. For the first time they have shown that the “symmetric”-type circular polarization (see green curves in Figures a and c) could be generated by the curvature radiation when the perturbation and modulation are operative. The sign of $V$ seems to correlated with the swing of $\psi$.

(D. Kumar & R. T. Gangadhara)

Chemical compositions of RV Tauri stars and related objects

We have undertaken a comprehensive abundance analysis for a sample of relatively unexplored RV Tauri and RV Tauri like stars to further their understanding of post-Asymptotic Giant Branch (post-AGB) evolution. From their study based on high resolution spectra and a grid of model atmospheres, they found the indications of mild s-processing for V820 Cen and IRAS 06165+3158. On the other hand, SU Gem and BT Lac exhibit the effects of mild dust-gas winnowing. We have also compiled the existing abundance data on RV Tauri objects and find that a large fraction of them are afflicted by dust-gas winnowing and aided by the present work, they find a small group of two RV Tauri’s showing mild s-process enhancement in our Galaxy. With two out of three reported s-process enhanced objects belonging to RV Tauri spectroscopic class C, these intrinsically metal-poor objects appear to be promising candidates to analyse the possible s-processing in RV Tauri stars.

(S. Sumangala Rao & Sunetra Giridhar)

Identification of metal-poor stars using the artificial neural network

We have constructed a library of 167 medium-resolution stellar spectra (R 1200) covering the stellar temperature range of 4200 to 8000 K, log g range of 0.5 to 5.0, and [Fe/H] range of -3.0 to + 0.3 dex. This empirical spectral library was used to train ANNs, yielding an accuracy of 0.3 dex in [Fe/H], 200 K in temperature, and 0.3 dex in log g. We
found that the independent calibrations of near-solar metallicity stars and metal-poor stars decreases the errors in $T_{\text{eff}}$ and $\log g$ by nearly a factor of two. We calculated $T_{\text{eff}}$, $\log g$, and $[\text{Fe/H}]$ on a consistent scale for a large number of field stars and candidate metal-poor stars. We extended the application of this method to the calibration of absolute magnitudes using nearby stars with well-estimated parallaxes. A better calibration accuracy for $M_v$ could be obtained by training separate ANNs for cool, warm, and metal-poor stars. The current accuracy of $M_v$ calibration is $\pm 0.3$ mag. A list of newly identified metal-poor stars is presented.

\cite{Giridhar2023}

**Differential image analysis of Globular clusters NGC 7099, NGC 7492, NGC 6333 and NGC 288**

We have made extended V and I time-series observations of four globular clusters NGC 7099, NGC 7492, NGC 6333 and NGC 288 using difference image analysis to obtain high-precision light curves of variable stars which enables us to search for new variable stars in these clusters and refine the periods of known variables. We have estimated the cluster parameters by performing a Fourier decomposition of the light curves of RR Lyrae stars for which good period estimates were available. We have estimate an age of $13.0 \pm 1.0$ Gyr for NGC 7099 by fitting theoretical isochrones to our colour-magnitude diagram (CMD). For NGC 7099 we find two new RR Lyrae variables, and confirm two additional RR Lyrae candidates from the literature. We also detect four other kind of variables, including an eclipsing blue straggler system, and an SX Phoenicis star. We find a cluster metallicity $[\text{Fe/H}]_{ZW} = -2.01 \pm 0.04$, a distance of $8.32 \pm 0.20$ kpc (using RR0 variables) for NGC 7099. In NGC 7492 we find that RR Lyra variable V2 is undergoing period change; using P-L relation of SX Phe stars a distance of $24.04 \pm 0.20$ kpc is estimated while $[\text{Fe/H}]_{ZW} = -1.68 \pm 0.04$ is estimated for NGC 7492. Similarly, we find $[\text{Fe/H}]_{ZW} = -1.62 \pm 0.04$, a distance of $8.99 \pm 0.20$ kpc for NGC 288, $[\text{Fe/H}]_{ZW} = -1.70 \pm 0.04$, a distance of $8.04 \pm 0.20$ kpc for NGC 6333.

\cite{Giridhar2023}

**On the binary helium star DY Cen-tauri: Chemical composition and evolutionary state**

DY Cen has shown a steady fading of its visual light by about 1 magnitude in the last 40 years suggesting a secular increase in its effective temperature. The authors have conducted non-LTE and LTE abundance analyses to determine the star’s effective temperature, surface gravity, and chemical composition using high-resolution spectra obtained...
over two decades. The derived stellar parameters for three epochs suggest that DY Cen has evolved at a constant luminosity and has become hotter by about 5000 K in 23 years. The authors show that the derived abundances remain unchanged for the three epochs. The derived abundances of the key elements, including F and Ne, are as observed for the extreme helium stars resulting from a merger of an He white dwarf with a C-O white dwarf. Thus, DY Cen by chemical composition appears to be also a product of a merger of two white dwarfs. This appearance seems to be at odds with the recent suggestion that DY Cen is a single-lined spectroscopic binary.

(Gajendra Pandey, N. Kameswara Rao*, Simon C. Jeffery* & David L. Lambert*)

**Discovery of relatively hydrogen-poor giants in the Galactic globular cluster Omega Centauri**

The results of our low-resolution spectroscopic survey for identifying the hydrogen-deficient (H-deficient) stars in the red giant sample of the globular cluster Omega Cen are reported. Spectral analyses were carried out on the basis of the strengths of (0,0) MgH band and the Mgb triplet. In our sample, four giants were identified with weak/absent MgH bands in their observed spectra, which is not as expected for their well determined stellar parameters. The Mg abundances for the program stars were determined from subordinates lines of the MgH band to the blue of the Mgb triplet, using the spectral synthesis technique. The derived Mg abundances for the program stars were as expected for the red giants of Omega Cen (Norris & Da Costa 1995), except for the four identified candidates. Determined Mg abundances of these four candidates are much lower than that expected for the red giants of Omega Cen, and are unacceptable based on the strengths of the Mgb triplet in their observed spectra. Hence, the plausible reason for the weak/absent MgH bands in the observed spectra of these stars is a relatively lower abundance of hydrogen in their atmospheres. These giants may belong to the group of helium enriched red giants of Omega Cen.

(B. P. Hema & Gajendra Pandey)

**Abundance pattern of Hercules stream**

The abundance plots of Hercules stream (red cross) for representative α elements as [X/Fe] versus [Fe/H]. Black and brown circles represent thick and thin disc stars respectively from Bensby et al. 2005.

Hercules stream is a prominent moving group in solar neighbourhood, with a rotational lag of 50 km/s with respect to the Local Standard of Rest. The authors have estimated abundances of 16 elements for 58 red giant members of the Hercules stream catalogued by Famaey et al. 2005. Results show that they are quite young and metal rich with a considerable range in age (170
Myr to 4.2 Gyr) and metallicity (-0.17 dex to +0.43 dex). Our results suggest that the member stars of the Hercules stream are part of the thin disc component which is contrary to the results in the literature which suggest that Hercules stream is a mixture of the thin and thick discs. Estimated abundances are presented in which shows a trend very similar to that of thin disc. However, in the super-metallicity region it is difficult to disentangle the thick and thin disc abundance trends. From these results we argued that the stream is resultant of orbital perturbations within the thin disc rather than due to cluster disruption or migration of stars from the merging satellites.

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

AFGL 333 in perspective: Stellar content, properties and star formation activity

The W3 giant molecular cloud is one of the most massive molecular clouds in the Perseus arm at a distance of 2.0 kpc and is well known for its high mass star formation activity. The AFGL 333 complex lies at the southern periphery of W3 and it contains several kinds of sources including a bright rimmed cloud (BRC 5), a compact HII (CHII) region associated with a cluster and a prominent dense filamentary structure associated with a molecular ridge. Using multi-wavelength data sets (optical, NIR, MIR, FIR and Radio), an extensive survey of this star forming complex has been undertaken with an aim to explore its hidden young stellar objects (YSOs) as well as to understand the structure and formation history. We obtained over 800 candidate YSOs (Class I and Class II) in the complex and their spatial distribution and clustering analysis identified new stellar aggregates across the region. The age analysis of YSOs based on CMDs, circumstellar disk fraction and SEDs shows evidences for multiple evolutionary status for various sub-regions of the complex. The morphology of this complex especially the BRC 5 facing the W4 super bubble is strongly suggestive of a large scale triggering due to its expansion. However, in a small scale, it is also suggesting a local triggering effect within the complex, generates secondary bursts of star formation either by forming or collapsing clumps and filaments (e.g. expansion of the CHII region).

(Jessy Jose)

Chemical imprints of the first based on metal poor stars from SDSS

The authors generated extensive synthetic grids, for deriving automated abundances of key elements (C, N, Mg, Fe, Sr, and Ba) from SDSS spectra. They have completed deriving
carbon abundances of 500,000 stars and Ba abundances for a subset of 30,000 stars with high S/N from SDSS-DR9 data release. Barium abundances along with carbon is used to differentiate the contribution of carbon from AGB and massive stars. Carbon rich stars with Ba enhancements dominate the metal rich end below $[\text{Fe/H}] < -3.0$ and their carbon abundances show a plateau with respect to their metallicity indicating a AGB contribution due 3rd dredge-up. The CEMP-no stars dominate the metal poor end. Similar to the CEMP-s star plateau, there is also a possibility to find plateau in the CEMP-no carbon abundances. A possible plateau may indicate, pre-pollution of carbon due to First stars.

(T. Sivarani, Susmitha Rani & *Lee et al.)

**Origin of r-process in Carbon enhanced metal poor stars**

One of the outstanding problem in the study of Carbon enhanced metal poor stars is that, about 60% of them have s- process rich composition along with high Eu enhancements. Since Eu mainly produced by r-process due to massive stars, the formation scenarios and the relative abundances of r+s versus s-only rich carbon stars seem to be puzzling. The authors have derived abundances for 39 elements, including 19 n-capture elements for a new r+s star HE 1405-0822, to study origin of r-process. They could not reproduce the r-process pattern (including Eu, Gd, Tb, Dy and Er) in HE1405-0822 with a superposition of scaled solar r-process pattern (assuming the main r-process pattern is universal). This means that the origin of r-process elements are more complicated than what is understand now. Similar study of more number of CEMP-s and CEMP-r+s stars will throw some light on the origin of r-process , i.e. a special “s/r” neutron-capture process which should be a single process with features in-between or a superposition of the s- and r-process, or a probably unlikely scenario, a stable triple stellar system.

(W. Y. Cui*, T. Sivarani & N. Christlieb*)

**Extreme Ultra-violet radiation constrains the habitable zone of low luminosity stars**

Upper limit on the Extreme Ultra-violet luminosity of M-dwarf stars of different spectral class which determines the habitability of planets.

The conventional “Circumstellar Habitable Zone” is defined as a region of a stellar system at which the temperature of an object should be appropriate for water to exist in liquid state. A rocky planet orbiting in this region is called a “Habitable Planet”. Recently, a large number of exoplanets have been discovered around M-type of stars and many of them are located in the habitable zone of such stars. This implies the existence of a large number of habitable planets in our galaxy. However, the conventional definition
of circumstellar habitable zone does not consider the effect of X rays and Extreme Ultraviolet (EUV) rays from the star. Since M-type of stars are faint and have low effective temperature, the habitable zone of these stars are very close to the stars and hence the planets are exposed to intense X-rays and EUV which not only ionize atoms and molecules but also strip out light elements and volatiles. Considering energy-limited hydrodynamical mass loss with an escape rate that causes oxygen to escape along with hydrogen, I present an upper limit for the ratio between the EUV and the bolometric luminosities of stars which constrains the habitability of planets around them. Application of the limit to planet-hosting stars with known EUV luminosities implies that many M-type of stars should not have habitable planets around them.

(Sujan Sengupta)

Characterizing the UV H-R Diagram for UVIT filter set

The authors have undertaken a study to characterize stellar properties spanning the H-R diagram as observed with this filter set. The stellar groups under investigation span all spectral types and luminosity classes as well as metallicity range of $-2.5 < [\text{Fe/H}] < +0.5$. The observed, flux-calibrated, Spectral Energy Distributions (SEDs) of stars spanning spectral classes and metallicities from a wide variety of spectral atlases and catalogues of past and current UV missions eg. TD1, IUE, HST, have been compiled. The UV Color-Magnitude Diagrams (CMDs) of stars have been generated from the expected magnitudes computed for UVIT. An example of the CMD is shown in the figure. It is demonstrated that (i) UVIT filter system offers a large color spreads which otherwise can only be achieved by combining data from different missions; (ii) Using certain combinations of filters we are able to segregate different classes of objects better than with ground based data alone. The calibration of the UVIT system and a detailed analysis of the UV color distribution of stellar groups are under progress.

(S. G. Bhargavi & Ashok Pati)

Magnetic fields in cometary globules - IV LBN 437

R-band polarimetry of a cometary globule, LBN 437 is carried out in order to study the magnetic field geometry of the cloud. The magnetic field geometry of LBN 437 is found to follow the curved shape of the globule head. This could be due to the drag
that the magnetic field lines could have experienced because of the ionizing radiation from the same exciting source that caused the cometary shape of the globule. The orientation of the outflow from the Herbig A4e star, LkHα 233 (V375 Lac), located at the head of LBN 437, is found to be parallel to both the initial ambient magnetic field and the Galactic plane.

(A. Soam*, G. Maheswar*, H. C., Bhatt, C. W., Lee* & A. N. Ramaprakash*)

A study of the starless cloud LDN 1570

The magnetic field geometry and the properties of the dust in the starless cloud LDN 1570 have been studied using multi-wavelength optical polarimetry and photometry. The magnetic field lines are found to be parallel to the cloud structures seen in the 250 micron images of LDN 1570. Based on the magnetic field geometry, the cloud structure, and the complex velocity structure, the authors conclude that LDN 1570 is in the process of formation due to the converging flow of material mediated by the magnetic field lines. A structure function analysis shows that in the LDN 1570 cloud region the large scale magnetic fields are stronger than the turbulent component of the magnetic fields. The estimated strength of the magnetic field suggests that the LDN 1570 region is subcritical, and hence could be strongly supported by the magnetic field lines. The distance to the cloud is estimated to be about 390 pc. The dust grains in the cloud, as indicated by the values of $\lambda_{\max}$ and $R_V$, are found to be larger than the average interstellar dust grains.


Faint stellar sequences for ground-based photometry

The proper photometric calibration of faint objects requires standard stars with known flux at similar levels of faintness. Though there are faint stellar standards that are used for calibration, often the flux is not known in all filter bands, particularly the 'U' and 'I' bands. We have started a program of photometric imaging in the U,B,V,R,I bands of faint standard fields as part of the performance testing of the new 1.3m JCBT at VBO. These calibrated fields will be important not only for ground-based imaging but will also bridge the gap in the U-band between the optical and the ultraviolet region to be observed with the Ultra-Violet Imaging Telescope.

(A. K. Pati)

Generation of Infrared Guide Star Catalogue for TMT Observations

The TMT IRGSC is a star catalogue to be prepared which should consist of sources with J magnitudes as faint as 22 mag covering the TMT observable sky from +89 to -45 degrees declination. The TMT IRGSC will be a critical resource for TMT operations that enables efficient planning and observing fulfilling a role similar to that of Guide Star Catalog I and II of the HST. No catalog currently exists with objects this faint in IR and it is highly essential to compute the expected NIR magnitudes from optical magnitudes. During the Phase I a methodology based on Kurucz stellar atmospheric model was developed to compute the JHKs magnitudes of stellar sources from their optical magnitudes (gri). The methodology was applied in three test fields in the CFHT Legacy Survey fields and was found to be satisfactory. In the Phase II of the TMT IRGSC,
For the probable stellar sources (identified using the extended star/galaxy criteria) in test field, T2, the difference between the observed and computed magnitudes are plotted against the observed J<sub>Vega</sub> magnitude. The left-upper, left-lower and right-lower panels show the difference when black body model, Nextgen stellar atmospheric model and Kurucz stellar atmospheric model was used to compute.

the fine tuning of the methodology to satisfy the source density criteria of NFIRAOS by interpolating the stellar models and the optimization of the star/galaxy classification are successfully completed in the first part of the Phase II. The feasibility study to use the PAN STARRS data for the final production of TMT IRGSC is also completed

(S. Subramanian)

2.3 Extragalactic Astronomy and Cosmology

Gamma-ray loud Narrow line Seyfert 1 galaxies

Spectral energy distributions of the NLSy1 galaxies PKS 1502+036 and PKS 2004-447. Here simultaneous data points are red in colour namely, Fermi-LAT(filled squares), Swift-XRT(filled diamonds) and Swift-UVOT(filled triangles). Archival data points are shown in green colour. The solid blue line gives the sum of all the modelled radiative components (BB: black body, Syn: Synchrotron, SSC: Synchrotron.

The extragalactic gamma-ray sky as revealed by the energetic gamma ray experiment telescope(EGRET) on board the Compton gamma-ray observatory(CGRO) and by the large area telescope(LAT) on board Fermi is dominated by the blazar class of active galactic nuclei (AGN). Among the extragalactic sources, apart from blazars, Fermi has also detected gamma-ray emission from five narrow line Seyfert 1 (NLSy1) galaxies. NLSy1 galaxies have narrow balmer emission lines (FWHM(Hbeta) < 2000 km/sec), weak O III and strong optical FeII lines compared to broad line Seyfert 1 galaxies. Their peculiar observational characteristics are attributed to them having low mass black holes (106 - 108 M<sub>Sun</sub>) at their centers. Many of the observed characteristics of a minor population(7%) of NLSy1 galaxies sources are indicative of the presence of relativistic jets in them and the detection of gamma-ray emission in five of them has confirmed their presence. A systematic study was performed
on two sources PKS 1502+036 and PKS 2004-447 using optical, X-ray and gamma-ray data from Swift and Fermi (i) to find the similarities and/or differences of these two sources with respect to the blazar class of AGN and (ii) to see if they fit into the traditional "blazar sequence". It is found that the broad-band spectral energy distribution of these sources resemble more to the flat spectrum quasars than to the BL Lac class of AGN and they fit into the traditional blazar sequence.

(Vaidehi S. Paliya, C. S. Stalin, Amit Shukla & Sunder Sahayanathan*)

Multiwaveband observation of Gamma-rays sources

Since the detection of VHE gamma-rays from Mrk 501, its broad band emission of radiation was mostly modelled using one zone emission scenario, which was quite effective in explaining the observed broad band emission to a large extent. But broad-band spectral and flux variability studies enabled by the multiwavelength campaigns carried out during the recent years have revealed rather complex behaviour of Mrk 501. The observed emission from Mrk 501 could be due to a complex superposition of multiple emission zones. Moreover, new evidences of detection of very hard intrinsic gamma-ray spectra obtained from Fermi-LAT observations have challenged the theories about origin of VHE gamma-rays. Studies by the authors, based on Fermi-LAT data indicate the existence of two separate components in the spectrum, one for low energy gamma-rays and the other for high energy gamma-rays. Using multiwaveband data from several ground and space based instruments, in addition to HAGAR data, the spectral energy distribution of Mrk 501 is obtained for various flux states observed during 2011. In the present work, this observed broadband spectral energy distribution is reproduced with a leptonic, multi-zone Synchrotron Self-Compton model.


Monitoring of gravitationally lensed quasars

Combined (210 image frames for a total exposure of 21 hours) R-band image centred on the doubly imaged gravitationally lensed quasar SDSS J1001+5027. The two lensing galaxies G1 and G2 are indicated in the zoomed image.

Studies of gravitationally lensed quasars can have both cosmological and astrophysical applications. One of the cosmological applications is to get an accurate estimate of the Hubble Constant $H_0$. On the astrophysical side, studies of micro-lensing signatures on the lensed quasar light-curves will enable to determine the spatial structure of the accretion disks of the lensed quasars. Many efforts have been spent over the years to determine $H_0$, but its value is still poorly constrained. One of the methods to estimate $H_0$ is the time delay method. Apart from accurate modelling of the lensing galaxy(ies) this method requires precise
measurements of the time delay(s) between images of multiply imaged quasars. This requires (a) long term monitoring observations with good time resolution and high S/N and (b) good time delay estimation methods. A set of 6 quasars is being monitored using the 2m HCT as part of the international COSmological MONitoring of GRAvitational Lenses (COSMOGRAIL) collaboration. Towards this program, a robust time delay estimation procedure called the “Difference Smoothing Technique” has been developed at IIA. This method also takes into account the unwanted micro-lensing signals present in the quasar light curves. Using this new method, in conjunction with other techniques we find a time delay of $119.3 \pm 3.3$ days for the doubly imaged quasar SDSS J1001+5027 using observations that span more than six years between March 2005 and July 2011. The observed field and the light curves are shown in

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

Optical variability of Active Galactic Nuclei

R-band light curves of images A and B in the lensed quasar SDSS J1001+5027 from data acquired during March 2005 to July 2011.

Intra-night optical variability of different classes of Active Galactic Nuclei (AGN) are known to show flux variations over the entire electromagnetic spectrum over a range of time scales. Intra-night optical variability (INOV) refers to optical flux variations on minute to hour time scales with amplitudes ranging from few hundredths to few tenths of a magnitude. Studies of this kind are extremely important as they help in probing the innermost regions of AGN which is beyond the reach of any imaging techniques available today. Earlier studies based on hundreds of nights of monitoring data imply that blazars show large amplitude INOV compared to radio-quiet quasars. We have carried out a systematic analysis of the incidence of INOV on six classes of AGN namely radio-quiet quasars (RQQs), radio-intermediate quasars (RIQs), lobe-dominated quasars (LDQs), low optical polarization core dominated quasars (LPCDQs), high optical polarization core dominated quasars (HPCDQs) and blazars detected in the TeV band (TeV blazars). For this we have used a sample of 77 AGN, observed on a total of 262 nights using 1-2m class optical telescopes located in India. We find the INOV duty cycle for these classes as: 10 per cent for RQQs using 68 nights of data, 18 per cent for RIQs using 31 nights of data, 5 per cent for LDQs using 35 nights of data, 17 per cent for LPCDQs using 43 nights of data, 43 per cent for HPCDQs using 31 nights of data and 45 per cent for TeV blazars using 54 nights of data.

(A. Goyal*, Gopal-Krishna*, P. J. Wiita*, C. S. Stalin & R. Sagar*)

Red Giants in Small Magellanic Cloud. I. Disk and tidal stream kinematics

One of the principle goals of contemporary astrophysics is to develop a more complete understanding of galaxy formation and evolution. In this context, the authors present results from the most extensive radial velocity survey of intermediate-age field stars
in the Small Magellanic Cloud (SMC) to date. Their analysis of a sample of 3065 sources, predominantly from the red-giant branch population, within a region of sky of approximately 37.5 square degrees, centred on the Small Magellanic Cloud, has unearthed a velocity gradient in the rest frame of the SMC that is similar in position-angle with that observed in the young, massive stellar population. The authors associate a kinematical structure towards the far north-west of our survey area with the tidal “conunter-bridge” tail. Their results reinforce the notion that the intermediate-age stellar population of the SMC is subject to substantial stripping by external forces.

(S. Annapurni, P. D. Dobbie*, A. A. Cole* & S. Keller*)

Red Giants in the Small Magellanic Cloud.II. Metallicity gradient and age-metallicity relation

The authors present results from the largest CaII triplet line metallicity study of Small Magellanic Cloud (SMC) field red giant stars to date, involving 3037 objects spread across approximately 37.5 deg\(^2\), centred on this galaxy. The authors find a median metallicity of \([\text{Fe/H}]=-0.99\pm0.01\), with clear evidence for an abundance gradient of \(-0.075\pm0.011\) dex/degree over the inner 5 degrees. They interpret the abundance gradient to be the result of an increasing fraction of young stars with decreasing galactocentric radius, coupled with a uniform global age-metallicity relation. The authors also demonstrate that the age-metallicity relation for an intermediate age population located 10 kpc in front of the NE of the Cloud is indistinguishable from that of the main body of the galaxy, supporting a prior conjecture that this is a stellar analogue of the Magellanic Bridge. The metal poor and metal rich quartiles of our RGB star sample (with complementary optical photometry from the Magellanic Clouds Photometric Survey) are predominantly older and younger than approximately 6Gyr, respectively. Consequently, the authors draw a link between a kinematical signature, tentatively associated by them with a disk-like structure, and the upsurges in stellar genesis imprinted on the star formation history of the central regions of the SMC. The authors conclude that the increase in the star formation rate around 5-6 Gyr ago was most likely triggered by an interaction between the SMC and LMC.

(S. Annapurni, P. D. Dobbie*, A. A. Cole* & S. Keller*)

Disk of the Small Magellanic Cloud as traced by Cepheids

The structure and evolution of disk of the Small Magellanic Cloud (SMC) are traced by the study of V and I band photometric data of Cepheids from OGLE III catalog. The orientation measurements and the star formation history are estimated from the study. A break in the PL relations of both the fundamental mode and first overtone Cepheids at
The two dimensional plot of deviation is shown. The details of all the panels are given in the plot itself.

P 2.95 days and P 1 day respectively are observed. A reddening map of the SMC disk is also presented. The orientation corrected depth/thickness of the SMC disk is found to be 2.32 pm 0.5 kpc. The scale height is estimated to be 1.08 pm 0.2 kpc. From the derived ages of the Cepheids, two peaks of enhanced star formation are identified at 100-140 Myr and 200-240 Myr which coincides with the suggested epoch (100-300 Myr) of recent interaction of the SMC with the Large Magellanic Cloud. The radial variation of the disk parameters mildly indicate structures/disturbances in the inner SMC (0.5 < r < 1.75 degree). Some of the Cepheids found in front of the fitted plane in the eastern regions are possibly the youngest tidally stripped counterpart of the H I gas of the Magellanic Bridge. The Cepheids behind the fitted plane are likely the population in the Counter Bridge predicted in the recent numerical simulations.

(S. Subramanian & A. Subramaniam)

Investigating AGN activity and black hole masses in Low Surface Brightness galaxies

The aim of the work is to understand the AGN activity in LSB galaxies and to estimate the mass of the black hole in the Seyfert I type galaxies. Hence to verify the M-sigma relation of LSB galaxies. From a sample of 1200 LSB galaxies in various catalogs, we retrieved SDSS spectra for 650 galaxies. From the SDSS provided emission line fluxes, the BPT diagram is constructed and the spectra of the 115 galaxies which are classified as Seyferts and LINERs are further analysed.

\[
M_{BH} \text{-sigma plot for the LSB galaxies. Black points represent the } M_{BH}\text{ and velocity dispersion of our sample galaxies. The blue points represent the galaxies in the study by Ramya et al. (2011). The solid line is the } M_{BH}\text{-sigma relation taken from Ferrarese & Merritt (2000), the dashed line is from Tremaine et al. (2002).}
\]

From the spectra we deconvolved the contributions from underlying dominant stellar population to get the emission lines. During this process the stellar velocity dispersion are also estimated. The emission lines are fitted with Gaussian profiles to get the accurate fluxes. The black hole masses of the sample galaxies which showed broad H\textalpha component are estimated from the broad H\textalpha luminosity.
and FWHM. Then the M - sigma relation of LSB galaxies are verified. We find the LSB galaxies are deviated from the M-sigma relation seen for normal galaxies.


The neutral atomic Hydrogen (HI) kinematics of the Large Magellanic Cloud (LMC)

The HI velocity map of the LMC. The locations of suggested gas outflows (a1, a2, a3) and accretion (b, c, d) are marked.

The neutral atomic Hydrogen (HI) kinematics of the Large Magellanic Cloud (LMC) is revisited in the light of two new proper motion estimates. The authors have analysed the intensity weighted HI velocity maps of ATCA/Parkes and GASS data sets and corrected the line of sight velocity field for the systemic, transverse, precession and nutation motions of the disk and estimated the kinematic parameters. The value of Position Angle (PA) of kinematic major axis estimated is found to be similar to the recent estimate of the PA using stellar tracers. The effect of precession and nutation in the estimation of PA is found to be significant. Most of the HI gas in the LMC is found to be located in the disk. 12.1% of the data points were detected as kinematic outliers. The authors have identified the well known Arms E, S, W, B and a new stream, Outer Arm, as part of various outlier components. The GASS data analysis brings out the velocity details of the Magellanic Bridge (MB) and its connection to the LMC disk. It is suggested that Arm B could be an infall feature, originating from the inner MB, while Arm E could be an outflow feature. The authors suggest possible outflows from both the LMC and the MB, which could be due to ram pressure. The velocity pattern observed in the MB suggests that it is being sheared. The authors suggest that the various outliers identified in this study are caused by a combination of hydrodynamical and tidal effects.

(G. Indu)

Blue early-type galaxies

A deep understanding of the origin and nature of underlying stellar content of unusual blue early-type galaxies (ETGs) is crucial in order to fully comprehend the processes in hierarchical galaxy formation. Blue ETG could be a triggered star formation phase of a passively evolving ETG due to the sudden availability of cold gas from tidal interactions or the end product of a gas rich merger. In order to understand the underlying nature of these unusual systems, we carried out a detailed structural analysis of a sub sample (55) of purely star forming blue ETGs classified based on their location on the line diagnostic diagrams. Majority of the star forming blue ETGs show tidal tails, ripples and/or close proximity to neighbouring galaxies. These are strong evidences for ongoing or recent interactions between galaxies which could have triggered the star formation responsible for the blue colors. Blue ETGs could be a transient phase for an otherwise passively evolving red ETG. We had studied six extreme
cases with close companions of similar redshift, among which two are clearly showing ongoing interactions potentially triggering the star formation in these galaxies. One galaxy show a jet feature which could be due to the complete tidal disruption of the companion galaxy. This is the first time a blue ETG is observed with ongoing tidal interactions supporting the claim that the blue color is due to triggered star formation from these interactions. Tidal interactions could play a major role in the observed increase of stellar mass in early-type galaxies over the past eight billion years. We plan to extend this study in ultraviolet, probing the ongoing star formation and in radio, investigating the molecular gas responsible for star formation in blue ETGs.

(K. George)

X-ray variability and the inner region in AGN

The authors present theoretical models of X-ray variability attributable to orbital signatures from an accretion disk including emission region size, quasi-periodic oscillations (QPOs) and its quality factor $Q$, and the emergence of a break frequency in the power spectral density (PSD) shape. They have conducted a time series analysis on X-ray light curves (0.3 keV to 10 keV) of a sample of AGN. A statistically significant bend frequency is inferred in 9 of 58 light curves (16%) from 3 AGN for which, the break timescale is consistent with reported BH spin but not with the reported BH mass.

Upper limits of $2.85 \times 10^7 M_\odot$ in NGC 4051, $8.02 \times 10^7 M_\odot$ in MRK 766 and $4.68 \times 10^7 M_\odot$ in MCG-6-30-15 are inferred for maximally spinning BHs. For REJ 1034+396, where a QPO at 3733 s was reported, we obtain an emission region size of (6-6.5) $M$ and a BH spin $\leq 0.08$. The relativistic inner region of a thin disk, dominated by radiation pressure and electron scattering is likely to host the orbital features as simulated $Q$ ranges from $6.3 \times 10^{-2}$ - $4.25 \times 10^6$, containing the observed $Q$. The derived value of $Q \sim 32$ for REJ 1034+396 therefore suggests that the AGN hosts a thin disk.

(P. Mohan & A. Mangalam)

Models of jet variability in AGN

The authors present a general relativistic (GR) model of jet variability in active galactic nuclei from a helical bulk flow along a fund-
Helical trajectory of an emitting test particle in Schwarzschild geometry, constrained along rotating magnetic field lines with footpoints on a Keplerian disk (at cylindrical radius $\varpi_o$) and asymptotically bound by a cylinder of radius $\varpi_f$ at large $z$.  

Channel shaped magnetic surface anchored to the accretion disk close to the black hole. They compare this model to a special relativistic (SR) and a GR cone model. There is an increased amplitude ($\sim 13.45 \%$); beamed portion and a systematic phase shift which differ from the SR model in the light curve. There is an increasing phase shift and a maximum amplitude increase ($\sim 1.6 \%$) compared to the GR cone model. The results strongly suggest the use of realistic magnetic surface geometries and a GR framework to describe effects on emission from orbital features in the jet. Simulated light curves (LCs) for the funnel model include Doppler and gravitational shifts, aberration, light bending and time delay. These LCs are used to study quasi-periodic oscillations (QPOs) and the power spectral density (PSD) shape. A power law shaped PSD with a slope of -1 to -2.5 and QPOs with timescales ranging from 0.11 to 4.5 days are inferred for black hole mass $M_\bullet = (0.1 - 5) \times 10^8 M_\odot$ and bulk flow Lorentz factors $\gamma_{\text{jet}} = 2 - 10$. The funnel model is applicable to radio, optical and X-ray emission from a wide class of jetted sources including actively accreting AGN, X-ray binaries and other compact sources such as neutron stars.

(P. Mohan & A. Mangalam)

**Parametric models of the periodogram**

Binned periodogram for the X-ray light curve of REJ 1034+396: fit portion is in blue and white noise region is in red. The best fit is the power law with Lorentzian QPO model peaked at 3733 s and the residue $\Delta \chi = (\text{data-model})/\sigma$ is shown below it.

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. The analysis is used to infer that power law with a Lorentian QPO model is the best fit to describe the power spectral density of the X-ray light curve of the narrow line Seyfert 1 galaxy, REJ 1034+396 with a QPO peaked at 3733 s.

(P. Mohan, A. Mangalam & S. Chattopadhyay*)

**VLBI imaging of the double peaked emission line AGN KISSR1494**

The authors have carried out dual-frequency phase-referenced VLBI observations of the Seyfert galaxy KISSR1494, which exhibits double peaked emission lines in its SDSS spectrum. They have detected a single slightly resolved radio component at 1.6 GHz (see Figure), but not at 5 GHz implying a spectral index steeper than -1.5±0.5. The high brightness temperature of the radio component (1.4E+7 K) and the steep radio spectrum support a nonthermal synchrotron origin. Following the black hole mass-stellar velocity dispersion relation, they estimate the black hole mass in KISSR1494 to be 1.0E+8 \( M_\odot \), accreting at an Eddington rate of 0.002.

The lack of double radio core or a core-jet structure is inconsistent with the binary black hole scenario or a powerful relativistic bipolar outflow as explanations for the double emission line peaks. The radio data are consistent with either the radio emission coming from the parsec-scale base of a synchrotron wind originating in the magnetised corona above the accretion disk, or coming from the inner ionised edge of the accretion disk or torus. In the former case, the NLR clouds may form a part of the broad outflow, while in the latter case, the NLR clouds may form a part of an extended disk beyond the torus. While with the present data, it is not possible to clearly distinguish between these two scenarios, there appears to be greater circumstantial evidence supporting the broad non-thermal accretion-disk coronal wind picture in KISSR1494.

A superposition of the 1.6 GHz VLBI contour images of KISSR1494 made using pure natural weighting (in grey-scale) and pure uniform weighting (in magenta). The contours are in percentage of the peak intensity and increase in steps of root 2: the lowest contour levels are \( \pm 32\% \) for both the images, and the peak intensities are 3.7E-4 Jy/beam for the grey-scale and 6.7E-4 Jy/beam for the magenta image. The convolved beam is of size 7x7 mas.

(P. Kharb)

**A helicity constrained model of galactic dynamo**

Magnetic fields correlated on kiloparsec scales are observed in disc galaxies. Their origin could be due to amplification of small scale seed fields by a turbulent dynamo. As a first step, the authors analytically build a galactic disk dynamo model while making
Variation of the ratio of relative helicity in corona and galactic disk as a function of force-free parameter \( \mu \) for different quadrupolar modes \( n \) of the disk field.

the usual assumptions of shear and the alpha effect. They use the general toroidal-polaroidal representation to calculate the absolute relative helicity in cylindrical geometry. The authors find quadrupolar solutions that are matched to different models of force-free corona. A limit cycle approach for the saturation of a dynamo (including a force-free corona) through an analytic study of the time dependent solutions of the dynamo equations is addressed. The authors incorporate the alpha-quenching equation with strength of the field calculated from the time dependent solutions. The flux transport terms are incorporated in the model through a dynamic evolution of the twist in the coronal field. This is used to estimate the mean field strength of the dynamo generated field.

(A. Prasad & A. Mangalam)

Self-consistent model of the evolution of black hole mass and spin

A theoretical model has been constructed that takes into account the mass and spin accreted by black hole and the angular momentum torque due to an electro-dynamical jet. The spin evolution is calculated with and without accretion; if the accretion stops the jet power indicates an increase before a gradual decline if the initial spin, \( a > \sqrt{3}/2 \), as a result of the hole’s increasing size. This naturally has implications for the evolution of the jet. Specific analytic forms have been calculated for the case of Bondi accretion and the thin disk. An important issue is the maximum spin \( a \) that can be achieved in disk accretion process using heuristic forms of angular momentum and accretion rates available from MHD simulations. Preliminary results indicate that the black hole achieves the maximum value when there is no jet. It is planned to compare this with fully relativistic MHD simulations.

(A. Mangalam)

Stellar disruption by SMBHs and its observational implications

It has been well established by observations that Supermassive Black Holes (SMBHs) of \( 10^6 - 10^8 M_\odot \) capture stellar debris from tidally disrupted stars that result in X-Ray and UV flashes. The star-star interaction changes the angular momentum of some stars into a loss cone for which \( L \leq L_{lc} \) (where \( L_{lc} \) is the angular momentum of the loss cone) and are captured by the black hole. These captured stars are tidally disrupted at the radius \( R_t \approx (M_\bullet/M_\star)^{1/3} R_\star \) where black hole’s tidal gravity exceed the stars self gravity. The mass fall back rate (\( M_\bullet \)) of the debris is roughly \( \dot{M} \propto t^{-5/3} \). In general, the debris circularizes to form an accretion disk due to stream-stream collision and relativistic precession of the debris orbits. We simulated the light curve profiles in different spectral bands with an approximate gas dynamical model to make theoretical predictions for the rate of detections of such events by various missions performing in either all sky survey (ASS) mode or deep imaging survey (DIS) mode.
UVIT survey of nearby Galaxies

A survey of nearby galaxies has been a part of the original proposal for the Ultra-Violet Imaging Telescope. The UVIT will have filters for a detailed sampling of the far UV and near UV wavelengths, contrasting with the GALEX UV mission which had just two broad bands. Together with the higher resolution of the UVIT, this provides a unique opportunity for studying star formation and stellar populations in nearby galaxies. The narrower filters in UVIT will also allow the mapping of extinction. The survey will include galaxies across the Hubble sequence, which is a classification based on morphology in the optical region. It will also include galaxies which are in groups, since gravitational interactions between galaxies in close proximity are seen to initiate star formation and lead to a change in morphology. A selection list of galaxies for such a survey is being made and known data for the galaxies are being compiled. Observations in the ground based U-band for many objects is lacking and such observations had been started with the 2m HCT. These will also be done with the new 1.3m telescope at VBO. The UVIT survey will enable the study of Star formation and its effect on morphology, the Stellar populations in the galaxies and the effect of interactions between galaxies on Star formation and the stellar populations.

(A. K. Pati)

Alternative cosmological theory

The topic – whether Einstein’s GR is the ultimate theory of gravity – has drawn a lot of research interest in the context of cosmology. The acceleration of the Universe can be explained either by a mysterious energy component or it could be the effect of a modified theory of gravity at large cosmological scale. As, all the evidences for dark energy is purely through its gravitation effects, both of the above explanation of dark energy is still viable. In general all modified theory of gravity introduces a long range cosmological force which plays the role of dark energy. Whereas in solar system scale, this force hides itself (through chameleon mechanism), so that the experimental tests of GR with huge accuracy is not violated. In this work, the authors have taken this alternative theory and derived the modified cosmology and constrained it from PLanck, HST, SDSS and WMAP data. Generally, this theory contains a parameter, which is a measure of the strength of the fifth force. It was found that the recent cosmological data allows the maximum value of this force to be 1/5th of gravitational force if it has to play the role of dark energy at 2 σ confidence.

(S. Das, Yvonne Y. Y. Wong* & Daniel Boriero*)

Dark matter

The authors proposed a scenario where the fundamental particles constituting the dark matter are low-mass fermions. While an eV-scale to keV-scale mass fermion like a neutrino or sterile neutrino could account for the
Dark Matter from degenerate micronuggets of ultralight trapped fermions

abundance of dark matter in the Universe it is typically rejected as a viable dark-matter candidate due to its excessive free-streaming prior to structure formation. We discuss here a scenario where some fraction of such ultralight fermions undergo a phase transition during the radiation dominated epoch driven by a scalar-mediated force and remain trapped in micronuggets of degenerate matter (akin to white dwarfs or neutron stars) that are stable over cosmological timescales. These TeV mass micronuggets as a whole behave like cold dark matter. Like the case of soliton star or fermion Q-star, the stability of the dark matter nugget is achieved when the fermi pressure is balanced by the attractive scalar force. In the Thomas-Fermi approximation, we numerically solve the radial profile of the scalar field, fermion mass and number density for the static configuration and find that the nugget radius can be as small as micro meter radius. By considering the fermion decay into the scalar, we show that the lifetime of the nugget can be larger than the age of the Universe. While any light sterile neutrino can match this scenario, we also consider whether an active neutrino could form such dark matter nugget and constraints from the self-interaction of dark matter.

(S. Das & Kris Sigurdson*)

2.4 Atomic and Molecular Physics

Atomic astrophysics

Atomic spectra plays an important role in many different situations in astrophysics. Theories that take into account relativistic and many-electron effects to determine the spectroscopic properties of closed shell atoms and ions–ionization potentials and polarizabilities have been used. Both these properties have been calculated to a high degree of accuracy. An important feature of our work was a high precision calculation of the ionization potential of the heavy element xenon, which was detected fairly recently in the spectrum of a hot white dwarf.

(B. P. Das)

Non-Accelerator Particle Physics

The electric dipole moment (EDM) of a physical system arises from parity and time-reversal violations. The CPT theorem implies that time-reversal violation and CP violation are equivalent. It therefore follows that the observation of an EDM is a signature of CP violation. Atomic and molecular EDM are ex-
cellent candidates for studying CP violation as well as probing new physics beyond the Standard Model of particle interactions. Our work in the past year focused on the EDM of atomic xenon. Using a relativistic theory which incorporated the interaction between the electrons in a rigorous manner, and combining with the latest EDM measurement of xenon, we determined limits on CP violating hadronic and semi-leptonic coupling constants. The accuracy of the measurement of xenon EDM is likely to improve by three or four orders of magnitude in the next few years. This would correspondingly improve the accuracy of the limits of the CP violating coupling constants from our work and it would then be possible to constrain certain supersymmetric models.

(B. P. Das)

Ultra-cool Atoms

The phases of ultra-cool matter is a topic of great current interest. It is possible to study the behaviour of ultra-cool atoms by suitably manipulating beams of laser light. The authors have examined the phases of ultra-cold atoms in lattices formed by lasers in the presence of an additional potential. Using a suitable quantum many-body theory which takes into account the interaction between the ultra-cool atoms as well as their hopping from one site to another, they have obtained novel phases involving superfluids and exotic insulators.

(B. P. Das)

Properties of super-heavy elements

Theoretical investigations of the super-heavy elements are extremely challenging and are often the sole source of useful chemical information. In this context, multi reference Fock-space coupled cluster has been applied to evaluate the ionization potential (IP), excitation energies (EE), nuclear magnetic hyperfine constant etc. for singly ionized Eka-Lead (Fl II). Similar calculations are also performed for Lead ion (Pb II) to assess the accuracy of the theoretical estimates of Fl ion. The higher IPs and EEs of Fl II with respect to Pb II, suggest Eka-Lead (Fl) to be less metallic and more inert than Pb.

(R. K. Chaudhuri)

The nuclear quadrupole moment (NQM)

The nuclear quadrupole moment (NQM) that emerges due to the non spherical distribution of the nuclear charge plays an important role in atomic, molecular, and solid state spectroscopy besides the direct interest in nuclear physics, where its determination can be used to check nuclear models. The information of NQM is also useful for the evaluation of the nuclear magnetic resonance measurements in biological systems. Here, state-of-the-art coupled cluster based linear response theory for electron detachment processes is employed to determine the electric field gradients (EFG) of halide nuclei. The EFGs resulted from these calculations are the combined with experimental nuclear quadrupole coupling constants (NQCC) to determine the nuclear quadrupole moments (NQM) halide nuclei.

(R. K. Chaudhuri)
2.5 Experimental Astrophysics and Instrumentation

Study of coronal abundances using X-ray solar monitor on board Chandrayaan-1 X-ray Spectrometer (C1XS)

The X-ray Solar Monitor (XSM) on the Indian lunar mission Chandrayaan-1 was used to study the 1.8-20 keV solar X-ray spectrum. It was used to derive absolute coronal abundances using intensities of emission-line complexes and the plasma temperature. The best estimates were obtained from a C2.8-class flare in 2009. The well-known first-ionization potential (FIP) effect is observed; abundances are enhanced for the low-FIP elements Fe, Ca, and Si, while the intermediate-FIP element S shows values close to the photospheric abundance. The derived coronal abundances show a quasi-mass-dependent pattern of fractionation. This study also suggested possible abundance variations with progression of the flare.

(S. Narendranath*, P. Sreekumar, L. Alha*, K. Sankarasubramanian, J. Huovelin* & P. S. Athiray)

Study of lunar surface elemental abundances using Chandrayaan-1 X-ray Spectrometer (C1XS)

Using data from the Chandrayaan-1 X-ray Spectrometer (C1XS) experiment onboard Chandrayaan-1, we detected the first unambiguous evidence of enhanced Sodium from the lunar surface using the X-ray fluorescence (XRF) technique. During the nine months of remote sensing observations (November 2008 - August 2009), C1XS measured XRF emission from the Moon under several solar flare conditions. The entire C1XS observational data were systematically analysed to address elemental abundances of major rock-forming elements viz., Mg, Al, Si and Ca including Na from the lunar surface. The derived abundances of Na (2-3 wt%) are significantly higher than what has been known from earlier studies. This supports recent theories and findings of intermediate plagioclase on the Moon. The qualitative and quantitative study of Na abundance by X-rays will be one of the prime science objectives of the CLASS instrument on India’s upcoming second mission to the Moon, Chandrayaan-2.

(P. S. Athiray, K. N. Kusuma*, S. Narendranath* & P. Sreekumar)

Coelostat drive system for SAG,ISRO

The Space Astronomy Group (SAG), ISRO Satellite Centre, is involved in the development of an IR Spectrometer for Planetary atmospheric applications. As part of the requirement to complete the end to end test of the spectrometer and to validate the radiative transfer model which is being developed at SAG in connection with the Mars Mission program and to study its performance by using the sunlight and possibility
The infrared spectrometer setup in the lab and the heliostat (outside) which feeds the solar image, installed at the Satellite Centre of ISRO in Bengaluru.

to obtain both the solar as well as terrestrial absorption lines, ISRO Satellite Centre sought to borrow a coelostat/heliostat system from IIA for tracking the solar beam inside the laboratory continuously for working with the infrared spectrometer instrumental set-up. The Ceolostat system comprising of 12 primary mirrors and 8 secondary mirrors, MO92 stepper motor drive system with variable thumbwheel operation mode for tracking control and hand set for adjustment of the image, were assembled and tested at IIA in December 2013. The 6 objective lens was installed so as to provide the solar image in the lab. The entire set up was positioned, aligned for true polar axis, and checked for tracking accuracy during the second week of February 2014. The second figure shows the experimental setup in the Lab and the Heliostat setup just outside the lab at the ISRO Satellite Centre, Bengaluru.

(N. Swaraj, S. P. Bagare, K. Sankarasubramanian & Bhavesh Jaiswal*)
Chapter 3

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Chapter 4

INSTRUMENTS AND FACILITIES

4.1 Systems Engineering Group

The Systems Engineering Group was recently formed in order to provide a coordinated support in several engineering disciplines like Electronics, Mechanical, Optics and Software in Instrumental Development, Maintenance and Facility Management Aspects. The Electrical and Civil groups also provide infrastructural development and maintenance support both at Bengaluru as well as other field stations. The major activities in which the group was involved in the current year include: 1. The Aluminization of the Primary mirror at VBT as well as several mirrors from Kodaikanal tunnel and other facilities. 2. Support for major projects of IIA like UVIT, Aditya and HESP. 3. Lab testing of the Two Channel photometer with a view to commission the instrument at one of the telescopes at VBO, possibly on the 1 meter Telescope. 4. Performance testing of control system for 30 inch for positioning, tracking and guiding. 5. Commencement of the building activities of Raman Science Centre at Leh. There are also several important initiatives planned in the coming year like aluminization of secondary mirror of VBT and HCT primary mirrors, a civil structure at CREST for TMT mirror polishing, installation and commissioning of H-alpha telescopes at Kodaikanal and other projects; some of which were kept pending for quite sometime.

(A. V. Ananth)

4.2 Photonics Laboratory

Adaptive Optics Experimentation Studies on an efficient and faster wavefront reconstruction method is being continued. Exploring wavefront sensing on extended objects has been taken up.

(J. P. Lancelot & Narsi Reddy)

Vacuum Coating

2.8 m and 1.6 m Coating Plant at VBO, Kavalur: Apart from periodic maintenance work at the 1.6 m and 2.8 m vacuum coating plants, aluminization work for the primary mirror of the Vainu Bappu Telescope, the primary mirror of the 30 inch telescope, 7 numbers of Kodaikanal tunnel mirrors and 7 numbers of coelostat mirrors are done

2.5 m Coating plant at IAO, Hanle: As part of the award of the annual maintenance contract to HHV, optics personnel were sent along with HHV engineers to assess the present condition of the plant. The AMC has been awarded to HHV and the spares for the plant have been ordered. Preparations are on to take up the work on the re-
aluminization of the HCT primary mirror.

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

4.3 Electronics Laboratory

Development of CCD camera

A CCD camera for the thirty inch telescope is getting ready with the DEWAR and the internal electronics being integrated with the controller. The liquid nitrogen DEWAR is a centre filling one with a capacity of 1.5 litres has a holding time in normal mode of about 24 hrs and about 12 hrs in inverted mode. The DEWAR with all internal boards and wiring is being tested for its performance. The temperature monitoring unit designed earlier is already tested and the dewar is mounted with AD590 as well as PT-100 temperature sensors and can monitor temperatures on the surface of cold finger.


4.4 OBSERVATORIES

4.4.1 Indian Astronomical Observatory

2m Himalayan Chandra Telescope

The 2m Himalayan Chandra Telescope (HCT) completed 11 years of utilization through competitive time allocation. In the three observing cycles for the year, 18 proposals were received for the 2013-Cycle2 (2013 May–August), 28 proposals for the cycle 2013-Cycle3 (2013 September–December) and 30 proposals for the cycle 2014-Cycle1 (2014 January–April). The telescope time was over subscribed by a factor 2 on an average, while the dark moon period was 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.

![JHKs colour-composite image of the supernova SN 2014J in the nearby galaxy M82 (J: blue; H: green; Ks: red) obtained with the TIRSPEC. The field-of-view is 5 arcmin x 5 arcmin. North is up, and east is to the left.](image)

The HCT was equipped with a new NIR instrument, the TIFR Near Infrared Spectrometer and Imager (TIRSPEC) developed by TIFR in collaboration with Mauna Kea Infrared (Hawaii). The detector array in the instrument is 1024x1024 Hawaii-1 array. With a 0.3 arcsec per pixel resolution, the instrument provides a Field of View (FoV) of 307 x 307 arcsec$^2$ in the imaging mode. In the Spectroscopic mode, a wavelength coverage from 1 micron to 2.5 micron with resolution of 1200 is available. Apart from the single order mode to cover 1.02-1.20 micron, 1.21-1.48 micron, 1.49-1.78 micron and 2.04-2.35 micron, cross disperse modes are also available to provide simultaneous wavelength coverage of 1.02-1.49 micron and also 1.50-2.45 micron.
The installation of this instrument at HCT was carried out by TIFR engineers with the help of IAO team during 2013 August–September. After a period of performance verification, the instrument was released for regular observations during January 2014. TIRSPEC replaces the NIR instrument that was available with the HCT.

The high resolution echelle spectrograph (HESP) is expected to be commissioned shortly. The preparatory work for its installation is continuing - the outer enclosure for housing the spectrograph in the pier area of the HCT was installed in November 2012, and temperature instability inside the enclosure is being monitored continuously.

The preventive maintenance of the telescope is carried out every month around full moon, which minimizes the downtime of the telescope during allotted nights. Various calibration and checks are done periodically to keep the performance of the telescope at its optimum level. In addition, annual maintenance was undertaken during the second fortnight of September 2013. The maintenance of the telescope, its backend instrument and dome assembly was carried out by the engineers and technical staff of IAO. Scientists from IIA associated with the operations of the telescope also participated in this activity.

Auxiliary Infrastructure at IAO

The power requirement of the Observatory is met by Solar Photo-Voltaic electric power, and the existing battery banks are continuously monitored for their efficiency.

An upgrade of the hardware for the dedicated satellite-based communication link between IAO and the CREST campus of IIA used for remote operations of the 2m HCT was undertaken. The new hardware includes Comtech MODEMS (1:1 Standby setup), LPOD (with 1:1 Hot Redundant System) and LNB (with 1:1 Hot Redundant System). During April-May 2013, the shifting of the link from the existing old and ageing DAMA hardware onto the New COMTECH modem and LPOD was implemented successfully at both the ends, in a phased manner. The transition included permanent installation of the indoor (modem) and outdoor units (LPOD and LNB) with proper cabling and electrical connections, with all possible safeguards, and configuring them. The RF cable was replaced with new low loss Belden RF cable and its length was shortened to minimize the loss at both ends. After various tests and optimizations with Carrier in Carrier and IP SubMux, the satellite link with new equipment is working satisfactorily with improved link latency. This activity was undertaken by the engineers at IAO and CREST. An additional bandwidth of 3 MHz+1.5 MHz has
also been allotted for satellite communication, which is awaiting clearances from the concerned authorities.

**Gamma-Ray Facilities at IAO**

The High Altitude Gamma Ray (HAGAR) facility is operated jointly by the IIA and Tata Institute of Fundamental Research (TIFR), Mumbai. 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 completed by Mr. Amit Shukla, IIA, during the current this year.

Bhabha Atomic Research Centre (BARC), Mumbai plans to install a 21-m imaging Atmospheric Cerenkov telescope Major Atmospheric Cerenkov Experiment (MACE) near HAGAR. Telescope control room, azimuth track, communication and power facilities are completed for installation of the telescope. Presently the complete telescope system is in its final stage of proof testing at Electronics Corporation of India Limited, Hyderabad. It is planned to be dismantled and shipped to IAO, Hanle later during the summer months of 2014.

**NLOT Site Characterization Activity**

The MASS-DIMM turbulence profiler acquired from TMT, USA is to be mounted on the Meade telescope that currently has the automated seeing monitor mounted. Since the mount+drive of the telescope is not very stiff, the results are unreliable beyond the wind speed of 4m/s. Therefore, the design and development of a sturdy Equatorial Fork Mount for the telescope has been initiated.

An automated lunar scintillometer developed at IIA, as an M.Tech project, has been successfully tested and installed at IAO, Hanle.

**Earth Sciences**

IIA has established two GPS stations at Leh and Hanle as a part of the 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 can download of data. VSAT equipment for the Leh GPS has reached Leh and is to be installed.

Space Physics Laboratories, VSSC/ISRO and IIA have collaboratively established an Aerosol Observatory at Hanle. The instruments are working well and data is being sent to SPL, Trivandrum.

Continuous carbon dioxide analyzer, PICARRO is working fine 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), Bengaluru 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. The data is being submitted to C-MMACS.

*(G. C. Anupama on behalf of IAO team)*
4.4.2 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. During this year 3 (Three) nos. of Telescope trainees were appointed on contractual basis.

(G. C. Anupama on behalf of IAO team)

4.4.3 Kodaikanal Observatory

Data Digitization

The Kodaikanal digitized images are now archived in the IIA data centre. The archive hosts 41,000 images of the Ca-K spectroheliograms as observed over a period from 1904 to 2007. The first results from these Ca-K digitized images have been published. The archive also hosts white light images 1904-till date (44000 plates). H-alpha spectroheliograms taken over 1904–1999 (38000 plates) have recently been digitized and archived. The calibration process is underway. The Ca-K spectroheliograms taken at the Kodaikanal Solar Observatory during 1904–2007 and digitized with 4k x 4k CCD have higher resolution (0.86 arcsec) than the other available historical data sets.

(IIA data digitization team)

Solar imaging telescope

A full disk solar imaging telescope WARM (White light Active Region Monitor), has been designed and developed in-house to facilitate long-term data products to the solar community. A two-mirror coelostat feeds sunlight to the WARM. An achromat with an effective aperture of 148 mm is used to image the Sun. The f/24 beam produces the Sun’s image of 33 mm in diameter. A non-polarizing beam splitter diverts the converging beam into two independent channels. In each channel secondary optical components are used to reimage the full disk on to two individual detectors. In the first channel a PCO2000 CCD is used to image the Sun in 430.5 nm with a pass band of 0.8 nm. In the second channel ANDOR iXON 888 CCD is used with a red filter centered at 630.25 nm. Both the CCDs are mounted on xyzq stages for focus, tilt and position adjustments. WARM is equipped with an optical bread board on to which the dual channel imaging system is set up. This set-up can serve as a test bed for the four-channel broad band imaging system planned for the proposed NLST and as a laboratory too for the development of back-end instruments.

(Hemanth Pruthvi, K. B. Ramesh, N. Vasanthraju* & Technical Team)
4.4.4 Vainu Bappu Observatory

1.3 meter telescope

The 1.3 meter telescope had been installed in February–March 2013, but oscillations were seen in some positions due to problems identified with the hydrostatic bearing pads. The vendor M/s DFM Engineering replaced the thrust pads of the south horseshoe bearing in May. Further problems of tripping of the drives, attributed to components of the electronics system, were solved in consultation with DFM over the next few months. In parallel, the dome drives and wheel assemblies were readjusted over a period of months to reduce vibrations. The solar power shutter drives were also tested and improved. The solar power system is being modified to also drive the electrically operated windows in the dome. Leakages noticed in the dome during the monsoon months were also rectified. The final acceptance testing of the telescope was completed in December 2013. A CCD detector of 2K X 4K pixels available at the VBO was mounted on one port for imaging using available filters. The smaller, fast ProEM 1024 detector used for telescope tracking tests was shifted to the side port of the instrument unit. Observations for testing and calibration of the system with standard stars spanning a range of brightness were started with both the detectors. Some scientific programs were also carried out.

(A. K. Pati & team)

30 inch telescope

Re-aluminization of 30 inch telescope primary mirror and re-installing the aluminized mirror in the telescope was completed. Balancing of the telescope was verified. In the meantime, the radial support system developed problems and the telescope tracking tests had to be deferred. Efforts are on to modify the support system and have the new radial support fabricated and installed in the mirror cell to prevent tilt of the mirror. Tracking performance check of the telescope can be resumed once the new unit is place.

(P. U. Kamath, V. K. Subramaniam and team)

Testing of telescopes

Design, detail engineering, manufacture and assembly of “Imager” for testing the 1.3 m telescope to check the image quality and field of view of the telescope has been completed. This instrument can also be mounted on other telescopes at VBO for similar checks.

The testing and preparation of mechanical systems for the aluminizing of the primary of the VBT was carried out prior to carrying out the work. Further, the removal of the Primary mirror from the telescope, aluminizing and re-installing the aluminized mirror in the telescope was done. Aluminizing of the secondary mirror is being planned.

Design, detail engineering, manufacture, inspection and interface check of “VBT fiber optic Launching Unit” was done. The unit holds the fiber optic cable on the top flange and houses beam splitter, Collimating Lens, Reflecting mirror and the ISIS3 CCD in the housing. This unit will soon be installed on the prime focus end of the telescope.

Preparation of RFP document for refurbishment of VBT dome busbar system was done in consultation with engineers at VBO Kavalur. Preparation of required drawing for this purpose and discussion with original vendor to check the feasibility of taking up the job has been completed. Design and detail engineering of VBT Dome ventilation fan structure and the layout has been completed. Fabrication of fan structure is being
The multi-band photo-polarimeter, which was under development, was completely dismantled and re-assembled after cleaning all the parts. The pulse counters were tested using laboratory signal generators and their performance was found to be satisfactory. All the macros developed for the PIC microcontrollers, which performs all the time-critical functions of the polarimeter, were checked, and the necessary modifications were made. The communication link between the electronic interface and the Linux machine used for the operation of the polarimeter was also thoroughly tested, and the stability of the link was found to be extremely good. The instrument has three photomultiplier tubes for the simultaneous recording of the signal in three spectral bands; two uncooled PMTs for the ultraviolet and blue region of the spectrum and a cooled PMT for the visual and red region. The dark counts from all the three PMTs were monitored for several days for their stability. All the optical components of the polarimeters, including the dichroic and glass filters, were mounted inside the polarimeter, and the alignment of the components were checked using a laser beam. Preparations were made for a thorough testing of the instrument as whole before taking it to Kavalur for field trials. Arrangements were made for obtaining a fiber-linked f/13 optics combination to test the data acquisition and analysis program using an artificial white light source in the laboratory. The results were found to be satisfactory. It is planned to take it to Kavalur soon to mount it onto the 1-m Carl Zeiss telescope and observe standard polarized and unpolarized stars for assessing its actual performance at the site.


### 4.4.5 Gauribidanur Observatory

**Gauribidanur RAdio Spectro-Polarimeter (GRASP)**

A new set-up for ground based spectropolarimetric observations of the solar radio transients in the frequency range 35-85 MHz has been recently commissioned at the Gauribidanur radio observatory. The front-end of the GRASP consists of two log-periodic dipoles (LPDs) designed and fabricated in-house at the observatory. While the orientation of the rms in one of the LPDs is in the
east-west direction, they are in the north-south direction for the other. After filtering and amplification, the radio frequency (RF) outputs from the individual LPDs are transmitted to the receiver room via two separate optic fiber cables buried 2 m below the ground level. They are connected to the inputs of a broadband four-port phase quadrature hybrid network. The latter has two outputs: one of them responds to the left circular polarization (LCP) and the other to the right circular polarization (RCP) components of the incident signal. The outputs of the hybrid are connected to two independent commercial spectrum analyzers to obtain the respective dynamic spectra. The sweep time and the instantaneous observing bandwidth are 100 ms and 250 kHz, respectively. The spectrum analyzers are interfaced to two personal computers (PCs) using standard GPIB interface. The computers are synchronized with a common GPS clock. This helps to achieve temporal coherence between the data acquired with the two systems. The total intensity (Stokes I) of the emission at each frequency is estimated offline by adding the observed amplitudes at the corresponding frequency in the aforementioned two spectra. The difference between the two amplitudes gives the circularly polarized intensity (Stokes V). The ratio of the above two gives the degree of circular polarization (dcp). Calibration tests indicate that the cross-talk between the two outputs of the hybrid is $< -40 \text{ dB}$, and the quadrature phase shift in the hybrid is consistent to an accuracy of 5 degrees in the above frequency range. The gain of the two LPDAs, the associated filter, amplifiers, optic fibre cable network were also nearly equal indicating that randomly polarized incident signal will result in outputs of equal amplitude in the two spectrum analyzers. The source region of the transient were identified using the two-dimensional images obtained simultaneously with the Gauribidanur RA dioheliograPH (GRAPH). Presently work is under progress on a FPGA-based digital receiver system for data acquisition with multi-bit resolution. This is expected to improve the sensitivity, dynamic range, temporal and spectral resolution.

![RCP Dynamic Spectrum on 2013-09-02](image)

Time profile of the type III solar radio burst observed with the GRASP on 2013 February 4 at a typical frequency of 80 MHz. The upper and lower panels correspond to the LCP and RCP, respectively.

**Gauribidanur RAdioheliograPH (GRAPH)**

Signal from the 64 antenna groups in the GRAPH, spread over a distance of 3 km, array are presently correlated in the band averaged mode using a 4096-channel correlator system comprising of discrete digital circuit elements. As a part of the augmentation of the GRAPH, a FPGA based digital backend system is being developed in-house at the Gauribidanur observatory. To this date, a prototype 8-channel system has been designed and fabricated. All possible correlations between signals from the different antenna groups can be performed with this system, either online or offline. A custom double side band (DSB) IP Core was designed using Verilog. Each IP comprises of a complex correlator unit contains sev-
Interference fringes obtained during the meridian transit observations of Cassiopeia-A on a long baseline (upper panel) and short baseline (lower panel) in the GRAPH in the offline correlation mode.

eral X-OR, X-NOR, latch, integration, and multiplexer circuits. The output from the FPGA is transmitted to the computer via a Gigabit ethernet cable. Ethernet Media Access Controller (MAC) takes care of the ethernet framing protocols and error detection of the frames. The FPGA chip used is Virtex-5 which has an on-chip Embedded Tri-mode Ethernet MAC (TEMAC). It interfaces with a PHYsical Layer (PHY) chip (Marvell 88E1111) which is a line-driver for driving and sensing the ethernet cable for data transmission. In order to handle more number of inputs and frequency channels the packet correlator is used. With this setup, the raw voltages are sampled and filled into a First-In-First-Out (FIFO) unit. From the FIFO, the data are read and transmitted via Gigabit ethernet port using the TEMAC. A customized network frame structure is used to carry out the above set of tasks. On the computer side, the Wireshark is used to debug the frames. Using TCPDUMP, the raw voltages are dumped to the harddisk for offline analysis. Using LabVIEW, the individual channel data are extracted and the cross power spectra are obtained. Presently they are working on handling the data slips using Lossless Gigabit Remote Packet Capture (GULP) with Linux.

(Radio Astronomy Group)

4.5 Library

IIA library strengthened its collections by adding 304 books in print as well as continuing the e-books access to SPIE Digital Library along with SPIE E-books, ASP Conference series and EAS publication series. The online access to “Encyclopaedia of Astronomy & Astrophysics” has been added during this year. IIA library continues to be a member of NKRC consortium and e-journals access facility is there with 19 major publishers. This year “Nature Geoscience” additionally has been added.

Document Delivery Services continue: Twenty seven interlibrary loan requests from IIA faculty and students were fulfilled as they are not there in the IIA collections. More than 55 requests from other libraries and individuals were catered to from our collections as part of the document delivery service.

Open Access Repository: IIA library is maintaining its open access repository by adding new and old research publications of IIA dynamically. IIA library has celebrated the Open Access Week during October 21–27, 2013 by creating and distributing the poster on “Connecting the Past with the Present through Open Access–IIA Archives” within the campuses of IIA.
Founders Day: The library displayed exhibits of M. K. V. Bappu on the Founders day, 10th August, 2013 and prepared a brochure “Vainu Bappu, the versatile Astronomer (1927–1982)” which was distributed.

Archives: The archival material has been widely used for research purposes nationally and internationally by Nehru Planetarium, Nehru Centre, Mumbai, ISRO, Kerala State Science & Technology Museum, Trivandrum. The historical contents which accessible through IIA Open Access Repository has attracted a visual Swedish artist Conny Karlsson Lundgren, who has used some of the contents from IIA archives on Isis Pogson, the daughter of N. R. Pogson for an art exhibition at Sweden. http://www.connykarlsson.se/87-Sylvia.

Bibliometric Analysis: IIA library has given substantial input to Annual Report & DST Report by submitting scientometric analysis of IIA research publications.

NKRC Meeting: IIA library hosted the National Knowledge Resource Consortium (NKRC) Nodal Officers meet 2013 at Kodaikanal Observatory, IIA, Kodaikanal during June 5–7, 2013 and it was well received by 60 participants from CSIR and DST members. Christina Birdie, B. S. Mohan and P. Prabahar presented an analysis of the “Trend in IIA Research Output; link to NKRC Resources” during the NKRC meeting held at IIA, Kodaikanal.

Library Training Program: Library continues to offer the two year’s library trainee programme, and the trainees are trained in all the sections of the library especially in the digitization procedure.
Chapter 5

UPCOMING FACILITIES

5.1 Thirty Meter Telescope

Two prototype actuators under test at ITCC laboratory.

In the academic year 2013–2014, the TMT project reached some key milestones. On 24 July, 2013 at the meeting of the board of Directors at Hawaii, USA, the scientific authorities of the respective partner countries executed the master agreement, agreeing for basic governing principles of the partnership, contributions, observing time etc. With the consent of the Department of Science and Technology, Govt. of India, Dr. P. Sreekumar, Director, IIA, signed the master agreement, representing India TMT. Prof. Eswar Reddy represented India TMT, in person, at the signing ceremony.

ITCC organized a National Workshop on TMT science and instrumentation in November 2013 at IIA, Bengaluru, which was attended by members from various research institutes and universities. This National Workshop was followed by an International Workshop, held at IIA, Bengaluru in January 2013. Members from industries associated with India TMT, IISc, ISRO and TMT projects in Canada and the USA were amongst the participants. Important outcome of this meeting was firming up of India TMTs interest in the participation of first light instruments, and laying of the roadmap for collaboration in instrumentation. As a result of this meeting, India is now participating in 6 mini-studies related to the opto-mechanical design of the optical first light instrument Multi Object Imager and Echellette (MOBIE). India TMT is leading the study of estimating the telescope and AO system polarimetric budget to understand the feasibility of the TMT for polarimetric observations. India TMT is also developing the Near-Infrared guide star catalogue for TMT adaptive Optics (AO) observations. Other major activity is completing of prototype development of India

**TMT in-kind work packages:** Edge sensors, actuators, segment support assembly, segment polishing, design and development of mirror coating systems, observatory software. Sensors and Actuator prototype development have been completed and have passed all the technical tests conducted at Jet Propulsion Lab (JPL). Work on SSAs
is being done at Godrej, Mumbai and ATL, Bengaluru. Assembly of 6 SSAs are expected to be completed by end of 2014. To efficiently manage and complete the India TMT share of observatory software which includes telescope control system software, India TMT signed an MOU with CDAC. Under the MOU, India TMT may off-load some of the works to CDAS. Another key work package is polishing of about 100 segments of size 1.44-m diameter each. India TMT is in the process of choosing a technology partner to train and build stress mirror polishing machines and set up a plant at IIA CREST campus.

(B. Eswar Reddy, For India TMT Group)

5.2 ADITYA 1

Visible Emission Line Coronagraph

Visible Emission Line Coronagraph (VELC) payload onboard Aditya(L1) is an enhanced version of VELC on Aditya-1. It is an internally occulted solar coronagraph with simultaneous imaging, spectroscopy and spectro-polarimetry channels. The primary science goals include, but not limited to, Diagnostics of the coronal and coronal loops plasma (Temperature, Velocity & Density), Heating of the corona, Development, dynamics & origin of CME’s, Studies on the drivers for space weather and Measurement of coronal magnetic fields in the corona (not planned by any mission so far). VELC is designed to image solar corona from $\pm 1.05 \, R_\odot$ to $\pm 3 \, R_\odot$ ($R_\odot$ is solar radius) with a plate scale of 2.5″/pixel. It has multi-slit spectroscopic channels at three emission lines namely 530.3nm, 789.2nm and 1074.7nm with spectral resolution of 65˚Å, 95˚Å and 150˚Å respectively. It is also capable of carrying out dual-beam spectro-polarimetry at 1074.7nm. FOV for spectroscopy and spectro-polarimetry is from $\pm 1.05 \, R_\odot$ to $\pm 1.5 \, R_\odot$. This project was approved by ADCOS, ISRO on 11-10-2013.

Optical design: VELC has an entrance aperture of 150mm and an off-axis parabola as a primary mirror (M1). M2 is a spherical mirror with a central hole acts as internal occultor. M3 rejects the solar disc light out of the instrument. A dichroic beam splitter (DBS1) splits the coronal light into an
Scatter distribution at the focal plane of continuum channel.

imaging channel at 500nm (Continuum) and to a spectroscopy channel >500nm. Spectrograph in VELC operates in near littrow configuration uses a plane reflective grating with 600 grooves/mm blazed at 42O as a dispersive element. A four element littrow lens acts as collimator and camera of the spectrograph. Optical design of the payload is optimized to meet science requirements. Tolerance analysis is carried out and fabrication and alignment tolerances are generated for optics. Thermal and ghost image analysis are also carried out on the finalized design. VELC payload alignment and performance evaluation schemes are being worked out. Experiments are being designed for calibrations of various narrow band filters, dichroic beam splitters and diffraction gratings etc.

**Mechanical design:** The overall instrument configuration is worked out, most of the component level designs are completed. Base line Design review is completed (BDR) for all subsystems including mechanical structure. The preliminary thermal and structural analysis is completed. The static, dynamic and thermal distortion analysis is carried out, the first global resonant frequency is close to 100 Hz which is acceptable. The maximum stress resulting in the structure at 100Hz is within the acceptable limits. This confirms that the mechanical configuration/design meets the specific requirements and instrument designed is stiff and strong to withstand dynamic loads. The technical specification and engineering drawings are being generated, procurement of long lead items like Titanium material etc are under progress. Equipment/instruments for up gradation of clean rooms are under progress.

There was remarkable progress and considerable effort and time was given towards selection of detector, configuring electronics interface, mechanical interface, thermal interface, optimizing camera electronics, on-board data processing schemes etc. Hence, it has been decided to retain 2K x 2K Scientific CMOS detector with 6.5 m pixel size as the visible detector for present VELC also. NIR channel for wavelength around 1 m is included in present VELC to achieve better scientific goals. For this channel, InGaAs (Indium Gallium Arsenide, 512 x 640array with 24m pixel size) is most suitable detector material when cryogenic cooling is not affordable. Contamination control: To meet the stringent requirement of particulate contamination levels, the present Class 100 Clean room facility in Prof. MGK Menon Lab will be upgraded to class 10 facility. A detailed up-gradation plan has been prepared and presented to various committees for approval. The design work for this activity is completed and we are in the process of procurement of related equipments and instruments. To measure the scatter of the mirror coupons a small scatterometer facility is designed and is being fabricated. A new particle fall-out meter is planned for monitoring the surface contamination and airborne contamination levels. To meet the required low RH levels of the project two numbers of desiccant type industrial de-humidifiers have been procured and will be installed soon. Aero-glaze paint has been qualified for quoting the optical bread-board, baffles etc. of VELC. The standing review committee on
scatter and contamination related issues discussed details of contamination control requirements and the measurement processes on 22 July 2014.

(VELC Team)

5.3 National Large Solar Telescope

India’s National Large Solar Telescope (NLST) of two meter aperture size is proposed to be set up in Ladakh region of Himalayas at a height of around 4300 meters. A high resolution spectrograph along with a polarimeter is planned as one of the backend instruments for NLST. Prototype development of the NLST Spectro-Polarimeter (SP) is proposed to be designed and developed for usage at the back focal plane of the Multi-Application Solar Telescope (MAST) recently installed at the Udaipur Solar Observatory. Design of the prototype SP has been discussed in detail along with the scientific goals. The SP is designed to be operated in three wavelengths to observe photospheric and chromospheric layers of the solar atmosphere simultaneously. Vector magnetic fields will be calculated in these layers. High resolution of the designed SP will provide accurate estimates of velocities. Highly resolved polarized line profiles will allow the user to obtain the height variation of vector magnetic fields when used along with suitable inversion codes.

Further to the detailed site survey report of 2011-12, observations were continued at the Pangong lake site Merak using automated weather station, all-sky camera, and sky radiometer. At the station Hanle, only the automated weather station observations were continued. However, observations for the site program at Devasthal in Uttarakhand were discontinued during the year. Detailed studies of the aerosol optical properties and sky transparency, along with sky brightness estimates, were carried out for Hanle and Merak stations. The results pertaining to aerosol optical properties are reported separately. The sky brightness estimates for extended durations show that both Hanle and Merak are well suited for coronagraphic observations. Extensive analysis of the meteorological parameters and the dependence of seeing under varying met conditions were initiated. Archiving of the extensive data was also carried out during the year.

Observations using sky radiometer model PM 01L by Prede of Japan, were continued at Merak and Hanle in Ladakh to monitor the aerosol content over the region. The instrument measures sun/sky irradiance at five wavelengths in the visible and Near IR regions. The data were processed using version 4.2 of Skyrad. Pack software to obtain the aerosol optical properties. Calibration and evaluation of the performance of the instrument were carried out using in-situ data during clear sky conditions for the years 2008–2011 for Hanle and 2012 for Merak. The uncertainties of the estimated aerosol optical depth (AOD) and single scattering albedo (SSA) at the five observed wavelengths are within 0.02, and 0.2 respectively, with reference to an air mass of 1. These results indicate the high quality of the data obtained and the stability of the instrument used. The AOD and SSA results are presented in Figure 1. The two stations therefore display the pristine conditions of the high-altitude sites. They have high sky transparency, comparable to those of sites at Mauna Loa (3400 m amsl) in the Pacific Ocean and Dome C in Antarctica. Also, the above results indicate that these sites are ideal for calibration of radiometers, similar to the station Mauna Loa where CIMEL radiometers of NASA’s
5.4 Ultra-Violet 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 Å), while the other observes in NearUV (2000–3000 Å) and VIS (3200–5500 Å). Images are made simultaneously in all the three channels with an angular resolution of 1.8 arcsec 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.

The vibration test of flight model test was completed last year, upon the post vibration tests it was found that except the VIS channel of the telescope, performance of rest all the subsystems were satisfactory. Upon diagnosis, it was found that star 250 sensor got de-bonded from its ceramic die. Presently detector of VIS channel is under repair by CSA in Canada. As a backup plan development of new detector for the VIS channel is under way in collaboration with the centers of ISRO. Unlike the original detector it would not be an intensified-imager, but would serve the important purpose of tracking drift of the satellites pointing with an accuracy of 0.2 arcseconds on time scale of seconds.

Several proposals for observations during the initial period of the mission are in the final stages of discussions. These proposals would be part of a set called “Baseline Science Proposals FOR ASTROSAT” and would showcase the science which can be done with ASTROSAT.

5.5 High Resolution Spectrometer for HCT

A high resolution spectrometer for the 2m Himalayan Chandra Telescope (HCT) at Indian Astronomical Observatory (IAO) Hanle providing high resolution $R \sim 60,000$ with an optional low resolution of 30,000 in unsliced mode is being fabricated. With the chosen design (based on white pupil concept) a continuous spectral coverage over 350-1000nm on a single CCD frame would be available. The project is largely supported by DST grant under 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 Feb 2013 (CIRL)).

Following the completion of the optical design in November 2011, the glass and mirror blanks and standard optical items have been procured. The grinding, polishing of all optical elements was completed in November 2013. The AR coating for lenses and prisms and HR coating for collimator, slit
and folding mirror was done by L3 warrior systems (USA) during December 2013-Jan 2014. Opto-mechanical fabrication of many system modules including Cassegrain assembly, Input optics, collimator assembly, echelle assembly, slit and fold mirror assembly, camera assembly, CCD interface assembly and exposure meter assembly are completed. The HESP F/2.6 camera (Petzval configuration) is designed to correct the various aberration introduced by the pre-optics. The performance test of the camera at Kiwistar optics is carried out using an interferometric setup. The on-axis and 4 degree off-axis performance test were made at 16 and 20°C temperatures at the test wavelength 632nm. For on axis tests PV ranged 0.529 to 0.531 waves and RMS 0.098-0.0990 waves while for 4 degree off-axis PV ranged in 2.113-2.2087 waves and RMS 0.283-0.298 waves.

HESP CCD system consists of E2V 234-81 chip of 4K x4K format with 15 µm square pixels. It is a back illuminated device coated with custom graded AR coating. It is operated with ARC GEN III controller. The CCD cryostat holding the CCD has a 3.6 litre capacity for LN$_2$ storage which gives around 24 hrs of holding time. A lakeshore temperature controller is used to control the operating temperature. The cryostat unit is equipped with auto-fill control unit. The CCD system has 4 readout amplifiers and the device can be read using any one or more outputs simultaneously. The technical specifications were tested at STFC-UKATC in November 2013 and again by the IIA team in March 2014 at Callaghan Innovation, New Zealand. The system gain and readout has been measured for different readout combinations and speeds. Linearity of the gain and full well capacity for different speeds and signal level measured.

**Spectrometer Enclosure:** At the Hanle site, the spectrograph will be housed in the west wing of the HCT building at the ground floor. A two layer thermal enclosure concept has been designed. An outer layer of 100mm thick PUF layer (Poly Urethane foam) is already installed Nov 2012. We have been monitoring the temperature inside this outer enclosure with the help of ten thermistor based sensors at different locations within PUF enclosure and a couple outside the PUF enclosure but within HCT building. This

The cassegrain unit of the High Resolution Spectrograph for HCT. It comprises of fold mirror, pinhole mirror, input selector and guide camera. The right figure shows the complete unit with its thermal enclosure.
temperature data and the estimates of heat sources within the enclosure are used to optimize the design of the active thermal control and the power requirements.

The system control software is being developed by IIA towards different operational steps. It would control the individual actuators of the instrument to desired location during the observation. The software is being developed on QT platform using C++ programming language. Since the controllers of different actuators are compatible with windows OS, this software is using windows 7 OS on server side, whereas the client is independent of OS, it can be installed on Linux operating system also. The system software has three modules related to Cassegrain, Spectrograph and Calibration light source units. The software includes an auto-guiding operation which would operate in close loop to keep the star on the input fiber. A graphic user interface (GUI) would display the status of different components as well as allow the selection of observation related parameters. The GUI would also show the temperature and pressure at different location of the spectrograph room as well as for the CCD detector. A separate Engineering mode would be used for system maintenance. The prototype of software was tested for limited functionality at Kiwi Star Optics (KSO), Callaghan Innovation; Wellington NZ during IIA team’s visit in March-April 2014. Further developments are made incorporating the user feedback and complete functionality.

The system modules for the HESP were completed in April 2014. The sub-assembly tests would be conducted during May–August 2014. The full system assembly tests at Kiwistar Optics, New Zealand with IIA team is scheduled in November 2014. The spectrograph would be transported and commissioned at IAO, Hanle during May–June 2015.

(HESP Team)
Chapter 6

STUDENTS’ PROGRAMS AND TRAINING ACTIVITIES

Student programs at the institute are carried out by the Board of Graduate Studies. The institute conducts a Ph.D. program, in collaboration with the Pondicherry University and an M.Tech-Ph.D. program, in collaboration with the Calcutta University. Apart from these, the institute also trains students through short term programs such as the visiting students program, the summer school and the summer project program. The highlights of these programs are summarised below.

6.1 Ph.D. Degree Awarded

Sumangala Rao was awarded the Ph.D. degree for her thesis entitled “Spectroscopic Studies of RV Tau and Related Objects” submitted to the Mangalore University. She carried out the work under the supervision of Sunetra Giridhar.

L. Anusha was awarded the Ph.D degree for her thesis titled “Advanced Numerical Methods for Polarized Line Formation Theory” submitted to the Mangalore University.

Prashanth Mohan was awarded the Ph.D. degree for his thesis titled “Models of Observational Signatures of Black Holes” submitted to the Bengal Engineering and Science University, Shibpur, West Bengal. He carried out the work under the supervision of Arun Mangalam.

Arya Dhar was awarded the Ph.D. degree for his thesis titled “Novel Quantum Phases in Ultracold Atoms in Optical Superlattices” submitted to the Mangalore University. He carried out the work under the supervision of B. P. Das.

6.2 Ph.D. Thesis Submitted

The following students have submitted their Ph.D. thesis:

K Chandrasekhar submitted his thesis titled “Small scale Transient Events in the Solar Corona” to the Pondicherry Univ., Puducherry. The research was done under the supervision of Dipankar Banerjee.

S. Krishna Prasad submitted his thesis titled “Spectroscopic studies of coronal structures using ground and space based data” to the Mangalore University. The research was done under the supervision of Dipankar
Banerjee and Jagdev Singh.

G. Indu submitted her thesis titled “The Structure, Kinematics and Evolution of the Magellanic Clouds” to the Pondicherry University, Puducherry. The research was done under the supervision of Annapurni Subramaniam.

P. Ramya submitted her thesis titled “Study of Stellar Streams in the Galaxy” to the Calicut University, Calicut. The research was done under the supervision of B. Eswar Reddy.

6.3 Completion of M.Sc. & M.Tech Program

The following student has completed his M.Sc. program:

V. Srinivasa Prasannaa, under the guidance of B. P. Das submitted his thesis titled “Single Ion Clocks: Theoretical Considerations” to the School of Sciences, IGNOU, for his M.Sc degree in Physics and Astrophysics.

The following students of the above program have completed their M.Tech. Degree under the IIA-CU integrated M.Tech-Ph.D. program.

Prasanna Deshmukh under the guidance of Padmakar Singh Parihar submitted his M.Tech. thesis titled “Development of Precision Controller for Thirty Meter Telescope Actuator” to the University of Calcutta.


Mayuresh N. Sarpotdar under the guidance of C. Kathiravan submitted his M.Tech thesis titled “FPGA based Digital Backend System for Low Frequency Radio Observations” to the University of Calcutta.

6.4 Visiting Internship Program

The visiting student’s internship program 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 program 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 Bengaluru or its field stations. Students carrying out their Ph.D. in Universities, and willing to visit IIA for collaborative research are also encouraged to apply for this program. During 2013–2014 thirty seven students did their projects under the guidance of the various academic staff members.

6.5 Summer Projects

School in Physics and Astrophysics

The summer school in Physics and Astrophysics, coordinated by the Board of Graduate Studies, is an yearly activity of the Indian Institute of Astrophysics (IIA). The main aim of the school is firstly 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 2013, the school was held at the Kodaikanal Observatory, during 14–24 May 2013.

Twenty five students participated in the school, of which twenty students each did a short term project for a duration of six weeks during June–July 2013, under the guidance of an IIA faculty in Bengaluru. During the second week of July, 2013 they also made presentations on the results of their project work. The program during the period 14–24 May 2013, in Kodaikanal consisted of series of lectures including Physics and Astrophysics mostly by the faculties of IIA, IISc, and RRI. Lectures were delivered on the following topics: (1) Newtonian Dynamics, (2) Sun and Heliophysics, (3) Radiative Process, (4) Solar magnetohydrodynamics, (5) Stellar Physics, (6) Astronomical Techniques, (7) Plasma Astrophysics, (8) Galaxies, (9) Helio and Astro-seismology, (10) Observational Cosmology, (11) Relativity and Cosmology and (12) High energy Astrophysics.

Summer Internship Program

Some of the students who participated in the school stayed on for another 6 weeks to do short projects. Twenty students did their projects under the guidance of the various academic staff members of the Institute.

International Research Experience for Students (IRES)

International Research Experience for US Graduate Students (IRES) program, sponsored by the National Science Foundation of USA and administered by the National Solar Observatory, Tucson, USA, was hosted by IIA. Under this program a few graduate students of the United States study astrophysics in India. The program aims to expose potential researchers to an international setting at an early stage in their careers. After completing an initial three year period of successful running, this program received a positive review and continued funding from the NSF and 2013 is the seventh year of the program at IIA. The students associate with a faculty member at IIA for a research project, and also undertake visits to IIA’s observatories and field stations.
Chapter 7

PUBLIC OUTREACH ACTIVITIES

7.1 Activities at Bengaluru

National Science Day

Distribution of prizes to the winner of quiz competition by Dr. P. Sreekumar.

National Science Day 2014 was celebrated at the Bengaluru campus of the Institute on 28 February 2014. All together 127 students from seven schools in Bengaluru participated in various activities that were organised. The schools which participated were, ACTS School, Christ School, Christ Academy, Seema School, Our lady of Fatima School, Government High School from Madivala and Narayana E-Techno School. The programs started with a drawing competition in the morning for the students. After the competition, the students were taken around the campus by student volunteers of IIA to locations where various experiments and displays were setup like 1. Observing the sun through the telescope and coelostat. 2. A demo of Balloon Experiment. 3. Visit to the Photonics Laboratory. 4. Demonstration of astronomical kits. 5. An exhibition of posters and models. Later the students assembled at the auditorium and a quiz competition was conducted in which the students participated enthusiastically. Following the quiz competition, there was the prize distribution by the Director of IIA Dr. P. Sreekumar, to the winners of the drawing and quiz competitions. First prize for the drawing competition was won by Versha of 9th standard, Christ Academy and the second prize went to K. P. Meghana of 9th standard, from Seema School. The third prize was won by N. Usha of 9th standard of ACTS Secondary School. In the quiz competition, ACTS Secondary School won the first prize and Christ Academy was the runner-up. Evening events started with a popular talk delivered by Prof. D. C. V. Mallik, titled “K. S. Krishnan: His Life and Work”. The science day celebration concluded with sky watch program arranged at the north lawn of IIA in which a large number of public participated. Students and staff of IIA volunteered and made this event a grand success.
Display of the paintings that won the first prize in the painting competition held at CREST Hosakote.

School children at the quiz competition conducted at the Bengaluru campus of IIA.

IIA graduate students showing Jupiter on the 12 inch Meade telescope to the school children, on National Science Day, at IIA campus, Bengaluru.

A talk session at rural residential school, Hosakere.
Going back to School: An outreach activity for school children

A group of IIA Ph.D student along with outreach committee members has initiated a brilliant 3-4 hours outreach program named “Going Back to school for school children”. This School outreach activity is divided in three sessions and handled by a group of IIA students. School children attend an hour long session in which a presentation on astronomy along with video screening is arranged. The second session comprises presentation of Stellarium, demonstration of astronomical kits and telescopes. Whereas, the third one is dedicated for the role-play, discussion and interaction with the students. The last two sessions are held in parallel. In addition to this astronomical activity kits are also distributed to participating students. The program is being well appreciated by student as well as teachers and a large number of request is received to conduct it to their schools. So far the program has been conducted at seven different schools in and around Bengaluru, benefiting about 800 students. At present Kannada and English are the preferred medium of communication, later it is also planned to have program in few other languages like, Hindi, Telugu and Tamil.

7.2 Activities at Vainu Bappu Observatory, Kavalur

Sky Watching Program

At VBO a regular outreach activity of sky watching for the public was organised every Saturday from 7 pm to 10 pm. During this time visitors were shown celestial objects through the 6 inch Carl Zeiss reflecting telescope. In addition to this, limited number of visitors mostly students from schools/colleges were permitted, on prior request, to visit VBT telescope dome. During January 2013 to March 2014, a total of 2894 students from schools/colleges and 5149 members of the general public visited the observatory. Only senior school and college groups were shown the larger telescopes. All visitors were shown celestial objects through the 15 cm telescope on Saturday evenings. Other groups that visited the observatory included a group of 40 engineers from GE Aviation, a group of 45 scientists and staff from the NAL, a group from the IIT Madras Astronomy Club, two batches of students each from the Bengaluru Planetarium and from the MPBIFR, Bengaluru.

Workshop on Astrophotography

An amateur astrophotography workshop was conducted at Vainu Bappu Observatory, Kavalur on 1st and 2nd February 2014. Fifteen students from IIA participated in this program along with few amateur astronomers and Astro-photographers from Bengaluru and Chennai. Practical sessions were conducted on 2nd Feb, 2014 by the invited guest and Astro-photographer Dr. Suresh Mohan, where the students were trained how to capture planet and deep-sky images with the aid of just a DSLR or amateur CCDs mounted on amateur catadioptric telescopes. On the 2nd of February, 2014, presentations were given on covering different subjects of astrophotographic techniques. Hands on session was also conducted on how to use softwares which are commonly used for astrophotography, especially in post-processing images, including noise reduction and image enhancement. Program was well appreciated by participants and it has been decided by the out-
reach committee of IIA to conduct such a workshop on regular basis.

*(Outreach Committee)*

### 7.3 Activities at Indian Astronomical Observatory, Hanle

IAO attracts many visitors, and many visits were permitted to the extent possible by the limited infrastructure.

### 7.4 Centre for Research & Education in Science & Technology

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. During this year 3 (Three) nos. of Telescope trainees were appointed on contractual basis.

The 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 astronomers gave popular lectures. The Amit Smriti Project, Aryabhatta, Bhopal; Jagdish Bose Science Talent Search Program and the Astronomy Program, Birla Institute of Fundamental Research, Bengaluru had organized visits by students to CREST.

National Science Day was celebrated at the CREST campus on February 28, 2014. More than 100 students from various school (New Horizon School, Global Residential School, Bharath Matha School, Omshree Public school etc.) visited the campus with their teachers. Posters in general astronomy and those highlighting the Institute’s facilities and work done at IIA in the field of Astronomy & Astrophysics were displayed. Drawing and quiz competitions were also held for the students. Remote operation of 2m HCT was demonstrated through Video Conferencing to IAO, Hanle. MGK Menon Lab activities were shown through CCTV’s network. These events were followed by a lecture “Basic Science and Astronomy” by B.C. Bhatt. The short movie “Cosmic collisions” was also shown to the students. The event was covered by the local press.

One Celestron CGE Pro 1100 EdgeHD model 11-inch reflector telescope has been purchased for outreach program at CREST Campus. This telescope was installed and commissioned at CREST during December 2013. CREST Telescope Trainees have been trained to operate this telescope.

*(B. C. Bhatt on behalf of CREST team)*

### Colloquium

19 December 2013  
Raymond F. Bishop  
University Manchester, UK  
*Confronting the quantum many-body problem: an overview of the coupled cluster methods and its applications in physics*

12 December 2013  
K. Porsezian  
Pondicherry University, Pondicherry  
*Linear and nonlinear propagation effects in*
optical fibers: Recent applications

28 November 2013
J. Srinivasan
Divecha Centre for Climate Change, IISc, Bengaluru
Should we be concerned about global warming?

12 November 2013
Kandaswamy Subramanian
IUCAA, Pune
Fluctuation to mean field turbulent dynamos: The search for coherence

11 June 2013
R. Srianand
IUCAA, Pune
Probing the Universe with QSO absorption lines

02 April 2013
N. Udayashankar
Raman Research Institute, Bengaluru
Adventures in low frequency radio astronomy and cosmology

Seminar

01 April 2014
Piyali Chatterjee
High Altitude Observatory, USA
Occurrences of fast and possibly cannibalistic coronal mass ejections: insights from flux rope simulations

14 March 2014
Masayuki Yamanaka
Kyoto University, Japan
Observational study of nearby Type Ia Supernovae with rise time

13 March 2014
Koji Kawabata
Hirosima University, Japan
SGMAP: Optical polarimetric survey project in Hirosima

12 March 2014
Nirupam Roy
Max-Planck-Institute for Radio-astronomy, Germany
Radio and X-ray observations of Novae

05 March 2014
Marilena Mierla
Royal Observatory of Belgium
Coronal mass ejections: detection, 3D reconstruction and propagation

04 March 2014
G. Thejappa
University of Maryland, USA
Solar type III radio bursts: Non-linear wave-wave interactions

25 February 2014
Anish Parwage
Indian Institute of Astrophysics, Bengaluru
Grid Garuda

18 February 2014
Jerome Martin
Institue of Astrophysics, Paris
Inflation after Planck

05 February 2014
Shri Kulkarni
Caltech, Pasadena CA 91125
Astronomy: This decade

31 January 2014
Sultana Nahar
Department of Astronomy
Ohio State University
Abundances and opacities of the Sun
30 January 2014
Matthias Bartelmann
Heidelberg University, Germany
The internal structure of galaxy clusters

20 January 2014
Herman Marshall
MIT, USA
Astrophysics with a Soft X-ray polarimeter

16 January 2014
Suresh Doravari
California Institute of Technology, USA
An introduction to LIGO: science, technology and research opportunities

15 January 2014
Dhrubaditya Mitra
Nordita, Stockholm
New paradigm of solar magnetic activity

15 January 2014
Vineeth Valsan
University of Ferrara, Italy
Extending the band of focusing X-ray telescopes beyond 100 keV: motivations and proposed solutions

06 January 2014
Bruce Basset
SAAO, South Africa
Rise of the machines: Machine learning and prospects for the future of empirical astrophysics

03 January 2014
Monique Pick
Observatoire de Paris, Meudon, France
Contribution of solar and heliospheric radio observations on our understanding of CMEs and transient events

18 December 2013
Harry van der Laan
Leiden University and University of Utrecht
The development of post-WWII Astronomy in Europe

17 December 2013
Chiranjib Konar
Institute of Astronomy Astrophysics, Academia Sinica, Taiwan
A new era of radio galaxy physics: theory vs. observations

12 December 2013
Jeremie Lasue
Institute for Research in Astrophysics and Planetology, Toulouse, France
Exploring Mars with ChemCam on-board Mars Science Laboratory

02 December 2013
L. V. E. Koopmans
Kapteyn Astronomical Institute, Univ. of Groningen
Constraints on Dark Matter in Galaxies from strong gravitational lensing

26 November 2013
Aveek Sarkar
IISER, Kolkata
Flux-tube texture of the Solar Wind: simulating plasma beta scaling of anisotropic magnetic field fluctuations

21 November 2013
Tobias C. Hinse
Korea Astronomy & Space Science Institute
Detection & dynamical aspects of extrasolar circumbinary companions

13 November 2013
P. Venkatakrishnan
Udaipur Solar Observatory
On net currents in Sunspots
13 November 2013
Kandaswamy Subramanian
IUCAA, Pune
Probing the universe using high redshift galaxies

23 September 2013
Ananta C. Pradhan
TIFR, Mumbai
A stellar population synthesis model for the study of ultraviolet star counts of the Galaxy

04 September 2013
Georges Meylan
Laboratoire d’astrophysique, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland
Gravitational lensing: an astrophysical tool

07 August 2013
Paul J. Wiita
The college of New Jersey, USA
Using Kepler to investigate AGN variability

06 August 2013
Yuri Shchekinov
Southern Federal University, Russia
Cosmological aspects of habitability

01 August 2013
Solai Jeyakumar
Universidad de Guanajuato, Mexico
Outflows in radio sources: Numerical simulations of jet cloud interaction

30 July 2013
Henning Flaecher
University of Bristol, UK
Searches for supersymmetry at the large Hadron Collider, CERN

18 July 2013
Soumen Basak
Centre d’Etudes de SACLAY, France
A needlet ILC analysis of WMAP 9-year data

03 July 2013
Girija Rajaram
CSRE, IIT, Bombay
Solar-terrestrial magnetic field interactions and their consequences

02 July 2013
Andrew Cole
School of Mathematics & Physics, Univ. Tasmania, Australia
The small Magellanic Cloud in space and time

20 June 2013
Bijaya Kumar Sahoo
Physical Research Laboratory, Ahmedabad
Possibility of temporal variation of the fine-structure constant

19 June 2013
Koshy George
Kapteyn Astronomical Institute
The Netherlands recent star formation in cluster early-type galaxies

30 May 2013
S. Sumangala Rao
Indian Institute of Astrophysics, Bengaluru
Spectroscopic Studies of RV Tau and related objects

28 May 2013
N. Kameswara Rao
Indian Institute of Astrophysics, Bengaluru
The odd ball R Cor Bor - DY Centauri

20 May 2013
M. Bianda
Istituto Ricerche Solari Locarno, IRSOL,
Switzerland

IRSOL Locarno and the collaboration with IIA

17 May 2013
K. Nagaraju
MaxPlanck Institute for Solar System Research, Germany

Fast solar polarimeter: Concept and laboratory test results

13 May 2013
Pankaj Agrawal
Institute of Physics, Bhubaneswar
Search the missing piece in the Standard Model - the Higgs Boson

19 April 2013
Surajit Paul
IUCAA, Pune
Blast wave like evolution of energy and galaxy cluster medium
Chapter 8

MISCELLANEOUS ACTIVITIES BY IIA STAFF

8.1 Talks given in national/international meetings outside IIA

Invited:

G. C. Anupama

P. Chingangbam

B. P. Das

M. Das

R. T. Gangadhara

S. Giridhar

J. Javaraiah


U. S. Kamath


P. Kharb

- AGN meeting titled “Workshop on Radio Studies of Galaxies and Galaxy Systems”, held March 4-6, 2014, at the Inter-University Centre for Astronomy & Astrophysics (IUCAA), Pune, titled Triggering jet activity and the Radio-loudness dichotomy.


- Physics Department, Indian Institute of Science (IISc), on September 10, 2013, titled Clues about Jet Propagation and Emission from a Multi-wavelength Study of MOJAVE Blazars.

P. K. Mahesh


A. Mangalam

- Analysis and Modeling of Light curves from Blazars in “Multiwavelength Study of Blazars: Data Acquisition and Modelling” at Manipal Centre for Natural Sciences, Manipal University, Manipal, July 8-9, 2013.


P. Mohan


- Models of Observational Signatures of Black Holes, Bengal Engineering and Science University, Shibpur, Howrah, March 11, 2014.
K. N. Nagendra


- *Sun as a Proving Ground for Polarized Light Scattering Theories Location* 32nd Scientific Meeting of the ASI, IISER, Mohali, March 20-22, 2014.

G. Pandey


K. P. Raju


K. B. Ramesh


K. E. Rangarajan

- *India’s National Large Solar Telescope*, EGU meeting in Vienna, April 11, 2013 in the session on “Large ground based solar observational facilities.”

B. Ravindra


M. Sampoorna


S. Sengupta


S. Shantikumar


P. Sreekumar

- *Science from FERMI* presented at the “National Symposium on VHE Gamma-ray Astronomy”, November 2013, organised by BARC.

C. S. Stalin

- “High energy emission from AGN”, October 7-9, 2013, Kashmir University, *Blazars in the era of Fermi*.


- “Radio Galaxy Workshop, March 4-6, 2014, IUCAA, Probing the Central Engine by Multi-band Monitoring of Blazars.”

A. Subramaniam


Contributed:

G. C. Anupama


S. Choudhury


M. Das


S. Das

• Plenary talk given at “Aspect of Cosmology”. Warm Dark Matter of the Universe.

R. T. Gangadhara


K. M. Hiremath


J. Jose

• Stellar Content of Selected Galactic Triggered Star Forming Regions presented during the conference “Massive Young Clusters: Milkyway to Far Location,” Puebla, Mexico, 02 December 2013.

P. Kharb


A. Mangalam

K. N. Nagendra


S. P. Rajaguru


K. E. Rangarajan

- Prototype Spectropolarimeter for National Large Solar Telescope, EGU meeting in Vienna on April 10, 2013 in the session on “Instrumentation for ground based solar telescopes.”

M. Safonova

- Planets in the Early Universe; Search for Planets in Globular Clusters by Microlensing: M4 results; Developing High-Altitude Balloon Science: UV Spectrograph to Observe Comet ISON. The 1st COSPAR Symposium “Planetary Systems of our Sun and other Stars.”


S. Subramanian


Lectures given in any national, international, in-house meeting, conference, workshop, school organized at IIA

S. G. Bhargavi


P. Chingangbam

- Symposium on Revelations from Planck, April 17, 2013.

K. George

- MOBIE, “ITCC Science and Instrumentation Meeting,” December 9-10, 2013, IIA.

U. S. Kamath

A. K. Pati

- **Nearby Galaxies and Stellar Population**, “ASTROSAT Baseline Science Meeting” meeting held during February 6-7, 2014.

A. Prasad


K. E. Rangarajan


B. Ravindra

- **Solar Instrumentations and Observations** Kodaikanal Summer school, “Kodaikanal Observatory”, May, 2013.

- **Probing the Chromosphere with Narrow Band Imager**, “NLST-ADITYA Science meeting”, IIA, Bengaluru, November 18-20, 2013.


T. Sivarani

- **Data pipeline for TMT**, and TMT HROS design, “India-TMT collaboration meeting”, January 2014, IIA, Bengaluru.

- **Milkyway satellites and challenges to Lambda CDM**, during the meeting on “Aspects of Cosmology,” at IIA.

S. Sengupta


- **In search of another Earth**, February 19, 2014, Invited colloquium at Presidency University, Kolkata.

P. Sreekumar


Invited lectures (not popular lecture) given in any academic institution other than IIA which is not a part of any meeting/conference

G. C. Anupama

- **Stellar Explosions** (IISc Colloquium: November 29, 2013).

S. G. Bhargavi

- **Stellar Structure and evolution**, lectures given at JN Planatarium as a part of REAP program.

B. P. Das

- **Present and Future Atomic Clocks**, Department of Physics, IIT Madras, Colloquium, February 26, 2014.

S. Das

- **Chameleon Cosmology and their Astrophysical Signatures**, ICTS, TIFR, Bengaluru.
K. George

- IISc Astrophysics Seminar on January 21, 2014, Recent star formation in cluster early-type galaxies.

K. M. Hiremath

- Internal Structure, Dynamics and Chemical Composition of the Sun, CMR Institute of Technology, September 26, 2013.

J. Jose

- Sh2-252 in Perspective: Stellar Content, Properties and Star Formation Activity Location, NOAO, Arizona, USA, December 13, 2013.

A. Mangalam

- A course of 14 lectures on Fluid Mechanics and Plasma Physics to MSc students at Pondicherry University during October-November 2013.

G. Pandey

- Recent Studies on Hydrogen-deficient Stars, February 11, 2014, Physics Department, IISc.

Anish Parwage

- Delivered a series of lectures on High Performance Computing at Gujarat Technical University (GTU), Gandhinagar, Gujarat for ME students from December 2-6, 2013.

K. E. Rangarajan

- Science Objectives of NLST, Applied Mathematics Dept., Univ. of Sheffield, April 19, 2013.

B. E. Reddy

- Excess Lithium in K giants: A puzzle to stellar models 16th May, 2013, NAOC, Beijing, China.

M. Safonova

- What can we learn from comets and how? Lecture at National Training Workshop, organized by DST and Vigyan Prasar, Guwahati Planetarium, 22-24 August, 2013.
- Search for Planets in Globular Clusters by Microlensing, “Time Variability and Transients session” at the 3rd Pro-Am meeting in astronomy, organized by ASI and Homi Bhabha Centre for Science and Education, Mumbai, October 26-27, 2013.

S. Sengupta

- Physics and Chemistry of Brown Dwarfs, February 18, 2014, Invited colloquium at S. N. Bose National Center for Basic Sciences, Kolkata (2) In search of another Earth, February 19, 2014, Invited colloquium at Presidency University, Kolkata.

T. Sivarani

- Colloquium at NCRA Pune, on Stellar Relics from the early Galaxy, April 2014.
Public communications

S. Das
- *Dark Energy and Dark Matter*, “7 slide presentation for IIA PhD students”.

Awards

D. Banerjee
- Associate Editor of the Journal *Solar Physics*.

P. Chingangbam
- *Council member*, Indian Association for General Relativity and Gravitation (IAGRG).

S. Choudhury
- *What does the Metallicity Map tell us about the Evolution of the Large Magellanic Cloud?* was awarded the best poster in the category of Extragalactic Astronomy and Cosmology, in ASI 2014 (March 20 - 22), held at IISER, Mohali.

S. Das
- Visiting faculty at UBC, Vancouver, Canada for Summer 2014. Has been nominated for Meudon Observatory, summer fellowship.

U. S. Kamath
- Member of the ISDT (International Science Development Team) on Time Domain Science for the TMT (Thirty Meter Telescope) Project.

P. Mohan
- PhD awarded in April 2014 from the Bengal Engineering and Science University, Shibpur, Howrah. He was guided by A. Mangalam.

K. N. Nagendra
- Serving as the main-editor of the proceedings of the 7th international Solar Polarization Workshop held in Kunming, China, September 9-13, 2013.
- Served as the member of SOC constituted to organize Solar Polarization Workshop 7.
- Serving as the member of SOC constituted to organize IAU Symposium 305 on “Polarimetry: From the Sun to Stars and Stellar Environments” to be held at Costa Rica, November 30-December 5, 2014.
- Will serve as the main-editor for the proceedings of IAU Symposium 305.

A. Prasad
- Shyama Prasad Mukherjee Fellowship for SRF by CSIR.

B. E. Reddy
- Member of SOC for IIA Symposium 298: Setting the Science for GAIA and LAMOST: Large Scale Stellar Population Surveys, Lijiang, China.
M. Sampoorna

- Young Scientist Platinum Jubilee award of NASI (National Academy of Sciences India) for the year 2013.
- Serving as the co-editor of the proceedings of the 7th international Solar Polarization Workshop held in Kunming, China, September 9-13, 2013.

A. Subramanian

- Fellow, Indian Academy of Sciences, Bengaluru.
- Fellow, National Academy of Sciences, Allahabad.
- Associate Editor, Bulletin of Astronomical Society of India.

Externally funded projects

G. C. Anupama

- DST-JSPS project A Study of Supernovae in the Nearby Universe - Building Blocks of High Redshift Universe (PIs: G. C. Anupama, K. Nomoto).

D. Banerjee

- Two-year DST and BELSPO bi-lateral Project Contemporary Physical Challenges for Heliospherical and Astrophysical Models (CHARM)/National Large Scale Telescope with Dipankar Banerjee, from IIA as the P.I and Tom Van Doorsselaere, Centre for Mathematics Plasma Astrophysics as the P.I. from the Belgian side.
- Principal Investigator of joint three year UKIERI Trilateral Research Partnerships between IIA, Queens University of Belfast and National Solar Observatory, USA.

R. Chaudhuri

- Relativistic Study of the Excited/Ionized States of Heavy Atoms using Coupled Cluster Based Linear Response Theory funded by DST-SERB.

B. P. Das

- Symmetry Violations in Atoms and Implications for the Standard Model of Particle Physics, Indian National Science Academy and Japan Society for the Promotion of Science.

S. Giridhar

- Development and Fabrication of High Resolution Spectrometer for the 2m HCT funded by SERB (DST).

K. M. Hiremath


J. P. Lancelot

- ISRO INSAT 3D Project. As per the MoU between ISAC and IIA, polishing of the sunshield panels for the MET payload for the INSAT 3DR2 has been completed during this period. (with M. G. Mohan, R. Ismail, P. Subramani).

B. E. Reddy

- Technology and prototype development of Giant Segmented Mirror Technology (GSMT), Department of Science and Technology, Govt. of India.

C. S. Stalin

- Estimation of H0 through monitoring of gravitationally lensed quasars, 2012 - 2014: Indo-Swiss collaborative project.
Workshop, conference, school etc. organized at IIA or outside IIA

G. C. Anupama
- Co-Chair, SOC, 32nd Scientific Meeting of the ASI, 2014 March 20-22, IISER, Mohali.

P. Bagare
- A one-day workshop on Astronomy and Astrophysics was organized at the Department of Studies in Physics, University of Mysore, on November 16, 2013.

S. Das
- Co-organizer for “Aspect of Cosmology” at IIA.

R. T. Gangadhara
- Organized the visit of Prof. Jocelyn Bell during January 7-12, 2014. -Organized (1) Interaction meeting with students

K. George
- Organising Committee member for ITCC Science and Instrumentation Meeting held on 9-10 December, 2013 at IIA.

A. Mangalam
- Serving as a member of SOC for ASI national meetings in the period September 2013- September 2016.

Anish Parwage
- Organized a one day workshop with NVIDIA on OpenACC technology under the guidance of Prof. B. P. Das IIA Auditorium, 05 September 2013.

A. Subramaniam

8.1.1 Popular lectures

B. C. Bhatt


M. Das
- Extragalactic Astronomy, Christ College INSPIRE program meeting for students, April 18, 2013, 2 lectures.

R. T. Gangadhara
- Discovery of Pulsars at Faculty Hall, IISc, January 9, 2014 and Universe and Us, Jawaharlal Nehru Planetarium, Bengaluru, on 11 January 2014. Women in Science on January 11, 2014 at IISc, which was held in sponsorship with Indian Academy of Sciences.

K. George

P. Kharb
- National Science Day, 2013, at IIA, titled Our Universe: A Short Journey from the Earth to Galaxy Superclusters.

J. P. Lancelot
A. Mangalam


A. K. Pati

- *Exploring the Universe*, 34th INSPIRE Internship Program for young talents, School of Biotechnology, IIT University, Bhubaneswar on February 19, 2014.

- *Exploring the Universe and Telescopes and Instruments* talks to visiting scientists from NAL Officers club, Vainu Bappu Observatory, Kavalur, 7 March, 2014.

M. Safonova


P. Sreekumar


8.1.2 Public Outreach

B. C. Bhatt

- Visited Sripuram, Sri Narayani Peedam, Thirumalaikodi, Vellore (TN) on September 29-30, 2013. A 6-inch Celestron telescope was installed. Telescope assembly and operations were demonstrated to Peedam officials and astronomical objects were shown to the general public gathered there. Some of the Peedam members were trained in assembling the telescope and pointing/looking towards far objects in sky. The aim is to spread scientific awareness through telescope viewing and also to introduce astronomy in nearby schools.

- Participated in the 3rd National Level Exhibition & Project Competition under DST-INSPIRE Award Program held at Pragati Maidan, New Delhi during October 8-10, 2013. Posters introducing astronomy and related work done at IIA were put up in the designated area of the exhibition.

- Attended annual general meeting of 101st Indian Science Congress held at Jammu University, Jammu, during February 3-7, 2013 and participated in “India Vision 2020-Mega Expo”.

S. Choudhury

- *Starry Messengers*, conducted by the Outreach committee of IIA, carried out in different schools of Bengaluru. The details are as follows: (1) July 05, 2014 at Oxford School, Devanahalli, Bengaluru. (2) December 21, 2013 at Reddyjina Sangha School, Koramangala, Bengaluru. (3) August 31, 2013 at Modern School, J P Nagar, Bengaluru. (4) 20 July, 2013 at MSR Highschool, Bengaluru.
M. Das

- Participated in science day, February 2014. Poster contributed on *Galaxies in our Universe* with Margarita Safonova.

R. T. Gangadhara

- *Discovery of Pulsars*, Faculty Hall, IISc, January 9, 2014.

P. Kharb


K. B. Ramesh

- Guest lectures on *The Sun and the solar system* in general astronomy courses held during the academic year 2013-2014 at MP Birla institute of Fundamental Research, Bengaluru.

M. Safonova

- Gravitational Lensing poster and Balloon Experiment at the National Science Day, IIA, 28 February 2014.
8.2 Staff Activities

8.2.1 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 13.36%, 11.55%, 4.33% 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.

8.2.2 Official Language Implementation

Four meetings were conducted 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 members capacity for doing official work in hindi, one Hindi Workshop was conducted for the employees working in Administration on 29 August, 2013. The report was sent to the Dept. of Science & Technology, New Delhi.

Hindi Day/Fortnight Celebration

The institute celebrated Hindi Fortnight from 2 September 2013 to 14 September 2013. During the occasion six competitions were conducted in the institute viz. “Hindi-English Noting” competition on 2 September 2013, “Hindi Speech competition on 4 September 2013, “Hindi Easy Writing competition on 6 September 2013, “Hindi Song” competition on 10 September 2013, “Picture Narration” competition on 11 September and “Hindi Visual-Quiz competition on 13 September 2013. 14 September 2013 was celebrated as “Hindi Day in the institute. Dr. P. Sreekumar, 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, read the Home Ministers message of Hindi Day. Cash awards were given to the winners. The function was concluded with a vote of thanks by Dr. S. Rajanatesan, Section Officer(Hindi). Two hindi competitions were conducted viz. Hindi Administrative Glossary and Hindi Visual-Quiz on the 17 September 2013 respectively at VBO, IIA, Kavalur. Cash awards were given to the winners.

(S. Rajanatesan)
Hindi Day was celebrated at the Institute on 14 September 2013. Various competitions were held and prizes distributed. (Standing : Left to Right) Dr. S. Rajanatesan, Amit Kumar, Dr. G. Pandey, Dr. P. Kumaresan (Administrative Officer), Dr. P. Sreekumar (Director), Malini Rajan, N. K. Pramila, Y. Yerappa, K. C. Viswanath, K. Bhaskaran, K. Shankaranarayanan & K. G. Erappa.
Chapter 9

STAFF LIST 2013 – 2014

Academic & Scientific Staff

Director: P.Sreekumar (w.e.f. 01.07.2013)

Director (Acting): Bhanu Pratap Das (upto 30.06.2013)

Distinguished Professor: S. Sirajul Hasan

Senior Professor: Bhanu Pratap Das, H. C. Bhatt, Jayant Murthy, T. P. Prabhu, Sunetra Giridhar


Scientist D: U. S. Kamath, B. A. Varghese

Scientist C: E. Ebenezer Chellasamy, B. S. Nagabhushana, Ravinder Kumar Banyal, N. Shantikumar Singh, G. S. Suryanarayana

Scientist B: Muthu Priyal, Nazia Afreen Ahmed, Namgyal Dorjey, Rajendra Bahadur Singh, K. Prabhu, G. Selvakumar

Research Associate B: M. Appakutty

Adjunct Scientist: Durgesh Tripati, K. Shankarasubramanian

Visiting Professor: S. N. Tandon

Visiting Scientist: S. G. Bhargavi, Koshy George, M. Safonova, Ramya Sethuram

Honorary Professor: V. K. Gaur

(Post Doctoral/Visiting Fellow: Jayashree Roy, Jessy Jose, Rajesh Gopal, Smitha Subramanian

Technical staff

Engineer G: A. V. Ananth

Engineer F: M. S. Sundararajan, G. Srinivasulu

Librarian: Christina Birdie

Engineer D: Amit Kumar, P. Anbazhagan, V. Arumugam, S. S. Chandramouli, Dorje Angchuk, Faseehana Saleem, S. Kathiravan, S. Nagabushana, B. Ravikumar Reddy, M. V. Ramaswamy, S. Sriram

Scientific Officer SD: Rekhesh Mohan, L. Yeswanth

Principal Document Officer: S. Rajiva


Sr. Technical Officer: K. Jayakumar, K. Kuppuswamy, R. Selvendran

Technical Officer B: N. Sivaraj, Narasimhappa

Engineer B: Mohd. Faisal Nawaz, V. Natarajan, K. Ravi, A. Ramachandran, S. Ramamoorthy, N. Raj Kumar, S. Suresh

Technical Officer: A. V. Velayuthan Kutty


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

Draughtsman E: V. K. Subramanian


Tech. Associate: V. Gopinath, Mallappa


Sr. Research Asst. B: V. Moorthy

Technical Asst. C: D. Premkumar, V. Robert

Consultant: Lt. Col Kuldip Chandar

Sr. Consultant: M. Nageswara Rao

Administrative staff

Administrative Officer: P. Kumaresan

Principal Staff Officer: K. Thiyagarajan

Accounts Officer: S. B. Ramesh

Purchase Officer: Y. K. Raja Iyengar

Stores Officer: D. Lakshmaiah

Sr. Asst. Acc. Officer: G. R. Venugopal

Sr. Section Officer: Meena, Narasimhamurthy, Pramila Mohan, S. Rajendran

Section Officer: K. Padmavathy, N. Valsalan, Ramaswamy, Diskit Dolker

Section Officer (Hindi): S. Rajanatesan

Sr. Office Superintendent: Malini Rajan, N. K. Pramila, N. Sathyabama, Uma Maileveloo, A. Veronica