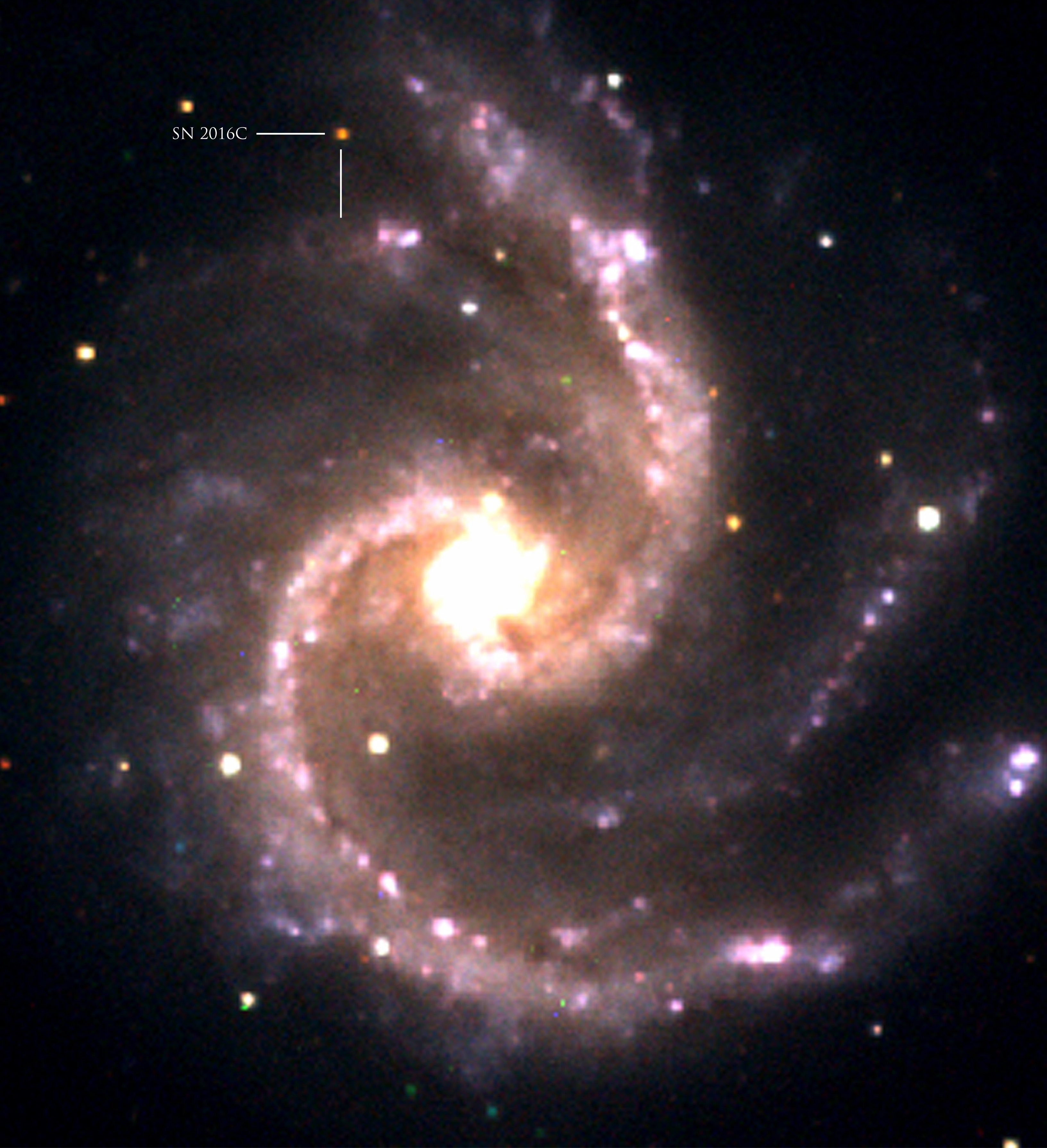
INDIAN INSTITUTE OF ASTROPHYSICS

Academic Report 2016-2017



INDIAN INSTITUTE OF ASTROPHYSICS

ACADEMIC REPORT

2016-2017

Edited by : Prof. S. Muneer (with support from Prof. G. C. Anupama, (Dean, IIA)).

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Front Cover : Colour composite of NGC 5247, a nearby spiral (SAbc) galaxy, observed with the 2-m Himalayan Chandra Telescope (HCT+HFOSC), Hanle, using broad band filters *BVR* on June 03, 2016. This galaxy hosted a bright type IIP supernova SN 2016C. *Photo Credit* : D K Sahu.

Back Cover : The Sun emitted an intense flare near its west limb on November 04, 2015 around 03:25 UT (~09:00 IST). The collage shows the simultaneous observations of the event in X-ray, visible, and radio wavelengths by the Scanning Sky Monitor (SSM) on-board ASTROSAT space mission, Kodaikanal H-alpha Telescope, and Gauribidanur RAdio SpectroPolarimeter (GRASP), respectively. Note the X-ray counts recorded in SSM are not from direct observations of the Sun. They correspond to X-rays scattered from the Earth when the latter came in the field of view of SSM during the solar flare. The SSM cameras were facing the Earth at the time of event. *Photo Credits* : V. Mugundhan, Anshu Kumari, K. Prabhu, Indrajit V. Barve of IIA (H-alpha and radio observations) and M.C.Ramadevi of ISAC-ISRO (SSM observations).

Cover Design by : Sanjiv Gorka

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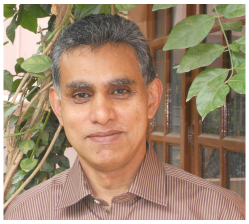

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Chapter 1

The Year In Review

The past year has again been a very productive year for the Indian Institute of Astrophysics. During the academic year 2016–17, IIA scientists have contributed significantly to solar and stellar studies, modeling efforts, design and development of astronomical instruments & facilities and continued to support many critical aspects of existing observational facilities. Activities in the area of solar research covered theoretical, computational and experimental research related to the Sun and solar system. Studies on exoplanets, novae, supernovae, and chemical abundance analysis of various types of stars were some of the topics in which the stellar astronomy group was engaged this year. Multiwavelength studies of active galaxies and transients continued to be areas of major interest at IIA. I will summarize below some of the major findings that emerged from activities this year.

Our Kodaikanal Observatory′s nearly 100-year long, daily full-disk image plate collection was fully digitized and now made available to scientists around the world. This unique collection, which provides the longest, consistently calibrated data set from a single observatory, is now being used to study changes across multiple solar cycles in a systematic manner. Simultaneous high resolution observations of the Sun in penumbral and transition regions revealed the presence of micro-jets and bright dots, respectively. The correlation between these new classes of events and their contribution to the heating of the solar atmosphere are being investigated. On the theoretical side, calculations related to the polarization properties of coronal emission lines were developed and applied to the Fe XIII 10747 Å line to explore its role as a diagnostic of coronal magnetic fields. EUV observations of the Sun, revealed outward propagation of jet-like features which induced transverse oscillations in near-by coronal magnetic field lines. Our Gauribidanur radioheliograph observations yielded a comprehensive picture of how the amplitude of density turbulence and the density modulation index vary with heliocentric distance in the solar wind, including its solar cycle dependence.

Three short-period Earth-sized planets transiting an ultracool dwarf star Trappist-1 (12 parsecs away), were discovered using TRAPPIST. Observations taken from the HCT contributed significantly in resolving the degeneracy of the orbital period of the third planet. Extensive monitoring of the Transitional Supernovae such as SNe iPTF13ebh and SN 2015bp during the pre-maximum, maximum and post-maximum phase was carried out using HCT. The two supernovae were found to be declining faster than the normal type Ia and producing lesser amount of ^{56}Ni.

Optical spectroscopic studies of classical Be stars revealed detection of a rare triple-peak Hα emission phase in 59 Cyg, and a rapid decrease in the emission strength of Hα in OT Gem. Approximately 250 variable stars were detected in a sample of 23 selected globular clusters. Abundance analyses of two newly discovered R Coronae Borealis (RCB) stars were conducted using high-resolution optical spectra and model atmospheres. Their chemical compositions place the pair among the majority class of RCBs. A semi-automated quantitative method was introduced to estimate the age and reddening of 1072 star clusters in the Large Magellanic Cloud (LMC) using the Optical Gravitational Lensing Experiment III survey data. This study revealed 308 newly parametrized clusters. Early results from the Ultra-Violet Imaging Telescope (UVIT) on board the ASTROSAT observatory, reported the discovery of a hot companion associated with one of the blue straggler stars (BSSs) in the old open cluster, NGC 188. The discovery demonstrated the capability of UVIT to accurately estimate the parameters of binary systems, using its filter systems. The excellent angular resolution of UVIT, better than design specification, has enabled high-resolution UV imaging of galaxies and star clusters.

In the area of extragalactic astronomy, many themes have been pursued including black hole astrophysics, energetics of active galaxies, magnetic fields in galaxies and cosmology. The themes pursued by the theoretical astrophysics group include relativistic astrophysics, magnetic fields, quantum chemistry, galactic gas dynamics and radiative transfer theory for the Sun and exoplanets. A dynamical model of tidal disruption events (TDE) was constructed assuming a time dependent accretion model, to calculate the rise time and the peak bolometric luminosity in terms of physical parameters.

On the large projects at IIA, the Thirty Meter Telescope (TMT) consortium in India, made significant progress on many fronts, including, development of the first prototype parts in India and its assembly at the pilot group facility in Pasadena, USA. Its performance satisfied design requirements. Construction of a large optics fabrication facility was started at the CREST campus and has reached its midway point. The design of the Visible Emission Line Coronograph (VELC) payload on Aditya-L1 successfully went through major reviews at ISRO and the laboratory model assembly is underway.

A solar H-alpha telescope with a narrow tunable passband was established at Kodaikanal Observatory in 2014 with capability to generate velocity maps of the full disk; a similar system to be installed in Merak, Ladakh, was fully assembled, tested at our CREST campus in Hosakote. The installation of the telescope at Merak is expected by mid 2017 when the more conducive working season opens up in Ladakh. IIA has been planning to setup the National Solar Telescope in Ladakh for a decade. We made good progress this year with the submission of the revised proposal to DST for funding consideration. During this year, substantial effort has gone into the design of the building, dome, additional characterization and consolidation of data on site, instrument design, obtaining Wildlife clearance, etc. We are very hopeful that formal approval will be provided this academic year to proceed with this large facility eagerly awaited by solar astronomers.

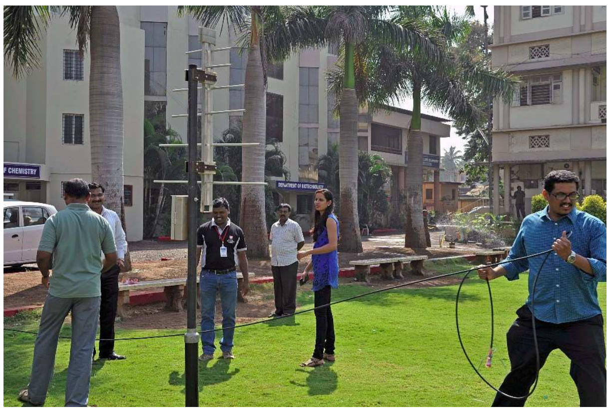

Figure 1.1: The IHY two element radio interferometer outreach kit was set up by IIA as a part of SCOSTEP / ISWI International Space Science School conducted at Kasturbai Walchand college, Sangli, Maharashtra during November 7–17, 2016. The functionality and observing capability of a basic radio interferometer was demonstrated to the participants.

IIA has taken a big step in the use of green energy with the installation of a 100 KVA solar photo-voltaic system on the roof of the main campus in Bengaluru. With the system connected to the grid, we expect a full return on the investment in about 7-8 years and we hope to continue this effort at all our filed stations. The Institute took various steps for the implementation of the Official Language and continued efforts to make equitable work environment by safeguarding the interests of SCs, STs, physically-challenged and women. Outreach activities during 2016–17 was enhanced significantly with the organization of many visits, lectures and programs to involve the school and college students, teachers and the wider public.

Our student program continues to flourish with many interesting research activities by students both under PhD(Physics) as well as under the MTech/PhD programs. The overall research output of the institute remains healthy. Let me close expressing my confidence in IIA continuing to uphold its responsibilities on major developmental programs and increasing its involvement in high-end instrument design for astronomy. I believe these activities will result in increased scientific productivity and retain the important role it plays in leading astronomy research in the country.

P. Sreekumar
Director

Chapter 2

RESEARCH

2.1 The Sun and the Solar System

Kodaikanal digitized white-light data archive (1921–2011): Analysis of various solar cycle features

Long-term sunspot observations are key to understanding and predicting the solar activities and its effects on space weather. Consistent observations, which are crucial for long-term variations studies, are generally not available due to upgradation/modification of observatories over the course of time. The authors present data for a period of 90 years acquired from persistent observation at the Kodaikanal observatory in India. They aim to build a uniform sunspot area time series along with their positions for a 90-yr period between 1921 and 2011, as obtained from the newly digitized and calibrated white-light images from the Kodaikanal observatory. The aim is to compare this new time series with known sources and confirm some of the earlier reported results with additional new aspects. The authors use an advanced semi-automated algorithm to detect the sunspots from each calibrated white-light image. Area, longitude and latitude of each of the detected sunspots are derived. Implementation of a semi-automated method is extremely necessary in such studies as it minimizes the human bias in the detection procedure. Daily, monthly, and yearly sunspot area variations, obtained from the Kodaikanal, compared well with the Greenwich sunspot area data. The authors find an exponentially decaying distribution for the individual sunspot area for each of the solar cycles. From the analyses of the histograms of the latitudinal distribution of the detected sunspots, Gaussian distributions were found, in both the hemispheres, with centers at $\sim 15^\circ$ latitude. The height of the Gaussian distributions are different for the two hemispheres for a particular cycle.

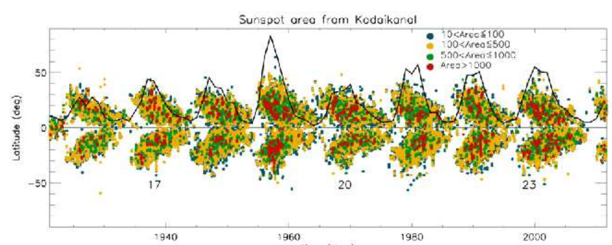

Figure 2.1: Butterfly diagram created using the individual sunspot area values (sizes) and their locations obtained from Kodaikanal white-light images. Cycle numbers are also printed on the plot. The solid black line represents the yearly averaged sunspot area (scaled).

(A&A, 2017, 601, 106)

(Mandal, Sudip; Hegde, Manjunath; Samanta, Tanmoy; Hazra, Gopal; Banerjee,

Dipankar; Ravindra, B.)

Automated Supergranule Detection from Kodaikanal Observatory 100 years Ca II K Specroheliograms

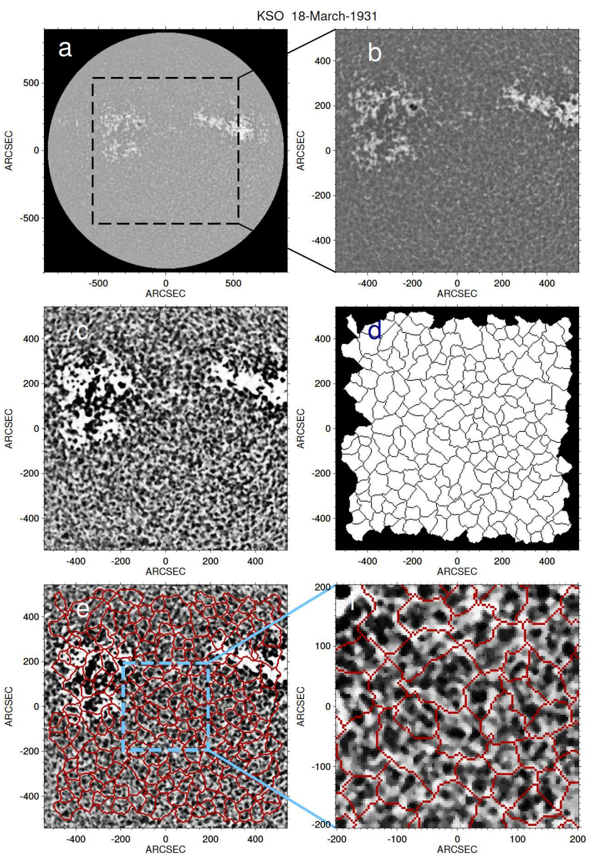

Figure 2.2: Different processing steps to detect supergranules. a) Ca II K disc centered image; b) A central window [as highlighted by the rectangle in (a)] used for further processing; c) Limb darkening corrected, intensity enhanced and smoothed version of (b); d) Detected supergranules using the Watershed transform [supergranule boundaries are shown in black]; e) Supergranule boundaries from (d) overplotted on (c); f) Magnified view of panel (e) having FoV of $400'' \times 400''$.

Kodaikanal Solar Observatory (KSO) has archived Ca II K full disc images in photographic plates and films from 1904 through 2007 with an unchanged optics. These data have been digitized and calibrated recently. The authors used the calibrated Ca II K spectroheliograms (1907–2007) to detect supergranules. They performed preprocessing and applied watershed method on the images to consistently segment supergranule boundaries/networks throughout the study time (Figure 2.2). Scales of those supergranule structures were calculated individually. Utilizing the plage detection presented in Chatterjee et al. (2016), the images were divided into active and quiet regions (AR, QRs). For supergranules of those two regions, the authors again calculated the scales, circularity and fractal dimension for the entire time span. All these time series were compared with sunspot number to understand how well correlated they are. The authors also explored how the effect of large-scale and small-scale magnetic fields can change the extent and sign of correlation with sunspot cycle (Chatterjee et al. 2017).
(The Astrophysical Journal, 2017, 841, 70)

(Chatterjee, S., Mandal, S., & Banerjee, D.)

Studies of synoptic solar activity using Kodaikanal Ca K data

The chromospheric network, the bright emission network seen in the chromospheric lines such as Ca II K and Hα, outline the supergranulation cells. The Ca images are dominated by the chromospheric network and plages which are good indicators of solar activity. Further, the Ca line is a good proxy to the UV irradiance which is particularly useful in the pre-satellite era where UV measurements are not available. The Ca spectroheliograms of the Sun from

Kodaikanal have a data span of about 100 years and covers over 9 solar cycles. The archival data is now available in the digitized form. Programs have been developed to obtain the activity indices and the length scales of the chromospheric network from the data. The preliminary results from the analysis are reported here. It is shown that the Ca II K intensity and the network boundary width are dependent on the solar cycle.
(Living around active stars Proceedings IAU Symposium No. 328, 2016 D. Nandi, A. Valio & P. Petit, eds.)

(K. P. Raju)

Simultaneous Longitudinal and Transverse Oscillations in an Active-Region Filament

Filaments support both longitudinal and transverse oscillations. In this work, the authors report a unique observation of the co-existence of large amplitude damped longitudinal oscillations and large amplitude damped transverse oscillations in an active-region filament. An M1.1 class flare was observed by the GOES satellite in Active Region AR 11692 on March 15, 2013. A filament was lying to the south-west of the active region as seen in Hα images from NSO/GONG as shown in Figure 2.3(a). By careful inspection of the Hα images, it appears that both longitudinal and transverse oscillations are present simultaneously in the filament. The period, damping time, and amplitude estimated from the fitting of a damped sinusoidal function as shown in Figure 2.3(b). The authors find that the oscillations in the two ends of the filament started with different phases, but with an almost identical oscillation period of 57 min. It is noted that the longitudinal oscillations at the two slit positions started at different times, possibly because the shock wave front interacted with the two parts of the filament at different time instances (see Figure 2.3(c)). The authors performed filament seismology and estimated the magnetic field strength at two dip locations. The estimated lower limit of the magnetic field strength $\sim(25\pm1)$ G at the location of both the slices, which is consistent with typical values of the measured magnetic field from observations.

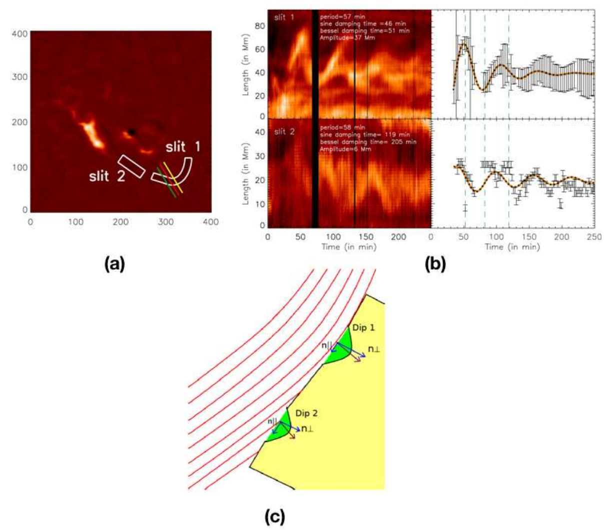

Figure 2.3: H-alpha filaments as seen from GONG and observed transverse and longitudinal oscillations. The cartoon depicts the scenario.

(Solar Physics, 2016, 291, 3303)

*(Pant, V. ; Mazumder, R.; *Yuan, D.; Banerjee, D.; *Srivastava, A. K.; *Shen, Y.)*

Comparison of Magnetic Properties in a Magnetic Cloud and Its Solar Source on 2013 April 11–14

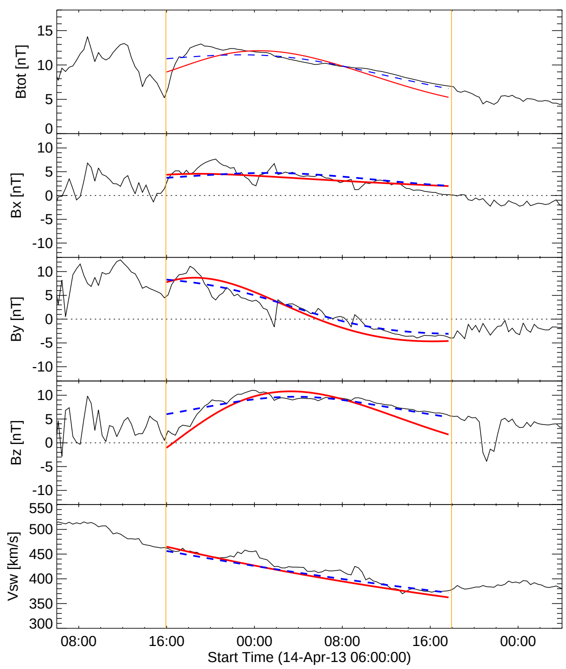

Figure 2.4: Cylindrically symmetric constant α linear force-free Lundquist model fitting (solid red) and non-linear force-free GH (dashed blue) model fitting, accounting effect of self-similar expansion, are potted against the in situ observations (black) in each panel. $T_0 = 1.1$ turn/AU is used for GH model.

In the context of the Sun–Earth connection of CMEs and magnetic flux ropes (MFRs), the authors studied the solar active region (AR) and the magnetic properties of magnetic-cloud (MC) event during 2013 April 14–15. The authors use in-situ observations from the ACE and source AR measurements from the SDO. The MCs magnetic structure is reconstructed from the Grad–Shafranov method, which reveals a northern component of the axial field with left handed helicity. The MC invariant axis is highly inclined to the ecliptic plane pointing northward and is rotated by 117° with respect to the source region PIL. The net axial flux and current in the MC are comparatively higher than from the source region. Linear force-free alpha distribution at the sigmoid leg matches the range of twist number in the MC of 1–2 au MFR. The MFR is nonlinear force-free with decreasing twist from the axis toward the edge. Therefore, a Gold–Hoyle (GH) configuration, assuming a constant twist, is more consistent with the MC structure than the Lundquist configuration of increasing twist from the axis to boundary. As an indication of that, the GH configuration yields a better fitting to the global trend of in-situ magnetic field components, in terms of rms, than the Lundquist model. These cylindrical configurations improved the MC fitting results when the effect of self-similar expansion of MFR was considered (Figure 2.4). For such twisting behavior, this study suggests an alternative fitting procedure to better characterize the MC magnetic structure and its source region links.
(ApJ, 2016, 828, 12)

(P. Vemareddy, C. Möstl, T. Amerstorfer*, W. Mishra*, C. Farrugia*, M. Leitner*)*

Variation in the Width of Transition Region Network Boundaries

The transition region network seen in solar extreme ultraviolet (EUV) lines is the extension of the chromospheric network. The network appears as an irregular web-like pattern over the solar surface outside active regions. The average width of transition region network boundaries is obtained from the two-dimensional autocorrelation function of SOlar and Heliospheric Observatory (SOHO)/ Coronal Diagnostic Spectrometer (CDS) synoptic images of the Sun in two emission lines, He I 586 Å and O V 630 Å during 1996 – 2012. The width of the network boundaries is found to be roughly correlated with the

solar cycle variation with a lag of about ten months. A comparison of the widths in the two emission lines shows that they are larger for the He I line. The SOHO/CDS data also show large asymmetry in boundary widths in the horizontal (x) and vertical (y) image directions, which is shown to be caused by image distortions that are due to instrumental effects. Since the network boundary widths are related to the magnetic flux concentration along the boundaries, the results are expected to have implications on the flux transport on the solar surface, solar cycle, and the mass and energy budget of network loops and jets.
(Solar Physics, 291, 3519, 2016)

(K. P. Raju)

Dynamics of subarcsecond bright dots in the transition region above sunspots and their relation to penumbral micro-jets

Sunspots are the region of concentrated strong magnetic fields seen in the photosphere of the Sun. They appear as dark in the central region known as umbra. Umbra is generally surrounded by a less darker region called penumbra. Though the sunspots have been observed over centuries, their fine structures and their counterparts in the higher solar atmosphere have been revealed in recent decades with the advancement of high-resolution and multi-wavelength observations. Penumbral micro-jets (PMJs) are one of the prominent fine-structure dynamic features observed by the Solar Optical Telescope (SOT) onboard the Hinode satellite in the sunspot at the chromospheric height. Furthermore, recently, high-resolution observations from the NASA's new Interface Region Imaging Spectrograph (IRIS) satellite reveal that small bright dots (BDs) appears ubiquitously in the transition region above sunspot penumbra. Both of these two prominent dynamical features in sunspots, one which is seen in the chromosphere (PMJs) and other which is seen in the transition region (BDs) are proposed to form due to the magnetic reconnection process. It is believed that the energy which releases during the reconnection process may play an important role in heating of the penumbra. Using simultaneous observation of the chromosphere from the SOT, the transition region from the IRIS and the corona using the Atmospheric Imaging Assembly (AIA) board the Solar Dynamics Observatory (SDO), the authors try to understand the formation mechanism of these dynamical features (BDs and PMJs) in the sunspot and their relation with each other.

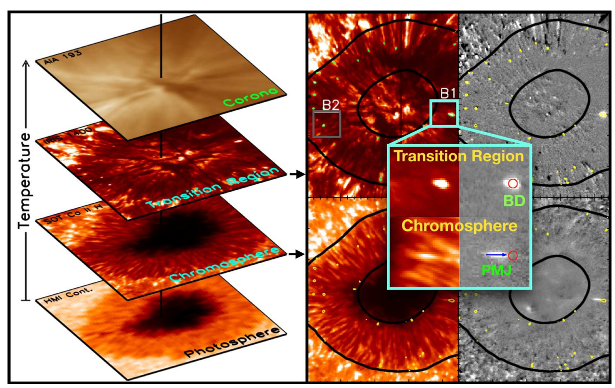

Figure 2.5: Multi layer atmosphere of the Sun (left panel) and Bright dots and penumbral Micro-jets (right panel).

(The Astrophysical Journal Letters, 2017, 835, L19)

*(Samanta, T., *Tian, H., Banerjee, D., & *Schanche, N.,)*

Peak flux of flares associated with Coronal Mass Ejections

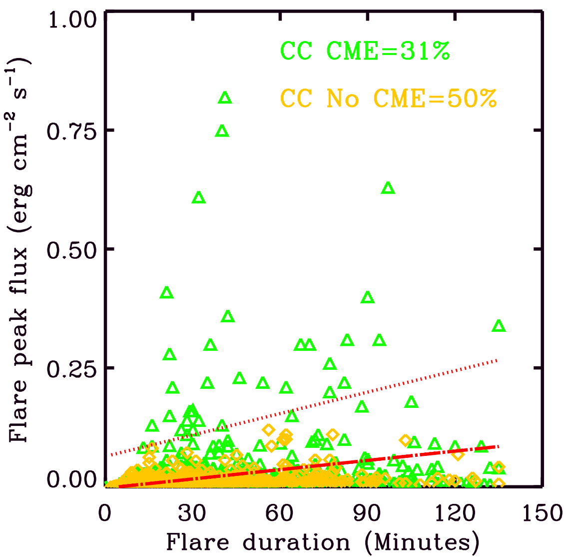

Figure 2.6: Peak flux of flares associated with CMEs is higher compared to peak flux of flares without associated CMEs. The dashed line represents the linear least squares fit for the data points (diamonds in yellow) representing the peak flux of flares associated with CMEs. The dashdotted line represents the linear least squares fit for the data points (triangles in green) representing the peak flux of flares without associated CMEs.

Findings such as the significant magnetic and current helicity in the case of active regions associated with both flares and coronal mass ejections in contrast to active regions where flares alone occur, presents a compelling reason to compare flares with and without associated flares. The authors use flare data from the solar geophysical data archive and the coronal mass ejections from the SOHO LASCO archive to study the difference between the two groups of flares. They find that the peak flux of flares associated with CMEs is distinctly higher across the entire range of flare durations. Higher peak flux of CME associated flares may be attributed to the sudden heating of plasma to higher temperature when associated with the ejection of CMEs.
(RAA, 2017, Vol. 17, No. 1, 7.)

*(Suryanarayana, G. S., *Balakrishna, K. M.)*

Transverse Oscillations in a Coronal Loop Triggered by a Jet

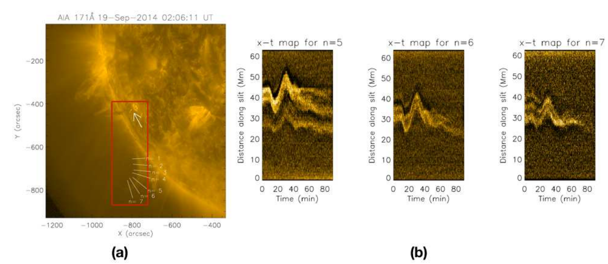

Figure 2.7: Image from the AIA instrument on board SDO (left panel) and observed oscillations in coronal loops (right panels).

Magnetohydrodynamic (MHD) waves are ubiquitous in the solar atmosphere. Kink oscillations (~95% of them) are triggered by nearby low coronal eruptions (LCE) observed in the extreme ultraviolet band. A statistical investigation of coronal loop oscillations observed with SDO found the association of transverse oscillations with blast waves that were due to a nearby flare, coronal mass ejections, type II radio bursts, etc. Thus different types of transients can trigger oscillations in nearby magnetic structures. In this study, the authors explored whether transients such as jets, which carry much less energy than coronal mass ejections (CMEs) or blast waves, can trigger oscillations in nearby coronal loops. A jet was originated from a

region close to the coronal loop as shown in the Figure 2.7(a). As the jet propagated outwards, transverse oscillations were observed in the coronal loop, lying at the south-east limb of the Sun. The observation was made using the extreme ultraviolet (EUV) passbands of the Atmospheric Imaging Assembly (AIA) onboard Solar Dynamics Observatory (SDO). Seven artificial slices were placed perpendicular to the coronal loop to detect transverse oscillations (Figure 2.7(a)). Corresponding to each slice, a time-distance map is generated as shown in Figure 2.7(b). Only one complete oscillation was detected with an average period of about 32 min. Using magnetohydrodynamic (MHD) seismologic inversion techniques, the magnetic field inside the coronal loop is estimated and found to be between 2.68 – 4.5 G. This is the first report on transverse oscillations triggered by a coronal jet.
(SoPh, 2016, 291, 3269)

*(*Sarkar, S.; Pant, V. ; *Srivastava, A. K.; Banerjee, D.)*

Constraining the solar coronal magnetic field strength using split-band type-II radio burst observations

Low-frequency radio (85-35 MHz) spectral observations of four different type II radio bursts, which exhibited fundamental-harmonic emission and split-band structure were reported. Each of the bursts was found to be closely associated with a whitelight coronal mass ejection (CME) close to the Sun. The authors estimated the coronal magnetic field strength from the split-band characteristics of the bursts, by assuming a model for the coronal electron density distribution. The choice of the model was constrained, based on the following criteria: (1) when the radio burst is observed simultaneously in the upper and lower bands of the fundamental component, the location of the plasma level corresponding to the frequency of the burst in the lower band should be consistent with the deprojected location of the leading edge (LE) of the associated CME; (2) the drift speed of the type II bursts derived from such a model should agree closely with the deprojected speed of the LE of the corresponding CMEs. With the above conditions, it is found that: (1) the estimated field strengths are unique to each type II burst, and (2) the radial variation of the field strength in the different events indicate a pattern. It is steepest for the case where the heliocentric distance range over which the associated burst is observed is closest to the Sun, and vice versa.

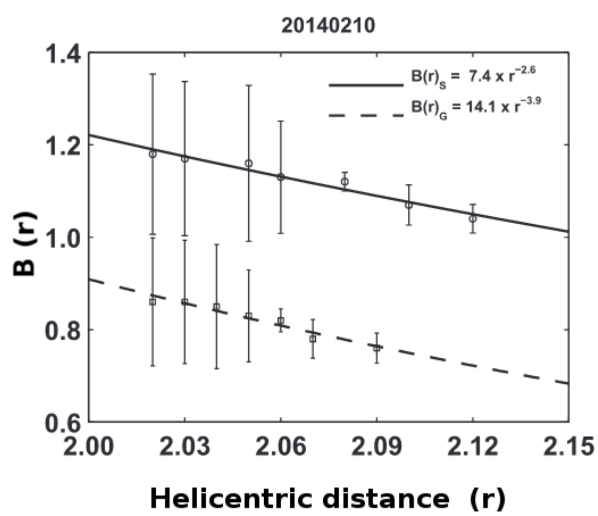

Figure 2.8: The magnetic field strength (B) estimated using the type-II spectrum observed with GLOSS on 10/02/2014. The circle and square symbols correspond to Saito and Gopalswamy models, respectively. The solid and dashed lines are the power law fit (with indices −2.6 and −3.9, respectively) to the estimates of the above models.

(ApJ, 2016, 832, 59)

*(Kishore, P., Ramesh, R., Hariharan, K., Kathiravan, C., *Gopalswamy, N.)*

Low-frequency radio observations of the solar corona with arcminute angular resolution: Implications for coronal turbulence and weak Energy Releases

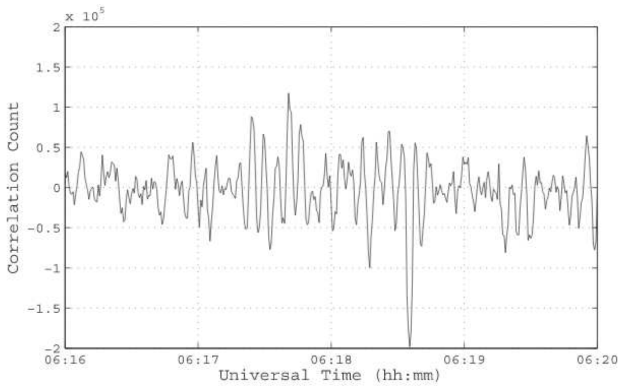

Figure 2.9: Interference fringes obtained with the long baseline interferometer setup when a type-III burst was observed on 09/08/2015. The fringes indicate the presence of structures in the solar corona whose sizes are less than an arcmin.

The authors of the present work report the first long baseline interferometer (length ≈8 km) observations of the solar corona at 37 MHz that were carried out recently with an approximate angular resolution of 1 arcmin at the Gauribidanur observatory. The results indicate that, (1) discrete radio sources of the aforesaid angular size or even lesser are present in the solar corona from where radiation at the above frequency originates. This constrains the angular broadening of radio sources at low frequencies due to scattering by density turbulence in the solar corona; and (2) the observed sources in the present case correspond to the weakest energy releases in the solar atmosphere reported so far. (ApJ, 2016, 831, 154)

*(Mugundhan, V., Ramesh, R., Barve Indrajit, V., Kathiravan, C., Gireesh, G. V. S., Kharb, P., *Misra, Apurva)*

Simultaneous near-Sun observations of a moving type IV radio burst and the associated white-light coronal mass ejection

The authors present a rare contemporaneous low-frequency (<100 MHz) imaging, spectral, and polarimetric observations of a moving type IV radio burst that had close spatio-temporal association with a white-light coronal mass ejection (CME) near the Sun. They estimate the electron density near the burst region from white-light coronagraph polarized brightness (pB) images of the CME as well as the two-dimensional radio imaging observations of the thermal free-free emission at a typical radio frequency such as 80 MHz. The authors analyze the burst properties such as the degree of circular polarization, the spectral index, and fine structures using the radio polarimeter and the radio spectral observations. The obtained results suggest that second harmonic plasma emission from the enhanced electron density in the leading edge of the CME is the cause of the radio burst. The strength of the coronal magnetic field (B) was determined for the first time based on this interpretation. The estimated value (B ≈ 1 gauss) in the CME leading edge at a heliocentric distance of $\approx 2.2 R_\odot$ agrees well with the similar B values reported earlier based on other types of observations.

Figure 2.10: A composite of the SOHO/LASCO–C2, SDO/AIA 193 images obtained on 31 March 2014 at 08:36 UT, and radio contours (up to 50% level) of the moving type IV burst observed that day with the GRAPH at 80 MHz. The enhanced white-light emission to the right of the radio burst source corresponds to the CME. The white circle (radius = 1 solar radii) at the center indicates the solar limb. The larger concentric gray circle (radius ∼2.2 solar radii) represents the occulting disk of the SOHO/LASCO–C2 coronagraph. Solar north is up and solar east is to the left in the image. The early stage of the CME can be noticed in the SDO/AIA 193 image also.

(SoPh, 2016, 291, 1405)

*(Hariharan, K., Ramesh, R., Kathiravan, C., *Wang, T. J.)*

Polarized Line Formation in Dynamic Atmospheres

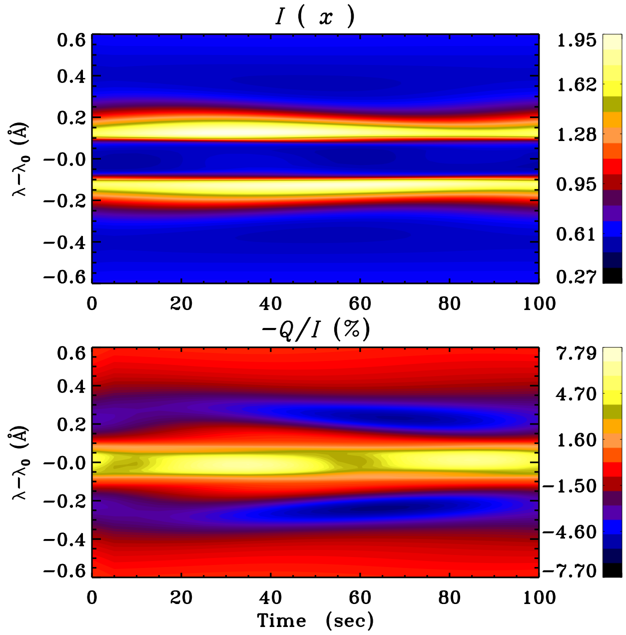

Figure 2.11: Time evolution of the emergent Stokes profiles of a very strong line formed in a semi-empirical atmosphere with a damped sine wave.

High-resolution observations of the outer layers of the Sun (namely, the chromosphere and transition region) show that these layers are not quiet and homogeneous but dynamic, and appear to change constantly on all observable scales. Analysis of such a complex environment requires detailed radiative transfer computations in dynamical atmospheres especially for optically thick lines. The linear polarization of radiation (which is produced by resonance scattering processes in these layers) is significantly affected by the dynamical nature of the solar (and in general stellar) atmospheres. In Sampoorna & Nagendra (2016), studies on the effect of non-relativistic non-monotonic time-dependent vertical velocity fields on the linearly polarized line profiles formed in semi-empirical atmospheres were presented. Figure 2.11 shows the response of a very strong line (representative of Ca II K line) to a damped sine wave in the atmosphere.

The effect of wave motion can be seen in the temporal fluctuation of the Doppler shifts and linear polarization amplitudes. Notice the distortions in profile shape produced by the velocity wave, which seem to propagate in wavelength space with an increase in time within a wave period.
(ApJ, 2016, 833, 32)

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

A scattering theory for coronal forbidden emission lines

The coronal magnetometry has been used ever since the detection of weak magnetic fields in the corona. Despite observations through ground and space borne coronographs, little has been understood about the nature of the coronal magnetic fields. One of the best ways to determine the properties of coronal magnetic fields is to study the polarization properties of coronal forbidden emission lines which are produced due to an anisotropic excitation of the ions present in the corona (see Figure 2.12a). Coronal forbidden emission lines arise from magnetic dipole (M1) transitions in these ions. In Megha et al. (2017), a theoretical framework has been developed based on classical oscillatory theory to calculate the polarized line profiles formed in the corona for the case of M1 transitions. This theory is applied to generate theoretical polarization diagram (see Figure 2.12b) corresponding to the Fe XIII 10747 Å line to explore diagnostic potential of this line. This theoretical work represents the first important step to handle Stokes line profiles data from spectro-polarimeters on board ADITYA-L1 mission.

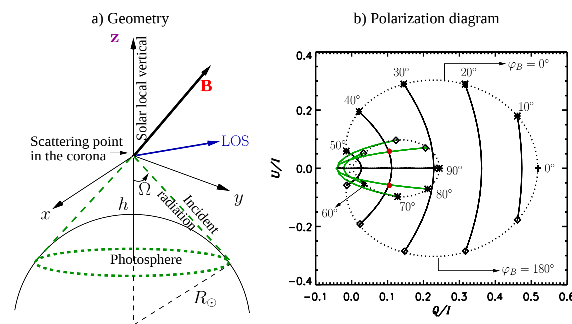

Figure 2.12: *Left*: Geometry describing the anisotropic illumination of ions in the corona by the photospheric radiation field. *Right*: Polarization diagram for varying field inclination and a constant field strength of 10 G. Line-of-sight is at a height of 0.5 solar radius above the solar limb. Apart from the traditional 180 degree ambiguity, notice the Van Vleck ambiguity around the field inclination of 54.7 degree.

(ApJ, 2017, 841, 129)

(Megha, A., Sampoorna, M., Nagendra, K. N., & Sankarasubramanian, K.)

2.2 Stellar and Galactic Astrophysics

Characterization of X-ray flare properties of AB Dor

Using the Sun as a prototype, the author addresses the strong similarities between the flares observed on the Sun and in low mass stars and the dynamo in these stars. The study presents an analysis of 30 intense X-ray flares observed on AB Dor using XMM-Newton data. The flares show a rapid rise (500-3000 s) and a slow decay (1000-6000 s). The study suggests that the scaling law between the flare temperature and flare emission measure is very similar to the relationship followed by solar flares. The frequency distribution of flare energies which is a crucial diagnostic to calculate the overall energy residing in a flare. The results of this study indicate that the large flare ($10^{33} <= E <= 10^{34}$ erg) may not contribute to the heating of the corona.
(IAUS, 2016, 320, 155L)

(Lalitha, S.)

Short-Term Hα Line Variations in Classical Be Stars: 59 Cyg and OT Gem

The authors present optical spectroscopic study of two classical Be stars, 59 Cyg and OT Gem obtained over a period of few months in 2009. They detected a rare triple-peak Hα emission phase in 59 Cyg and a rapid decrease in the emission strength of Hα in OT Gem, which are used to understand their circumstellar disks. The authors find that 59 Cyg is likely to be rapid rotator, rotating at a fractional critical rotation of ~0.80. The radius of the Hα emission region for 59 Cyg is estimated to be $R_d/R_* \sim 10.0$, assuming a Keplerian disk, suggesting that it has a large disk. The stars are classified that have shown triple-peaks into two groups and find that the triple-peak emission in 59 Cyg is similar to ζ Tau. OT Gem is found to have a fractional critical rotation of ~0.30, suggesting that it is either a slow rotator or viewed in low inclination. OT Gem is observed to have a large reduction in the radius of the Hα emission region from ~6.9 to ~1.7 in a period of three months, along with the reduction in the emission strength. The present observations suggest that the disk is lost from outside to inside during this disk loss phase in OT Gem.

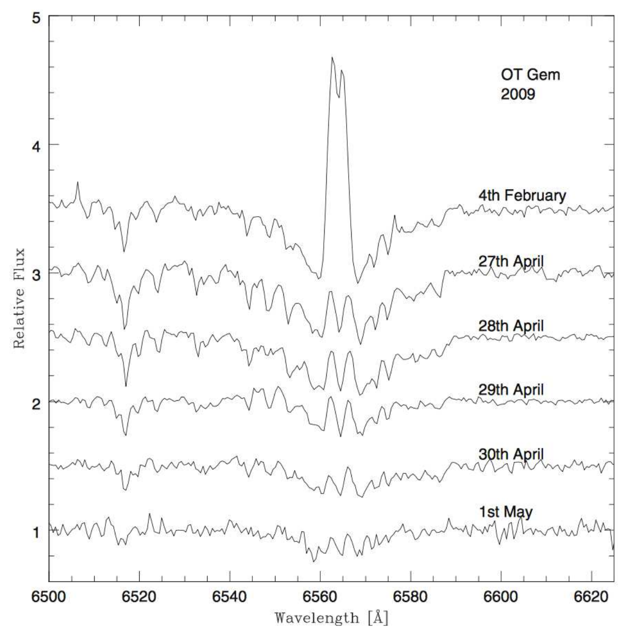

Figure 2.13: Time series of OT Gem Hα line from February to May 2009 obtained using 1.0-m telescope at VBO. Spectra are offset and labelled with the observation date, the oldest appears at the top and most recent at the bottom. Note that although the spectra are displayed evenly spaced, they are not evenly distributed in time.

(Journal of Astrophysics and Astronomy,

2017, Volume 38, Issue 1, article id.6, 10 pp.)

*(*Paul, K. T.; *Shruthi, S. B.; Subramaniam, Annapurni)*

Structure and variability in the corona of the ultrafast rotator LO Pegasi

Active low-mass ultrafast rotators produce flares, probably as a result of magnetic reconnection. Consequently the coronae of these stars exhibit very large X-ray luminosities and high plasma temperatures, as well as a pronounced inverse FIP effect. The authors observed LO Peg an ultrafast rotator with XMM-Newton and report the results of the observation and investigate the temporal evolution of coronal properties like the temperatures, emission measures, abundances, densities and the morphology of the involved coronal structures. They find two distinguishable levels of activity with significant X-ray variability both in phase and amplitude, implying the presence of an evolving active region on the surface. The X-ray flux varies by 28%, possibly due to rotational modulation. The authors report that during their observation of a large X-ray flare, at the onset of the flare they obtain clear signatures for the occurrence of the Neupert effect. During the flare a significant emission measure increase in the hotter plasma component is observed, while the emission measure in the cooler plasma component is only marginally affected, indicating that different coronal structures are involved. The flare plasma also shows an enhancement of iron by a factor of ≈2. The present studies show that the X-ray properties of the LO Peg are very similar to those of other low-mass ultrafast rotators, i.e., the X-ray luminosity is very close to saturation, its coronal abundances follow a trend of increasing abundance with increasing first ionisation potential, the so-called inverse FIP effect.
(A&A, 2017, 602A, 26L)

*(Lalitha, S.; *Schmitt, J. H. M. M.; *Singh, K. P.)*

Constraints of the physics of low-mass AGB stars from CH and CEMP stars

The authors of the present work analyze an already published sample of CH stars, whose spectra have been taken with the ELODIE and HDS spectrographs. All spectra have been reduced with the same atmosphere model and, thus, they represent the largest CH homogeneous sample available to date. For this reason, the sample can be used to constrain the physics and the nucleosynthesis occurring in the internal layers of low mass AGB stars. CH stars, in fact, have been polluted in their past evolution from an already extinct AGB companion and, thus, show s-process enriched surfaces. The effects induced by different prescriptions for convection and rotation on the expected AGB s-process distributions are discussed. The reference theoretical FRUITY set only fits part of the observations. Moreover, the s-process observational spread for a fixed metallicity cannot be reproduced. At [Fe/H]> -1, a good fit is found when rotation and a different treatment of the inner boundary of the convective envelope are simultaneously taken into account. In order to increase the statistics at low metallicities, a selected number of CEMP stars are included in the analysis and, therefore, additional AGB models are computed down to [Fe/H] $= -2.85$. Present theoretical models are

unable to attain the large [hs/ls] ratios characterizing the surfaces of those objects. It is speculated that on the reasons of such a discrepancy, verifying the possibility that the observed distributions derive from a proton mixing episode leading to very high neutron density (the so-called i-process).
(The Astrophysical Journal, 2016, 833, 181)

(Sergio Cristallo, Drisya Karinkuzhi, Aruna Goswami, L Piersanti*, and D. Gobrecht*)*

Abundance analyses of the new R Coronae Borealis stars: ASAS-RCB-8 and ASAS-RCB-10

Abundance analyses of the two newly discovered R Coronae Borealis (RCB) stars ASAS-RCB-8 and ASAS-RCB-10 were conducted using high-resolution optical spectra and model atmospheres. Their chemical compositions place the pair among the majority class of RCBs. ASAS-RCB-10 is one of the most N-poor majority RCBs with an above average O abundance. Relative to ASAS-RCB-10, ASAS-RCB-8 is H poor by 1.6 dex, O-poor by 0.7 dex but N-rich by 0.8 dex suggesting a higher contamination by CNO-cycled material.
(Accepted in PASP)

*(B. P. Hema, Gajendra Pandey, *Devika Kamath, N. Kameswara Rao, *David Lambert, and *Vincent M. Woolf)*

Non-Local Thermodynamic Equilibrium abundance analyses of the extreme helium stars: V652 Her and HD 144941.

Optical high-resolution spectra of V652 Her and HD 144941, the two extreme helium stars with exceptionally low C/He ratios, have been subjected to a non-LTE abundance analysis using the tools TLUSTY and SYNSPEC. Defining atmospheric parameters were obtained from a grid of non-LTE atmospheres and and a variety of spectroscopic indicators including He I and He II line profiles, ionization equilibrium of ion pairs such as C II/C III and N II/N III. The various indicators provide a consistent set of atmospheric parameters. In contrast to the non-LTE analyses, the LTE analyses – LTE atmospheres and a LTE line analysis – with the available indicators do not provide a consistent set of atmospheric parameters. The principal non-LTE effect on the elemental abundances is on the neon abundance. It is generally considered that these extreme helium stars with their very low C/He ratio result from the merger of two helium white dwarfs. Indeed, the derived composition of V652 Her is in excellent agreement with predictions by Zhang & Jeffery (2012) who model the slow merger of helium white dwarfs; a slow merger results in the merged star having the composition of the accreted white dwarf. In the case of HD 144941 which appears to have evolved from metal-poor stars a slow merger is incompatible with the observed composition but variations of the merger rate may account for the observed composition. More detailed theoretical studies of the merger of a pair of helium white dwarfs are to be encouraged.
(Submitted to ApJ)

*(Gajendra Pandey and *David L. Lambert)*

SUBARU/HDS study of CH stars: elemental abundances for stellar

neutron-capture process studies

A comprehensive abundance analysis that are likely to provide rare insight into the chemical history of lead stars is still lacking. The authors present results from high resolution (R $\sim$ 50000), spectral analyses of three CH stars, HD 26, HD 198269, and HD 224959. Considering local thermodynamic equilibrium and using model atmospheres, they have derived the stellar parameters, the effective temperatures T_{eff}, surface gravities log g, and metallicities [Fe/H] for these objects. The stars are found to exhibit large enhancements of heavy elements relative to iron in conformity of previous studies. Large enhancement of Pb with respect to iron is also confirmed. Updates on the elemental abundances for several s-process elements (Y, Zr, La, Ce, Nd, Sm, Pb) along with the first-time estimates of abundances for a number of other heavy elements (Sr, Ba, Pr, Eu, Er, W) are reported. The relative contribution of the two neutron-capture processes, r and s, to the observed abundances of heavy elements are examined using a parametric model based analysis. The present analysis suggest that neutron-capture elements in HD 26 primarily originate in s-process while the major contributions to the abundances of neutron-capture elements in the more metal-poor objects HD 224959 and HD 198269 are from r-process. It is possible that the latter two objects are formed mostly from materials that are pre-enriched with products of r-process.
(MNRAS, 2016, 455, 402)

(Aruna Goswami, Aoki Wako, Drisya Karinkuzhi))*

Abundance analysis of light s-process enhanced mild barium stars

Detailed chemical composition studies of stars with enhanced abundances of neutron-capture elements can provide observational constraints for neutron-capture nucleosynthesis studies and clues for understanding their contribution to the Galactic chemical enrichment. The authors present abundance results from high-resolution spectral analyses of a sample of four chemically peculiar stars characterized by s-process enhancement. High-resolution spectra (R $\sim$ 42000) of these objects spanning a wavelength range from 4000 to 6800 Å are taken from the ELODIE archive. The authors have estimated the stellar atmospheric parameters, the effective temperature T_{eff}, the surface gravity log g and metallicity [Fe/H] from local thermodynamic equilibrium analysis using model atmospheres. They report estimates of elemental abundances for several neutron-capture elements, Sr, Y, Zr, Ba, La, Ce, Pr, Nd, Sm, Eu and Dy. While HD 49641 and HD 58368 show [Ba/Fe] $\geq$ 1.16, the other two objects HD 119650 and HD 191010 are found to be mild barium stars with [Ba/Fe] $\sim$ 0.4. The derived abundances of the elements are interpreted on the basis of existing theories for understanding their origin and evolution.
(MNRAS, 2016, 463, 1213)

(Upakul Mahanta, Drisya Karinkuzhi, Aruna Goswami, Kalpana Duorah*))*

Chemical analysis of a Carbon-enhanced very metal-poor star: CD-27 14351

The authors present the first time abundance analysis of a very metal-poor carbon-enhanced star CD−27 14351 based on a high

resolution (R $\sim$ 48,000) FEROS spectrum. The abundance analysis performed using Local Thermodynamic Equilibrium (LTE) model atmospheres shows that the object is a cool star with stellar atmospheric parameters, effective temperature T_{eff} = 4335 K, surface gravity log g = 0.5, microturbulence = 2.42 km/s, and, metallicity [Fe/H] = −2.6. The star exhibits high carbon and nitrogen abundances with [C/Fe] = 2.89 and [N/Fe] = 1.89. Overabundances of neutron-capture elements are evident in Ba, La, Ce, and Nd with estimated [X/Fe] > 1, the largest enhancement being seen in Ce with [Ce/Fe] = 2.63. While the first peak s-process elements Sr and Y are found to be enhanced with respect to Fe, ([Sr/Fe] = 1.73 and [Y/Fe] = 1.91) the third peak s-process element Pb could not be detected in the spectrum at the given resolution. Europium, primarily a r-process element also shows an enhancement with [Eu/Fe] = 1.65. With [Ba/Eu] = 0.12 the object CD−27 14351 satisfies the classification criterion for CEMP-r/s star. The elemental abundance distributions observed in this star is discussed in light of chemical abundances observed in other CEMP stars from literature.
(The Astrophysical Journal, 2017, 834, 61)

(Drisya Karinkuzhi, Aruna Goswami, and Thomas Masseron)*

Binarity and Accretion activities in AGB stars and shaping of Planetary Nebulae

The geometry and the mass-ejection during the AGB to PN transformation are widely believed to be due to binarity, however the observational probes are lacking. The authors have undertaken a programme to obtain multi-epoch UV spectra using HST/STIS of a few late type stars, Y Gem and EY Hya, that show strong and variable far-UV fluxes. These observations show a strong and variable accretion of matter onto an accretion disk in a binary systems. The continuum will be used to derive the temperature and size of the accretion hotspot and the line emission provides the physical parameters of the flow. Optical counterpart of the UV variation is monitored using VBT echelle spectrograph to track the velocities and time scales of the enhanced mass transfer and subsequent ejection of bullets. These bullets are believed to shape the circumstellar envelopes around late AGB stars which later can be evolved to different aspherical morphologies of planetary nebulae.

(C. Muthumariappan, R. Sahai, M. Morris*, S. Scibelli*)*

A Hot Companion to a Blue Straggler in NGC 188 as Revealed by the Ultra-Violet Imaging Telescope (UVIT) on ASTROSAT

The capability of UVIT to accurately estimate the parameters of binary systems, using its filter systems was demonstrated in this work. The result was announced by ISRO in their *highlight of the week*, and was covered by various news papers. The authors present early results from the Ultra-Violet Imaging Telescope (UVIT) on board the ASTROSAT observatory and the discovery of a hot companion associated with one of the blue straggler stars (BSSs) in the old open cluster, NGC 188. Using fluxes measured in four filters in UVIT's far-UV (FUV) channel, and two filters in the near-UV (NUV)

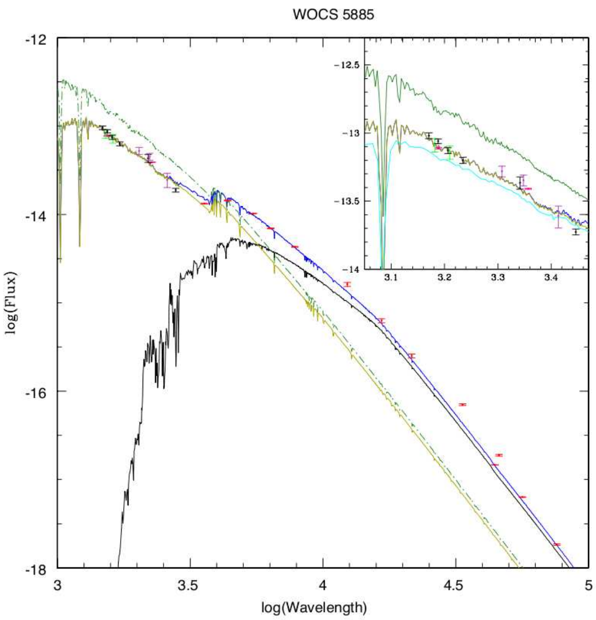

Figure 2.14: The extinction-corrected spectral energy distribution (SED) of WOCS-5885. The black (UVIT), magenta (GALEX) and green (UIT), pink (UVOT) points indicate the UV fluxes (shown in the inset as well); all other flux measurements are shown in red. Kurucz Model spectra (Log(g) = 5.0) for the separate components are shown in gold (17 000 K) and black (6 000 K), with the composite spectrum in blue. For comparison, a hotter spectrum of temperature (20 000 K) is shown in dark green. A helium rich model spectrum is also shown for a temperature of 16 000 K, $\log g = 4.0$, H= 0.30, He =0.70, and CN = 0.00005 from Jeffery et al. (2001), in Cyan. Scaling factors of 4.45E-22 and 3.1E-23 have been used to combine the 6 000 K and 17 000 K spectra, respectively. The unit of wavelength is Å and flux is $ergs\ cm^{-2}\ s^{-1}\ \AA^{-1}$. The data points which were not considered for the final reduced χ^2 value are, GALEX(NUV), U, W1, W2, I2, I3.

channel, the spectral energy distribution (SED) of the star WOCS-5885 was constructed, after combining with flux measurements from GALEX, Ultraviolet Imaging Telescope, Ultraviolet Optical Telescope, SPITZER, WISE, and several ground-based facilities. The resulting SED spans a wavelength range of 0.15 μm to 7.8 μm. This object is found to be one of the brightest FUV sources in the cluster. Bigger and more luminous than a white dwarf, yet cooler than a sub-dwarf, the authors speculate that it is a post-AGB/HB star that has recently transferred its mass to the BSS, which is known to be a rapid rotator. This binary system, which is the first BSS with a post-AGB/HB companion identified in an open cluster, is an ideal laboratory to study the process of BSS formation via mass transfer.
(ApJ Letters, 2016, Volume 833, p27)

*(Annapurni, Subramaniam; Sindhu, N.; Tandon S., N.; Kameswara, Rao N.; *Postma, J.; *Patrick, Côté; *Hutchings, J.; *Ghosh S., K.; K., George; *Girish, V.; Mohan, R.; Murthy, J.; Sankarasubramanian, K.; Stalin C., S.; Sutaria, F.; Mondal, C.; Sahu, S.)*

The evolution of the Milky Way: new insights from open clusters

The authors of the present work analysed high-dispersion spectra of red giant members in the 12 open clusters (OCs) and derived stellar parameters and chemical abundances for 26 species for them. They confirm that the radial metallicity gradient of OCs is steeper (flatter) for $R_{gc} < 12$ kpc (>12 kpc). They demonstrate that the sample of clusters constituting a steep radial metallicity gradient of slope -0.052 ± 0.011 dex kpc^{-1} at $R_{gc} < 12$ kpc are younger than 1.5 Gyr and located close to the Galactic mid-plane ($|z| < 0.5$ kpc) with kinematics typical of the thin

disc. Whereas the clusters describing a shallow slope of -0.015 ± 0.007 dex kpc^{-1} at R$_{gc} > 12$ kpc are relatively old, thick disc members with a striking spread in age and height above the mid-plane ($0.5 < | z | < 2.5$ kpc). The present investigation reveals that the OCs and field stars yield consistent radial metallicity gradients if the comparison is limited to samples drawn from the similar vertical heights. The authors argue via the computation of Galactic orbits that all the outer disc clusters were actually born inwards of 12 kpc but the orbital eccentricity has taken them to present locations very far from their birthplaces.
(MNRAS, 2016, 463, 4366)

*(*Reddy, Arumalla B. S.; *Lambert, David L.; Giridhar, Sunetra)*

CCD time-series photometry of variable stars in globular clusters and the metallicity dependence of the horizontal branch luminosity

The authors describe and summarize the findings from their CCD time-series photometry of globular clusters (GCs) program and the use of difference image analysis (DIA) in the extraction of very precise light curves even in the crowded central regions down to $V \approx$19 mag. They have discovered approximately 250 variable stars in a sample of 23 selected GCs and have, therefore, updated the census of variables in each system and in some cases they have actually completed it down to a certain magnitude. The absolute magnitude and [Fe/H] for each individual RR Lyrae is obtained via the Fourier decomposition of the light curve. An average of these parameters leads to the distance and metallicity of the host GCs. The authors have also calibrated the $P-L$ relation for SX Phe stars which enables an independent calculation of the cluster distance. They present the mean [Fe/H], M$_V$ and distance for a group of selected GCs based exclusively on the RR Lyrae light curve Fourier decomposition technique and set on a rather unprecedented homogeneous scale. The luminosity dependence of the horizontal branch (HB) via the M$_V$-[Fe/H] relation is also discussed. It is found that this relation should be considered separately for the RRab and RRc stars.
(RMxAA, 2017, 53, 121)

*(*Arellano Ferro, A.; *Bramich, D. M.; Giridhar, S.)*

Interstellar Medium and Star Formation Studies with the Square Kilometre Array

Stars and planetary systems are formed out of molecular clouds in the interstellar medium. Although the sequence of steps involved in star formation are generally known, a comprehensive theory which describes the details of the processes that drive formation of stars is still missing. The Square Kilometre Array (SKA), with its unprecedented sensitivity and angular resolution, will play a major role in filling these gaps in our understanding. The authors present a few science cases that the Indian star formation community is interested in pursuing with SKA, which include investigation of AU-sized structures in the neutral ISM, the origin of thermal and non-thermal radio jets from protostars and the accretion history of protostars, and formation of massive stars and their effect on the surrounding medium.
(Journal of Astrophysics and Astronomy,

2016, 37, 38)

*(*Manoj, P. , *Vig, S., *Maheswar, G., Kamath, U. S., & *Tej, A)*

Modulation of X-ray emission due to planetary positions

Star-planet interaction (SPI) can be induced by magnetic and tidal fields. Magnetic heating of the star by the planet can be detected as stellar activity modulated with the orbital period. The authors of the present work present the multi epoch X-ray study of planet-bearing star HD 162020 with a 14 Jupiter mass planet at 0.074 au. They compare the X-ray fluxes and variation of the spectra at different epochs. They find weak indications of an influence of the planet on their host stars that might cause X-ray activity.
(Submitted for publication in A&A)

*(Lalitha Sairam and *Spandan Dash)*

X-ray properties of magnetically active planet-bearing host stars

A large amount of high-energy radiation can be produced by stellar activity, which is absorbed by the atmosphere of the planet leading to mass-loss by irradiation. The authors present a systematic study of high-energy emission in planet-bearing host stars, Kepler-63, Kepler-210, WASP-19 and HAT-P-11, based on XMM-Newton observations. They derived the X-ray luminosities which determines the energy input for the planetary atmosphere and the corresponding activity levels.
(Submitted for publication in MNRAS)

(Lalitha Sairam, Spandan Dash and J. H. M. M. Schmitt*)*

Temperate Earth-sized planets transiting a nearby ultracool dwarf star

Star-like objects with effective temperatures of less than 2,700 K are referred to as ultracool dwarfs. This heterogeneous group includes stars of extremely low mass as well as brown dwarfs (substellar objects not massive enough to sustain hydrogen fusion), and represents about 15 per cent of the population of astronomical objects near the Sun. Core-accretion theory predicts that, given the small masses of these ultracool dwarfs, and the small sizes of their protoplanetary disk, there should be a large but hitherto undetected population of terrestrial planets orbiting them–ranging from metal-rich Mercury-sized planets to more hospitable volatile-rich Earth-sized planets. Three short-period Earth-sized planets transiting an ultracool dwarf star Trappist-1, only 12 parsecs away are discovered. The inner two planets receive four times and two times the irradiation of Earth, respectively, placing them close to the inner edge of the habitable zone of the star. The data suggest that 11 orbits remain possible for the third planet, the most likely resulting in irradiation significantly less than that received by Earth. The infrared brightness of the host star, combined with its Jupiter-like size, offers the possibility of thoroughly characterizing the components of this nearby planetary system.
(Nature, 2016, vol 533, page 221)

*(*Gillon, Michael et al. (including D K Sahu))*

Recurrent Nova in M31

The most recent outburst of the recurrent nova M31N 2008-12a in the Andromeda galaxy that occurred on 10 December 2016 was observed spectroscopically and photometrically with the HCT, on days 3 and 4 since discovery. This recurrent nova is remarkable in having a recurrence period of $\sim$ 1 year only. The HCT spectra showed hydrogen Balmer lines, and appeared similar to that seen in previous eruptions. The FWHM velocity of the Hα line was measured to be $\sim$ 2900 km/s on Dec 13.58 and $\sim$ 2700 km/s on Dec 14.55.

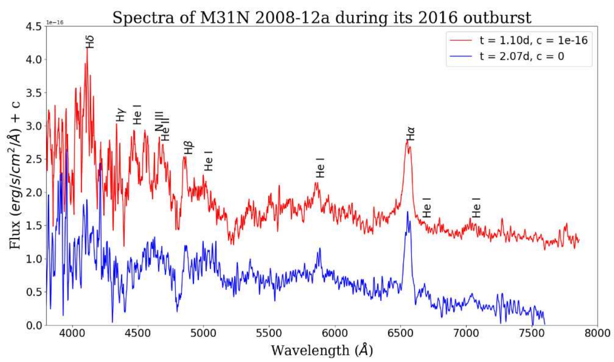

Figure 2.15: HCT Spectra of the recurrent nova M31N 2008-12a during its 2016 outburst.

(Astronomer's Telegram, 2016, 9865, 1)

(M. Pavana, G. C. Anupama)

Dead or Alive? Long-term evolution of SN 2015bh (SNhunt275)

Supernova (SN) 2015bh (or SNhunt275) was discovered in NGC 2770 on 2015 February with an absolute magnitude of $M_r \sim -13.4$ mag, and was initially classified as a SN impostor. Photometric and spectroscopic evolution of SN 2015bh from discovery to late phases ($\sim$ 1 yr after) was studied using data collected from various observing facilities. The archival images of the host galaxy up to $\sim$ 21 yr before discovery, revealed a burst $\sim$ 1 yr before discovery, and further signatures of stellar instability until late 2014. Later on, the luminosity of the transient slowly increases, and a broad light curve peak is reached after about three months. It is proposed that the transient discovered in early 2015 could be a core-collapse SN explosion. The pre-SN luminosity variability history, the long-lasting rise and faintness of first light curve peak suggest that the progenitor was a very massive, unstable and blue star, which exploded as a faint SN because of severe fallback of material. Later on, the object experiences a sudden brightening of 3 mag, which results from the interaction of the SN ejecta with circumstellar material formed through repeated past mass-loss events. Spectroscopic signatures of interaction are however visible at all epochs.
(MNRAS, 2016, vol 463, page 3894)

*(*Elias-Rosa, N et al. (including G C Anupama and D K Sahu))*

Thermonuclear Supernovae

Type Ia supernovae with a relatively high $\Delta m_{15}(B)$, relatively low ejecta velocity, a moderate velocity gradient and a peculiar evolution of R(Si II) line ratio have been termed as transitional type Ia events. They have fainter absolute B maximum and produce less ^{56}Ni compared to normal type Ia bridging the gap between the "normal" and the faint events. This is a rare class, with only a few well studied objects. Transitional SNe iPTF13ebh and SN 2015bp

were studied in detail spanning the pre-maximum, maximum and post-maximum phases. iPTF13ebh and SN 2015bp both showed a decline rate faster than seen in normal type Ia, with $\Delta m_{15}(B) = 1.79 \pm 0.01$ and $\Delta m_{15}(B) = 1.72 \pm 0.04$, respectively. Both objects showed C II 6580 Å feature in the pre-maximum phase. The velocity gradient of the Si II 6355 Å line in the post-maximum epoch placed both iPTF13ebh and SN 2015bp in the FAINT subclass. The respective bolometric light curves indicate the amount of ^{56}Ni synthesized to be ~ 0.28 $M_\odot$ in iPTF13ebh and $\sim$ 0.2 $M_\odot$ in SN 2015bp. Although the amount of ^{56}Ni synthesized is similar in iPTF13ebh and SN 2015bp, the ejected mass was found to be different, at $M_{ej} = 1.26$ $M_\odot$ and $M_{ej} = 0.9$ $M_\odot$ respectively. SN 2015bp appeared to be a sub-Chandrasekhar mass white dwarf event. The studies of these two objects highlight the diversity within the transitional Ia events, and the need for the study of more such events.
(MNRAS, 2017, (accepted))

(S. Srivastav, G. C. Anupama, D. K. Sahu, C. D. Ravikumar)*

Core Collapse Supernovae

[1] The analysis of the optical photometric and spectroscopic data of the supernova ASASSN-14dq obtained with the HCT indicated the supernova to be a type IIP event, with a plateau of $\sim$ 85 days. Preliminary results indicated $\sim 0.04 M_\odot$ of ^{56}Ni was synthesized during the explosion.
(Poster presented at ASI–2016)

(Avinash Singh, Shubham Srivastav, G. C. Anupama, D. K. Sahu)

[2] The nearby type Ic supernova ASASSN-16fp (SN 2016coi) was monitored fairly extensively with the HCT. The analysis of the data obtained during the early phase (-10 to $+33$ days with respect to $B-$maximum) indicates the event to have a slow photometric evolution, similar to the broad-lined Ic events such as SN 2002ap and SN 2012ap. However, the expansion velocity at $\sim$ 16000 km s^{-1} is lower than that seen in the other two events. Analytical modelling of the quasi-bolometric light curve suggests a kinetic energy of $\sim 7 \times 10^{51}$ erg, with a total ejected mass estimate of ~ 4.5 $M_\odot$, and a ^{56}Ni mass estimate of ~ 0.1 $M_\odot$.
(Submitted to MNRAS)

(Brajesh Kumar, Avinash Singh, Shubham Srivastav, D. K. Sahu, G. C. Anupama)

Optical Variability of Narrow-line and Broad-line Seyfert 1 Galaxies

The authors of the present work studied optical variability (OV) of a large sample of narrow-line Seyfert 1 (NLSy1) and broad-line Seyfert 1 (BLSy1) galaxies with $z < 0.8$ to investigate any differences in their OV properties. Using archival optical V-band light curves from the Catalina Real Time Transient Survey that span 5–9 years and modeling them using damped random walk, the authors estimated the amplitude of variability. They found NLSy1 galaxies as a class show lower amplitude of variability than their broad-line counterparts. In the

sample of both NLSy1 and BLSy1 galaxies, radio-loud sources are found to have higher variability amplitude than radio-quiet sources. Considering only sources that are detected in the X-ray band, NLSy1 galaxies are less optically variable than BLSy1 galaxies. The amplitude of variability in the sample of both NLSy1 and BLSy1 galaxies is found to be anti-correlated with Fe II strength but correlated with the width of the Hβ line. The well-known anti-correlation of variability-luminosity and the variability-Eddington ratio is present in the data. Among the radio-loud sample, variability amplitude is found to be correlated with radio-loudness and radio-power suggesting jets also play an important role in the OV in radio-loud objects, in addition to the Eddington ratio, which is the main driving factor of OV in radio-quiet sources.
(ApJ, 2017, 842, 96R)

(Rakshit, Suvendu; Stalin, C. S.)

Spectral and time series analyses of the Seyfert 1 AGN: Zw 229.015

The authors of the present work analyse the spectra of the archival XMM–Newton data of the Seyfert 1 AGN Zw 229.015 in the energy range 0.3–10.0 keV. When fitted with a simple power law, the spectrum shows signatures of weak soft excess below 1.0 keV. The authors find that both thermal Comptonization and relativistically blurred reflection models provide the most acceptable spectral fits with plausible physical explanations to the origin of the soft excess than do multicolour disc blackbody and smeared wind absorption models. This motivated them to study the variability properties of the soft and the hard X-ray emissions from the source and the relationship between them to put further constraints on the above models. The present analysis reveals that the variation in the 3.0–10.0 keV band lags that in the 0.3–1.0 keV by 600^{+290}_{-280} s, while the lag between the 1.0–10.0 keV and 0.3–1.0 keV is 980^{+500}_{-500} s. This implies that the X-ray emissions are possibly emanating from different regions within the system. From these values, the authors estimate the X-ray emission region to be within $20R_g$ of the central supermassive black hole (where $R_g = GM/c^2$, M is the mass of black hole, G Newton's gravitational constant and c the speed of light). Furthermore, they use XMM–Newton and Kepler photometric light curves of the source to search for possible non-linear signature in the flux variability.
(MNRAS, 2017, 466, 3951A)

*(*Adegoke, Oluwashina; Rakshit, Suvendu; *Mukhopadhyay, Banibrata)*

A Catalog of Narrow Line Seyfert 1 Galaxies from the Sloan Digital Sky Survey Data Release 12

The authors present a new catalog of narrow-line Seyfert 1 (NLSy1) galaxies from the Sloan Digital Sky Survey Data Release 12 (SDSS DR12). This was obtained by a systematic analysis through modeling of the continuum and emission lines of the spectra of all the 68,859 SDSS DR12 objects that are classified as "QSO" by the SDSS spectroscopic pipeline with z < 0.8 and a median signal-to-noise ratio (S/N) > 2 pixel^{-1}. This catalog contains a total of 11,101 objects, which is about 5 times larger than the previously known NLSy1 galaxies. Their monochromatic continuum luminosity at 5100 Å is found to be strongly correlated with Hβ, Hα, and [O III] emission line

luminosities. The optical Fe II strength in NLSy1 galaxies is about two times larger than the broad- line Seyfert 1 (BLSy1) galaxies. About 5% of the catalog sources are detected in the FIRST survey. The Eddington ratio (ξ_{Edd}) of NLSy1 galaxies has an average of log ξ_{Edd} of -0.34, much higher than -1.03 found for BLSy1 galaxies. Their black hole masses (M_{BH}) have an average of log M_{BH} of 6.9 $M_{\odot}$, which is less than BLSy1 galaxies, which have an average of log M_{BH} of 8.0 $M_{\odot}$. The M_{BH} of NLSy1 galaxies is found to be correlated with their host galaxy velocity dispersion. The present analysis suggests that geometrical effects playing an important role in defining NLSy1 galaxies and their M_{BH} deficit is perhaps due to their lower inclination compared to BLSy1 galaxies.
(ApJS, 2017, 229, 39R)

*(Rakshit, Suvendu; Stalin, C. S.; *Chand, Hum; *Zhang, Xue-Guang)*

X-ray flux variability of active galactic nuclei observed using NuSTAR

The authors present results of a systematic study of flux variability on hourly timescales in a large sample of active galactic nuclei (AGN) in the 3–79 keV band using data from Nuclear Spectroscopic Telescope Array. Their sample consists of four BL Lac objects (BL Lacs), three flat spectrum radio quasars (FSRQs) 24 Seyfert 1, 42 Seyfert 2 and eight narrow line Seyfert 1 (NLSy1) galaxies. They find that in the 3–79 keV band, about 65 per cent of the sources in their sample show significant variations on hourly time-scales. Using the Mann–Whitney U-test and the Kolmogorov–Smirnov test, the authors find no difference in the variability behaviour between Seyfert 1 and 2 galaxies. The blazar sources (FSRQs and BL Lacs) in the sample are more variable than Seyfert galaxies that include Seyfert 1 and Seyfert 2 in the soft (3–10 keV), hard (10–79 keV) and total (3–79 keV) bands. NLSy1 galaxies show the highest duty cycle of variability (87 per cent), followed by BL Lacs (82 per cent), Seyfert galaxies (56 per cent) and FSRQs (23 per cent). The authors obtained flux doubling/halving time in the hard X-ray band less than 10 min in 11 sources. The flux variations between the hard and soft bands in all the sources in their sample are consistent with zero lag.
(MNRAS, 2017, 466, 3309R)

(Rani, Priyanka; Stalin, C. S.; Rakshit, Suvendu)

2.3 Cosmology and Extragalactic Astronomy

Star clusters in the Magellanic Clouds - I. Parametrization and classification of 1072 clusters in the LMC

The authors introduced a semi-automated quantitative method to estimate the age and reddening of 1072 star clusters in the Large Magellanic Cloud (LMC) using the Optical Gravitational Lensing Experiment III survey data. This study brings out 308 newly parametrized clusters. In a first of its kind, the LMC clusters are classified into groups based on richness/mass as very poor, poor, moderate and rich clusters, similar to the classification scheme of open clusters in the Galaxy. A major cluster formation episode is found to happen at 125 ± 25 Myr in the inner LMC. The bar region of the LMC appears prominently in the age range 60-250 Myr and is found to have a relatively higher concentration of poor and moderate clusters. The eastern and the western ends of the bar are found to form clusters initially, which later propagates to the central part. It is demonstrated that there is a significant difference in the distribution of clusters as a function of mass, using a movie based on the propagation (in space and time) of cluster formation in various groups. The importance of including the low-mass clusters in the cluster formation history is demonstrated. The catalogue with parameters, classification, and cleaned and isochrone fitted colour-magnitude diagrams of 1072 clusters, which are available as online material, can be further used to understand the hierarchical formation of clusters in selected regions of the LMC.

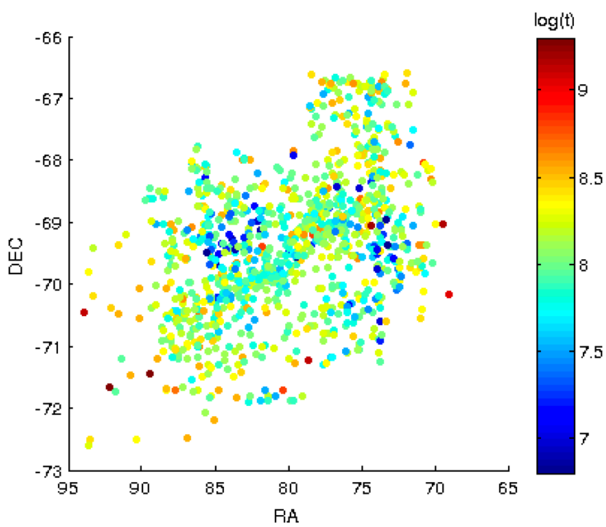

Figure 2.16: Plot shows spatial distribution of estimated ages of all the 1072 clusters studied in the Large Magellanic Cloud.

(MNRAS, 2016, Volume 464, p1446)

(Nayak, P. K.; Subramaniam, A.; Choudhury, S.; Indu, G.; Sagar, Ram)

Near Infrared Imaging of Bars in Low Surface Brightness Galaxies

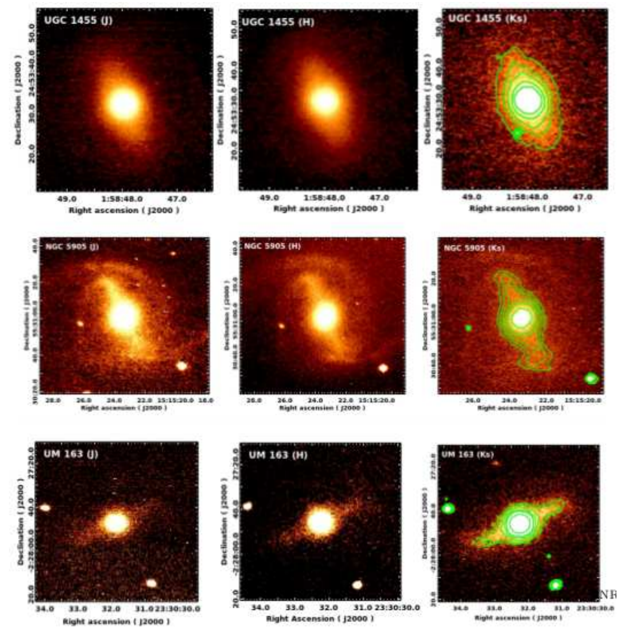

Figure 2.17: The panel shows the near-infrared images of three galaxies UGC1455, NGC5905 and UM163 in J, H and K bands. The observations were done with TIRSPEC on HCT.

A near-infrared (NIR) imaging study of barred low surface brightness (LSB) galaxies using the TIFR NIR Spectrometer and Imager is presented. LSB galaxies are dark matter dominated, late-type spirals that have low-luminosity stellar discs but large neutral hydrogen (H I) gas discs. Using Sloan Digital Sky Survey images of a very large sample of LSB galaxies derived from the literature, it is found that the barred fraction is only 8.3 per cent. The authors imaged 25 barred LSB galaxies in the J, H, K_S wavebands and 29 in the K_S band. Most of the bars are much brighter than their stellar discs, which appear to be very diffuse. Image analysis gives deprojected mean bar sizes of $R_b/R_{25} =$

0.40 and ellipticities e ≈ 0.45, which are similar to bars in high surface brightness galaxies. Thus, although bars are rare in LSB galaxies, they appear to be just as strong as bars found in normal galaxies. There is no correlation of R_b/R_{25} or e with the relative H I or stellar masses of the galaxies. In the (J – K_S) colour images most of the bars have no significant colour gradient which indicates that their stellar population is uniformly distributed and confirms that they have low dust content.
(MNRAS, 2016, 462, 2099)

(Honey, M.; M. Das; J. P. Ninan; M. Purvankara*)*

A Study of the Effect of Bulges on Bars in Disk galaxies

The authors use N-body simulations of bar formation in isolated galaxies to study the effect of bulge mass and bulge concentration on bar formation. Bars are global disk instabilities that evolve by transferring angular momentum from the inner to outer disks and to the dark matter halo. It is well known that a massive spherical component such as halo in a disk galaxy can make it bar stable. In this study the effect of another spherical component is explored, the bulge, on bar formation in disk galaxies. Both the bulge mass and concentration are varied in the models. Two sets of models are used, one that has a dense bulge and high surface density disk. The second model has a less concentrated bulge and a lighter disk. In both models the authors vary the bulge to disk mass fraction from 0 to 0.7. Simulations of both the models show that there is an upper cutoff in bulge to disk mass ratio Mb=Md above which bars cannot form; the cutoff is smaller for denser bulges (Mb=Md = 0:2) compared to less denser ones (Mb=Md = 0:5). A new criteria is defined for bar formation in terms of bulge to disk radial force ratio (Fb=Fd) at the disk scale lengths above which bars cannot form. It is found that if Fb=Fd > 0.35, a disk is stable and a bar cannot form. Present results indicate that early type disk galaxies can still form strong bars in spite of having massive bulges.
(MNRAS, submitted and under revision.)

(Sandeep Kumar Kataria and Mousumi Das)*

Flux and Polarization Variability of OJ 287 during the Early 2016 Outburst

The gamma-ray blazar OJ 287 was in a high activity state during 2015 December–2016 February. Coinciding with this high brightness state, this source was observed for photometry on 40 nights in R-band and for polarimetry on nine epochs in *UBVRI* bands. During the period of observations, the source brightness varied from 13.20 ± 0.04 mag to 14.98 ± 0.04 mag and the degree of polarization (P) fluctuated between 6.0% ± 0.3% and 28.3% ± 0.8% in R-band. Focusing on intranight optical variability (INOV), it is found that a duty cycle of about 71% using χ^2-statistics, similar to that known for blazars. From INOV data, the shortest variability timescale is estimated to be 142 ± 38 minutes, yielding a lower limit of the observed Doppler factor $\delta_0 = 1.17$, the magnetic field strength B ≤ 3.8 G, and the size of the emitting region $R_s < 2.28 \times 10^{14}$ cm. On internight timescales, a significant anticorrelation between R-band flux and P is found. The observed P at U-band is generally larger than that observed at longer-wavelength bands, suggesting a

wavelength-dependent polarization. Using V-band photometric and polarimetric data from Steward Observatory obtained during our monitoring period, a varied correlation is found between P and V-band brightness. While an anticorrelation is sometimes seen between P and V- band magnitude, no correlation is seen other times, thereby suggesting the presence of more than one short-lived shock component in the jet of OJ 287.
(ApJ, 2017, 835, 275R)

*(Rakshit, Suvendu; Stalin, C. S.; Muneer, S.; *Neha, S.; Paliya, Vaidehi S.)*

Resolving the dual AGN and tracing the helical jets in 2MASXJ12032061+1319316

High-resolution radio continuum observations of the double-peaked emission-line galaxy 2MASXJ12032061+1319316 with the Karl G. Jansky very large array at 6, 8.5, 11.5 and 15 GHz are presented in this work. The radio emission has a prominent S-shaped morphology with highly symmetric radio jets that extend over a distance of ∼1.5 arcsec (1.74 kpc) on either side of the core of size ∼0.1 arcsec (116 pc). The radio jets have a helical structure resembling the precessing jets in the galaxy NGC 326 which has confirmed dual active galactic nuclei (AGN). The nuclear bulge velocity dispersion gives an upper limit of $(1.56 \pm 0.26) \times 10^8$ $M_\odot$ for the total mass of nuclear black hole(s). The authors present a simple model of precessing jets in 2MASXJ1203 and find that the precession time-scale is around 10^5 yr: this matches the source lifetime estimate via spectral ageing. They find that the expected supermassive black hole (SMBH) separation corresponding to this time-scale is 0.02 pc. The double-peaked emission lines in 2MASXJ1203 are used to determine an orbital speed for a dual AGN system and the associated jet precession time-scale, which turns out to be more than the Hubble time, making it unfeasible. It is concluded that the S-shaped radio jets are due to jet precession caused either by a binary/dual SMBH system, a single SMBH with a tilted accretion disc or a dual AGN system where a close pass of the secondary SMBH in the past has given rise to jet precession.

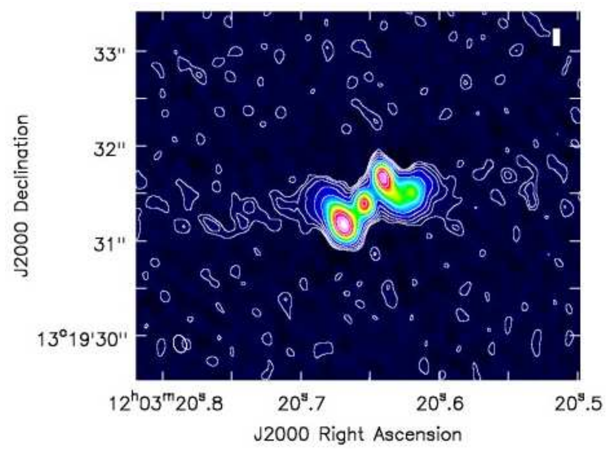

Figure 2.18: The above figure shows the 11.5 GHz EVLA image of 2MASXJ12032061+1319316 made with with robust=0.5 (natural) weighting. The intensity contours are overlaid and have 0.0.60, 1.25, 2.5, 5, 10, 20, 40, 60, 80% of the peak values of 5.5 mJy. The beam is approximately 0:2.

(MNRAS, 2016, 465, 4772)

(Rubinur K., M. Das, P. Kharb)

TeV Blazar Mrk 421

A seven year study of Mrk 421 indicated the flux to be highly variable across all timescales. The variability is energy dependent and is maximum in the X-ray and VHE bands. A strong correlation was found between the *Fermi*-LAT (gamma) and radio bands, and between *Fermi*-LAT and optical, but no correlation was found between *Fermi*-LAT and X-ray. Lognormality in the flux distribution was clearly detected. This is the third blazar, following BL Lac and PKS 2155+304 to show this behaviour. The SED was well fit by a one-zone SSC model, and variations in the flux states could be attributed mainly to changes in the particle distribution. A strong correlation was seen between the break energy γ_b of the particle spectrum and the total bolometric luminosity.

(A. Sinha, A. Shukla*, L. Saha*, B. S. Acharya*, G. C. Anupama, P. Bhattacharjee*, R. J. Britto*, V. Chitnis*, T. P. Prabhu, B. B. Singh*, P. R. Vishwanath*)*

A peculiar multi-wavelength flare in the Blazar 3C 454.3

The blazar 3C454.3 exhibited a strong flare seen in γ-rays, X-rays, and optical/NIR bands during 3 − 12 December 2009. Emission in the V and J bands rose more gradually than did the γ-rays and soft X-rays, though all peaked at nearly the same time. Optical polarization measurements showed dramatic changes during the flare, with a strong anti-correlation between optical flux and degree of polarization (which rose from $\sim$3% to $\sim$ 20%) during the declining phase of the flare. The flare was accompanied by large rapid swings in polarization angle of $\sim 170°$. This combination of behaviors appear to be unique. Available cm-band radio data during the same period show no correlation with variations at higher frequencies. Such peculiar behavior may be explained using jet models incorporating fully relativistic effects with a dominant source region moving along a helical path or by a shock-in-jet model incorporating three-dimensional radiation transfer if there is a dominant helical magnetic field. It is found that spectral energy distributions at different times during the flare can be fit using modified one-zone models where only the magnetic field strength and particle break frequencies and normalizations need change. An optical spectrum taken at nearly the same time provides an estimate for the central black hole mass of $\sim 2.3 \times 10^9 M_\odot$.

*(*Alok C. Gupta, A. Mangalam, *Paul J. Wiita et al.)*

Core Shift effect in Blazars

The authors studied the pc-scale core shift effect using radio light curves for three blazars, S5 0716+714, 3C 279 and BL Lacertae, which were monitored at five frequencies (ν) between 4.8 GHz and 36.8 GHz using the University of Michigan Radio Astronomical Observatory (UMRAO), the Crimean Astrophysical Observatory (CrAO), and Metsahovi Radio Observatory for over 40 years. Flares were Gaussian fitted to derive time delays between observed frequencies for each flare (Δt), peak amplitude (A), and their half width. Using $A \propto \nu^\alpha$, α is inferred in the range −16.67 to 2.41 and using $\Delta t \propto \nu^{1/k_r}$, $k_r \sim 1$, employed in the context of equipartition between magnetic and kinetic energy density for parameter estimation. From the estimated core position offset ($\Omega_{r\nu}$) and the core radius ($r_{\rm core}$), it is inferred that opacity model may not be valid in all cases. The mean magnetic field strength at 1 pc (B_1) and at the core ($B_{\rm core}$), are in agreement with previous estimates. The magnetically arrested disk model is applied to estimate black hole spins in the range $0.15 - 0.9$ for these blazars, indicating that the model is consistent with expected accretion mode in such sources (see Figure 2.19). The power law shaped power spectral density has slopes -1.3 to -2.3 and is interpreted in terms of multiple shocks or magnetic instabilities.

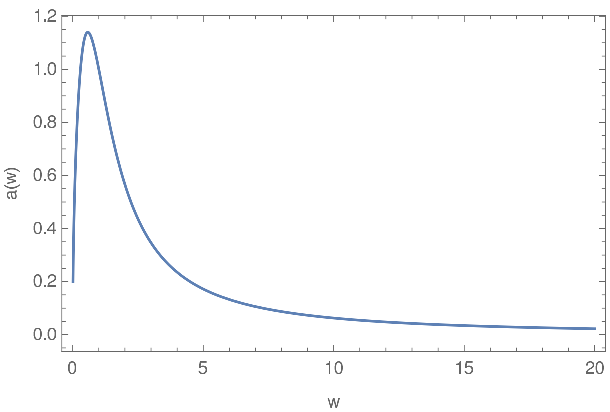

Figure 2.19: The spin parameter a is plotted a function of the parameter w. The values of $0.296 < w < 1$ are disallowed since they yield spin values $a > 1$.

(A. Agarwal, P. Mohan*, Alok C. Gupta*, A. Mangalam et al.)*

Gamma-ray emitting high redshift blazars

The extragalactic gamma-ray sky is dominated by the blazar class of active galactic nuclei (AGN). They are energetic sources in the sky with their relativistic jets pointed close to the line of sight. Their broad band spectral energy distribution is known to have a two hump structure, the low energy hump is believed to be produced by synchrotron emission processes and the high energy hump is believed to be produced by inverse Compton emission processes. Though blazars form the dominant population of the extragalactic sources detected by the Fermi gamma-ray telescope launched in the year 2008, no blazars beyond redshift greater than z > 3.1 has been detected by Fermi. Such non-detection of blazars above z of 3.1 could be due to the shift of the inverse Compton peak in these sources to lower energies to which the LAT instrument on-board Fermi is insensitive. Recent improvement in analysis has led to an enhancement of LAT sensitivity to lower energies and thereby has enhanced its capability to detect blazars above z of 3.1. With an aim to detect high redshift blazars, the authors of the present work selected all radio-loud quasars with the radio-loudness parameter greater than 10, and for those quasars searched for the detection of gamma-rays using about 8 years of Fermi data. The search led to the discovery of five gamma-ray emitting blazars with z > 3.1.
(ApJL, 2017, 837, L5)

*(*Ackermann M. et al. (including C. S. Stalin))*

Parsec-scale jet properties of the quasar PG 1302−102

The quasar PG 1302−102 is believed to harbor a supermassive binary black hole (SMBBH) system. Using the available 15 GHz and $2 - 8$ GHz, multi-epoch Very Long Baseline Array data, the authors constrain the pc-scale jet properties based on the inferred mean proper motion, including a bulk Lorentz factor $\geq$ 5.1 $\pm$ 0.8, jet inclination angle $\leq$ 11°4 $\pm$ 1°7, projected position angle = 31°8, intrinsic half opening angle $\leq$ 09 $\pm$ 0°1 and a mean $2 - 8$ GHz spectral index of 0.31. A general relativistic helical jet model is presented and applied to predict quasi-periodic oscillations of $\sim$ 10 days, power law power spectrum shape and a contribution of up to $\sim$ 53 percent to the observed variable core flux density. The model is used to make a case for high resolution, moderately sampled, long duration radio interferometric observations to reveal signatures due to helical knots and distinguish them from those due to SMBBH orbital activity including a phase difference $\sim \pi$ and an amplitude ratio (helical light curve amplitude/SMBBH light curve amplitude D_R) of $0.2 - 3.3$ (see Figure 2.20). The prescription can be used to identify helical kinematic signatures from quasars, providing possible candidates for further studies with polarization measurements. It can also be used to infer promising SMBBH candidates for the study of gravitational waves if there are systematic deviations from helical signatures.

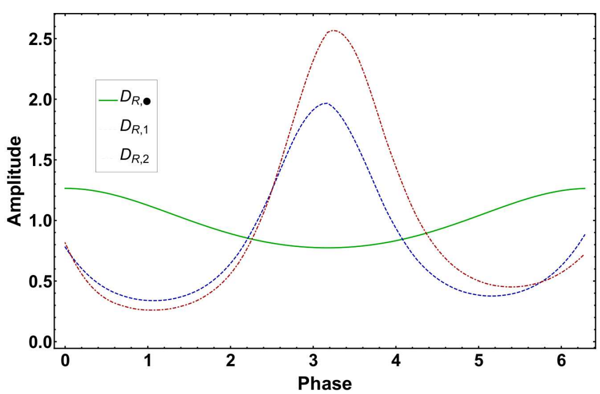

Figure 2.20: Comparison of $D_R = S_\nu/\tilde{S}_\nu$ between helical jet and SMBBH scenario ($D_{R,\bullet}$, thick green line) with $D_{R,j}$ (blue dashed line: case (i); red dot-dashed line: case (ii)) for 1 complete cycle. Note: cycle for SMBBH scenario $\sim$ years; for helical jet $\sim$ days.

(P. Mohan, T. An*, S. Frey*, A. Mangalam, et al.)*

Probing magnetic fields with Square Kilometre array and its precursors

Origin of magnetic fields, its structure and effects on dynamical processes in stars to galaxies are not well understood. Lack of a direct probe has remained a problem for its study. The first phase of Square Kilometre Array (SKA-I), will have almost an order of magnitude higher sensitivity than the best existing radio telescope at GHz frequencies. In this contribution, the authors discuss specific science cases that are of interest to the Indian community concerned with astrophysical turbulence and magnetic fields. The SKA-I will allow observations of a large number of background sources with detectable polarization and measure their Faraday depths (FDs) through the Milky Way, other galaxies and their circum-galactic mediums. This will probe line-of-sight magnetic fields in these objects well and provide field configurations. Detailed comparison of observational data (e.g., pitch angles in spirals) with models which consider various processes giving rise to field amplification and maintenance (e.g., various types of dynamo models) will then be possible. Such observations will also provide the coherence scale of the fields and its random component through RM structure function. Measuring the random component is important to characterise turbulence in the medium. Observations of FDs with redshift will provide important information on magnetic field evolution as a function of redshift. The background sources could also be used to probe magnetic fields and its coherent scale in galaxy clusters and in bridges formed between interacting galaxies. Other than FDs, sensitive observations of synchrotron emission from galaxies will provide complimentary information on their magnetic field strengths in the sky plane.

The core shift measurements of AGNs can provide more precise measurements of magnetic field in the sub parsec region near the black hole and its evolution. The low band of SKA-I will also be useful to study circularly polarized emission from Sun and comparing various models of field configurations with observations.
(Journal of Astrophysics & Astronomy on Science with SKA, 2016, Vol. 37, Issue 4)

*(*Subhashis Roy, Sharanya Sur, *Kandaswamy Subramanian, A. Mangalam, *Hum Chand, *T. R. Seshadri)*

Formation of supermassive black holes at high redshifts

It is proposed that a collapsing gas maintaining its temperature at $\sim 10^4$ K can undergo a rapid collapse resulting into a intermediate mass ($10^4 - 10^5$ $M_\odot$) black hole by the redshift ~ 25 which can turn in to a supermassive black hole ($10^8 - 10^9$ $M_\odot$) by the redshift of 6-7 by Eddington limited accretion of gas around it. To achieve this, the collapsing gas needs a heating mechanism to counter the H_2 cooling and avoid fragmentation. In this work the authors consider the heating which can come from accretion disks around primordial black holes (PBH). Primordial black holes are the black holes which were formed due to the direct collapse of sufficiently high over-dense regions in the universe during the inflation or other early phase transitions in the universe. Latest constraints on the abundance of PBHs are used and it is demonstrated that under the limits of observational constraints on the PBH abundances, PBH accretion disks can heat the collapsing gas to an extent that the H_2 formation is inhibited and the collapsing gas can maintain its temperature at $\sim 10^4$ K until a critical density $n_{cric} \approx 10^3$ (Figure 2.21) is reached at which the roto-vibrational states of H_2 approach local thermodynamic equilibrium. H_2 cooling then remains inefficient and the gas temperature stays near $\sim 10^4$ K, even as it continues to collapse at higher densities.

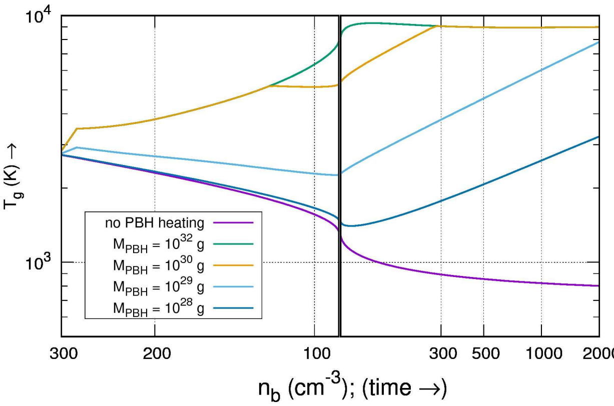

Figure 2.21: The Evolution of gas temperature (T_g) with gas density (n_b) as it collapses is shown for various values of the PBH mass (M_{PBH}).

(Submitted to Journal of Astrophysics and Astronomy (JAA))

(Kanhaiya L. Pandey and A Mangalam)

Energy distribution of braided fields derived from NLFFF solutions

The authors of the present work use semi-analytic solution of the nonlinear force-free field equation to construct three-dimensional magnetic fields that are applicable to the solar corona and study their statistical properties for estimating the degree of braiding exhibited by these fields. A new formula is presented for calculating the winding number and compare it with the formula for the crossing number. The comparison is shown for a toy model of two helices and for realistic cases of nonlinear force-free fields; it is concluded that while conceptually the formulae are nearly the same but the resulting distributions calculated for a given topology can be different. The authors also calculate linkages, which are useful topological quantities that are independent measures of the contribution of magnetic braiding to the total free energy and relative helicity of the field. Finally, they derive new analytical bounds for the free energy and relative helicity for the field configurations in terms of the linking number. These bounds will be of utility in estimating the braided energy available for nano-flares or for eruptions.

(A. Prasad & A. Mangalam)

The effects of the small-scale behaviour of dark matter power spectrum on CMB spectral distortion

Despite numerous astronomical and experimental searches, the precise particle nature of dark matter is still unknown. The standard Weakly Interacting Massive Particle (WIMP) dark matter, in spite of successfully explaining the large-scale features of the universe, has long-standing small-scale issues. The spectral distortion in the Cosmic Microwave Background (CMB) caused by Silk damping in the pre-recombination era allows one to access information on a range of small scales $0.3 Mpc \leq k \leq 10^4 Mpc^{-1}$, whose dynamics can be precisely described using linear theory. In this paper, the authors investigate the possibility of using the Silk damping induced CMB spectral distortion as a probe of the small scale power. Four suggested alternative dark matter candidates are considered—Warm Dark Matter (WDM), Late Forming Dark Matter (LFDM), Ultra Light Axion Matter (ULA) dark matter and Charged decaying dark matter (CHDM); the matter power in all these models deviate significantly from the ΛCDM model at small scales. The spectral distortion of CMB is computed for these alternative models and compare the results with the ΛCDM model. It is shown that the main impact of alternative models is to alter the sub-horizon evolution of Newtonian potential which affects the late-time behaviour of spectral distortion of CMB.
(JCAP 1604 (2016) no.04, 012)

*(*A. Sarkar, *R. mondal, S. das, *S. Sethi, *S. bharadwaj, *D. Marsh)*

2.4 Theoretical Physics & Astrophysics

Viewing the ground and excited electronic structures of Platinum and its ion through the window of relativistic coupled cluster method

Highly accurate electronic structure calculations are often needed to supplement scant experimental data. The authors performed high precision calculation for the ground and some selected low lying excited/ionized states of Pt and its ions with four component relativistic spinors. Their calculation establishes the stability of its negative ion and reproduces the binding energy of this state within 10 wavenumber. The first ionization potential is estimated to be 72005 wavenumber, deviating from the experiment by just 200 wavenumber (0.3 percent). The magnetic hyperfine coupling constants of Pt and its ions are

also computed to ascertain the accuracy of the scheme. The magnetic hyperfine value of the ground state of Pt was found to be 5.78 GHz which is in very good agreement with the experimental data of 5.70 GHz. To the best of authors′ knowledge, this is the first relativistic ab initio calculation of the ionization potential and magnetic hyperfine coupling constant for the neutral and ionic states of Pt at a high level of correlation treatment.
(J. Chem. Phys., 2017, 146, 011102)

*(*Suvonil Sinha Ray, Rajat K. Chaudhuri, and *Sudip Chattopadhyay)*

Model of a fluxtube with a twisted magnetic field in the stratified solar atmosphere

The authors build a single vertical straight magnetic fluxtube spanning the solar photosphere and the transition region which does not expand with height. They assume that the fluxtube containing twisted magnetic fields is in magnetohydrostatic equilibrium within a realistic stratified atmosphere subject to solar gravity. Incorporating specific forms of current density, I_p and gas pressure, p in the Grad–Shafranov equation in terms of the poloidal flux function Ψ which is given by $I_p^2(\Psi) = \alpha\Psi^2 + \beta\Psi + I_0^2$ and $p(\Psi) = a\Psi^2 + b\Psi$, the magnetic flux function is solved. The solution is found to be separable with a Coulomb wave function in radial direction while the vertical part of the solution decreases exponentially. Employing the fluxtube boundary conditions and taking a realistic ambient external pressure for the photosphere to transition region, a family of solutions is derived for reasonable values of the fluxtube radius, R and magnetic field strength at the base of the axis, B_0 that are the free parameters in the model (see 2.22). The authors find that their model estimates are consistent with the magnetic field strength and the radii of Magnetic bright points as estimated from observations and simulations. They also derive thermodynamic quantities inside the fluxtube which are in good agreement with observations.

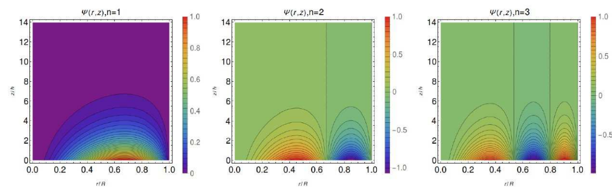

Figure 2.22: The vertical cross–sections of normalized poloidal flux function for three different modes n for $R = 100$ km and $B_0 = 1$ kG are shown. The contours represent the magnetic lines of force in the $r - z$ plane. The amplitude of the flux function, normalized to the peak value, is represented by a colour bar. The horizontal axis is scaled to the radius of the fluxtube R and the vertical axis is scaled with the pressure scale height, $h = 162$ km.

(S. Sen & A. Mangalam)

Polarized line formation in arbitrary magnetic fields

Magnetic fields in the solar atmosphere leave their fingerprints in the polarized spectrum of the Sun via the Hanle and Zeeman effects. While the Hanle and Zeeman effects dominate respectively in the weak and strong field regimes, both these effects jointly operate in the intermediate field strength regime. Therefore it is necessary to solve the polarized line transfer equation including the combined influence of Hanle and Zeeman effects. Further it is required to take into ac-

count the effects of partial frequency redistribution (PRD) in scattering when dealing with strong chromospheric lines with broad damping wings. In Sampoorna et al. (2017), a robust numerical method has been developed based on operator perturbation to solve this problem of Hanle-Zeeman polarized PRD line transfer problem in a two-level atom with zero nuclear spin. The authors of the present work compare the PRD idealization of angle-averaged Hanle-Zeeman redistribution matrices with the full treatment of angle-dependent PRD, to indicate when the idealized treatment is inadequate and what kind of polarization effects are specific to angle-dependent PRD.
(ApJ, 2017, (In press))

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

Lower-level polarization and Partial Frequency Redistribution

In the well-established theories of polarized line formation with partial frequency redistribution (PRD) for a two-level and two-term atom, it is generally assumed that the lower level of the scattering transition is unpolarized. However, the existence of unexplained spectral features in some lines of the linearly polarized spectrum of Sun, points toward a need to relax this assumption. There exists a density matrix theory that accounts for the polarization of all the atomic levels, but it is based on the approximation of complete frequency redistribution (CRD). In Supriya et al. (2016), a theoretical formulation is presented to solve the problem of polarized line formation in magnetized media, which includes both the effects of PRD and the lower level polarization (LLP) for a two-level atom. To demonstrate the usefulness of the formulation, the authors of the present work consider two case studies in the non-magnetic regime, namely, the $J_a = 1$, $J_b = 0$ and $J_a = J_b = 1$, where J_a and J_b represent the total angular momentum quantum numbers of the lower and upper states, respectively. The present studies show that the effects of LLP are significant only in the line core. This leads the authors to propose a simplified numerical approach to solve the concerned radiative transfer problem.
(ApJ, 2016, 828, 84 (10 pages))

*(Supriya, H.D., Sampoorna, M., Nagendra, K. N., *Stenflo, J.O., & Ravindra, B.)*

Importance of Cross-redistribution in Scattering Polarization

Scattering on a multi-level atomic system has dominant contributions from resonance and Raman scattering. While initial and final levels are the same for resonance scattering, they are different for Raman scattering. The frequency redistribution for resonance scattering is described by the partial frequency redistribution (PRD) functions, while that for Raman scattering is described by cross-redistribution (XRD) function. In Sampoorna et al. (2013, ApJ, 770, 92) an approximate approach was formulated to treat XRD together with the polarization of light. To study the importance of XRD to polarization, the authors of the present work consider multiplet systems such as a four-level atomic system with three allowed transitions which are coupled through XRD. Main result of such a study is that XRD (line-interlocking effects) produces significant effect on the linear polarization profiles when the wavelength separations between the line components of the multiplet

are small like in the cases of Mg I b and Ca I triplets.
(ApJ, 2017, 838, 95 (6 pages))

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

Detecting exomoon around self-luminous exoplanets through polarization

Comparisons of synthetic spectra to observed data clearly implies that most of the exoplanets directly imaged to date have dusty atmospheres. In that respect the atmospheres of these planets are very similar to that of L Brown dwarfs. Hence, like the L dwarfs, it is expected that radiation of these planets as well as those likely to be detected in the future, should be linearly polarized in the near-infrared due to scattering by dust grains (Marley & Sengupta 2011, MNRAS). For a homogeneous distribution of scatterers, the net polarization integrated over a spherical planetary disk is zero. On the other hand rotation induced oblateness causes asymmetry and gives rise to significant amount of polarization (Sengupta & Krishan 2001, ApJ Letters; Sengupta & Marley 2010, ApJ; Marley & Sengupta 2011, MNRAS). Image polarimetric data of L dwarfs shows increase in the amount of polarization with the increase in spin rotation velocity implying dominant role played by the asymmetry due to rotation-induced oblateness. Apart from asymmetry in the disk due to rotation-induced oblateness, net non-zero disk integrated polarization may arise if the stellar disk is occulted by a planet. In Sengupta and Marley (2016, ApJ), it was suggested that similar to the transit polarization of stars, occulted by planets, the self-luminous directly imaged exoplanets should also give rise to detectable amount of time dependent polarization if the object is eclipsed by a sufficiently large natural satellite or exo-moon. Hence, it is proposed that exomoons around self-luminous directly imaged planets can be detected through time dependent image polarimetric observation.
(Astrophys. J., 2016, 824, 76.)

(Sujan Sengupta)

Detecting Exoplanets around L and T brown dwarfs through transit polarimetry

Giant exoplanets around brown dwarfs have been discovered via direct imaging, the radial velocity method and by using the gravitational microlensing method. These discoveries clearly imply that formation of exoplanets with sizes ranging from Jovian to sub-Earth is possible around brown dwarfs either through a binary star formation mechanism or through the scale-down core-accretion mechanism of planet formation around a star. Discovery of these planets may greatly increase the number of detected exoplanets. However, owing to the limitation of available technology, substantially low mass planetary companion to brown dwarfs can only be discovered at present by using the gravitational microlensing technique. It has been demonstrated in Sengupta (2016, AJ) that time-resolved image polarimetry can be a potential tool for detecting planets transiting cloudy L dwarfs. Using detailed atmospheric models for cloudy L dwarfs, the scattering polarization is calculated and it is shown that the asymmetry induced by a transiting Earth-sized planet gives rise to significant amount of disk-integrated linear polarization in both I and J bands at the

inner contact points of the transit ingress/ egress phase which may be detected by existing imaging polarimeters.
(Astronom. J., 2016, 152, 98.)

(Sujan Sengupta)

Physics of TDEs by black holes

The authors have constructed a dynamical model of tidal disruption events (TDEs) that includes physical parameters such as black hole (BH) mass $M_\bullet$, specific orbital energy E and angular momentum J, star mass $M_\star$ and radius $R_\star$, and the pericenter of the star orbit $r_p(E,\ J,\ M_\bullet)$. They have calculated the capture rate of stars $\dot{N}_t$, in the galactic center for a stellar density profile $\rho \propto r^{-\gamma}$ with an initial mass function, by solving the steady state Fokker-Planck equation and integrating over the $\{E,\ J\}$ phase space. Assuming a steady accretion model, the authors calculate the rise time, the peak bolometric luminosity in terms of these physical parameters and a typical light curve of TDEs which is then compared with the detectors sensitivity to obtain the duration of flare detection. The crucial point is that the J plays an important role in the stellar dynamical process through $\dot{N}_t$ and the accretion process through pericenter $r_p(E,\ J)$ which impacts the detectable TDE rates; this has not been taken into account in previous calculations.

For the standard ΛCDM model, black hole mass function of quiescent galaxies, the authors calculated the detection rate of TDEs by various ongoing and future survey missions Large Synoptic Survey Telescope (LSST), Pan-STARRS 3π in optical bands and eROSITA in X-ray band and discuss the follow up of TDEs through observations in various spectral bands from X-rays to radio wavelengths. The rise time of the TDEs, the peak bolometric luminosity depends on these physical parameters and a typical light curve of TDEs for various All Sky Survey (ASS) and Deep Sky Survey (DSS) missions is calculated and given a high detectable event rate with eROSITA in X-rays and iPTF/ZTF, Pan-STARRS and LSST in the optical, the time gap between alert from search missions and follow-up through ground and space observatories in various spectral bands needs to be reduced to capture the event during its rise time since the peak luminosity and time are functions of physical parameters. The Indian observatories such as SSM of ASTROSAT in X-ray and International Liquid Mirror Telescope (ILMT) in optical is capable of TDE search with follow-up through Himalayan Chandra Telescope (HCT), Devasthal 3.6m Optical Telescope (DOT) in optical band, ASTROSAT UVIT in UV bands, ASTROSAT SXT and LAXPC in X-rays bands and GMRT for radio observations (see Fig. 2.23).

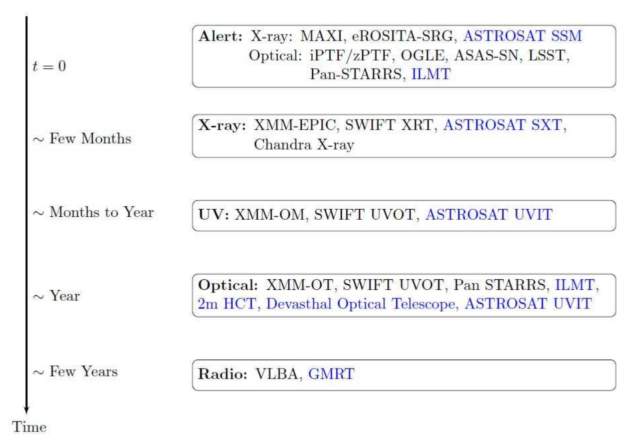

Figure 2.23: The detection and follow up missions for TDEs are shown along with the typical timescale of observations in various spectral bands starting from the time of the alert. The blue color highlights Indian observatories.

The authors have also constructed a self similar model of a time dependent accretion disk in both super and sub-Eddington phase with fallback from outer debris and a general viscosity prescription $\Pi_{r\phi} \propto \Sigma_d^b r^d$ where Σ_d is surface density, r is the radius and b and d are constants that depends on the nature of pressure in the disk. The specific choice of radiative and alpha viscosities and its parameters is decided by the expected disk luminosity and evolution time scale being in the observed range. The outflow wind structure in super-Eddington phase is modeled analytically using vertical momentum equation. The transition dynamics of disk between the super-Eddington to sub-Eddington phases has also been constructed and modeled the evolutionary track of TDEs. The time dependent accretion models were fitted to the observations in X-ray, UV and optical bands and found that the time dependent model shows a good fit to the observations compared to steady accretion models (see Fig. 2.24).

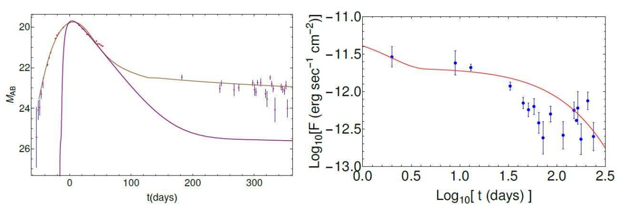

Figure 2.24: *Left:* Time-dependent super-Eddington model (blue) shows good fit compared to the super-Eddington steady accretion model of Mageshwaran & Mangalam (2015) (purple) to the PS1-10jh observations in g band (Gezari et al. 2012). The deduced physical parameters for time dependent models are $\bar{e} = 0.0001$, $\ell = 1$, $M_6 = 7.5$, $m = 2.65$ and black hole spin $j = 0.85$. *Right*: Time dependent sub Eddington model fit to the X-ray observation XMMSL1 J061927.1-655311 (Saxton et al. 2014) in X-ray band and the derived parameters are $\bar{e} = 0.00316$, $\ell = 0.9$, $M_6 = 3.15$, $m = 1.77$ and black hole spin $j = 0.15$.

(T. Mageshwaran & A. Mangalam)

Formation and Evolution of Elliptical Galaxies

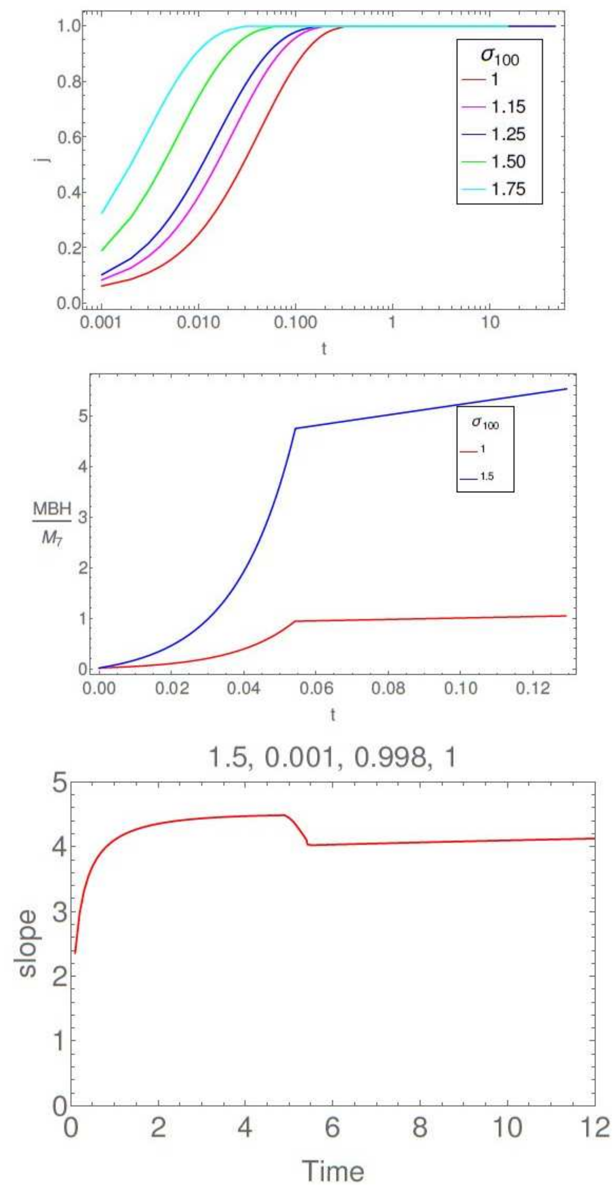

Figure 2.25: Evolution of the spin parameter, mass and slope of $\log(M_\bullet) - \log(\sigma)$ plot as a function of time.

The spin and the mass of a supermassive black hole (SMBH) evolve as it grows from a smaller seed mass and the growth is mainly dependent on two processes, gas accretion and consumption of stars. In the case of gas accretion with cooling sources, the flow is momentum driven, after which the black hole reaches a saturated mass and subsequently it grows only by consumption of stars. The authors have assumed the accretion rate to be a fraction of the Eddington accretion rate and for the stellar ingestion they have assumed a power law density profile for the stellar cusp in the frame work of relativistic loss cone theory that includes the effect of the black hole spin. They have then calculated the capture radius which is defined as maximum of the tidal radius and the horizon radius. A critical mass value ($\simeq 3 \times 10^8 M_\odot$) is obtained beyond which capture radius is defined by the horizon instead of the tidal radius (figure 2.26). The authors calculate the impact of the evolution on the spin, mass of the SMBH and $M_\bullet - \sigma$ relation (figure 2.25) as a function of redshift in a ΛCDM cosmology and compare it with available observations.

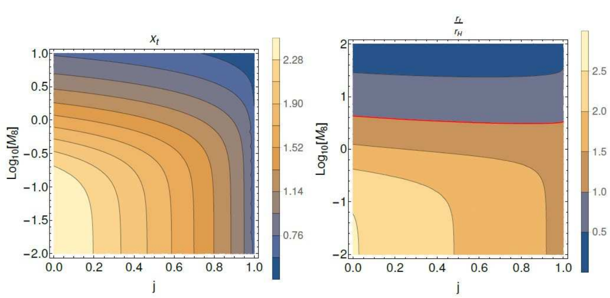

Figure 2.26: Tidal radius (in units of R_s) as a function of (j, M_8) and j, their ratio as function of j, M_8 (up), x_{lc}.

For galaxies whose intensity profiles are described by the Nuker profiles available from observational data; mass density is calculated using the Abel inversion formula and obtain the stellar potential assuming spherical symmetry. For power law galaxies the potential is obtained using Poisson's equation. From the total potential using the Eddington's formula the distribution function of stars is obtained and the resulting velocity dispersion along the LOS (figure 2.27). Applying an assumed proportionality relation holds between M_{Bulge} and $M_\bullet$ to several galaxies the resulting $M_\bullet - \sigma$ relation is obtained (see Figure 2.28). This is used for comparison with our evolutionary model.

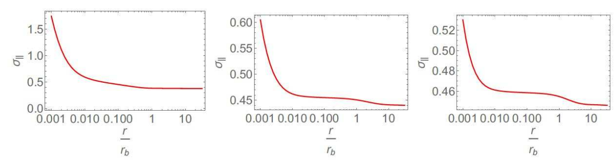

Figure 2.27: Dispersion plots of 3 elliptical galaxies NGC 3115, NGC 4472, NGC 4486, where r_b is the break radius of those galaxies.

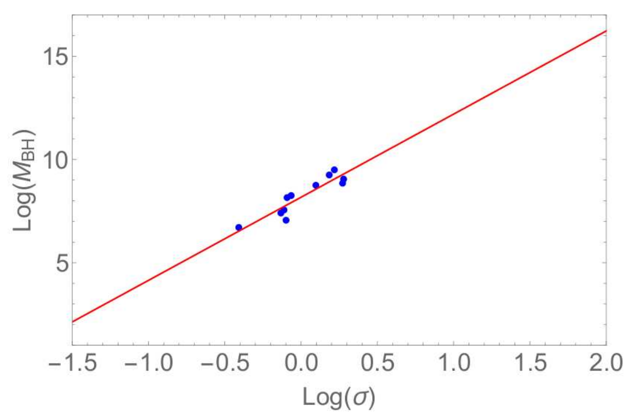

Figure 2.28: $log(M_\bullet)$ - $log(\sigma)$ plot for 11 elliptical galaxies following Nuker profile where $\frac{M_\bullet}{M_{Bulge}} = 0.0014$.

(Dipanweeta Bhattacharyya & A. Mangalam)

Parameter study of QPOs in XRBs and AGNs

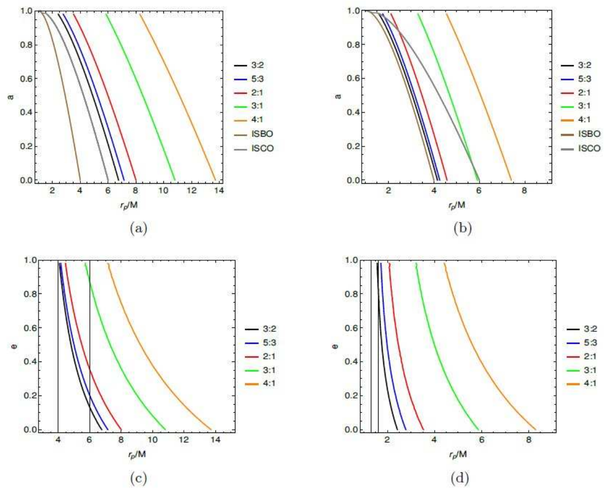

Figure 2.29: The frequency ratio $(\nu_\phi/(\nu_\phi - \nu_r))$ contours in $(a,\ r_p)$ plane for different eccentricities. (a): $e = 0$, (b) $e = 0.9$. The frequency ratio $(\nu_\phi/(\nu_\phi - \nu_r))$ contours in $(e,\ r_p)$ plane for different spin values. (c): $a = 0$, (d): $a = 0.98$. The vertical lines represent ISCO (outer) and ISBO (inner).

Black hole X-ray binaries (BHXRBs) are systems with an accreting primary black hole and a secondary main-sequence (non-degenerate) star. These objects show Quasi-Periodic Oscillations (QPOs), which are the broad peaks in their Fourier power density spectrum. QPOs have been seen with frequencies that range from a few Hz to a few hundred Hz in BHXRBs. The authors of the present work discuss constraints on the emission region allowed by stationarity, the bound orbit phase volume in Kerr geometry and derive conditions, from the dynamics of the equatorial plane, on the following parameters: energy, angular momentum of the particle orbit and the spin of the black hole. Novel analytic expressions are presented for general bound orbit trajectories, and for its radial and azimuthal frequencies that have general utility in various problems. These formulae are applied to the relativistic precession model and a specific non-linear resonance model to study the commensurability of the QPO frequencies in BHXRBs. Explanation for this commensurability (eg. 3:2) is still a question to be addressed and a successful determination of the correct oscillation mechanism would yield invaluable measurement constraints on black hole mass and spin (see Fig. 2.29). The authors have also developed a statistical approach in the context of a general kinematic model for estimating these parameters and its errors given three near simultaneous frequency detection. Low frequency QPOs in BHXRBs may also be associated with jets. Previous disk-jet coupling studies relate different spectral states with the presence of radio jets. Low-frequency QPOs by helical jets is explained in Schwarzschild geometry by including various relativistic effects of gravitational Doppler shift and light bending effects on the emission.

(Prerna Rana & A. Mangalam)

2.5 Experimental Astrophysics & Instrumentation

Optical design and performance modelling of the Adaptive Optics module for 1.3-m JCBT telescope

The authors describe a methodology for designing and performance modelling of a natural guide star (NGS) adaptive optics system (AO) intended for 1.3-m telescope, Kavalur. They determined the AO system component specifications using r_0 and coherence time. The system is designed for f/8, Cassegrain focus for a wavelength range of 550 nm to 1.15 micron; to provide an image of 1:50 field of view (FOV) for science imaging and 15 arcsec FOV for wavefront sensing (WFS). The design contains a tip-tilt mirror along with a deformable mirror (DM) to compensate low and high order wavefront distortions. The performance of AO design is further evaluated by an open source Monte-Carlo simulation code.

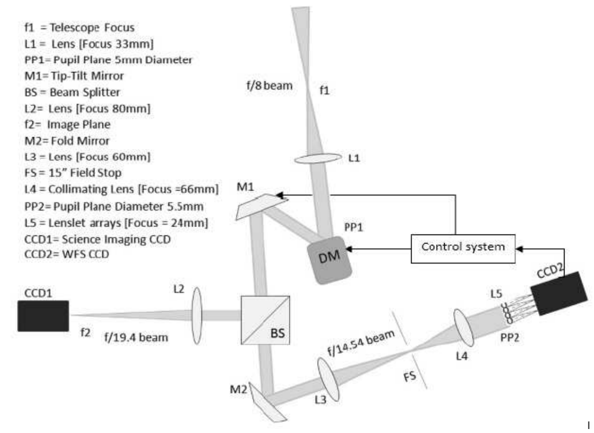

Figure 2.30: Layout of the adaptive optics system design. The f/8 beam from the telescope is directed to the lens L1, Deformable mirror, tip-tilt, beam splitter and one to the science CCD and the other to the WFS.

(International Conference on Light and Light based Technologies (ICLLT), Nov 26-28 (2016), Tezpur University, Assam.)

(V. Sreekanth Reddy, Suraj Haldar, Ravinder K. Banyal, R. Sridharan)*

Towards Radial Velocity Measurements with Iodine Absorption Cell on VBT Echelle Spectrograph

The authors of the present work have discussed their completed work on mechanical design, temperature controller and hardware interface of the I_2 cell. They have presented their analysis of the I_2 FTS data, statistics and algorithm used to construct the line list for VBT spectrograph. Some preliminary results of solar spectra and bright stars observations with Iodine cell are also shown (See the Figures). An outline of the adopted approach to develop radial velocity analysis code for the Iodine cell is given.

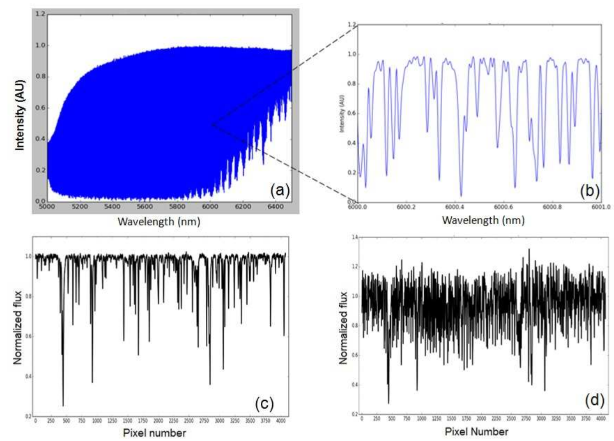

Figure 2.31: (a) High resolution spectra of Iodine cell taken with FTS (b) Expanded view of I2 spectra (c) Solar Spectra taken with VBT Echelle (d) Solar spectra with Iodine cell.

(The 34th Meeting of the Astronomical Society of India, University of Kashmir, Srinagar, 10-13 May 2016.)

(Sireesha Chamarthi, Ravinder K. Banyal, U. Lekme, S. Sriram, K. Ravi and Gajendra Pandey)*

Stability analysis of VBT Echelle spectrograph for precise radial velocity measurements

Instrument instability is a major limitation for science programmes relying on high precision Doppler spectroscopy. Modern spectrographs are designed to reach 1–10 m/s RV precision. They are operated in a

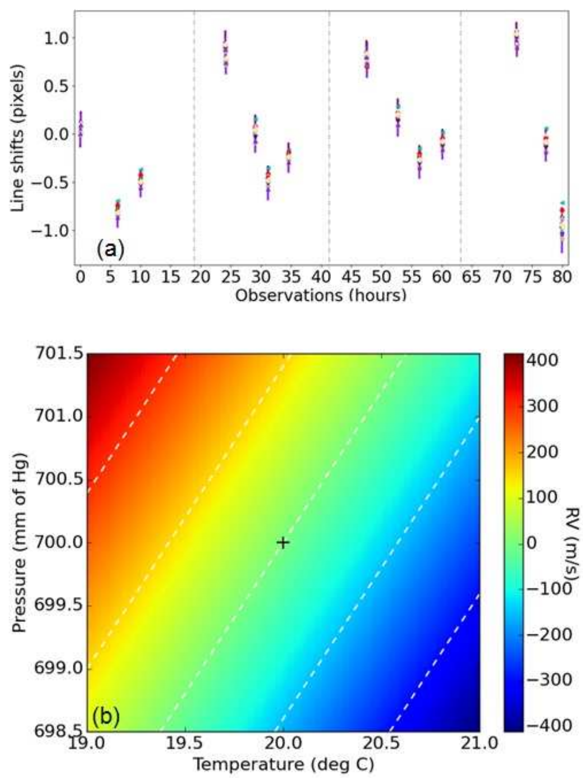

Figure 2.32: Measured line shift for VBT Echelle during 4 days observational test run. The y axis displays the order-wise line shift computed for each consecutive observation. The coloured circles stacked along vertical direction represent shift for each Echelle order. (b) Estimation of RV errors caused by variations of refractive index of air and its dependence on pressure and temperature fluctuations. The cross symbol in the middle indicates the nominal operating conditions of T and P in the Echelle room.

highly stable vacuum environment. The Echelle operating at VBT, Kavalur is a general purpose spectrograph, which is not designed for vacuum conditions. The authors are taking measures to enhance its RV precision using Iodine absorption cell and improving the thermal and mechanical stability of the spectrograph. They conducted a series of experiments to measure the stability of the spectrograph. Their analysis shows (see the Figure 2.32(a)) that spectrograph has an overnight drift exceeding 0.8 pixels and 1 pixel drift over 4 days of observations. The nightly drift was seen to be systematically modulated in all observations. In addition, individual orders in each ThAr frame shows different scatter. An independent record of the temperature is currently unavailable but it is strongly suspected that the day to night temperature variations to be responsible for modulating the pixel drift. The authors have also modeled the dry air refractivity and its dependence on temperature and pressure changes in the Echelle room. The RV error (Figure 2.32(b)) measured in test observations is consistent with prediction based on dispersion model of the dry air.
(Accepted for publication in Journal of Optics.)

(Sireesha Chamarthi, Ravinder K. Banyal, S. Sriram and Gajendra Pandey)

Supernovae study: Context of the 4-m ILMT facility

The authors of this work have done a detailed calculation of the expected number of supernova events which can be detected by the ILMT. They calculate the detection rate for the Type-1a supernovae and the core-collapse supernovae for all the three proposed bands (i', g', r') of ILMT. They have used flat cosmology with $\Omega_m = 0.31$, and h $= 0.68$ which are consistent with the recent Planck results. The absolute magnitude distribution of the supernovae is taken from recent studies and have been adjusted for the Hubble parameter value h $= 0.68$. The progenitor mass range for the type 1a supernovae is taken to be 3-8 $M_\odot$ and for core-collapse it is taken to be 8-50 $M_\odot$. For core collapse, all the 4 types (Ibc, IIL, IIP and IIn) have been considered. For the calculation of (magnitude limited) detection rate, the expected magnitude limits for the ILMT in different bands have been used. Figure 2.33 shows the results of the theoretical estimate of the number of supernovae type-1a and the core collapse supernovae which can be detected (per year (3.1×10^7 sec of observation time) per square degree) using ILMT-ARIES (Nainital).

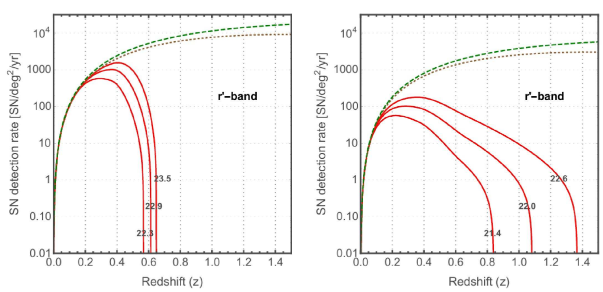

Figure 2.33: Supernova detection rate using ILMT-ARIES, Nainital for supernovae Type-1a (left) and core collapse supernovae (right). The dotted-brown and the dashed-green lines show the cosmic supernova rate with and without dust correction respectively. The solid-red lines correspond to the expected magnitude limited supernova detection rate observed by the ILMT. The set of three magnitude limits respectively correspond to 1, 2 and 3 night integration time.

(Submitted to Bulletin de la Société Royale des Sciences de Liège.)

(Brajesh Kumar, S. B. Pandey, Kanhaiya L. Pandey, G. C. Anupama and J. Surdej*)*

An approach to mitigate telescope optics polarization

In polarimetric observations of astronomical sources, instrumental polarization and polarization crosstalk from the telescope affect the measurements. They arise due to the reflections from the mirror surfaces of the telescope. An analytical model was developed to estimate these values for the Thirty Meter Telescope (TMT). The model determines an instrumental polarization of 1.2% and crosstalk of 40% at 0.6m. The analyses indicated that the Nasmyth (tertiary) mirror of the telescope, (used to fold and steer the light to the various instrument ports) is the primary source of the high values of IP and crosstalk. An optical layout to cancel out the effects introduced by the Nasmyth mirror was designed. Different configurations were studied to reduce/cancel the effect of the IP and crosstalk before the light from the Nasmyth mirror reaches the instrument. While the optical components introduced after the tertiary mirror reduce the telescope instrumental polarization and cross talk, it leads to a reduction in the intensity due to additional reflections.
(Oral presentation in the International Conference on Light and Light Based Technologies held during November 26-28, 2016 at Tezpur University, Tezpur, Assam.)

(Ramya M. Anche, G. C. Anupama, K. Sankarasubramanian)

A dual cavity Fabry-Perot device for high precision Doppler measurements in astronomy

The Doppler survey for many astronomy programmes requires high resolution spectrograph with exceptional long term stability in RV precision. The authors have proposed a double cavity FP design for aiding high precision Doppler measurements in astronomy.

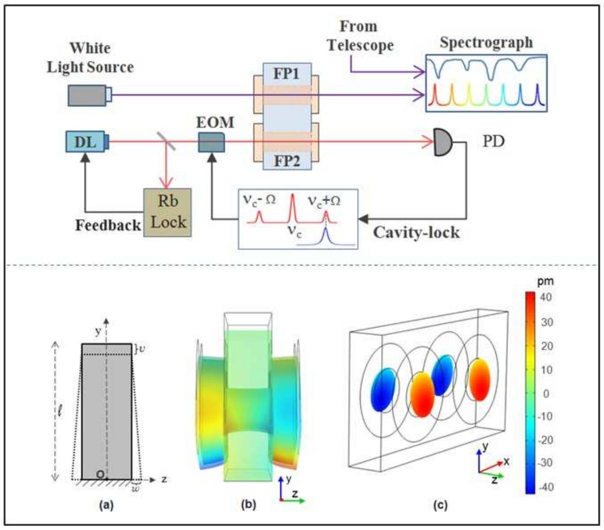

Figure 2.34: *Top panel*: Schematic of dual FP cavity-lock setup. A collimated white light beam feeds FP1 to generate wideband comparison spectra for astronomy spectrograph and the high-finesse FP2 facilitates cavity drift tracking with the help of frequency stabilized diode laser. *Bottom panel*: (a) Compression of a prismatic bar by self-weight. (b) Side view of FP cavity deformed under self-weight. The entire structure is vertically compressed and horizontally expanded from original configuration. (c) The z displacement and tilt of the cavity mirrors (magnified view) from their nominal positions.

The proposed device has two parallel optical cavities embedded inside a 10 mm thick monolithic ULE block. A low-finesse *astro-cavity* is meant to generate multiline reference spectra for spectrograph calibration while a high finesse *lock-cavity* is needed to provide steep discriminant signal for tracking the cavity drift. The differential length changes in two cavities due to temperature and vibration perturbations are quantitatively analyzed using finite element method. An optimized mounting geometry with fractional length changes $\Delta L/L \approx 1.5 \times 10^{-12}$ is suggested. The authors also identify conditions necessary to suppress relative length variations between two cavities well below 10^{-10} m, thus facilitating accurate dimension tracking and generation of stable reference spectra for Doppler measurement at 10 cms^{-1} level.

(Journal of Astronomical Instrumentation (JAI), 2017, 6, 1750001-16.)

(Ravinder K Banyal and Ansgar Reiner)*

Development of a Fabry-Perot Wavelength Calibrator for High Precision Doppler Spectroscopy

There are two major challenges that need to be overcome for doing high precision spectroscopy. First is the spectrograph instability (zero-point drift) largely caused by slow temperature and pressure changes and second is to do with the limitations imposed by traditional calibration methods. The accuracy of the wavelength solution obtained from the emission lamps has serious drawbacks arising from the uneven line spacing, large intensity variations, limited wavelength coverage and spectral contamination from unknown sources. The authors propose a wavelength calibrator using Fabry-Perot (FP) interferometer to achieve a 1–10 m/s radial velocity precision. A large number of wideband (500 nm–650 nm) transmission lines of the FP will provide a highly stable and uniform frequency scale for a medium resolution (R ∼ 40000-60000) astronomy spectrograph. A frequency locking mechanism is also described that is proposed to control and eliminate the long term cavity drift by anchoring the complete transmission spectra of the FP cavity to intrinsically stable fundamental atomic lines of the Rb-cell. In terms of stability and spectral coverage, FP calibrator is expected to reach a performance level of a laser frequency comb but with a significantly lesser cost and completely off-the-shelf components.

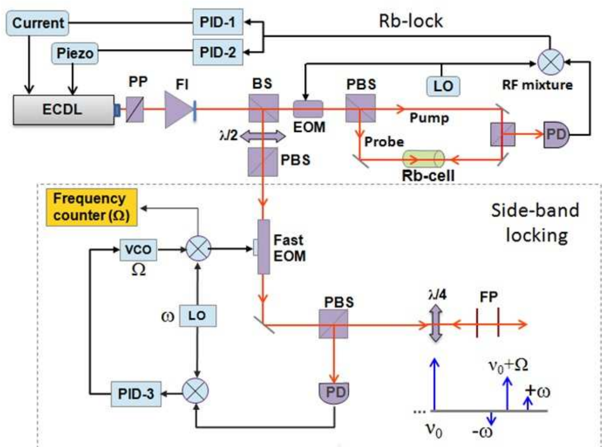

Figure 2.35: An experimental layout for drift measurement with a frequency locked diode laser.

(The 34th Meeting of the Astronomical Society of India, University of Kashmir, Srinagar, 10-13 May 2016.)

(Ravinder K. Banyal, Tanya Das, B. Ravindra and T. Sivarani)

Expected performances of a Laue lens made with bent crystals

In the context of the LAUE project devoted to build a Laue lens prototype for focusing celestial hard X-/soft gamma-rays, a Laue lens made of bent crystal tiles, with 20-m focal length, is simulated. The focusing energy passband is assumed to be 90–600 keV. The distortion of the image produced by the lens on the focal plane, due to effects of crystal tile misalignment and radial distortion of the crystal curvature, is investigated. The corresponding effective area of the lens,

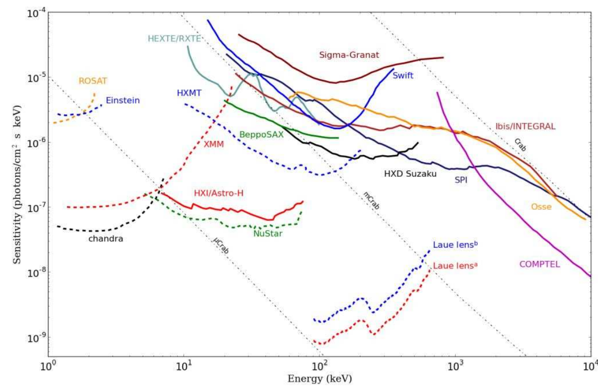

Figure 2.36: The 3σ sensitivity with $T_{obs} = 10^5$ s and $\Delta E = E/2$ of past and present direct-view instruments (continuous lines), and of the past and current focusing telescopes (dashed lines) in the X–/Gamma–ray domain, compared with the sensitivity achievable with the simulated Laue lens made of Ge(111) bent crystal tiles in the 90–600 keV energy pass band in the case of crystals with correct curvature radius and without any misalignment (red curve) and in the case of a Laue lens made of crystal tiles with maximum radial distortion of 6 m and a maximum misalignment in the crystal positioning of 30 arcsec (blue curve).

its point spread function and sensitivity are calculated and compared with those exhibited by a nominal Laue lens with no misalignment and/or distortion. Such analysis is crucial to estimate the optical properties of a real lens, in which the investigated shortcomings could be present. The expected sensitivity to emission lines of the simulated lens is also investigated. Up to 200 keV, a large improvement (more than two orders of magnitude) with respect to the INTEGRAL IBIS and SPI instrument sensitivity is found. This unprecedented sensitivity is very important, e.g., for a deep study of the 158 keV Ni^{56} line emitted at the early epoch of Type 1a supernovae. However an optimization of the lens at higher energies is recommended for deep nuclear science studies, like that of the origin of the positron annihilation line at 511 keV from the Galactic Center region. This optimization can be achieved with a larger diameter of the lens and an optimization of crystal thickness and/or material.

(Submitted for publication in Journal of Astronomical Telescopes, Instruments, and Systems.)

(E. Virgilli, V. Valsan, F. Frontera*, E. Caroli*, V. Liccardo*, J. B. Stephen*)*

Development of x-ray optics

Multilayer x-ray optics development is an ongoing program at IIA with collaborators at RRCAT, Indore and ISRO Satellite Centre, Bengaluru. The long term objective is to develop maturity in design, fabrication and testing skills that will cater to the needs of future EUV and x-ray telescopes for solar system exploration as well as for solar and stellar astronomy.

The authors explored new designs to use combinations of grazing incidence and multilayer optics to develop short focal length soft x-ray optics for planetary studies. The design was specifically tailored to study x-ray lines arising from charge exchange reactions in the exosphere of Mars. When multiply ionised heavy ions in the solar wind, interact with neutrals in the exosphere, the deexcitation of the resulting ions produce characteristic emission lines at soft x-rays (< 1 keV). Measurement of such lines enables better understanding of how solar wind interaction results in loss of atmosphere in planets. This is an important open question in addressing habitability of Earth-like exoplanets in habitable zones under different host star environments.

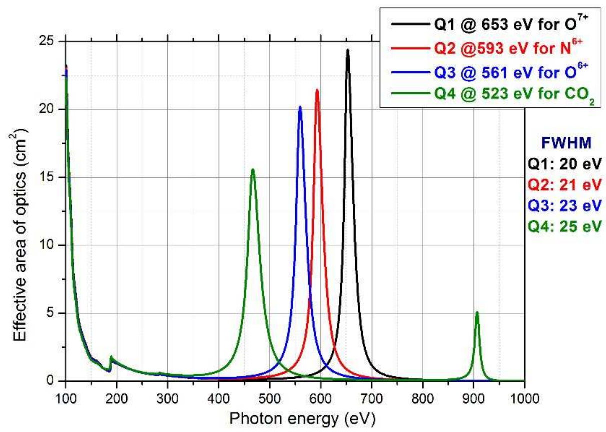

Figure 2.37: Effective area of optics for each quadrant; 4 quadrants imaged within a x-ray CCD system provides simultaneous measurement of x-ray line intensities of 4 charge-exchange lines expected from solar wind interaction with the Mars exosphere.

In a separate work, the authors completed a design of a simple x-ray polarimeter using multilayer mirrors that operates below 1 keV using five different multilayer mirrors, each tailored to provide polarisation information at a specific narrow band. This used the special property of reflection of soft x-rays at Brewster angles ($\sim$ 45 deg for x-rays at 1 keV) which preferentially reflects S-polarised photons. Steps are being taken to pursue further testing of multilayer mirrors in synchrotron beams and in laboratory setups.

(S. S. Panini, P. Sreekumar, K. C. Shyama Narendranath, M. Nayak*, P. S. Athiray*)*

Chapter 3

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Table 3.1: Publication List

Year	Published in Journals	Published in Proceedings	Total
April 2012 – March 2013	94	16	110
April 2013 – March 2014	103	16	119
April 2014 – March 2015	128	29	157
April 2015 – March 2016	120	31	151
April 2016 – March 2017	106	23	129
Total	551	115	666

Chapter 4

INSTRUMENTS AND FACILITIES

4.1 System Engineering Group (SEG)

The Systems Engineering Group (SEG) provides engineering support to all activities in the Institute such as instrument development, maintenance of the observatories and laboratories, and augmentation of the facilities. The group has been involved in the major projects like ITMT, VELC payload development, and proposal of NLST. In the current year, the group has completed the following works:

- The Lab for Payload Operations Centre of UVIT and refurbishment of optics laboratory has been completed at Bangalore campus.
- The Hα telescope has been installed and tested in CREST campus before it was shifted to Merak for observations. At present the installation work of the telescope is in progress.
- Re-aluminization of 2.3-m primary mirror of VBT has been successfully completed, re-alignment has been completed recently.
- The DIMM telescope and 30$''$ telescope in VBO, Kavalur are made operational.
- Fabrication and testing of 16$''$ telescope for IAO, Hanle.
- Andor-LUCA based auto-guiding instrument made functional in VBT.
- A 1000 class clean room facility for CCD systems servicing has been setup in STARS building of VBO. The vacuum failure issues of CCD dewars being addressed in this facility.
- Liquid nitrogen dewars for mosaic CCDs are developed and tested.
- The grid connected 100 KW SPV system has been synchronized to the power grid and producing about 500 KWh energy on a typical day.

The following works are at various stages of completion:

- The Raman Science Centre building at Leh and ITCC office building in Bangalore campus are in completion stage.
- Upgradation of clean room facility in CREST campus for VELC payload on ADITYA mission is in progress.
- An advance mirror coating facility for HCT telescope has been under installation.
- Upgradation of cooling mechanism for Echelle spectrograph in VBT is under progress.

- The installation of power systems at RSC, Leh has been taken up by the group and about to finish the job.

The group has initiated the following works:

- Construction of ITMT-OFF building at CREST campus, accommodation for Engineers at IAO, Hanle and student hostel facility at Radio astronomy observatory at Gauribidanur.
- Modernization of the existing 2.8-m mirror aluminizing plant at VBO.
- Development of CMOS CCD camera system.
- Upgradation of the multi-channel photopolarimeter.
- The aged dome of 40″ telescope is taken up taken up for repairs.
- Upgradation of power house in CREST campus to suite the requirements of ITMT-OFF facility.
- Rewiring and refurbishing VBT control electronics.

Day-to-day maintenance and minor works for newly coming up facilities are taken up internally by the group. The group is developing RF instruments for Radio telescopes. The group is also actively involved in student activities and public outreach programmes.

4.2 Observatories

4.2.1 Indian Astronomical Observatory

Himalayan Chandra Telescope

After installation of Hanle Echelle SPectrometer (HESP), a fibre-fed, high resolution spectrograph, the HCT now offers, imaging (optical and NIR), low/medium resolution spectroscopy (optical and NIR), and optical high resolution spectroscopy. This has resulted in increase of demand for observing time with the HCT. For 2016-Cycle2 (2016 May–August) 39 proposals, 2016-Cycle3 (2016 September–December) 42 proposals and 2017-Cycle1 (2017 January–April) 46 proposals were received. The telescope time was over subscribed by a factor 2.5 on an average, while the dark moon period was over subscribed by a factor 3.

Soon after its installation in 2000, the telescope is in continuous use by astronomers and has produced good numbers of research papers in reputed journals. Most of the electronic components of the telescope are getting aged, finding spare is difficult and hence the telescope needs to be upgraded. It is planned to upgrade the telescope control system and the secondary mirror drive.

The preventive maintenance activities of HCT were carried out around full moon period, as the demand of telescope time during bright moon period is usually low. During the monthly preventive maintenance, telescope and instruments were inspected and its components were cleaned. All the telescope related calibrations and look-up tables were updated periodically. This helps in bringing the down-time of the telescope to a minimum. Annual maintenance of the HCT was carried out during August 15–30, 2016. A thorough inspection and performance evaluation of various optical, mechanical, electrical and electronics components were carried out. A team of engineers from IAO and HCT astronomers participated in these activities.

Gamma Ray Facilities at IAO

The High Altitude Gamma Ray (HAGAR) observatory, operated jointly by IIA and Tata Institute of Fundamental Research (TIFR) Mumbai, has been in regular use since 2007. The telescope array has been used for monitoring supernova remnants, active galactic nuclei and other interesting gamma-ray sources. In 2016, a standard calibration method has been set up to calculate time offset of the detectors. This on-line set-up will also monitor the relative gain of each photo-multiplier and the following signal processing chain in the Data Acquisition System. The setup uses a single laser source (wavelength: 405 nm) coupled with optical fiber cables of length 85-m which transmit pico-second light flashes from a laser source to all the 49 PMTs. The calibration set-up has minimized the dependency on fixed angle observations and resulted in an increase of the available observing time by $\sim$10%.

The 21-m Major Atmospheric Cerenkov Experiment (MACE) telescope, being installed by Bhabha Atomic Research Center (BARC) near HAGAR, is nearing completion. It is planned to install the apex portion of boom with camera on the telescope structure in the summer of 2017 and the first light with 40 mirrors is expected towards the end of 2017.

NLOT site Characterization

Site characterization for NLOT is being continued at Hanle. The extinction monitor and cloud monitor is continuously gathering data for documenting the site conditions and its seasonal variation. The Sky radiometer (PREDE, POM-01, Japan), equipped with scanning radiometer, automatic sun tracker and rain sensor, was reinstalled at IAO Hanle in 2015. It is being operated continuously to measure direct and diffuse solar irradiance at several wavelengths from near UV to NIR region. The observed direct and diffuse irradiance are used to estimate aerosol optical depth, size distribution, single scattering albedo, asymmetry parameters at various wavelengths. The performance and calibration of the instrument are performed periodically (every month) using the in-situ observation at the site.

Earth Sciences, Atmospheric Physics related activities

Under the Aerosol Radiative Forcing over India (ARFI) project of ISRO-GBP, a high altitude Himalayan Aerosol Observatory was set up in 2009 at IAO Hanle by Space Physics Laboratory (SPL), Vikram Sarabhai Space Center (VSSC), Trivandrum in collaboration with IIA. The aim of the project is to characterize regional aerosols incorporating the heterogeneity in space, time and spectral domains and its impact on regional and global climatology. This observatory, consisting of four instruments, has been in continuous operation for measuring the Solar radiation, black carbon, nanometer size particles, including identification of new particle formation, their dynamics and other relevant parameters.

IIA has established two GPS stations at Leh and Hanle as a part of National GPS Network in collaboration with CSIR Fourth Paradigm Institute. The same is working fine and data is being transferred through ftp and mail. Air sampling of 1 litre glass flasks is being carried out continuously to study the CO_2 as a part of Carbon Dioxide Observatory operated jointly by IIA, CSIR Fourth Paradigm Institute and Laboratoire des Sciences du Climate de lEnvironment (LSCE) France.

NLST related activities at Merak

Figure 4.1: Weather station installed at Merak.

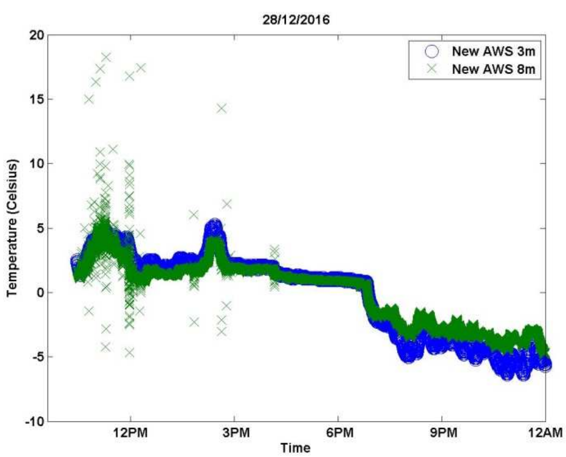


Figure 4.2: Comparison of temperature at 3-m and 8-m heights.

At Merak, the site characterization activities restarted in the month of November 2016 for the NLST project. The automatic weather station is deployed to take data of temperature, pressure, wind speed, direction at three meter and eight meter heights. The data are analyzed and compared at two different heights. The all sky camera is also installed to view the cloud coverage and to find the number of available clear days for observations.

The observations of the Sun in G-band using the 40-cm DFM telescope is restarted at Merak. A 100 nm band width G-band filter is used to isolate the 430.5 nm wavelength. A 2K×2K pixel CMOS camera is used to make the partial disk observations of the Sun. These images are used to track the sunspot and magnetic activities on the Sun

The preparations for installing the H-alpha telescope at Merak started during the summer of 2016. The civil work is completed and the telescope will be installed during the summer of 2017.

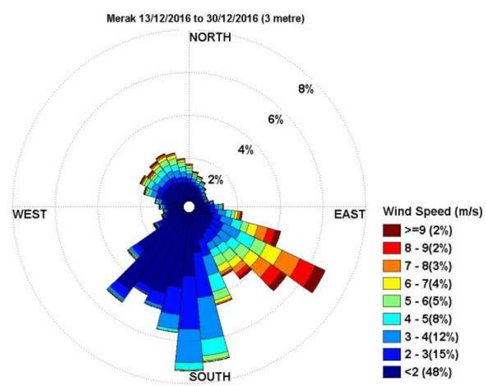


Figure 4.3: Comparison of wind velocity and direction at 3-m and 8-m heights.

Figure 4.4: The telescope pier and the walls constructed for installation of the H-alpha telescope at Merak.

4.2.2 Centre for Research and Education in Science and Technology (CREST)

Since the HCT is open to users, it's remote operation is being carried out from CREST Campus, Hoskote. A point-to-point dedicated satellite link between Hoskote and Hanle is used for remote operation of the telescope and transfer of observed data. The dish antennae used for communication have almost completed their expected lifetime, replacing them with new set of antennae is planned.

Construction of Optics Fabrication Facility for segmented mirrors polishing for TMT project has been taken with a floor area of about 25,000 Sqft. and ceiling height of about 10-m. The project involves provision of HVAC, clean room facility, lift, EOT Crane etc. for the entire facility. The Civil structural work is continuing. An additional power house is also being constructed to accommodate electrical equipment. Around 40% of the project is completed.

One of the two 20-cm H-alpha telescopes, procured from NIAOT (Nanjing Institute of Astronomical Optics & Technology) China, to make the full-disk observations of the solar chromosphere in H-alpha wavelength, was installed at CREST during November 2015 to test its functionality. The trial runs of the telescope were carried out. The required tuning of hardware was done to improve tracking of the telescope. The control software of the telescope is being written. The performance test of the telescope will be conducted and after confirming its satisfactory performance the telescope will be sent to Merak.

Figure 4.5: The 20-cm H-alpha telescope during test operation at CREST, Hoskote.

CSIR- Institute of 4-Paradigm (4PI), Bengaluru has set up a Green House Gas (GHG) station in the CREST campus of IIA at Hoskote. In 2016, two instruments Picarro 2301 measuring CO_2, CH_4 and LGR measuring N_2O, CO were installed in a cabin. This GHG station was inaugurated in October 2016. This station is also a reference station, equipped for calibration of secondary cylinders with the primary cylinders supplied by NOAA, USA. The primary cylinders are as per the standards prescribed by WMO. Adjacent to the cabin a 32 meter tower is installed. Air inlets are installed at the top of the tower for sucking air into the GHG instruments for measurements and for flask sampling. The data from the instruments are downloaded to CSIR 4PI regularly. The GHG data from these instruments will be used for inversion to estimate GHG fluxes.

Sky Conditions, Indian Astronomical Observatory, Hanle, Ladakh

Year	Month	Photometric nights	Spectroscopic nights	Total nights
2016	April	8	19	30
	May	13	21	31
	June	12	19	30
	July	11	19	31
	August	2	9	31
	September	19	26	30
	October	24	29	31
	November	26	29	30
	December	25	28	31
2017	January	13	21	31
	February	13	18	28
	March	16	22	31
	Total	182 (50%)	260 (71%)	365

4.2.3 Kodaikanal Observatory

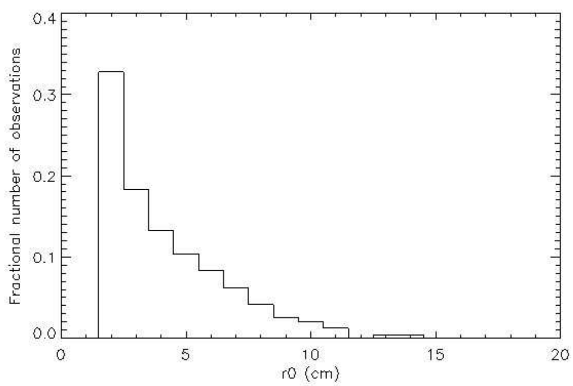


Figure 4.6: Histogram of measured r_0 values with KTT.

Image Quality Monitoring Experiments at Kodaikanal Tunnel Telescope (KTT)

In connection with the adaptive optics (AO) for the proposed National Large Solar Telescope (NLST), it is planned to use KTT as a test bench. As a first step, an experimental set up to measure and monitor image quality was installed at KTT in January 2017. A dichroic beam splitter was used to deflect the beam sideways, allowing only light less than 600 nm. A suitable combination of neutral density filters and blue continuum filters were introduced in the path of the beam just before the focus. A single data set contained a burst of 200 solar images (of either a sunspot as and when available or 'quiet' Sun region of the photosphere) of size ∼38 arcsec×38 arcsec with an exposure time of ∼10-20 ms. The data was recorded with a cadence of ∼15 min. The median root-mean-square (rms) image motion and the Fried′s parameter (r_0), derived from about four months of observations are ∼1.01 arcsec and ∼3.9 cm, respectively. The observations are being continued. In view of the above value of r_0, it is planned to implement AO in the I band (900 nm) or in the infrared (1000 nm) in KTT. A dedicated laboratory facility is being set-up at IIA, Bangalore to test/calibrate the AO components.

Spectro-polarimetric observations of active regions on the Sun with KTT

The dual-beam polarimeter at KTT has been enabled for spectro-polarimetric observations of the Sun. This involves automatic rotation of the wave-plates, scanning the region of interest, and the polarimetric calibration. One of the main goals of this experiment is to infer the vector magnetic field simultaneously in the photosphere and the chromosphere using the magnetic sensitive Fe I line and the H-alpha line, respectively. The above Fe I line is at 656.92 nm, about 0.6 nm on the red side of the H-alpha line.

Spectroscopic observations of solar prominences with KTT

Spectroscopic observations of prominences in H-alpha line have been initiated at KTT to understand their physical properties such as temperature, density and velocity distribution.

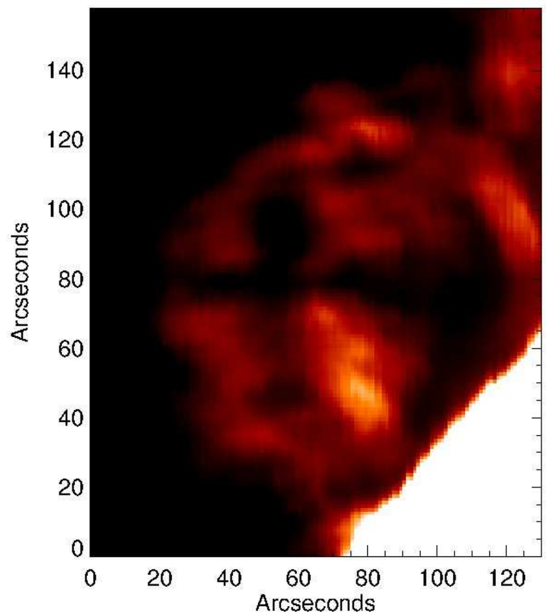


Figure 4.7: Raster observations of a prominence obtained with the KTT on 2017 May 9 at ∼02:30 UT. The passband is 0.015 nm centered around H-alpha line core.

Ca-K Latitude Scan – Synoptic observations with KTT

The Sun as a Star studies provide information about the solar variability with time. The Ca-K line is a proxy to the solar UV radiation and hence useful for Space Weather studies (i.e. the study of the Sun induced disturbances in the terrestrial and the near-Earth environment). Ca-K line profiles as function of latitude can be used to understand the solar dynamo and flows in the Sun by determining the movement of the activity as a function of latitude and time. These observations are very useful in monitoring active belts of the Sun and their variation with the solar cycle. Latitude scanning after integrating the corresponding longitudes on the solar disk in Ca-K line is an ongoing synoptic observing programming at the KTT.

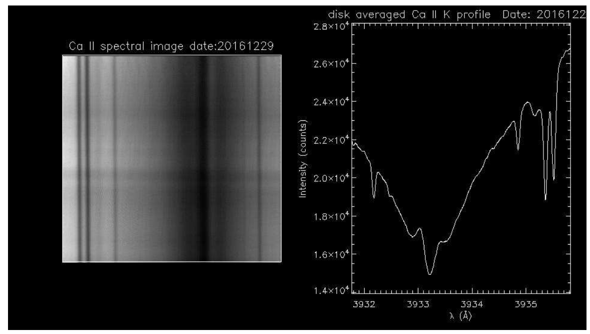


Figure 4.8: (Left) Ca-K spectrum observed with the KTT on 2016 December 29 at ∼02:30 UT; (Right) Ca-K line profile averaged over the disk.

Whitelight Active Region Monitor (WARM)

WARM is a two channel imaging telescope with one channel containing a G-band filter, and the other channel containing a Ca-K filter. A two mirror coelostat system is used to track the Sun. Solar images in the above two wavelength bands are obtained simultaneously using ANDOR and PCO drivers for MATLAB, with a cadence of ∼1 min. The code also controls the shutter unit that shields the cameras. Software for image reduction (till flat fielding at present) are also written in MATLAB. DayStar Ca-K line Quantum filter with a central wavelength of 393.37 nm and a passband of 0.2 nm is used. This helps to observe the activities in the solar chromosphere. The filter has a separate heating unit to tune the filter system to the central wavelength. The solar disk is imaged onto a 1024×1024 ANDOR CCD camera. The resolution of the images is ∼4 arcsec. The set-up has been implemented from January 2017.

H-alpha Telescope

Observations with the new H-alpha telescope in Kodaikanal is fully automated now. Full disk images of the solar chromosphere are obtained every day with a cadence of ∼1 min. The data are calibrated using codes written in Python, and the images are uploaded in the institute web server.

Digitization Programme

Kodaikanal Solar Observatory (KSO) has been acquiring full disk images of the Sun since early 1900. The images have been taken in three different filters: White-light (photosphere), Ca-K (lower chromosphere) and H-alpha (upper chromosphere). Originally, the images have been captured in photographic plates and films. Recently, the digitization of these plates/films, into high resolution standard astronomical images, has been completed for all the three filters. These century long data sets have also been calibrated (standard flat, bias and rotation corrections) for better scientific use. All the raw files along with the calibrated ones are now hosted at the institute web server for access by the user community.

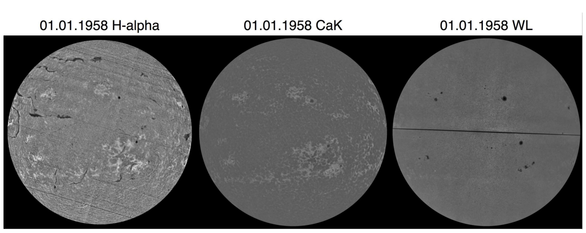


Figure 4.9: Digitized images of the white-light, Ca-K, and H-alpha observations carried out on 1958 January 1 at Kodaikanal.

Radio Spectral Observations

Low frequency radio observations are sensitive to weak non-thermal energy releases in the solar atmosphere since the associated coherent plasma emission mechanism can give rise to very high brightness temperatures. In view of this, a new radio spectrograph has been installed and commissioned recently in the frequency range 440-40 MHz for coordinated observations with the H-alpha telescope. The combined data are expected to provide unique information on the location as well as the energy budget.

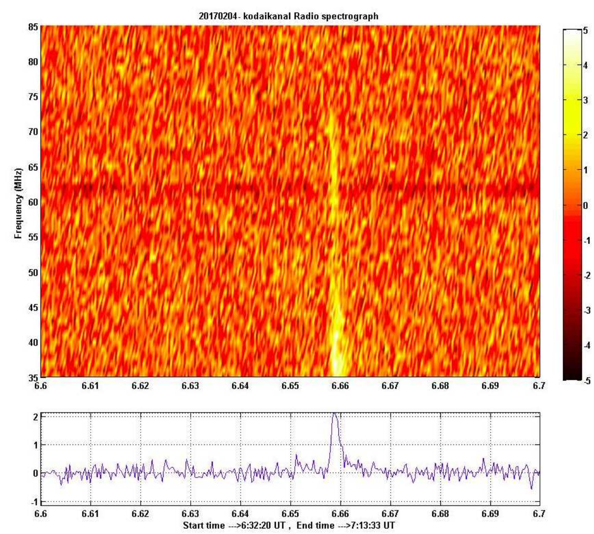


Figure 4.10: Spectrum of a type III solar radio burst observed with the Kodaikanal radio spectrograph on 2017 February 4 at 06:40 UT and the integrated light curve. The temporal and spectral resolutions are ∼1 sec and ∼1 MHz, respectively.

Sky conditions: Kodaikanal

Year	Month	Number of Observations						Seeing conditions*				
		6″ Refractor	WARM Telescope			Hα Telescope	Tunnel Telescope	5	4	3	2	1
		PHGM	G-band	Red cont.	CaK	Line center	Scans					
2016	April	28	-	-	-	21	4	10	-	18	-	-
	May	23	-	-	-	21	4	5	2	13	3	-
	June	14	-	8	-	10	-	1	-	10	3	-
	July	14	-	12	-	12	2	-	-	10	4	-
	August	18	-	17	-	18	2	2	-	11	5	-
	September	18	-	16	-	19	14	2	-	14	2	-
	October	20	-	14	-	17	9	3	2	5	10	-
	November	18	-	21	-	21	12	5	1	2	10	-
	December	19	6	22	-	23	16	11	-	4	4	-
2017	January	23	23	-	2	24	22	16	-	6	1	-
	February	24	26	-	25	24	0	16	-	6	2	-
	March	23	23	-	23	21	6	3	-	10	10	-
	Total	242						74	5	109	54	-

PHGM: Photoheliograms observed through 6-inch telescope.

*Seeing conditions (1-very poor, 2-poor, 3-fair, 4-good, 5-excellent)

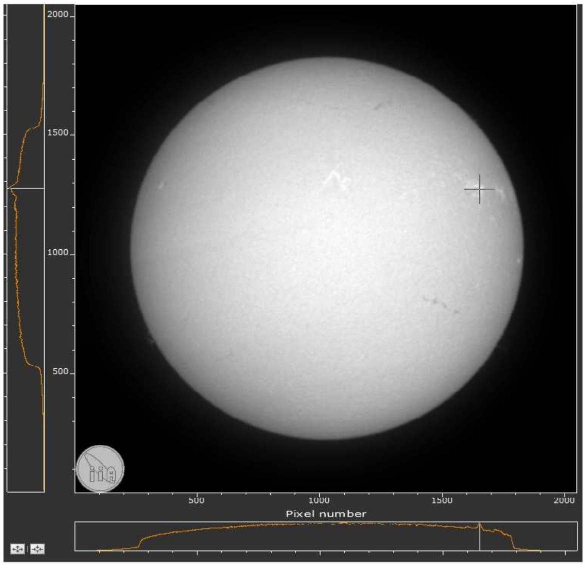


Figure 4.11: Kodaikanal H-alpha observations corresponding to Figure 4.10 showing the location of the activity (indicated by the '+' symbol). Solar north is straight up and east is to the left. The integrated light curve along the east-west and north-south directions on the Sun are shown in the lower and left panels, respectively. One can notice that the transient is weaker in H-alpha observations as compared to the radio observations.

4.2.4 Vainu Bappu Observatory

Reflectivity measurements of VBT′s primary

Before the aluminisation of VBT primary mirror, the reflectivity of the primary mirror surface was measured with hand held reflectometer. The reflectivity measurement were carried out after cleaning the primary mirror with distilled water. As the average reflectivity was found below 60% due to the degradation in the aluminum material and the number of pinholes, it was decided to go for primary mirror aluminisation. The coating chamber for VBT primary mirror was calibrated and made ready for aluminisation.

VBT Primary mirror re-aluminization and subsequent optical/ mechanical alignment

Primary mirror aluminisation activity of VBT was taken up during the period December 2016 through January 2017 by the optics and mechanical team of IIA. The support system of the primary mirror were tested for their performance by load checking. All the moving parts of support systems (30 axial floating support, three defining supports and 18 radial floating and three radial defining support) were lubricated for their smooth performance. The levelling of the axial support systems were tested when the primary mirror cell was in the mirror carriage unit. After coating of primary mirror, the primary mirror was loaded into the primary mirror cell. Primary mirror optical/ mechanical axis alignment were carried out, imaging at prime focus was done with 1K×1K imager (without wynne corrector).

On completion of primary mirror alignment, secondary mirror was integrated into the telescope structure and alignment activity was carried out. Secondary mirror was loaded into the structure and telescope balancing was done and then the alignment activity was started. The location of the center of secondary mirror with respect to the mechanical axis was measured with alignment telescope. But it was corrected to the optical axis with the alignment telescope using auto-collimation. After checking the image quality, OMR spectrograph was mounted and few standard objects' spectra were taken and compared with the spectra observed (under similar conditions) prior to aluminisation activity to quantify the telescope performance.

VBT Echelle′s smart optical table

Test on the vibration isolation system of the optical table of VBT echelle spectrometer in VBT coudẽ laboratory has been conducted. The performance of the optical table with different environmental conditions were studied and was found satisfactory.

New calibration unit for Echelle spectrometer and its upgradation

New fiber launching unit along with a calibration source unit is designed, fabricated and tested at the prime focus of the VBT. The new fiber launching unit is designed to improve the fiber coupling loss and the on-fiber guiding error that were present in the earlier fiber launching unit at the prime focus. The calibration unit is decoupled from the fiber launching unit. Wavelength calibration and flat field sources are fed to the fiber launching unit with the help of calibration fiber by keeping the calibration source unit on a stationary platform. The guiding error is improved to 15 to 20% along with the auto-guiding mode.

As the part of maintenance, the spectrometer was realigned and tested with new f/ratio converter pre-optics. Iodine cell and new slit unit were integrated in the spectrometer for radial velocity observations. Study on thermal and mechanical stability of the spectrograph has been initiated.

Autoguider for modified VBT Echelle Acquisition unit

A new acquisition unit was installed at the prime focus of VBT for Echelle Spectrograph (Sriram et al.). The light for the autoguider camera comes through a beam splitter. The target object is guided using only 4% of the incoming beam. Andor LUCA EMCCD (∼0.6 kg) is being used as the camera. With EM gain the camera could easily detect the required faintness level and the star could be comfortably guided with minimal exposure time.

Each pixel is 0.27 arc second and the guiding performance was:
RA ± 2 pixels for 93.9% of the total time
Dec ± 2 pixels for 93.7% of the total time
The guiding implementation is done using Andor Solis program which runs like a macro of Solis commands, similar to Twin telescope guiding at Kodaikanal. However, there are few changes in methodology like thresholding and using the values greater this value for computing centroids. The ‘outbyte’ command in Solis is not operational, which makes the implementation cumbersome. There is one ‘execute’ command under Solis to run any command under a DOS prompt which was used to operate a parallel port using Tvicport drivers. Through the parallel port the telescope relays were operated when required to be guided. Frequent calling of these commands made the computer to crash. A minimum gap of 70 milliseconds is now used to operate the telescope relays. The autoguiding system after about 40 days of testing, became fully stable by 10^{th} February and is now satisfactorily working. The guiding is initiated for a drift greater or equal to than 2 pixels (0.54 arcsec) and stopped if the drift is less than one pixel (0.27 arcsec). A typical value of 20-50 EM gain with less than 0.5 second exposure time is sufficient to guide 12^{th} star under reasonable sky condition.

DIMM Telescope

The 40 cm DIMM telescope has been upgraded and put into operation from December 2016 onwards. The telescope had few problems which were corrected during this period. The 1″ filters present in the DIMM have gone bad. A new set of filters could not be accommodated in the existing filter wheel, hence a new filter wheel was fabricated and installed. Positioning of filters through Seeing Monitor program was wrong and the Source code was modified to position the filters properly.

A GPS receiver module and a UT time synchronizing program have been installed since the GPS module in the DFM-TCS system had failed. Hour angle information of seeing measurement has been included into the R_0 log file by modifying the program. The delivered Serial port based Dome shutter control was erratic and was not suitable for remote operation through Intranet. A simple and robust Shutter controller was made, installed and the source code was modified to operate through DFM-TCS program.

From January 2017, Seeing measurements are being carried out when the clear sky is available. Remote operation was successfully tried from a remote computer on the Intranet.

Scientific programs carried out at the VBO

Abundance of H poor ejecta in Pne with Worf-Rayet type central stars, Medium resolution spectroscopic studies of IRAS sources with far-IR colors similar to post-AGB stars and planetary nebulae, High resolution spectroscopic studies on lithium abundances and rotational velocities of early F-dwarfs, Studies of hydrogen deficient stars, Characterizing the stellar magnetic activity of bright planet-host stars, Observations of radial velocity standards using Iodine-Cell and the Echelle spectrometer, Observations of new contact binary systems and Observations of supernovae and novae were the programmes at VBT.

The following programmes were carried out at JCBT: Tracing H-poor ejecta in the Pne with Wolf-Rayet type central stars, Study of stars spot related activities in W-UMa, Search for exoplanets in open clusters, Intranight variability of AGN, Photometric survey of star forming region, K2 Parallel monitoring, Differential photometry of eclipsing binaries and cataclysmic variables, Photometry of supernovae (ToO), and contact binaries, Intranight variability of MAGN.

The programmes at 1-m telescope were: Polarimetry of Post-AGB stars, BL Lac objects, Novae, symbiotic stars, Be stars, RV Tauri stars and polarization standard stars using a two beam, multichannel polarimeter. Medium resolution spectroscopic observations of Be stars using the UAGS spectrograph with a pixis-400 peltier cooled CCD detector.

Sky conditions at VBO

The following table gives the summary of night sky conditions for the months April 2016 to March 2017. The columns list the number of nights having 2 or more continuous hours and 4 or more continuous hours of nights classified as fit for spectroscopic or photometric studies. It is to be noted that for nights classified as “photometric” the sky has to be fully clear for the stated number of hours.

(VBO Team)

Sky Conditions at VBO

Year	Month	Spectroscopic Hours		Photometric Hours	
		2 hrs or more	4 hrs or more	2 hrs or more	4 hrs or more
2016	April	24	20	5	4
	May	13	8	0	0
	June	2	1	0	0
	July	2	1	0	0
	August	2	1	0	0
	September	0	0	0	0
	October	4	1	0	0
	November	24	21	4	2
	December	18	14	5	4
2017	January	23	22	3	2
	February	28	26	13	6
	March	21	18	7	5
Total (nights)		161	133	37	23

4.2.5 Gauribidanur Radio Observatory

Gauribidanur RAdioheliograPH (GRAPH) augmentation

Phase–II of the GRAPH augmentation work is currently underway. Once completed, GRAPH will have the capability to routinely produce simultaneous two-dimensional images of the solar corona (overlying the solar disk as well as off the solar limb) in total intensity (Stokes I) and circularly polarized intensity (Stokes V), for the first time at different spot frequencies in the range of ∼120-30 MHz. Such observations will be useful to estimate the global as well as the localized coronal magnetic field, and their radial variation over the heliocentric distance of ∼1-2 solar radii in the solar atmosphere. To achieve this, work is going on to install 128 new log-periodic dipole antennas (LPDAs) adjacent to the existing similar number of LPDAs in the North-South arm of the GRAPH array. The orientation of the new 128 LPDAs will be orthogonal to the present 128 LPDAs. The 128 LPDAs in each orientation will be arranged as 16 groups, with 8 LPDAs per group. Effectively, there will be 16 groups of LPDAs in 0 deg orientation (with respect to the terrestrial north), and as many groups of LPDAs in 90 deg orientation. Radio frequency signal (in the range ∼120-30 MHz) from each of these 32 groups of LPDAs will be correlated with the corresponding signal from each of the existing 32 groups of LPDAs (all in 90 deg orientation) in the East-West arm of the array using a 4096 channel FPGA based correlator system. A prototype LPDA that can observe the frequency range ∼120-30 MHz was fabricated in-house at the Gauribuidanur observatory to compare its performance with the existing LPDAs since the structural dimensions of the aluminium materials used for fabrication this time were different. The performance of the new LPDA was found to be satisfactory. Mass production of 128 new LPDAs are being carried out in-house at present. Work in connection with mass production and testing of different components of the analog front end receiver are also concurrently going on. On the digital receiver side, interleaved sampling and analog-to-digital (ADC) conversion up to 400 MHz rate has been characterized. The data were stored on BRAMs on a FPGA, and transmitted to the computer through a 1-Gbit Ethernet link. Trial observations were carried out using the 440-40 MHz spectral antenna system.

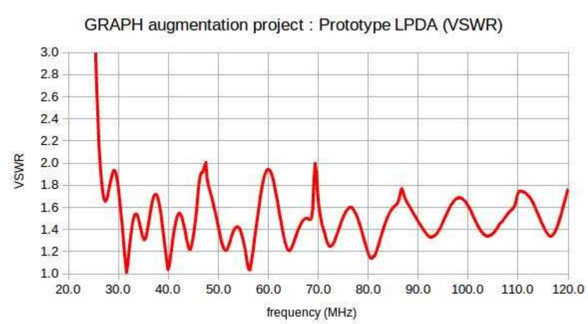


Figure 4.12: Impedance measurements with the prototype LPDA designed in-house at the Gauribidanur observatory. A Voltage Standing Wave Ratio (VSWR) of ∼1 corresponds to a transmission/reception efficiency of ∼100% (ideal case). VSWR ∼2 indicates an efficiency of ∼90%. One can notice that the LPDA itself acts as a high pass filter with cut-off at ∼30 MHz.

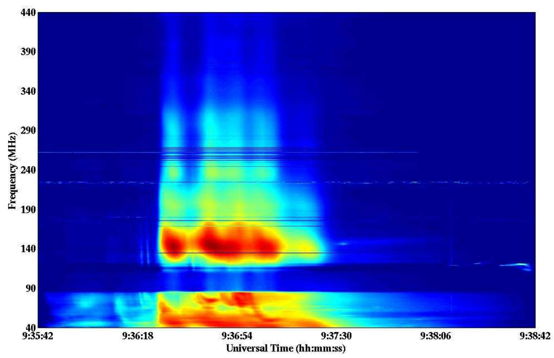


Figure 4.13: Radio signatures of flare accelerated electrons drifting outwards through the solar atmosphere along 'open' coronal magnetic field lines at velocities ∼0.3c observed with the new digital backend receiver under development in Gauribidanur. The temporal and spectral resolutions are ∼100 msec and ∼100 kHz, respectively. Note that radio emission at higher frequencies originate closer to the Sun and at an earlier epoch, compared to the radio emission at lower frequencies.

Gauribidanur LOw-frequency Solar Spectrograph (GLOSS)

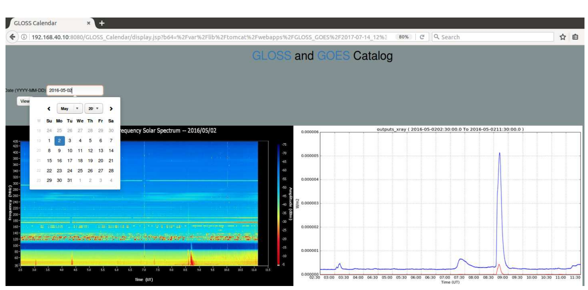


Figure 4.14: Simultaneous GLOSS and GOES/XRS observations of transient energy releases in the solar atmosphere during the interval ∼02:30-11:30 UT on 2016 May 2. One can notice that the weak burst observed with the GLOSS during the interval 04:00-04:30 UT (i.e. 4.0-4.5 UT) is not present in the GOES/XRS observations.

A web portal to access and plot GLOSS data by the user community has been developed. A new database model was adopted to run the web based data query and the plotting tool. DRUPAL web management package was installed and integrated for this purpose. A PYTHON code was developed for interactive plotting of the data obtained simultaneously with the GLOSS, and the soft X-Ray Spectrometer (XRS) onboard the Geostationary Operational Environmental Satellite (GOES). The motive is to identify weak non-thermal energy releases in the solar corona (potential candidates to address the coronal heating problem) to which the low frequency radio observations are typically sensitive, and look for their possible signatures in the X-ray wavelength range to get a multi-wavelength perspective. The tool will be shortly installed in the institute web server.

4.3 Ultra-Violet Imaging Telescope (UVIT)

The Ultra-Violet Imaging Telescope (UVIT) on board the ASTROSAT, the first Indian space observatory launched on 28 September 2015, has been operational for the last 19 months. The first 4 months were dedicated for performance verification and in-orbit calibrations, followed by proposal based observations for about one year.

The initial results of calibration as well as some early science results are published, while the results of the full calibration for all the filters and gratings in FUV and NUV channels have been submitted for publication.

The performance of the telescope is monitored using regular sensitivity checks. The science targets observed during the period include star clusters, galaxies, galaxy clusters, AGN, Chandra deep field, exo-planets, planetary nebulae, supernovae remnants etc.

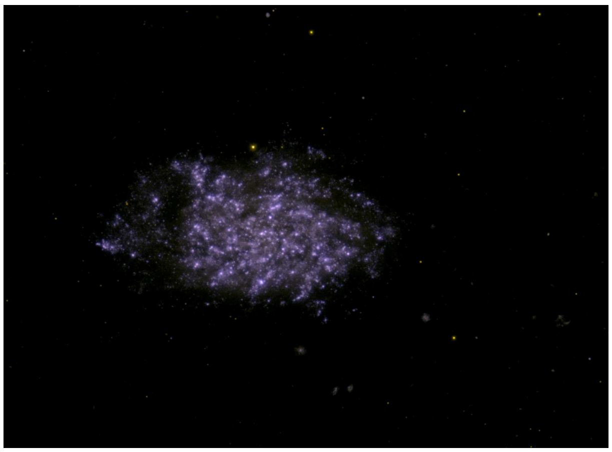


Figure 4.15: False Colour UVIT image of the galaxy NGC 7793, one of the brightest members of the Sculptor group of galaxies. This group is located near the south Galactic pole, at a distance of 3.38 Mpc. The UVIT image shows many bright star forming knots throughout the disk. A number of extended FUV bright structures are also seen along the periphery of the disk.

The overall performance of the instrument has been consistent with the calibrations done on the ground. In particular, the sensitivity in FUV and NUV is found to be within 80% to 90% of the expected, the spatial resolution in FUV and NUV exceeds the expectation, and relative astrometric accuracy over the field is about 0.5 arcsec (rms). The effective area curves for all the filters and gratings, and dispersions and resolutions for the gratings are made available in the UVIT website, `http://uvit.iiap.res.in/` The calibrations for absolute timing accuracy are yet to be done, and more data are required to fully characterize flat-field variations for all the filters. The calibrations done as of now are sufficient to derive science from all observations carried out using UVIT. Some examples of early images obtained from UVIT are given in Figures 4.15–4.17. More images can be found at `http://uvit.iiap.res.in/`.

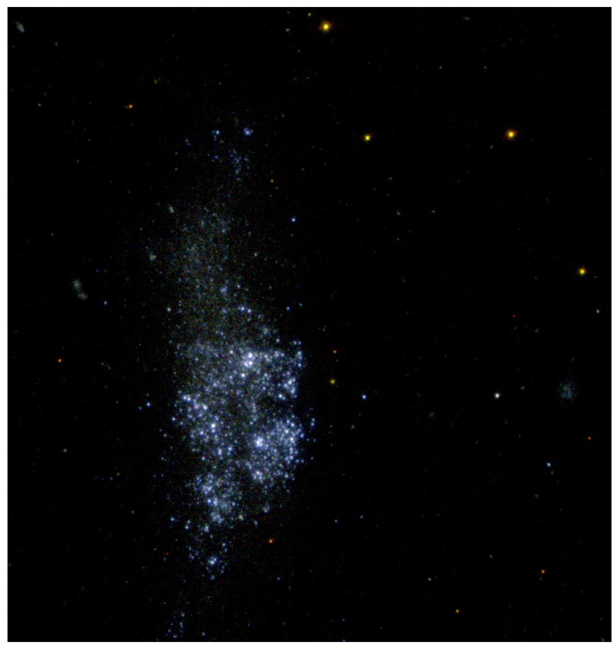


Figure 4.16: False colour composite image of the galaxy Wolf-Lundmark-Melotte (WLM) observed in the FUV and NUV with the UVIT. WLM is a dwarf irregular galaxy located at about 995 kpc. The galaxy is known as living cosmic fossil as it formed during the early epoch of the Universe and has not interacted with any other galaxy. The bright blue sources are the recent star forming regions of the galaxy. The point sources seen in the image are the star clusters or stellar groups of the galaxy.

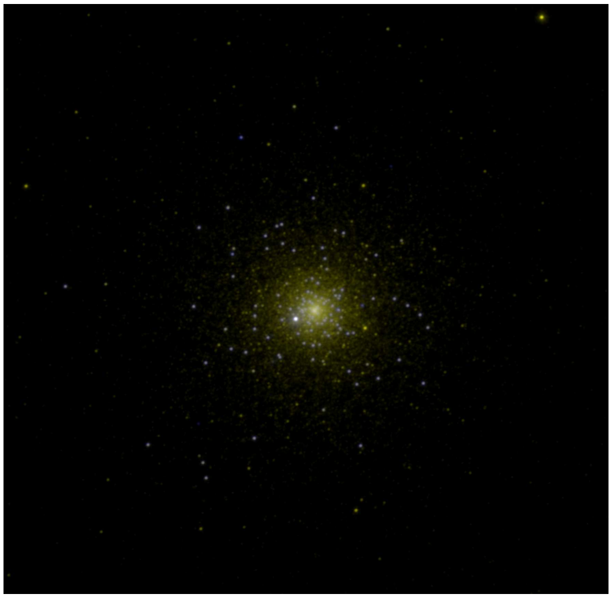


Figure 4.17: NGC 1851 is a massive globular cluster located in the Southern constellation of Columba. It is an unusual cluster speculated to be a merger of two individual clusters. It has been known to have a bimodal horizontal branch in the H-R diagram. In this colour composite image, the blue dots are the blue horizontal branch stars mostly distributed in the 2-4 arcmin radius of the cluster. These stars have evolved off the red giant branch phase and are now burning helium in their cores.

Indian as well as international astronomers have access to the observing time of ASTROSAT and UVIT through proposals. Certain amount of observing time is also fixed for routine calibration observations.

UVIT–Payload Operations Centre

The UVIT–payload operations centre (UVIT–POC), operating at the Indian Institute of Astrophysics, is entrusted with the responsibility of receipt of dump orbit wise data as well as merged data sets that pertain to a single observational ID. These observations referred to as L1 data sets are run through custom made software to check for the correctness of FILTER keyword. The corrected files are then run through the L2 pipeline chain (developed jointly by the Space Applications Centre, SAC, Ahmedabad and the National Centre for Radio Astrophysics, NCRA, Pune) to produce astronomical images both in pixel co-ordinate system as well as astronomical coordinate system. Quality checks (that take into account of the PSF of the obtained images and the observing time relative to the requested time by the proposers) on those images are performed. The corrected L1 data set along with the L2 products are then transferred to the Indian Space Science Data Centre (ISSDC), Bangalore for dissemination to the principal investigators of the proposals. The processed L2 products sent to ISSDC from the UVIT-POC are science ready images and the PIs can directly use those images for their respective science. The status of the L1 data received at UVIT–POC, their processing and subsequent delivery to ISSDC can be known at `http://uvit.iiap.res.in/dataStatus/`. Users of UVIT are encouraged to routinely check the website `http://uvit.iiap.res.in` for news and updates.

In addition to the routine job of processing L1 to L2 and sending them to ISSDC, UVIT–POC is also involved in developing various software tools that help in UVIT proposal preparation, access the safely of the field for observations by selection of proper FUV, NUV and VIS filters and generation of light curves of the sources in the field. This light curve generation tool has several options to choose the source region, the background region and the time resolution. The UVIT–POC also serves as an one stop location for all support related to observations with UVIT and analysis of the data from UVIT. UVIT–POC also regularly hosts UVIT data analysis workshops (to train new users of UVIT) and science meetings to bring together users of UVIT to discuss new results and plan new important and challenging observations to understand the cosmos. To run the day-to-day handling of data coming from UVIT, the UVIT–POC is manned by two research trainees and two engineering trainees.

4.4 Computational Facilities

Firmware of all critical hardware devices like firewall, switches etc. were updated to mitigate security threats, if any. All critical servers such as mail server, anti-spam server, web server, ERP server, computational servers etc. in the Data Center were kept up-to-date by upgrading the software to its latest version or updating with latest security patches, to minimize the exposure to vulnerabilities. To ensure security of internet traffic, we have also implemented SSL certificates across all IIA public servers. Keeping in view of the recent malware attacks on Windows OS worldwide, IIA computer center has brought a centralized anti-virus solution with anti-malware features to counter such threats.

The servers/ hardware infrastructures, hosting the critical services were kept up to date by replacing the old servers/ hardware with new servers/ hardware when they were nearing their end of life. Network augmentation was carried out by installing new generation wireless access points at various locations after identifying the locations with weak signal strength (e.g. Bhaskara Hostel). RAO, Gauribidanur became one of the first remote field stations of IIA to be provided with NKN connectivity after IIA's proposal, requesting for NKN connectivity at IIA remote field stations, got approved by NKN.

To facilitate better monitoring of Data Center and Data Center support system such as PACs and UPS, a new BMS (Building Monitoring System) was procured and put up in place.

All the above measures were taken towards strengthening IT security and providing better services to the end users at IIA.

HPC Activities

An order is placed for a new High Performance Computing (HPC) cluster. The new cluster will replace the existing one which was installed more than 6 years ago.

IIA Web server Activities

Migration of IIA web services to a new server is in the final stages with latest CMS in place. It is also expected to have better security features and performance along with improved user experience design.

ERP

An Enterprise Resource Planning (ERP) software custom made for IIA has been implemented for use within IIA, Bangalore and its various field stations. Generally, this type of system consists of modules such as Human Resources, Accounting, Finance, and Purchase etc. Once implemented, an ERP system will enable employees to manage resources in all areas, to simulate different scenarios and to obtain real-time consolidated information. E-tendering module has been successfully implemented in the ERP package to facilitate online response to IIA tender requests.

4.5 Library

The Library supports all aspects of research by providing information resources and continued to collaborate with the scientific community to build the collection of books and e-resources. The Library enhanced its collection by adding books, journals, and e-resources, which includes the centers at Bangalore, and field stations. The emphasis is now given to electronic resources as it facilitates its use in all campuses, equally and simultaneously. IIA Library continues to be a member of the NKRC consortium and has electronic journals and electronic resources access with 12 major publishers. Library also purchases and maintains Hindi books in support of the Official Language Act.

Developmental Activities

During the year the Library Committee was reconstituted, and took up reform of the procedures for collection to ensure the development of Library materials that support the Institution's mission while the emphasis is now given to need based collection development. The committee approved the requirement of three new computers since the existing ones are obsolete, two new ACs and two de-humidifiers for the archives in the Library, and the new photocopying machine for the Library. The committee also reviewed the existing infrastructure, facilities, software, procedures, policies, man power and future plans.

Document Delivery Services

As no Library can be completely self-sufficient, the Library also provides document delivery service through Inter-Library Loan. The number of Inter-Library Loan requests for articles from other institutes fulfilled by IIA Library was 125 and that of requests of IIA faculty fulfilled by other libraries was 80.

Institutional Repository

The institutional repository consists of publications by the scientific and technical community of IIA. During the year research articles, technical reports, PhD theses, and Integrated MTech-PhD theses were uploaded to the repository. Currently, IIA's open access repository is ranked 853 in the list of top Web of Repositories covered worldwide as of January 2017 and contains 6888 records.

Archives

The historical contents in the archives have been used for research purposes by IIA scientific community, and also by researchers nationally and internationally. The present archival collection is under the process of re-classification and re-arrangement for enhanced organization, access, preservation of unique records and also for the better visibility.

Bibliometric Analysis

IIA Library has given extensive input to Annual Reports and DST Reports by submitting scientometric analysis of IIA research publications from time to time.

Library Training and Internship Programme

The Library trainee program is continued and three new trainees joined the Library and are training to carry out all the Library activities.

Chapter 5

UPCOMING FACILITIES

5.1 Thirty Meter Telescope

India TMT Activities

During this year, project continued its effort of securing site for TMT construction. TMT project explored sites in the northern hemisphere as alternate sites for TMT project in case building TMT in Hawaii is unviable due to legal process. One of the sites explored was Hanle, Ladakh for which a detailed report was prepared by India TMT team. In October, 2016, TMT board of Governors, after careful deliberation, identified Observatorio del Roque de los Muchachos (ORM) on La Palma in the Canary Islands, Spain as the primary alternative to Hawaii. However, Mauna Kea continues to be the preferred choice. Project is making all efforts to secure re-permit for Mauna Kea site, and in parallel project is working with Spanish government to obtain all the required statuary permits to begin construction latest by April, 2017. While waiting for site issue to be resolved, technical works across partner countries progressing well though at relatively slower phase.

Within the country, India TMT made good progress on its assigned work packages. Sub systems such as edge sensors, actuators, segment support assembly (SSA) and controls developed as part of prototype manufacturing activity were assembled at pilot group facility, Pasadena, USA, and their performance tested against design requirements. Mr. Prasanna Deshmukh from IIA/India TMT participated in the assembly and tests in August, 2016. The tests carried out warranted minor changes in the design and process of manufacturing. These are being addressed at various industries and institutes in the country such as CTTC, Bhuvaneswar, CMTI, Bengaluru, NCAIR, IIT Mumbai, IPA, Bengaluru, and partnering institutes. In this period, India TMT made serious efforts of identifying capable industry partners for production qualification for Edge sensors, Actuators, and SSAs and partners for third party inspection of hardware parts which is one of the key elements. On the software front, Telescope Control Systems (TCS) concept design has been completed in December, 2016, and preliminary design (PD) is underway which is being done by Honeywell India. Preliminary Design (PD) phase of common software within the observatory software (OSW) work package contract is being done at Thoughtworks, Pune. India TMT team made significant contribution to the design development of WFOS instrument. The team completed their analysis of spot, sensitivity and distortion maps with real collimator with two choices of camera for red and blue channel configuration for both low/medium resolution spectra.

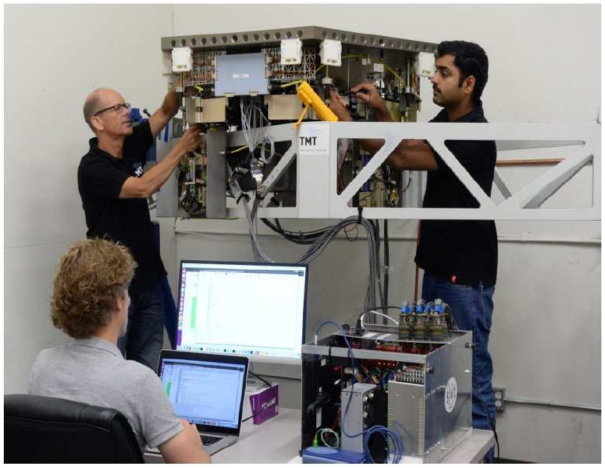


Figure 5.1: Assembly of M1 controls (Sensors, actuators, SSAs) and testing at TMT facility, Pasadena, USA of mirror performance against design requirements. Most of the hardware was shipped from India.

Another significant development was in the area of segment polishing. The India TMT Executive Council, in its meeting held in April 2016, chaired by the Secretaries of DST and DAE, approved the development of a large optics fabrication facility at IIA's CREST campus. This facility will be used for the fabrication of ∼90 M1 segments of 1.52-m diameter each. Civil work for the facility commenced in August, 2016. The facility will house custom built equipment for stress mirror polishing (SMP) a preferred technique, CNC and CMM machines. Once completed, this facility, also known as India TMT Optics Fabrication Facility (ITOFF), is expected to cater to the needs of large optics fabrication in the country.

Apart from engaging in fulfilling the delivery of hardware and software as our in-kind contribution to the project, India TMT is actively working towards development of human resources. As part of this vision 6 senior PhD and PDF fellows from India participated in the work shop on "Preparing TMT Future Leaders" held in December, 2016, in Hilo, Hawaii. A day long workshop on "High resolution Spectroscopic Instruments for TMT project" was held in Srinagar on the sideline of ASI-2016. In October 2016, India TMT conducted a one day workshop on infrared instruments for TMT which was attended by about 40 members across institutes in the country and also few experts from Japan. In January 2017, India TMT conducted a two week workshop on science, instruments and data analysis aspects of TMT project at IUCAA, Pune. This was attended by about 70 MSc and PhD students who were given hands-on programmes on optical and IR data reduction and analysis .

Figure 5.2: Architecture model of ITOFF (left) and work on progress at CREST, IIA (right).

5.2 Visible Emission Line Coronagraph on ADITYA(L1)

Current Status

BDR, SRC and PDR reviews are completed and the recommendations of these committees have been incorporated in the pay-load. Fabrication process of different subsystems are in progress. It is expected to complete the laboratory model by October 2017. This will enable the team to study the structure metrology and pay-load integration schemes. Changes, if any, will be incorporated in qualification model. The qualification model is expected to be ready by June 2018. The facility augmentation for pay-load integration and calibration is in progress. Many of the sophisticated metrology instruments have been procured and installed. The design of large vacuum facility and the Coronagraph Scatter Measurement Facility are completed. Installation and commissioning of these systems are expected to be completed by February 2018.

5.3 National Large Solar Telescope

Major milestones are listed below.

Clearance from wildlife board

A letter of approval for the Merak site came from Ministry of Defence in the year March, 2016. Following this, the NLST team submitted all the necessary documents for the environmental clearance to the Wildlife board of Jammu and Kashmir. The standing committee of state board for Wildlife recommended the proposal (18/May/2016). The state board for Wildlife forwarded the application with recommendation to the National Board for Wildlife, New Delhi. The standing committee of National Board for Wildlife (NBWL) conducted a meeting on March 2^{nd} 2017 in Indira Paryavaran Bhavan, New Delhi. The proposal was put in front of the standing committee of NBWL. The standing committee recommended the proposal for the utilization of 7.6 ha forest land from Changthang Cold Desert Wildlife Sanctuary for establishment of National Large Solar Telescope.

Building and Dome Design

The mechanical design of the telescope, dome and rotating platforms are undertaken with the help of mechanical Engineers at IIA. The building concept and design plan are undertaken with the civil engineers. The weather station and all sky camera are installed at the site to get the daily weather conditions at Merak.

Detailed Project Report (DPR)

The NLST team at IIA reworked on the Detailed Project Report of the project and prepared a detailed document with Merak as a site. The team also prepared the report for the Standing Finance Committee of Department of Science and Technology (DST) and submitted to the DST.

Endorsement by the IIA Governing Council

The IIA Governing Council during its meeting on September 15, 2016 & February 14, 2017, reviewed the project and recommended it for funding.

Endorsement by the Mega Facilities for Basic Research

The permission from the Ministry of Defence has been received for the availability of the Merak site in Ladakh for the large telescope set up. The committee recommended with necessary budgetary provision for creating Large Solar Telescope Facility at Merak as early as possible.

Chapter 6

STUDENT PROGRAMS AND TRAINING ACTIVITIES

Student programmes at the Institute are carried out by the Board of Graduate Studies. The institute conducts a PhD programme, in collaboration with the Pondicherry University and an MTech–PhD Programme, in collaboration with the Calcutta University. Apart from these, the Institute also trains students through short term programmes such as the visiting students programme, the summer school and the summer project program. The highlights of these programmes are summarized below.

6.1 PhD Degree Awarded

Five students were awarded PhD Degree during 2016 – 2017.

Sajal K Dhara was awarded (on 23 May 2016) the PhD degree for his thesis titled "Radio Polarization Studies of The Solar Corona At Low Frequencies" submitted to the University of Calcutta. He carried out the above work under the supervision of B. Ravindra.

Ramya P. was awarded (on 26 May 2016) the PhD degree for her thesis titled "Study of Steller streams in the Galaxy" submitted to the University of Calicut. She carried out the above work under the supervision of B. Eswar Reddy.

Arun Surya was awarded (on 8 June 2016) the PhD degree for his thesis titled "Image Retrieval in Astronomical Interferometers Affected by Atmospheric Turbulence" submitted to the University of Calcutta. He carried out the above work under the supervision of S. K. Saha and R. Ramesh.

Vaidehi Sharan Paliya was awarded (on 29 August 2016) the PhD degree for his thesis titled "General Physical Characteristics of gamma ray Emitting Beamed AGNs in Fermi Era" submitted to the University of Calicut. He carried out the above work under the supervision of C. S. Stalin.

Anantha Chanumolu was awarded (on 28 January 2017) the PhD degree for her thesis titled "High Resolution Fibre Fed Echelle Spectrograph: Calibration and Characterisation for Precise Radial Velocities And Chemical Abundances" submitted to the University of Calcutta. She carried out the above work under the supervision of T. Sivarani.

Table 6.1: **Number of PhDs awarded over the past five years**

Year	No.
April 2012 – March 2013	2
April 2013 – March 2014	5
April 2014 – March 2015	7
April 2015 – March 2016	10
April 2016 – March 2017	5
Total	29

6.2 PhD Thesis Submitted

Five students have submitted PhD thesis during 2016 – 2017.

Tarun K Sharma submitted his thesis titled "Development of Instruments for Astronomical Site Characterization and their Application" to the University of Calcutta on 16.06.2016. The research was done under the supervision of P. S. Parihar.

P. Kishore submitted his thesis titled "Development of a Broadband Radio Spectropolarimeter for Solar Observations" to the University of Calicut on 04.08.2016. The research was done under the supervision of C. Kathiravan.

C. R. Sangeetha submitted her thesis titled "Magnetoconvective Flows and Waves in the Lower Solar Atmosphere" to the Pondicherry University on 27.01.2016. The research was done under the supervision of S. P. K. Rajaguru.

Tanmoy Samanta submitted his thesis titled "On the coupling between lower and upper atmosphere of the Sun" to the Pondicherry University on 31.01.2017. The research was done under the supervision of Dipankar Benerjee.

Sreejith, A. G. submitted his thesis titled "Studies of earth's atmosphere from space and near space" to the University of Calcutta on 16.03.2017. The research was done under the supervision of Jayant Murthy.

6.3 Completion of MTech Program

The following students from the 8th batch of the above programme have completed their MTech Degree under the IIA–CU integrated MTech–PhD programme.

K. Pavan Kumar under the guidance of Gajendra Pandey and C. Muthumariappan submitted his MTech thesis titled "Proposed Optical Designs of the Dual Beam Imaging Polarimeter for the 1.3-m JCBT" to the University of Calcutta on July 2016.

Aritra Chakraborty under the guidance of K. B. Ramesh submitted his MTech thesis titled "Instrument Design Consideration for the Observation of the Sun at NIR wavelengths (around 1.63 micron)" to the University of Calcutta on July 2016.

Souvik Bose under the guidance of K. Nagaraju submitted his MTech thesis titled "High–Precision Full Stokes Spectropolarimetery of the Sun–as–a star Instrument Design Aspects" to the University of Calcutta on July 2016.

Tanya Das under the guidance of Ravinder K. Banyal submitted her MTech thesis titled "Development of a Fabry-Perot Cavity Stabilization System" to the University of Calcutta on July 2016.

6.4 School in Physics and Astrophysics

The summer school in Physics and Astrophysics, coordinated by the Board of Graduate studies, is a yearly activity of the Indian

Institute of Astrophysics. The main objective of the school is to introduce students of MSc, BE/BTech degree courses to the field of Astronomy and Astrophysics and secondly to motivate them to take up research careers in Astronomy and Astrophysics. For the year 2016, the school was held at the Kodaikanal Observatory, during May 20 to June 3.

Twenty four students participated in the school; eight of these students also carried out short term projects for a duration of six weeks during June–July, 2016 under the guidance of IIA faculty in Bangalore as well as in Kodaikanal observatory. During the last week of the program these students made presentations on the results of their project works. The program during the period May 20 to June 3 in Kodaikanal observatory consisted of a series of lectures including Physics and Astrophysics mostly by the faculty members of IIA. The topics covered included observational Astronomy (U. S. Kamath), Sun physics and instrumentation (K. B. Ramesh, Vema Reddy, Hemanth Pruthvi), Radiative Processes (R. T. Gangadhara), High Energy Astrophysics (C. S. Stalin), Radio Astronomy (Kathiravan), Stellar Spectroscopy (Sunetra Giridhar), Star formation, ASTROSAT and UVIT (Annapurni Subramaniam), Galaxies (Preeti Kharb), MHD (S. P. Rajaguru), Cosmology (Pravabati Chingangbam), Stellar and Galactic chemical evolution (Aruna Goswami), InfraRed Astronomy (C. Muthumariappan).

Local arrangements of the school were efficiently done by the staff of the Kodaikanal Observatory under the guidance of R. Selvendran. The school was organized by summer school committee with Aruna Goswami as the coordinator and U. S. Kamath and C. Muthumariappan as members.

6.5 Visiting Students Programme (VSP)

The visiting student's internship programme is conducted by the Indian Institute of Astrophysics (IIA) with an aim to promote scientific research interest in college and university students. Students selected for this programme work on specific projects that form a part of ongoing research at IIA. Based on the nature of the project, the students are asked to work at either the main campus of IIA in Bangalore or its field stations. Students carrying out their PhD in Universities, and willing to visit IIA for collaborative research are also encouraged to apply for this programme. During 2016–2017 seventy three students did their projects under the guidance of the various academic staff members.

6.6 Attendance/ Presentations in Meetings

Talks given in national/ international meetings

Bhoomika

- *Variability in Blazar jets through Optical and GeV observations*, January 10th to 13th, 2017, "Wide Band Spectral and Timing Studies of Cosmic X-ray Sources" - International conference at TIFR.

Joby, P. K

- *Analytic Tensor Minkowski functionals and their applications to Cosmology*, 18-20 May 2017, 29th IAGRG meeting, IIT Guwahati.

Joice Mathew

- *An Ultraviolet imager on a CubeSat for astronomical transient studies*, May 2016, 5th Interplanetary CubeSat Workshop, University of Oxford, Oxford, UK.

- *Development of an Ultraviolet Cosmic Imager for Space Flight*, February 2016, National Space Science Symposium, 2016 held at VSSC, Indian Space Research Organization (ISRO), Trivandrum.

Kshama S Kurian

- *Intranight optical variability of Narrow line Seyfert 1 galaxies*, January 10th to 13th, 2017, "Wide Band Spectral and Timing Studies of Cosmic X-ray Sources" – International conference at TIFR.

Mugundhan, V

- *Long-Baseline Interferometric observations of sub-arc minute structures in the Solar Corona*, March 1–4, 2017, URSI Regional Conference on Radio Sciences, 2017 at NARL Tirupathi.

Pavana, M

- *Jet Triggering Mechanisms in Black Hole Sources*, Jan 20–23 2016, TIFR, Mumbai.

Prasanna Deshmukh

- *A soft Actuator for Prototype Segmented Mirror Telescope*, June 06, 2016, SPIE Student Travel Grant, SPIE AT&I 2016, Edinburgh, UK.

- *Primary mirror active control system simulation of Prototype Segmented Mirror Telescope*, January 07, 2017, Indian Control Conference 2017, IIT, Guwahati.

Prasanta K Nayak

- *Star Clusters In the Magellanic Clouds-I: Parameterisation and Classification of 1072 Clusters in the LMC*,
  - August 8–12, 2016, "Star Clusters: From Infancy to Teenagehood", Max-Planck Haus, Heidelberg, Germany.
  - December 5–7, 2016, "Star and Planet Formation: Insights and Intricacies", IIST Trivandrum.

Prerna Rana

- *Kinematic models for QPOs in BHBs*, January 10–13, 2017, "Wide Band Spectral and Timing Studies of Cosmic X-ray Sources", TIFR Mumbai.

- *Dynamics of bound orbits in Kerr geometry and QPO frequency ratios*, 6–10 March, 2017, 35th meeting of Astronomical Society of India (ASI).

- *Relativistic kinematic models for QPOs and jets in black hole systems*, 22 March, 2017, IUCAA resource center, Department of Physics and Astrophysics, University of Delhi.

Ramya M Anche

- *Design of an optical layout to mitigate the instrumental polarization due to telescope optics of thirty meter telescope(TMT)*, 26–28, November 2016, International conference on light and light based technologies (ICLLT), Tezpur University, Assam.

Rubinur Khatun

- *Radio Observations of Candidate Dual Active Galactic Nuclei in Double Peaked Emission Line Galaxies*,
  - May 10–13, 2016, 35th ASI at Kashmir University, Kashmir.
  - November 3–5, 2016, SKA Pathfinders Radio Continuum Surveys 2016 at the ICG, Goa.
  - January 10–13, 2017, Wide Band Spectral and Timing Studies of Cosmic X-ray Sources at TIFR, Mumbai.

Sandeep K Kataria

- 3rd to 14th October 2017, Introductory school for parallel programming, International Center for Theoretical Physics, Trieste, Italy.

Snehalata Sahu

- *UVIT Imaging of Globular Cluster NGC 288*, 6–10 March, 2017, ASI–2017: B. M. Birla Auditorium, Jaipur.

Sreejith, A. G

- January 2017, University of Massachusetts, Lowell, MA, USA.
- March 2017, University of Calcutta, Kolkata.

Sreekanth Reddy, V

- *Optical design and performance modeling of an adaptive optics module for 1.3-m JCB telescope*, November 26–28, 2016, International Conference on Light and Light based Technologies (ICLLT), 40th conference of optical society of India, Tezpur central university, Assam.

Susmitha Rani Anthony

- Oral presentation, ASI 2016, Srinagar.

Vaibhav Pant

- August, 2016, IBUKS meeting held at KU Leuven, Belgium.

Varun Kumar

- *Design and analysis of planar flexible inductor for segment edge sensing in Segmented Mirror Telescopes*, ASI – 2017, Jaipur.

Vidhya, G

- *Tensor Minkowski Functionals as a tool to analyze Cosmic Microwave Background*, October 2016, 5th Neighbourhood Astronomy Meeting at ISRO Head Quarters, Bengaluru.

Poster presentations in national/ international meetings

Ambily, S

- *Near UV Imager with an MCP-based Photon Counting Detector*, SPIE Astronomical Instrumentation 2016 at Edinburgh, UK.

Amit K Mandal

- *Determination of the size of the dust torus in H0507+164 through Optical-Infrared monitoring*, 6–10 March, 2017, ASI – 2017: B. M. Birla Auditorium, Jaipur.

Annu Jacob

- *Optics for prototype segmented mirror telescope*, May 2016, 34th meeting of Astronomical society of India, Jammu Kashmir.

- *Pyramid sensor for aligning and phasing segmented mirror telescope*, March 2017, 35th meeting of Astronomical Society of India, Jaipur.

Avrajit Bandyopadhyay

- *Metal poor G-band stars in the Galactic halo and globular clusters : Exploring the common origin*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.

Bhoomika

- *The Connection between Optical and GeV flux Variation in Blazars*, 6–10 March 2017, XXXV Meeting of Astronomical Society of India, B. M. Birla Auditorium, Jaipur.

Chayan Mondal

- *NGC 300 : Discovery of an extended young outer disk*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.
- *UVIT imaging of WLM : Understanding star formation in the dwarf irregular galaxy*, 6–10 March, 2017, ASI – 2017: B. M. Birla Auditorium, Jaipur.

Dipanweeta Bhattachrya

- $M_\bullet - \sigma$ *relation and Galactic Structure*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.
- *Evolution of black hole nuclei in ellipticals*, 6–10 March, 2017, ASI – 2017: MP Birla Auditorium, Jaipur.

Hemanth Pruthvi

- *Developing scanning-slit spectrograph for imaging the Sun*, 26th June – 1st July, 2016, SPIE Astronomical Telescopes + Instrumentation 2016, Edinburgh, UK.

Honey, M

- *NearInfrared Imaging of Barred Low Surface Brightness Galaxies*, July 11–15, 2016, Munich Joint Conference hosted by ESO, Garching, Germany.

Joice Mathew

- *An Ultraviolet imager to study bright UV sources*, July, 2016, SPIE Astronomical Telescopes + Instrumentation, Edinburgh, Scotland.

Kshama S Kurian

- *AGN and starburst activity in Seyfert galaxies*, ASI annual meeting 2017 in BISR, Jaipur.

T. Mageshwaran

- *Accretion and wind dynamics of tidal disruption events*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.
- *Stellar, accretion and wind dynamics of tidal disruption events*, 12–16 September 2016, IAU symposium 324, Ljubljana, Slovenia.

Megha, A

- *Coronal Plasma Diagnostics using Visible and Near-IR Coronal Emission Lines*, May 2016, ASI – 2016, Srinagar.
- *Polarized scattering matrix for magnetic dipole transitions*, Solar Polarization 8, a workshop in honour of Egidio Landi Degl'Innocenti held in Florence, Italy.

Prasanta K Nayak

- *Star Clusters In the Magellanic Clouds-I: Parameterisation and Classification of 1072 Clusters in the LMC*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.
- *Propagation of Cluster Formation in the SMC : Signature of LMC-SMC-MW Interactions*, 6–10 March, 2017, ASI – 2017: B. M. Birla Auditorium, Jaipur.

Prolay Krishna Chanda

- *Recent star formation in outer regions of SMC: TDG in the making?*, ASI annual meeting 2017 in BISR, Jaipur.

Rubinur Khatun

- *Radio Observations of Candidate Dual Active Galactic Nuclei in Double Peaked Emission Line Galaxies*,
  - November 7–11, 2016, SKA2016: science for the SKA generation at the ICG, Goa.
  - March 6–10, 2017, Astronomical Society of India, B. M. Birla Auditorium, Jaipur.

Samrat Sen

- *Model of a flux tube with twisted magnetic fields*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.

Snehalata Sahu

- *Revealing the UV properties of Galactic Globular Clusters using GALEX and HST observations*, 10–13 May, 2016, ASI – 2016: Kashmir University, Kashmir.

Sreejith, A. G

- July 2016, SPIE astronomical telescopes +instrumentation, Edinburgh, UK.
- January 2017, 229th AAS meeting, Grapevine, Texas, USA.

Vaibhav Pant

- 2017, Astronomical Society of India meeting held at Jaipur, Rajasthan.

Varun Kumar

- *Inductive Edge Sensor for Segmented Mirror Telescope*, ASI – 2016, Srinagar.

Attendance in meetings/ workshop

Annu Jacob

- *SERB School workshop on optical metrology*, June 2016, Tezpur.
- *Thirty Meter Telescope Future leaders*, 3–7, December, 2016, Hawaii, USA.

Anwesh Kumar Mishra

- *SERB School on Optical Metrology*, June 01–June 21, 2016, Tezpur University.

Avinash Surendran

- *16th Annual International Summer School on Adaptive Optics*, July 31–Aug 5, 2016, University of California, Santa Cruz, USA.
- *Scalable Generic Adaptive Optics on FPGA*, Thirty Meter Telescope (TMT) Office, Pasadena, California.

Hemanth Pruthvi

- *National workshop: Data Intensive Science*, 13th – 18th February, 2017, Pune.

Joby, P. K

- *Neighbourhood Astronomy meeting 2016*, 5th October 2016, ISRO HQ Bengaluru.
- *GIAN course on "Inflation and reheating"*, 25–30 November, IIT Madras.

Mugundhan, V

- *Kochi ST radar science user's workshop*, February 9 & 10, 2017, at ACARR, CUSAT.

Nirmal, K

- *School on optical metrology*, June 1–21, 2016, Tezpur University.

Pavana, M

- *Data Intensive Science*, Feb 13–18 2017, workshop conducted by IUCAA.

Ramya M Anche

- *Thirty Meter Telescope Future leaders*, 3–7, December, 2016, Hawaii, United States of America.

Sandeep K Kataria

- *ASI – 2016*, 9–13 May 2016, University of Kashmir.
- *ASI – 2017*, 6–10 March 2016, Birla Auditorium, Jaipur.

6.7 Awards and Recognition

Amit Kumar Mandal
Vaibhav Pant

- *Best Poster awards in the Extragalactic and Sun & solar systems categories, respectively*, during the 35th Annual Meeting of the Astronomical society of India held at B. M. Birla Auditorium, Jaipur, during 6–10 March 2017.

Anshu Kumari

- *Best Poster award in Instrumentation category*, during the 34th Annual Meeting of the Astronomical Society of India held at Kashmir University, Srinagar during May 10–13, 2016.

S. S. Panini

- *The OSI best oral presentation award* during the XL conference of the Optical Society of India held during November 26–28, 2016 at Tezpur University, Tezpur, Assam.

Ramya M Anche

- *Best oral presentation award* by the Optical Society of America during the International Conference on Light and Light Based Technologies held during November 26–28, 2016 at Tezpur University, Tezpur, Assam.

Sajal Kumar Dhara

- *K D Abhyankar Best thesis presentation award*, by the Astronomical Society of India (ASI) for the year 2017 during the 35th annual meeting of ASI at B. M. Birla Auditorium, Jaipur, during 6–10 March 2017.

Chapter 7

PUBLIC OUTREACH

7.1 Celebration of Science Day

National Science day 2017 was celebrated at IIA on February 28, 2017. Programmes were also organized at all the field stations on the occasion. The students observed the Sun with a Coelostat set-up, followed by visits to the Optics Division, and the IC-NAPP lounge where various science experiments were kept. Prof. Mousumi Das gave a lecture on 'Galaxies'. Competitions such as drawing and painting, essay writing, quiz were conducted for the school children. About 150 students participated in the programs; Astronomy books and kits were given as prizes to the winners of competitions. In the evening a public lecture was arranged. Prof. Annapurni Subramanian gave a talk on the topic, 'How the Indian space observatory discovered the making of a Vampire star', to highlight the scientific results obtained using the ASTROSAT / UVIT observations. A sky-watch session was arranged for the public in the late evening.

Prof. B. C. Bhatt at CREST campus, Hoskote and Sri. Dorje Angchuk at IAO, Hanle, delivered scientific presentations to the visiting school children. About 100 students at each location from the nearby schools took part in the programs. The lab facilities in CREST campus were shown to the school children. Prof. Muthumariappan and Dr. Ebenezer gave talks at VBO, Kavalur and KSO, Kodaikanal, respectively. The number of student participants in each observatory was around 150. Extensive sky-watch programs were arranged at both the places. School children and the public were encouraged to observe the night-sky.

Figure 7.1: Participants of the National Science Day at CREST Campus, Hoskote.

7.2 Outreach Lecture Series

The public outreach committee organized a series of lectures named 'The Journey through the Universe' on every Saturday afternoon starting from February, 2017. College students with science, engineering and arts curriculum were encouraged to attend the lectures. Professor G. Srinivasan

Figure 7.2: Students of SJCIT Engineering college visiting GRO.

delivered about sixteen lectures until March 31, 2017. Topics such as the Sun, planetary systems, stars, etc. were covered very extensively. Hundreds of students who attended those lectures appreciated the program very much.

7.3 Students′ Visit to IIA and its Observatories

(a) **IIA**
About 350 students from various schools and colleges visited IIA during the current academic year. For each visit, a tour to Photonics division, a poster session to introduce about the observing facilities, and a talk by one of the faculty members were arranged.

(b) **GRO, Gauribidanur**
About 250 students from six Engineering colleges visited Gauribidanur observatory. They were explained about the functionality of the radio telescopes, analog and digital receivers.

The two-element radio interferometer kit which was designed at Gauribidanur observatory for the outreach activity was taken for a demo during the SCOSTEP / ISWI International space science school held at Kasturbai Walchand college, Sangli, Maharashtra.

(c) **KSO, Kodaikanal**
As Kodaikanal is a well known tourist place, it attracts thousands of visitors to KSO museum. During April - June and December - January, the museum was visited by about 10,000 people per month. During the above months, the museum was functioning continuously on all days.

(d) **VBO, Kavalur**
Night sky-watch program was continued as usual on every Saturday whenever the sky was clear. A total number of 10,455 persons visited VBO. This included groups from 27 schools (1693 students), 18 colleges (997 students), 2 science forum groups, MPBIFR, students from Aryabhat Foundation, Bhopal etc. REAP students visited VBO in batches. Under the school student awareness program conducted by Education Dept. of Dharmapuri district, about 800 school students visited VBO in four batches.

Prof. Rajaram Nithiyanda, former director of NCRA, stayed at VBO from 6^{th} to 10^{th} June and delivered two talks titled ‘The Story of Radio Astronomy and the GMRT’ and ‘The Six faces of S. Chandrasekhar’ to VBO staff.

The 89^{th} Birth anniversary of Prof. M. K. Vainu Bappu was celebrated on 10^{th} August, 2016. Selected students from five colleges were invited to attend the function. Fifty two students and eight teachers participated. Prof. Sunetra Giridhar gave a talk on ‘Stellar Spectroscopy’ in the morning session. A Speech competition (related to Astronomy) was held in the afternoon followed by visit to telescope facilities.

7.4 IIA Stalls

The Institute had put up its stalls in the following public outreach events:

(a) **Indian Science Congress, Tirupati**
IIA took part in the 104th Indian Science Congress held at Sri Venkateswara University, Tirupati during January 3–7, 2017. A stall was allotted by DST in its pavilion to showcase our exhibits. The basic principles of operation of optical telescopes, the model of UVIT, the upcoming Indian space missions and TMT, etc. were shown to school, college students and to the general public. In addition, the observational facilities of IIA, research and computational facilities available at IIA were explained to college students to motivate them to pursue their career in Astronomy. About 10,000 people had visited our stall and the interested school, college students and the general public were given IIA brochures to highlight about our research and developmental activities at our Institute in the field of astronomy and astrophysics.

Figure 7.3: The IIA stall at the Indian Science Congress, Tirupati.

(b) **Federal Institute of Science And Technology, Ernakulam**
The Federal Institute of Science and Technology (FISAT), Angamaly, Ernakulam had conducted 'FISAT International Space Olympiad 2016' on 27th and 28th of January, 2017 as part of a 30 day (January 27, 2017–February 28, 2017) national science day celebrations. IIA had collaborated with FISAT and kept stalls to demonstrate about 'Balloon based UV experiments', to explain a poster session (with a theme on IIA's research and developmental programs, students internship and PhD programs, IIA's existing and upcoming ground- and space-based observing facilities) and a sky-watch program. Prof. Jayant Murthy and Prof. Muthumariappan gave talks on 'Extra-terrestrial intelligence' and 'Interstellar medium, respectively. About 1500 students from schools and colleges in and around Ernakulam participated in the events.

(c) **Jawaharlal Nehru Planetarium, Bangalore**
Based on the discussions between the Directors of IIA and JN planetarium, it was decided to showcase the models of UVIT and IAO for the inauguration of JN planetarium after it was renovated and installed with new projectors. The honorable chief minister of Karnataka had inaugurated the planetarium on January 17, 2017. Our Engineers and PhD scholars volunteered on that day and for the next few days to explain our exhibits and posters to the visitors. The exhibits were displayed in JNP hall/ lounge for the next few months continuously for the public.

Chapter 8

MISCELLANEOUS ACTIVITIES BY IIA STAFF

8.1 Talks given in National/ International Meetings outside IIA

Invited:

G. C. Anupama

- *GROWTH – India*, July 25-28, 2017, Annual GROWTH Conference, Caltech, Pasadena, U.S.A.
- *Ground Based Facilities for Exoplanet Studies: What IIA has to Offer*, March 5, 2017, ASI Workshop on Exoplanets, Jaipur.
- *Time Domain Astronomy (2 lectures)*, 18, 19 January 2017, TMT training school on observational astronomy, IUCAA, Pune.
- *Time Domain Astronomy – Explosive Transients*, 4–7 November 2017, Annual Meeting of the Indian Academy of Sciences, Bhopal.

D. Banerjee

- *Small Scale Transients as seen from IRIS, spectroscopic signature*, 15 April 2016, IRIS 7 workshop at Shandong University, Weihai, Shandong, China.
- *Small scale transients and their role in the generation of waves*, 13 June 2016, IBUKS, Leuven, Belgium.
- *MHD Waves in coronal Holes*, 1 September 2016, SOLARNET5, Queens University of Belfast, UK.
- *Simultaneous longitudinal and transverse oscillations in active region filament*, 16 January 2017, ISSI EC workshop at Beijing, China.
- *Study of waves from Aditya L1 mission and NLST*, 30 March 2017, ISSI, Bern, Switzerland.

R. K. Chaudhuri

- *Viewing the ground and excited electronic structures through the window of coupled cluster method*, 18/01/2017, Vidyasagar-Satyendranath Bose National Workshop 2017 on Nuclear and Astrophysics, Vidyasagar University, Midnapur, West Bengal.

M. Das

- *Star Formation in Galaxies*, February 03, 2017, Workshop on Stellar Astrophysics, Christ University, Bangalore.
- *Star Formation in Galaxies*, 20–23 February 2017, Winter School in Astronomy, Birla Science Center, Hyderabad.
- *Dual AGN in Galaxy Merger Remnants*, October 05, 2016, Neighbourhood Astronomy Meeting (NAM), Bangalore.

S. Das

- *Astrophysical Constraints on non-wimp dark matter*, 19/01/2017, Aspect of early universe cosmology, SINP, Kolkata.

R. T. Gangadhara

- *Pulsar Radio Emission and Polarization*, 6–13 January, 2016, Neutron Stars: A Pathfinder Workshop, NCRA-TIFR, Pune.
- *Pulsar Radio Emission Mechanism*, June 15–17, 2016, Workshop on Science with the uGMRT, NCRA-TIFR, Pune.

S. Giridhar

- *Hanle Echelle Spectrograph an echelle Spectrograph for 2-m HCT: System description and early science results*, 30-3-2017, NESSEMA at Pt. Ravishankar University Raipur (Ch).

A. Goswami

- *The case of precise abundance*, May 9, 2016, Workshop on high resolution optical spectroscopy, ASI–2016, Srinagar.

U. S. Kamath

- *MIR Imager for the 2-m Himalayan Chandra Telescope*, 18 October 2016, TMT–MICHI Workshop at TIFR Balloon Facility (Hyderabad).
- *Optical and NIR observations of eruptive young stars*, 5–7 December 2016, Star and Planet Formation : Insights and Intricacies at IIST (Thiruvananthapuram).

C. Kathiravan

- *Radio physics of the Sun – Part - I, II & III*, 12/11/2016, SCOSTEP / ISWI ISSS & Smt. Kasturbai Walchand college, Sangli, Maharashtra.
- *Hands-on session : Two element radio interferometer*, 14/11/2016, SCOSTEP / ISWI ISSS & Smt. Kasturbai Walchand college, Sangli, Maharashtra.
- *Introduction to radio telescopes*, 21/02/2017, Coronal and Interplanetary shocks: Data analysis from SOHO, Wind and e-CALLISTO data & Mekelle University, Ethiopia.
- *Solar radio astronomy*, 23/02/2017, Coronal and Interplanetary shocks: Data analysis from SOHO, Wind and e-CALLISTO data & Mekelle University, Ethiopia.

A. Mangalam

- *Models of Tidal Disruption Events and Comparison with Observations*, 15–18 November 2016, First BINA Workshop, Nainital.
- *A model for jet polarization and emission in blazars*, January 10–13, 2017, at “Wide Band Spectral and Timing Studies of Cosmic X-ray Sources”, TIFR Mumbai.

K. N. Nagendra

- *Polarized Line Formation: Methods and Solutions*, September 13, 2016, International Conference on “Solar Polarization 8”, held in Florence, Italy.

V. Panditi

- *Magnetic Flux ropes from the Sun*, 10-Nov-2016, SCOSTEP/ISWI international school, Sangli, Maharashtra.
- *Sun-Earth connection of CME magnetic flux ropes*, 5-Oct-2016, ISRO HQ, Bengaluru.

T. P. Prabhu

- *Observational Facilities for Astronomy in India*, 2016 October 1, 100 hour Certificate Course in Astronomy and Astrophysics, MP Birla Institute of Fundamental Research, Bangalore.

S. Sengupta

- *Exoplanets–The fascinating new customers for Astronomers*, March 06, 2017, New Initiatives in the field of Exoplanetary Science in India, XXXV Meeting of Astronomical Society of India B. M. Birla Auditorium, Jaipur.

P. Sreekumar

- Presentation to the visiting *Parliamentary Committee on Papers Laid on the Table, Rajya Sabha*, 29th September 2016, Bengaluru.
- *Special meeting on Exoplanets at Kodaikanal Observatory*, 6–8 October, 2016, organised jointly by IIA and ISRO.
- *X-ray imaging in Astrophysics*, February 2, 2017, Christ University talk at IUCAA Astronomy Workshop.
- *X-ray instrumentation for Space Payloads*, March 13, 2017, Space Physics Laboratory, VSSC.

C. S. Stalin

- *Extragalactic Astronomy*, 15 February 2017, Meenakshi College Madurai.
- *Narrow Line Seyfert 1 galaxies and their multi-wavelength properties*, 10–13 January 2017, Wide band spectral and timing studies of cosmic X-ray sources, TIFR, Mumbai.

A. Subramaniam

- *In-orbit calibration of UVIT on ASTROSAT*, 30 June 2016, SPIE meeting, Edinburgh, UK.
- *Early science results from the UVIT*, 8 March 2017, Annual meeting of the ASI.
- *Discovery of the hot companion to a Blue Straggler in NGC 188*, 5 October 2016, Neighborhood Astronomy Meeting, ISRO headquarters, Bangalore.

S. Sur

- *Galaxy Outflows without Supernovae*, 12th May 2016, ASI 2016, Srinagar University.
- *High Performance computing in astrophysical turbulence and magnetic fields*, 9th September 2016, NKN – Garuda Partners Meet, NIAS Bangalore.

Contributed:

R. Banyal

- *References for precision wavelength calibration: Etalons and Laser Combs*, 09-05-2016, Tools and trends in high resolution optical spectroscopy, ASI, University of Kashmir, Srinagar.
- *FP wavelength calibration and thermo-optical studies of 2-m class lightweighted mirror*, 18-10-2016, MICHI workshop, TIFR Hyderabad campus.
- *Advancing Scientific Temper*, 10-06-2017, Science for Gender Equality and Social Justice, Kannada University, Hampi.

B. C. Bhatt

- *International Conference on "Instrumentation and Science with 3.6-m DOT and 4.0-m ILMT Telescopes"*, November 15–18, 2016, Aryabhatta Research Institute of Observational Sciences, Nainital.

M. Das

- *A Study of the Galaxies within the Bootes Void*, March, 2017, Astronomy Society of India, Jaipur.
- *Dual AGN in Nearby Galaxies*, November 17, 2016, BINA workshop, ARIES, Nainital.

A. Goswami

- *CEMP stars: evolution, nucleosynthesis, observations and the impact on cosmochemistry*, May 10, 2016, ASI-2016, Srinagar.

- *Carbon-Enhanced Metal-Poor stars: binarity, evolution, nucleosynthesis, and, the impact on cosmochemistry*, August 9, 2013, International conference on 'Blowing in the wind: connecting the inside and the outside of stars', ICISE, Quy Nhon, Vietnam.

C. Muthumariappan

- *3D Morphology of the PN IRAS 18333-2357*, 10th October 2016, IAU Symposium 323: Planetary Nebulae-Multiwavelength probes of Stellar and Galactic Evolution.

K. Nagaraju

- *Spectropolarimetric observations of a small scale reconnection event in the chromosphere simultaneously in Hα and Ca II at 854.2 nm*, 6–10 March 2017, XXXV meeting of the Astronomical society of India, Jaipur.

V. Panditi

- *Recurrent eruptions by converging and shearing polarities in a solar active region*, 10-Mar-2017, ASI-2017, Jaipur.

P. Parihar

- *Indian Participation to the Thirty Meter Telescope Project: Impact and Current Status*, 15-08-2016, SAAO, Capetown, SA.
- *A step towards realization of a large Optical–NIR telescope in India*, 09-03-2017, 17th Meeting of ASI, Jaipur, India.

S. Rakshit

- *Differential Interferometry of the Broad line region of Quasars*, 10–13 May 2016, Astronomical society of India annual meeting, Srinagar, India.
- *A catalog of Narrow Line Seyfert 1 galaxies from SDSS DR12*, 16–21, October 2016, International conference on "Shining from the heart of darkness: black hole accretion and jets", Kathmandu, Nepal.
- *Properties of Narrow Line Seyfert 1 galaxies*, 15–17 Nov 2016, The first BINA Workshop, Nainital, India.

L. Sairam

- *A study of coronal magnetic activity in RS CVn/BY Dra*, 11 May 2016, ASI Kashmir.

M. Sampoorna

- *Comoving Frame Method for Polarized PRD Line Transfer with Velocity Fields*, September 13, 2016, International Conference on "Solar Polarization 8", held in Florence, Italy.

C. S. Stalin

- *Narrow Line Seyfert 1 galaxies*, 6–10 March 2017, ASI meeting, Jaipur.

S. Sur

- *Outflows from high surface density galaxies*, 17th February, 2017, Physics of the ISM – 6 years of ISM–SPP 1573, University of Cologne, Germany.

V. Valsan

- *Development of Stressed Mirror Polishing Technology*, 10–13 May, 2016, ASI meeting, University of Kashmir, Srinagar.

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

Invited:

G. C. Anupama

- *Photometry of Transiting Exoplanets Using Ground Based Facilities*, October 7–9, 2016, IIA-ISAC National Symposium on Extrasolar Planets, Kodaikanal Solar Observatory.

R. T. Gangadhara

- *Radiative Processes in Astrophysics –I*, May 20, 2016, Summer School, Kodaikanal Observatory.
- *Radiative Processes in Astrophysics –II*, May 21, 2016, Summer School, Kodaikanal Observatory.

U. S. Kamath

- *Observational Astronomy (3 lectures)*, May 2016, Kodaikanal Summer School.

C. Kathiravan

- *Solar radio astronomy : Part – I & Part - II*, 24/05/2017, Summer school 2016, Kodaikanal observatory.
- *Solar radio astronomy : Hands-on session*, 24/05/2017, Summer school 2016, Kodaikanal observatory.
- *Solar radio astronomy : Part – III*, 25/05/2017, Summer school 2016, Kodaikanal observatory.

K. Nagaraju

- *The Sun*, 19–20 May 2017, Kodaikanal Summer School, Kodaikanal.

G. Pandey

- *Surface abundances of planet hosting stars*, October 7 and 8, 2016, IIA-ISAC National Symposium on Exoplanets, Kodaikanal Solar Observatory.

K. P. Raju

- *The Solar Atmosphere*, 11/01/2017, Winter school on solar physics, Kodaikanal.

B. Ravindra

- *Sunspots: Theory and observations*, January 2017, Winter school at Kodaikanal Observatory.

S. Sengupta

- *Extra-solar Planets : The Final Frontiers. Invited lecture at IIA-ISAC National Symposium on Extra-solar Planets*, October 7–8, 2016, IIA, Kodaikanal Solar Observatory, Kodaikanal.

A. Subramaniam

- *UVIT and the its impact in Indian Astronomy*, 23 March 2017, DST training program, NIAS, Bangalore.
- *Early science results from UVIT*, 16 March 2017, Master Control Facility (MCF), ISRO, Hassan.
- *UVIT on ASTROSAT*, 9 February 2017, Ethiraj College, Chennai.

S. Sur

- *Fundamentals of Magnetohydrodynamics*, 8–9 January, 2017, Kodai winter school, Kodaikanal.

Contributed:

R. Banyal

- *Towards Radial Velocity Measurements with Iodine Cell and Fabry-Perot Reference*, 08-10-2016, IIA-ISAC National Symposium on Exoplanets, Kodaikanal.

V. Panditi

- *Solar Transient events and short term variability*, 2-Jun-2016, Kodaikanal Observatory, Kodaikanal.

L. Sairam

- *Stellar magnetic activity and their effects on the habitability of orbiting planets*, 7 October 2016, Exoplanet symposium.

M. Sampoorna

- *Polarized Line Formation in Moving Atmospheres*, August 17, 2016, GC-III meeting at IIA Auditorium.

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

- *The Thirty Meter Telescope – India Perspective*, 23 February 2017, Kavli-IPMU, Kashiwa Campus, University of Tokyo, Japan.

D. Banerjee

- *Filament Detection and Analysis from H-alpha Spectroheliograms of Kodaikanal Observatory*, 18 April 2016, Colloquium at NAOC, Beijing.
- *New results from Kodaikanal Digitised Data Archive*,
  - June 21, 2016, Colloquium at Royal Observatory of Belgium, Brussels.
  - September 5, 2016, Colloquium at Armagh Observatory, N. Ireland.
  - December 1, 2016, Colloquium at CESSI, IISER (Kolkata).
  - January 10, 2017, Colloquium at Big Bear Solar Observatory, USA.

R. Banyal

- *Optical detectors in Astronomy*, 09-01-2017, Winter School, Kodaikanal.
- *Adaptive optics in Astronomy*, 03-03-2017, Sri Sathya Sai University, Prashanti Niliayam, A.P.

M. Das

- *GMRT Low Frequency Observations of Gas Around Void Galaxies*, November 2016, SKA-Continuum Surveys Meeting (SPARCS), Goa.
- *GMRT Radio Observations of Bootes Void Galaxies*, November 2016, SKA Meeting, Goa.
- *Low Frequency Radio Observations of the Gas Around Void Galaxies*, July 3rd-9th, 2016, Large Scale Structure and Galaxy Flows, Quy Nhon, Vietnam.
- *Radioastronomy lecture*, March 2017, Christ University.

S. Das

- *Beyond Lambda CDM*, 17/10/2016, TIFR Mumbai.

G. Pandey

- *Stellar Spectroscopy I and II*, 16 July 2016 and 6 August 2016, M. P. Birla Institute of Fundamental Research.

P. Parihar

- *A step towards realization of a large Optical–NIR telescope in India*, 19-05-2016, ARIES, Nainital, India.

D. K. Sahu

- *Peculiar Type Ia supernovae – An observational perspective*, January 13, 2017, Astronomy-Particle Physics, Experimental Physics-Cosmology (APEC) seminar at Kavli, IPMU, Univ. of Tokyo.

L. Sairam

- *An overview of a multi wavelength mission- Astrosat*, 31 August 2016, Hamburger Sternwarte.

C. S. Stalin

- *Astronomy: From Ground and Space*, 28 February 2017, IETE Bangalore Centre, Bangalore.

A. Subramaniam

- *Lectures on star formation and stellar Evolution*, 3 February 2017, Astronomy Meeting, Christ University, Bangalore.

S. Sur

- *Outflows from high surface density galaxies*, July 2016, on an academic visit to IUCAA, Pune.

8.2 Awards, Recognition, Professional Membership, Editorship etc.

G. C. Anupama

- Elected as Fellow, Indian Academy of Sciences, Bangalore.

R. Banyal

- ASI member.

S. Rakshit

- National Postdoctoral Fellowship.

A. Subramaniam

- Associate Editor, JAA (2017–2019).

8.3 Externally Funded Projects

G. C. Anupama

- PI of the DST–JSPS project, *Studies of low redshift supernovae – steps towards understanding the universe at high redshift (2015–2017).*

- Indian PI of the International Project, *"GROWTH: Global Relay of Observatories Watching Transients Happen"*, funded by IUSSTF–SERB (2015–2018) under the PIRE programme.

D. Banerjee

- *Contemporary physical challenges for heliospherical and astrophysical models (CHARM) / National Large Scale Telescope*, DST and BELSPO bilateral project.

- *Long term study of the sun using Kodaikanal Digitized data*, funded by DST.

R. Banyal

- PI of the project, *Development of a stabilized Fabry-Perot wavelength calibrator for precision Doppler spectroscopy*, funded by SERB.

- Co-PI: *Ultraviolet observations of the sky from balloons and satellites*, funded by SERB.

R. K. Chaudhuri

- *Profiling the electronic structure properties of relativistic and non-relativistic systems using computationally cost effective ab initio methods*: EMR/2015/000124.

A. Goswami

- *Estimation of surface chemical composition of CEMP stars and AGB nucleosynthesis*, funded by the DST, SERB.

J. Murthy

- *Ultraviolet observations of the sky from balloons and satellites*, funded by the DST, SERB.

G. Pandey

- *Aspects in Stellar and Galactic Evolution*, project funded by DST.

V. Panditi

- *A Study on the Formation and Initiation of Magnetic Flux Ropes*, funded by DST.

P. Parihar

- *Exploring Design Options for New Optical Telescopes in South Africa and India*, Indo–South African Bilateral Joint Project funded by the Department of Science & Technology, Govt. of India and National Research foundation, Republic of South Africa.

L. Sairam

- INSPIRE faculty fellowship DST–DFG Indo-German Joint project.

P. Sreekumar

- *Joint center for Solar coronal composition and its evolution with solar activity*, funded by IUSSTF.

C. S. Stalin

- PI of the Indo–Polish project for the period 2015–2018.

8.4 Workshop, Conference, School etc. Organized at IIA or outside IIA

G. C. Anupama

- SOC Member, *IIA–ISAC National Symposium on Extrasolar Planets*, 7–9 October 2016.
- SOC Member, *ASI Workshop on Exoplanets*, 5 March 2017.
- SOC Member, *TMT Science Forum 2016*.

R. Banyal

- Organized the *Solar Physics winter school* in Kodaikanal January 8–15, 2017.
- Coordinated the *Astronomy lecture series* at IIA by G. Srinivasan.

A. Goswami

- Organized *Summer school on 'Physics and Astrophysics'* at Kodaikanal Solar Observatory as a school coordinator during May 20 – June 3, 2016.

K. Nagaraju

- *Kodaikanal Winter School on Solar Physics* in Kodaikanal.

K. N. Nagendra

- Served as a Member representing India, on the International Scientific Organizing Committee, formed to organize the *8*$^{\text{th}}$ *International Workshop on SOLAR POLARIZATION (SPW8)* held in Florence, Italy, during September 12–16, 2016.

L. Sairam

- Organised a one day workshop on *New Initiatives in the field of Exoplanetary Science in India* at XXXV Astronomical Society of India meeting held at Jaipur on 6 March 2017.

S. Sengupta

- *IIA–ISAC National Symposium on Extrasolar Planets*, October 7–8, 2016, IIA, Kodaikanal Solar Observatory, Kodaikanal.

8.5 Popular Lectures

G. C. Anupama

- *A Career in Astronomy*, 3 March 2017, "Women in Science: Career in Science–Current Opportunities in Science and Technology", a workshop sponsored by the Indian Academy of Sciences, and held at NMKRV College, Bengaluru.

R. Banyal

- *Extrasolar Planet: Discovering the new worlds*, 24 February 2017,
  - Thiagarajar college of engineering Madurai, TN Science Forum.

  - Fatima college Madurai.
  - SVN College, Madurai.

M. Das

- *Galaxies in our Universe*, February, 2017, Science Day talk.

C. Muthumariappan

- *Optical Astronomy in India*, 29^{th} July 2016, Tamilnadu Science forum students visiting Vainu Bappu Observatory.

- *Optical and Infra-red Astronomy*, 28^{th} January 2017, Space Olympiad organised by FISAT Ernakulam.

L. Sairam

- *Exoplanet detection and their habitability*, 3 May 2017, for Astronomy Olympiads at Visvesvaraya Industrial and Technological Museum.

S. Sengupta

- *Search For Extra-terrestrial Life*, February 28, 2017, Science Day special Lecture, IISER, Pune.

P. Sreekumar

- *Physics + Astronomy is really exciting*, April 19, 2016, Space Camp for school children, IISc.

- *Exploring the Universe: Current and future programs*, 16^{th} March 2017, IIT-Roorkee, Dept. of Physics.

A. Subramaniam

- *How the Indian Observatory discovered the making of a Vampire star*, 28 February 2017, National Science Day lecture, IIA.

8.6 Public Communication

R. Banyal

- Planned and organized several illustrations and experiments for the visit of high school children on science day celebration in IIA on 28 Feb 2017. These experiments include light reflection, refraction, total internal reflection, scattering and demonstration of space-time curvature with a stretched membrane fixed to a circular frame and the weight in the middle.

C. Kathiravan

- Member of the Public outreach committee from April, 2016 to December, 2016 and contributed to the outreach programs organized during the period.

C. Muthumariappan

- Founder's Day celebration at VBO on 10^{th} August 2016. Total of 70 selected PG physics students from five colleges participated in the event. A quiz programme on Science and Astronomy was conducted.

- Chief Guest lecture on 'Astronomical Instruments and Techniques' was given at the PMC–Tech Engineering College, Hosur, 15^{th} February 2017

P. Parihar

- As a part of outreach activities, given several popular lectures at IIA and also participated in various outreach programs.

L. Sairam

- Authored a popular article for the quarterly bulletin of Jawaharlal Nehru Planetarium titled "M-dwarfs as extra-solar planet hosts", April 2016 edition.

8.7 Involvement with the Scientific Community

G. C. Anupama

- Member, Academy Summer Fellow selection committee (2016).
- Co-Opted Committee Member, PAC (Physical Sciences), Science and Engineering Research Board (SERB) (2015–2017).
- Member, DOT Time Allocation Committee.
- Member of the SKA–India science working group on Transients.
- Convenor, TMT International Science Development Team on Time Domain Astronomy.

A. Mangalam

- Chair of Theoretical Astrophysics group at IIA since August 2015.
- Chair of the Library committee.
- SOC for ASI national meetings for September 2013–September 2016.
- Member, Committee for Post Doctoral fellowships since October 2010.
- IIA representative for JAP syllabus committee.
- Member of the media interaction committee since April 2015.
- Member, the Colloquium committee.
- Member, Committee for ERP project management since October 2010.
- Beta tester for the software *Mathematica*.

K. N. Nagendra

- Visited Istituto Ricerche Solari Locarno (IRSOL) at Locarno, Switzerland for three weeks in September 2016, to collaborate with Profs. J. O. Stenflo, M. Bianda, Drs. L. Belluzzi, and R. Ramelli.
- Providing theory support for French experimental Physics group headed by Prof. William Guerin, Institut non-lineaire de Nice (INLN), University of Nice, France, on polarized light scattering on laser cooled Rubidium atoms to test the axioms of quantum light scattering theory on atoms.

T. P. Prabhu

- Chair, Devasthal Optical Telescope Time Allocation Committee.
- Member, Subject Area Committee on Physical Sciences, Swarna Jayanti Fellowship Award Programme, DST.

P. Sreekumar

- IIA–4th Paradigm Institute: setup of monitoring station at CREST campus – Nov 2016.
- IIA–BARC – setup of MACE telescope in Hanle.
- IIA–ISRO – development of Visible Emission Line Coronograph on Aditya-L1 mission.
- IIA–SPL/VSSC – trace gas monitoring station at Hanle.
- Member, Governing Council of J. N. Planetarium.
- Member, Science Advisory Council, Space Physics Laboratory, VSSC.
- Member, International Program Advisory Committee, LIGO.

8.8 Official Language Implementation (OLI)

OLIC Meeting

Four meetings were conducted in the Institute; on June 27, 2016, September 23, 2016, December 27, 2016 & March 30, 2017 and the reports were sent to the Dept. of Science & Technology, New Delhi and to the Member Secretary, TOLIC, Bengaluru.

Hindi Workshop

In order to expedite the implementation of Official Language in the Institute and to improve the staff members capacity for doing official work in Hindi, two Hindi Workshops were conducted for the employees working in Administration on June 16, 2016 and November 21, 2016. The reports were sent to the Dept. of Science & Technology, New Delhi.

Hindi Day/ Fortnight Celebration

The Institute celebrated the Hindi Fortnight from September 14, 2016 to September 30, 2016. During the occasion, seven competitions were conducted in the Institute viz., "Hindi-English Noting" competition on September 14, 2016, "Hindi Suptan" competition on September 16, 2016, "Hindi Easy Writing" competition on September 19, 2016, "Hindi Song" competition on September 20, 2016, "Hindi Visual-Quiz" competition on September 21, 2016, "Hindi Dictation" competition on September 22, 2016, and "Hindi 'Antakshari" competition on September 26, 2016. Hindi Pakwada closing ceremony was observed on November 21, 2016 in the institute. Dr. P. Sreekumar, Director presided over the function. Dr. Gajendra Pandey, Associate Professor gave the welcome speech. Chairman addressed the audience and congratulated all the employees for their efforts taken towards official language implementation in their official work. He also encouraged them to keep up this pace as it is the moral responsibility of all staff members to accomplish official work in Hindi. Dr. S. Rajanatesan, Section Officer (Hindi) read the Official Language implementation activity report. Chairman distributed the cash prizes to the winners. The function was concluded with a vote of thanks by Dr. S. Rajanatesan.

Two Hindi competitions were conducted viz., "Hindi-English Noting" competition and "Hindi Visual-Quiz" competition on September 30, 2016 at VBO, IIA, Kavalur. Cash awards were given to the winners to encourage them and to motivate other staff members to participate in the activities in the forthcoming years.

Chapter 9

PEOPLE

Director: P. Sreekumar

Academic & Scientific Staff

Senior Professor: G. C. Anupama, Jayant Murthy, Sunetra Giridhar (up to 30.06.2016)

Professor: Annapurni Subramaniam, Arun Mangalam, R. K. Chaudhuri, Dipankar Banerjee, B. Eswar Reddy, R. T. Gangadhara, R. Kariyappa (up to 31.05.2016), Prajval Shastri, B. Raghavendra Prasad, K. B. Ramesh (up to 30.09.2016), R. Ramesh

Associate Professor: Aruna Goswami, B. C. Bhatt, Gajendra Pandey, K. M. Hiremath, U. S. Kamath, Mousumi Das, S. Muneer, Muthumariappan, P. S. Parihar, S. Paul Kaspar Rajguru, Pravabati Chingangbam, K. P. Raju, D. K. Sahu, A. Satya Narayanan (up to 31.05.2016), S. K. Sengupta, Sivarani Thirupathi, C. S. Stalin

Scientist E: B. A. Varghese

Reader: E. Ebenezer Chellasamy, Firoza Sutaria, C. Kathiravan, Nagaraju. K, Piyali Chatterjee, Preeti Kharb (up to 20.09.2016), Ravinder Kumar Banyal, B. Ravindra, M. Sampoorna, Sharanya Sur, Subinoy Das

Scientist D: Rekesh Mohan, N. Shantikumar Singh, R. Sridharan

Scientist C: G. S. Suryanarayana

Scientist B: Namgyal Dorjey, G. Selvakumar

Research Associate B: M. Appakutty

Adjunct Scientist: K. Sankarasubramanian

Adjunct Professor: A. N. Ramaprakash

Visiting Professor: K. N. Nagendra, G. Srinivasan, S. N. Tandon

Visiting Scientist: Brajesh Kumar, Margarita Safonova (up to 16.09.2016), Wasim Iqbal (up to 12.08.2016)

Honorary Professor: S. S. Hasan (up to 30.06.2016), K. E. Rangarajan, P. Venkatakrishnan

Consultant: C. H. Basavaraju, Christina Birdie, Lt. Col Kuldip Chandar, Y. K. Raja Iyengar (up to 31.05.2016), Sandra Rajiva

Post Doctoral Fellow: Arun Surya, Ashish Raj, K. Drisya (up to 3.09.2016), Hema. B. P, Kanhaiya Lal Pandey, Koshy George, Suvendu Rakshit, Vineeth Valsan

Technical staff (permanent)

Engineer F: G. Srinivasulu

Engineer E: V. Arumugam, Faseehana Saleem, P. M. M. Kemkar, P. K. Mahesh, S. Nagabushana, R. Ramachandra Reddy, M. V. Ramaswamy, B. Ravikumar Reddy, S. Sriram, J. P. L. C. Thangadurai

Engineer D: Amit Kumar, P. Anabazhagan, Dorje Angchuk, S. Kathiravan, Sanjiv Gorka, K. C. Thulasidharen, Tsewang Dorjai, P. Umesh Kamath

Principal Scientific Officer: R. Selvendran

Engineer C: Anish Parwage, K. Anupama, K. Dhananjay, A. Ramachandran, K. Ravi, Sonam Jorphail, Tashi Thsering Mahay, Vellai Selvi

Technical Officer B: Narasimhappa

Engineer B: Chinchu Mohanan. K, V. S. Gireesh Gantyada, Indrajit V. Barve, Mallappa, Naveen Kumar Mishra (05.01.2017 to 28.02.2017), M. Rajalingam, N. Raj Kumar (06.01.2017 to 17.04.2017), S. Ramamoorthy, Tsewang Gyalson, Vinay Kumar Gond

Technical Officer: M. R. Somashekar, C. V. Sri Harsha

Tech. Associate B: D. Babu (up to 20.08.2016), P. Kumaravel, J. Manoharan, S. Venkateshwara Rao

Sr. Tech. Asst. C: R. Ismail Jabillullah, A. Muniyandi, T. K. Muralidas (up to 30.09.2016)

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

Sr. Research Asst. B: V. Moorthy

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

Technical Associate: K. Sagayanathan, P. R. Sreeramulu Nayaka

Administrative staff

Sr. Administrative Officer: P. Kumaresan

Principal Staff Officer: K. Thiyagarajan (up to 31.01.2017)

Accounts Officer: S. B. Ramesh

Assistant Personnel Officer: Narasimha Murthy

Stores & Purchase Officer: K. P. Vishnu Vardhan

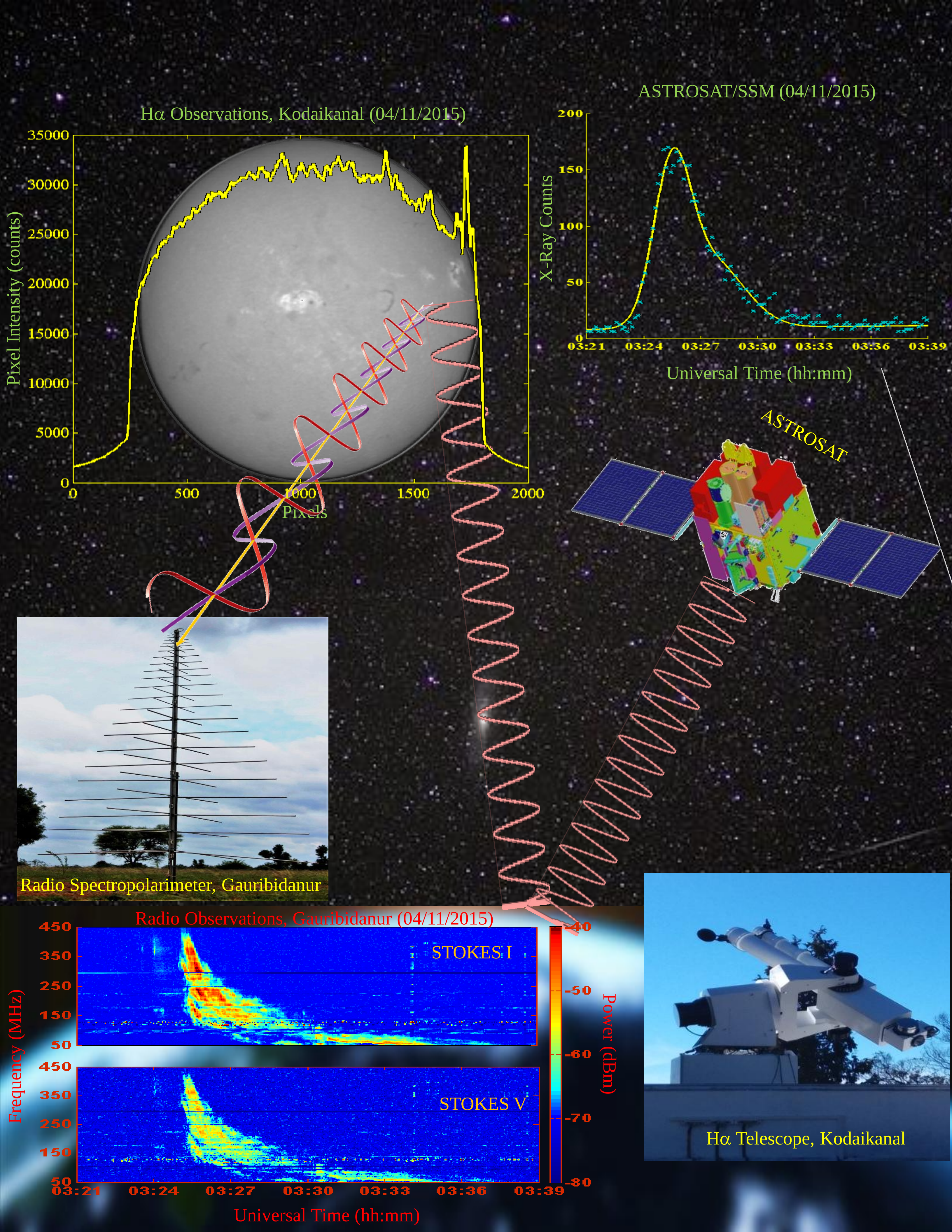
Sr. Section Officer: K. Padmavathy, Pramila Mohan

Section Officer (SG): Maliny Rajan, N. K. Pramila, N. Sathya Bama, Uma Maileveloo

Section Officer: Diskit Dolker, Ramaswamy, N. Valsalan (up to 30.11.2016), V. Vijayaraj

Section Officer (Hindi): S. Rajanatesan

Sr. Office Superintendant: A. Veronica



Hα Observations, Kodaikanal (04/11/2015)
Pixel Intensity (counts)
Pixels
ASTROSAT/SSM (04/11/2015)
X-Ray Counts
Universal Time (hh:mm)
ASTROSAT
Radio Spectropolarimeter, Gauribidanur
Radio Observations, Gauribidanur (04/11/2015)
STOKES I
STOKES V
Frequency (MHz)
Power (dBm)
Universal Time (hh:mm)
Hα Telescope, Kodaikanal