INDIAN INSTITUTE OF ASTROPHYSICS

ANNUAL REPORT

2016-2017

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

Published on behalf of : The Director, Indian Institute of Astrophysics, Sarjapura Road, Bengaluru 560034, INDIA.

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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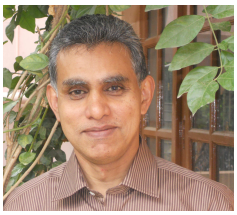

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Chapter 1

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 heliocen-

tric 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.

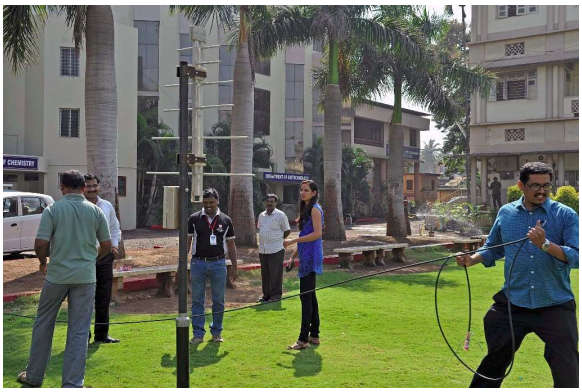

Figure 1.1: The IHY two element radio interferometer outreach kit was set up by IIA as a part of SCOSTEP / ISWI International Space Science School conducted at Kasturbai Walchand college, Sangli, Maharashtra during November 7–17, 2016. The functionality and observing capability of a basic radio interferometer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

The sunspots exhibit movement in addition to their apparent change in position due to the rotation of the Sun. These sunspot motions are predicted to release energy in the forms of flares due to the reconnection of oppositely directed magnetic flux tubes. Data were analyzed to obtain quantitative estimates of the motion of sunspots and verify the association with the duration of the flares.

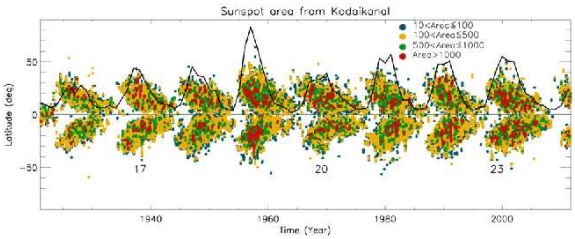

Figure 2.1: Butterfly diagram created using the individual sunspot area values (sizes) and their locations obtained from Kodaikanal white-light images. Cycle numbers are also printed on the plot. The solid black line represents the yearly averaged sunspot area (scaled).

In a related work, histograms of the latitudinal distribution of the sunspots generated using data from the Kodaikanal Solar Observatory (KSO) for nearly 100 years reveal a Gaussian-like pattern in both the northern and southern hemispheres of the Sun, with centers at ∼15 degree latitude in the respective hemispheres. But the amplitude of the distributions in the two hemispheres are different for any given sunspot cycle.

Moving up in the solar atmosphere, high resolution observations reveal the presence of micro-jets in the penumbral regions of the sunspots at the chromospheric heights. Simultaneous observations of the overlying transition regions reveal bright dots that correlate with these jet-like features. The relation between these new class of events and their contribution to the heating of the solar atmosphere are being investigated.

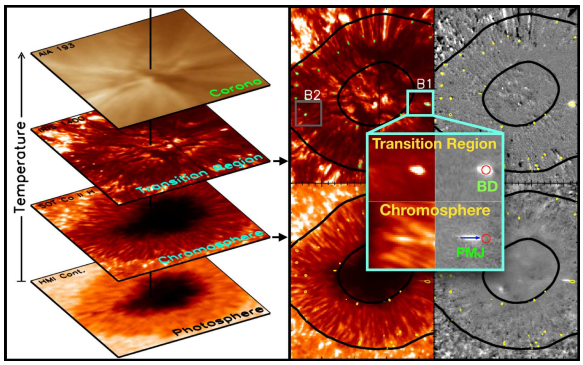

Figure 2.2: Multi-wavelength observations showing the penumbral micro-jets (PMJ) and the bright dots (BD).

Spectral line observations of the solar transition region (between the chromosphere

and the corona) in extreme ultra-violet (EUV) band often show web-like pattern outside sunspot active regions. Analysis indicates that the width of the network boundaries vary with the solar cycle with a lag of about 10 months. Observations of the underlying solar chromosphere in the Ca II K spectral line indicate that network boundary width as well as the intensity of the line vary with the solar cycle. Since the width is related to the magnetic flux concentration along the boundaries, these results provide information on the flux transport to the solar surface and the solar cycle. Ca II K images of the Sun from the Kodaikanal Solar Observatory for a period of about 100 years (∼9 solar cycles) are now available in the digitized form. Work is currently on to obtain quantitative information on the chromospheric network from the data. Interestingly, Ca II K observations are also good proxy to the UV irradiance which is of geophysical importance. In a parallel work, the sizes of the supergranular cells (one of the prominent features in the Ca II K images, and outlined by the aforementioned network boundary) in the quiescent and active regions on the Sun inferred from the above data set and their variation with the variation with the solar cycle were studied.

Another set of EUV observations revealed outward propagation of jet-like features which induced transverse oscillations in the near-by coronal magnetic field lines (i.e. coronal loops). These are the first observations of such oscillations. Estimates of the field strength in the loop based on these oscillations indicate that the values are in the range ∼3-4 G. Analysis of similar oscillations of a H-alpha filament in the lower atmosphere indicates that the lower limit to the field strength in the filament is ∼25 G.

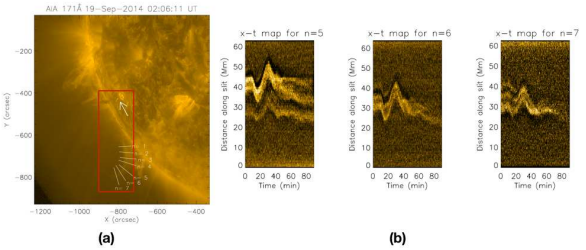

Figure 2.3: (Left panel) EUV observations of the coronal loop. (Right panel) Time-distance plots showing oscillations of the loop.

Constrained estimates of the coronal magnetic field strength (B) using observations with the Gauribidanur LOw-frequency Solar Spectrometer (GLOSS) indicate B varies as $r^{-3.3}$ in the radial distance (r) range ∼1.63-1.76 solar radii, $r^{-2.7}$ over r ∼1.68-1.91 solar radii, and $r^{-1.7}$ over r ∼2.0-2.4 solar radii. The value of B associated with a coronal mass ejection (CME) was observed using data obtained with the GRAPH, and the value is ∼1 G in the CME leading edge at a heliocentric distance of ∼2.2 solar radii.

Figure 2.4: 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.

Calculations related to the polarization properties of coronal emission lines were developed, and the same was applied to the Fe XIII 10747 Å line to explore its diagnostic potential of the coronal magnetic field. Similar work to understand the effect of non-relativistic, non-monotonic time-dependent vertical velocity fields on the linearly polarized line profiles formed in semi-empirical atmospheres were also carried out.

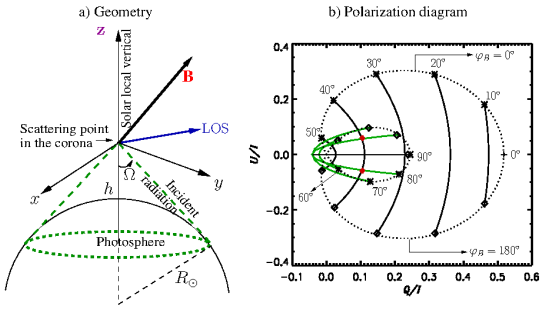

Figure 2.5: (Left panel) Geometry describing the anisotropic illumination of ions in the corona by the photospheric radiation field. (Right panel) Polarization diagram for varying field inclination and a constant field strength of 10 G. Line-of-sight is at a height of 0.5 solar radius above the solar limb.

The amplitude of the density turbulence spectrum (C_N^2) and the density modulation index (δN/N) in the solar wind between 10 and 45 solar radii was estimated using data obtained with the Gauribidanur RAdioheliograPH (GRAPH). This yielded a comprehensive picture of the: (i) manner in which C_N^2 and δN/N vary with heliocentric distance in the solar wind, and (ii) solar cycle dependence of these quantities. Existing theories claim that the scattering of radio waves (and the resultant angular broadening of discrete radio sources) due to aforementioned density turbulence argues inhibit observations of small scale features in the solar corona, particularly at low radio frequencies. But the first ever long baseline observations of the Sun at low frequencies from Gauribidanur indicate that the above may not be true. Structures of angular size $<$ 1 arc min, consistent with white light observations during total solar eclipses, were observed. In the context of Sun-Earth connection, the near-Earth properties of a magnetic cloud ejected from the solar atmosphere, and the associated sunspot active region on the Sun were studied. The

results indicate that the magnetic field lines in the cloud has a constant twist.

2.2 Stellar and Galactic Astrophysics

Studies on exoplanets, novae, supernovae, and chemical abundance analysis of various types of stars were some of the topics in which IIA astronomers engaged this year.

Star-like objects with effective temperatures of less than 2,700 K are referred to as ultracool dwarfs. 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.

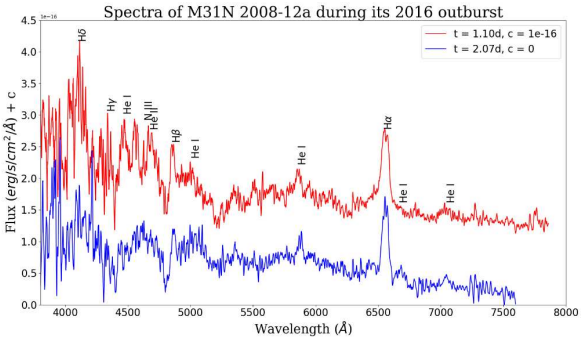

Figure 2.6: HCT Spectra of the recurrent nova M31N 2008-12a during its 2016 outburst.

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 ~ 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 ~ 2900 km/s on Dec 13.58 and ~ 2700 km/s on Dec 14.55.

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 (NGC 2770) up to $\sim$ 21 yr before discovery, revealed a burst $\sim$ 1 yr before discovery. 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.

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 ~ 0.2 M$_\odot$ in SN 2015bp, and, the ejected mass $M_{\rm ej} \sim 1.26$ M$_\odot$ and 0.9 M$_\odot$ respectively.

The analysis of the optical photometric and spectroscopic data of the supernova ASASSN-14dq obtained with the HCT indi-

cated 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.

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 $\sim$ 4.5 $M_\odot$, and a ^{56}Ni mass estimate of $\sim$ 0.1 $M_\odot$.

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. 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 object could be 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.

The optical spectroscopic study of two classical Be stars, 59 Cyg reported 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. 59 Cyg is likely to be a rapid rotator, rotating at a fractional critical rotation of $\sim$0.80. The radius of the Hα emission region for 59 Cyg is estimated to be $Rd/R_* \sim 10.0$, assuming a Keplerian disk, suggesting that it has a large disk. OT Gem is found to have a fractional critical rotation of $\sim$0.30, suggesting that it is either a slow rotator or viewed in low inclination. In OT Gem, a large reduction in the radius of the Hα emission region from $\sim$ 6.9 to $\sim$ 1.7 was observed in a period of three months, along with the reduction in the emission strength. Observations suggest that the disk is lost from outside to inside during this disk loss phase in OT Gem.

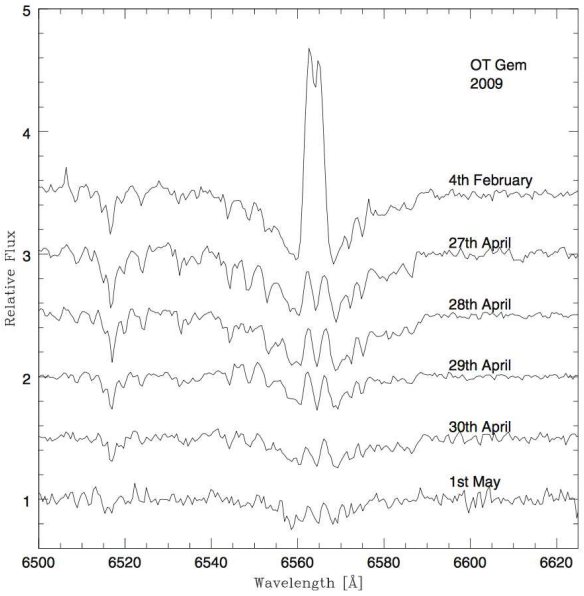

Figure 2.7: Time series of OT Gem Hα line from February to May 2009 obtained using 1.0-m telescope at VBO. Spectra are offset and labelled with the observation date, the oldest appears at the top and most recent at the bottom. Note that although the spectra are displayed evenly spaced, they are not evenly distributed in time.

A detailed chemical composition study was performed for a sample of four chemically peculiar stars characterized by s-process enhancement base on high-resolution (R $\sim$ 42000) ELODIE spectra. The stellar atmospheric parameters, the effective tem-

perature T_{eff}, the surface gravity log g and metallicity [Fe/H] are estimated from local thermodynamic equilibrium analysis using model atmospheres. Elemental abundances are derived 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.

A detailed abundance analysis of a very metal-poor carbon-enhanced star CD−27 14351 was performed based on a high resolution (R $\sim$ 48,000) FEROS spectrum, using Local Thermodynamic Equilibrium (LTE) model atmospheres. Analyses show 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 first peak s-process elements Sr and Y are also found to be enhanced with respect to Fe, ([Sr/Fe] = 1.73 and [Y/Fe] = 1.91). 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.

A homogeneous sample of 22 CH stars elemental abundance data is 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 model (FRUITY set) only fits part of the observations; 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. The theoretical models are unable to attain the large [hs/ls] ratios characterizing the surfaces of those objects. The reasons of such a discrepancy is speculated verifying the possibility that the observed distributions derive from a proton mixing episode leading to very high neutron density (the so-called i-process).

Analyses of high-dispersion spectra of red giant members in the 12 open clusters (OCs) were performed. The stellar parameters and chemical abundances for 26 species were determined for these objects. The radial metallicity gradient of OCs is confirmed to be steeper (flatter) for Rgc < 12 kpc (>12 kpc). It was demonstrated that the sample of clusters constituting a steep radial metallicity gradient of slope -0.052 ± 0.011 dex kpc^{-1} at Rgc < 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. The clusters describing a shallow slope of -0.015 ± 0.007 dex kpc^{-1} at Rgc > 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 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. It is argued 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.

Using CCD time-series photometry approximately 250 variable stars are detected

in a sample of 23 selected globular clusters (GCs). The absolute magnitude and [Fe/H] for each individual RR Lyrae is obtained via the Fourier decomposition of the light curve. The mean [Fe/H], M_V and distance for a group of selected GCs are determined based exclusively on the RR Lyrae light curve Fourier decomposition technique. Calibration of the P-L relation for SX Phe stars enabled an independent calculation of the cluster distance.

Multi-epoch UV spectra were obtained using HST/STIS for two 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 system. The continuum is 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.

Abundance analyses of 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.

Non-LTE abundance analyses of two extreme helium stars V652 Her and HD 144941, with exceptionally low C/He ratios, were performed using the tools TLUSTY and SYNSPEC. Defining atmospheric parameters were obtained from a grid of non-LTE atmospheres 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. 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. While the derived composition of V652 Her is in excellent agreement with model predictions of slow merger of helium white dwarfs scenario; 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.

2.3 Cosmology and Extragalactic Astronomy

The many themes that have been pursued include black hole astrophysics, phenomena in active galaxies, magnetic fields in galaxies and cosmology.

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 pc-scale jet properties was constrained based on the inferred mean proper motion, including a bulk Lorentz factor, jet inclination angle, projected position angle, intrinsic half opening angle and a mean $2 - 8$ GHz spectral index of 0.31. A general relativistic helical

jet model was presented and applied to predict quasi-periodic oscillations of ∼10 days, power law power spectrum shape and a contribution of up to ∼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. It can also be used to infer promising SMBBH candidates for the study of gravitational waves if there are systematic deviations from helical signatures.

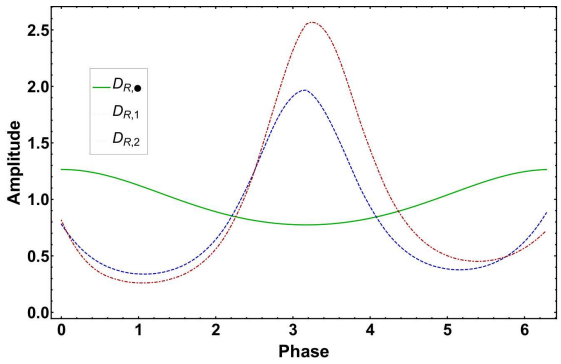

Figure 2.8: Comparison of the Doppler ratio, $D_R = S_\nu/\tilde{S}_\nu$ between helical jet and SMBBH scenario ($D_{R,\bullet}$, thick green line) with $D_{R,j}$ (blue dashed line: case (i); red dot-dashed line: case (ii)) for 1 complete cycle. Note: cycle for SMBBH scenario ∼ years; for helical jet ∼ days.

The pc-scale core shift effect was studied using radio light curves for three blazars, S5 0716+714, 3C 279 and BL Lacertae monitored at five frequencies 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. The magnetically arrested disk model was 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.

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 brings out 308 newly parametrized clusters. It was 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 was demonstrated.

High-resolution radio continuum observations were carried out with the Karl G. Jansky very large array at 6, 8.5, 11.5 and 15 GHz of the double-peaked emission-line galaxy 2MASXJ12032061+1319316. The radio emission has a prominent S-shaped morphology with highly symmetric radio jets that extend over a distance of 1.74 kpc on either side of the core of size 116 pc (see Fig. 2.9). The radio jets have a helical structure resembling the precessing jets in the galaxy NGC 326 which has confirmed dual active galactic nuclei (AGN). It is proposed 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.

Low surface brightness (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 was found that the barred fraction is only 8.3 per cent.

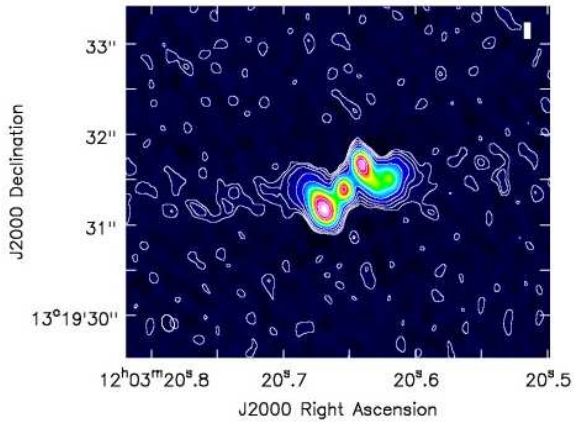

Figure 2.9: The above figure shows the 11.5 GHz EVLA image of 2MASXJ12032061+1319316 made with with robust=0.5 (natural) weighting. The intensity contours are overlaid and have 0.0.60, 1.25, 2.5, 5, 10, 20, 40, 60, 80% of the peak values of 5.5 mJy.

Bars are global disk instabilities that evolve by transferring angular momentum from the inner to outer disks and to the dark matter halo. In this study the effect of another spherical component was explored, the bulge, on bar formation in disk galaxies. The results indicate that early type disk galaxies can still form strong bars in spite of having massive bulges.

With an aim to detect high redshift blazars, all radio-loud quasars with the radio-loudness parameter greater than 10 were searched for the detection of gamma-rays using about 8 years of Fermi data, and the search led to the discovery of five gamma-ray emitting blazars with $z > 3.1$.

A new catalog of narrow-line Seyfert 1 (NLSy1) galaxies from the Sloan Digital Sky Survey Data Release 12 (SDSS DR12) was presented. This catalog contains a total of 11,101 objects, which is about 5 times larger than the previously known NLSy1 galaxies. Our analysis suggests that geometrical effects playing an important role in defining NLSy1 galaxies and their MBH deficit is perhaps due to their lower inclination compared to BLSy1 galaxies.

We analyze the spectra of the archival XMM-Newton data of the Seyfert 1 AGN Zw 229.015 and estimate the X-ray emission region to be within 20 gravitational radii of the central supermassive black hole.

A seven year study of Mrk 421 indicated the flux to be highly variable across all timescales. 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. A strong correlation was seen between the break energy γ_b of the particle spectrum and the total bolometric luminosity.

Two dark matter models—Late Forming Dark Matter (LFDM) and Ultra-Light Axion (ULA) models—where the matter power spectra show novel effects on small scales were probed with two cosmological observables: the neutral hydrogen (H I) redshifted 21-cm signal from the epoch of reionization, and the evolution of the collapsed fraction of H I in the redshift range 24×10^5 (for LFDM) and the axion mass $m_a > 2.6 \times 10^{-23}$ eV (for ULA).

The possibility of using the Silk damping induced CMB spectral distortion as a probe of the small scale power was investigated to show that the main impact of alternative models is to alter the sub-horizon evolution of the Newtonian potential which affects the late-time behavior of spectral distortion of CMB.

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 ∼3% to ∼ 20%) during the declining phase of the flare. This combination of behaviors appear to be unique. The 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.

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 Kilometer Array (SKA-I), will have almost an order of magnitude higher sensitivity than the best existing radio telescope at GHz frequencies. 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. A 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. Observations of FDs with redshift will provide important information on magnetic field evolution as a function of redshift. The core shift measurements of AGNs can provide more precise measurements of the magnetic fields 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.

2.4 Theoretical Physics & Astrophysics

The themes that have been pursued 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, the peak bolometric luminosity in terms of physical parameters and a typical light curve of TDEs which is then compared with the detector sensitivities to obtain the duration of flare detection. The crucial point is that the angular momentum plays an important role in the stellar dynamical process and the accretion process through pericenter location which impacts the detectable TDE rates; this has not been taken into account in previous calculations. A good fit of the time dependent accretion models to the observations in X-ray, UV and optical bands is found as compared to steady accretion models (see Fig. 2.10).

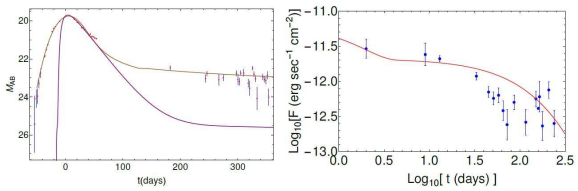

Figure 2.10: *Left:* The time-dependent super-Eddington model (blue) shows good fit compared to the super-Eddington steady accretion model (purple) to the PS1-10jh observations in g band. The deduced physical parameters for time dependent models are $\bar{e} = 0.0001,\ \ell = 1,\ M_6 = 7.5,\ m = 2.65$ and black hole spin $j = 0.85$. *Right*: The time dependent sub Eddington model fit to the X-ray observation XMMSL1 J061927.1-655311 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 $j = 0.15$.

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 impact of the evolution on the spin, the mass of the SMBH and $M_\bullet - \sigma$ relation as a function of redshift in a ΛCDM cosmology was calculated and compared with available observations (see Fig. 2.11). Applying a proportionality relation between M_{Bulge} and $M_\bullet$ to several galaxies a resulting $M_\bullet - \sigma$ relation was found which compares well with the evolutionary model.

Black hole X-ray binaries (BHXRBs) show Quasi-Periodic Oscillations (QPOs), which are the broad peaks in their Fourier power density spectrum. Novel analytic expressions were derived for general bound orbit trajectories, and for its radial and azimuthal frequencies that have general utility in various problems. The commensurability (eg. 3:2) is explained within the context of the relativistic formulae that is developed. Low frequency QPOs in BHXRBs may also be associated with jets and can explain helical jets in Schwarzschild geometry by including various relativistic effects of gravitational Doppler shift and light bending effects on the emission.

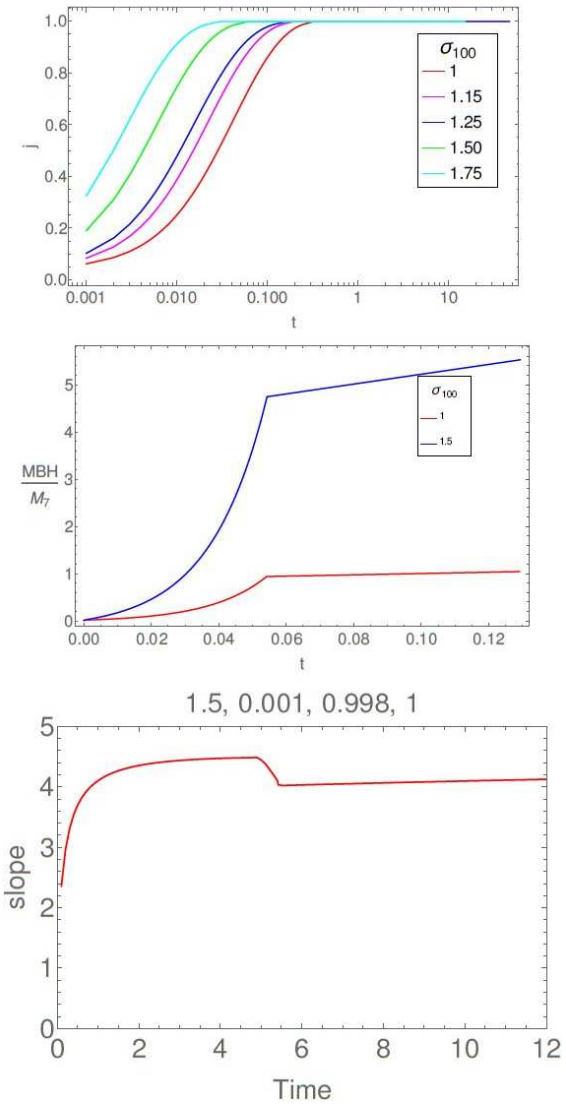

Figure 2.11: Evolution of the spin parameter, mass and slope of $\log M_\bullet - \log \sigma$ plot as a function of time.

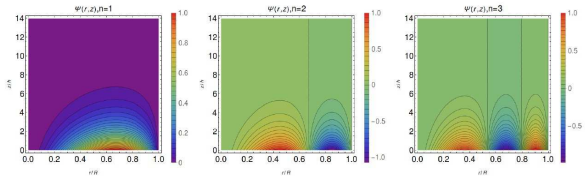

Figure 2.12: The vertical cross–sections of normalized poloidal flux function for three different modes n for $R = 100$ km and $B_0 = 1$ kG are shown. The contours represent the magnetic lines of force in the $r-z$ plane. The amplitude of the flux function, normalized to the peak value, is represented by a color 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.

A single vertical straight magnetic fluxtube spanning the solar photosphere and the transition region was constructed. We assume twisted magnetic fields in magnetohydrostatic equilibrium within a realistic stratified atmosphere subject to solar gravity. A family of solutions was derived for reasonable values of the fluxtube radius and magnetic field strength at the base of the axis that are the free parameters in our model (see Fig 2.12). It is found that our model estimates are consistent with the magnetic field strength and the radii of Magnetic bright points as estimated from observations and simulations. Also, the resulting thermodynamic quantities inside the fluxtube are found to be in good agreement with observations.

Primordial black holes (PBH) 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. 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 heating can come from accretion disks around primordial black holes (PBH) which are distributed inside the collapsing dark matter halo and might constitute a good fraction (~ 0.1; given by recent constraints on $f_{PBH} = \Omega_{PBH}/\Omega_{CDM}$ coming from CMB data and other observables) of dark matter for certain mass of the PBH (~ 10 $M_\odot$).

Highly accurate electronic structure calculations are often needed to supplement scant experimental data. High precision calculations for the ground and some selected low lying excited and ionized states of Pt and its ions with four component relativistic spinors were performed that 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 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.

Semi-analytic solutions of the nonlinear force-free field equation were used 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 for the winding number was presented and compared with the formula for the crossing number. It was concluded that while conceptually the formulae are nearly the same but the resulting distributions calculated for a given topology can be different. New analytical bounds for the free energy and relative helicity for the field config-

urations were derived in terms of the linking number which will be of utility in estimating the braided energy available for nano-flares or for eruptions.

Scattering on a multi-level atomic system has dominant contributions from resonance and Raman scattering. The main result of such a study is that line-interlocking effects produce 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.

Magnetic fields in the solar atmosphere leave their fingerprints in the polarized spectrum of the Sun via the Hanle and Zeeman effects. The partial re-distribution (PRD) idealization of angle-averaged Hanle-Zeeman redistribution matrices was compared 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.

A theoretical formulation to solve the problem of polarized line formation in magnetized media was made, which includes both the effects of PRD and the lower level polarization for a two-level atom. The study shows that the effects are significant only in the line core.

Comparisons of synthetic spectra to observed data clearly imply that most of the exo-planets directly imaged to date have dusty atmospheres. It is proposed that exo-moons around self-luminous directly imaged planets can be detected through time dependent image polarimetric observation. It has been demonstrated that time-resolved image polarimetry can be a potential tool for detecting planets transiting cloudy L dwarfs by the asymmetry induced by a transiting Earth-sized planet which gives rise to a significant amount of disk-integrated linear polarization which may be detected by existing imaging polarimeters.

Chapter 3

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.

3.1 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 3.1: **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

3.2 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.

3.3 Completion of MTech Program

The following students from the 8^{th} 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.

3.4 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.

3.5 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.

3.6 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, 229$^{\text{th}}$ 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

- *16$^{\text{th}}$ 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*, 13$^{\text{th}}$ – 18$^{\text{th}}$ 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.

3.7 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 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.

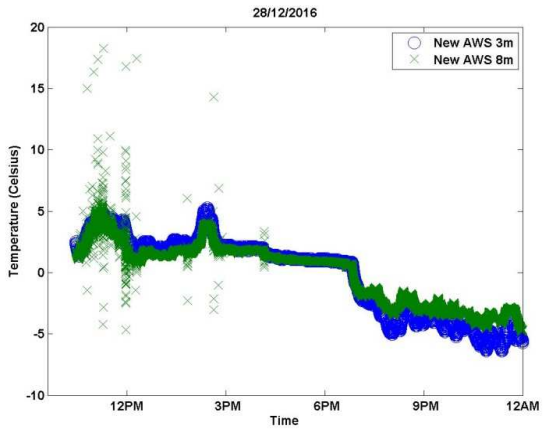

Figure 4.2: Comparison of temperature at 3-m and 8-m heights.

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.

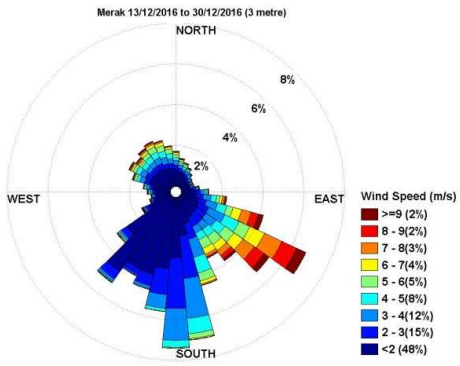

Figure 4.3: Comparison of wind velocity and direction at 3-m and 8-m heights.

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.

4.2.3 Kodaikanal Observatory

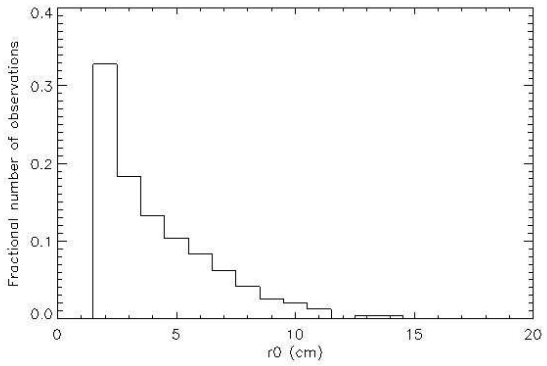

Figure 4.6: Histogram of measured r_0 values with KTT.

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.

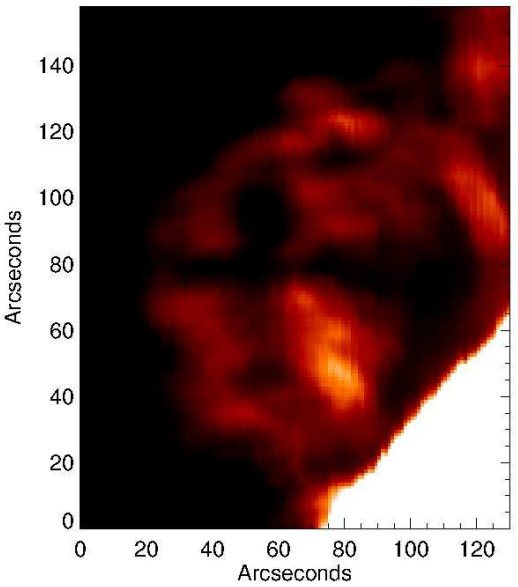

Figure 4.7: Raster observations of a prominence obtained with the KTT on 2017 May 9 at ∼02:30 UT. The passband is 0.015 nm centered around H-alpha line core.

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.

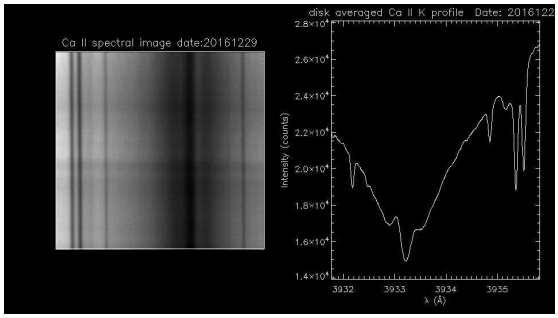

Figure 4.8: (Left) Ca-K spectrum observed with the KTT on 2016 December 29 at ∼02:30 UT; (Right) Ca-K line profile averaged over the disk.

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.

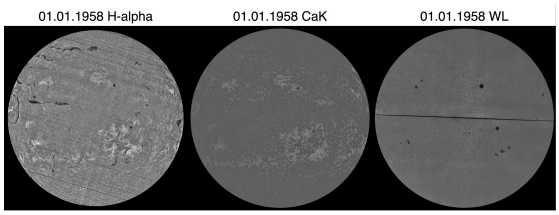

Figure 4.9: Digitized images of the white-light, Ca-K, and H-alpha observations carried out on 1958 January 1 at Kodaikanal.

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.

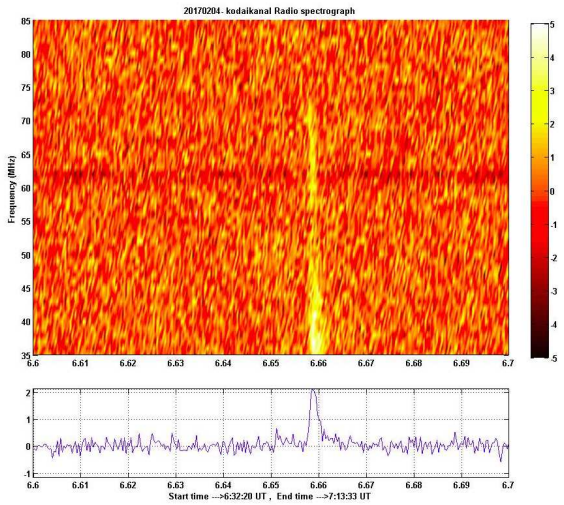

Figure 4.10: Spectrum of a type III solar radio burst observed with the Kodaikanal radio spectrograph on 2017 February 4 at 06:40 UT and the integrated light curve. The temporal and spectral resolutions are ∼1 sec and ∼1 MHz, respectively.

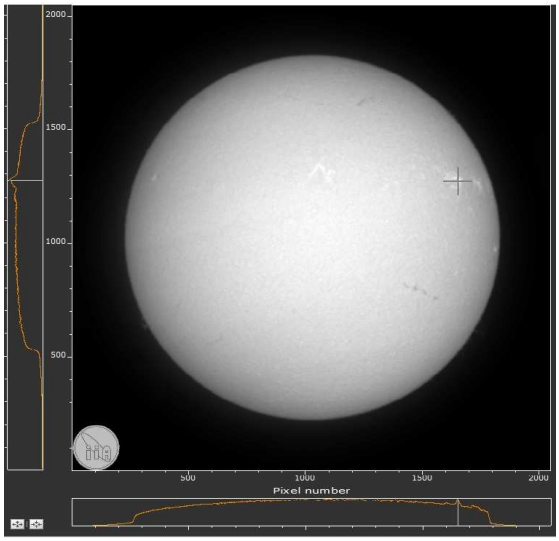

Figure 4.11: Kodaikanal H-alpha observations corresponding to Figure 4.10 showing the location of the activity (indicated by the '+' symbol). Solar north is straight up and east is to the left. The integrated light curve along the east-west and north-south directions on the Sun are shown in the lower 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.

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.

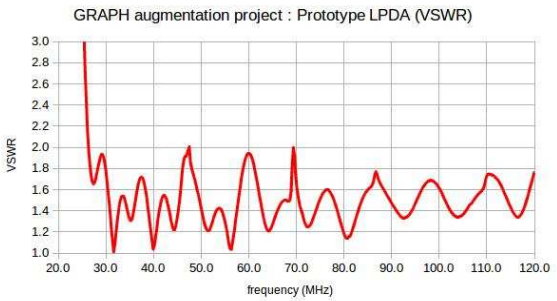

Figure 4.12: Impedance measurements with the prototype LPDA designed in-house at the Gauribidanur observatory. A Voltage Standing Wave Ratio (VSWR) of ∼1 corresponds to a transmission/reception efficiency of ∼100% (ideal case). VSWR ∼2 indicates an efficiency of ∼90%. One can notice that the LPDA itself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

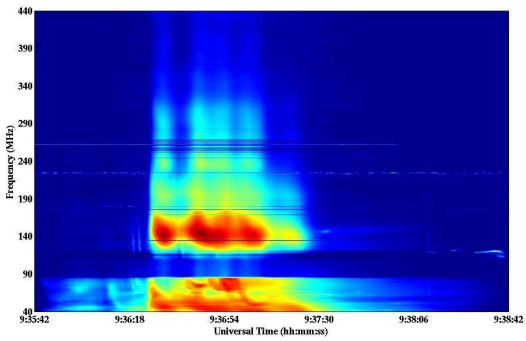

Figure 4.13: Radio signatures of flare accelerated electrons drifting outwards through the solar atmosphere along 'open' coronal magnetic field lines at velocities ∼0.3c observed with the new digital backend receiver under development in Gauribidanur. The temporal and spectral resolutions are ∼100 msec 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)

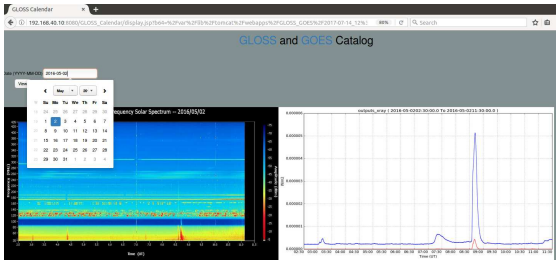

Figure 4.14: Simultaneous GLOSS and GOES/XRS observations of transient energy releases in the solar atmosphere during the interval ∼02:30-11:30 UT on 2016 May 2. One can notice that the weak burst observed with the GLOSS during the interval 04:00-04:30 UT (i.e. 4.0-4.5 UT) is not present in the GOES/XRS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

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/`.

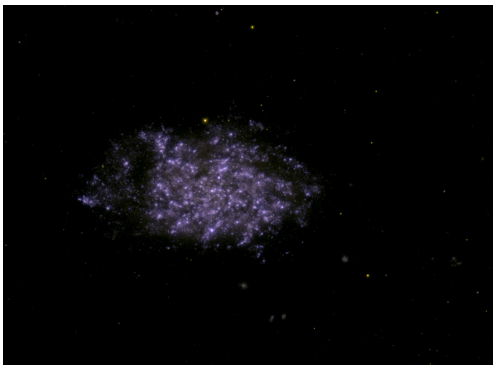

Figure 4.15: False Colour UVIT image of the galaxy NGC 7793, one of the brightest members of the Sculptor group of galaxies. This group is located near the south Galactic pole, at a distance of 3.38 Mpc. The UVIT image shows many bright star forming knots throughout the disk. A number of extended FUV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

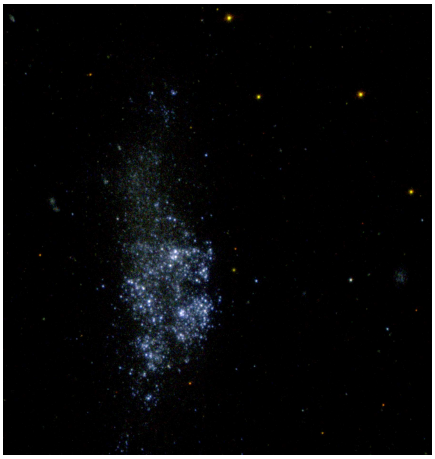

Figure 4.16: False colour composite image of the galaxy Wolf-Lundmark-Melotte (WLM) observed in the FUV and NUV with the UVIT. WLM is a dwarf irregular galaxy located at about 995 kpc. The galaxy is known as living cosmic fossil as it formed during the early epoch of the Universe and has not interacted 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.

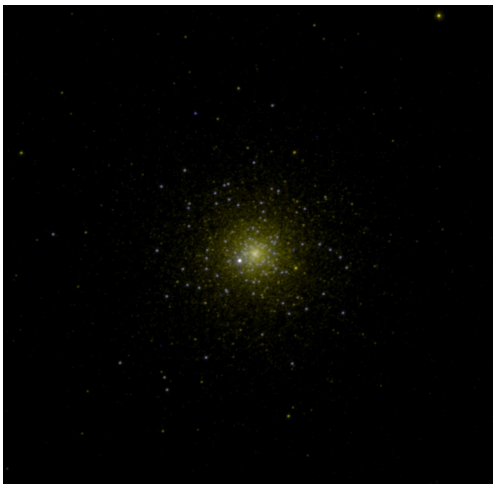

Figure 4.17: NGC 1851 is a massive globular cluster located in the Southern constellation of Columba. It is an unusual cluster speculated to be a merger of two individual clusters. It has been known to have a bimodal horizontal branch in the H-R diagram. In this colour composite image, the blue dots 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.

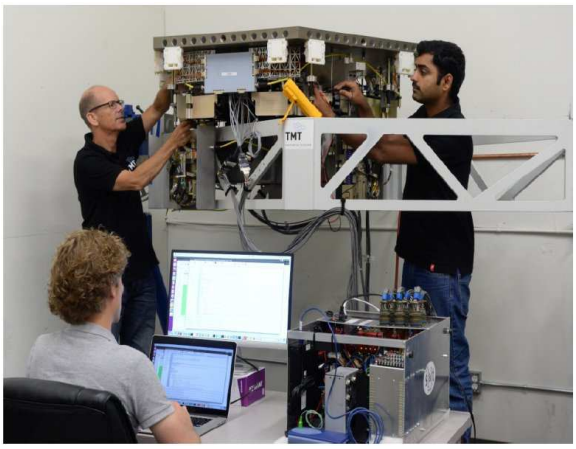

Figure 5.1: Assembly of M1 controls (Sensors, actuators, SSAs) and testing at TMT facility, Pasadena, USA of mirror performance against design requirements. Most of the hardware was shipped from India.

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 2nd 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

PUBLIC OUTREACH

6.1 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 ICNAPP 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 6.1: Participants of the National Science Day at CREST Campus, Hoskote.

6.2 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 6.2: 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.

6.3 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.

6.4 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 6.3: 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 7

MISCELLANEOUS ACTIVITIES BY IIA STAFF

7.1 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*, 10$^{\text{th}}$ 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, 17$^{\text{th}}$ 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*, 17$^{\text{th}}$ 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 Nilayam, 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 3^{rd}-9^{th}, 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.

7.2 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).

7.3 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.

7.4 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^{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.

7.5 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*, 29th July 2016, Tamilnadu Science forum students visiting Vainu Bappu Observatory.

- *Optical and Infra-red Astronomy*, 28th 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*, 16th 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.

7.6 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 10th 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, 15th 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.

7.7 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–4$^{\text{th}}$ 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.

7.8 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.

7.9 Welfare of SC/ST Staff & Physically Challenged

A senior officer of the Institute has been functioning as the liaison officer to support the welfare of the SC/ST staff members. Special consideration as per norms during recruitment and regular assessment has been provided to these categories of employees. As of the end of the year, members belonging to the SC, ST and OBC categories constitute 14.60%, 12.85% & 11.06% respectively of the total strength. In addition, reservations continue to be extended to OBCs and physically disabled persons. Proactive efforts are continuously made towards their welfare. Facilities and mechanisms have been provided for special administrative as well as technical

training of staff from the historically disadvantaged categories.

7.10 Committee against Sexual Harassment

A Gender Amity Cell has been functioning in the Institute in order to provide a platform to take up and discuss gender related issues. Gender Amity Cell works towards ensuring sensitisation and awareness amongst all members regarding gender inequality and sexual harassment. The Institute has its Internal Complaints Committee against Sexual Harassment and this Committee actively takes up all the internal complaints and issues as per the Sexual Harassment of Women (Prevention, Prohibition and Redressal) at Workplace Act, 2013.

A general seminar was organized at the Institute on December 9, 2016 and Ms Shakun Doundiyakhed delivered a talk titled 'Towards gender equity at the work place'.

Chapter 8

PUBLICATIONS

8.1 In Journals

[1] *Ackermann, M., et al. (including Stalin, C. S.,) 2017, The Astrophysical Journal Letters. Vol. 837, No. 1, L5. *Gamma-Ray Blazars within the first 2 billion years*

[2] *Ajello, M., et al. (including Paliya, Vaidehi S.,) 2016, The Astrophysical Journal, Vol. 826, No. 1, 76.
NuSTAR, Swift, and GROND Observations of the Flaring MeV Blazar PMN J0641–0320

[3] Ambily, S., Mayuresh, Sarpotdar., Mathew, J., Sreejith, A. G., Nirmal, K., Prakash, A., Safonova, M., Murthy, J., 2017, Journal of Astronomical Instrumentation, Vol. 6, No. 1, 1750002.
Development of Data Acquisition Methods for an FPGA-Based Photon Counting Detector

[4] *Anantha, Ch., et al. (including Sivarani, T., Giridhar, S.,) 2017, Experimental Astronomy, Vol. 43, No.1, pp. 39–58.
Performance results of HESP physical model

[5] *Anthonisamy, Arockia Bazil Raj., *Durairaj, Padmavathi., Lancelot, J. P., 2016, IET Communications, Vol.10, No. 9, pp. 1096 – 1103.
Performance analysis of free space optical communication in open-atmospheric turbulence conditions with beam wandering compensation control

[6] *Arockia Bazil Raj, A., Lancelot, J. P., 2016, Journal of Optical Technology, Vol. 83, No.1, pp. 55–68.
Seasonal investigation on prediction accuracy of atmospheric turbulence strength with a new model at Punalkulam, Tamil Nadu

[7] *Balona, L. A., et al. (including Pandey, G., Hema, B. P.,) 2016, Monthly Notices of the Royal Astronomical Society, Vol. 460, No. 2, pp. 1318–1327.
The hot γ Doradus and Maia stars

[8] Banyal, R. K., *Reiners, A., 2017, Journal of Astronomical Instrumentation, Vol. 6, No. 1, 1750001.
A dual cavity Fabry-Perot device for high precision Doppler measurements in astronomy

[9] *Bertello, L., et al. (including Singh, J.,) 2016, Solar Physics, Vol. 291, No. 9, pp 2967–2979.
Correlation between sunspot number and Ca II K emission index

[10] *Bertello, L., et al. (including Singh, J.,) 2016, Asian Journal of Physics, Vol. 25, No. 3, pp. 295–310.
Solar Ca II K Observations

[11] *Bhat, S. S., *Paul, K. T., Subramaniam, A., *Mathew, B., 2016, Research in Astronomy and Astrophysics, Vol. 16, No. 05, pp.

* *Collaborators from other Institutions*

76.
Spectroscopic study of Be-shell stars: 4 Her and 88 Her

[12] *Bhattacharya, D., Sreekumar, P., *Mukhopadhyay, B., *Tomar, I., 2016, Research in Astronomy and Astrophysics, Vol. 16, No. 4, 54.
Does black hole spin play a key role in the FSRQ/BL Lac dichotomy?

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The WiFeS S7 AGN survey: Current status and recent results on NGC 6300

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Balloon UV experiments for astronomical and atmospheric observations

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In-orbit performance of UVIT on ASTROSAT

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The InfraRed Imaging Spectrograph (IRIS) for TMT: latest science cases and simulations

8.3 Technical Reports, Monographs, Circulars, ATel

[130] Pavana, M., Anupama, G. C., 2016, ATel, 9865, 1.
HCT Spectra of the recurrent nova M31N 2008-12a during its 2016 outburst

[131] Safonova, M., Nirmal, K., Sreejith, A. G., Mayuresh, Sarpotdar., Ambily, S., Prakash, A., Mathew, J., Murthy, J., Anand, D., Kapardhi, B. V. N., Suneel Kumar, B., Kulkarni, P. M., 2016, IIA Technical Report Series No. 16, Report No: IIA-TRS-1616, pp.1–9.
Measurements of gondola motion on a stratospheric balloon flight

8.4 Books

[132] Chaudhuri, R. K., Chattopadhyay, S. K., 2016, *Many-body methods for atoms and molecules.*, Boca Raton, CRC Press, ISBN: 9781482211900

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8.5 Popular Articles

[134] Sengupta, S., 2016, Resonance, Vol. 21, No. 7, pp. 641–652.
The Search for another earth

[135] Sengupta, S., 2016, Resonance, Vol. 21, No. 10, pp. 899–910.
The search for another earth – Part II

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Black Holes in Our Universe: Do they Inch up the Mass Ladder?

8.6 HCT Publications by non-IIA Users

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Baug, T.; Dewangan, L. K.; Ojha, D. K.; Ninan, J.P., 2016, APJ, 833, 85B.

[138] *Star-formation activity in the neighborhood of W-R 1503-160L star in the mid-infrared bubble N46*,
L. K. Dewangan, T. Baug, D. K. Ojha, P. Janardhan, J. P. Ninan, A. Luna, and I. Zinchenko, 2016, APJ, 826, 1, 27.

[139] *Properties of dust particles in comets from photometric and polarimetric observations of 67P*,
E. Hadamcik., E. Hadamcik., A. C. Levasseur-Regourd., A. C. Levasseur-Regourd., D. C. Hines., A. K. Sen., J. Lasue., J. -B. Renard., 2016, MNRAS, 462 (Suppl_1): S507-S515

[140] *Episodic high-velocity outflows from V899 Mon: a constraint on the outflow mechanisms*,
J. P. Ninan., D. K. Ojha., N. S. Philip., 2016, APJ, 825, 1, 65.

[141] *Simulation studies of MACE-I: Trigger rates and energy thresholds*,
Chinmay Borwankar., Nilay Bhatt., Subir Bhattacharyya., R. C. Rannot., A. K. Tickoo., R. Koul., Satyendra Thoudam., 2016, Astroparticle Physics, Vol. 84, 97–106.

[142] *Multiwavelength Variability Study of the Classical BL Lac Object PKS 0735+178 on Timescales Ranging from Decades to Minutes*,
Arti Goyal., Łukasz Stawarz., Michał Ostrowski., Valeri Larionov., Gopal-Krishna., Paul J. Wiita., Santosh Joshi., Marian Soida., and Iván Agudo., 2017, APJ, 837, 2, 127.

[143] *Radio and infrared study of the star-forming region IRAS 20286+4105*,
Varsha Ramachandran., S. R. Das., A. Tej ., S. Vig., S. K. Ghosh ., D. K. Ojha., 2017, MNRAS, 465, 4, 4753–4771.

[144] *Hα imaging survey of Wolf-Rayet galaxies: morphologies and star formation rates*,
S. Jaiswal, A. Omar, 2016, MNRAS, 462, 92

[145] *A multiwavelength investigation of the H II region S311: Young stellar population and star formation*,
R. K. Yadav, et al., 2016, MNRAS, 461, 2502

Table 8.1: 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 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

Chapter 10

AUDITORS' REPORT & STATEMENT OF ACCOUNTS

CONTENTS

2335
V.K. Niranjan & Co.
Chartered Accountants
Office : 080-2226 7769
080-2228 5005
Mobile : +91-8762442895

Ref. No.: I-5351/20788/2017-18

Date : 31/07/2017

INDEPENDENT AUDITORS' REPORT
TO THE MEMBERS OF INDIAN INSTITUTE OF ASTROPHYSICS,

Report on the Financial Statements;

We have audited the accompanying financial statements of INDIAN INSTITUTE OF ASTROPHYSICS which comprise the Balance Sheet as at 31st March 2017, the Statement of income and expenditure for the year ended 31st March 2017, and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements;

Themanagement is responsible for preparation of financial statements that give a true and fair view of the financial position and financial performance of the Institute in accordance with the accounting principles generally accepted in India. This responsibility also includes the maintenance of adequate accounting records for safeguarding of the assets of the Institute and for preventing and detecting frauds and other irregularities; selection and application of appropriate accounting policies; making judgments and estimates that are reasonable and prudent; and design, implementation and maintenance of adequate internal financial controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility;

Our responsibility is to express an opinion on these financial statements based on our audit.We conducted our audit of the financial statements in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal financial control relevant to the Institute's preparation of the financial statements that give a true and fair view in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by the Institute's Management as well as evaluating the overall presentation of the financial statements.

V.K. NIRANJAN & CO. Chartered Accountants BANGALORE

2335
V.K. Niranjan & Co.
Chartered Accountants
Office : 080-2226 7769
080-2228 5005
Mobile : +91-8762442895

Ref. No: Date :

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion on thefinancial statements.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, except for the effects of the matter described in the 'Basis for Qualified Opinion' paragraph above, the aforesaidfinancial statements, give the information required and give a true and fair view in conformity with the accounting principles generally accepted in India;

a) In case of the Balance Sheet, of the state of affairs of the Institute as at March 31, 2017;

b) In case of the Statement of Income and Expenditure Account, of the excess of expenditure over income forthe year ended on that date;

Report on other Legal and Regulatory Requirements

We further report that:

a) We have sought and obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit.

b) In our opinion proper books of account as required by law have been kept by the Institute so far as appears from our examination of those books and proper returns adequate for the purposes of our audit.

c) The Balance Sheet, the Statement of Income and Expenditure account dealt with by this Report are in agreement with the books of account.

d) In our opinion, the aforesaid financial statements comply with the Accounting Standards.

Place: BENGALURU
Dated:31/07/2017

for V K NIRANJAN & CO
Chartered Accountants
Firm's Reg. No. 002468S

V.K. NIRANJAN & CO. 22267769 22285005 BANGALORE 560 009 Chartered Accountants

CA NIRANJAN V K
PARTNER
M No. 021432

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU -560034

BALANCE SHEET AS AT 31ST MARCH, 2017

(Amount in Rs.)

	SCH	As at 31.03.2017	As at 31.03.2016
I. SOURCES OF FUNDS			
CAPITAL FUND	1	72,31,11,011	67,98,11,510
GENERAL FUND	2	5,000	5,000
CURRENT LIABILITIES & PROVISIONS	3	52,44,48,331	45,05,70,127
TOTAL		1,24,75,64,342	1,13,03,86,637
II. APPLICATION OF FUNDS			
FIXED ASSETS	4	65,74,48,900	64,36,08,985
CURRENT ASSETS: ADVANCES AND DEPOSITS	5	3,20,12,030	2,46,48,295
CASH AND BANK BALANCES:	6		
IIA Account		6,69,01,779	2,06,63,733
External Projects Account		49,12,01,633	44,14,65,623
TOTAL		1,24,75,64,342	1,13,03,86,637
Notes on Accounts:	15		

Note:- The Schedules and Notes on accounts referred to above form an integral part of the Balance Sheet & Income & Expenditure Account.

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P.KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

V.K. NIRANJAN & CO. 22357769 22265005 BANGALORE 560 009 Chartered Accountants

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO.
CHARTERED ACCOUNTANTS....2
1049, "Maria Arcade", Dr. Rajkumar Road
4th M Block, Rajajinagar, Bengaluru-560 010
Phone: 080-23357769/8762442895

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

INCOME AND EXPENDITURE ACCOUNT UNDER PLAN
FOR THE YEAR ENDED 31ST MARCH, 2017

(Amount in Rs.)

	SCH	2016-17	2015-16
A. INCOME			
Grant-in-aid	7	51,00,09,479	50,29,10,750
Other Income	8	17,25,038	45,35,435
TOTAL - A		**51,17,34,517**	**50,74,46,185**
B. EXPENDITURE			
Salaries and Allowances	9	33,79,19,634	27,00,03,969
Office Expenditure	10	1,56,46,837	1,54,58,015
Working Expenses	11	12,49,91,517	14,07,18,231
Stores & Consumables	12	37,16,942	29,94,223
Depreciation	4	5,79,97,050	6,05,84,662
TOTAL - B		**54,02,71,980**	**48,97,59,099**
C. SURPLUS / (DEFICIT) FOR THE YEAR (A - B)		(2,85,37,463)	1,76,87,086
Notes on Accounts:	15		

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P. KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

V.K. NIRANJAN & CO. 22217769 22215005 BANGALORE 560 009 Chartered Accountants

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO.
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INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

INCOME AND EXPENDITURE ACCOUNT UNDER NON-PLAN

FOR THE YEAR ENDED 31ST MARCH, 2017

(Amount in Rs.)

	SCH	2016-17	2015-16
A. INCOME			
Grant-in-aid	13	10,00,000	50,00,000
TOTAL - A		10,00,000	50,00,000
B. EXPENDITURE			
Salaries and Allowances	14	10,00,000	50,00,000
TOTAL - B		10,00,000	50,00,000
Notes on Accounts:	15		

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P. KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO. Chartered Accountants 22257769 22235005 BANGALORE 560 009

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INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

RECEIPTS AND PAYMENTS ACCOUNT UNDER PLAN
FOR THE YEAR ENDED 31ST MARCH, 2017

(Amount in Rs.)

		SCH	2016-17	2015-16
RECEIPTS				
Opening Balance				
IIA Account			2,06,58,733	42,34,916
External Projects Account			44,14,65,623	19,46,73,306
Grant-in-aid	57,40,69,000			
Add:Interest from Bank and Staff Advances	77,77,443	A	58,18,46,443	55,80,19,681
Other Receipts		B	17,25,038	45,35,435
Advance Recoveries / Credits/Adjustments		C	55,14,45,186	56,76,45,717
TOTAL			1,59,71,41,023	1,32,91,09,055
PAYMENTS				
Recurring Expenditure		D	48,22,65,990	48,02,45,438
Non-Recurring Expenditure		E	7,18,36,964	5,81,08,931
Deposits and other payments		F	48,49,39,657	32,86,30,330
Closing Balance				
IIA Account		6	6,68,96,779	2,06,58,733
External Projects Account		6	49,12,01,633	44,14,65,623
TOTAL			1,59,71,41,023	1,32,91,09,055

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P.KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

V.K. NIRANJAN & CO. Chartered Accountants 22357769 BANGALORE 560 009

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO.
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INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

RECEIPTS AND PAYMENTS ACCOUNT UNDER NON-PLAN FOR THE YEAR ENDED 31ST MARCH, 2017

(Amount in Rs.)

	SCH	2016-17	2015-16
RECEIPTS			
Opening balance		5,000	5,000
Grant-in-aid	G	10,00,000	50,00,000
TOTAL		10,05,000	50,05,000
PAYMENTS			
Recurring Expenditure	H	10,00,000	50,00,000
Closing Balance	6	5,000	5,000
TOTAL		10,05,000	50,05,000

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P.KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO. Chartered Accountants © 22207769 22203005 BANGALORE 560 009

V.K. NIRANJAN & CO.
CHARTERED ACCOUNTANTS
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INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

ACCOUNT FOR THE YEAR ENDED 31-03-2017

PARTICULARS	As at 31.03.2017	As at 31.03.2016
	Rs.	Rs.
SCHEDULE -1		
CAPITAL FUND		
As per Previous Balance Sheet	67,98,11,510	60,70,15,493
Add: Grants received during the year		
(Non-Recurring Expenditure)	7,18,36,964	5,51,08,931
	75,16,48,474	**66,21,24,424**
Add/(Less): Surplus/(Deficit) for the year (Plan)	(2,85,37,463)	1,76,87,086
TOTAL	**72,31,11,011**	**67,98,11,510**
SCHEDULE -2		
GENERAL FUND		
As per Previous Balance Sheet	5,000	5,000
TOTAL	**5,000**	**5,000**
SCHEDULE -3		
CURRENT LIABILITIES & PROVISIONS		
Audit Fee Payable	95,580	86,640
Earnest Money Deposit	59,93,825	43,64,325
Security Deposit	52,38,370	37,49,232
Caution Deposit	8,98,380	9,02,380
GLSI Payable	2,42,992	1,927
External Projects Fund	51,19,79,184	44,14,65,623
TOTAL	**52,44,48,331**	**45,05,70,127**

V.K. NIRANJAN & CO. Chartered Accountants BANGALORE 560 009

..7

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU - 560034

SCHEDULE-4

FIXED ASSETS AS AT 31.03.2017

Sl. No.	Description	Gross Block				Depreciation Block					Net Block	
		As on 01.04.2016	Additions During the year	Transfer/ Adjustment	As on 31.03.2017	Rate %	As on 01.04.2016	For the Year	Transfer/ Adjustment	As on 31.03.2017	As on 31.03.2017	As on 31.03.2016
		Rs.	Rs.	Rs.	Rs.		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Land	2,48,98,870	-	-	2,48,98,870	-	-	-	-	-	2,48,98,870	2,48,98,870
2	Buildings	34,22,76,212	17,16,994	-	34,39,93,206	5%	10,50,32,875	1,19,48,017	-	11,69,80,892	22,70,12,314	23,72,43,337
3	MGK Menon Laboratory	12,20,13,171	3,47,062	-	12,23,60,233	5%	61,00,659	58,12,979	-	1,19,13,638	11,04,46,595	11,59,12,512
4	Vainu Bappu Telescope	5,30,85,009	82,604	-	5,31,67,613	15%	5,30,63,217	15,659	-	5,30,78,876	88,737	21,792
5	2m Telescope (HCT)	45,30,13,898	-	-	45,30,13,898	15%	45,28,32,582	27,197	-	45,28,59,779	1,54,119	1,81,316
6	HAGAR	5,12,54,355	-	-	5,12,54,355	15%	3,61,77,255	22,61,565	-	3,84,38,820	1,28,15,535	1,50,77,100
7	Capital Equipments	97,71,80,259	3,85,96,181	-	1,01,57,76,440	15%	86,84,02,218	2,21,06,133	-	89,05,08,351	12,52,68,089	10,87,78,041
8	Furniture	2,60,19,435	1,04,845	-	2,61,24,280	10%	2,48,66,714	1,25,757	-	2,49,92,471	11,31,808.8	11,52,721
9	Vehicles	1,50,59,268	-	-	1,50,59,268	15%	1,37,94,224	1,89,757	-	1,39,83,981	10,75,287	12,65,044
10	Computers	14,08,95,029	26,82,507	-	14,35,77,536	60%	13,62,41,751	44,01,471	-	14,06,43,222	29,34,314	46,53,278
11	Books and Journals	15,03,92,662	47,39,296	-	15,51,31,958	60%	14,64,34,341	52,18,570	-	15,16,52,911	34,79,047	39,58,321
12	Typewriter	2,55,369	-	-	2,55,369	15%	2,55,368	-	-	2,55,368	1	1
13	HESP	4,55,74,392	5,28,073	-	4,61,02,465	15%	68,36,159	58,89,946	-	1,27,26,105	3,33,76,360	3,87,38,233
14	Building at Leh (WIP)	4,26,38,039	2,01,29,839	-	6,27,67,878	-	-	-	-	-	6,27,67,878	4,26,38,039
15	NLST (WIP)	4,76,15,660	20,33,922	-	4,96,49,582	-	-	-	-	-	4,96,49,582	4,76,15,660
16	NLOT (WIP)	14,74,718	8,75,641	-	23,50,359	-	-	-	-	-	23,50,359	14,74,718
	Total Rs.	2,49,36,46,346	7,18,36,964	-	2,56,54,83,310		1,85,00,37,362	5,79,97,050	-	1,90,80,34,414	65,74,48,900	64,36,08,985

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PARTICULARS		As at 31.03.2017	As at 31.03.2016
		Rs.	Rs.

SCHEDULE - 5

CURRENT ASSETS

A) INVENTORY			
Stock on hand - Stores & Consumables		5,34,431	7,91,457
(As Certified by the Management)			
B) ADVANCES TO SERVICE PROVIDERS			
Deposit for Residential Accommodation		6,31,491	6,31,491
Deposit with Hamsa Service Station		6,000	6,000
Deposit with KEB		4,19,534	3,94,364
Deposit with St.Philomena Hospital		10,000	10,000
Deposit with Telephone Dept.		3,94,282	3,95,158
Deposit with TNEB		2,97,220	2,41,225
Deposit with CPWD		5,75,062	5,75,062
C) LOANS & ADVANCES			
Festival Advance		9,000	36,294
House Building Advance		25,53,421	33,69,377
LTC Advance		98,700	2,59,160
Motor Car Advance		14,51,478	17,38,202
Motor Cycle Advance		13,48,822	15,91,903
Computer Advance		2,40,976	4,86,436
Contingent Advance		15,333	24,000
Travelling Advance		50,000	2,65,205
Amt receivable from CSIR (Avijeet Prasad)		10,11,900	11,91,900
Amt receivable from CSIR (Nancy Narang)		9,71,205	3,21,786
Tax Deducted at Source Credits from ITD		-	3,75,000
Margin LC		70,79,310	17,80,000
Amt receivable from Aditya Project		-	1,01,64,275
Advance to Contractors		1,43,13,865	-
	TOTAL	**3,14,77,599**	**2,38,56,838**
	TOTAL (A+B)	**3,20,12,030**	**2,46,48,295**

V.K. NIRANJAN & CO. Chartered Accountants 22267769 22265005 BANGALORE 560 009

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PARTICULARS	As at 31.3.2017	As at 31.3.2016
	Rs.	Rs.

SCHEDULE - 6

CASH AND BANK BALANCES

Cash on Hand		
Bangalore	21,477	31,122
Kodaikanal	29,495	11,036
Kavalur	12,252	3,584
Leh	49,094	25,105
Hoskote	8,556	6,433
Cash at Banks		
Bank of Baroda, Bangalore (2/74)	7,97,239	5,79,747
Bank of Baroda, Bangalore (SB A/c 1/1565)	6,28,17,824	7,06,79,345
Bank of Baroda, Bangalore (TMT SB A/c 1/1575)	46,44,17,900	38,71,63,708
State Bank of India, Kodaikanal (SB A/c)	8,04,946	1,77,805
Indian Overseas Bank, Kavalur (SB A/c)	16,91,590	7,10,463
State Bank of India, Leh	8,94,283	6,60,510
State Bank of Mysore, Bangalore	1,65,261	3,59,071
State Bank of Mysore, Hoskote	9,268	9,268
State Bank of Mysore, Hoskote (SB A/c)	4,15,815	8,37,575
Union Bank of India, Bangalore	1,58,846	2,49,187
Union Bank of India, Bangalore (SB A/c)	2,56,84,721	1,99,836
Canara Bank, Gauribidanur	1,02,302	4,03,016
HDFC Bank, Bangalore	22,544	22,544
TOTAL	**55,81,03,412**	**46,21,29,356**
Plan	**6,68,96,779**	**2,06,58,733**
Non-Plan	**5,000**	**5,000**
External Project Fund	49,12,01,633	**44,14,65,623**

V.K. NIRANJAN & CO. Chartered Accountants 22267769 22265005 BANGALORE 560 009

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PARTICULARS		2016-2017	2015-2016
		Rs.	Rs.
SCHEDULE - 7			
Grant-in-aid - PLAN		57,40,69,000	55,39,00,000
(Ministry of Science & Technology, Dept of Science & Technology)			
Add: Bank Interest	62,67,012		
Interest on Staff Advances	15,10,431	77,77,443	41,19,681
Less : Amount transferred to Capital Fund			
(Non Recurring Expenditure during the year)			
Fixed Assets		7,18,36,964	5,51,08,931
TOTAL		51,00,09,479	50,29,10,750
SCHEDULE- 8			
OTHER INCOME			
Licence Fees		4,81,159	3,94,936
Others / Misc Income		12,43,879	41,40,499
TOTAL		17,25,038	45,35,435
SCHEDULE-9			
SALARIES AND ALLOWANCES			
Pay & Allowances		19,23,42,424	18,87,58,796
Uniform and Washing Allowance		1,40,480	8,730
Leave Travel Concession		35,05,927	23,76,400
Medical Expenses		3,63,10,631	2,76,21,466
Honorarium		17,60,926	6,96,846
CPF Institute Contribution		67,288	97,779
NPS Institute Contribution		42,30,060	37,24,835
Ad-Hoc Bonus		12,45,167	3,43,673
OtherTerminal Benefits		4,10,89,745	5,40,456
Children Education Allowance		20,04,494	18,80,090
Overtime Allowance		89,207	1,02,862
Pension Contribution		5,51,33,285	4,38,52,036
		33,79,19,634	27,00,03,969
SCHEDULE - 10			
OFFICE EXPENDITURE			
Postage & Courier		2,29,405	2,28,946
Conveyance		1,25,612	2,04,306
Printing and Stationery		7,45,274	7,49,374
Vehicle Maintenance		25,01,127	22,71,011
Advertisement Expenses		7,03,006	3,36,159
Audit fee		95,580	84,360
Legal Fee		5,26,735	7,80,800
Guest House Expenses		34,24,873	38,70,650
Travel - International		19,78,797	12,89,477
Travel - Domestic		53,16,428	56,42,932
TOTAL		1,56,46,837	1,54,58,015

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V.K. NIRANJAN & CO. Chartered Accountants BANGALORE 560 009 22267769 22265005

PARTICULARS	2016-2017	2015-2016
		Rs.
SCHEDULE-11		
WORKING EXPENSES - PLAN		
Property Tax	12,42,118	15,33,841.00
Electricity & Water Charges	1,36,78,970	1,45,68,187.72
Telephone charges	20,95,672	23,22,093.00
Travel Expenses & Field Trips	31,33,730	38,29,709.00
Repairs, mainteance for Computers, Electrical, Electronics, Mech & Optical Equipments & Manpower Outsource Charges	6,45,94,702	7,14,05,722.00
Other Expenses, Training, Public Outreach	22,77,029	56,71,009.70
Conference/Meetings/Workshops/Schools	12,18,746	29,12,713.00
Rent for Hiring Accommodation	5,71,302	5,51,640.00
Canteen Expenses	30,37,955	26,79,653.00
Lease rent for Observatories (VBO,Kavalur & Gauribidanur)	59,340	8,51,180.00
Research Scholarship, PDF, Visting Professorship	3,05,78,206	3,36,58,906.00
Welfare Measures for Scheduled Tribes	23,93,747	-
HAGAR Expenses	1,10,000	7,33,577.00
TOTAL	12,49,91,517	14,07,18,231
SCHEDULE - 12		
STORES & CONSUMABLES		
Opening Balance	7,91,457	2,44,728
Add: Purchases during the year	34,59,916	35,40,952
	42,51,373	37,85,680
Less: Closing Stock	5,34,431	7,91,457
Consumption during the year	37,16,942	29,94,223
SCHEDULE - 13		
GRANTS-IN-AID (NON - PLAN)		
Grant-in-aid	10,00,000	50,00,000
Ministry of Science & Technology (Dept.of Science & Technology)		
SCHEDULE 14		
SALARIES & ALLOWANCES - NON PLAN		
Pay and Allowances	10,00,000	50,00,000
TOTAL	10,00,000	50,00,000

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PARTICULARS		2016-2017	2015-2016
			Rs.

SCHEDULE - A
GRANTS - IN - AID (PLAN)

Grant-in-aid - Plan		57,40,69,000	55,39,00,000
(Ministry of Science & Technology, Dept of Science & Technology)			
Add: Bank Interest	62,67,012		
Interest on Advances to Staff	15,10,431	77,77,443	41,19,681
TOTAL		**58,18,46,443**	**55,80,19,681**

SCHEDULE - B
OTHER RECIEPTS

Licence Fee	4,81,159	3,94,936
Other Receipts	12,43,879	41,40,499
TOTAL	**17,25,038**	**45,35,435**

SCHEDULE - C

ADVANCE RECOVERIES, CREDITS / ADJUSTMENTS

Advances (Travelling & LTC)	*5,24,365*	4,59,300
Contingent Advance	27,30,748	33,64,142
Caution deposit from Research scholars	65,000	1,65,000
Earnest Money Deposit	24,09,500	29,92,000
House Building advance	15,65,956	14,84,230
Computer Advance	3,35,460	5,82,753
Festival Advance	1,09,500	1,65,375
Motor Car Advance	4,66,724	5,39,645
Motor Cycle Advance	2,67,081	3,18,577
Security deposit from Contractors	16,67,723	8,01,478
Margin Letter of Credit	40,50,000	46,50,000
GLSI	2,42,992	1,927
Income Tax Refund	3,75,000	75,000
Exp reimbursed from Aditya Project	20,11,64,275	38,76,788
External Projects	32,94,70,396	54,59,24,774
Recd from CSIR (Avijeet Prasad&Nancy Narang)	2,30,581	-
Advance recovered from Contractors	49,77,552	20,00,000
Telephone Deposit	876	-
Consumable Stores	7,91,457	2,44,728
TOTAL	**55,14,45,186**	**56,76,45,717**

V.K. NIRANJAN & CO. Chartered Accountants BANGALORE 560 009

PARTICULARS	2016-2017	2015-2016
	Rs.	Rs.

SCHEDULE - D

RECURRING EXPENDITURE - PLAN

A) Salary and Allowances		
Pay and Allowances	19,23,42,424	18,87,58,796
Honorarium	17,60,926	6,96,846
Pension Contribution	5,51,33,285	4,38,52,036
Medical Expenses	3,63,10,631	2,76,21,466
CPF Institute Contribution	67,288	97,779
NPS Institute Contribution	42,30,060	37,24,835
Gratuity/Leave Encashment/Retirement Benefits	4,10,89,745	5,16,11,456
Uniform,Washing and Over Time Allowance	2,29,687	1,11,592
Ad-Hoc Bonus	12,45,167	3,43,673
Children Education Allowance	20,04,494	18,80,090
Leave Travel Concession	35,05,927	23,76,400
	33,79,19,634	**32,10,74,969**
B) Administrative Expenditure		
Postage & Courier	2,29,405	2,28,946
Conveyance	1,25,612	2,04,306
Printing and Stationery	7,45,274	7,49,374
Vehicle Maintenance	25,01,127	22,71,011
Advertisement Expenses	7,03,006	3,36,159
Audit fee	86,640	84,360
Legal / Professional Fee	5,26,735	7,80,800
Guest House & Mess Expenses	34,24,873	38,70,650
	83,42,672	**85,25,606**
C) Travelling Allowances		
Travel - Domestic	53,16,428	56,42,932
Travel - International	19,78,797	12,89,477
	72,95,225	**69,32,409**
D) Working Expenses		
Property tax	12,42,118	15,33,841
Electricity & Water charges	1,36,78,970	1,45,68,188
Telephone charges	20,95,672	23,22,093
Lease rent for Observatories (VBO,Kavalur & Gauribidanur)	59,340	8,51,180
Rent for Hiring Accommodation	5,71,302	5,51,640
Repairs & Maintenance	1,33,97,200	1,81,75,388
Manpower Outsource Exp	4,12,83,589	3,72,11,959
Communication Charges	99,13,913	1,60,18,375
Consumables forLabs (computer, electronic	37,16,942	29,94,223
Other Expenses, Public Outreach, Bank Charges etc.	22,77,029	56,71,010
Travel expenses	31,33,730	38,29,709
Meeting/Workshop/Schools/Conferences etc.	12,18,746	29,12,713
Canteen expenses	30,37,955	26,79,653
Research Scholarship, PDF, Visting Professorship	3,05,78,206	3,36,58,906
Welfare Measures for Scheduled Tribes	23,93,747.00	-
HAGAR Expenses	1,10,000	7,33,577
TOTAL	**12,87,08,459**	**14,37,12,454**
TOTAL(A+B+C+D)	**48,22,65,990**	**48,02,45,438**

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V.K. NIRANJAN & CO. Chartered Accountants BANGALORE 560 009

PARTICULARS	2016-2017	2015-2016
	Rs.	Rs.

SCHEDULE - E

NON-RECURRING EXPENDITURE - PLAN - NET

Computers	26,82,507	54,35,417
Capital equipment	3,85,96,181	1,95,81,517
Civil Works	2,18,46,833	1,71,23,034
Furniture	1,04,845	5,70,536
Books & Journals	47,39,296	65,47,024
Vainu Bappu Telescope	82,604	-
MGK Menon Lab for Space Sciences	3,47,062	6,65,270
NLST	20,33,922	16,61,790
HESP/Himalayan Chandra Telescope	5,28,073	61,55,534
NLOT	8,75,641	3,68,809
TOTAL	**7,18,36,964**	**5,81,08,931**

SCHEDULE -F

ADVANCE PAYMENTS / DEPOSITS & OTHER PAYMENTS (Current Assets)

House Building Advance	7,50,000	3,75,000
Margin for LC	93,49,310	64,30,000
Computer Advance	90,000	3,06,067
Motor Car Advance	1,80,000	3,87,600
Festival advance	82,206	1,20,000
Motor cycle advance	24,000	78,000
Contingent Advance	27,22,081	33,75,142
External Projects	25,89,56,835	29,91,32,458
Advances paid to Vendors	1,92,91,417	-
Deposit with KEB	25,170	61,240
Earnest Money Deposit	7,80,000	18,32,500
Advances (TA, LTC)	*1,48,700*	5,24,365
Deposit with TNEB	55,995	5,621
Refund of Security Deposit	1,78,585	84,531
Caution Deposit	69,000	68,500
GLSI	1,927	-
CSIR Students Scholarship	7,00,000	10,16,786
Aditya Project Grants	19,10,00,000	1,40,41,063
Consumable Stores	5,34,431	7,91,457
TOTAL	**48,49,39,657**	**32,86,30,330**

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V.K. NIRANJAN & CO. Chartered Accountants BANGALORE 560 009

PARTICULARS	2016-2017	2015-2016
	Rs.	Rs.

SCHEDULE-G
GRANT-IN-AID (NON-PLAN)

Grant-in-aid Ministry of Science & Technology (Dept.of Science & Technology)	10,00,000	50,00,000

SCHEDULE - H
RECURRING EXPENDITURE - NON-PLAN

Salary and Allowances Pay and Allowances	10,00,000	50,00,000

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P.KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

As per our report of even date,
for V.K.NIRANJAN & Co.,
Chartered Accountants
F.R.NO: 002468S

V.K. NIRANJAN & CO. 22357769 22356005 BANGALORE 560009 Chartered Accountants

NIRANJAN V.K.
Partner
M.No: 021432

Place: BENGALURU
Date: 31.07.2017

V.K. NIRANJAN & CO.
CHARTERED ACCOUNTANTS
1049, "Maria Arcade", Dr. Rajkumar Road
4th M Block, Rajajinagar, Bengaluru-560 010
Phone: 080-23357769/8762442895

SCHEDULE: - 15

SIGNIFICANT ACCOUNTING POLICIES ANDNOTES ON ACCOUNTS FOR THE YEAR ENDED 31.03.2017

A. SIGNIFICANT ACCOUNTING POLICIES:

1. ACCOUNTING CONVENTION:

The Financial Statements are prepared on the basis of Historical cost convention and on the accrual method of accounting, except Bank Interest, which is accounted on 'Cash Basis', as in previous years. The guidelines given by the Government of India for drawing Financial Statements for central autonomous bodies have been adopted, to the extent that they are directly applicable.

2. FIXED ASSETS:

Fixed assets are stated at cost of acquisition less depreciation. The same was verified physically on periodical basis by the Management.

3. DEPRECIATION:

Method of Depreciation is charged on WDVat rates as stated in the Fixed Assets Schedule. The amount of depreciation has been debited to the Income & Expenditure Accountas per the guidance of C&AG Audit. The rate of depreciation has been charged as per the Income Tax Act, 1961 and guidance of C&AG Audit.

4. INVENTORY:

Stocks on hand such as spares, materials, consumables are valued at cost.

5. GOVERNMENT GRANTS:

Government grants received from DST are accounted on receipt basis and the same have been separately shown under Plan and Non-Plan in the Annual accounts of the Institute. Out of the total Plan grant amount received, an amount equal to the amount of non recurring expenditure incurred during the year is directly credited to the Capital Fund A/c, the balance of Plan grants is reckoned as Income and shown in Income & Expenditure Account as Grants-in-Aid. The interest earned on Government Grants such as bank interest and interest on staff advances has been credited to Grants-in-aid account.

6. FOREIGN CURRENCY TRANSACTIONS:

Transactions denominated in foreign currency are accounted at the exchange rates prevailing as on the dates of the transaction.

7. RETIREMENT BENEFITS:

- Institute's Contribution to Provident Fund and Pension Fund are charged to Income and Expenditure Account of the Institute. Apart from this, any deficit in the Provident Fund and Pension Fund amount is borne and provided for in the accounts of the Institute on payment basis.

- Estimated liability for Gratuityon the date of Balance Sheet has notbeen quantified. The same is accounted for on actual cash basis payment.

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8. Non-Plan grants have been fully utilized only for payment of non-plan salaries and allowances and a separate Receipts & Payments Account, and Income & Expenditure Account have been prepared.

9. The Schedule 3 under Current Liabilities includes the Security Deposit &EMD of Projects account.

B. NOTES ON ACCOUNTS:

1. In the opinion of the Management, the Current Assets, Advances and Deposits have been recorded at the actual value of transactions in the ordinary course of activities. The aggregate amount is shown in the Balance Sheet.

2. Previous year figures have been re-grouped wherever necessary.

3. Figures have been rounded off to the nearest rupee.

INDIAN INSTITUTE OF ASTROPHYSICS Bangalore

S.B.RAMESH
Accounts Officer

P.KUMARESAN
Sr Administrative Officer

P.SREEKUMAR
Director

for V.K.NIRANJAN& Co.,
Chartered Accountants
F.R.NO: 002468S

NIRANJAN V.K., FCA
Partner
M No.021432

Place: BENGALURU
Date:31.07.2017

V.K. NIRANJAN & CO. 22267769 22285005 BANGALORE 560 009 Chartered Accountants

V.K. NIRANJAN & CO.
CHARTERED ACCOUNTANTS
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Phone: 080-23357769/8762442895