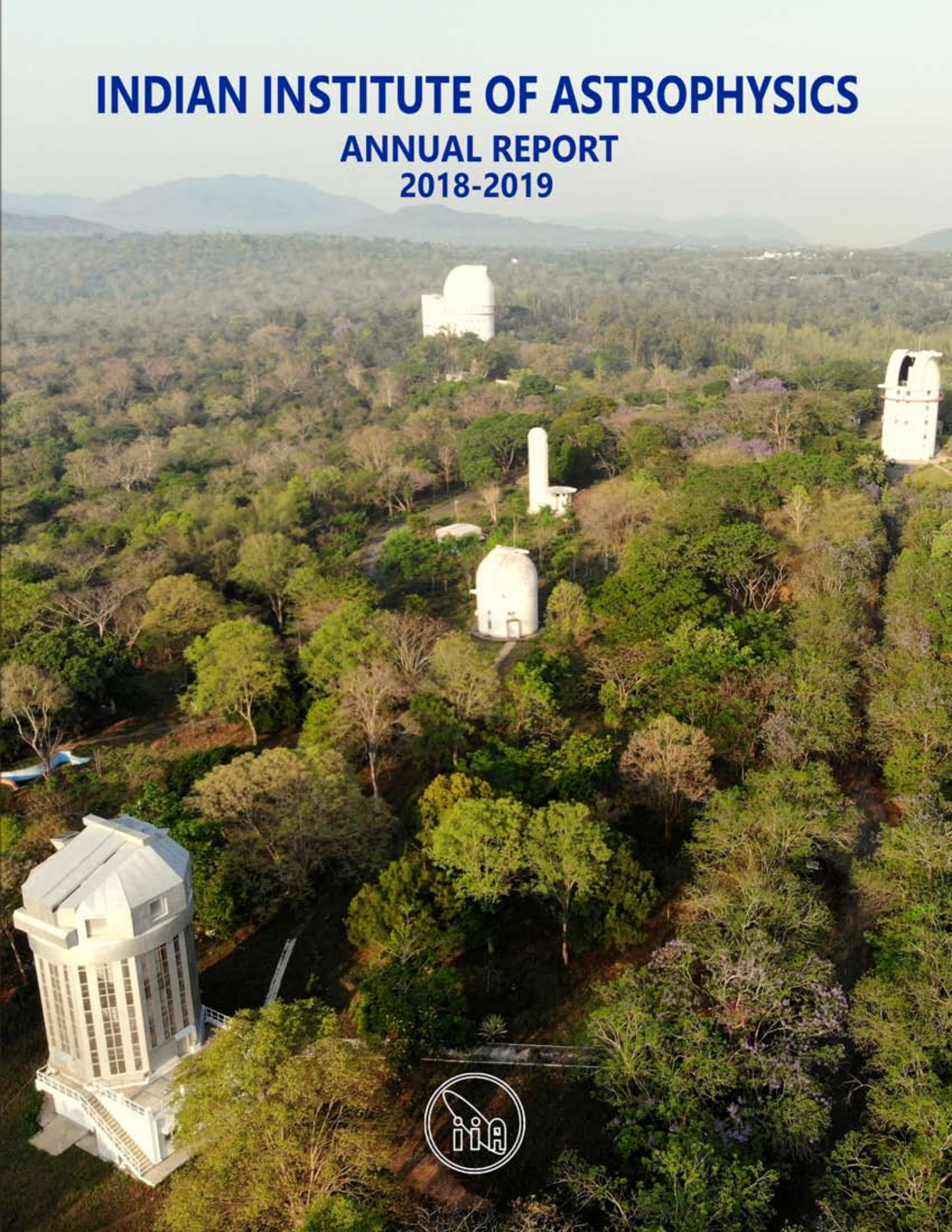
INDIAN INSTITUTE OF ASTROPHYSICS

ANNUAL REPORT
2018-2019



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Edited by : S. Muneer & G. C. Anupama

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Front Cover : Aerial view of the Vainu Bappu Observatory at Kavalur. The Observatory entered its 50^{th} year of operations in 2018.
Image Credit : Deshmukh Prasanna Gajanan & Mayuresh Sarpotdar

Back Cover : The GROWTH - India Telescope at Mt. Saraswati, IAO, Hanle. The telescope was installed and commissioned in 2018.
Image Credit : Dorje Angchuk

Cover Design: Sanjiv Gorka

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1 The Year In Review

It gives me great pleasure to present the highlights of achievements in research and development activities at Indian Institute of Astrophysics. The year 2018-19 witnessed noteworthy developments in research, development, teaching programmes and the public outreach. IIA continues to be at the forefront in training new generation of young researchers in the astrophysical sciences as well as in creating new observational facilities and maintaining them. The Institute celebrated 50th year of successful operations of the Vainu Bappu Observatory at Kavalur. A commemorative book highlighting the history of VBO and the interesting science results was released on this occasion.

Solar physics research community at the Institute explored a wide range of topics this year from deep solar interior to the corona and beyond. Studies on the characteristics of latitudinal patterns of solar magnetic network using the Calcium K spectroheliograms of the Sun from Kodaikanal Observatory over a data-span of about 100 years along with similar data from Mount Wilson Observatory, has yielded new information on the long term behaviour of the solar cycles with implications for interior dynamics and the magnetic dynamo. A study of build-up and eruption of coronal non-potential magnetic structure in an emerging active region demonstrated the fast injection of helicity per unit flux is the crucial factor for severe space-weather events.

The stellar astronomy group pursued research in novae, supernovae, variable star population in globular clusters, hydrogen deficient stars, and chemical abundance analysis of various types of stars. UVIT data revealed UV variability in eighteen RR Lyrae stars, and detection of new variables in the central region of the Horizontal Branch population of the globular cluster NGC 1851. A comprehensive spectral analysis of the 2011 outburst of the recurrent nova T Pyxidis revealed the complex structure of the ejected shell. Multiwavelength observations of broad-line type Ic Supernova SN 2014ad revealed expansion velocity of its ejecta is highest among all the supernovae of the same class studied so far, and it was the result of an energetic explosion of progenitor star massive than 20 solar masses.

Black hole astrophysics, phenomena in active galaxies, galaxy morphology and star formation in galaxies are some of the topics pursued by the cosmology and extragalactic astronomy group. The group reported the discovery of a rare, large, double-lobed radio source associated with the narrow lined Seyfert-1 galaxy at a redshift of 0.435. Based on the HCT observations, the sizes of the dusty torii in AGN H0507+164 has been estimated and this is the first time such measurement was carried out on the source.

The theoretical astrophysical group is engaged in relativistic astrophysics, magnetic fields, quantum chemistry, galactic magnetic fields, radiative transfer theory for the Sun and the exoplanets. A model was devel-

oped for pulsar radio emission due to collective plasma emission. Collective radio emission due to relativistic plasma constrained to move in dipolar magnetic fields could explain the pulsar radio emission and polarization properties.

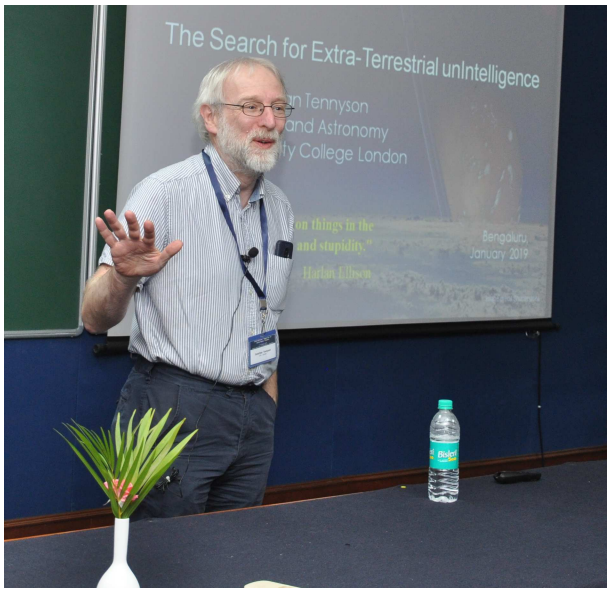


Figure 1.1: *Jonathan Tennyson, University College, London*, delivering a special lecture.

India-TMT led by IIA, made significant progress on its assigned work packages. India-TMT successfully delivered 20 numbers of M1 control system Actuators. They met performance tests at TMT laboratory in Pasadena, USA. The construction of Optics Fabrication Facility at IIA, CREST, Hosakote has been completed and will be commissioned shortly.

For the establishment of National Large Solar Telescope (NLST) at Merak in the Ladakh region, Indian Institute of Astrophysics paid the cost of the land to J&K Government for use of 7.6 ha of land. A 20 cm Hα telescope and all site survey instruments are functional and generating data at the site.

In the Visible Emission Line Coronograph on ADITYA (L1) Space Mission front, subsystems for Proto Flight model are being fabricated and are expected to be available by July 2019. The Proto Flight integration and calibration activities will begin in August 2019. All the required calibration facilities for the Visible Emission Line Coronograph are functional.

The 'GROWTH-India telescope' was installed and commissioned at Indian Astronomical Observatory, Hanle in June 2018. This telescope, which is country's first robotic telescope, was constructed as a joint partnership between the Indian Institute of Astrophysics and the Indian Institute of Technology Bombay. The GROWTH-India project is funded by DST-SERB and administered by IUSSTF.

A Proposal from the Institute for a 1 m class UV-Optical imaging and spectroscopic space telescope is recommended by ISRO.

Figure 1.2: Functioning of coelostat for imaging the Sun is demonstrated to the visitors on the *National Science Day*.

The small payloads group at IIA is pioneering the use of low cost small payloads to carry out long term observations covering large areas of the sky.

Site Survey Group consisting of academic members are identifying a suitable site for a 10 m class Optical-Infrared telescope.

Graduate Studies programme of the Institute has 82 students. During the academic year, nine students were awarded PhD Degree and fourteen others submitted their PhD thesis on a wide range of topics. One student completed her MTech Degree under the IIA-University of Calcutta integrated MTech-PhD programme. The Institute has a variety of programmes for manpower development such as research and engineer trainee programme, internship programme, visits of students and staff from other institutions, projects as part of academic course work etc.

Observing facilities of the Institute are optimally utilized by the scientists and astronomers. We get significant number of observing proposals from universities and other research institutions. A newer generation of $2K \times 4K$ CCD was procured for HFOSC as a replacement for the old one which was in use since 2002. The new system was installed on the HCT during annual maintenance in August 2018. The antennae used for the satellite communication between Hanle and Hosakote have been replaced with new dishes in order to meet the mandatory requirement. The 2.8-meter mirror coating at VBO is being renovated.

UVIT is producing good quality science data and important results are being published in international refereed journals.

The Green House Gas station installed by CSIR-Institute of 4-Paradigm (4PI), Bengaluru, in the CREST Campus Hosakote continues to be functional.

The computing facilities of the Institute are further upgraded and updated with new hardware and software. The Institute made concerted efforts to archive historical books and documents. IIA archives continue to get many visitors.

An MoU was entered into with LEOS/ISRO for the Design and Development of a Warping Fixture for Stressed Mirror Polishing and Process for Hex cutting and Pocketing of Mirror Segments. Another MoU was entered between IIT Roorkee and IIA in April 2018 for a period of 10 years, for the installation and maintenance of a Multiwavelength Airglow Imager at Indian Astronomical Observatory, Hanle, Ladakh.

The Institute took various steps for implementation of the Official Language and continued efforts to make equitable work environment by safeguarding the interests of SCs, STs, differently-abled and women.

Jayant Murthy
Director (Acting)

2 Research

2.1 The Sun and the Solar System

Research in solar physics at the Institute in this year has ranged from studies of deep solar interior, near-surface dynamics of magnetic fields, lower solar atmosphere, the corona and beyond.

Deep structure of meridional circulation in the solar convection zone has been determined using time-distance helioseismology performed on data from NASA's Solar Dynamics Observatory (SDO)/ Helioseismic and Magnetic Imager (HMI) observations. With improvements in seismic inversions using spherical Born kernels, current results have reinforced the earlier inferences, that return flow of meridional circulation in the deep layers is likely below $0.8\,R_\odot$. These results have major implications for the dynamics of solar interior and the working of the solar dynamo that drives all solar activity and space weather. Attempts made to decipher the sub-photospheric magnetic topology of solar active regions using a combination of vector magnetic field observations by HMI and a realistic 3D numerical simulation indicate that a large active region might maintain a buoyant magnetic iceberg below the photosphere than a smaller one, as the former will suppress turbulence more efficiently.

A detailed procedure involving radiation magneto-hydrodynamic (MHD) simulations has been developed to test the generation, propagation and dissipation of MHD waves, especially the Alfvén waves, in a realistic set-up of solar atmosphere. Magnetohydrostatic solutions that can describe the equilibrium structure of open and closed magnetic configurations of twisted flux tubes have been obtained. These analytical solutions can be used as background models in numerical simulations of wave propagation through flux tubes in the solar atmosphere.

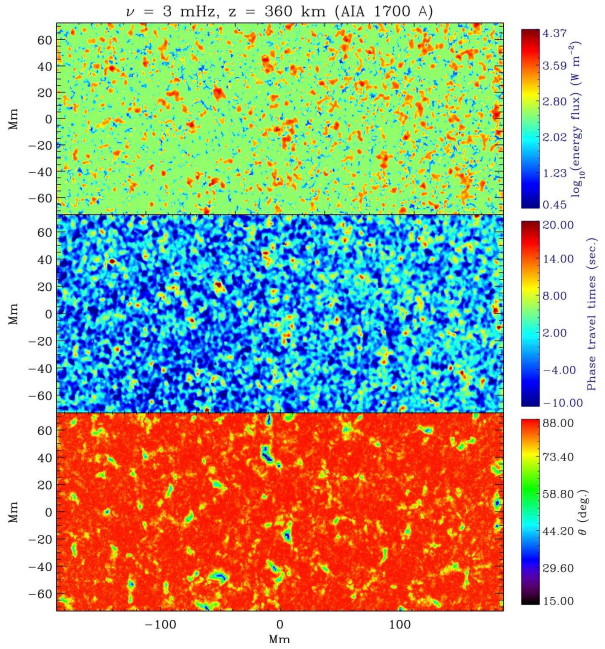


Figure 2.1: Maps of magnetic inclination angle θ (*b*ottom panel), phase travel time, and logarithm of energy flux over the quiet-network area for acoustic waves of frequency 3 mHz propagating from 170 km (HMI line-core intensity $I_{\rm co}$) to 360 km (AIA 1700 Å).

Using the recent results on the lower at-

mospheric wave dynamics and chromospheric heating, a potential new mechanism is explored on low-frequency acoustic wave emission within the largely vertical quiet-network magnetic fields. This research makes an upward revision of (magneto-)acoustic wave energy from the photospheric layers to heat the chromosphere.

Using the Calcium K spectroheliograms of the Sun from Kodaikanal Observatory over a data-span of about 100 years covering over 9 solar cycles, temporal and latitudinal variations of the sizes and relative intensities of the chromospheric magnetic network have been studied. Signatures of solar cycle dependence in the form of varying phase difference over latitudes indicating equatorward flux transfer within $\pm 30°$ latitudes have been derived implicating the possible roles of meridional circulation, torsional oscillations, or the bright point migration. Using the same long term data sets from Kodaikanal along with similar ones from Mount Wilson Observatory, USA, a study of the characteristics of latitudinal patterns of solar magnetic network has yielded new information on the long term behaviour of the solar cycles with implications for interior dynamics and the magnetic dynamo.

Using magnetic field (photospheric) and coronal observations from NASA's SDO, a study of build-up and eruption of coronal non-potential magnetic structure in an emerging active region (AR 12673) has been carried out. This study demonstrates that the fast injection of helicity per unit flux is the crucial factor for severe space-weather events. It also explains the formation of the flux rope and recurrent eruptive nature of the AR 12673 as due to the critically stable state of the sheared arcade. With an aim of deriving a precursor of flaring active regions, a numerical experiment based on a weighted horizontal magnetic gradient (WGM) has been tested using a MHD simulation of solar-like flares. The tests indicate that WGM method provides a reliable flare precursor.

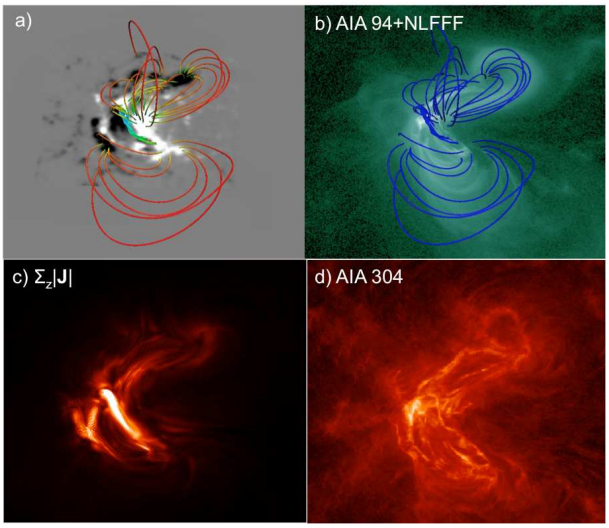


Figure 2.2: Magnetic field extrapolation by force-free field approximation to the corona. *a*) Field lines showing the magnetic structure of AR 12673 on September 4, 2017 at 18:00 UT. Background is radial magnetic field map. *b*) Magnetic structure on coronal 94 Å image. *c*) Map of vertically integrated electric current. *d*) Coronal image of 304 Å from AIA.

An analysis of the characteristics of coronal green line, Fe XIV 5302.86 Å, using Fabry-Perot interferometric observations made during the total solar eclipse of 21 June 2001 that occurred in Lusaka, Zambia has been carried out. This study, performed in the radial range of $1.1-1.5\,R_\odot$, examines the Doppler velocity, half-width, centroid, and asymmetry and their correlations with each other at various points in the corona capturing information on the coronal dynamics. In another study, statistical correlations between the acceleration of coronal mass ejections (CME's) and other related parameters

such as flare energy have been analysed yielding a positive correlation between flare energies and acceleration.

A statistical study of coronal waves in the polar plumes and interplumes has been carried out using a large sample of extreme ultraviolet imaging data with high spatial and temporal resolutions obtained from Atmospheric Imaging Assembly (AIA)/ Solar Dynamics Observatory (SDO) yielding results on the turbulence induced damping of such waves. An automated Coronal Mass Ejection (CME) detection algorithm has been developed for the purpose of implementation in the Visible Emission Line Coronograph instrument onboard the ADITYA-L1 mission, and has been tested using data from existing coronagraph COR-1 onboard NASA's STEREO/SECCHI spacecraft.

A recently commissioned high-resolution radio spectropolarimeter instrument operating in the frequency range of 15–85 MHz at GRO has been used to study solar noise storms at low frequencies.

2.2 Stellar and Galactic Astrophysics

Studies on, novae, supernovae, variable star population in globular clusters, hydrogen-deficient stars, and chemical abundance analysis of various types of stars are some of the topics in which IIA astronomers engaged this year.

The spectroscopic and ionized structural evolution of nova T Pyx during its 2011 outburst was studied using optical spectroscopy. The physical conditions and the geometry of the ionized structure of the nova ejecta was modelled for a few epochs using the photo-ionization code, CLOUDY in 1D and pyCloudy in 3D. The average ejected mass was estimated to be 7.03×10^{-6} $M_{\odot}$. The ionized structure of the ejecta was found to be a bipolar conical structure with equatorial rings, with a low inclination angle of $14.75° \pm 0.65°$. At the late post-outburst phase, it appears that the [O III] lines come from an expanding ejecta while the hydrogen and helium lines from the accretion disc.

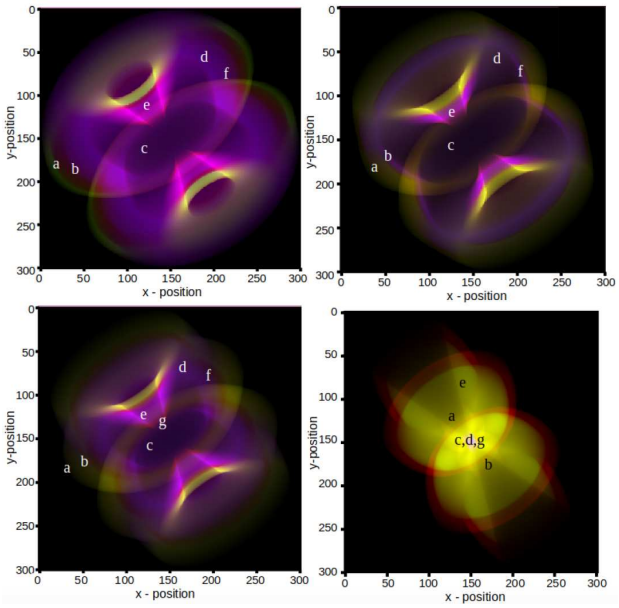


Figure 2.3: Evolution of the geometry of ejecta on day 224 (*top left*), 252 (*top right*), 336 (*bottom left*), and 1064 (*bottom right*). Note the formation of multiple equatorial rings and also the spatial distribution of the ionized lines as the system evolves.

Optical, broadband imaging polarimetric observations of T Pyx obtained from day 1.36 – 29.33 during the early phases of the outburst showed a variation in degree of polarization similar to that observed during the 1967 outburst. This could be either due to asymmetry in the initial ejecta and/or the presence of silicate grains.

The Andromeda galaxy nova M31N 2008-12a has been observed in eruption every single year since its discovery in 2008. This un-

precedented frequency indicates an extreme object, with a massive white dwarf and a high accretion rate, making it a most promising candidate for the single-degenerate progenitor of a Type Ia supernova known to date. The eruptions of M31N 2008-12a were found to display remarkably homogeneous multi-wavelength properties.

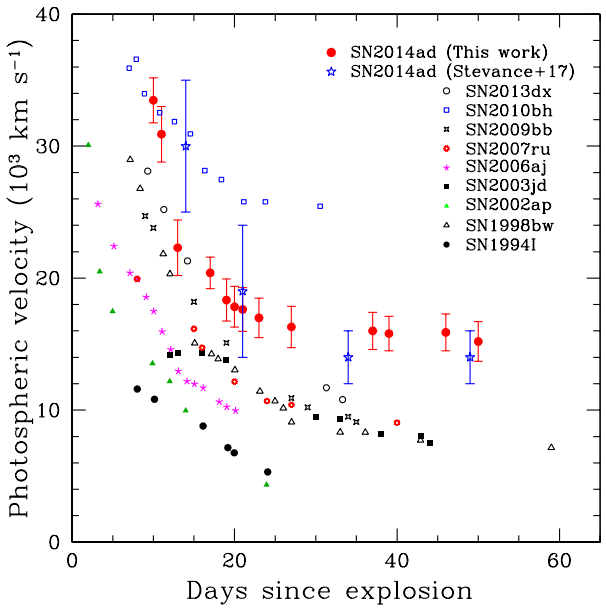


Figure 2.4: Temporal evolution of photospheric velocity of SN 2014ad. For comparison the Si II line velocities of other Type Ic SNe are plotted.

Optical and ultraviolet photometry, and optical spectroscopy of the broad-line (BL) Type Ic supernova SN 2014ad, covering the evolution of the SN during −5 to +87 d with respect to the date of maximum in *B*-band is performed. The expansion velocity of SN 2014ad is found to be higher than all other well observed BL Type Ic SNe except the GRB associated SN 2010bh. The explosion parameters indicate that it was an energetic explosion with a kinetic energy of $\sim(1\pm0.3)\times10^{52}$ ergs, and a total ejected mass of $\sim (3.3 \pm 0.8)$ $M_\odot$. About 0.24 $M_\odot$ of ^{56}Ni was synthesized in the explosion. The mass of the progenitor star is estimated to be ≥ 20 $M_\odot$. The metallicity of the host galaxy near the supernova region is estimated to be ~ 0.5 $Z_\odot$.

The photometric and spectroscopic monitoring of the He-rich Type IIb supernova (SN) 2015as showed that the light curve of SN 2015as reaches the *B*-band maximum about 22 d after the explosion, at an absolute magnitude of -16.82 ± 0.18 mag. At ∼75 d after the explosion, its spectrum shows a transition from SN II to a SN Ib. Optical broadband (*UBVRI*) photometric and low-resolution spectroscopic observations of the ASASSN-14dq, a luminous Type II-P SN indicated a plateau duration of ∼90 d with a plateau decline rate of 1.38 mag $(100\ d)^{-1}$ in the *V*-band, which is higher than most Type II-P SNe.

AT 2018cow (ATLAS 18qqn), the first fast-luminous optical transient to be found in real time at low redshift was studied as part of a comprehensive worldwide campaign. The spectra and temporal evolution were found to be better explained by a tidal disruption event (TDE) than a supernova (SN).

A study on the variable star population in the globular cluster Pal 13 was conducted with new CCD time series photometry. The distance and metallicity are determined through Fourier decomposition of RR Lyrea light curves. The search for variable stars revealed the variability of a red giant cluster member and of three probably non-member stars; two RRab stars and one W Virginis star or CW.

CCD time series photometry is used to determine the physical parameters of the RR Lyrae stars in the globular clusters NGC 4147 and NGC 6171, and used to

estimate the cluster mean metallicity and distance. It is observed that the RRab and RRc stars do not share the inter-mode region in the horizontal branch. NGC 4147 can be classified as of intermediate Oosterhoff type. Its horizontal branch structure and metallicity make a good case for extragalactic origin. It follows the distribution of Oo I type globular clusters in the M_V−[Fe/H] plane, as depicted from the RRc stars. The distribution of RRab and RRc stars in NGC 6171 seems well segregated around the first overtone red edge of the instability strip. This positions NGC 6171 among Oo I−type clusters where the pulsating modes are neatly separated in the horizontal branch. Two new irregular variables of the Lb type are reported.

A complete census of the blue horizontal branch (BHB) and blue straggler star (BSS) population within a 10 arc minute radius from the centre of the globular cluster NGC 288 was carried out, based on images from the Ultraviolet Imaging Telescope (UVIT). Two extreme horizontal branch (EHB) candidates, with temperatures ranging from 29,000 to 32,000 K were detected. The radial distribution of 68 BSSs suggests that the bright BSSs are more centrally concentrated than the faint BSSs and the BHB stars. It was found that the BSSs have a mass range of $0.86-1.25\,M_\odot$ and an age range of 2 – 10 Gyr, with peaks at $1\,M_\odot$ and 4 Gyr respectively.

High-resolution optical spectra of two mildly hydrogen-poor or helium-enhanced giants, LEID 39048 and LEID 34225 were analysed. Unlike normal giants, the spectra of these stars show weaker MgH bands. The magnesium abundance derived from MgH bands is less by 0.3 dex or more for LEID 39048 and LEID 34225 than that derived from Mg I lines. This difference is attributed to the hydrogen deficiency or helium enhancement in their atmospheres. These stars provide the first direct spectroscopic evidence for the presence of the He enhancement in the metal-rich giants of ω Cen.

A detailed chemical abundance study was conducted for a sample of twelve potential CH star candidates based on high resolution spectroscopy. First time abundance analysis was presented for the objects HE 0308−1612, CD−281082, HD 30443, and HD 87853. The object CD−281082 is shown to be a very metal-poor object with [Fe/H] = −2.45, and enriched in carbon with [C/Fe] = 2.19. With a ratio of [Ba/Eu] $\sim$ 0.02 the star satisfies the classification criteria of a CEMP-r/s star. The objects CD−382151 with [Fe/H] = −2.03 and HD 30443 with [Fe/H] = −1.68 are found to show the characteristic properties of CH stars. HE 0308–1612 and HD 87853 are found to be moderately metal-poor with [Fe/H] $\sim$ −0.73; while HE 0308−1612 is moderately enhanced with carbon ([C/Fe] $\sim$ 0.78) and shows spectral properties of CH stars. Five objects in the sample show spectral properties that are normally seen in barium stars.

High resolution spectroscopic analysis was performed for three metal-deficient barium stars HD 36650, HD 207585 and HD 219116 based on HCT/HESP data, FEROS and VLT/UVES spectra. The analysis clearly shows that the surface chemical composition of these barium stars are enriched by s-process nucleosynthesis products coming from their former companion low-mass AGB stars. A discussion on the distribution of abundance ratios based on the existing nucleosynthesis theories was presented.

A detailed study of the abundance patterns of various heavy elements in a sample of potential Carbon-Enhanced Metal-Poor

(CEMP) stars was conducted based on spectra obtained using 2-m HCT/HESP. Analysis shows the object HE 0110−0406 to exhibit characteristic properties of CH giants. The observed surface chemical composition of CEMP-r/s stars with enhancement of both s- and r-process elements cannot be explained either by s-process or r-process nucleosynthesis alone. An alternative process called 'i-process (intermediate process) nucleosynthesis' is suggested as a possible production mechanism. The elemental abundance patterns of two potential CEMP-r/s candidates HE 0308−1612 and HE 0017+0055 are critically examined based on existing nucleosynthesis theories and models, if i-process could explain the observed abundance patterns of these objects.

The evolution of Li in the RGB stars was studied based on a large data set of about 300 thousand stars collected from the GALAH spectroscopic survey combined with the Gaia astrometry. The analysis shows a well populated RGB with well-defined luminosity bump and red clump with significant number of stars at each of these two key phases. In this sample, 335 new Li-rich giants with A(Li) $\geq$ 1.80 $\pm$ 0.14 are discovered of which 20 are Li-super-rich giants with A(Li) $\geq$ 3.20 dex. It was found that most of the Li-rich and Li-super-rich giants lie at the red-clump region which, when combined with stellar evolutionary timescales on RGB, indicates that the Li enhancement origin may lie at RGB tip during He-flash rather than by external source of merging of sub-stellar objects or during luminosity bump evolution. It was also found that, the Li-rich giants are more prevalent in the thin disk than the thick disk and the halo.

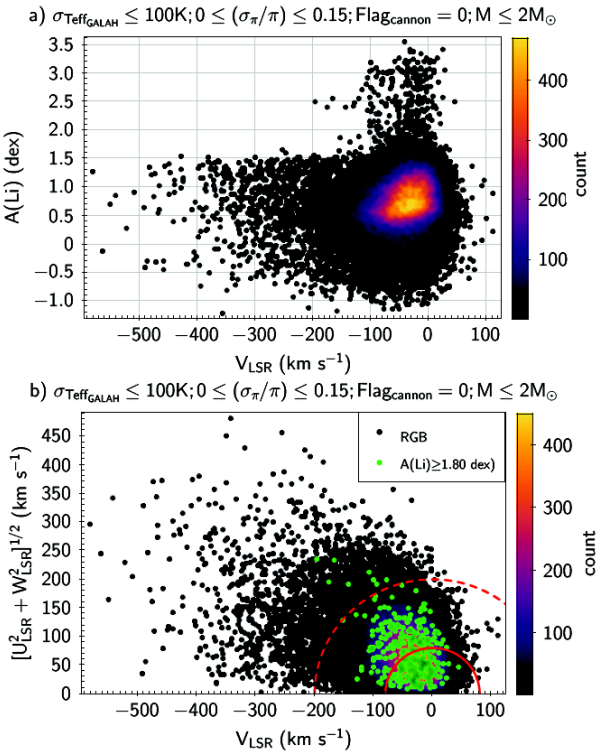


Figure 2.5: Distribution of selected RGB sample in A(Li) vs V_{LSR} plane and in the form of Toomre Diagram. Plotted in *b)* are the approximate boundaries separating thin and thick disk (V_{Total} = 80 km s^{-1}, continuous red circle), and thick disk and halo (V_{Total} = 200 km s^{-1}, dotted red circle).

A multi-wavelength polarization measurements obtained for over 200 stars projected on the high latitude molecular cloud complex MBM 33-39 suggest that the size of the dust grains in these clouds is similar to those found in the normal interstellar medium of the Milky Way.

A systematic search for molecular outflows in 68 Very Low Luminosity Objects (VeLLOs) from single-dish observations in CO isotopologues led to the identification of 15 VeLLOs as proto-brown-dwarf (proto-BD) candidates, and 4 VeLLOs as likely faint protostar candidates. The outflow forces and internal luminosities for more than half of the proto-BD candidates seem to follow the evolution-

ary track of a protostar with an initial envelope mass of $0.08\,M_\odot$, indicating that some BDs may form in less massive dense cores in a similar way to normal stars.

A study on the formation and evolution history of the Milky Way was conducted by dissecting it into different components based on kinematic selection of stars belonging to the thin disc, thick disc, halo of the Galaxy, and using astrometric and radial velocity data from the Gaia DR2.

2.3 Cosmology and Extragalactic Astronomy

The many themes that have been pursued include black hole astrophysics, phenomena in active galaxies, galaxy morphology and star formation in galaxies.

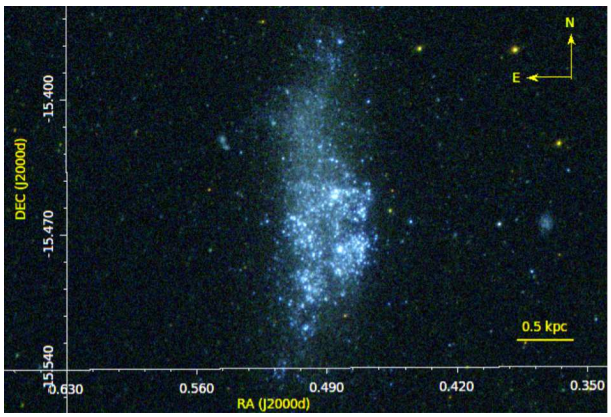


Figure 2.6: UVIT Imaging of WLM: Demographics of Star-forming Regions in the Nearby Dwarf Irregular Galaxy

A study of star-forming regions and their demographics in the nearby dwarf irregular galaxy WLM using Ultraviolet Imaging Telescope (UVIT) multiband observations in three filters, F148W, N245M, and N263M was carried out. WLM is likely to have a large fraction of low-mass compact star-forming regions with mass $M < 103\,M_\odot$, in agreement with the size and mass of the CO clouds. The star formation rate of WLM to be $\sim 0.008\,M_\odot\ \mathrm{yr}^{-1}$ was estimated, which is similar to the average value measured for nearby dwarf irregular galaxies.

To understand the possible mechanisms of recurrent jet activity in radio galaxies and quasars, which are still unclear, sources with a large range of linear sizes (220 – 917 kpc), and hence time scales of episodic activity were studied. A new double-double radio galaxy with a candidate quasar was identified, and the upper spectral age limits for eight sources estimated which showed marginal evidence of steepening at higher frequencies.

Among the many varieties of active galactic nuclei (AGNs) known, narrow-line Seyfert 1 (NLSy1) galaxies are a puzzling class, particularly after the discovery of γ-ray emission in a handful of them using observations from the Fermi Gamma-ray Space Telescope. A rare, large, double-lobed radio source was discovered associated with the narrow lined Seyfert-1 (NLSy1) galaxy, SDSS J103024.95+551622.7, at a redshift of 0.435. The lobe separation is 116 kpc which is the second-largest known projected size among NLSy1 radio sources.

H I, optical, and near-infrared observations of the nearby bulgeless, dwarf spiral galaxy NGC 4701 was carried out. The galaxy lies in the Virgo filament and is one of the most gas-rich dwarfs in our local environment. The observations lead us to conclude that NGC 4701 is a classic example of a late-type dwarf spiral galaxy and its nature supports the idea that dwarfs also follow a morphological sequence similar to spirals on the Hubble Sequence.

The suppression of star formation in the inner kpc regions of barred disk galaxies due to the action of bars is known as bar-quenching. The significance of bar-quenching in the global quenching of star formation in the barred galaxies and transforming them into passive galaxies is investigated. By constructing the star formation rate-stellar mass plane of 2885 local Universe face-on strong barred disk galaxies ($z < 0.06$) identified by Galaxy Zoo, it was found that the offset of the quenched barred galaxies from the main sequence relation is not dependent on the length of the stellar bar. This implies that the bar quenching may not be contributing significantly to the global quenching of star formation in barred galaxies.

2.4 Theoretical Physics & Astrophysics

The themes that were pursued include relativistic astrophysics, magnetic fields, quantum chemistry, galactic magnetic fields and radiative transfer theory for the Sun.

Black holes at the centers of the galaxies grow mainly by the processes of accretion, mergers, 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. Besides, the effect of mergers on the growth of black hole spin and mass was included to study its evolution as a function of redshift in a ΛCDM cosmology using an initial seed mass and spin distribution functions. For the stellar ingestion, a power-law density profile for the galaxy taken as an input to a new relativistic loss cone theory that includes the effect of the black hole spin. Using this framework, useful predictions have been made for the evolution of the $M_\bullet - \sigma$ relation and retrodiction of black holes properties.

A model was developed for pulsar radio emission due to collective plasma emission. Collective radio emission due to relativistic plasma constrained to move in dipolar magnetic fields could explain the pulsar radio emission and polarization properties. The estimated brightness temperature seems to agree with the observations. The polarization angle predicted by the model is in good agreement with the rotating vector model.

IVO-SSMRPT is an affordable and accurate type of state-specific multireference perturbation (SSMRPT) theory that adds dynamic correlation energy to improved virtual orbital (IVO) complete active space configuration interaction (CASCI) wave functions using a single-root parametrization of multi-root Hilbert-space ansatz. It was applied to many chemically important di- and tri-radicals to analyze the geometries and electronic properties of spectroscopic interest for both closed- and open-shell singlet- and non-singlet ground as well as excited states. It was observed that IVO-SSMRPT identifies optimized geometries, splitting between multiplets and frequencies for several radicals that are similar to those displayed by current generation state-of-the-art methods but with decreased computational effort.

Alternate and new closed-form analytic solutions for the non-equatorial eccentric orbits around a Kerr black hole by using the transformation. The application of the solutions is straightforward and numerically fast. Specialized formulae for equatorial, spherical and separatrix orbits were found. A study of the non-equatorial analog of the previously studied equatorial separatrix orbits is carried out where a homoclinic orbit asymptotes to an energetically bound spherical orbit. Such

orbits simultaneously represent an eccentric orbit and an unstable spherical orbit, both of which share the same E and L values. These formulae have applications to study the gravitational waveforms from extreme-mass ratio inspirals (EMRIs) using an adiabatic progression of a sequence of Kerr geodesics, besides relativistic precession and phase space explorations.

Extended stellar atmospheres are known to be dynamic, with low to high-speed stellar winds originating in their layers. Such macroscopic velocity fields produce Doppler shift, an aberration of photons, and also give rise to advection. All these effects can modify the amplitudes and shapes of the emergent polarization profiles. The velocity field causes Doppler dimming in the red wing giving rise to a decrease in the polarization at the red wing peak, while it causes Doppler brightening in the blue wing giving rise to blue-shifted broader polarization peak in the blue wing. Polarized profiles provide a sensitive diagnostic of the velocity fields present in the line formation regions.

The historical observations of polarized jet emission for Blazars were reviewed and previous models discussed. Motivated by this, a model for the polarization of both steady and transient behavior using a helical magnetic field was presented. The variety of observed correlations and anti-correlations between the electric polarization angle, the degree of polarization and optical flux can be explained by this model. Also, the phenomena of quasi-periodic oscillations (QPO) behavior seen in jets in X-ray Binaries (XRBs) is also explained by a model based on helical trajectories of emitting blobs and the resulting time scales and harmonics of the QPO are derived. In both the models, the input parameters are the inclination angle, the Lorentz factor of the jet and pitch angle of the magnetic helix.

A model of tidal disruption events (TDEs) was developed with input physical parameters that include the black hole (BH) mass $M_\bullet$, the specific orbital energy E, the angular momentum J, the star mass $M_\star$ and radius $R_\star$. The rise time of the TDEs, the peak bolometric luminosity was obtained in terms of these physical parameters and a typical light curve of TDEs for various All-Sky Survey and Deep Sky Survey missions. The expected detection rates and the follow-up strategy of TDEs through observations in various spectral bands from X-rays to radio wavelengths were proposed.

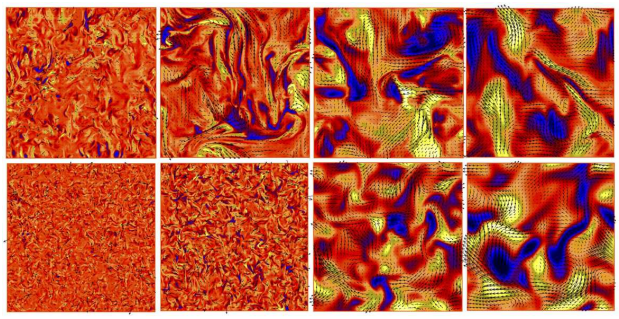


Figure 2.7: 2D slices of the normalized z-component of the magnetic field ($B_z/B_{\rm rms}$) in the $x-y$ plane for two subsonic, magnetic Prandtl number Pm = 1 runs having $k_{\rm f} = 1.5$ (*upper row*) and $k_{\rm f} = 10$ (*bottom row*), respectively. The different columns correspond to : kinematic (*first column*), saturated (*second column*) and decaying phases (*last two columns*). The fields are strong in blue and yellow regions and negligible in orange regions. The field in the plane of the slices are shown with vectors whose length is proportional to the field strength.

The decay of turbulence and magnetic fields generated by Fluctuation dynamo action in the context of galaxy clusters where such a decaying phase can occur in the aftermath of a major merger event was explored. Aided by numerical simulations that

start from a kinetically dominated regime, we focussed on the decay of the steady-state RMS velocity and the magnetic field for a wide range of conditions that include varying the compressibility of the flow, the forcing wave number, and the magnetic Prandtl number. Irrespective of the compressibility of the flow, both the RMS velocity and the RMS magnetic field decay as a power-law in time with the field structure eventually homogenized on the scale of the simulation domain. Using numerical simulations, it was shown that such dynamo generated fields are sufficiently coherent with the rms value of Faraday rotation measure (RM) of the order of 45 – 55 percent of the value expected in a model where fields are assumed to be coherent on the forcing scale of turbulence.

3 Student Programmes And Training Activities

Student programmes at the Institute are coordinated by the Board of Graduate Studies (BGS). The Institute conducts a PhD programme, in collaboration with the Pondicherry University and an MTech–PhD (Int.) programme, in collaboration with the University of Calcutta. 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 programme. In the academic year 2018–2019, two students joined the IIA–PU PhD programme in June-2018, and one student has joined in January 2019. Five students joined the IIA-CU Integrated PhD programme in June 2018, four of them are continuing with the programme. The highlights of these programmes are summarized below.

3.1 PhD Degree Awarded

Nine students were awarded PhD Degree during 2018–19.

Vaibhav Pant was awarded the PhD degree on April 13, 2018, for his thesis titled "Dynamics of coronal transients as seen from space observations" submitted to the Pondicherry University. The research was done under the supervision of Dipankar Banerjee.

Sreejith, A. G. was awarded the PhD degree on April 21, 2018, for his thesis titled "Studies of earth's atmosphere from space and near space" submitted to the University of Calcutta. He carried out the above work under the supervision of Jayant Murthy.

Tarun K. Sharma was awarded the PhD degree on April 27, 2018, for his thesis titled "Development of Instruments for Astronomical Site Characterization and their Application" submitted to the University of Calcutta. He carried out the above work under the supervision of Padmakar Singh Parihar.

K. Hariharan was awarded the PhD degree on May 28, 2018, for his thesis titled "Solar Radio Observations at Low Frequencies with High Spectral and Temporal Resolution" submitted to the University of Calcutta. He carried out the above work under the supervision of R. Ramesh.

Srinivasa Prasanna V. was awarded the PhD degree on June 6, 2018, for his thesis titled "The Search for the Electric Dipole Moment of the Electron (eEDM) in Mercury Halides using the Relativistic Coupled Cluster Theory" submitted to the University of Calicut. He carried out the above work under the supervision of B. P. Das and Pravabati Chingangbam.

Vidya G. was awarded the PhD degree on June 6, 2018, for her thesis titled "Geometrical and topological properties of CMB polarization fields" submitted to the Indian Institute of Science, Bengaluru. She carried out the above work under the supervision of Pravabati Chingngbam and Prateek Sharma,

IISc under the Joint Astronomy Programme (JAP), IISc, Bengaluru.

T. Mageshwaran was awarded the PhD degree on July 27, 2018, for his thesis titled "Physics of tidal disruption events around black holes" submitted to the Pondicherry University. He carried out the above work under the supervision of Arun Mangalam.

Honey M. was awarded the PhD degree on August 14, 2018 for her thesis titled "Evolution of Low Surface Brightness Galaxies" submitted to the Pondicherry University. She carried out her research work under the supervision of Mousumi Das.

Sudip Mandal was awarded the PhD degree on February 14, 2019, for his thesis titled "Multiwavelength study of waves and Solar atmospheric magneto-seismology" submitted to the Pondicherry University. The research was carried out under the supervision of Dipankar Banerjee.

Table 3.1: **Number of PhDs awarded over the past five years**

Year	No.
April 2014 – March 2015	7
April 2015 – March 2016	10
April 2016 – March 2017	5
April 2017 – March 2018	7
April 2018 – March 2019	9
Total	38

3.2 PhD Thesis Submitted

Fourteen students have submitted their PhD thesis during 2018–2019.

Joice Mathew submitted his thesis titled "Ultra Violet Space Instrumentation and Studies of Astronomical Objects" to the University of Calcutta on June 06, 2018. The research was done under the supervision of Jayant Murthy.

Nirmal K. submitted his thesis titled "Spatial Heterodyne Spectrometer and Associated Instrumentation for Space and Ground Observatories" to the University of Calcutta on September 26, 2018. The research was done under the supervision of Jayant Murthy.

Satya Ranjan Behera submitted his thesis titled "Design and Development of closed-loop AO system for 2-m class telescopes at IIA" to the University of Calcutta on September 26, 2018. The research was done under the supervision of B. Raghavendra Prasad.

Ambily S. submitted her thesis titled "Development of Detectors for Space Missions and Balloon Flights" to the University of Calcutta on November 27, 2018. The research was done under the supervision of Jayant Murthy.

Sarpotdar Mayuresh Nandkumar submitted his thesis titled "Development of UV Astronomical Instruments for Balloon and Space Payloads" to the University of Calcutta on November 27, 2018. The research was done under the supervision of Jayant Murthy.

V. Mugundhan submitted his thesis titled "Design of Digital Receivers for low Frequency Radio Astronomy" to the University of Calcutta on November 27, 2018. The research was done under the supervision of R. Ramesh.

Joby P. K. submitted his thesis titled "Confronting physics of the early Universe with cosmological observations" to the Uni-

versity of Calicut on January 4, 2019. The research was done under the supervision of Pravabati Chingangbam.

Prasanta Kumar Nayak submitted his thesis titled "Study of Star cluster populations in the Magellanic Clouds" to the Pondicherry University on January 09, 2019. The research was done under the supervision of Annapurni Subramaniam.

Nancy Narang submitted her thesis titled "Study of Small-Scale Features observed in Solar Atmosphere" to the Pondicherry University on January 18, 2019. The research was done under the supervision of Dipankar Banerjee.

Deshmukh Prasanna Gajanan submitted his thesis titled "Modeling, Simulation and Implementation of Primary Mirror Control System for the Prototype Segmented Mirror Telescope" to the University of Calcutta on February 13, 2019. The research was done under the supervision of Padmakar Singh Parihar.

Ramya M. Anche submitted her thesis titled "Determination of Polarimetric Capabilities of Astronomical Telescopes" to the University of Calcutta on February 13, 2019. The research was done under the supervision of G. C. Anupama.

Priyanka Rani submitted her thesis titled "Temporal and Spectral Characteristics of Active Galactic Nuclei in X-rays using NuSTAR" to the Pondicherry University on February 26, 2019. The research was done under the supervision of C. S. Stalin.

Sindhu N., CSIR-SRF, submitted her thesis titled "Multiwavelength study of old open clusters: NGC 188 and M67" to the Vellore Institute of Technology (VIT) on March 20, 2019. The research was done under the supervision of Annapurni Subramaniam and Anuradha C., VIT, Vellore.

Subhamoy Chatterjee submitted his thesis titled "Characterizing Image Quality of Solar Ultraviolet Imaging Telescope On Board Aditya L1-Mission and Long-term Study of The Sun" to the University of Calcutta on March 25, 2019. The research was done under the supervision of Dipankar Banerjee.

3.3 Completion of MTech programme

Shanti Prabha C., from the 10^{th} batch of the above programme has completed her MTech Degree under the IIA–CU integrated MTech–PhD programme. She has submitted her MTech thesis titled "Development of Image Stabilization System for the Kodaikanal Tower Telescope" to the University of Calcutta on July 2018. The work was done under the guidance of R. Sridharan.

3.4 Visiting Students' Internship Programme

The Visiting Students' Internship Programme (VSP) is conducted with an aim to promote scientific research interest in college and university students. Students selected for this programme work typically for about three to six months on specific projects that form a part of the ongoing research at IIA. Based on the nature of the project, the students are assigned to work at either the main campus of IIA in Bengaluru or at 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 2018–2019 about thirty students (selected through a rigorous process of online

application and further screening) did their projects under the guidance of the academic staff members of the institute. At the end of the tenure, the students presented a seminar on their project work.

3.5 School in Physics and Astrophysics

The school in Physics and Astrophysics, coordinated by the Board of Graduate Studies, is an yearly activity of the Institute. The main aim of the school is firstly to introduce students of BSc, MSc, BE/BTech degree courses to the field of Astronomy and Astrophysics and secondly to motivate them to take up a career in Astronomy and Astrophysics. The programme has two components; a two-week long summer school at Kodaikanal Solar Observatory where the Institute's faculty members deliver pedagogical lectures on various topics in Astronomy and Astrophysics. In the second part of the programme, a few selected students will carry out a month-long summer project under the supervision of IIA academic members. Similar to the Internship Programme, depending on the needs of the project, the selected students are assigned to work either in the Bengaluru campus or at any of the Institute's field stations.

For the year 2018, the summer school in Kodaikanal was held during May 16–30. A total of 36 students (including seven students from PU, under IIA–PU MoU) selected through a competitive evaluation process, participated in the school. The topic of the lectures included Observational Astronomy (Sudhanshu Barway), Radiative processes in Astrophysics (M. Sampoorna), Stellar Structure and Evolution (Firoza Sutaria), InfraRed Astronomy (C. Muthumariappan), The Sun (K. Nagaraju), Star Formation (Annapurni Subramaniam), Stellar Spectroscopy (Gajendra Pandey), Radio Astronomy (C. Ebenezer), Galaxies (Mousumi Das), High Energy Astrophysics (C. S. Stalin), Introduction to MHD (S. P. K. Rajaguru), Cosmology (Pravabati Chingangbam) and Astronomical Instrumentation (R. Sridharan). Thereafter, 14 students (including 7 students from the PU) also carried out short-term research projects during May 31–June 30, 2018, under the guidance of IIA faculty members in Bengaluru and in its field stations. During the last week of the programme the students made presentations on the results of their project works.

Local arrangements of the school were efficiently done by the staff of the Kodaikanal Observatory under the guidance of Dr C. Ebenezer. The school was organized by summer school coordinator Dr Sharanya Sur along with Prof. Aruna Goswami (Chairperson, BGS).

In addition to the above, nine students carried out short-term projects under the guidance of IIA faculty members during May to July 2018, under the Indian Academy of Sciences Summer Research Fellowship Programme. IIA and Academy jointly conducted a school on 'Observational Astronomy' during June 4–August 3, 2018. Thirty six students participated in the school. The school was coordinated by G. C. Anupama and Ram Sagar.

3.6 Attendance/ Presentations in Meetings

Talks given in national/ international meetings

Anirban Bhowmick

- *Detection of Fluorine in Extreme Helium Stars*, 10 – 14 September 2018, talk in the International conference- '4th Conference on Hydrogen Deficient Stars (HDEF-4)', held at Armagh, in North Ireland, UK.
- *Understanding the enigmatic cool Hydrogen Deficient Stars*, April 2018, Neighbourhood Astronomy Meeting at IIA, Bengaluru.

Anshu Kumari

- *New Evidence for a Coronal Mass Ejection-driven High Frequency Type II Burst near the Sun*, 09 – 15 March, 2019, URSI-Asia Pacific Radio Science conference at Indian Habitat Centre, New Delhi.
- *Low frequency observations of a type II radio burst*, 18 – 22 February 2019, Astronomical Society of India (ASI) meeting at Christ (Deemed to be University), Bengaluru.
- Remote talk on *Estimation of Coronal Magnetic Fields using LOFAR*, 14 September 2018, CESRA 2018 Summer School, ROB, Belgium.
- *Interferometric Observations and Estimation of Solar Coronal Magnetic Fields using Stokes Parameters*, 29th August, 2018, LOFAR Status Meeting at ASTRON, the Netherlands.
- *Simultaneous Multi-wavelength observations of a CME on 04th November 2015*, 5 – 6 April 2018, Neighbourhood Astronomy Meeting at Indian Institute of Astrophysics, Bengaluru.
- *Coronal and Interplanetary Shocks: Analysis of Data from SOHO, Wind, and e-CALLISTO*, 19 May – 02 June 2018, at the COSPAR Capacity-Building Workshop, Mekelle University, Ethiopia.

Athira Unni

- *Precision chemical abundance of exoplanet host stars*,
  - February 18 – 22, 2019, ASI meeting-2019, Christ (Deemed to be University), Bengaluru.
  - September 24 – 28, 2018, at Young Astronomers' Meet.

Bhoomika

- *Multiband Variability analysis of Fermi Bright Blazars*, 18 – 22 February 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

Chayan Mondal

- *UVIT view of IC 2574 : Are the star formation driven by expanding and colliding shells?*, 18 – 22 February 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

Deepak

- *The Galactic Halo: Stellar Populations and Formation History*, February 18 – 22, 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

- *Archaeology of the Galaxy in the Era of Large Astrometric and Spectroscopic Surveys*, 14 – 17 November 2018, at S. N. Bose National Centre for Basic Sciences, Kolkata, India.

Kshama S Kurian

- *A comparative analysis of AGN activity and star formation in NLSy1 and BLSy1 galaxies*, 24 – 28 July 2019, at the European Week of Astronomy & Space Science, held in Lyon, France.

Nancy Narang

- *High-Frequency Dynamics of an Active Region Moss as observed by IRIS*, 18 – 22 February 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

S. S. Panini

- Presented a special lecture on *Multilayer fabrication and Testing and a simple X-ray polarimeter*, at MIT Kavli Institute, Cambridge, USA.
- Presented a talk on *Thermal and temporal stability of W/B4C multilayer mirrors for astronomical applications*, at Young Astronomers Meet (YAM) held at Physical Research Laboratory (PRL), Ahmedabad, India.

Pavana M

- *Modelling the ejecta of Galactic Nova, ASASSN-16ma*, 18 – 22 February 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

Prerna Rana

- *Commensurability of QPO Frequencies in BHXRB*, 1 – 7 July 2018, at the Fifteenth Marcel Grossmann meeting, University of Rome, Rome, Italy.

Raghubar Singh

- *Enhancement of Li in red giants*, 27 November 2018, conference on "Chemical evolution and nucleosynthesis across milky way" at MPI House, Heidelberg.
- *Spectroscopic and asteroseismic study of Li-rich giants*, 21 February 2019, ASI-2019, Christ (Deemed to be University), Bengaluru.

Ritesh Patel

- *Automated detection of CMEs in SWAP images*, 24 – 28 September 2018, at Young Astronomers' Meet, PRL Ahmedabad.

Samrat Sen

- *Magnetohydrostatic equilibria of flux tubes*, 5$^{\text{th}}$ April, 2018, Contributed talk in the "Neighbourhood Astronomy Meeting", at Indian Institute of Astrophysics, Bengaluru.

Subhamoy Chatterjee

- *Kodaikanal Ca II K and Hα data calibration and analysis*, 28 – 31 August 2018, in EC meeting ISSI, Bern, Switzerland.
- *Long-term Solar Data and Image processing Techniques*, 10 – 16 June 2019, Solar Physics Summer School at Raman Science Center, Leh, India.

Poster presentations in national/ international meetings

Bhoomika

- *Temporal correlation between the optical and γ-ray flux variations in the blazar 3C 454.3*, 14 – 19 October 2018, in the International Fermi Symposium, Baltimore (MD), USA.

Chayan Mondal

- *UVIT imaging of WLM: Demographics of Star-forming Regions in the Nearby Dwarf Irregular Galaxy*, September 2018, at 15$^{\text{th}}$ Potsdam Thinkshop: 'The role of feedback in galaxy formation: from small scale winds to large-scale outflows', Potsdam, Germany.

Dipanweeta Bhattacharya

- *Evolution of the $M_\bullet - \sigma$ Relation*, 14 – 18 May 2018, IAU Symposium 342- 'Perseus in Sicily: from black hole to cluster outskirts' at Noto, Sicily, Italy.

P. P. Fazlu Rahman

- *Gaussianity and Statistical Isotropy of Galactic Foregrounds using PLANCK*, 11 – 15 February 2019, Asia-Pacific Winter School and Workshop on Gravitation and Cosmology, YITP, Kyoto University, Japan.

Nancy Narang

- *High-Frequency Dynamics of a Moss Region as observed by IRIS*, 25 – 29 June 2018, in IRIS-9 Meeting.

S. S. Panini

- *Solar X-ray imager and higher resolution X-ray spectrometer: Design and Science prospects*, at 37$^{\text{th}}$ conference of ASI held at Christ (Deemed to be University), Bengaluru, India.

Prerna Rana

- *Alternate Forms For Trajectories of Bound Orbits in Kerr Geometry*, 1 – 7 July 2018, at the Fifteenth Marcel Grossmann meeting, University of Rome, Rome, Italy.

Ritesh Patel

- *Automated detection of CMEs in Visible Emission Line Coronagraph on-board ADITYA-L1*, 18 – 22 February 2019, ASI meeting-2019, Christ (Deemed to be University), Bengaluru.

Subhamoy Chatterjee

- *Extended Solar Cycles*, 18 – 22 February 2019, Astronomical Society of India meeting-2019, Christ (Deemed to be University), Bengaluru.

Attendance in meetings/ workshop

P. P. Fazlu Rahman

- Attended *Frontiers in 21 cm Cosmology*, 17 – 18 December 2018, Kodaikanal Solar Observatory, Kodaikanal.
- *Cosmology – The Next Decade*, 3 – 29 January 2019, ICTS, Bengaluru.

Harsh Mathur

- Attended *IIA Solar Summer School*, at Leh from 10$^{\text{th}}$ June to 15$^{\text{th}}$ June 2019.

Pavana M

- Attended *GROWTH winter school*, 3 – 5 December 2018, at IIT Mumbai.

Ritesh Patel

- Visited Royal Observatory of Belgium as Guest Investigator of PROBA2 from September 1 to 10, 2018.

3.7 Awards and Recognition

Anshu Kumari

- *Summer Project fellowship at ASTRON*, The Netherlands Institute of Radio Astronomy, the Netherlands during June-August, 2018 on "LOFAR Observations of a group of radio type III solar bursts".

S. S. Panini

- Awarded with *AWSAR Award*, by the Department of Science and Technology (DST), Government of India for the best scientific story based on the PhD work.

4 Instruments And Facilities

4.1 System Engineering Group

The System Engineering Group (SEG) is supporting major activities of the Institute like infrastructure creation, involvement in scientific projects related to ground- and space-based instrumentation and their maintenance activities. The SEG consists of engineers with technical staff belonging to Electronics & Instrumentation, Mechanical, Electrical, Civil and Optics Divisions who provide support in the design, development, operation and maintenance of telescopes, their instruments and peripherals.

Some of the major activities that were carried out by the SEG during the year 2018 –19 are noted below:

The **Optics Division** was involved in the tolerance budget analysis of Indian Spectroscopic imaging Space telescope (INSIST) and error budget for the M1 mirror of the Mauna Kea Spectroscopic Explorer (MSE).

The fabrication of the seven segmented primary mirror of size 100 mm each segment and six inch flat mirror fabrication for student spectrograph as part of the public outreach programme were carried out at the fabrication facility of the Optics Division.

Aluminization of 24 inch mirrors (40 nos.) for BARC (GOALS Observatory, Mt. Abu) were carried out at the coating facilities at VBO, Kavalur.

The **Electronics & Instrumentation Division** finalised all the electrical interfaces of VELC payload with ADITYA-L1 spacecraft. For the detector system hardware realization, all the observation modes and logics were finalized. Calibration and environment test documents were also prepared.

Development of the detector system for INSIST, details of testing and its integration with S/C and its regular in-orbit operations were carried out.

In other work, a system design for STAR250 CMOS camera for use in ground-based telescopes was carried out. It includes hardware design, programming and its fabrication. The programme is recently initiated, power supplies were fabricated, PCB design for sensor board and FPGA board is ready. PCB fabrication and components mounting is pending.

In a collaborative project with CeNSE, IISc, a multi-gain readout circuit for a UV Sensor was developed and tested with 2 different sensors provided by CeNSE.

The antennae for the communication link between CREST, Hosakote and IAO, Hanle which was installed about 20 years ago was replaced with two numbers of 3.8 m antennae each installed at IAO Hanle and CREST Hosakote. All 4 dishes (two each at Hanle and Hosakote) underwent the NOCC test successfully.

The **Electrical Division** is involved in the

replacement of electrical panels at the Koramangala campus of IIA, which were installed about 40 years ago. A few of them were replaced this year. The solar energy system which has facility to feed back to the supply electrical grid continues to work efficiently.

The **Mechanical Engineering Division** was involved in the fabrication and realization of Lab Model of VELC (Visible Emission Line Coronagraph). The model includes the Optical bench, opto-mechanical mounts (with dummy optics), baffles and side covers etc.

The air-conditioning system for the Coudé instrument of VBT which was installed about 20 years ago, was appended with a new system with better laminar flow of air over the instrument. The hardware upgradation 2.8 m vacuum coating plant was completed and the automatic control software is being tested.

The CCD imager for the 70 cm GROWTH-India Telescope (IAO, Hanle) was designed and fabricated by the mechanical division.

Design, detailed engineering and realization of 6″ coelostat, a 2 mirror system with a spectrograph has been completed. The unit has been extensively tested for its performance. This was undertaken as part of the outreach programme.

The **Civil Engineering Division** was involved in the construction of India TMT Optical Fabrication Facility (ITOFF) building at CREST, Hosakote which is nearing completion.

The optics laboratory at Koramangala campus was renovated. Renovation of canteen building and installation of kitchen equipments at CREST was done and the work on a compound wall for the CREST campus was also initiated.

4.2 Observatories

4.2.1 Indian Astronomical Observatory

Himalayan Chandra Telescope (HCT)

The 2 m HCT completed fifteen years of successful operation in 2018. This national facility is continuously in use by the astronomical community within the country and from abroad. With the availability of instruments for imaging and low resolution spectroscopy in optical and near infrared (NIR) and high resolution spectroscopy in optical, it has almost all the capabilities which a 2 m class telescope can offer. This has resulted in a good number of science publications from this facility in reputed journals. Due to its unique capability of switching between various instruments and modes of observation, over the years demand of the telescope time has increased significantly. For 2018-Cycle-02 (2018 May – August) 53 proposals, 2018-Cycle-03 (2018 September – December) 52 proposals and 2019-Cycle-01 (2019 January – April) 64 proposals were received, which is an increase of $\sim 20\%$ as compared to the previous year. The telescope time was oversubscribed by a factor 3 on an average, while the dark moon period was over subscribed by a factor ~ 3.5.

The Institute takes extreme care in maintaining this remotely located facility. This ensures that the facility is available to the astronomical community throughout the year. The personnel from IAO and CREST are carrying out preventive maintenance on a monthly basis and a comprehensive annual maintenance of the telescope and the instruments. The annual maintenance of the HCT was carried out during August 21 –

September 5, 2018.

The efforts to upgrade the control system of the telescope and the secondary mirror drive initiated over the past years is progressing well. An expression of interest from vendors to carry out the work was requested and the potential companies were identified to carry out the first phase i.e. feasibility study of the refurbishment of the telescope.

A newer generation of $2K \times 4K$ CCD was procured as a replacement for the old one which was in use since 2002. The new system was installed on the HCT during annual maintenance in August 2018. The CCD is a grade 0 E2V 4482-0-E93 with $15\,\mu$ square pixels. The chip is a deep depletion, non-AIMO back-side illuminated CCD. The technical specification of the new CCD is almost identical to the existing one and its performance is found to be similar. The new CCD has some additional features like faster readout, larger dynamic range, large liquid nitrogen holding capacity of the dewar housing the CCD etc. The CCD control and the data acquisition are provided under a Linux PC which also accommodates a custom-made PCI interface card. The acquisition and control software allows a complete control of camera controller, selection of readout speeds, gains, readout modes (full frame or window and binning) etc.

Upgrade of the NIR instrument, TIRSPEC is planned. The existing Hawaii-1 PACE array detector with a cutoff wavelength of 2.5 micron, is planned to be replaced by a fast readout science grade array Hawaii-1RG (H1RG).

Installation of GROWTH-India Telescope at IAO Hanle

The GROWTH-India Telescope (GIT) is a 70 cm CDK-700 Alt-Az telescope with focal ratio f/6.5, developed by Planewave Instruments. It was installed and commissioned at Mt. Saraswati IAO, Hanle during June-September 2018. The primary research focus of this telescope is time domain astronomy – the study of explosive transients and variable sources in the Universe. This facility is the result of a collaborative programme between Indian Institute of Astrophysics and Indian Institute of Technology, Mumbai, with support from DST-SERB and IUSSTF. This is India's first fully automated robotic telescope and is connected via a satellite link to CREST Campus of IIA and Indian Institute of Technology, Mumbai. It has two Nasmyth ports, Andor iKon-XL-230, thermoelectrically cooled CCD with 4096×4108 pixels is installed at one of the ports. The camera provides fast and low noise readout for frequencies upto 4 MHz. The pointing accuracy of the telescope is found to better than 3.5 arc seconds.

Figure 4.1: Installed GROWTH-India Telescope at Hanle.

The GIT offers wide field imaging capabilities with a field of view of $\sim 45' \times 45'$ in Sloan u', g', r', i', z' filters. The filter wheel assembly to mount the filters was developed and fabricated at IIA Bengaluru. It is a single axis motion controller, the filter wheel is driven by stepper motor and the position in-

formation is obtained using an incremental encoder.

The dome of the GIT is controlled using MaxDome II controller system, which provides complete automated control of telescope dome and associated shutter. The MaxDome II controller is selected as the dome and shutter can be directly interfaced with Ascom and RTS2 compatible telescopes such as CDK-700. In order to make the already existing dome control system compatible with MaxDome II controller system, an intermediate controller (Local controller) was designed and developed locally at IAO, Hanle. This controller was made using a general purpose microcontroller board. The required interface software was developed under LabVIEW. The telecsope and dome are found to be working well and the observations are being carried out regularly.

HImalayan Gamma Ray Observatory (HIGRO)

[1] **MACE**

Installation of mechanical structure of the 21 m diameter Major Atmospheric Cherenkov Experiment (MACE) telescope being developed by BARC is completed. Camera housing is mounted on the boom and the camera related equipments are installed and extensively tested during the winter months for operation. A total of 64 numbers of camera integrated modules and 1024 PMTs were installed in the camera housing. A total of 50 mirror panels out of 356 have been installed. The telescope tracking and pointing test was also carried out during this period. Installation of Camera parking shelter is in progress.

[2] **HAGAR**

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.

Earth Sciences, Atmospheric Physics related activities

The experiments related to Earth Science and Atmospheric Physics, considering topography and pristine high-altitude location of the site has been carried out continuously. These experiments include studies of greenhouse gases, kinematic and structural deformation inside the earth's crust using GPS network over the region (under a joint MoU between IIA and CSIR Fourth Paradigm Institute, Formerly CSIR CMMACS, Bengaluru), characterization of regional aerosols incorporating the heterogeneity in space, time and spectral domains and its impact on regional and global climatology (under the Aerosol Radiative Forcing over India (ARFI) project of ISRO - GBP). In collaboration with Raman Research Institute (RRI) and University of Tokyo, a sky radiometer is operational to study atmospheric transparency at 220 GHz. Hanle site has many potential qualities for calibration of several instruments used in the large network for aerosol studies such as AERONET (https://aeronet.gsfc.nasa.gov/) and SKYNET (http://atmos3.cr.chiba-u.jp/skynet/). Since the site is located in the periphery of Tibetan Plateau and Trans-Himalaya, studies of earth-crust, plate tectonic movement are major thrust area for Earth Science research.

NLST related activities at Merak

At Merak, the deployed NLST site survey instruments such as weather station, all sky camera, Solar Differential Image Motion Monitor, Shadow Band Range scintillometers, are continue to work and obtaining data. These data sets are analysed on monthly and yearly basis. At the site the wind direction is N-W to S-E direction most of the time and it is along the lake channel. The installed Hα telescope is continue to make observations of the Sun whenever the sky is clear. This is the declining phase of solar cycle 24 and a very few transient events can be seen on the Sun. The telescope has recorded a few such transient events. The Hα data has been used to track the activities on the Sun and also used to find the r_0 value at the site. The median value of r_0 extracted from this data set spanning about 5 months is 6 cm and about 30% of the data set show r_0 value larger than 7 cm.

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

The construction of India TMT Optics Fabrication Facility (ITOFF) for polishing mirror segments of the Thirty Meter Telescope has been completed. The infrastructure including various services such as lift, HVAC, electrical, CCTV, fire fighting etc. are being installed. Once the ITOFF is operational, the power requirement of the Campus is expected to rise. To cater this requirement, related equipments are procured and are being installed in a newly built power house inside the Campus.

The HCT is remotely operated from CREST Campus, Hosakote (near Bengaluru), through a dedicated point-to-point extended C band satellite link between CREST Campus Indian Astronomical Observatory, Hanle, Ladakh (J&K), since 2000. The antennae used for communications are ECIL made, 3.8 m diameter. These systems are obsolete and irrepairable. They are now replaced with New Technology 3.8 m Antennae. At both the stations one pair of antennae were installed. All the four New Technology dishes cleared the mandatory tests successfully. As new facilities are coming up at IAO, Hanle, the existing link speed of 2 Mbps is inadequate for communication, remote operation and transfer of the observed data. The link speed is now upgraded to 3 Mbps + 1.5 Mbps.

For better connectivity between CREST and IIA, Bengaluru and IAO, Hanle the analogue intercom exchange is upgraded to an IP based telephone exchange. The internet connectivity at CREST Campus is upgraded by replacing the radio link by optical fiber network with a data rate of 10 Mbps. OFC will be laid for connecting all the stand alone CCTV cameras in the Campus. In order to further enhance security inside the campus it was planned to construct boundary wall. The construction of the boundary wall has already started.

The scientific and technical activities at CREST Campus have increased considerably over the period of years. The number of people visiting and the number of people stationed at CREST are also increased. The existing kitchen facility at CREST was found to be inadequate and it was proposed to enhance the kitchen and dinning facility. Work was done to extend the kitchen and dinning area, kitchen is also augmented with new kitchen equipments.

The Institute takes extra care in harvesting rain water. This ensures that adequate water supply is available in the Campus. In continuation of the process, recharge pits

were constructed in and around the existing borewells. In addition, a large collection pit has been constructed.

The Green House Gas (GHG) station installed by CSIR – Institute of 4-Paradigm (4PI), Bengaluru, in the CREST Campus Hosakote is working well. This station is also used as a reference station for calibration of the GHG instruments and secondary cylinders set up in the country, with the primary cylinders supplied by NOAA, USA.

4.2.3 Kodaikanal Observatory

Latitudinal Scan of Ca II K spectrum

Latitudinal scan of Ca II K spectrum of the Sun is an ongoing synoptic observational programme at Kodaikanal Tower Tunnel Telescope (KTT) to study the long term variation of magnetic activity of the Sun. Longitudinally averaged spectral line at 393.3 nm due to singly ionized Calcium atoms are recorded as a function of latitude of the Sun on regular basis. Analyzing these spectra provide information about chromospheric dynamics associated with the underlying magnetic field activity on the Sun.

Testing of Tip-Tilt system

A tip-tilt system to correct for random image shifts caused due to atmospheric seeing as well as instrument jitter was tested at KTT on 9th March, 2019. The tip-tilt system was integrated with the existing dual-beam polarimeter at KTT. The system was tested by tracking a sunspot (NOAA 12734). This exercise is part of development of adaptive optics system for KTT.

Hα Telescope

The Hα telescope is operational at Kodaikanal Observatory for the past 5 years. Everyday under clear sky conditions full-disk images of the Sun were obtained in the line center of Hα, with 1-min cadence. Calibration frames were also obtained every day. From April 01, 2018 to March 31, 2019, a total of 74,009 images were obtained on 217 days.

WARM Telescope

The White Light Active Region Monitor (WARM) telescope obtains the full-disk solar photospheric and chromospheric images of the Sun. The photospheric observations made daily in 430.54 nm wavelength whose passband is 0.8 nm. The chromospheric observations are made in 393.3 nm wavelength. Flat-field and dark images were also taken every day. The calibrated images are used to extract the information about sunspots and plages on daily basis. From April 01, 2018 to March 31, 2019, a total of 84,787 images were obtained on 239 days.

4.2.4 Vainu Bappu Observatory

Three major telescopes were operated on scheduled allotments during the year 2018 – 19 and the 30 inch telescope was also used for observations. The 1.3 m JCBT control PC failed in October and was substituted by DIMM telescope control PC to restore the operation.

VBT was operated in two modes, Echelle spectrograph in prime mode and OMR spectrograph in Cassegrain mode. JCBT used 2K $\times$ 4K CCD system at through port and ProEM CCD with the tip-tilt instrument mounted at west port for seeing measurements. UAGS and photo-polarimeter were used for observations at 1 m Carl Zeiss telescope. Imaging was done at 30 inch telescope

using TEK1K CCD system. Dust particles seen inside the Echelle 4K × 4K CCD dewar was removed in the clean room in May and a system calibration was done in the lab. Frequent spells of evacuation was required for 2K × 4K dewar at JCBT. The CCD shutter required to be re-tuned twice for reliable operation. The TEK1K CCD system clocks, at 30 inch telescope, were re-tuned and serviced for better operation. VBT dome drive failed in February and was restored to operating condition within two days.

The 30 inch telescope tracking tests were done in August and the autoguider performance also was checked as ± 0.6 arcsecs for 93% of the time for longer exposures. The performance of the worm shaft aligned remains crucial for both axes, particularly DEC, which required to be realigned twice. The performance was best tuned and observations started in November.

A new PAC unit synchronized with old PAC unit was installed for VBT Echelle room to avoid vibration and better laminar flow.

ProEM CCD system at JCBT was successfully tested for remote data acquisition; a ProEM add-in acts as server waiting to get request for observation along with details like exposure time, number of frames, file name etc. and initiate observations.

The client testing was done using simple *Python* code, which now requires a GUI for user-friendly operation. For transfer of acquired data, a routine within add-in module is added to communicate with a data server application to transfer data to the remote client. Integrated testing is under process.

Renovation of Vacuum coating plant

The 2.8 meter mirror coating plant machines are controlled with seven nodes, namely Air Compressor and Water Pump node, Diffusion Pump and Refrigeration node, Vacuum Pumps node, Pneumatic valves node1, Pneumatic Valves node2, Discharge Cleaning node and Filament firing node. The coating plant can be operated in auto mode using the Node Master and 7 Node controllers by developing a control software in any platform which can communicate through RS232 serial port. The installation and testing of all nodes with updated firmware has been completed and a trial run has been made. A software diagnostic tool was developed to operate individual nodes without checking interlock mechanism and to troubleshoot any breakdown.

Celebrating 50 years of Vainu Bappu Observatory

The history of VBO traces back to 1945, when a committee headed by M. N. Saha recommended the establishment of a large sized telescope for stellar astronomy for the development of astronomy in India. The execution of the recommendation had to await M. K. Vainu Bappu who assumed the position of Director of the Kodaikanal Observatory, which mainly specialised in solar astronomy, in 1960. Kodaikanal was not the best site in peninsular India for a major optical astronomy observatory. Bappu set out to find a suitable location for an optical observatory which had access to southern skies as well as proximity to the centres of technology. In 1962, Bappu identified a site near Kavalur village of Javadi Hills, Tamil Nadu and land were procured for the development of the observatory. A 38 cm reflector was made in the Kodaikanal workshop in 1967 and was the first telescope to be used at Kavalur Observatory. Scientific observations from Kavalur started in 1968 using this telescope. This telescope continued to make important contributions in stellar photometry for several

decades.

After setting up the optical observatory at Kavalur, Bappu had bigger plans and his approach towards the development of the observatory was multi-pronged. A 40 inch (1.02 m) aperture telescope was acquired from Carl Zeiss and was installed in 1972. Presently, the telescope is equipped with a stellar optical polarimeter and a medium resolution spectrograph. In 1971, the Kodaikanal Observatory became an autonomous society, the Indian Institute of Astrophysics, and the headquarters was shifted to Bengaluru.

Further efforts by Bappu was to indigenously build a 2.3 m telescope and in 1976, the Governing Council of IIA, approved the project and the telescope to be built at Kavalur Observatory. Under his leadership the activities to build the telescope started. Bappu chose the site where the telescope to be installed, but did not live to see the installation. He passed away in August 1982, and the responsibility of the completion of the project was taken over by J. C. Bhattacharya, who was closely associated with Bappu right from the conception. The 'first light' through optics was witnessed on October 31, 1985 and Bhattacharya obtained the first photograph of the Pleiades cluster on November 2, 1985. The telescope was inaugurated by the late Prime Minister Shri Rajiv Gandhi on January 6, 1986. On that occasion, the telescope and the Kavalur Observatory were formally named after M. K. Vainu Bappu. A few months later, the IIA Governing Council dedicated the telescope as a National Facility. Presently, prime focus fiber-fed Echelle spectrograph and a low resolution spectrograph at Cassegrain focus are available with the telescope. A speckle interferometer was developed to achieve high angular resolution images.

The requirement of a modern telescope to complement the observations from the 40-inch and the VBT led to the installation of a 1.3 m aperture telescope at Vainu Bappu Observatory in 2013. This telescope was named after J. C. Bhattacharya during the inauguration in April 2014. It is presently equipped with two CCD cameras for imaging.

Vainu Bappu Observatory (VBO) has been serving as the main hub to conduct scientific observations in optical astronomy for the past five decades. The facilities at VBO have been used by astronomers all over the world, that has resulted in several PhD theses and research articles. Facilities at VBO has been extensively used for studies ranging from Solar system objects to far away galaxy clusters. Some of the notable scientific contributions include the discovery of the rings of Uranus, observations of 1987A SN, discovery of Fluorine lines in R Coronae Borealis stars and long-term observations of blazars. The VBO has played (and continues) a major role in shaping the course of optical astronomy in the country. IIA's expertise gained by developing and maintaining VBO led to many future projects.

Figure 4.2: Release of the coffee table book by Prof. B. V. Sreekantan

To mark VBO's 50 years' journey of scientific endeavours and to remember the people

involved in its development, a meeting was organised on August 9, 2018 at IIA, Bengaluru campus. The VBO - 50 celebrations began with the garlanding of Prof. Bappu's bust by Prof. P. C. Agarwal, followed by an overview of VBO by Prof. T. P. Prabhu. On this occasion, a coffee table book, depicting the making of VBO and its 50 years of scientific journey, was released by Prof. B. V. Sreekantan. People from different parts of India and abroad were present in the meeting. The inauguration ceremony was followed by talks by scientists who shared their memories about VBO and presented the scientific results obtained using the facilities at VBO. As part of VBO - 50 event, a meeting was organised on 10^{th} August, 2018 at VBO, Kavalur. A visitors' museum showcasing the development of VBO and scientific results from the facility was opened to the public by Prof. A. K. Kembhavi. A bust of Bappu on the floor of VBT was unveiled and in the following session several participants shared their experiences during the development of VBO and their association with Prof. Vainu Bappu. The reminiscences by the participants gave a lot of encouragement and motivation for the younger generation.

Figure 4.4: Participants of the VBO - 50 event at Koramangala

Figure 4.5: Inauguration of the visitors' centre at VBO by Prof. A. K. Kembhavi

Figure 4.3: Participants of the VBO - 50 event at VBO

4.2.5 Gauribidanur Radio Observatory

Gauribidanur RAdioheliograPH (GRAPH) augmentation

Figure 4.6: LPD antennae seen in the foreground were installed recently as part of GRAPH augmentation project. The individual dipoles in each LPD antenna are oriented along 0° (Celestial North is the reference). Antennae noticed in the background are oriented along 90° and they are part of the existing GRAPH.

Measuring the magnetic field strength (B) in the solar corona is important since it plays a major role in the formation and evolution of structures in the solar corona. Presently the determination of B in the near-Sun corona is generally obtained by mathematical extrapolation of the observed line-of-sight component of the photospheric magnetic field. Since the circularly polarized radio emission associated with different types of non-thermal energy releases can be used to estimate B, a dedicated instrument to obtain two-dimensional images of the solar corona via its polarized radio emission would be very useful. To realize this, the existing GRAPH is currently being augmented with additional antennae having perpendicular (90°) orientation with respect to the existing antennae. In this connection, 128 Log Periodic Dipole (LPD) antennae that work in the 30 – 120 MHz frequency range were recently fabricated in house. All of them were tested and mounted on to RCC poles in the North-South 'arm' of the GRAPH. The orientations of the arms of the new LPDs are perpendicular to those of the old array as mentioned earlier. Since the LPDs belong to the linearly polarized broadband antenna category, the new antennae shall receive the radio waves whose plane of vibration is in perpendicular direction to those received by the antennae in the old array. This arrangement is essential to measure the flux density of the polarized radio emission that are generated in the aftermath of transient flares, Coronal Mass Ejections, etc. in the solar atmosphere. The reception characteristics of the new antennae were studied and were found to work satisfactorily. The other RF modules such as the analog front-end receivers, RF filters, Declination control modules, etc. were also fabricated in house, and are being tested. The development of FPGA based digital back end system is also being carried out.

Radio observations of the solar chromosphere

Recently a new *Ku* band antenna system was installed at the Gauribidanur observatory using the commercially available low-cost TV dish antenna modules and a radio frequency (RF) spectrograph. The system was used regularly to observe the the ∼11 GHz radio emission that emanates from the upper solar chromosphere/ transition region. The objective of this observational setup is to understand the intricate connection between various types of transient activities that originate in the chromosphere and in the corona. The simple mechanical fixtures that were used earlier to steer the antennas to various RA

and DEC had very limited positioning accuracy. In order to improve the latter and for observing radio emission from other cosmic sources also for calibration, low cost motors were procured and installed recently. One of them controls the RA pointing whereas the other one controls the DEC. The control signals are generated using *Arduino* microcontroller with the help of a PC; *Python* based scripts are used to feed in the coordinates of the cosmic sources. The operating voltage of the motors is about 15 V and they cover the sky up to $\pm 70°$ with respect to local zenith. Observations of the Sun and Moon were carried out with the new pointing system. Also, in order to improve the sensitivity of the observing system, two such dish antennas were combined together to form a correlation interferometer.

Low-frequency array for pulsar observations

The present understanding of Pulsars, the highly magnetized and rapidly rotating Neutron stars, are primarily due to the observations obtained at high radio frequencies. Due to various constraints, observations of pulsars at low frequencies are limited. In view of the above, it was decided to explore the possibility to observe pulsars at radio frequencies < 100 MHz with the LPD antenna array in the Gauribidanur observatory. A new receiver setup was designed for this purpose. The signal received by the antennas are first high-pass filtered and then amplified using low-noise amplifiers. The amplified signals are then combined using a beam-former module and latter transmitted to the receiver room via low-loss coaxial cables. In the receiver room, a digital back end system having a 4-channel broadband ADC and a FPGA with maximum 100 MHz bandwidth processing capability are used to process the signal further. Also, since pulsar observations require very high spectral and temporal resolution, the receiver system is being designed to give a spectral resolution of 10 kHz and temporal resolution of 0.5 ns. The estimated mean sensitivity of the system for a 30 MHz bandwidth (centered at ~ 60 MHz) and one hour integration is about 2 Jy. Testing and characterization of the new observing system is being carried out to realize the goal. Also new software pipelines to process and to analyze the pulsar data are being written. Once the full-fledged system is readied, trial observations with known Pulsars whose flux density are above the sensitivity limit will be carried out with the new system.

4.3 Ultra-Violet Imaging Telescope (UVIT)

The Ultra-Violet Imaging Telescope (UVIT) is one of the five payloads onboard AstroSat, India's first multi-wavelength Astronomical Observatory, launched by the Indian Space Research Organization (ISRO) on 28 September 2015. Since its launch, various types of celestial sources are routinely observed by UVIT. Monthly calibration observations by the instrument team indicate no degradation in sensitivity of UVIT since its launch. UVIT is producing good quality science data and important results are being published in international refereed journals. About three dozen research articles were already published in high impact international refereed journals and several others are under various stages of preparation. Some of the areas where UVIT is providing very important observations include (a) structure of planetary nebula (b) star formation in star clusters and (c) star formation in external galaxies.

The UVIT Payload Operation Centre

(UVIT- POC) at the Indian Institute of Astrophysics, receives UVIT data that gets dumped at the ground station from the Indian Space Science Data Centre (ISSDC). The UVIT- POC processes the Level 1 (L1) data received from ISSDC to generate science ready Level 2 (L2) data products. These L2 products after quality checks are routinely transferred to ISSDC for archival and dissemination to the principal investigators (PIs). In addition to generating science ready products, the POC also (i) monitors the health of the payload (ii) carries out regular calibrations (iii) carries out periodic release of the L2 processing pipeline and calibration database, and (iv) develops software tools that help the proposers in planning observations, and off-line data analysis. In addition to the above, POC is also involved in imparting training to potential users of UVIT to extract science information from data acquired with UVIT.

Figure 4.7: A view of a session in progress in the meeting "Muti-wavelength Astronomy: Three years of AstroSat Observations"

Between the period 01 April 2018 and 31 March 2019, the POC has received data pertaining to 278 proposals requesting observations with UVIT. Majority of the L1 data produces received at the POC for the above period have been processed and sent back to ISSDC for release to the PIs. The POC is working in close co-ordination with ISRO on a daily basis to finish the analysis of the pending data and its subsequent release to ISSDC. The POC activities are supported by two research trainees (for data analysis) and one software trainee (for software development). During 5 – 7 March 2019, a national level science meeting titled "Multi-Wavelength Astronomy: Three years of AstroSat Observations" was organized in IIA by the UVIT- POC. A total of 90 researchers participated in meeting and presented new results obtained from UVIT.

4.4 Computational Facilities

Computer Center Activities

All critical servers namely mail server, anti-spam server, web server, ERP server, computational servers etc., in the Data Center are kept up-to-date by upgrading the system and application software to its latest version and updating the system with latest security patches, to minimize the exposure to vulnerabilities. The firmware of all network devices viz., firewall, switches etc., are kept up-to-date on regular basis to mitigate security threats, if any.

The hardware infrastructures hosting the critical services are kept up-to-date by replacing the old servers/ hardware with new servers/ hardware when they are nearing their end of life. Couple of printers have also been procured to cope with increasing load on the existing printers. These new printers have several built-in features like scanning, photocopying etc.

The Institute has an ongoing computer trainee programme which imparts training to young engineers to provide system and application support to a wide range of users in IIA and skill them to be industry ready as a part of IIA's contribution to the socio-economic cause.

Computational Activities

A High Performance Computing (HPC) cluster has recently been procured and installed for the parallel computing community at IIA. Institute has also procured new servers to address the computational requirements from sequential and *Mathematica* workloads.

Web Related Activities

IIA web services with latest CMS have been migrated to a new server. The new web server has been optimized for better performance with improved user interface design. The server has been implemented with better security features and centralized authentication for accessing the Intranet. As per the directive of Ministry of Finance, the Institute is publishing its tender enquiries, corrigenda thereon and details of bid awards on the Central Public Procurement Portal (CPPP).

ERP

The Institute is using an Enterprise Resource Planning (ERP) software custom made for IIA, Bengaluru and its various field stations. This consists of modules such as Human Resources, Accounting, Finance, and Purchase etc. Hardware infrastructure hosting the ERP software has been upgraded and optimized for better performance. The software has evolved over a period of time to include new reports as required for each module including indents and inventory.

4.5 Library

IIA library is one of the oldest Astronomy library in the world, and it acts as the primary learning resource centre for the Institute. Library houses one of the world's premier collections of books, journals, conference proceedings, databases, slides, charts, and theses in the fields of Astronomy and Astrophysics. In this academic year, 109 books, 18 ebooks, 417 conference proceedings (e-version) were added and subscribed 78 active serial titles with the existing collection. The library continued to be the member of National Knowledge Resource Consortium (NKRC) which strengthens our e-resources by getting online access to 4600 journals published by 15 publishers. The library continues to get access to e-books and databases, Annual Reviews of Astronomy & Astrophysics, Astronomical Society of the Pacific (ASP) conference series, Proceedings of IAU Symposium, SPIE Digital Library, SPIE e-books collection and JSTOR general science collection. The Library continues to provide, e-mail based services like, book recommendation request, new additions of books and journals, other services like reminders, reservations, overdue intimation and e-mail based reference services. The library served 85 inter-library loan requests to other libraries and 25 requests from our faculty members and students. The library continued to use the facilities of IISc, RRI and other DST and CSIR libraries for inter library loan requirements. IIA Library has given extensive inputs to the institute's Annual and DST Reports by providing scientometric analyses of IIA research metrics from time to time.

Digital Repository

IIA Digital Repository has the digitized scholarly publications of IIA and archival materials which is more than 200 years old. The repository collects, preserves, and disseminates in digital format the research output created by the IIA research community. During the year, research articles, technical reports, PhD and MTech theses

were uploaded to the repository. As on date, the total number of publications in the repository is 7252.

Archives

The Archives was established in 2008 with a mandate to collect, catalogue and preserve all documents, images, and other articles of relevance to the Institute. The Institute's original correspondences, manuscripts, articles, photographs, and annual reports have been uploaded to Digital Repository.

Library Training and Internship Programme

The Library trainee programme is continued and the trainees have been trained in the Library and Archives sections.

Book Exhibition

IIA Library conducted a Book Exhibition from January 23 to 24, 2019 at ICNAAP Lounge, IIA, Bengaluru. Prof. Jayant Murthy, Director (Acting) inaugurated the programme and it was well received by the faculty members, students and other staff. Over 14 book publishers and sellers put up their stalls at the exhibition and more than twenty thousand books on various topics such as engineering, mathematics, physics, astronomy and astrophysics were on display.

4.6 Instrumentation Paper Award

The Indian Institute of Astrophysics has a rich history of theoretical, observational and experimental astronomy research over the years. To promote focused activities in instrumentation and experimental astronomy in IIA, Prof. K. E. Rangarajan has instituted an annual award to honour and encourage the research work done in the aforementioned areas.

The Instrumentation Paper Award for the year 2016 was awarded to V. Mugundhan, R. Ramesh, Indrajit V. Barve, C. Kathiravan, G. V. S. Gireesh, P. Kharb, and Apurva Misra for their paper (The Astrophysical Journal, Volume 831, Issue 2, article id. 154, 7 pp. (2016)) titled *Low-frequency radio observations of the solar corona with arcminute angular resolution: implications for coronal turbulence and weak energy releases.*

5 Future Facilities

5.1 Thirty Meter Telescope

The Thirty Meter Telescope (TMT) International Observatory (TIO) is a mega ground-based astronomy project being built by Japan, China, India, Canada and research organizations in the USA and to be set up on Mauna Kea in Hawaii. TMT will be built at an estimated cost of 1.47 billion US Dollars (2012 base year USD). India's participation in TMT is an approved project at 10% level with a budget of Rs. 1299.80 crores. Of which 70% is in terms of in-kind contributions by providing a number of sub-systems to the project. To efficiently manage India's contributions, India TMT Coordination Centre (ITCC), has been formed at IIA, Bengaluru jointly by DST and DAE – two funding agencies of the project in the country.

All the legal hurdles are overcome with the Mauna Kea site at Hawaii. TMT Board is preparing to commence the construction. Government of Hawaii will be providing all the logistics for safe access to the site. Attorney General of Govt of Hawaii attended the 7 – 8 May 2019 TMT International Observatory (TIO) board meeting and assured the board all the necessary help from the state for the TMT construction. This is expected to begin on 15th July, 2019.

India's in-kind contribution includes Segment Support Assembly (SSA), Actuators, Edge Sensors, Segment Polishing, Observatory Software (OSW) and Telescope Control Systems (TCS), Segment Coating, and Science Instruments.

Tremendous progress has been made in each of the work packages and they are listed below.

Segment Polishing and ITOFF construction

The construction of Optics Fabrication Facility at IIA, CREST, Hosakote, at a cost of Rs. 30.00 crores (approx.) has been completed and will be commissioned shortly. All associated equipments required for the above facility are being procured. A global tender for supply, installation and commissioning of equipment and transfer of technology for polishing primary mirror segments of the Thirty Meter Telescope was floated and the contract is being finalized and entered into. A MoU was entered into with LEOS/ISRO for the Design and Development of a Warping Fixture for Stressed Mirror Polishing and Process for Hexcutting and Pocketing of Mirror Segments.

Segment Support Assembly

A contract was signed with L&T to manufacture 100 numbers of PMA kits and 90 numbers of subcells with a Production Qualification Phase of 10 numbers of PMA kits and 4 numbers of subcells. The raw material procurement and preparation of

various project related plans is in progress. ITCC has identified and placed developmental orders with Mid-Size vendors to manufacture some of the critical components of the Segment Support Assemblies (SSA). This effort to manufacture SSA parts and assembly is taken up to gain the cost benefits of lower overheads costs of the Mid-Size industries for the balance 480 numbers of SSA. India has to deliver a total of 580 numbers of SSA.

Actuators

20 prototype Actuators were manufactured through Indian Vendors and sent to Project Office for testing and acceptance. All the actuators have qualified in the tests.

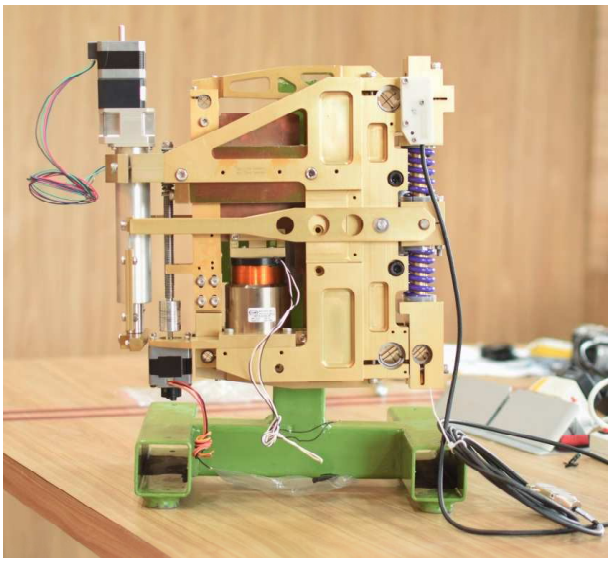


Figure 5.1: One of the 20 prototype actuators manufactured in India and delivered to project office for life tests.

Central Diaphragm

Development of prototype Central Diaphragm, which is a key component for SSA was successfully completed and a few vendors have qualified based on Revision H of the design. Currently, the part design is now revised to Revision T based on the which the qualification is ongoing with previously qualified and other additional identified vendors.

Edge Sensors

The trial of Laser etching and gold coating of Edge sensor was undertaken with RRCAT, ARCI & other vendors and the work is in progress.

Telescope Control Software and Observatory control software

Phase-I development of software for Telescope Control System work package is completed and work on next phase is taken up. The Common software has been completely developed and has been released internally for testing. Executive software has successfully passed the Final Design Review and now into the development phase. Simultaneous testing and validation with project office is going on.

ThoughtWorks Technologies (India) Pvt Ltd. successfully completed and delivered these software modules to connect and integrate various sub-systems to the telescope. *ThoughtWorks Technologies* also created several demonstrations as part of designing a software to execute commands for the operation of the telescope and its subsystems.

Preliminary design phase of Telemetry Control system software has been completed and work in progress for further phases and tests.

Science Instruments

India-TMT is one of the core teams contributing to the design and development of

the TMT Wide Field Optical Spectrograph (WFOS). During 2018-19, ITCC contributed to the trade study of fiber and multi-slit concepts of the design. A detailed performance analysis of both the concepts based on science requirement merit function and instrument flexure analysis was completed. Optical distortion and sensitivities are studied for the key subsystems. A flexure compensation tool and automated fiber allocation tool were developed. In the current phase (starting 2019), India-TMT has initiated a work share agreement to develop the instrument control software and the design of the grating exchanger, rotation system and camera articulation system. It will also be involved in the design of the calibration subsystem as well.

India is also spearheading the efforts as a P.I. country for the design and development of TMT HROS - a second generation high resolution optical spectrograph.

Meetings Organised

A one day workshop on *TMT Science and Instrumentation workshop* was organised during the 37th ASI meeting at Christ (Deemed to be University), Bengaluru on 18th February, 2019. Similarly an international meeting was held on *TMT HROS - 2nd generation science instrument* during February 16–17, 2019. The meeting was attended by several national and international participants.

5.2 Visible Emission Line Coronagraph on ADITYA(L1)

Visible Emission Line Coronagraph (VELC), onboard Aditya-L1 space mission payload consists of 18 optical assemblies (40 optical elements), four mechanisms (three multi-operational and one single operation), four detector systems etc. It is a multi institutional project with IIA as the lead institution. Several ISRO centers such as SAC, LEOS, VSSC, URSC etc. are developing various subsystems for this payload. All of these systems have to be integrated, tested and calibrated to achieve the designed system performance. Sub-system level tests are being carried out in ISO-4 clean facility.

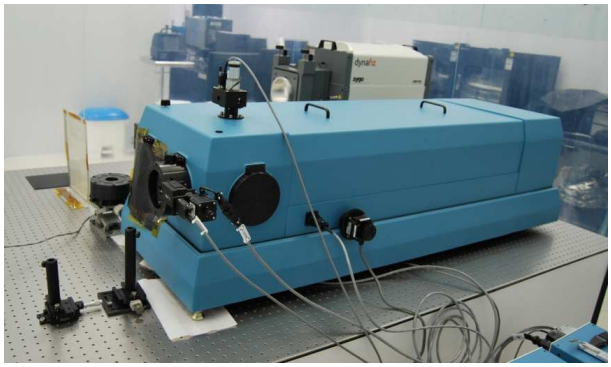


Figure 5.2: High resolution monochromator

A detailed document on Integration and Calibration of VELC was submitted to ISRO. Aditya-L1 Test Plan Committee reviewed the same and the comments were incorporated. As detailed in the document, several test and calibration activities are initiated. Team VELC at IIA set up the required experimental infrastructure to carryout test and calibration activities of the subsystems supplied by vendors. A high resolution monochromator, FUV-VIS spectrophotometer, profilometer and Fizeau interferometers were installed during this period for test and calibration activities of subsystems and the payload.

Attaining the design specifications during the operation of the mission depends on working of the individual components of the payload as well as the coordination between various components. In addition, it

depends also on the calibration of the components on-ground and in-orbit. In-orbit calibrations should continue throughout the mission, time to time to assess the performance of the payload for getting optimum science from the mission.

Figure 5.3: FUV-VIS Spectrophotometer facility

To get the first approximation of working of the payload, its subsystems should be well calibrated on-ground before integration. Post integration, system level calibration is very crucial in order to evaluate the performance of the integrated payload. Calibration tests or the performance measurements that should be carried out are: a) various optical subsystems of the payload calibration of reflective and refractive optical elements of the payload and b) calibration of spectroscopic and spectro-polarimetric optical elements.

Calibration of Spectroscopic components

Narrow band transmission filters

VELC payload comprises of four channels i.e. one imaging and three spectroscopy channels. The coronal light is imaged in the continuum channel over the field of view (FOV) of 1.05 $R_\odot$ to 3 $R_\odot$ through narrow band pass filter (NBF). The narrow band pass filter is centered around 500 nm with FWHM of 10 Å is used in continuum channel. The three spectroscopic channels are at the three emission lines viz. Fe XIV (530.3 nm), Fe XI (789.2 nm) and Fe XIII (1074.7 nm). The transmission profile of the filter over the FOV across the spectral band plays a vital role in achieving the required performance. Calibration of the filter to evaluate its performance is a must prior to its use in the payload. Each filter is calibrated across the spectral band over which transmission of the filter falls off to OD 3 compared to the peak transmission. All these measurements are carried out at their respective converging beams. Tests carried out as part of the calibration are: a) filter transmission, b) variation in transmission over the clear aperture of the filter, and c) focal shift due to the filter.

Grating

The diffraction grating is an integral component of the VELC payload for the spectroscopic channel as well as the spectro-polarimetric channel. Calibration of the diffraction grating for the critical parameters such as grating efficiency, dispersion and polarisation are of paramount importance. The grating efficiency calculated/ measured is an absolute quantity. The absolute efficiency of a grating is the percentage of incident monochromatic radiation on a grating that is diffracted into the desired order. The efficiency described is determined by both the groove profile (blaze) and the reflectivity of the grating's coating.

Spectropolarimetry

VELC has the unique feature of coronal magenetic field measurments in the FOV of 1.05 to 1.5 $R_\odot$. Polarization modulators are an integral part of the spectropolarimetric channel. VELC consists of two polarization mod-

ulators, one rotating placed close to the relay lens assembly, second is stationary placed close to the slit plane. Zero order polymer-based quarter wave plates are used as the polarization modulators are used in VELC. Calibration of the polarization modulators for the critical parameters such as retardance, uniformity, and wavefront error are carried out. Retardance describes the phase shift between the polarization component projected along the fast and slow axis. Retardance is specified in units of degrees, waves, or nanometres. Wavefront specifications describe the extent to which the wavefront leaving the lens or components conforms to the ideal or desired shape. Polarization modulator should conserve the state of polarization either circular or plane. All these components are calibrated for their expected performance both pre- and post-thermovac processes.

Polarization Beam Displacers

Polarization Beam Displacers (PBD) are an integral part of the spectropolarimetry channel. VELC consists of two PBDs which introduce a beam separation of 1.875 mm. The optical path difference introduced between the ordinary and extraordinary rays is in order of mm, which results in shift of the image plane of extraordinary rays. Hence, a HWP is mounted after first PBD, which rotates the polarization state of the beams by 90°. This ensures the path difference between the beams after passing through the combination is zero. Calibration of PBDs for critical parameters such as beam separation and extinction ratio are carried out at Prof. MGK Menon Laboratory for Space Sciences.

Since VELC is a very complex payload, the realization philosophy for the payload is: 1) Laboratory Model, 2) Proto Flight Model and finally 3) Qualification Model. The Laboratory Model is built with all the dummy sub-systems to ensure that the structure metrology is as per the design.

Figure 5.4: Laboratory Model of VELC

VELC will be tested and calibrated at different stages of integration. A detailed Test Plan Document has been made and reviewed by expert committee. Performance tests of VELC are carried out in vacuum environment after necessary corrections post air calibration. A new vacuum calibration facility has been established for this purpose.

The final performance of VELC, to achieve the proposed science goals, depends on the control of instrument background. The disk light scattered from the surface micro-roughness of primary mirror is the major contributor towards instrument scatter. Payload team has adopted multiple methods for the estimation of scatter and measurement of scattered light from the primary mirror and the payload. These include theoretical estimation, development of Near Specular Scatterometer (NSS) and development of Coronagraph Scatter Measurement Facility (CSMF) for testing the integrated payload level scatter measurements for the flight model. NSS is set up and several detailed measurements have been carried out on witness coupons. It is being modified slightly to measure the scatter light from the

primary mirror with a larger area coverage. CSMF facility is being integrated and is expected to be functional by October 2019.

Strict contamination control protocols are being followed to minimize the mirror degradation during the integration and calibration process. Accelerated studies on effect of contamination on VELC are being carried out. These studies will give an indication of the health of the payload at the end of five years of operation.

5.3 National Large Solar Telescope

A survey of major sites across India during 2007 – 2011, led to the identification of Merak on the Shore of Pangong TSO Lake as the best possible site for the installation of the proposed 2 m class optical and near Infra-Red (IR) National Large Solar Telescope (NLST). After obtaining the clearance from the National wildlife board, the forest advisory committee approved 7.6 ha forestland for the establishment of the NLST. The Department of Science & Technology released the payment for taking sanctioned land on lease. The payment has been made to the J&K Government for leasing the project land. The land lease document activities are under process with the Hill Council, Ladakh.

Some of the activities undertaken by the NLST project team are highlighted here. The seeing and other meteorological parameters are more suitable for a telescope of aperture size 2 m and above. The site survey measurements were continued post 2011. The SDIMM data provides day time seeing conditions at 6 m height above the ground. The corrected annual hours of observation are 1437 hrs and annual hours for $r_0 > 7$ cm are 610 hrs. It is also observed that summer months are best for observation with median $r_0 \sim 6$ cm and during winter months median will reduced to $\sim$ 5 cm which is still good seeing condition. SHABAR analysis shows that the median r_0 at 20 m height is around 10.4 cm. The median r_0 values increases steadily with height. A height of 20 m is desired for NLST based on this analysis. A 20 cm aperture Hα telescope was installed during August 2017. The Fried's parameter r_0 estimated from the long exposure Hα images of the Sun shows that the median r_0 as 6 cm which is consistent with SDIMM observations.

IIA Mechanical team has made signficant progress towards the conceptual design of the telescope, instrument rotator table, NLST building, dome concepts and maintenance/ handling concepts. A preliminary study has also been done for selection of the drives for elevation and azimuth rotation. On the basis of the dome type whether retractable or closed, the NLST building design also changes. So the building design for retractable dome and closed dome have been generated for comparison and found that retractable dome has more advantage over closed dome from the point of local seeing, primary focus heat stop, dome size, cost etc. So retractable dome has been proposed for NLST. The proposal for choosing retractable dome is under consideration by NLST science team.

5.4 Indian Spectroscopic and Imaging Space Telescope

In response to the call for future astronomy mission by the Indian Space Research Organization (ISRO), a proposal for a 1-m

class UV-Optical imaging and spectroscopic space telescope, named as Indian Spectroscopic and Imaging Space Telescope (INSIST) was submitted. Combining a large focal area with a simple and efficient optical design, INSIST is expected to produce HST-quality imaging and moderate resolution spectra of astronomical sources. The main science drivers for this mission span a wide range of topics, starting from evolution of galaxies in groups and clusters, chemodynamics and demographics of the nearby universe, stellar systems with accretions, to stars with planetary systems, to cosmology near and far.

INSIST, an observatory class mission, will have a high resolution imaging ($\sim 0.2''$) capability with a large field of view, to achieve a detection limit of 26 magnitude in the UV and 29 magnitude in the optical, for an exposure time of 1 ksec. It also proposes a moderate resolution multi-object spectrograph (R=1000–2000), capable of obtaining spectra up to a limiting magnitude of 20 in UV, for about 20–30 objects within a field of 0.2 sq. degrees. This proposal is lead by the Indian Institute of Astrophysics, in collaboration with several Indian Institutions. A similar project, CASTOR, is being considered by CANADA, which is also going through a preliminary design phase. A strategic collaboration is envisaged for some specific components of the project so as to have a combined mission.

All the submitted proposals were reviewed by a committee set up by the ISRO and INSIST was recommended to proceed further. ISRO approved the INSIST project to proceed to a pre-project phase of one year, along with a seed funding of 30 Lakhs. The seed funding is provided for the development and delivery of prototypes of a few identified critical components. The funds were released to IIA in March 2019, thereby earmarking the start of the pre-project phase of INSIST mission. Various teams to complete the detailed study on technical and scientific aspects are in place. Discussions with the CASTOR team members are progressing well. Detailed design and project plan are expected to be ready in the next one year.

5.5 National Large Optical-InfraRed Telescope

A group of scientists at IIA formed National Optical-Infrared telescope (NLOT) Site Survey Group (NSSG) and engaged in characterizing a suitable site for the proposed 10 m class telescope. An intermediate, 10 m class telescope is needed for undertaking broader science cases, which would lead to the identification of forefront science cases for the TMT. Based on the scientific observations carried out at Hanle for more than a decade using the Himalayan Chandra Telescope (HCT), the Site Survey Group has identified Hanle as the most suited location for a 10 m class telescope. The site yields higher percentage of clear nights and very low humidity level and hence allowing scientists to extend the operational wavelengths to infrared regime. For accurate night time seeing measurements, a dedicated small size telescope will be installed at Hanle. This telescope is designed and developed in IIA. The telescope was fully tested for its performance at the CREST campus, Hosakote.

In an attempt to compare the current proposed site for NLOT at Hanle with those that are at a higher altitude but around Hanle region, the NSSG identified two more sites, one at Kalak-Taktal and another at Rangdong. The altitude of the sites are

5486 m and 5055 m respectively. Measurements on the meteorological parameters such as wind speed and direction, air temperature, air pressure, humidity and precipitation, etc. were collected for a period of more than 10 years for the chosen sites. The data sets were analysed by the NSSG and the results were compared with that of Hanle site. It is found that the site at Hanle is better than both Kalak-Taktal and Rangdong in terms of the weather parameters. Apart from these the the infrastructure developed over the past several years and the approachability make Hanle one of the best sites for the proposed 10 m class telescope.

In order to garner a wider national level participation, a one day workshop was organized by IIA as a part of 2019 Astronomical Society of India (ASI) annual meeting held at Christ (Deemed to be University), Bengaluru. Objectives of the workshop were:

[1] Create consensus for a 10 – 12 m class optical telescope among Indian astronomers.

[2] Initiate discussion on science requirements for a 10 – 12 m size telescope.

[3] Discussion on viable telescope technology (already available and/ or to be developed) for constructing a 10 – 12 m size optical-NIR telescope.

[4] Discussion on effective use of technology/infrastructure being created in India for the TMT project.

[5] Formation of nationwide working groups comprising of astronomers and engineers who can start working towards realizing the 10 – 12 m size telescope, observatory and related backend instruments.

After detailed deliberations, the participants agreed that:

a) There is a strong need for a 10 m class telescope in the country.

b) The telescope be sited at Hanle.

c) The science requirements should be firmed up by June 2019.

d) A detailed project report should be ready by June 2020.

IIA is in the process of preparing a proposal for the NLOT which will be submitted to the DST by the end of June, 2019. The proposal will briefly describe the background, scientific motivation, efforts that are being carried out at IIA for the TMT project and eventually for the NLOT, required initial budget for the preparation of DPR and a tentative final cost for the installation of the telescope.

Figure 5.5: Participants of the ASI-2019 Workshop on *NLOT*

5.6 Mauna Kea Spectroscopic Explorer

The Mauna Kea Spectroscopic Explorer (MSE) is a planned 11.25 m aperture segmented telescope leading the world in the arena of multi-object spectroscopy of samples between thousand and millions of astrophysical objects. With a field of view of about 1.52 sq. degree wide, it will be capable to observe at a wide range of spectral resolutions, from $R = 2500$ to $R = 40,000$, with a massive multiplexing of 4332 spectra per exposure.

IIA is working in collaboration with MSE team on two aspects. First, on developing a Segment Support Assembly (SSA) for the Primary mirror (M1) segments, and second on estimating the error budget in the image quality. The M1 has 60 segments each of about 1.45 m dia. In ideal case, all the 60 segments together need to form a monolithic shape M1. And, each segments profile, at its position, needs to be matched with the monolithic profile. The deviation from the monolithic shape is assigned as the error contributing to the image quality. All sources of possible deviation are considered to quantify the error budget. An agreement has been signed with MSE for the error budget work package.

5.7 The Small Payloads Group: Astronomy with micro-satellites

The small payloads group at IIA is pioneering the use of low cost small payloads to carry out long term observations covering large areas of the sky. Such science cases are not feasible with large telescopes that are designed for deep observations of individual sources or regions in the sky. The core of the scientific endeavours are based on instruments (detectors, optics and electronics) developed and integrated in-house. Required expertise is developed in all areas of instrument design, from the initial optical and mechanical design to the fabrication of the completed astronomical instrument. These payloads take around 3 – 4 years to develop and are aptly matched to the duration of PhD theses, so that students can take the responsibility for the entire mission. Two doctoral students from the group were awarded PhD this year. The selected projects help develop skilled manpower who can go on to contribute in nation's mega science projects such as the TMT-India, LIGO-India, etc.

Relatively unexplored Ultraviolet (UV) wavelength is an exciting part of astrophysical spectrum. This region of the electromagnetic spectrum is not accessible from the ground because the ozone in the atmosphere absorbs most of the UV radiation. Compact spectrographs are being buiit in the Institute to map the sky in the ultraviolet wavelengths (900 – 3000 Å). These are being built with Israeli, German and Russian academic collaborations. At about 30×30×40 cm in dimensions, these space payloads are relatively small and are designed for long term observations of the sky. The sky will be mapped in the spectral lines from the coronal gas (C III 977 Å, O VI 1032/1038 Å); hot gas (C IV 1548/1550 Å) and warm gas (N III 1750 Å); along with the Lyman and Werner bands of molecular hydrogen from cold gas. Once operational, spectroscopic data from these instruments will provide valuable information about physical processes in the diffuse regions of our Galaxy (interstellar medium, supernova remnants, star forming regions) as well as external galaxies.

A confirmed flight opportunity is available for the near-UV spectrograph (1800 – 2800 Å) on-board the upcoming Chinese Space Station, expected to be operational in 2022. A possible flight opportunity is also available with the ISRO for a far-UV spectrograph (900 – 1800 Å).

6 Public Outreach

6.1 National Science Day

National Science Day (NSD) programme is held every year at IIA on February 28. The emphasis this year was on demonstration of basic physics experiments. Students and teachers from nearby schools and colleges were invited to take part in the demonstration session; eight schools and two colleges participated in the events. All the participants appreciated the demonstration. There was a public lecture in the evening by Prof. Balasubramanian Ananthanarayan, IISc, Bengaluru, on the topic 'Joys of discovery in modern Science' followed by sky watch for the general public and students.

Figure 6.1: One of the demonstration sessions at IIA Campus on the National Science Day.

As in the previous year, the NSD programmes were conducted in the observatories too. Several schools in the vicinity of the observatories participated in various activities conducted at the respective places. At VBO, Prof. Muthumariappan gave a talk on 'Introduction to Astronomy'. Mr G. Selvakumar and Mr A. Ramachandran gave talks on 'Site selection criteria for an observatory' and 'Optical telescopes control', respectively. The students then were taken to VBT and were shown the operations of telescope and images taken with it. Night sky watch programme was also arranged for the students using 14-inch Celestron telescope.

6.2 Teacher training programme

A one day training programme/ workshop was organized at IIA on September 15, 2018 for teachers from Government schools, as part of India International Science Festival 2018 (IISF-2018). The Public Outreach Committee (POC) contacted the officers of DIET for the selection and deputation of teachers for the training. About 50 teachers from various schools located in south Bengaluru attended the programmes. This was a precursor event to IISF-2018 which was conducted at Lucknow during October 5–8, 2018. The objective was to promote IISF-2018 programmes and to motivate the participants towards explaining the basic Science and Astronomy experiments to their students in a simple and interesting way. The teachers were also introduced to various themes that comprise IISF-2018 activities

and were requested to share the related information with their school children and other school staff. In order to give wider publicity to IISF-2018, brochures and fliers were distributed to the teachers for displaying them in the school noticeboards. On the occasion, IIA also donated basic Science and Astronomy kits to all the teachers in order to demonstrate the experiments in their schools.

Figure 6.2: One of the hands-on sessions during the Teacher training programme.

Prof. P. R. Vishwanath, former faculty member of IIA, gave a talk on the topic 'Classical Experiments in Physics'. He talked about the early basic science inventions and the necessity for encouraging students to ask questions. Dr B. S. Shylaja, former Director, Jawaharlal Nehru Planetarium, Bengaluru spoke about 'Introducing Experimental Astronomy to Students'. She explained the basic techniques to observe the night sky, how seasons occur, etc. This was followed by a presentation on 'Science and scientific thinking' in *Kannada* by Prof. Prajval Sastri, faculty member, IIA. Mr Ramaswamy, teacher, Govt school, Tumkur shared his thoughts on the title 'My experience as a science teacher'. The students and faculty members also gave two hands-on sessions (one in the forenoon and the other in the afternoon) under various titles. All the talks were well received and appreciated by the participants.

IISF-2018 outreach programmes were conducted at KSO, Kodaikanal on September 19, 2018. The IISF programmes were introduced to the participants from schools and colleges. Scientific talks were arranged in the auditorium. The museum was kept open throughout the day for the students and teachers from schools, colleges, and for the general public.

Figure 6.3: Participants of IISF-2018 outreach programme at KSO, Kodaikanal.

6.3 IIA Stalls

The following are the public outreach events wherein IIA had set up its stalls:

(a) **India International Science Festival (IISF-2018): Participation in DST stall at Lucknow**

IIA faculty members, Post Doctoral fellows and students represented IIA in the 4th India International Science Festival (IISF) which was held at Indira Gandhi Parithisthan, Lucknow during October 5–8, 2018. All members presented their work under various themes. We were allotted a stall and our posters, exhibits, etc. were displayed.

Figure 6.4: The IIA stall at the IISF-2018, Lucknow.

(b) **Bengaluru Tech Summit 2018, conducted at Palace grounds, Bengaluru**

The Government of Karnataka organized a Tech Summit at the Bangalore palace grounds during November 29–December 01, 2018 in order to bring in research institutions and the industry together to establish/ promote coordination between science and technology institutions in the country and the industries. The POC kept a stall there to display IIA's observing facilities, research highlights of the Institute, major upcoming projects, etc. Students from various colleges and many industrialists visited the stall.

(c) **Indian Science Congress 2019 Expo**

IIA participated in the 106th Pride of Expo organized by Indian Science Congress at Jalandhar, Punjab during January 3-7, 2019. Model display of IIA's mega science projects such as ADITHYA, TMT, and UVIT attracted the public.

(d) **Karnataka Science and Technology Academy 2018 Expo**

The Karnataka Science and Technology Academy organized a two day science expo in NMKRV Women's college, Bengaluru during February 1-2, 2019. Here too, the IIA put up a stall to showcase IIA's research facilities, information about our observatories, etc.

6.4 Students' Visit to IIA and its Observatories

(a) **IIA**

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

(b) **GRO, Gauribidanur**

About 550 students from ten Engineering colleges from India and one (Radboud University) from The Netherlands, visited Gauribidanur Observatory. They were explained about the functionality of the radio telescopes, analog and digital receivers.

Figure 6.5: Students of Radboud University visiting GRO.

(c) **IAO, Hanle**

IAO, Hanle had a large number of the visitors; the approximate count of the visitor to the observatory was 4750 which included people from all walks of life (tourists, defense personnel, and local population). Students and teachers from schools such as Druk Padma Karpo School, Leh (Shey), Siddartha Public School, Leh (Stok) and Government Higher Secondary School, Nyoma, etc. visited the observatory. IAO attracts several astrophotographers during the summer season. Groups namely, the Debor group, the Global and the K2 group visited during this year.

(d) **CREST, Hosakote**

There were many educational visits to CREST during the academic year. The groups were shown the research activities carried out at CREST and MGK Menon Space Laboratory. The Himalayan Chandra Telescope (HCT) at Hanle and its operations were demonstrated to them through video link. The groups were also taken to exhibition area at CREST and were explained about the exhibits.

(e) **VBO, Kavalur**

The night sky watching through 6-inch Carl Zeiss telescope has been continued on every Saturday. A Visitors' Centre was inaugurated on August 10, 2018 by IIA Governing Council chairman Prof. Ajit Kembhavi. Display of posters and videos on the history of VBO were arranged for the visitors. The total number of visitors was 13,260 including 3,864 school students and 1718 college students. Apart from the general visitors' programme on Saturdays, the school and college students are permitted to see the 2.34-m Vainu Bappu Telescope with prior permission and they were explained about IIA's research activities.

Founder's day celebrations

Prof. Vainu Bappu's Birthday celebrations were held on August 11, 2018 after VBO - 50 function on August 10, 2018. Students from nearby college were invited to take part in the celebrations. Prof. Ranjan Gupta delivered a talk titled 'India's involvement in Mega Projects in Astronomy' in the morning session. In the afternoon, speech competition was conducted for the college students on the topics related to Astronomy and Astrophysics. A jury consisting of Prof. Muthumaraiappan and Dr Ravinder Banyal conducted the competition and distributed prizes to the winner and runner up.

6.5 IIA–Cambridge University Academics Joint Outreach Programme

A team of students from the University of Cambridge (UK) visited India during April, 2018 to promote Mathematics and Physics among school children. The team brought the required material for conducting activities on topics such as relativity, concept of infinity, curved geometry, etc. An IIA-Cambridge joint outreach programme was conducted at Bengaluru and VBO. Seven schools from Bengaluru and four schools nearby VBO, Kavalur took part in the joint outreach programmes.

Figure 6.6: One of the IIA–Cambridge University joint outreach sessions.

6.6 IIA outreach team's visits to schools

IIA's Outreach Team visited two schools in Bengaluru on Saturdays during the academic year. The team gave introductory talks on the Sun and Solar system, Stars and Galaxies. Demonstrations were also given to the students using Astronomy kits. A Total of about 200 students participated in the events.

6.7 Public talks/lectures/ discussions/ communications

The following IIA faculty members were involved in public lectures/ outreach activities.

G. C. Anupama

- *Interviewed by DD, Bengaluru on the Occasion of National Science Day*, 28 February 2019.
- *Interview given to Rajya Sabha TV on the GROWTH Project.*

R. Banyal

- *Planets around other stars*, 12 January 2019, talk at 'Astronomy for Young minds', B. V. Jagadeesh Science Centre, Bengaluru.
- Participated in the *Teacher's training programme*, 15 September 2018, IIA, Bengaluru.
- Participated in the *Science day programme*, 28 February 2019, IIA, Bengaluru.

Binukumar

- Participated in the demonstration of *High Altitude Balloon experiments for UV Astronomy*, 23rd March, 2019, Indian Institute of Science, Bengaluru.

B. Kumar

- Participated in the *India International Science Festival*, 05 – 08 October 2018, Lucknow, UP.

K. Nagaraju

- Participated in the *India International Science Festival*, 05 – 08 October 2018, Lucknow, UP.

S. Nandi

- *Astronomy and Astrophysics for school children*, 20 June 2018, talk given at Baidyapur Ramkrishana Vidyapith, Baidyapur, West Bengal.
- Participated in *Women scientists & Entrepreneur conclave*, The India International Science Festival (IISF), Lucknow, during 05 – 08 October 2018.

G. Pandey

- *Stellar Spectroscopy I and II*, June–October 2018, lectures given at '100-hr Course' conducted at/by MPBIFR, Bengaluru.

V. Panditi

- Participated in the *Karnataka Science and Technology Academy-2019 Expo*, 1–2 February 2019, NMKRV college, Jayanagar, Bengaluru.

R. Sridharan

- *Gravitational Wave Astronomy*, 12 September 2018, talk given at IIA Auditorium to the students of Whilefield global school.
- *Exoplanets*, 05 February 2019, talk given at IIA Auditorium to the high school students from Keshavraj Vidhyalaya, Latur, Maharashtra.

A. Subramaniam

- *Astrosat Picture of the Month*, March 2019; November 2018; July 2018; April 2018.

7 Other Scientific Activities By IIA Staff

7.1 Talks given in National/ International Meetings outside IIA

Invited:

G. C. Anupama

- *Ground Telescopes for SSA- IIA Experience*, 14 June 2018, International Workshop on Space Situational Awareness, NIAS, Bengaluru.
- *Supernovae Ia and progenitors*, 15 November 2018, EXPUNIV Workshop at S. N. Bose National Centre for Basic Sciences, Kolkata.
- *Observations of low redshift supernovae from IAO*, 6 December 2018, International GROWTH Annual Meeting, IIT Bombay, Mumbai.
- *Follow up of GW-EM in Optical and NIR*, 16 January 2019, LIGO-India Multi-Messenger Astronomy Meet, Khandala.

S. Das

- *Dark sector of our universe*, 03 January 2019, 30th IAGRG Meeting, BITS, Hyderabad.

A. Goswami

- *Exploring the universe with metal-poor stars*, 14–17 November 2018, International Conference on 'Exploring the Universe: Near Earth Space Science to Extra-Galactic Astronomy (EXPUNIV2018)', S. N. Bose National Centre for Basic Sciences, Kolkata.

B. Kumar

- *The slow evolving stripped envelope supernova SN 2016coi (ASASSN-16fp)*, 06–08 December 2018, 3rd GROWTH annual meeting, Indian Institute of Technology, Mumbai.

A. Mangalam

- *Super-massive black hole demographics*, 16th November, 2018, EXPUNIV, SNBCBS, Kolkata.

G. Pandey

- *The exotic stars: Extreme Helium and R CrBs*, 14–16 March 2019, Advances in Physics from Small to Large Scales (APSLS-2019), Kumaun University, Nainital.

P. Parihar

- *Some Technological Efforts toward NLOT*, 18 February 2019, XXXVII ASI meeting 2019, Christ (Deemed to be University), Bengaluru.

T. P. Prabhu

- *Indian Large Optical Telescope: Digging Through History*, One Day Workshop on National Large Optical-NIR Telescope, 18 February 2019, ASI-2019, Bengaluru.

S. P. Rajaguru

- *Meridional Flow Inversions*, 17–21 March 2019, TIFR - Max-Planck Institute (Göttingen) Workshop.
- *Meridional Circulation in the Solar Convection Zone: Current Consensus from Helioseismology*, 18–22 February 2019, XXXVII ASI Meeting, Christ (Deemed to be University), Bengaluru.

B. Ravindra

- *Imaging Instruments for Large Solar Telescopes*, 21 February 2019, XXXVII ASI Meeting, Christ (Deemed to be University), Bengaluru.

B. E. Reddy

- *Overabundance of Li in red giants: Current Status*, 8th October, 2018, IAC, Tenerife, Spain.
- *Lithium Enrichment in red giants: An observational Perspective to the Li enrichment in the Galaxy*, 14th January, 2019, TIFR, Mumbai.

C. S. Stalin

- *Optical and UV astronomy in practice*, 10 May 2018, International Center for Theoretical Sciences, Bengaluru.
- *Results from UVIT onboard AstroSat*, 03–05 September 2018, Workshop on Observing Universe with AstroSat, Manipal Center for Natural Sciences, Manipal University.
- *Ultraviolet Imaging Telescope onboard AstroSat: Recent Results*, 8–10 October 2018, 2nd Bina Workshop, Royal Observatory, Belgium.
- *Gamma-ray emitting Narrow Line Seyfert 1 galaxies*, 14–17 November 2018, 'Exploring the Universe, Near Earth space science to Extragalactic Astronomy', S. N. Bose Center, Kolkota.
- *Astronomy from Ground and Space*, 12–14 December 2018, 'Advances in Observational Astronomy', University of Calicut, Calicut.

A. Subramaniam

- *UV astronomy - stars and galaxies*, 11 March 2019, COSPAR capacity building workshop, IISER Mohali.
- *Basics of Observational Astronomy*, 13 September 2018, Workshop for Women in Astronomy, Alphonsa College, Pala.

S. Subramanian

- *Tracing the connection between compact spheroids in early Universe with the local Universe massive bulges*, 21 February 2019, ASI 2019, Christ (Deemed to be University), Bengaluru.

Contributed:

R. Banyal

- *Application of frequency stabilized laser in Fabry-Perot drift tracking*, 15 September 2018, Modern Engineering Trends in Astronomy, NCRA, Pune.

Binukumar

- *CubeSat – UV spectrograph for studying atmospheres of planets orbiting*

M-dwarfs, 7–9 February 2019, International Conference on Small Satellites, Research Centre Immarat, Hyderabad, India.

- *Stratospheric Altitude Microbiology Probe for Life Existence and Micrometeorite collector. A method of collection of Stratospheric Samples Using Balloon-Borne Payload system*, 14–17 November 2018, International Conference on Exploring the Universe: Near Earth Space Science to Extragalactic Astronomy, SNB National Centre for Basic Sciences, Kolkata, India.

S. Das

- *Probing dark matter through reionization*, 22 January 2019, International conference: Cosmology for next decade, ICTS.

A. Goswami

- (1) *Stellar and Galactic studies with the 2-m Himalayan Chandra Telescope*, and (2) *Spectroscopic study of the Carbon-Enhanced Metal-Poor stars*, 9–12 October 2018, BINA (BELGO–INDIAN Network for Astronomy & Astrophysics) as an expanding international collaboration, Royal Observatory of Belgium.

A. Mangalam

- *Evolution of the $M_\bullet - \sigma$ relation*, 13–18 May 2018, IAU Symposium 342, Noto, Sicily, Italy.

- (1) *Alternate Forms for Trajectories of Bound Orbits in Kerr Geometry*, and (2) *Commensurability of QPO Frequencies in BHXRB*, 1–7 July 2018, Fifteenth Marcel Grossman meeting, Rome.

K. Nagaraju

- *Solar Coronal Magnetic Field Measurements using MSSP/VELC on-board Aditya-L1*, 3–11 January 2019, 37$^{\text{th}}$ annual meeting of ASI, Christ (Deemed to be University), Bengaluru.

S. Nandi

- *GMRT low-frequency study of recently identified DDRGs*, 18–22 March 2019, The Metrewavelength Sky–II, NCRA TIFR, Pune.

- *Multi-frequency study of a large sample of double-double radio galaxies*, 20–31 August 2018, A short talk and poster presented in XXX General Assembly of the International Astronomical Union Vienna.

S. S. Ningombam

- *Prospective of the climate change over the Ladakh region in the trans-Himalaya*, 24–28 April 2018, Workshop on Behavioural adaptation with climate change in Himalayan Regions, sponsored by DST (GoI), held at ARIES, Nainital.

- *Absorption and scattering of light by soot particles during active fires events detected from MODIS and CALIPSO: A case study of fine and coarse mode aerosols using AERONET data*, 29–31 January 2019, 20$^{\text{th}}$ National Space Science Symposium-2019, Pune University.

- *An overview of aerosol measurements over the high-altitude trans Himalayan region using Skynet data during 2008-2018*, 13–15 February, 2019, 5$^{\text{th}}$ International Skynet Workshop, Prithvi Bhavan, Ministry of Earth Sciences (GoI), New Delhi.

V. Panditi

- (1) *Coronal storage of magnetic helicity as a flux rope formation and its eruption, NORDITA, Stockholm*, 25 March 2019, and (2) *Measurements of helicity flux transfer from solar active regions and relevance to the eruptive nature*, 7 March 2019, Solar Helicities in Theory and Observations, NORDITA, Stockholm, Sweden.
- *Research on solar drivers of space-weather: Sun-Earth connection of magnetic flux ropes*, 30 October 2018, SDO workshop, Ghent, Belgium.

K. P. Raju

- *Variations of the Chromospheric Ca K Intensity from Kodaikanal Archival Data*, 20–31 August 2018, IAU 30 General Assembly, Vienna, Austria.

M. Sampoorna

- *Polarized line formation in spherically symmetric expanding atmospheres*, 24 October 2018, International Conference.

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

Invited:

G. C. Anupama

- *Time Domain Astronomy*, IIA-Academy Summer School in Astronomy and Astrophysics, IIA.
- *Observations of novae from VBO - A Personal Experience*, 9 August 2018, VBO-50, IIA.
- *Image Data Reduction*, 4 & 5 December 2018, GROWTH Winter School, IIT-Bombay.

R. Banyal

- *Adaptive Optics for Astronomy-I*, 4 June 2018, IIA-Academy summer school, IIA, Bengaluru.
- *Adaptive Optics for Astronomy-II*, 9 July 2018, IIA-Academy summer school, VBO, Kavalur.
- *Solar Telescope and Observations*, 3 January 2019, Kodai Winter School for Solar Physics, Kodiakonal.

P. Chatterjee

- Three Lectures on *MHD and dynamo theory*, 06 January 2019, Kodaikanal solar observatory.

S. Das

- *Dark matter-dark radiation interaction and cosmic reionization*, 11 December 2018, Frontiers in 21 cm cosmology, KSO, IIA.

S. Giridhar

- *Association of four decades starting from 1977*, 10 August 2018, VBO-50 Celebrating 50 years of Vainu Bappu Observatory.

M. Gopinathan

- *Sites for the NLOT*, 18 February, 2019, One Day Workshop on National Large Optical-NIR Telescope.
- *M Dwarf environments and future UV missions*, 7–9 January 2019, International Symposium on Exo-solar Planets.

A. Goswami

- *Studies on metal-poor stars using VBO observing facilities*, 9–10 August 2019, VBO-50, IIA Bengaluru.
- *Stellar Nucleosynthesis*, 04 June – 03 August 2018, Academy-IIA Summer School: 'Astrophysics: An observational view of the universe', IIA Bengaluru.

U. S. Kamath

- *Classical and recurrent novae*, June 2018, IIA-IAS Summer School.

B. Kumar

- *Uniqueness of the 4-m International Liquid Mirror Telescope and Science cases*, 04 June – 03 August 2018, Astrophysics: An observational view of the Universe, IIA, Bengaluru.

A. Mangalam

- *Deducing the demographics of supermassive black holes*, 6$^{\text{th}}$ October, 2018, AGN Science, IIA Bengaluru.
- *Solar MHD*, 4 January, Winter School in solar physics, Kodaikanal.
- *Magnetohydrostatic equilibria of flux tubes*, 5–6 April 2018, NAM, IIA.

G. Pandey

- *High resolution spectroscopy*, 9–21 July 2018, VBO-50: Academy-IIA School at VBO, Kavalur, India.
- *Stellar atmosphere and stellar evolution*, 04 June – 03 August 2018, Academy-IIA Summer School on Observational Studies, IIA, Bengaluru.
- *Lectures on Stellar Spectroscopy*, 22–24 May 2018, Kodai Summer School 2018, Kodaikanal.

T. P. Prabhu

- *Vainu Bappu Observatory – An Overview*, 9 August 2018, VBO-50, IIA Bengaluru.

S. P. Rajaguru

- *Solar Interior and Helioseismology*,
  - May 2018, Kodaikanal Summer School, Kodaikanal Solar Observatory, IIA.
  - January 2019, Kodaikanal Winter School on Solar Physics, Kodaikanal Solar Observatory, IIA.

B. Ravindra

- *Sunspots: Theory and observations*, 5$^{\text{th}}$ January, 2019, Kodaikanal winter school on solar physics.

M. Sampoorna

- *Radiative Processes in Astrophysics*, 16–18 May 2018, IIA Summer School 2018, held in Kodaikanal Solar Observatory, IIA, Kodaikanal.

C. S. Stalin

- *Observations with the Ultra Violet Imaging Telescope: Status*, 5–7 March 2019, Multiwavelength Astronomy: Three years of AstroSat Observations, IIA.

A. Subramaniam

- *ISM and star formation*, May 2018, IIA summer school, Kodaikanal.

Contributed:

K. Nagaraju

- *Spectropolarimetric observations of Sun from Kodakanal observatory*, 5 – 6 April 2018, Neighborhood Astronomy meet, IIA.

S. Nandi

- *Evolutionary sequence of large-scale radio sources*, 27 September 2018, GC II meeting, IIA.
- *Restarting activity in the nucleus of PBC J2333.9-2343. An extreme case of jet realignment*, 13 June 2018, Journal club talk.

V. Panditi

- *Solar Activity: Flares and CMEs*, 10 January 2019, Winter School, Kodaikanal.

R. Sridharan

- *DM-Technology*, 15 June 2018, Instrumentation Discussion Forum, IIA Auditorium.
- *Astronomical Instrumentation-I, II & III*, 30 May 2018, IIA Summer School Kodaikanal Observatory.
- *Speckle Imaging and Interferometry I & II*, 16–17 July 2019, Academy-IIA School VBO Kavalur.

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

R. Banyal

- *Kepler Mission and Exoplanets*, 17 February 2019, Jawaharlal Nehru Planetarium.

S. Das

- *Dark matter from sterile neutrino nuggets*, February, 2019, TIFR Mumbai.
- *Late forming dark matter from sterile neutrino*, 24 January 2019, IISER Pune.

S. Giridhar

- *Basic concepts of Astronomy*, 28 July – 9 August 2018, lectures given to MSc Physics/ Astrophysics students, Pondicherry University, Pondicherry.

A. Mangalam

- *Magnetohydrostatic equilibria of flux tubes*, 12–16 February, 2018, Dynamic Sun II, Solar Magnetism from Interior to the Corona; Siem Reap, Angkor Wat, Cambodia.

V. Panditi

- *Injection of helicity flux and the eruptive nature of solar Active Regions*,
  - 8 October 2018, MPS, Göttingen, Germany.
  - 19 October 2018, NORDITA, Stockholm, Sweden.

P. Parihar

- *Participation to the Thirty Meter Telescope Project: Current Status and Impact*, 09 November 2018, NAOC, Beijing, China.
- *Report on Indian Large Optical-NIR Telescope Project*,

  - November 05, 2018, NIAOT, Nanjing, China.
  - December 03, 2018, Indo-Japan Meeting, IUCAA.

T. P. Prabhu

- *Facilities in India for Observational Astronomy*, 22 September 2018, '100 hour certificate course in Astronomy and Astrophysics', MPBIFR, Bengaluru.
- *Milky Way Galaxy*, (10 Lectures) 24 September – 6 October 2018, MSc Physics, Astrophysics I, Unit III, Pondicherry University, Pondicherry.
- *Extragalactic Astronomy*, (10 lectures) 11–23 March 2019, MSc Physics, Astrophysics III, Unit III, Pondicherry University, Pondicherry.
- *Interstellar Medium*, (10 lectures) 11–16 February 2019, MSc Physics, Astrophysics III, Unit I, Pondicherry University, Pondicherry.

A. Subramaniam

- *ASTROSAT and impact on Indian Astronomy*, 29 November 2018, NIAS, Bengaluru.
- *Studies of stellar population using ASTROSAT*, 30 July 2018, NCRA Colloquium.

S. Sur

- *Faraday rotation signatures of Fluctuation dynamos in young galaxies*,
  - September 03, 2018, Astrophysics Colloquium, Georg-August University, Göettingen, Germany.
  - September 07, 2018, Institute seminar, Hamburger Sternwarte, Germany.

7.2 Awards, Recognition, Professional Membership, Editorship etc.

G. C. Anupama

- Elected as President, Astronomical Society of India.
- Member, IUCAA Governing Council.

R. Banyal

- IAU membership.

P. Chatterjee

- Review editor for *Frontiers Astronomy and Space Sciences*.

R. T. Gangadhara

- Awarded Visiting Scientists at NAOC, Beijing under CAS President's International Fellowship Initiative (PIFI) on 2 January 2019 for research achievements.

B. Kumar

- IAU Junior Membership.

A. Mangalam

- Member of Science Working Group Astrosat.

G. Pandey

- IAU membership.

T. P. Prabhu

- Associate Editor, Journal of Astrophysics & Astronomy, Indian Academy of Sciences and Astronomical Society of India.

S. P. Rajaguru

- Top Cited Author Award (India)–2018 of IOP (Institute of Physics) - AAS (American Astronomical Society) Journals, for papers published over the period of 2015–2017.

D. K. Sahu

- IAU membership.

A. Subramaniam

- Chief Editor of *Journal of Astrophysics and Astronomy*.

S. Subramanian

- Ramanujan Fellowship from SERB.

7.3 Externally Funded Projects

G. C. Anupama

- Indian PI of the International PIRE Project, *Global Relay of Observatories Watching Transients Happen (GROWTH)*, funded by DST-SERB and administered by IUSSTF.

R. Banyal

- *Fabry-Perot wavelength calibrator*, funded by SERB/DST.

P. Chatterjee

- Co-PI of computing time at CDAC-PARAM YUVA-II under grant name Hydromagnetic-Turbulence-PR.

R. K. Chaudhuri

- *Profiling the electronic structure properties of relativistic and nonrelativistic systems using computationally cost effective ab initio methods*, DST No: EMR/2015/000124 (PI).

- *Time dependent linear and nonlinear response properties of atomic systems: Effect of classical and quantum plasma environment and spatial confinement*, DST No. EMR/2017/000737.

S. Das

- *Probing fundamental nature of dark matter through upcoming 21 cm signals from reionization*, IUSSTF grant.

A. Goswami

- *Galactic evolution of neutron-capture elements: Insight from chemical analysis of carbon-enhanced metal-poor stars*, Funded by DST.

A. Mangalam

- *Relativistic, Magnetic, and Dynamical Astrophysics*, Core Research Grant, SERB.

G. Pandey

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

V. Panditi

- *Formation and eruption of magnetic flux ropes*, funded by the Department of Science and Technology.

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.

D. K. Sahu

- *Multi-Wavelength and Multi-Messenger Studies of the Transient Universe*, DST-BRICS project, funded by DST.
- *Theoretical studies in Explosion Physics of nearby supernovae based on high quality optical and Near Infrared observational data*, DST-JSPS project, funded by DST.

A. Subramaniam

- PI of the DST-DAAD (2018-2020) visitation programme, titled *Signatures of recent interaction in the Magellanic Clouds*.
- Co-Investigator in the SERB project *Panchromatic study of Classical Be stars*.

S. Sur

- *Understanding Fluctuation dynamos in galaxies and clusters*, Funded by DST SERB

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

G. C. Anupama

- *VBO-50*, 9-10 August 2018
- *IIA-Academy Summer School in Astronomy and Astrophysics*
- *GROWTH Winter School and GROWTH Annual Meeting*, 4–7 December 2018, IIT Bombay, Mumbai

R. Banyal

- Member, Organizing Committee, *Kodai Winter School for Solar Physics*, 3–11 January 2019.
- Member, Organizing Committee, *Active Galactic Nuclei (AGN) Science*, 6 October 2018 at IIA.
- LOC Member, *International Symposium on Extra-Solar Planets*, 7–9 January 2019.

S. Das

- Co-organizer, *Reionization history of the Universe*, 8–9 March 2018, Bielefeld, Germany.

A. Goswami

- Member of the SOC & LOC, Academy–IIA Summer School: *Astrophysics: An observational view of the universe*, , 4 June – 3 August 2018, IIA, Bengaluru.
- Member of the SOC, *VBO-50*, 9–10 August 2018, IIA Bengaluru, and VBO, Kavalur.

- Member of SOC, International conference *BINA (BELGO–INDIAN Network for Astronomy & Astrophysics) as an expanding international collaboration*, Royal Observatory of Belgium, 9–12 October 2018, Brussels.

K. Nagaraju

- Member, Organizing Committee, *Kodaikanal Winter School*, 3–11 January 2019.

G. Pandey

- Member, SOC & LOC, *VBO-50: To commemorate the 50 years of scientific observations from VBO*, 9–10 August 2018.

S. P. Rajaguru

- Member, Organizing Committee, *Active Galactic Nuclei (AGN) Science*, 6 October 2018 at IIA.

R. Sridharan

- Member, Organizing Committee, *Kodaikanal Winter School*, 2019.

C. S. Stalin

- Organized *Multiwavelength Astronomy: Three years of AstroSat Observations*, 5–7 March 2019, IIA, Bengaluru.

A. Subramaniam

- Co-Chair of the *Annual meeting of the ASI*, February 2019.

S. Sur

- Co-ordinator for *IIA Summer School*, 2018.

8 Publications

8.1 In Journals

[1] *Akshaya, M. S.; Murthy, J; *Ravichandran, S.; *Henry, R. C.; *Overduin, James., 2018, The Astrophysical Journal, Vol. 858, No. 2, 101.
The Diffuse Radiation Field at High Galactic Latitudes

[2] *Anjum, Ayesha; Das, Mousumi; Murthy, J; *Gudennavar, S. B.; *Gopal, Rajesh; *Bubbly, S. G., 2018, Journal of Astrophysics and Astronomy, Vol. 39, No. 5, 61.
Template-based classification of SDSS-GALEX point sources

[3] *Appleby, Stephen; Chingangbam, Pravabati; *Park, Changbom; Hong, *Sungwook E.; *Kim, Juhan; Ganesan, Vidhya, 2018, The Astrophysical Journal, Vol. 858, No. 2, 87.
Minkowski Tensors in Two Dimensions: Probing the Morphology and Isotropy of the Matter and Galaxy Density Fields

[4] *Appleby, Stephen; Chingangbam, Pravabati; *Park, Changbom; *Yogendran, K. P.; Joby, P. K., 2018, The Astrophysical Journal, Vol. 863, No. 2, 200.
Minkowski Tensors in Three Dimensions: Probing the Anisotropy Generated by Redshift Space Distortion

[5] *Arkhipova, V. P.; Parthasarathy, M.; *Ikonnikova, N. P.; *Ishigaki, M.; *Hubrig, S.; *Sarkar, G.; *Kniazev, A. Y., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 3, pp. 3935-3952.
Line identification and photometric history of the hot post-AGB star Hen 3-1013 (IRAS 14331-6435)

[6] *Arun, Kenath; *Gudennavar, S. B.; *Prasad, A.; Sivaram, C., 2019, Astrophysics and Space Science, Vol. 364, No. 2, 24.
Effects of dark matter in star formation

[7] Bandyopadhyay, Avrajit; Sivarani, T; Susmitha, Antony; *Beers, Timothy C.; Giridhar, Sunetra; Surya, Arun; *Masseron, Thomas., The Astrophysical Journal, Vol. 859, No. 2, 114.
Chemical Composition of Two Bright, Extremely Metal-poor Stars from the SDSS MARVELS Pre-survey

[8] *Bharat Kumar, Yerra; Singh, Raghubar; Reddy, Bacham E.; *Zhao, Gang., 2018, The Astrophysical Journal Letters, Vol. 858, No. 2, L22.
Two New Super Li-rich Core He-burning Giants: A New Twist to the Long Tale of Li Enhancement in K Giants

[9] *Bhattacharya, Debbijoy; *Gulati, Sanna; Stalin, C. S., 2019, Monthly Notices of the Royal Astronomical

* *Collaborators from other Institutions*

Society, Vol. 483, No. 3, pp. 3382-3389.
Intra-night optical variability of misaligned active galaxies

[10] *Bose, Souvik; Nagaraju, K., 2018, The Astrophysical Journal, Vol. 862, No. 1, 35.
On the Variability of the Solar Mean Magnetic Field: Contributions from Various Magnetic Features on the Surface of the Sun

[11] Chatterjee, Subhamoy; Banerjee, D.; *McIntosh, Scott W.; *Leamon, Robert J.; *Dikpati, Mausumi; *Srivastava, Abhishek K.; *Bertello, Luca., 2019, The Astrophysical Journal Letters, Vol. 874, No. 1, L4.
Signature of Extended Solar Cycles as Detected from Ca II K Synoptic Maps of Kodaikanal and Mount Wilson Observatory

[12] *Chaudhuri, S. K.; *Mukherjee, P. K.; Chaudhuri, R. K.; *Chattopadhyay, S., 2018, Physics of Plasmas, Vol. 25, No. 4, 042705.
Equation of motion approach for describing allowed transitions in Ne and Al3+ under classical and quantum plasmas

[13] *Choudhury, S.; Subramaniam, A.; *Cole, A. A.; *Sohn, Y.-J., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 475, No. 4, pp. 4279-4297.
Photometric metallicity map of the Small Magellanic Cloud

[14] *Dar, Ajaz Ahmad; Parihar, Padmakar S.; *Saleh, Parvej; *Malik, Manzoor A., 2018, New Astronomy, Vol. 64, pp. 34-39.
Search for variable stars in the open cluster NGC 2509

[15] *Dar, Ajaz Ahmad; Parihar, Padmakar S; *Malik, Manzoor Ahmad., 2018, Research in Astronomy and Astrophysics, Vol. 18, No. 9, 112.
Photometry and spectroscopy of II Peg, IM Peg and UX Ari

[16] *Dar, Ajaz Ahmad; Parihar, Padmakar S; *Saleh, Parvej; *Malik, Manzoor Ahmad., 2018, Research in Astronomy and Astrophysics, Vol. 18, No. 12, 155.
Variable stars in M 37

[17] Das, Mousumi; *Sengupta, Chandreyee; Honey, M., 2019, The Astrophysical Journal, Vol. 871, No. 2, 197.
The Extended H I Disk and Star Formation in the Dwarf Spiral Galaxy NGC 4701

[18] Das, Subinoy; *Mondal, Rajesh; *Rentala, Vikram; *Suresh, Srikanth., 2018, Journal of Cosmology and Astroparticle Physics, No. 08, 045.
On dark matter-dark radiation interaction and cosmic reionization

[19] *Dastidar, Raya; *Misra, Kuntal; *Hosseinzadeh, G.; *Pastorello, A.; *Pumo, M. L.; *Valenti, S.; *McCully, C.; *Tomasella, L.; *Arcavi, I.; *Elias-Rosa, N.; *Singh, Mridweeka; *Gangopadhyay, Anjasha; *Howell, D. A.; *Morales-Garoffolo, Antonia; *Zampieri, L.; *Kumar, Brijesh; *Turatto, M.; *Benetti, S.; *Tartaglia, L.; *Ochner, P.; Sahu, D. K.; Anupama, G. C.; *Pandey, S. B., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 479, No. 2, pp. 2421-2442.
SN 2015ba: a Type IIP supernova with a long plateau

[20] Deepak; Reddy, Bacham E., 2018, The Astronomical Journal, Vol. 156, No. 4, 170.

Radial Velocity Comparison of Gaia DR2 and RAVE DR5 Survey: A Systematic Offset in Radial Velocities among a Group of Highly Accurate Radial Velocity Stars

[21] *Deras, D.; *Arellano Ferro, A.; Muneer, S.; Giridhar, Sunetra.; *Michel, R., 2018, Astronomische Nachrichten, Vol. 339, No. 603, pp. 603-614.
Physical parameters of RR Lyrae stars in NGC 6171

[22] *Devarapalli, Shanti Priya; *Jagirdar, Rukmini; Parthasarathy, M.; Sahu, D. K.; *Mohan, Vijay; Bhatt, B. C.; *Thomas, Vineet S., 2018, Astrophysics and Space Science, Vol. 363, No. 4, 69.
Low resolution spectroscopy of selected Algol systems

[23] *Dey, Lankeswar., et al. (including Raj, A.)., 2018, The Astrophysical Journal, Vol. 866, No. 1, 11.
Authenticating the Presence of a Relativistic Massive Black Hole Binary in OJ 287 Using Its General Relativity Centenary Flare: Improved Orbital Parameters

[24] *Dikpati, Mausumi; *McIntosh, Scott W.; Chatterjee, Subhamoy; Banerjee, D.; *Yellin-Bergovoy, Ron; *Srivastava, Abhishek., 2019, Scientific Reports, Vol. 9, 2035.
Triggering The Birth of New Cycle's Sunspots by Solar Tsunami

[25] *Folsom, C. P.; *Fossati, L.; *Wood, B. E.; Sreejith, A. G.; *Cubillos, P. E.; *Vidotto, A. A.; *Alecian, E.; *Girish, V.; *Lichtenegger, H.; Murthy, J.; *Petit, P.; *Valyavin, G., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 4, pp. 5286-5295.
Characterization of the HD 219134 multiplanet system I. Observations of stellar magnetism, wind, and high-energy flux

[26] *Gangopadhyay, Anjasha; *Misra, Kuntal; *Pastorello, A.; Sahu, D. K.; *Tomasella, L.; *Tartaglia, L.; *Singh, Mridweeka; *Dastidar, Raya; *Srivastav, S.; *Ochner, P.; *Brown, Peter J.; Anupama, G. C.; *Benetti, S.; *Cappellaro, E.; Kumar, Brajesh; Kumar, *Brijesh; *Pandey, S. B., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 3, pp. 3611-3630.
SN 2015as: a low-luminosity Type IIb supernova without an early light-curve peak

[27] George, K.; Joseph, P.; *Cote, P.; *Ghosh, S. K.; *Hutchings, J. B.; Mohan, R.; *Postma, J.; Sankarasubramanian, K.; Sreekumar, P.; Stalin, C. S.; Subramaniam, A.; Tandon, S. N., 2018, Astronomy & Astrophysics, Vol. 614, A130.
Dissecting star formation in the "Atoms-for-Peace" galaxy. UVIT observations of the post-merger galaxy NGC 7252

[28] *George, K.; Joseph, P.; Mondal, C.; Subramanian, S.; Subramaniam, A.; *Paul, K. T., 2019, Astronomy & Astrophysics, Vol. 621, L4.
Insights on bar quenching from a multiwavelength analysis: The case of Messier 95

[29] George, K.; *Poggianti, B. M.; *Gullieuszik, M.; *Fasano, G.; *Bellhouse, C.; *Postma, J.; *Moretti, A.; *Jaffé, Y.; *Vulcani, B.; *Bettoni, D.; *Fritz, J.; *Côté, P.; *Ghosh, S. K.; *Hutchings, J. B.; Mohan, R.; Sreekumar, P.; Stalin, C. S.; Subramaniam, A.; Tandon, S. N., 2018, Monthly Notices of the

Royal Astronomical Society, Vol. 479, No. 3, pp. 4126-4135.
UVIT view of ram-pressure stripping in action: star formation in the stripped gas of the GASP jellyfish galaxy JO201 in Abell 85

[30] *Goyal, A., et al. (including Raj, A.)., 2018, The Astrophysical Journal, Vol. 863, No. 2, 175.
Stochastic Modeling of Multiwavelength Variability of the Classical BL Lac Object OJ 287 on Timescales Ranging from Decades to Hours

[31] *Gurumath, S. R.; Hiremath, K. M.; *Ramasubramanian, V., 2019, Publications of the Astronomical Society of the Pacific, Vol. 131, No. 995, 014401.
Angular Momentum of Stars and their Planets

[32] *Harvey-Smith, Lisa; *Hardwick, Jennifer A.; *De Marco, Orsola; Parthasarathy, M; *Gonidakis, Ioannis; *Akhter, Shaila; *Cunningham, Maria; *Green, James A., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 479, No. 2, pp. 1842-1849.
The nature of the Stingray nebula from radio observations

[33] Hema, B. P.; Pandey, Gajendra; *Srianand, R., 2018, The Astrophysical Journal, Vol. 864, No. 2, 121.
High-resolution Spectroscopy of the Relatively Hydrogen-poor Metal-rich Giants in the Globular Cluster ω Centauri

[34] *Henze, M., et al. (including Anupama, G. C.)., 2018, The Astrophysical Journal, Vol. 857, No. 1, 68.
Breaking the Habit: The Peculiar 2016 Eruption of the Unique Recurrent Nova M31N 2008-12a

[35] Honey, M.; *van Driel, W.; Das, M.; *Martin, J.-M., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 4, pp. 4488-4500.
A study of the H I and optical properties of Low Surface Brightness galaxies: spirals, dwarfs, and irregulars

[36] *Jiang, Chaowei; *Zou, Peng; *Feng, Xueshang; *Hu, Qiang; *Liu, Rui; Vemareddy, P.; *Duan, Aiying; *Zuo, Pingbing; *Wang, Yi; *Wei, Fengsi., 2018, The Astrophysical Journal, Vol. 869, No. 1, 13.
Magnetohydrodynamic Simulation of the X9.3 Flare on 2017 September 6: Evolving Magnetic Topology

[37] Joby, P. K.; Chingangbam, Pravabati; *Ghosh, Tuhin; Ganesan, Vidhya; *Ravikumar, C. D., 2019, Journal of Cosmology and Astroparticle Physics, No. 01, 09.
Search for anomalous alignments of structures in Planck data using Minkowski Tensors

[38] Kameswara Rao, N.; *De Marco, O.; Krishna, S.; Murthy, J.; *Ray, A.; Sutaria, F.; Mohan, R., 2018, Astronomy & Astrophysics, Vol. 620, A138.
Planetary nebulae with UVIT. II. Revelations from far-UV vision of Butterfly nebula NGC 6302

[39] Kapahtia, Akanksha; Chingangbam, Pravabati; *Appleby, Stephen; *Park, Changbom., 2018, Journal of Cosmology and Astroparticle Physics, No. 10, 011.
A novel probe of ionized bubble shape and size statistics of the epoch of reionization using the contour Minkowski Tensor

[40] *Karak, Bidya Binay; Mandal, Sudip;

Banerjee, D., 2018, The Astrophysical Journal, Volume 866, No. 1, 17.
Double Peaks of the Solar Cycle: An Explanation from a Dynamo Model

[41] Karak, Bidya Binay; *Miesch, Mark., 2018, The Astrophysical Journal Letters, Vol. 860, No. 2, L26.
Recovery from Maunder-like Grand Minima in a Babcock-Leighton Solar Dynamo Model

[42] Karak, Bidya Binay; *Miesch, Mark; *Bekki, Yuto., 2018, Physics of Fluids, Vol. 30, No. 4, 046602.
Consequences of high effective Prandtl number on solar differential rotation and convective velocity

[43] Karinkuzhi, Drisya; Goswami, Aruna; *Sridhar, Navin; *Masseron, Thomas; Purandardas, Meenakshi., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 3, pp. 3086-3096.
Chemical analysis of three barium stars: HD 51959, HD 88035, and HD 121447

[44] Kataria, Sandeep Kumar; Das, Mousumi., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 475, pp. 2, pp. 1653-1664.
A study of the effect of bulges on bar formation in disc galaxies

[45] *Kharb, P.; *Vaddi, S.; *Sebastian, B.; Subramanian, S.; Das, M.; *Paragi, Z., 2019, The Astrophysical Journal, Vol. 871, No. 2, 249.
A Curved 150 pc Long Jet in the Double-peaked Emission-line AGN KISSR 434

[46] *Kim, Gwanjeong; *Lee, Chang Won; Maheswar, G.; *Kim, Mi-Ryang; *Soam, Archana; *Saito, Masao; *Kiyokane, Kazuhiro; *Kim, Sungeun., 2019, The Astrophysical Journal Supplement Series, Vol. 240, No. 2, 18.
CO Outflow Survey of 68 Very Low Luminosity Objects: A Search for Proto-brown-dwarf Candidates

[47] *Korsós, M. B.; Chatterjee, P.; *Erdélyi, R., 2018, The Astrophysical Journal, Vol. 857, No. 2, 103.
Applying the Weighted Horizontal Magnetic Gradient Method to a Simulated Flaring Active Region

[48] Kumar, Brajesh; Pandey, Kanhaiya L.; *Pandey, S. B.; *Hickson, P.; *Borra, E. F.; Anupama, G. C.; *Surdej, J., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 2, pp. 2075-2085.
The zenithal 4-m International Liquid Mirror Telescope: a unique facility for supernova studies

[49] *Kumar, P.; *Chand, H.; *Srianand, R.; Stalin, C. S.; *Petitjean, P.; *Gopal-Krishna., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 479, No. 4, pp. 5075-5082.
Polarimetric and spectroscopic study of radio-quiet weak emission line quasars

[50] *Kumar, Yerra Bharat; Reddy, Bacham E; *Zhao, Gang., 2018, Journal of Astrophysics and Astronomy, Vol. 39, No. 2, 25.
Identifying Li-rich giants from low-resolution spectroscopic survey

[51] Lalitha, Sairam; *Schmitt, J. H. M. M.; *Dash, Spandan., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 477, No. 1, pp. 808-815.
Atmospheric mass-loss of extrasolar planets orbiting magnetically active host stars

[52] *Liang, Zhi-Chao; *Gizon, Laurent; *Birch, Aaron C.; *Duvall, Thomas L.; Rajaguru, S. P., 2018, Astronomy & Astrophysics, Vol. 619, A99.
Solar meridional circulation from twenty-one years of SOHO/MDI and SDO/HMI observations. Helioseismic travel times and forward modeling in the ray approximation

[53] *Malkov, Oleg et al. (including Murthy, J.)., 2018, Open Astronomy, Vol. 27, No. 1, pp. 62-69.
Interstellar extinction from photometric surveys: application to four high-latitude areas

[54] Mandal, Amit Kumar; Rakshit, Suvendu; Kurian, Kshama S.; Stalin, C. S.; *Mathew, Blesson; *Hoenig, Sebastian; *Gandhi, Poshak; Sagar, Ram; *Pandge, M. B., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 475, No. 4, pp. 5330-5337.
Determination of the size of the dust torus in H0507+164 through optical and infrared monitoring

[55] *Mandal, K.; *Hanasoge, S. M.; Rajaguru, S. P.; *Antia, H. M., 2018, The Astrophysical Journal, Vol. 863, No. 1, 39.
Helioseismic Inversion to Infer the Depth Profile of Solar Meridional Flow Using Spherical Born Kernels

[56] Mangalam, A., 2018, Journal of Astrophysics and Astronomy, Vol. 39, No. 6, 68.
Polarization and QPOs from jets in black hole systems

[57] *Mathew, Blesson; *Manoj, P.; *Narang, Mayank; *Banerjee, D. P. K.; *Nayak, Pratheeksha; Muneer, S.; *Vig, S.; Pramod Kumar, S.; *Paul, K. T.; Maheswar, G., 2018, The Astrophysical Journal, Vol. 857, No. 1, 30.
Excitation Mechanism of O I Lines in Herbig Ae/Be Stars

[58] Mathew, Joice; Ambily, S.; Prakash, Ajin; Sarpotdar, Mayuresh; Nirmal, K.; *G. Sreejith, A.; Safonova, Margarita; Murthy, J; *Brosch, Noah., 2018, Experimental Astronomy, Vol. 45, No. 2, pp. 201-218.
Wide-field ultraviolet imager for astronomical transient studies

[59] Mathew, Joice; Nair, B. G.; Safonova, Margarita; Sriram, S.; Prakash, Ajin; Sarpotdar, Mayuresh; Ambily, S.; Nirmal, K.; *Sreejith, A. G.; Murthy, J; Kamath, P. U.; Kathiravan, S.; Prasad, B. R.; *Brosch, Noah; *Kappelmann, Norbert; *Gadde, Nirmal Suraj; *Narayan, Rahul., 2019, Astrophysics and Space Science, Vol. 364, No. 3, 53.
Prospect for UV observations from the Moon. III. Assembly and ground calibration of Lunar Ultraviolet Cosmic Imager (LUCI)

[60] *Mishra, Preetish K.; *Wadadekar, Yogesh; Barway, Sudhanshu., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 478, No. 1, pp. 351-358.
Why are classical bulges more common in S0 galaxies than in spiral galaxies?

[61] Mondal, Chayan; Subramaniam, Annapurni; George, Koshy., 2018, The Astronomical Journal, Vol. 156, No. 3, 109.
UVIT Imaging of WLM: Demographics of Star-forming Regions in the Nearby Dwarf Irregular Galaxy

[62] *Montiel, Edward J.; *Clayton, Geoffrey C.; *Sugerman, B. E. K.; *Evans, A.; *Garcia-Hernández, D. A.;

Kameswara Rao, N.; *Matsuura, M.; *Tisserand, P., 2018, The Astronomical Journal, Vol. 156, No. 4, 148.
The Double Dust Envelopes of R Coronae Borealis Stars

[63] *Narang, Mayank; *Manoj, P.; *Furlan, E.; *Mordasini, C.; *Henning, Thomas; *Mathew, Blesson; Banyal, Ravinder K.; Sivarani, T., 2018, The Astronomical Journal, Vol. 156, No. 5, 221.
Properties and Occurrence Rates for Kepler Exoplanet Candidates as a Function of Host Star Metallicity from the DR25 Catalog

[64] Nayak, P. K.; Subramaniam, A.; *Choudhury, S.; Sagar, Ram., 2018, Astronomy & Astrophysics, Vol. 616, A187.
Star clusters in the Magellanic Clouds. II. Age-dating, classification, and spatio-temporal distribution of the SMC clusters

[65] *Neha, S.; Maheswar, G.; *Soam, A.; *Lee, C. W., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 4, pp. 4442-4458.
Polarization of seven MBM clouds at high Galactic latitude

[66] Ningombam, S. S.; Vemareddy, P.; *Song, H.-J., 2018, Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 178, pp. 32-46.
The recent signs of total column ozone recovery over mid-latitudes: The effects of the Montreal Protocol mandate

[67] Ningombam, S. S.; *Larson, E. J. L.; *Dumka, U. C.; *Estelles, V.; *Campanelli, M.; *Steve, C., 2019, Atmospheric Pollution Research, Vol. 10, No. 2, pp. 608 – 620.
Long-term (1995-2018) aerosol optical depth derived using ground based AERONET and SKYNET measurements from aerosol aged-background sites

[68] Nirmal, K; Sridharan, R; Sriram, S; Murthy, J; Ambily, S; Safonova, Margarita; Sreejith, A. G; Mathew, Joice; Sarpotdar, Mayuresh., 2018, Journal of Astronomical Telescopes, Instruments, and Systems, Vol. 4, 025001.
Design and modeling of a tunable spatial heterodyne spectrometer for emission line studies

[69] *Paliya, Vaidehi S.; *Zhang, Haocheng; *Böttcher, Markus; *Ajello, M.; *Domínguez, A.; *Joshi, M.; *Hartmann, D.; Stalin, C. S., 2018, The Astrophysical Journal, Vol. 863, No. 1, 98.
Leptonic and Hadronic Modeling of Fermi-LAT Hard Spectrum Quasars and Predictions for High-energy Polarization

[70] Pant, V.; Datta, A.; Banerjee, D.; Chandrashekhar, K.; *Ray, S., 2018, The Astrophysical Journal, Vol. 860, No. 1, 80.
Twisting/Swirling Motions during a Prominence Eruption as Seen from SDO/AIA

[71] Parthasarathy, M.; *Jasniewicz, G.; *Thěvenin, F., 2019, Astrophysics and Space Science, Vol. 364, No. 1, 18.
The puzzling high velocity G5 supergiant star HD 179821: new insight from Gaia DR2 data

[72] Patel, Ritesh; *Amareswari, K.; Pant, Vaibhav; Banerjee, D.; Sankarasubramanian, K.; Kumar, Amit., 2018, Solar Physics, Vol. 293, No. 7, 103.

Onboard Automated CME Detection Algorithm for the Visible Emission Line Coronagraph on ADITYA-L1

[73] Pavana, M.; Anche, Ramya M.; Anupama, G. C.; *Ramaprakash, A. N.; Selvakumar, G., 2019, Astronomy & Astrophysics, Vol. 622, A126.
Optical spectroscopic and polarization properties of 2011 outburst of the recurrent nova T Pyxidis

[74] *Perley, Daniel A et al. (including Singh, Avinash, Anupama, G. C. Brajesh Kumar)., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 484, No. 1, pp. 1031-1049.
The fast, luminous ultraviolet transient AT2018cow: extreme supernova, or disruption of a star by an intermediate-mass black hole?

[75] Prabhakar, Maya; Raju, K. P.; *Chandrasekhar, T., 2019, Solar Physics, Vol. 294, No. 3, 26.
Characteristics of the Solar Coronal Line Profiles from Fabry-Perot Interferometric Observations

[76] Prabhu, K.; Ravindra, B.; Hegde, Manjunath; *Doddamani, Vijayakumar H., 2018, Astrophysics and Space Science, Vol. 363, No. 5, 108.
Recurring coronal holes and their rotation rates during the solar cycles 22-24

[77] Pruthvi, Hemanth; Nagaraju, K; Ravindra, B; Ramesh, K. B., Journal of Astronomical Telescopes, Instruments, and Systems, Vol. 4, No. 4, 048002.
Solar spectropolarimetry of Ca II *8542 Å line: polarimeter development, calibration, and preliminary observations*

[78] *Rahna, P. T.; Das, M.; Murthy, J; *Gudennavar, S. B.; *Bubbly, S. G., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 1, pp. 1212-1234.
A study of the star-forming regions in the spiral galaxy NGC 2336 using the Ultraviolet Imaging Telescope (UVIT)

[79] Raj Kumar, N.; Raghavendra Prasad, B.; Singh, Jagdev; Venkata, Suresh., 2018, Experimental Astronomy, Vol. 45, No. 2, pp. 219-229.
Optical design of visible emission line coronagraph on Indian space solar mission Aditya-L1

[80] Rajaguru, S. P.; *Sangeetha, C. R.; *Tripathi, Durgesh., 2019, The Astrophysical Journal, Vol. 871, No. 2, 155.
Magnetic Fields and the Supply of Low-frequency Acoustic Wave Energy to the Solar Chromosphere

[81] Raju, K. P., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 478, No. 4, pp. 5056-5062.
Temporal and latitudinal variations of the length-scales and relative intensities of the chromospheric network

[82] Rakshit, Suvendu; Johnson, Ansu; Stalin, C. S.; *Gandhi, Poshak; *Hoenig, Sebastian., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 483, No. 2, pp. 2362-2370.
WISE view of narrow-line Seyfert 1 galaxies: mid-infrared colour and variability

[83] Rakshit, Suvendu; Stalin, C. S.; *Hota, Ananda; *Konar, Chiranjib., 2018, The Astrophysical Journal, Vol. 869, No. 2, 173.
Rare Finding of a 100 Kpc Large, Double-lobed Radio Galaxy Hosted in the Narrow-line Seyfert 1 Galaxy SDSS J103024.95+551622.7

[84] Ramya, P.; Reddy, Bacham E.; *Lambert, David L., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 484, No. 1, pp. 125-145.
Chemical compositions of giants in the Hyades and Sirius superclusters

[85] Rana, Prerna; Mangalam, A., 2019, Classical and Quantum Gravity, Vol. 36, No. 4, 045009.
Astrophysically relevant bound trajectories around a Kerr black hole

[86] *Rana, Sandeep; *Ghosh, Tuhin; *Bagla, Jasjeet S.; Chingangbam, Pravabati., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 1, pp. 970-980.
Non-Gaussianity of diffuse Galactic synchrotron emission at 408 MHz

[87] Rani, Priyanka; Stalin, C. S., 2018, The Astrophysical Journal, Vol. 856, No. 2, 120.
Coronal Proerties of the Seyfert 1 Galaxy 3C 120 with NuSTAR

[88] *Rao, V. Koteswara; *Gopal, K. Rama; *Reddy, R. Ramakrishna; *Amareswari, K.; Sankarasubramanian, K., 2019, Journal of Astrophysics and Astronomy, Vol. 40, No. 1, 1.
Relation between solar flares and halo coronal mass ejections

[89] Ravindra, B.; Kesavan, Prabhu; Thulasidharen, K. C.; Rajalingam, M.; Sagayanathan, K.; Kamath, P. U.; Dorjey, Namgyal; Dorjee, Angchuk; Kemkar, P. M. M.; Dorjai, Tsewang; Banyal, Ravinder K., 2018, Journal of Astrophysics and Astronomy, Vol. 39, No. 5, 60.
Intallation of solar chromospheric telescope at the Indian Astronomical Observatory, Merak

[90] *Ray, S. S.; *Manna, S.; *Ghosh, A.; Chaudhuri, R. K.; *Chattopadhyay, S., 2019, International Journal of Quantum Chemistry, Vol. 119, No. 4, e25776.
Multireference perturbation theory with improved virtual orbitals for radicals: More degeneracies, more problems

[91] *Rebecca, Louise; *Arun, Kenath; Sivaram, C., 2018, Astrophysics and Space Science, Vol. 363, No. 7, 149.
Dark energy constraints on masses and sizes of large scale cosmic structures

[92] *Saha, S.; *Basak, S.; *Safonova, M.; *Bora, K.; *Agrawal, S.; *Sarkar, P.; Murthy, J., 2018, Astronomy and Computing, Vol. 23, No. 141.
Theoretical validation of potential habitability via analytical and boosted tree methods: An optimistic study on recently discovered exoplanets

[93] *Sahai, R.; *Sánchez Contreras, C.; *Mangan, A. S.; *Sanz-Forcada, J.; Muthumariappan, C.; *Claussen, M. J., 2018, The Astrophysical Journal, Vol. 860, No. 2, 105.
Binarity and Accretion in AGB Stars: HST/STIS Observations of UV Flickering in Y Gem

[94] Sahu, D. K.; Anupama, G. C.; *Chakradhari, N. K.; Srivastav, S.; *Tanaka, Masaomi; *Maeda, Keiichi; *Nomoto, Ken'ichi., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 475, No. 2, pp. 2591-2604.
Broad-line Type Ic supernova SN 2014ad

[95] Sahu, Dipen; *Liu, Sheng-Yuan; *Su, Yu-Nung; *Li, Zhi-Yun; *Lee, Chin-Fei; *Hirano, Naomi; *Takakuwa, Shigehisa., 2019, The Astrophysical Journal, Vol. 872, No. 2, 196.

Implications of a Hot Atmosphere/Corino from ALMA Observations toward NGC 1333 IRAS 4A1

[96] Sahu, Snehalata; Subramaniam, Annapurni; *Côté, Patrick; Kameswara Rao, N; *Stetson, Peter B., Monthly Notices of the Royal Astronomical Society, Vol. 482, No. 1, pp. 1080-1095.
UVIT-HST-GAIA view of NGC 288: a census of the hot stellar population and its properties from UV

[97] *Salhab, R. G.; *Steiner, O.; *Berdyugina, S. V.; *Freytag, B.; Rajaguru, S. P.; *Steffen, M., 2018, Astronomy & Astrophysics, Vol. 614, A78.
Simulation of the small-scale magnetism in main-sequence stellar atmospheres

[98] *Sasikumar Raja, K.; *Subramanian, Prasad; *Ingale, Madhusudan; Ramesh, R.. 2019, The Astrophysical Journal, Vol. 872, No. 1, 77.
Dissipation Scale Lengths of Solar Wind Turbulence

[99] Sengupta, Sujan., 2018., The Astrophysical Journal, Vol. 861, No. 1, 41.
Polarization of Trappist-1 by the Transit of Its Planets

[100] *Shetye, S.; *Van Eck, S.; *Jorissen, A.; *Van Winckel, H.; *Siess, L.; *Goriely, S.; *Escorza, A.; Karinkuzhi, D.; *Plez, B., 2018, Astronomy & Astrophysics, Vol. 620, A148.
S stars and s-process in the Gaia era. I. Stellar parameters and chemical abundances in a sub-sample of S stars with new MARCS model atmospheres

[101] Sindhu, N.; Subramaniam, A; *Radha, C. Anu., 2018., Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 1, pp. 226-243.
Ultraviolet stellar population of the old open cluster M67 (NGC 2682)

[102] Singh, Avinash; *Srivastav, S.; Kumar, Brajesh; Anupama, G. C.; Sahu, D. K., 2018., Monthly Notices of the Royal Astronomical Society, Vol. 480, No. 2, pp. 2475-2500.
ASASSN-14dq: a fast-declining Type II-P supernova in a low-luminosity host galaxy

[103] Singh, Raghubar; Reddy, Bacham E.; *Kumar, Yerra Bharat., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 482, No. 3, pp. 3822-3830.
Spectroscopic study of two new super Li-rich red clump K giants

[104] Sivaram, C.; *Arun, Kenath; *Prasad, A., 2018, Astrophysics and Space Science, Vol. 363, No. 10, 202.
Extremal charged black holes, dark matter and dark energy

[105] *Soam, Archana; Maheswar, G.; *Lee, Chang Won; *Neha, S.; *Kim, Kee-Tae., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 4, pp. 4782-4793.
Magnetic fields in multiple bright-rimmed clouds in different directions of H II region IC 1396

[106] Sridharan, R.; Ravindra, B.; Prabhu, K., 2019, Solar Physics, Vol. 294, No. 1, 5.
Measurement of Astronomical Seeing Using Long Exposure Solar Images

[107] *Srivastava, A. K ., et al. (including Banerjee, D.)., 2018, Frontiers in Astronomy and Space Sciences, Vol. 5, 38.
The Extended Solar Cycle: Muddying the Waters of Solar/Stellar Dynamo Modeling Or Providing Crucial Observational Constraints?

[108] *Sukanya, N.; Stalin, C. S.; Joseph, P.; Rakshit, S.; *Praveen, D.; *Damle, R., 2018, Journal of Astrophysics and Astronomy, Vol. 39, No. 6, 65.
Long-term ultraviolet variability of Seyfert galaxies

[109] *Sun, Ning-Chen., et al. (including Subramanian, Smitha.)., 2018, The Astrophysical Journal, Vol. 858, No. 1, 31.
The VMC Survey. XXIX. Turbulence-controlled Hierarchical Star Formation in the Small Magellanic Cloud

[110] *Sunaga, A.; Prasannaa, V. S.; *Abe, M.; *Hada, M.; *Das, B. P., 2018, Physical Review A, Vol. 98, No. 4, 042511.
Enhancement factors of parity- and time-reversal-violating effects for monofluorides

[111] Surendran, Avinash; *Burse, Mahesh P.; *Ramaprakash, Anamparambu N.; Parihar, Padmakar S., 2018, Journal of Astronomical Telescopes, Instruments, and Systems, Vol. 4, 039002.
Scalable platform for adaptive optics real-time control, part 2: field programmable gate array implementation and performance

[112] Surendran, Avinash; *Burse, Mahesh P.; *Ramaprakash, Anamparambu N.; *Paul, Jyotirmay; Das, *Hillol K.; Parihar, Padmakar S., 2018, Journal of Astronomical Telescopes, Instruments, and Systems, Vol. 4, 039001.
Scalable platform for adaptive optics real-time control, part 1: concept, architecture, and validation

[113] Suryanarayana, G. S.; *Balakrishna, K. M., 2018, Advances in Space Research, Vol. 61, No. 9, pp. 2482-2489.
CME productivity associated with Solar Flare peak X-ray emission flux

[114] *Vaddi, S.; *Kharb, P.; *Daly, R. A.; *O'Dea, C. P.; *Baum, S. A.; Deo, D. K.; *Barbusca, T. C.; Murali, Chintak., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 484, No. 1, pp. 385-408.
A VLA-GMRT look at 11 powerful FR II quasars

[115] *Vaghmare, Kaustubh; Barway, Sudhanshu; *Väisänen, Petri; *Ramphul, Rajin; *Wadadekar, Yogesh; *Kembhavi, Ajit K., Monthly Notices of the Royal Astronomical Society, Vol. 480, No. 4, pp. 4931-4947.
A SALT spectral study of S0s hosting pseudobulges

[116] *Vasantharaju, N.; Vemareddy, P.; Ravindra, B.; *Doddamani, V. H., 2018, The Astrophysical Journal, Vol. 860, No. 1, 58.
Statistical Study of Magnetic Nonpotential Measures in Confined and Eruptive Flares

[117] Vemareddy, P., 2019, The Astrophysical Journal, Vol. 872, No. 2, 182.
Very Fast Helicity Injection Leading to Critically Stable State and Large Eruptive Activity in Solar Active Region NOAA 12673

[118] Vemareddy, P.; *Demóulin, P., 2018, The Astrophysical Journal, Vol. 857, No. 2, 90.
Study of Three-dimensional Magnetic Structure and the Successive Eruptive Nature of Active Region 12371

[119] *Vidotto, A. A.; *Lichtenegger, H.; *Fossati, L.; *Folsom, C. P.; *Wood, B. E.; Murthy, J.; *Petit, P.; *Sreejith,

A. G.; *Valyavin, G., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 481, No. 4, pp. 5296-5306.
Characterization of the HD 219134 multi-planet system II. Stellar-wind sputtered exospheres in rocky planets b & c

[120] *von Essen, C., et al. (including Lalitha, S.)., 2018, Astronomy & Astrophysics, Vol. 615, A79.
Kepler Object of Interest Network. I. First results combining ground- and space-based observations of Kepler systems with transit timing variations

[121] *Yepez, M. A.; *Arellano Ferro, A.; Muneer, S.; Giridhar, Sunetra., 2018, Revista Mexicana de Astronomía y Astrofísica Vol. 54, pp. 15-36.
The variable star population in the globular cluster NGC 6934

[122] *Yu, W.; *Farrugia, C. J.; *Lugaz, N.; *Galvin, A. B.; *Möstl, C.; *Paulson, K.; Vemareddy, P., 2018, Solar Physics, Vol. 293, No. 12, 165.
The Magnetic Field Geometry of Small Solar Wind Flux Ropes Inferred from Their Twist Distribution

[123] *Zemcov, Michael., et al. (including Murthy, J.)., 2018, Publications of the Astronomical Society of the Pacific, Vol. 130, No. 993, pp. 115001.
Astrophysics with New Horizons: Making the Most of a Generational Opportunity

8.2 Conference Proceedings

[124] Agarwal, Aditi., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 321-324.
Multi-band optical variability studies of Blazars

[125] *Agrawal, S.; *Basak, S.; *Bora, K.; Murthy, J., 2018, 2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI), pp. 1775-1780.
A Comparative Analysis of the Cobb-Douglas Habitability Score (CDHS) with the Earth Similarity Index (ESI)

[126] Ambily, S.; Mathew, Joice; Sarpotdar, Mayuresh; Murthy, J.; *Aggarval, V. K.; *Nagabhushanam, S.; *Rao, Divya A.; *Jeeragal, Sachin; Nirmal, Kaipachery; *Sreejith, A. G.; Gopalakrishnan, Binukumar; Safonova, Margarita., 2018, Space Telescopes and Instrumentation 2018: Ultraviolet to Gamma Ray, Proceedings of the SPIE, Vol. 10699, 106993E.
PIONS: a CubeSat imager to observe variable UV sources

[127] Anche, Ramya M.; Anupama, G. C.; Sriram, S.; Sankarasubramanian, K.; *Skidmore, Warren., 2018, Adaptive Optics Systems VI, Proceedings of the SPIE, Vol. 10703, 107034K.
Estimation of polarization aberrations and its effect on the point spread function of the Thirty Meter Telescope

[128] Anche, Ramya M.; *Packham, Chris; Anupama, G. C.; Sankarasubramanian, K.; Maheswar, G.; *Puravankara, Manoj., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Vol. 10702, 1070298.
The estimation of the instrumental polarization and crosstalk at the focus

of the mid-infrared imaging system for the Thirty Meter Telescope

[129] Banerjee, D.; Patel, R.; Pant, V.; ADITYA Team., 2018, Space Weather of the Heliosphere, Proceedings of the IAU Symposium, Vol. 335, pp. 340-343.
The Inner Coronagraph on Board ADITYA-L1 and Automatic Detection of CMEs

[130] Bhatt, B. C., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 112-116.
Facilities at Indian Institute of Astrophysics and New Initiatives

[131] Chamarthi, Sireesha; Banyal, Ravinder K.; Sriram, S., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Vol. 10702, 1070275.
Estimation of asymmetries in point spread function for the echelle spectrograph operating at Vainu Bappu Telescope for high precision radial velocity studies

[132] *Chand, Hum; Rakshit, Suvendu; *Jalan, Priyanka; *Ojha, Vineet; *Srianand, Raghunathan; *Vivek, Mariappan; *Mishra, Sapna; *Omar, Amitesh; *Kumar, Parveen; *Joshi, Ravi; *Gopal-Krishna; *Kumar, Rathna., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 291-298.
Probing the central engine and environment of AGN using ARIES 1.3-m and 3.6-m telescopes

[133] Das, Mousumi; Rubinur, Khatun; *Kharb, Preeti; *Varghese, Ashlin; *Novakkuni, Navyasree; *James, Atul., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 299-306.
Dual Active Galactic Nuclei in Nearby Galaxies

[134] Das, Tanya; Banyal, Ravinder K.; Kathiravan, S.; Sivarani, T.; Ravindra, B., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Vol. 10702, 107026.
A Development of a stabilized Fabry-Perot based wavelength calibrator for precision Doppler spectroscopy

[135] *Dastidar, Raya; *Kumar, Brijesh; Sahu, D. K; *Misra, Kuntal; *Singh, Mridweeka; *Gangopadhyay, Anjasha; Anapuma, G. C; *Pandey, Shashi Bhushan., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 356-359.
Core-collapse SNe of type IIP and their progenitors: The case study of PNV J01315945+3328458

[136] *Gangopadhyay, Anjasha; *Misra, Kuntal; *Pastorello, Andrea; Sahu, D. K; *Singh, Mridweeka; *Dastidar, raya; Anapuma, G. C; *Kumar, Brijesh; *Pandey, Shashi Bhushan., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 351-355.
Light Curve and Spectral Evolution of Type IIb Supernovae

[137] Jacob, Annu; Parihar, Padmakar; *Divakaran, Sindhu; *James, Melvin K., 2018, Ground-based and Airborne Telescopes VII, Proceedings of the SPIE, Vol. 10700, 107001G.
Aligning and phasing segmented mirror telescope with the pyramid sensor

[138] Kumar, Brajesh; *Pandey, Shashi Bhushan; Pandey, Kanhaiya Lal; Anapuma, G. C; *Surdej, Jean., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 80-87.
Supernovae study: Context of the 4-m International Liquid Mirror Telescope

[139] *Kumar, Brijesh., et al. (including Maheswar, G.)., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 29-41.
3.6-m Devasthal Optical Telescope Project: Completion and first results

[140] Kumar, Varun; Parihar, Padmakar; *Nakulan, Athul; *Manoharan, Arjun., 2018, Ground-based and Airborne Telescopes VII, Proceedings of the SPIE, Vol. 10700, 1070061.
Design considerations of an inductive sensor for segmented mirror telescopes

[141] *Liang, Zhi-Chao; *Gizon, Laurent; *Birch, Aaron C.; *Duvall, Thomas L., Jr.; Rajaguru, S. P., 2018, Catalyzing Solar Connections, 2018 SDO Science Workshop, 59.
Twenty-one-year helioseismic measurement of solar meridional circulation from SOHO/MDI and SDO/HMI: Anomalous northern hemisphere during cycle 24

[142] *Malkov, O. Yu., et al. (including Murthy, J.)., 2018, Stars and Satellites, Proceedings of the Memorial Conference Devoted to A.G. Masevich 100th Anniversary, INASAN Science Proceedings. edited by B. M. Shustov and D. S. Wiebe. Moscow: Yanus-K, pp. 416-423.
Study of interstellar extinction

[143] Mangalam, A; Mageshwaran, T., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 307-315.
Physics and observations of tidal disruption events

[144] Mathew, Joice; Nair, B. G.; Sriram, S.; Kamath, P. U.; Prakash, Ajin; Sarpotdar, Mayuresh; Ambily, S.; Nirmal, K; *Sreejith, A. G.; *Safonova, Margarita; Murthy, J.; *Brosch, Noah., 2018, Space Telescopes and Instrumentation 2018: Ultraviolet to Gamma Ray, Proceedings of the SPIE, Vol. 10699, 106992V.
Opto-mechanical assembly and ground calibration of LUCI

[145] *Mishra, Alka; *Kantharia, Nimisha G.; Das, Mousumi., 2018, 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 365-370.
Giant Low Surface Brightness Galaxies

[146] Nagaraju, K.; Phanindra, D. V. S.; *Krishna Prasad, S.; *Shankar Rao, D. S.; Sreekumar, P., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Volume 10702, 107024X.
Full Stokes polarimetry using dual-frequency liquid crystals

[147] Nirmal, K.; Sridharan, R.; Sriram, S.; Ambily, Suresh; Mathew, Joice; Sarpotdar, Mayuresh; Murthy, J.; Gopalakrishnan, Binukumar; *Safonova, Margarita., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Volume 10702, 107024V.
Wavelength calibration of a tunable spatial heterodyne spectrometer

[148] Parihar, Padmakar; Deshmukh, Prasanna; Jacob, Annu; Kumar, Varun; Goudar, Abhishek; Sriram, S.; Nagabhusan, S.; Amitkumar, S.; Govinda, K. V.; Sandeep, D. S.; Kemkar, P. M. M.; Anupama, G. C., 2018, Ground-based and Airborne Telescopes VII, Proceedings of the SPIE, Vol. 10700, 107001A.
Prototype segmented mirror telescope: a pathfinder of India's Large Optical-NIR telescope project

[149] *Pradhan, Bikram; *Delchambre, Ludovic; *Hickson, Paul; *Akhunov, Talat; *Bartczak, Przemyslaw; Kumar, Brajesh; *Surdej, Jean., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 88-91.
Present status of the 4-m ILMT data reduction pipeline: application to space debris detection and characterization

[150] Rakshit, Suvendu; Stalin, C . S; *Chand, Hum; *Zhang, Xue-Guang., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 379-386.
Properties of Narrow line Seyfert 1 galaxies

[151] Safonova, Margarita., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 360-364.
Gravitational Lensing and Microlensing in Clusters: Clusters as Dark Matter Telescopes

[152] Sagar, Ram., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 391-397.
Scientific Summary of the First BINA Workshop

[153] Singh, Raghubar; Reddy, B. E., 2018, Astrometry and Astrophysics in the Gaia sky, Proceedings of the IAU Symposium, Vol. 330, pp. 348-349.
Understanding Li enhancement in K giants and role of accurate parallaxes

[154] Sriram, S.; Kumar, Amit; Surya, Arun; Sivarani, T.; Giridhar, Sunetra; Kathiravan, S.; Anand, M. N.; *Jones, Damien; *Grobler, Deon; *Jakobsson, Robert; Chanumolu, Anantha; Unni, Athira; Dorje, Angchuk; Dorje, Tsewang; Gyalson, Tsewang., 2018, Ground-based and Airborne Instrumentation for Astronomy VII, Proceedings of the SPIE, Vol. 10702, 107026K.
Hanle echelle spectrograph: design and performance

[155] *Surdej, Jean., et al. (including Kumar, Brajesh; Sagar, Ram.)., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 68-79.
The 4-m International Liquid Mirror Telescope

[156] Surya, Arun; *Radovan, Matthew; Thirupathi, Sivarani; Sriram, S.; Divakar, Devika; *Fucik, Jason., 2018, Modeling, Systems Engineering, and Project Management for Astronomy VIII, Proceedings of the SPIE, Volume 10705, id. 107051G.
Flexure compensation simulation tool for TMT-WFOS Spectrograph

[157] *Thakur, Parijat; *Mannaday, Vineet Kumar; *Jiang, Ing-Guey; Sahu, D. K; *Chand, Swadesh., 2018, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, Vol. 87, pp. 132-136.
Investigating Extra-solar Planetary System Qatar-1 through Transit Observations

[158] *Theophilus, A.; *Saha, S.; *Basak, S.; Murthy, J., 2018, 2018 IEEE Symposium Series on Computational Intelligence (IEEE SSCI), pp. 2139-2147.
A Novel Exoplanetary Habitability Score via Particle Swarm Optimization of CES Production Functions

[159] *Valsan, Vineeth; Sriram, S.; Basheer, Alikhan; Varadhachari, Janani; Anupama, G. C., 2018, Optical Manufacturing and Testing XII, Proceedings of the SPIE, Vol. 10742, 1074210.
Sensitivity and tolerance analysis of 2D Profilometer for TMT primary mirror segments

Table 8.1: **Number of publications over the past five years**

Year	Published in Journals	Published in Proceedings	Total
2014–15	128	29	157
2015–16	120	31	151
2016–17	106	23	129
2017–18	129	3	132
2018–19	123	36	159
Total	606	122	728

8.3 Technical Reports, Monographs, Circulars, ATel

[160] A. Singh, S. Srivastav*, B. Kumar, H. Kumar*, V. Bhalerao*, G.C. Anupama, D.K. Sahu, 2018 ATel 11759, 1.
AT2018cow: HCT spectroscopic follow-up

[161] A. Singh, V. Bhalerao*, G.C. Anupama, C. Mondal, S. Sahu, 2018 ATel 11822, 1.
AstroSat UVIT Observations of AT2018cow

[162] A. Singh, B. Kumar, D.K. Sahu, G.C. Anupama, S.B. Pandey*, V. Bhalerao*, 2019 GCN 23798, 1.
GRB 190114C: Optical follow-up from HCT

[163] B. Kumar, S. Srivastav*, A. Singh, H. Kumar*, V. Bhalerao*, G.C. Anupama, D.K. Sahu, 2018 ATel 11748, 1.
AT2018cow - HCT spectroscopy

[164] B. Kumar, S.B. Pandey*, A. Singh, D.K. Sahu, G.C. Anupama, P. Saha, 2019 GCN 23742, 1.
GRB 190114C: Optical detection from HCT

[165] B. Kumar, A. Singh, A. Raj, S.B. Pandey*, D.K. Sahu, G.C. Anupama, 2019 GCN 23853, 1.
GRB 190202A: R and I band observation from HCT

[166] Brajesh Kumar, Avinash Singh, D.K. Sahu, G.C. Anupama, 2019, ATel, 12383, 1.
GRB 181201A : Optical observations from HCT

[167] H. Kumar*, S. Srivastav*, U. Stanzin, T. Stanzin, V. Bhalerao*, G.C. Anupama, 2018 ATel 12324, 1.
Blazar BZQJ0348-2749 - GROWTH India optical follow-up

[168] H. Kumar*, S. Srivastav*, T. Stanzin, V. Bhalerao*, G.C. Anupama, 2018 ATel 12332, 1.
ATLAS18bcde (AT2018kpo) follow-up from GROWTH-India

[169] H. Kumar*, S. Srivastav*, G. Waratkar*, T. Stanzin, V. Bhalerao*, G.C. Anupama, 2019 GCN 23733, 1.
GRB190114C: GROWTH-India detection of optical afterglow

[170] H. Kumar*, S. Srivastav*, G. Waratkar*, T. Stanzin, V. Bhalerao*, G.C. Anupama, 2019 GCN 23874, 1.
GRB190202: GROWTH-India detection of optical afterglow

[171] H. Kumar*, G. Waratkar*, S. Srivastav*, T. Stanzin, V. Bhalerao*, G.C. Anupama, 2019, GCN 23896, 1.
GRB190211: GROWTH-India detection of optical afterglow

[172] M. Pavana, B.S. Kiran, D.S. Sujith, G.C. Anupama, 2018, ATel, 12195, 1.
Recurrent Nova M31N-2008-12a: Optical Spectroscopy of the 2018 Outburst

[173] S. Srivastav*, A. Singh, B. Kumar, H. Kumar*, V. Bhalerao*, G.C. Anupama, D.K. Sahu, A. Bandyopadhyay, 2018 ATel 11766, 1.
AT2018cow: further follow-up with the HCT

[174] S. Srivastav*, M. Pavana, U. Stanzin, T. Stanzin, G.C. Anupama, V. Bhalerao*, 2018 ATel 12203, 1.
M31N-2008-12a follow-up with GROWTH-India telescope

[175] Viraj Karambelkar*, Harsh Kumar*, Shubham Srivastav*, Gaurav Waratkar*, Urgain Stanzin, Varun Bhalerao*, G.C. Anupama, 2019, ATel, 12476, 1.
Photometric follow-up of AT2019ahd (ATLAS19car) with GROWTH-India

[176] Viraj Karambelkar*, Harsh Kumar*, Gaurav Waratkar*, Shubham Srivastav*, Urgain Stanzin, Varun Bhalerao*, G.C. Anupama, 2019, ATel, 12570, 1.
Photometric follow-up of blazar TXS 1515-273 with GROWTH-India

8.4 HCT Publications by non-IIA Users

[177] Dutta, Somnath; Mondal, Soumen; Joshi, Santosh; Jose, Jessy; Das, Ramkrishna; Ghosh, Supriyo., 2018, Monthly Notices of the Royal Astronomical Society, Vol. 476, No. 2, pp. 2813-2824.
Optical photometric variable stars towards the Galactic H II region NGC 2282

[178] Ghosh, Supriyo; Mondal, Soumen; Das, Ramkrishna; Banerjee, D. P. K.; Ashok, N. M.; Hambsch, Franz-Josef; Dutta, Somnath., 2018, The Astronomical Journal, Vol. 155, No. 5, 216.
Phase-dependent Photometric and Spectroscopic Characterization of the MASTER-Net Optical Transient J212444.87+321738.3: An Oxygen-rich Mira

[179] Grimm, S. L., et al., 2018, Astronomy & Astrophysics, Vol. 613, A68.
The nature of the TRAPPIST-1 exoplanets

[180] Hsieh, H. H., et al., 2018, The Astronomical Journal, Vol. 156, No. 5, 223.
The 2016 Reactivations of the Main-belt Comets 238P/Read and 288P/(300163) 2006 VW139

[181] Molina, R. E.; Pereira, C. B.; Arellano Ferro, A., 2018, Astronomische Nachrichten, Vol. 339, No. 680, pp. 680-697.
Chemical composition of post-AGB star candidates

[182] Mondal, A.; Das, R.; Shaw, G.; Mondal, S., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 483, No. 4, pp. 4884-4992.
A photoionization model grid for novae: estimation of physical

[183] Paswan, A.; Omar, A.; Jaiswal, S., 2019, Monthly Notices of the Royal Astronomical Society, Vol. 482, No. 3, pp. 3803-3821.
Optical spectroscopy of star-forming regions in dwarf Wolf-Rayet galaxies

9 Colloquia/ Seminars Given By Visitors

9.1 Colloquia

17 April 2018
Gravity and Decoherence
Joseph Samuel
Raman Research Institute, Bengaluru

15 May 2018
Cell division and cell death: two sides of a random coin?
Mukund Thattai
National Centre for Biological Sciences, Bengaluru

19 June 2018
Tigers on islands
Uma Ramakrishnan
National Centre for Biological Sciences, TIFR, Bengaluru

24 July 2018
Diffuse Radio Emission in Galaxy Clusters
K. S. Dwarakanath
Raman Research Institute, Bengaluru

26 July 2018
Not-so-simple stellar populations in nearby, resolved massive star clusters
Richard de Grijs
Macquarie University, Sydney

02 August 2018
Observational Aspects of Triggered Star Formation in the Milky Way
Devendra Ojha
Tata Institute of Fundamental Research, Mumbai

08 October 2018
Time stamping starbursts in interacting galaxies with SALT and other telescopes
Petri Vaisanen
South African Astronomical Observatory

11 December 2018
Virtual Water Trade and Water Sustainability: A Regional and Global Scenario
Prashant Goswami
CSIR, National Institute of Science, Technology and Development Studies, New Delhi

22 January 2019
Probing the Solar Structure and Dynamics
H. M. Antia
Tata Institute of Fundamental Research, Mumbai, India

23 January 2019
Planck cosmological legacy: Highlights
Francois R. Bouchet
Institute of Astrophysics, Paris

01 February 2019
KPZ story
Satya N. Majumdar
Laboratoire de Physique Theorique et Modeles Statistique, Paris

9.2 Seminars

02 April 2018
Flows and magnetic fields associated with rapid and slow penumbral decay
Meetu Verma
Leibniz-Institut für Astrophysik Potsdam (AIP), Germany

19 April 2018
A Viable Scenario for Inflationary Magnetogenesis
T. R. Seshadri
Department of Physics and Astrophysics, University of Delhi

20 April 2018
Alfvén Wave Dissipation in the Solar Atmosphere
David Jess
Queen's University Belfast, UK

03 May 2018
Whither Dark Matter Search?
Pijushpani Bhattacharjee
Saha Institute of Nuclear Physics, Kolkata

18 May 2018
Star Formation Scenario in Wolf-Rayet Galaxies
Abhishek Paswan
ARIES, Nainital

11 June 2018
Decoding cosmic fingerprints: constraining the generation and evolution of primordial fluctuations
Dhiraj Kumar Hazra
Istituto Nazionale Di Fisica Nucleare, Bologna, Italy

09 July 2018
Chemical Characterization of Extrasolar Planets
Nikku Madhusudhan
Institute of Astronomy, University of Cambridge, UK

16 July 2018
Looking for Primordial Black Holes in the CMB
Vivian Poulin
Johns Hopkins University

20 July 2018
A Data Scientific Exploration of SDSS-GALEX Cross-matched Data
Suryoday Basak
PES University

07 August 2018
Exploring the brighter end of Supernovae luminosity distribution
Subhash Bose
Kavli Institute for Astronomy and Astrophysics, Peking University, China

21 August 2018
Science with the Upgraded SMA in the Next Decade
Ramprasad Rao
ASIAA / SMA Hawaii

14 September 2018
Solar magnetism and its effects on surface gravity modes: Implications for space weather
Nishant K. Singh
Max Planck Institute for Solar System Research, Göttingen, Germany

24 October 2018
Stellar stream substructures – Important Galactic Archaeological Tools for the Milky Way Galaxy
Khyati Malhan
University of Strasbourg, France

26 October 2018
Nature of Sources that reionized the Universe
Mahavir Sharma
ICC, Durham University, UK

12 November 2018
How big is the Sun as viewed from space? Would it be a pulsating star?
Jean Pierre Rozelot
Université de la Côte dÁzur OCA Departement

19 November 2018
Gas-galaxy connection at low and high redshift
Ravi Joshi
Kavli Institute for Astronomy and Astrophysics, Beijing

26 November 2018
Probing neutron stars and their environments in the Galactic neighbourhood
Chandrayee Maitra
Max Planck Institute for Extraterrestrial Physics, Garching

27 November 2018
Cosmic-ray origin and propagation: Implication from new measurements and future perspectives
Satyendra Thoudam
Department of Physics and Electrical Engineering, Linnaeus University, Sweden

30 November 2018
Kilohertz to Zetahertz Emission from the Sun: Evidence of Shock Source from Fermi, Wind, and SOHO Observations
Nat Gopalswamy
NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

17 December 2018
Observations of hot Jupiters in Ultraviolet wavelengths and their significance
Sreejith A. G.
Space Research Institute, Austrian Academy of Sciences, Graz

17 December 2018
Direct Observation of the Origin of Solar Spicules and their role in Coronal Heating
Tanmoy Samanta
Peking University, China

18 December 2018
Observing the transients Universe: the SALT and future programmes
David Buckley
SAAO, Capetown

20 December 2018
Masses and Densities of Nuclear Star Clusters in the Nearest Galaxies
Renuka Pechetti
University of Utah

20 December 2018
Non-equilibrium energy transfer in the solar chromosphere
L. S. Anusha
Max Planck Institute for Solar System Research, Göttingen, Germany

27 December 2018
MUSEQuBES CGM Surveys: From Low-z Star-forming Galaxies to High-z Lyman-alpha Emitters
Sowgat Muzahid
Leiden Observatory, Leiden

10 January 2019
Cosmic rays from pulsars
Tanvi Karwal
John Hopkins University

10 January 2019
Properties of Chromospheric Magnetic Field of Sunpots
Jayant Joshi
Rosseland Center for Solar Physics, Institute of Theoretical Astrophysics, University of Oslo

11 January 2019
The missing link between superstellar clusters and globular clusters
Divakara Mayya
INAOE, Mexico

01 February 2019
HERA: Probing the EoR power spectrum with a redundant array
Deepthi Gorthi
University of California, Berkeley, USA

13 February 2019
Exploring Galactic Lithium evolution with LAMOST
Bharat Kumar Yerra
NAOC, Beijing, China

25 February 2019
Investigating missing energy in the solar corona using a 3D MHD model
Vaibhav Pant
CmPA, KU Leuven, Belgium

27 February 2019
The VISTA view of the Magellanic Clouds
Cameron Bell
Leibniz Institute for Astrophysics, Potsdam, Germany

22 March 2019
Neutron star mergers and the origin of heavy elements in the Universe
Masaomi Tanaka
Astronomical Institute, Tohoku University, Japan

28 March 2019
How relativistic jets from AGNs affect the host galaxy
Dipanjan Mukherjee
University of Torino, Torino, Italy

9.3 Special Lectures

09 July 2018
Awareness about Gender Amity, Role of Employer and Committee in Prevention of Sexual harassment – a few case studies
S. K. Srivastava
Chief Administrative Officer (Retired) LRDE, DRDO, Govt of India, Ministry of Defence, Bengaluru

06 October 2018
Black Holes, Neutron Stars and Gravitational Waves
Roger D. Blandford
KIPAC, Stanford University, Stanford CA, USA

08 January 2019
The Search for Extra-Terrestrial Unintelligence
Jonathan Tennyson
University College, London, UK

08 March 2019
Archaeometric and archaeotechnological insights on bronzes from southern India
Sharada Srinivasan
NIAS, Bengaluru

10 Miscellaneous

10.1 Official Language Implementation (OLI)

OLIC Meeting

Four meetings were conducted in the Institute on 04-06-2018, 28-09-2018, 27-12-2018 & 27-02-2019 and the reports were sent to the Dept of Science & Technology, New Delhi and the Member Secretary, TOLIC, Bengaluru.

Hindi Workshop

In order to implement Official Language in the Institute and to improve the official work in Hindi by the staff members, four Hindi Workshops were conducted for the employees working in Administrative section on 28-06-2018, 11-09-2018, 20-12-2018 and 27-03-2019.

Hindi Day/ Fortnight Celebration

The Institute celebrated the Hindi Fortnight from September 14 to September 30, 2018. During the occasion seven competitions were conducted in the Institute, namely 'Hindi Supatan' competition on September 17, 'Hindi Sulekh' competition on September 18, 'Hindi Song' competition on September 19. 'Hindi Dictation' competition on September 20, 'Memory Power' competition on September 24, 'Hindi-English Noting' competition on September 25, and 'Hindi Antakshari' competition on September 26. 'Hindi Pakwada' closing ceremony was observed on December 3, 2018 in the Institute. Dr B. Raghavendra Prasad, Senior Professor presided over the function. Mr Shripathi K., Administrative Officer was present on the occasion. Smt. S. Vasumathi, Deputy Administrative Officer gave welcome speech. Prof. Prasad addressed the audience and congratulated all the employees for their efforts towards accomplishing their official work in Hindi. He also distributed cash prizes to the winners. Dr S. Rajanatesan, Section Officer (Hindi) read the Official Language implementation activity report. The function was concluded with a vote of thanks.

Two Hindi competitions were conducted, namely 'Hindi-English Noting' competition and 'Hindi Supatan' competition on October 23, 2018 at VBO, IIA, Kavalur. Similarly, two Hindi competitions were conducted, namely 'Hindi Supatan' competition and 'Hindi Sulekh' competition on October 25 & October 26, 2018 respectively at IIA, Kodaikanal. Cash awards were given to the winners to encourage them and to motivate other staff members to participate in the Hindi implementation activities.

10.2 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 12%, 13% & 14% 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.

10.3 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 Handbook on 'Sexual Harassment of Women at Workplace' is available at the Institute's website https://www.iiap.res.in/files/Handbook_on_Sexual_Harassment_of_Women_at_Workplace.pdf. Similarly an intranet web page on Gender Issues is made available at https://www.iiap.res.in/intranet/gender.

An event in connection with the International Women's day was organised at the Institute on 8th March, 2019. Ms Sharada Srinivasan, Padma Shri awardee (2019), NIAS, Bengaluru delivered a special lecture titled '*Archaeometric and archaeotechnological insights on bronzes from southern India*'.

Internal Complaints committee conducted a meeting at the Koramangala campus on 04 March 2019 and Gender Amity Cell convened on 19 March 2019 and reviewed various arrangements made to promote greater gender awareness in the Institute.

11 People

Director: P. Sreekumar (up to 30.06.2018)

Director (Acting) & Senior Professor: Jayant Murthy

Academic & Scientific Staff

Senior Professor: G. C. Anupama, R. K. Chaudhuri, B. Raghavendra Prasad

Professor: Annapurni Subramaniam, Arun Mangalam, Aruna Goswami, Dipankar Banerjee, B. Eswar Reddy, R. T. Gangadhara, K. M. Hiremath (up to 31.05.2018), P. S. Parihar, Prajval Shastri (up to 30.09.2018), K. P. Raju, R. Ramesh, D. K. Sahu, S. K. Sengupta

Associate Professor: B. C. Bhatt, Gajendra Pandey, C. Kathiravan, Maheswar Gopinathan, Mousumi Das, S. Muneer, Muthumariappan, S. Paul Kaspar Rajguru, Pravabati Chingangbam, B. Ravindra, M. Sampoorna, Sivarani Thirupathi, C. S. Stalin, Umanath S. Kamath

Reader: E. Ebenezer Chellasamy, Firoza Sutaria, Nagaraju. K., Piyali Chatterjee, Ravinder Kumar Banyal, Sharanya Sur, Subinoy Das

Assistant Professor: Smitha Subramanian

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

Scientist C: G. Selvakumar, G. S. Suryanarayana

Scientist B: Namgyal Dorjey

Research Associate B: M. Appakutty (up to 31.05.2018)

Adjunct Scientist: K. Sankarasubramanian

Adjunct Professor: A. N. Ramaprakash

Visiting Professor: K. V. Govinda

Visiting Scientist: Margarita Safonova

Honorary Professor: P. Sreekumar, S. N. Tandon

Consultant: C. H. Basavaraju, Jagdev Singh, Lt. Col Kuldip Chandar, P. Umesh Kamath, Viswanatha Narasimhaiah

Post Doctoral Fellow: Arun Surya, Ashish Raj, Bala Sudhakara Reddy. A., Bari Maqbool, Binukumar, Dipen Sahu, Hema B. P, Kanhaiya Lal Pandey, Koshy George, Rahna. T., Sumana Nandi, Vineeth Valsan

Technical staff

Engineer F: G. Srinivasulu (up to 30.04.2018)

Engineer E: Amit Kumar, V. Arumugam, Faseehana Saleem (up to 28.02.2019), S. Kathiravan, P. M. M. Kemkar, P. K. Mahesh, S. Nagabushana, R. Ramachandra Reddy (up to 13.10.2018), M. V. Ramaswamy, B. Ravikumar Reddy, S. Sriram

Engineer D: P. Anabazhagan, Dorje Angchuk, Sanjiv Gorka, K. C. Thulasidharen, Tsewang Dorjai, P. Umesh Kamath (up to 28.02.2019)

Principal Scientific Officer: R. Selvendran

Engineer C: Anish Parwage, K. Anupama, K. Dhananjay (up to 26.05.2018), V. S. Gireesh Gantyada, D. V. S. Phanindra, A. Ramachandran, S. Ramamoorthy, K. Ravi (up to 20.03.2019), Sai Prabhath Deevi (up to 26.04.2019), Sonam Jorphail, Tashi Thsering Mahay, Vellai Selvi

Librarian: Arumugam Pitchai

Engineer B: Chinchu Mohanan. K, Indrajit V. Barve, Mallappa, Manoj Kumar Gubbala, M. Rajalingam, Totan Chand, Tsewang Gyalson, Vinay Kumar Gond

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

Technical Associate B: P. Kumaravel, K. Sagayanathan, S. Venkateshwara Rao

Sr. Technical Assistant C: R. Ismail Jabillullah, A. Muniyandi (up to 30.06.2018)

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

Research Associate B: V. Moorthy

Research Associate: C. Velu

Technical Assistant C: D. Premkumar, V. Robert (up to 31.05.2018)

Technical Associate: P. R. Sreeramulu Nayaka

Sr. Mechanical Assistant B: N. Thimmaiah

Sr. Technical Assistant B: Phuntsok Dorjay

Administrative staff

Administrative Officer: Shripathi. K

Accounts Officer: S. B. Ramesh

Deputy Administrative Officer: Vasumathi. S

Staff Officer: Pramila Mohan (up to 30.09.2018)

Stores & Purchase Officer: K. P. Vishnu Vardhan

Section Officer (SG): Maliny Rajan, N. K. Pramila (up to 31.12.2018), N. Sathya Bama, Uma Maileveloo

Section Officer: Diskit Dolker, Ramaswamy, P. Selvakumar, Srinivasa Rao. V., V. Vijayaraj

Section Officer (Hindi): S. Rajanatesan

12 Auditors' Report & Statement Of Accounts

Gireesha Vijayan & Associates
CHARTERED ACCOUNTANTS

Cell : 9880004161
Tel : 080-4144 0645

No. 2012, Ground Floor, High point 2,
Next to Hotel Chalukya, Bangalore - 560 001.
E-mail : cagvassociates@gmail.com / gireeshatl@yahoo.com

Independent Auditor's Report

To

The Members of the INDIAN INSTITUTE OF ASTROPHYSICS,

Report on the Financial Statements

Opinion

We have audited the accompanying financial statements of **INDIAN INSTITUTE OF ASTROPHYSICS** which comprises the Balance Sheet as at March 31, 2019, the Statement of Income & Expenditure Account and statement of receipts and Payments Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies and other explanatory information.

Responsibility of Management for the Standalone Financial Statements

The Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance in accordance with the accounting principles generally accepted in India, "This responsibility also includes maintenance of adequate accounting records and safeguarding of the assets of the Institute and for preventing and detecting frauds and other irregularities; selection and application of appropriate implementation and maintenance of 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 statement that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with Standards on Auditing will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

Opinion,

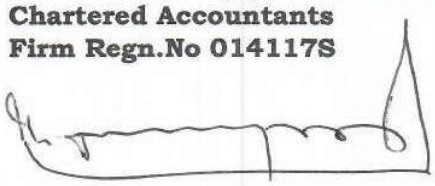
In our opinion, and to the best of Our Information and according to the explanations given to us, the aforesaid financial statements give the information required and give a true and fair view in conformity with the accounting principles generally accepted in India.

a. In case of Balance sheet, of the state of affairs of the Institute as at 31st march 2019:
b. In case of statement of Income & expenditure Account, of Excess of Expenditure over Income for the year ended on that date;
c. In case of receipts and payments account for the year ended on that date;

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 purpose of our Audit.
b. In our opinion, proper books of account as required by law have been kept by the Company so far as it appears from our examination of those books.
c. The Balance Sheet, the Statement of Income & Expenditure Account and the Receipts and Payments Account dealt with by this Report are in agreement with the books of account.

For Gireesha Vijayan & Associates
Chartered Accountants
Firm Regn.No 014117S



Vijayan.G.
Partner.
M.No.036348.

Place: Bangalore.
Date: 31/07/2019.

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU
BALANCE SHEET AS AT 31ST MARCH 2019

Amt. In Rupees

	Sch	Current Year	Previous Year
CORPUS/CAPITAL FUND AND LIABILITIES			
Corpus/Capital Fund	1	787,999,083	729,499,716
Reserves & Surplus	2	-	-
Earmarked & Endowment Funds	3	308,604,381	603,737,069
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6		-
Current Liabilities & Provisions	7	23,025,529	21,939,876
TOTAL		**1,119,628,993**	**1,355,176,661**
ASSETS			
Fixed Assets	8	764,957,426	697,215,006
Investments- from earmarked & endowment funds	9	-	-
Investments-Others	10		-
Current Assets, Loans & Advances	11	354,671,567	657,961,655
TOTAL		**1,119,628,993**	**1,355,176,661**

S. Vasumathi
(VASUMATHI S)
Accounts Officer

(SHRIPATHI.K)
Administrative Officer

(JAYANT MURTHY)
Director

As per our report of even date
for Gireesha Vijayan Associates
Chartered Accountants
FRN 014117S

(VIJAYAN.G)
Partner
M No.036348

Date: 31.07.2019
Place :Bengaluru

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2019

Amt. in Rupees

	Sch	Current Year	Previous Year
INCOME			
Income from Sales/Services	12	-	-
Grants/Subsidies	13	657,477,000	489,913,000
Fee/Subscriptions	14	449,705	378,980
Income from Investments (earmarked/endowment funds)	15		-
Income from Royalty, Publication etc.	16		-
Interest Earned	17	4,864,224	10,031,488
Other Income	18	4,651,759	3,868,380
Increase/Decrease in stock of finished goods	19	-	-
TOTAL (A)		**667,442,688**	**504,191,848**
EXPENDITURE			
Establishment Expenses	20	463,341,509	348,104,373
Other Administrative Expenses	21	177,734,945	179,346,240
Expendtiture on Grants/Subsidies etc.	22	-	-
Interest	23	-	-
Depreciation (Net Total at the year end as per Schedule 8)		64,472,071	60,173,530
TOTAL (B)		**705,548,525**	**587,624,143**
Balance being Surplus/(Defecit) Carried to Corpus/Capital Fund		**-38,105,837**	**-83,432,295**
Significant Accounting Policies	24		
Contingent Liabilities and Notes on Accounts	25		

(VASUMATHI S)
Accounts Officer

(SHRIPATHI.K)
Administrative Officer

(JAYANT MURTHY)
Director

As per our report of even date
for Gireesha Vijayan Associates
Chartered Accountants
FRN 014117S

(VIJAYAN. G)
Partner
M No.036348

Date: 31.07.2019
Place :Bengaluru

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

RECEIPTS AND PAYMENTS STATEMENT FOR THE YEAR ENDED MARCH 31, 2019

Amt. in Rupees

Receipts	Current year 18-19	Previous year 17-18	Payments		Current year 18-19	Previous year 17-18
I.Opening Balances			**I.Expenses**			
a) Cash in hand	95,281	120,874	a) Establishment Exp (Sch.20)		463341509	348,104,373
b) Bank Balances			b) Admin Expenses (Sch 21)		177734945	179,346,236
i) in current accounts	3,552,497	2,127,199				
ii) in deposit accounts	602,894,175	-	**II.Payments made against projects**		563,634,148	603,685,321
iii) in savings accounts		803,182,077	**III.Investments made UVIT & Aditya Pmts**			
iv) in Stamps (Franking M/C)		-	a) Out of Earmarked/End. Funds			-
II.Grants Received			b) Out of own funds		-	-
a) From Govt. of India		-				
i) Capital Grants	96,605,200	89,816,000	**IV.Increase in Current Assets**		495818	53,282,715
ii) Recurring Grants	657,477,000	489,913,000	**V.Capital Expenditure**			
b) From State Govt.		-	a) Purchase of fixed assets		13,493,778	76,169,421
c) From other sources		-	b) Expenditure on Work-in-progress		118,720,713	23,770,219
			VI.Refund of surplus money/Loans			
III.Project Receipts	268,501,460	448,116,468	a) To the Govt. of India			-
V.Increase in Current Liabilities	3,577,391	17,216,110	b) To the State Govt.			-
VI.Decrease in Current Assets	41,810,898	33,875,042	c) To other providers of funds			-
VII.Interest Received						
a) On Bank deposits	4,021,387	8,618,259	**VII.Finance Charges (Interest)**			
b) on Loans, Advances etc.	842,837	1,413,229	**VIII.Decrease in Current Liabilities**		2491735	7,745,381
			IX.Closing Balances:			
VIII.Other Income (Specify)		-	a) Cash in hand		70,876	95,281
IX.Amount Borrowed		-	b) Bank Balances			-
X.Any other receipts	5,101,464	4,247,360	i) current account	IIA	5,268	3,552,497
			ii) savings account		221,017,232	602,894,175
			UVIT		1,150,910	-
			ADITYA		122,322,658	
TOTAL	**1,684,479,590**	**189,86,45,618**	**TOTAL**		**168,44,79,590**	**189,86,45,618**

(VASUMATHI S)
Accounts Officer

(SHRIPATHI.K)
Administrative Officer

(JAYANT MURTHY)
Director

As per our report of even date
for Gireesha Vijayan Associates
Chartered Accountants
FRN 014117S

(VIJAYAN.G)
Partner
M No.036348

Date: 31.07.2019
Place :Bengaluru

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year		Previous Year	
Schedule 1- Corpus/Capital Fund				
Balance as at the beginning of the year	729499720	-	723,116,011	
Add: Capital Grants	96605200	826,104,920	89,816,000	812,932,011
Add/Deduct: Balance of net Income/(Expenditure) transfer from the Income & Expenditure Account	-38,105,837	-38,105,837	-83,432,295	-83,432,295
Balance as at the Year End		**787,999,083**		**729,499,716**

	Current Year		Previous Year	
Schedule 2 - Reserves & Surplus				
1, Capital Reserve:				
As Per last Account	-		-	
Addition during the year	-		-	
Less: Deduction during the year	-	-	-	-
2, Revaluation Reserve:				
As Per last Account	-		-	
Addition during the year	-		-	
Less: Deduction during the year	-	-	-	-
3, Special Reserve:				
As Per last Account	-		-	
Addition during the year	-		-	
Less: Deduction during the year	-	-	-	-
4, General Reserve:				
As Per last Account	-		-	
Addition during the year	-		-	
Less: Deduction during the year	-	-	-	-
Balance as at the Year End		-		-

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

Schedule 3- Earmarked/Endowment / Project Funds

Sl No	Funding Agency	Project Name	Opening Balance (2018-19)	Received during the year	Utilisation			Total Utilisation	Balance as on 31/03/2019
					Capital Expenditure	Revenue Expenditure	Advances/LC		
		Funded by Government Agencies							
1	DAE	DAE - TMT		100,809,822		90,146,083	-	90,146,083	10,663,739
2	DST	DST - TMT	388009126	132,584,574		380,808,837	-	380,808,837	139,784,863
3		DST - GSMT	15609006				-	-	15,609,006
4		DST Indo-South Africa (P04) - P.Parihar	501594				-	-	501,594
5		DST Indo-Polish (P05) - C S Stalin	392370				-	-	392,370
6		DST INDO-BELGIUM (P3) - D Banerjee	41155				-	-	41,155
7		DST INSPIRE(15275) - Vema Reddy	-140848	1,324,324		1,299,369	-	1,299,369	-115,893
8		DST INSPIRE (1478) - Lalitha Sairam	-142626	1,421,888		205,740	-	205,740	1,073,522
9		DST - Annapurni S	0				-	-	-
10		DST-JSPS (P211) - G C Anupama	0			-	-	-	
11		DST-JSPS (P218) D.K. Sahu		234,400		21,190		21,190	213,210
12		IDST INDO-UK UKIERI - D Banerjee	-78440				-	-	-78,440
13		DST - G C Anupama	11628				-	-	11,628
14		INDO-SWISS PEP - C S Stalin	0				-	-	-
15		DST N-PDF (1563) - Brajesh Kumar	212430	817,389		871,022	-	871,022	158,797
16		DST N-PDF (2648) - Aditi Agarwal	285147	868,590		952,838	-	952,838	200,899
17		DST-WOS (83) - Maya Prabhakar	348865	202,214	90,750	443,217	-	533,967	17,112
18		INDO-RUSSIAN (265) - Jayant Murthy	342458	6,849			-	-	349,307
19		DST-Smitha-Ramanujan Fellowship		760,000		93,094	-	93,094	666,906
20		Indo-German - Lalitha Sairam	479153				-	-	479,153
21		DST-DAAD-Annapurni S		301,540		226,278	-	226,278	75,262
22		INSIST-ISRO-Annapurni S		3,000,000				-	3,000,000
23		DST-SERB-Arun Mangalam		1,190,500				-	1,190,500
24		DST-Aruna Goswami - EMR		648,819		252,483		252,483	396,336
25		BRICS-MuMeSTU-D.K.Sahu		335,000				-	335,000
26		Newton Bhaba Phd Placement- Annapurni		126,000				-	126,000
27		Sharanya SUR		665462		56,321	-	56,321	609,141
28		BRICS - D Banerjee		1058107		846,561	-	846,561	211,546
29	ISRO	ISRO Aditya	184042271	17,015,863	66,560,682	12,174,794	-	78,735,476	122,322,658
30		ISRO (ARFI)- G C Anupama	1350601				-	-	1,350,601
31		ISRO UVIT	1192354	60,626		102,070	-	102,070	1,150,910
32	IUSSTF	IUSSTF PIRE GROWTH - G C Anupama	4839487	55,000		2,809,417	-	2,809,417	2,085,070
33		IUSSTF -Solar Coronal - P Sreekumar	98456			166,400	-	166,400	-67,944
34		IUSSTF-Mousumi DAS JC-014		405,571		309,970		309,970	95,601
35	SERB	SERB (1450) - Jayant Murthy	4084658	95,263		909,002	-	909,002	3,270,919
36		SERB (941) - Ravindra Banyal	1493048	484,764		265,593	-	265,593	1,712,219
37		SERB (124) - Rajat Chaudhury	920985	224,708	12,400	78,150	-	90,550	1,055,143
38		SERB (2470) - Gajendra Pandey	107406			458,070	-	458,070	-350,664
39		SERB - HEP - 010/2013 - A Goswami	687628	200,000		887,628	-	887,628	-
40		SERB - Kodai Digi (625) - D Banerjee	-645489	1,400,000		754,511	-	754,511	-
41		SERB - P Shalima	-18039				-	-	-18,039
42		SERB- MATRICS Pravabati		220,000		20,000		20,000	200,000
43	CSIR	CSIR [03/890(005)] N Sindhu	-422387			20,000		20,000	-442,387
44	NASI	NASI - Ram Sagar	-28709	920,000		888,765	-	888,765	2,526
45		NASI - Amit Mondal	-381550	873,600		429,000	-	429,000	63,050
46	IAU	IAUS 340 - D Banerjee	545331.03	190,587		473,913	-	473,913	262,005
		TOTAL	**603737069**	**268,501,460**	**66,663,832**	**496,970,316**	-	**563,634,148**	**308,604,381**

Girdhar Vijayan & Associates Chartered Accountants FRN 01[illegible]17S

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year		Previous Year	
Schedule 4- Secured Loans & Borrowings				
TOTAL		-		-

	Current Year		Previous Year	
Schedule-5- Unsecured Loans & Borrowings				
TOTAL		-		-

	Current Year		Previous Year	
Schedule 6- Deferred Credit Liabilities				
TOTAL		-		-

	Current Year		Previous Year	
Schedule-7- Current Liabilities & Provisions				
A. Current Liabilities				
1. Sundry Creditors				
a) For goods	-		166,322	
b) Audit fee/others		-	8,937,041	-
2. Earnest Money Deposit	15,908,063	-	12,682,289	-
3. Statutory Liabilities		-		-
a) Overdue	-	-	-	-
b) Others	-	-	-	-
4. Other Current Liabilities	408,491	16,316,554		21,785,652
TOTAL (A)		16,316,554		21,785,652
B. PROVISIONS				
1.Taxation/Audit Fee payable	97,350	97,350	88,500	88,500
1. Gratuity	-		-	
2. Superannuation / Pension	-		-	
3. Accumulated Leave Encashment	-		-	
4. Group Insurance		-	65,724	65,724
5. manpower	6,611,625	6,611,625		
TOTAL (B)		6,708,975		154,224
TOTAL (A+B)		23,025,529		21,939,876

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

Schedule 8- Fixed Assets

Description	GROSS BLOCK				Rate	DEPRECIATION				NET BLOCK	
	Cost /Valuation as at the beginning of the year	Additions during the year 2018-19	Deductions during the year	Cost / Valuation at the end of the year		Cost /Valuation as at the beginning of theyear	Additions During the year	Deductions during the year	Cost / Valuation at the end of the year	As at the end of current year	As at the end of Previous Year
1	2	4	5	6	7	8	9	10	11	12	13
1. Land											
a) Freehold	24,898,870		-	24,898,870			-	-	-	24,898,870	24,898,870
b) NLST		56,564,200		56,564,200						56,564,200	
2. Buildings				-							
a) On freehold land	348,858,120	6,959,922	-	355,818,042	5%	128,574,753	11,362,164	-	139,936,917	215,881,125	220,283,367
3. MGK Menon Laboratory	122,360,233		-	122,360,233	5%	17,435,968	5,246,213	-	22,682,181	99,678,052	104,924,265
4. Vainu Bappu Telescope	53,393,327	12,922	-	53,406,249	15%	53,126,044	42,031	-	53,168,075	238,174	267,283
5. 2M Telescope	453,013,898		-	453,013,898	15%	452,882,897	19,650	-	452,902,547	111,351	131,001
6. HAGAR	51,254,355	16,310	-	51,270,665	15%	40,361,150	1,636,427	-	41,997,577	9,273,088	10,893,205
7. Scientific Equipment	1,115,428,605	33,832,851	-	1,149,261,456	15%	935,280,641	32,097,122	-	967,377,763	181,883,693	180,147,964
8. Vehicles	16,711,268			16,711,268	15%	14,393,074	347,729	-	14,740,803	1,970,465	2,318,194
9. Furniture & Fixtures	27,013,272	641,936	-	27,655,208	10%	25,194,551	246,066	-	25,440,617	2,214,591	1,818,721
10. Computer Peripherals	154,613,631	16,915,524	-	171,529,155	40%	146,231,386	10,119,108	-	156,350,494	15,178,661	8,382,245
11. Library Books	159,339,333	3,777,048	-	163,116,381	40%	154,727,480	3,355,560	-	158,083,040	5,033,341	4,611,853
Capital Work in Progress				-							
Building at Leh	80,069,373	6,549,731	-	86,619,104		-	-	-	-	86,619,104	80,069,373
NLST	54,286,250	3,555,778	-	57,842,028		-	-	-	-	57,842,028	54,286,250
NLOT	4,182,415	3,388,269	-	7,570,684		-	-	-	-	7,570,684	4,182,415
TOTAL	2,665,422,950	132,214,491	-	2,797,637,441		1,968,207,944	64,472,071	-	2,032,680,015	764,957,426	697,215,006

INDIAN INSTITUTE OF ASTROPHYSICS,BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year		Previous Year	
Schedule 9- Investments from Earmarked/Endowment Funds				
1. In Fixed Deposits				
RRI Pension Fund	-		-	
RRI Provident Fund	-	-	-	-
2. Other Approved Securities	-		-	
3. Shares	-		-	
4. Debentures / Bonds	-		-	
5. Subsidiaries and Joint Ventures	-		-	
6. Retirement funds vested in SBI Life Insurance Limited	-	-	-	-
TOTAL		-		-

	Current Year		Previous Year	
Schedule-10 Investment (Others)				
1. In Government Securities	-		-	
2. Other Approved Securities	-		-	
3. Shares	-		-	
4. Debentures / Bonds	-		-	
5. Subsidiaries and Joint Ventures	-		-	
6. Others (Specify)-Fixed Deposits	-	-	-	-
TOTAL		-		-

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year		Previous Year	
Schedule 11- Current Assets, Loans & Advances				
A. CURRENT ASSETS				
1. Inventories				
a.Stores & Spares	-	625,317	-	409,999
b.Loose tools	-		-	
c.Stock in trade	-	-	-	-
2. Sundry Debtors				
a.Debts outstanding for a period exceeding six mnt	-		-	
b.Others	60,500	60,500	-	-
3. Cash balances in hand (Including cash imprest)	70,876	-	95,281	-
4. Bank Balances	5,268			
a. With Scheduled bank	1,150,910			
On Current Accounts	122322658		3,552,497	
On Deposit Accounts (includes margin money)	221,017,232			
Margin Money - IIA	672,000		600,000	
Margin Money - ISRO Aditya Project			-	
On Savings Accounts		345,238,944	602,894,175	607,141,952
b. With Non - Scheduled bank				
On Current Accounts	-		-	
On Deposit Accounts	-		-	
On Savings Accounts	-	-	-	-
5. Post office - Savings Accounts		-		-
TOTAL (A)		**345,924,761**		**607,551,951**
B. LOANS/ADVANCES AND OTHER ASSETS				
1. Advances and other amounts recoverable in cash				
On Capital Account	-		-	
Deposits	2,252,229		2,252,829	
TMT - Project	766,113		41,190,550	
Advance to Staff Members	4,638,359	7,656,701	6,096,220	49,539,599
2. Income Accrued				
On Investments-Others			-	
On Loans & Advances (CSIR JRF)	1,090,105	1,090,105	870,105	870,105
3. Claims Receivable				
TOTAL (B)		**8,746,806**		**50,409,704**
Grand Total (A+B)		**354,671,567**		**657,961,655**

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year		Previous Year	
Schedule 12- Income from Sales/Service				
1, Income From Sale				
2, Income from Services		-		-
TOTAL		-		-

	Current Year		Previous Year	
Schedule 13- Grants/Subsidies				
(Irrevocable Grants & Subsidies Received				
1. Central Government				
a. Revenue Grants	657,477,000.00	657,477,000	489,913,000	489,913,000
2. State Government		-		-
3. Government Agencies				
4. Institutions/ Welfare Bodies				
5. International Organisations				
6. Non Recurring Expenditure during the year - Trf to Capital Fund				
TOTAL		657,477,000		489,913,000

	Current Year		Previous Year	
Schedule 14- Fees/Subscriptions				
1. Licence fees				
2. Annual Fees/Subscriptions	-		-	
3. Seminar/Program Fees	-		-	
4. Consultancy Fees	-		-	
5. Others (Specify)	-	-	-	-
TOTAL		-		-

	Current Year		Previous Year	
Schedule 15- Income from Investments				
(Income on investments from earmarked/endowment funds)				
1. Interest	-			
a) On govt. securities				
b) Other bonds/debentures				
2. Dividends	-		-	
a) On Shares				
b) On Mutual Fund Securities				
3. Rents	-		-	
4. Others (Specify)	-	-		-
TOTAL		-		-

	Current Year		Previous Year	
Schedule 16- Income from Royalty/Publication				
1. Income from Royalty	-			
2. Income from Publications				
3. Others (Specify)	-	-		-
TOTAL		-		-

	Current Year		Previous Year	
Schedule 17- Interest Earned				
1. On term Deposits				
a. With Scheduled Banks	-		-	
b. With Non Scheduled Banks	-		-	
c. With Institutions	-		-	
d. Others	-	-	-	-
2. On Savings Accounts				
a. With Scheduled Banks	4,021,387		8,618,259	
b. With Non Scheduled Banks			-	
c. Post office savings Accounts	-		-	
d. Others	-	4,021,387	-	8,618,259
3. On Loans				
a. Employees/Staff	842837	842837	1,413,229	
b. Others			-	1,413,229
TOTAL		**4,864,224**		**10,031,488**

	Current Year		Previous Year	
Schedule 18- Other Income				
1) Profit on sale/disposal of assets				
a) Own Assets				
b) Assets acquired out of grants				-
2) licence fee	449,705	449,705		378,980
3) Overhead Income, Tender Fee and Other Receipts	4,651,759	4,651,759	3,868,380	3,868,380
TOTAL		**5,101,464**		**4,247,360**

	Current Year		Previous Year	
Schedule 19- Increase/(Decrease) in stock of finished goods				
TOTAL		-		-

INDIAN INSTITUTE OF ASTROPHYSICS, BENGALURU

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT AS AT 31ST MARCH 2019

Amt.in Rupees

	Current Year	Previous Year
Schedule 20- Establishment Expenses		
a) Salary & Wages	253581627	201,534,940
b) Allowances & Bonus	10585986	6,658,085
c) Contribution to Provident Fund	76530	4,764,460
d) Contribution to Other Provident Fund (NPS)	6404487	5,098,156
e) Staff Welfare Expenses	40325626	30,679,875
f) Employees' Retirement and Terminal Benefits & Pension	152367253	99,368,857
TOTAL	463341509	**34,81,04,373**

	Current Year	Previous Year
Schedule 21- Other administrative expenses		
1) Advertisement	692100	804,277
2) Audit Fee	97350	88,500
3) AMCs/ Repairs	9891358	10,011,387
4) Bank Charges	246958	119,657
5) Canteen Expenses	3065312	2,851,703
6) Conveyance	195182	220,447
7) Electricity & Water Charges	13122052	14,080,945
8) Field Trips Expenses	9022307	3.329.601
9) Guest House	1954436	2,738,517
10) Leased Rent for Observatories	177313	634,532
11) Legal Charges	1241200	1,349,300
12) Maintenance of Campus, Outsourced Manpower etc.	90813952	72,662,899
13) Other Expenses	3882244	4,442,190
14) PhD Programme, PDFs, Visiting Fellowship	2077347	28,204,677
15) Postage & Courier	148523	210,992
16) Printing & Stationery	959532	610,883
17) Property Tax	1108776	851,133
18) Public Outreach Expenses	523951	412,861
19) Stores & Consumables	4981751	5,347,216
20) Summer Schools/Conference/Workshops	2962469	1,055,022
21) Telephone and Communication Charges	16558429	11,758,098
22) Travel Expenditure	2943346	7,990,570
23) Vehicle Maintenance / Transport	2540304	2,593,257
24) Welfare measures for Scheduled Tribes	8528753	6,977,576
TOTAL	177734945	**179,346,240**

	Current Year	Previous Year
Schedule 22- Expenditure on Grants, Subsidies ETC		
a) Grants given to Institutions/Organisations	-	-
b) Subsidies given to Institutions/Organisations	-	-
TOTAL	-	-

	Current Year	Previous Year
Schedule 23- Interest		
a) On Fixed Loans	-	-
b) On Other Loans (including bank Charges)	-	-
c) Others (Specify)		
TOTAL	-	-

Schedule-24: SIGNIFICANT ACCOUNTING POLICIES

1. ACCOUNTING CONVENTION:

The Financial Statements are prepared on the basis of historical cost convention unless otherwise stated and on accrual basis of accounting. 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

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

3. DEPRECIATION:

The Depreciation is charged on WDV at rates as stated in the Fixed Assets Schedule. The amount of depreciation has been debited to the Income & Expenditure Account as per the guidance of CAG Audit. The rate of depreciation has been charged as per the Income Tax Act, 1961 except Buildings which are depreciated at 5%.

4. INVENTORY:

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

5. GOVERNMENT GRANTS:

Government Grants received are accounted on receipt basis and the same have been separately shown under Capital Grants and Recurring Grants in the Annual Accounts of the Institute. Out of the total Grants, the Capital Grant is directly credited to the Capital Fund Account, the Recurring Grant accounted as Income and shown in Income & Expenditure Account. The interest earned on Government Grants such as Bank Interest and Interest on Staff Advances has been credited to Income & Expenditure Account.

6. FOREIGN CURRENCY TRANSACTIONS:

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

7, RETIREMENT BENEFITS:

a) Institute's contribution to Provident Fund and Pension Fund are charged to Income a 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.

b) Estimated liability for Gratuity on the date of Balance Sheet has not been quantified. The same is accounted for on actual cash basis payment.

8. The Schedule-3: Earmarked/ Endowment Fund is the Unspent Balances of the Projects at the year end.

Schedule-25: CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

A. Contingent Liabilities:

1. Claims against the Institute not acknowledged as Debt : Nil
2. Bank Guarantees given by the Institute : Nil
3. Disputed Demands in respect of Taxes : Nil

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. In the Receipts and Payments Accounts, the amount shown in Project Receipts includes Grants received during the year, Interest received from banks and the difference in value of LC and actual payment pertaining to projects during the last year.

3. In the Receipts and Payments Account, the amount shown in Project Payments includes Capital Expenditure, LC Payments and the Revenue Expenditures pertaining to projects during the year.

4. Previous year figures have been re-grouped wherever necessary,

5. The figures have been rounded off to the nearest rupee.

S. Vasumathi

VASUMATHI S
Accounts Officer

SHRIPATHI K
Administrative Officer

JAYANT MURTHY
Director

As per our report of even date
For Gireesh Vijayan & Associates
Chartered Accountants
FRN 0141175

VIJAYAN G
Partner
M No.036948

Date: 31.07.2019
Place: Bangalore