ARIES

Aryabhatta Research Institute of Observational Sciences

Annual Report 2019-20

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES

(An Autonomous Institute under DST, Govt. of India)

Manora Peak, Nainital - 263 001, India

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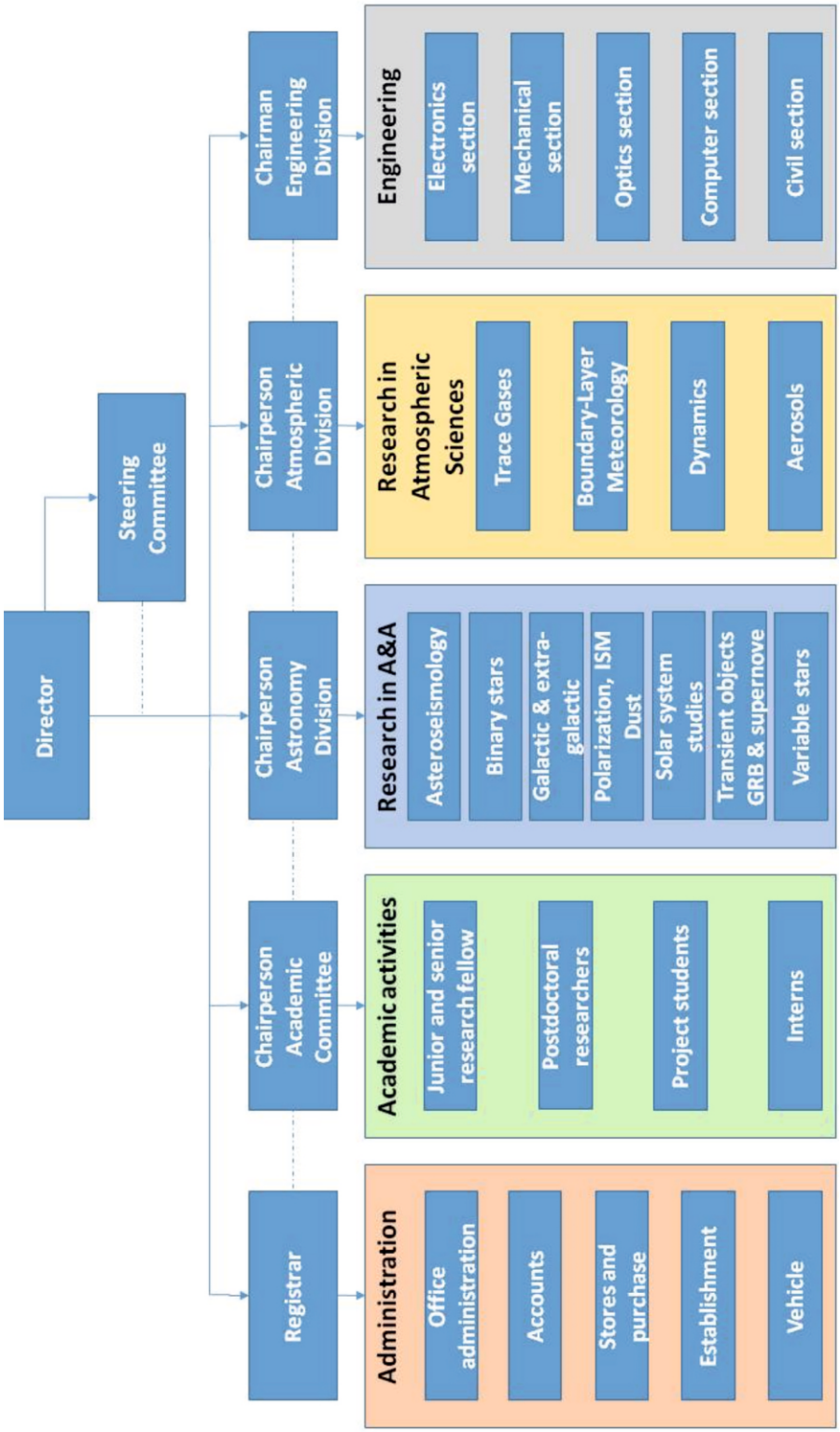
Front Cover: 3.6m Devasthal Optical Telescope (DOT) Building.

September, 2020

Contents

Organizational Structure



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THE YEAR IN REVIEW

It gives me a great pleasure to present the highlights of ARIES's achievements on many fronts in 2019–20. The Institute has made significant contributions in research, academic, developmental activities, and public outreach. I would like to point out that I have taken charge on 12th December 2019. I have been very lucky, I am happy to report that two major observational facilities, namely the 3.6m Devasthal Optical Telescope (DOT) and the ST Radar started functioning with its full potential soon after I joined ARIES, but the credit should go to my predecessor and my colleagues in ARIES for their hard work.

Scientists at the Institute continue their research activities with great vigor in their respective fields, the focus areas being the Astronomy and Astrophysics (A&A) and Atmospheric Sciences. In the field of Atmospheric Sciences, research on air pollution and climate change, observations of trace gases (including greenhouse gases), characterization of aerosols, meteorology and dynamics, radiation budget, satellite data and modeling of lower troposphere phenomena with a particular emphasis over central Himalayas and Indo-Gangetic plains have been taken up. In the field of Sun and Solar System Astronomy, observations and modeling of the transients such as solar flares, jets, spicules, coronal mass ejections and other solar eruptive phenomena; magneto-hydrodynamic waves in the solar atmosphere, space weather phenomena and impact of solar transients on interplanetary space have remained the main focus. Long term study of the sun using century long ground based and modern space-based data has also been initiated. Study of exo-planetary systems, formation and evolution of stars and star clusters, stellar pulsations and variability, characterization of interstellar matter and molecular clouds, X-ray emissions from stars, and X-ray binaries have been performed by the Stellar and Galactic Astronomy group. Extra-galactic Astronomy group devoted their efforts for the radio and optical studies of external galaxies; optical flux and spectral variability of active galactic nuclei (AGN); optical follow-up of gamma-ray bursts (GRBs) and supernovae; multi-wavelength studies of extragalactic transient sources e.g. GRBs, supernovae, and blazars. In the front of theoretical Astrophysics, analytical and numerical studies of fluids e.g. accretion processes around compact objects like white dwarfs, neutron stars, and black holes have been performed.

In terms of Major Accomplishments within this period one can highlight that with the 3.6m Devasthal Optical Telescope (DOT) several verification tests were performed with the instruments during the current financial year. The replacement of azimuth motor and gluing of pads of the telescope has been completed. In terms of the backend instruments on DOT, the first light instrument 4Kx4K CCD Imager is ready to be used for the Astronomical community for the upcoming observing cycle. Discovery of several variable stars in a Globular Clusters NGC 4147 was possible because of the deep observations with the Imager instrument mounted on the 3.6m DOT. Several publications with the data taken from 3.6m DOT are under preparation.

TIFR-ARIES Near Infrared Spectrometer (TANSPEC) is built in collaboration with ARIES, TIFR and MKIR, Hawaii for the 3.6m DOT. It is a medium resolution spectrograph (dual mode, R~2750, R-150-350) cum

imager having sensitivity in the wavelength range from 550 to 2540 nm. TANSPEC was delivered and mounted on the 3.6m DOT successfully during March - April 2019 and January-February 2020. The initial commissioning run was very encouraging, and several calibration tests have been successfully carried out. The in-house designed and developed spectrograph AD-FOSC was commissioned on the 3.6-m DOT for upcoming science observations. The AD-FOSC is built in ARIES with a cost of ~4 Crore INR, which is less than half the cost of a similar but imported instrument. Several up-gradations are being implemented in the AD-FOSC at extremely competitive cost with completely in-house design and development efforts. TANSPEC and AD-FOSC both are now available for the scientific community for regular observation.

Several cosmic explosive phenomena, such as GRBs and Supernovae, were observed with ARIES telescopes and remarkable contribution was made towards progenitor scenario of such transients. A wide variety of Supernovae, including the newly discovered class of Super Luminous Supernovae, were investigated for a detailed characterization and estimation of explosion parameters. The first GRB with a detected TeV emission was studied. Intra-night optical monitoring of various class of AGNs were carried out. Radio-quiet AGNs show comparatively much lower duty cycle and low amplitude in the intra-night light curves. Quasi-simultaneous multi-wavelength observation of blazars using various ground and space based telescopes around the globe were carried out. Blazars show large amplitude flux and spectral variation on diverse time scales, spectral energy distribution was explained by one and two zone leptonic models. In the recent study of some of the young and intermediate-age open clusters in the Galaxy suggests that many intermediate age Galactic open clusters show multiple population of star formation and epoch of star formation varies as much as 650 Myrs. Star formation in star clusters is non-coeval and may continue for more than five Myrs. It does not cease after the formation of massive stars in the cluster. Formation of massive stars further trigger next generation of star formation at the periphery of the cluster regions.

Eleven open star clusters have been studied to know the galactic structure and galactic motion towards their location. Their updated physical parameters are derived using the cluster members selected from kinematical data. Our study shows that most of the clusters are rotating in a circular orbit around the Galaxy. Five delta scuti type and two W UMa type variable stars in four clusters were discovered. Three polars have been discovered as eclipsing polar, increasing census of long period eclipsing polar to 7 using the Indian optical telescope. The accretion geometry of an only disc-less accretor V2400 Oph is identified as disc accretor in few observations. For the first time the Wolf-Rayet star WR 121a is found to be a colliding wind binary with an orbital period of 4.1 days. Based on photometric observations of a star-forming region Cygnus, 31 variables stars were discovered in which 14 show periodic variability. Further, analysis of the Kepler space data of 170 hump and spike stars, it was found that the spikes in the frequency spectra is not strongly dependent on the appearance of star-spots on the stellar surface.

Solar Physicists studied the dynamical properties of solar events like flares jets, filaments, CMEs and magnetic fields, using ground-based and space-based imaging and spectroscopic instruments.

In the Atmospheric Science division, ARIES has operationalised ST Radar (206.5 MHz) and observations are being obtained up to about 20 km height. These observations are used to estimate the first ever estimation on turbulence parameters, which are found to be higher than southern Indian region. Additionally, INSAT-3D data have been used for retrieving the vertical ozone profiles over the Himalayan region for the first time. Trace gases and aerosols: Balloon-borne measurements of temperature, water vapor, ozone and aerosol backscatter provided unprecedented insights into the Asian summer monsoon anticyclone thermal structure.

Important collaborations (National and Global) were established during this year. Notables are, a project entitled “Flares from F to M-type mass stars” in collaboration with IoA, Russia. A project entitled “Probing fundamental characteristics of extreme

astrophysical phenomena" was followed in collaboration with scientists from South Africa, Russia and India. A multinational collaborative project "Multi-wavelength variability of Blazars" led by ARIES scientist which involve about 30 scientists and Ph.D. students and Post Doctoral Fellows from Japan, China, India, Georgia, Bulgaria, Serbia, Spain, Poland, Brazil and USA is in progress. The project entitled "Observational signature of super massive Black Holes: TeV blazars in multi-wavelength view" is an INDO-Poland bilateral scientific exchange project funded by DST, Govt. of India. Collaboration with Liege University, Belgium on project "International Liquid Mirror Telescope (ILMT)", funded by ARIES, Belgium and Canada is also progressing very well. BINA (Belgo-Indian Network for Astronomy and Astrophysics) is a research network funded by BELSPO (Belgian Science Policy Office) and DST (Department of Science & Technology, India).Collaboration with Space Research Institute, Graz, Austria on "Probing a hot Jupiters environmental and physical conditions: numerical modeling vs observations" is funded by DST, India. "Indo-Thai Collaboration for Studying Pulsating Variables at Different Evolutionary Stages" is funded by DST, India. A project entitled "Fostering of the next generation of scientist for better understanding of air quality in monsoon Asia and Oceania region" funded by APN, involving scientists from 18 countries is also progressing well. A project entitled "Influence of massive stars on the formation and evolution of low mass stars"is funded by DST, India. A project entitled "Physics of radio bright gamma ray burst afterglows" in collaboration with IIST, Thiruvanthapuram was initiated and funded by DST, India. Project entitled "Devasthal Optical Telescope – AGN Reverberation Monitoring (DOT-ARM): probing AGN black-hole masses and broad line regions" was initiated and funded by SERB, India.

Several meetings and workshops were hosted during this period. ARIES hosted "I-TMT Science and Instruments Workshop" during 17 - 19 October 2019. This workshop was mainly focused on the ongoing development of the first- and second-generation instruments. Around 130 participants from around more than 20 institutions, universities actively participated during the workshop and discussions were conducted about how India could contribute better towards this ongoing mega-projects particularly towards instrumentation. IGAC-MANGO Meeting, Science Workshop, and Training Course was organized by ARIES at Nainital during 28-30 November 2019. The sessions devoted to science-policy and science communication comprised four main components: an invited talk, a panel discussion, a video presentation and a sharing talk on case-study related to science communication. These were covered in different plenary and parallel sessions and were well received by the participants. Nearly 40 researchers from 17 countries participated in the meeting.

As a part of outreach activities, nearly 8200 visitors benefited from the Science Outreach Programmes at ARIES out of which 60% were students from all over the country. ARIES participated in the "*Vigyan Samagam, pushing the frontiers of science"* programme at a National level. Celebrations of Bapu Khagol Mela in Uttarakhand were co-ordinated by ARIES which was organized by Nehru Planetarium, Delhi. Many other activities were also organized and executed by ARIES. ARIES outreach team coordinated the visit of Her Royal Highness Princess Maha Chakri Sirindhron of Thailand, Thai Ambassador and other VIP dignitaries during 12-13 Feb 2020 and earlier in November-December 2019. Her Royal Highness expressed keen interest in future scientific collaborations with ARIES.

Dipankar Banerjee

Director

Research Highlights

The scientists of ARIES carry out research mainly on topics related to Astronomy and Astrophysics, Atmospheric Sciences and Instrumentation. The research activities of the institute are divided into two working groups. The groups are

1. Working Group – I (WG I) – Galactic & Extragalactic Astronomy

2. Working Group – II (WG II) – Solar Physics & Atmospheric Sciences

The working group members are responsible for the annual planning and monitoring of the activities on the academic and technical matters. In this section, a brief highlight of the scientific and instrumentation achievements of the institute, during the period 2019-20, are presented.

Research Working Group – I

All the scientists working on topics related to Galactic and Extragalactic astronomy are the members of WG – I. The group consists of 15 scientists. The group members are actively involved in collaboration with scientists of national and international institutions in the fields of near earth objects, individual stars, star formation, open cluster systems, globular cluster systems, large magellanic cloud (LMC), active galactic nuclei (AGN), quasars, blazars, gamma ray bursts (GRBs), supernovae and numerical simulations. The highlights of the scientific publications by the members are briefly presented below.

Galactic Astronomy

1. Stellar Variability

Census of Variable Stars in Open Star Clusters

At ARIES, Nainital a long term project to search and characterize the variable stars in galactic open clusters is being executed since last one decade using Indian observational facilities. As a part of this project, the time-series observations of open star clusters Stock 8 and NGC1960 were carried out aiming to search and study the new variable stars. Various new variables stars such as β Cep, δ Scuti, Gamma-Dor, slowly pulsating B stars, rotational variables, non-pulsating B stars, T-Tauri variables and Herbig Ae/Be were detected in the studied clusters. The light variation is attributed to spots, binarity, pulsation and asymmetry dust distribution etc. The acquired data was used to determine various physical parameters and studied their evolutionary status. **[Lata, S.,** et al. (including **Pandey, A. K.** & **Panwar, N**.) (2019). *Astron. Jr., 158*:68 (15pp); **Joshi, Y. C., Maurya, J., John, A. A., Panchal, A., Joshi, S.** & **Kumar, B.** (2020). *Mon. Not. Roy. Astron. Soc., 492,* 3602-3621.]

Census of Variable Stars in the Globular Cluster NGC4147

The first result from 3.6-m Devasthal Optical Telescope is in the form of detection of new variable stars in the core region of the globular cluster NGC 4147. The time-series photometric observations in the V and R bands were carried out using 4K X 4K CCD imager. A total of 42 periodic variables were identified in the central region where 28 were detected the first time. The metallicity of NGC 4147 estimated from the light curves of RRab and RRc stars with the help of Fourier decomposition. The distance of the cluster is derived using the periodic analysis of RRab stars that is in well agreement to the distance estimated using the observed *V/(V - R)* color-magnitude diagram. **[Lata, S.**, et al. (including 22 authors).(2019). *Astron. Jr., 158*:51 (18pp)**]**

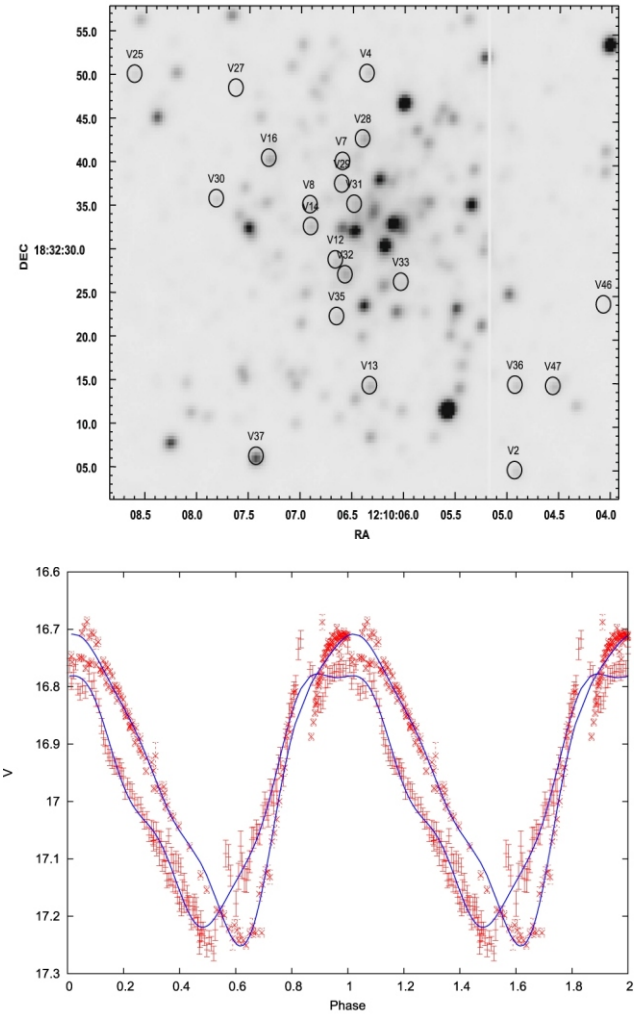


Figure 1: Top panel : The central probed region of globular cluster NGC 4147. Bottom panel: Light curves of a RRc type variable with best fitted Fourier series.

Studies of Stellar Variability in Magellanic Clouds and M31

We examined reddening distribution across the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) using the Classical Cepheids discovered in the OGLE Phase IV survey. On comparing with well calibrated P-L relations of these two galaxies, we determined reddening in each segment and found clumpy structures in the reddening distributions. The period-age relations were used to derive the age of the Cepheid populations in both the galaxies. We investigated age and spatio-temporal distributions of Cepheids to understand the recent star formation history in the Magellanic Clouds and found an evidence of a common enhanced Cepheid population in the MCs at around 200 Myr ago which appeared to have occurred due to close encounter between the two clouds. Apart from these important results on Cepheids variables, under the Nainital Microlensing survey, we carried out photometric and spectroscopic follow-up observations of a prominent Hubble-Sandage variable star AF And. This star had shown a prominent outburst in January 1999, followed by a gradual decrease in brightness of about 1.5 mag for the next 3 yr with a declining rate of about 0.0015 mag/day, leading to a

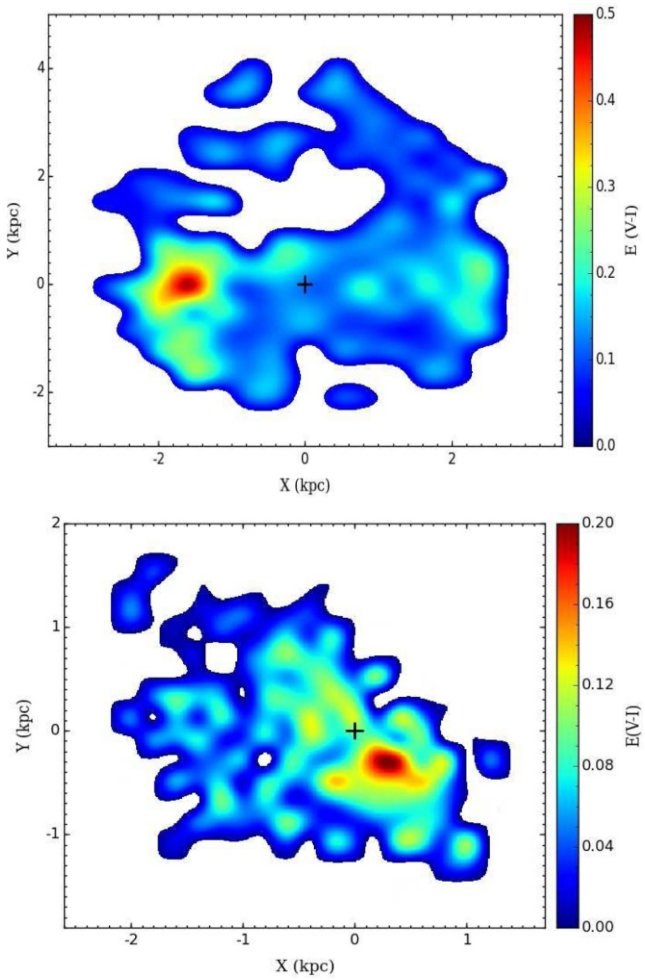


Figure 2 : Reddening maps of LMC (top) and SMC (bottom) emanating from the P–L diagrams of the Cepheids in the LMC. The optical center of the LMC is shown by a + symbol. The color bar represents the interpolated reddening E (V−I) (See Joshi et al. 2000 for more detail).

quiescent phase towards the end of 2001. The spectroscopic analysis of this star shows prominent Balmer and He I emission lines along with the comparatively weaker Fe II and forbidden Fe II emission lines. Asymmetric emission line profiles in its spectrum suggested that a huge mass-loss rate in the star via stellar winds. Using a weak P Cygni profile of the He I emission line, the wind terminal velocity for AF And was found to be around in between 280 to 300 km/s. **[Joshi, Y. C. & Panchal, A.,** (2019). *Astron.& Astrophy., 628*, A51; **Joshi, Y. C.**, Sharma, K., **Gangopadhyay, A.,** Gokhale, R. & **Misra, K.** (2019). *Astron. Jr., 158,* 175**]**

Study of Variability in the Star-forming regions

The photometric variability of pre-main-sequence (PMS) stars in the Pelican Nebula (IC 5070), Cygnus OB7 and Sh 2-170 were studied at optical wavelengths to explore star-disk interactions, accretion, spots, and other physical mechanisms associated with young stellar objects. Several variable stars were identified towards these star forming religions. It is found that a larger fraction of main-sequence (MS) field variables show periodic variability as compared to the PMS variables. The photometric analysis reveled that the amplitude of variability in Sh 2-170 show an increasing trend with the near-IR/mid-IR excess while in IC 5070 no correlation was found between the optical amplitudes or periods with the physical parameters (mass and age) of PMS stars. In Cygnus OB7 region we found all observed sun-like protostars are variable. Few smooth, stable periodic variables were identified which are possibly eclipsing binary. **[**Dutta, S., Mondal, S., **Joshi, S.** & Das, R. (2019). *Mon. Not. Roy. Astron. Soc.*, *487,* 1765-1776.; Bhardwaj, A., **Panwar, N.,** Herczeg, G. J., Chen, W. P. & Singh, H. P. (2019). *Astron. & Astrophy., 627*, A135 (1-16 pp); **Sinha, T.,** et al. (including **Sharma, S., Pandey, A. K., Pandey, R.** & **Ghosh, A**.) (2020). *Mon. Not. Roy. Astron. Soc.*, *493,* 267-287**]**

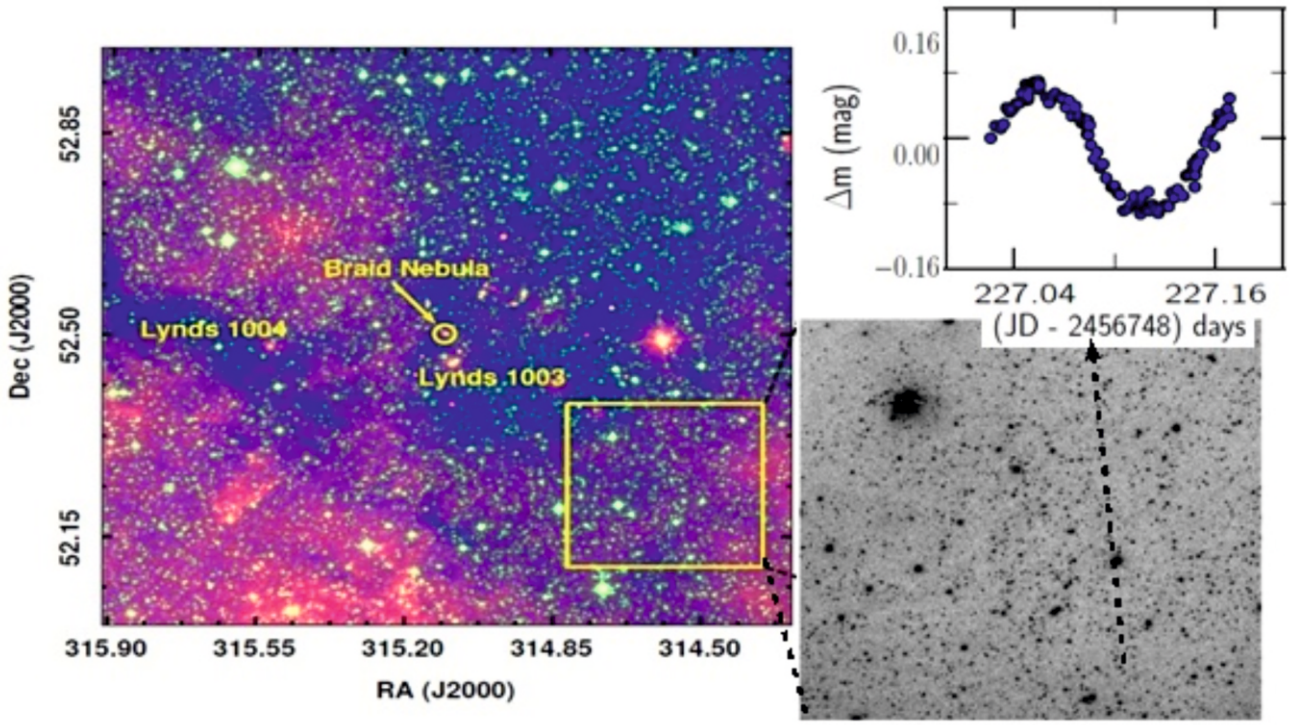


Figure 3: Left panel: Infrared view (red: WISE W3, green: WISE W1, blue: 2MASS Ks) of dark cloud Lynds 1003 and Lynds 1004 towards Cygnus OB7. The braid nebula is also marked with a circle. Right panel (lower): Optical I-band image of the studied region taken from 1.3m DFOT, ARIES, Nainital. Right panel (upper): One example of observed differential light curve is plotted with the observed intensity of stars as a function of time.

Study of Rotation and Spots in Normal A and Am/Fm Stars

To search and study the pulsational variabilities in Ap and Am/Fm stars, a dedicated ground-based project the 'Nainital–Cape Survey' was initiated between astronomers of India and South Africa. The success of this legacy survey and recent discovery of 'hump and spike' features in the frequency spectra of a number of normal A and Am stars motivated us to start another collaboration with the astronomers of Uganda. Using the frequency analysis of long-term ultra-precise photometry from Kepler mission, we computed the rotation frequencies, equatorial rotational velocity (V_{rot}) and spot size. On fitting the auto-correlation functions of the light curves with the appropriate model, we determined the star-spot decay time-scale. Very interestingly, we did not find any significant difference in the average spike amplitude and spot radius between chemically peculiar metallic line A and normal A type stars. Probably, the existence of the spikes in the frequency spectra may not be strongly dependent on the appearance of star-spots on the stellar surface. **[**Trust, O., Jurua, E., Cat, P. D. & **Joshi, S.** (2020). *Mon. Not. Roy. Astron. Soc.*, *492,* 3143-3155**]**

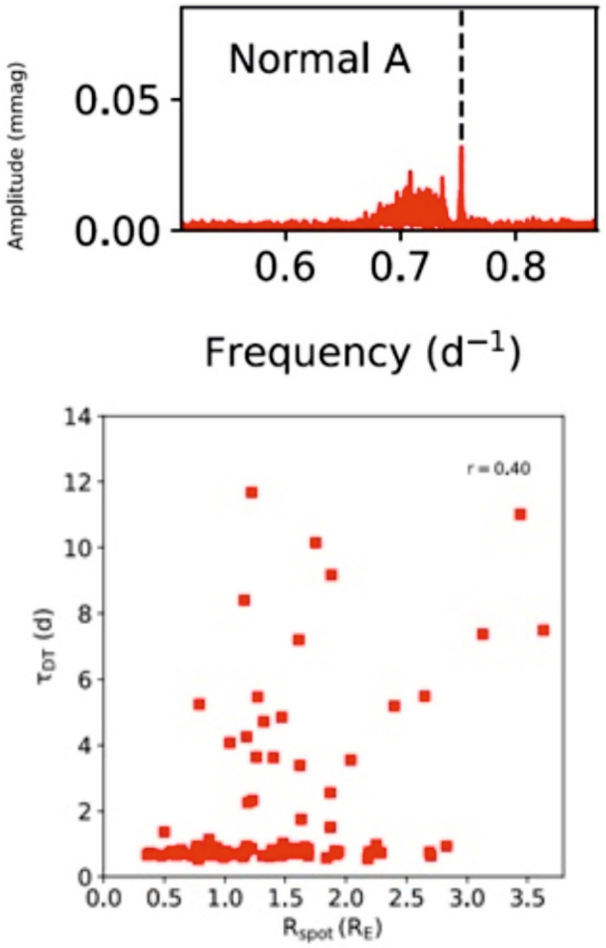


Figure 4: Top panel: Hump and Spike (shown with dotted line) in a normal A-type star. Bottom panel : The correlation between the spot radius (Rspot) and the decay time-scale (τDT) for A-type stars. The correlation coefficient (r-value) is given at the top right corner.

Optical and X-ray studies of magnetic cataclysmic variables

Three new polars are identified as eclipsing polars for the first time using photometric data from 1.04-m and 1.3-m telescopes of ARIES, spectroscopic data from 2.0-m HCT, and X-ray data from ROSAT. It is found that the eclipsed component in all three polars is not only the white dwarfs but also it includes the extended accretion region. It was also found that both accreating poles in these polars are always visible and cyclotron radiation is present along the line of cite. Optical spectra of these systems show the presence of high-ionization emission

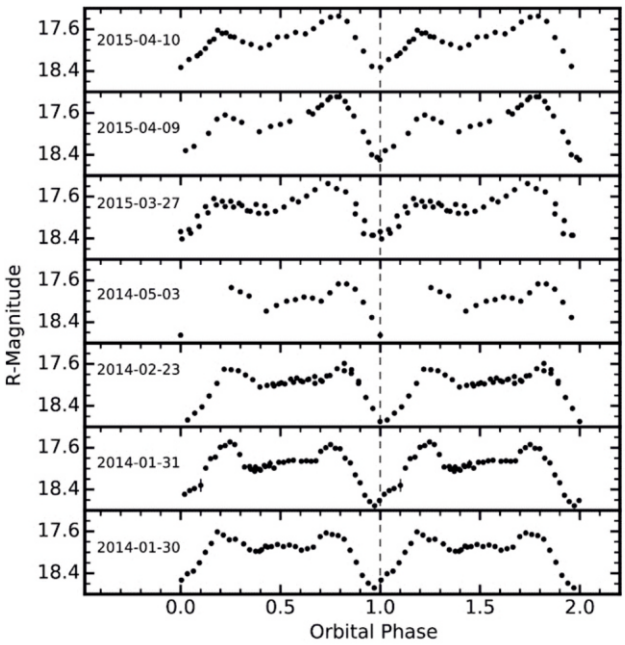


Figure 5: The R-band light curve of a polar RX J0859.1+0537 as observed from 1.04-m at ARIES and 1.3-m telescopes at Devasthal.

lines along with the strong Balmer emission lines with an inverted Balmer decrement. Using the cyclotron hump observed in the optical spectra of these polars, the magnetic field was estimated in between 40 - 50 MG. In other study, a discless IP, V2400 Oph was found to accreate via disc using the X-ray data from XMM-Newton and Suzaku. The spin period of 929 s was determined for the first time using X-ray data. The central energy of Fe Kα appears to be redshifted and found to be modulated with the white dwarf rotation, where modulations are at minimum around the spin minimum, indicating that the redshifted line is originated from pre-shock accreting material via fluorescence. **[Joshi, Arti**, **Pandey, J. C.,** Raj, A., Singh, K. P., Anupama, G. C. & Singh, H. P. (2020). *Mon. Not. Roy. Astron. Soc.*, *491,* 201-214; **Joshi, Arti, Pandey, J. C.** & Singh, H. P. (2019). *Astron. Jr., 158:*11 (14pp)**]**

Massive Wolf-Rayet binaries and Associated winds

In this project, two massive Wolf Rayet binaries WR 25 and WR 121a were studied using the long term X-ray data from XMM-Newton, Chandra, Suzaku, Swift, and NuStar. In the case of WR 25, the wind collision is found to be adiabatic but with a significant deviation concerning the expected 1/D (D is binary separation) dependence of the X-ray luminosity around periastron passage. This deviation may tentatively be explained by a lower pre-shock velocity close to periastron favoring a brief switch to the radiative regime, especially if the velocity drop is enhanced by sudden radiative braking. A detailed X-ray study of the deeply embedded Wolf– Rayet star WR 121a has also been carried out using long-term X-ray data. For the first time, a periodic variation of 4.1 days has been detected in the X-ray light curve of WR 121a. The X-ray variations in WR 121a was found to be due to the wind collision region which is being eclipsed by the secondary star in a binary orbit. It was found that radiative inhibition and radiative braking are the most likely processes that are severely affecting the wind collision in this short-period massive binary system. **[Arora, B., Pandey, J. C.** & Becker, M. De. (2019). *Mon. Not. Roy. Astron. Soc.*, *487,* 2624-2638; **Arora, B.** & **Pandey, J. C.** (2020). *Astrophy. Jr., 891:104* (11pp)**]**

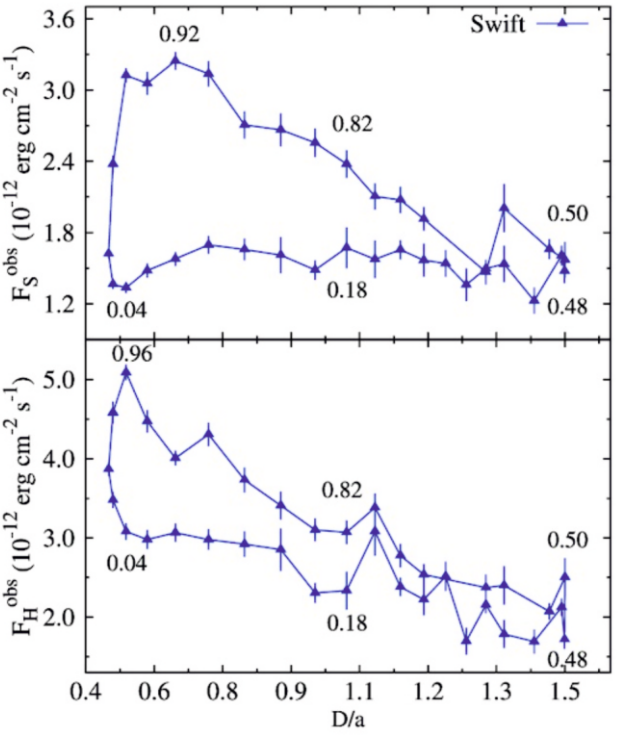


Figure 6: Intrinsic hard (F_H) and soft (F_S) X-ray flux as a function of binary separation (D) for the Wolf-rayet star WR 25.

Study of dust and ISM towards galactic anti-center direction

This project aims to study the dust and grain properties toward the galactic anti-centre direction using the polarimetric observations from 1.04-m Sampurnannd telescope. For our purpose, we have selected several stars clusters in the Perseus arm of the Milky Way. A total of six stars clusters have been observed and two clusters have been analysed. Broadband B V, R, and I band linear polarimetric observations of 73 stars in the direction of the open star cluster Casado Alessi 1 have been carried out. The polarization was found to be wavelength dependent being maximum near the V-band indicating the ISM origin of the polarization. From the present study, we found the dust grains toward the cluster appear to be aligned, possibly due to the galactic magnetic field. **[Singh, S., Pandey, J. C., Yadav, R. K. S.** & **Medhi, B. J.** (2020). *Astron. Jr., 159:*99 (12pp)**]**

2. Star formation

Stellar Cores in the Sh 2-305 H II Region

Using deep optical and near-infrared photometry along with multiwavelength archival data, a detailed study of the Galactic H II region Sh 2-305 was carried out to understand the star/star-cluster formation. On the basis of excess infrared emission, 116 young stellar objects (YSOs) were identified within a field of view of ~18.5 × 18.5 arcsec^2 around Sh 2-305. The average age, mass, and extinction (AV) for this sample of YSOs were found to be 1.8 Myr, 2.9 solar mass, and 7.1 mag, respectively. The density distribution of stellar sources along with minimal spanning tree calculations on the location of YSOs reveals at least three stellar subclusterings in Sh 2-305. One cluster is seen toward the center (i.e., Mayer 3), while the other two are distributed toward the north and south directions. Two massive O-type stars (VM2 and VM4; ages ~5 Myr) are located at the center of the Sh 2-305 H II region. The analysis of the infrared and radio maps traces the photon-dominant regions (PDRs) in Sh 2-305. The association of the younger generation of stars with the PDRs is also investigated in Sh 2-305. This result suggests that these two massive stars might have influenced the star formation history in Sh 2-305. This argument is also supported by the calculation of various pressures driven by massive stars, the slope of the mass function/K-band luminosity function, star formation efficiency, fraction of Class I sources, and mass of the dense gas toward the subclusterings in Sh 2-305. **[Pandey, R., Sharma, S., Panwar, N.,** Dewangan, L. K., Ojha, D. K., Bisen, D. P., **Sinha, T., Ghosh, A.** & **Pandey, A. K.** (2020). *Astrophy. Jr., 891:*81 (24pp)**]**

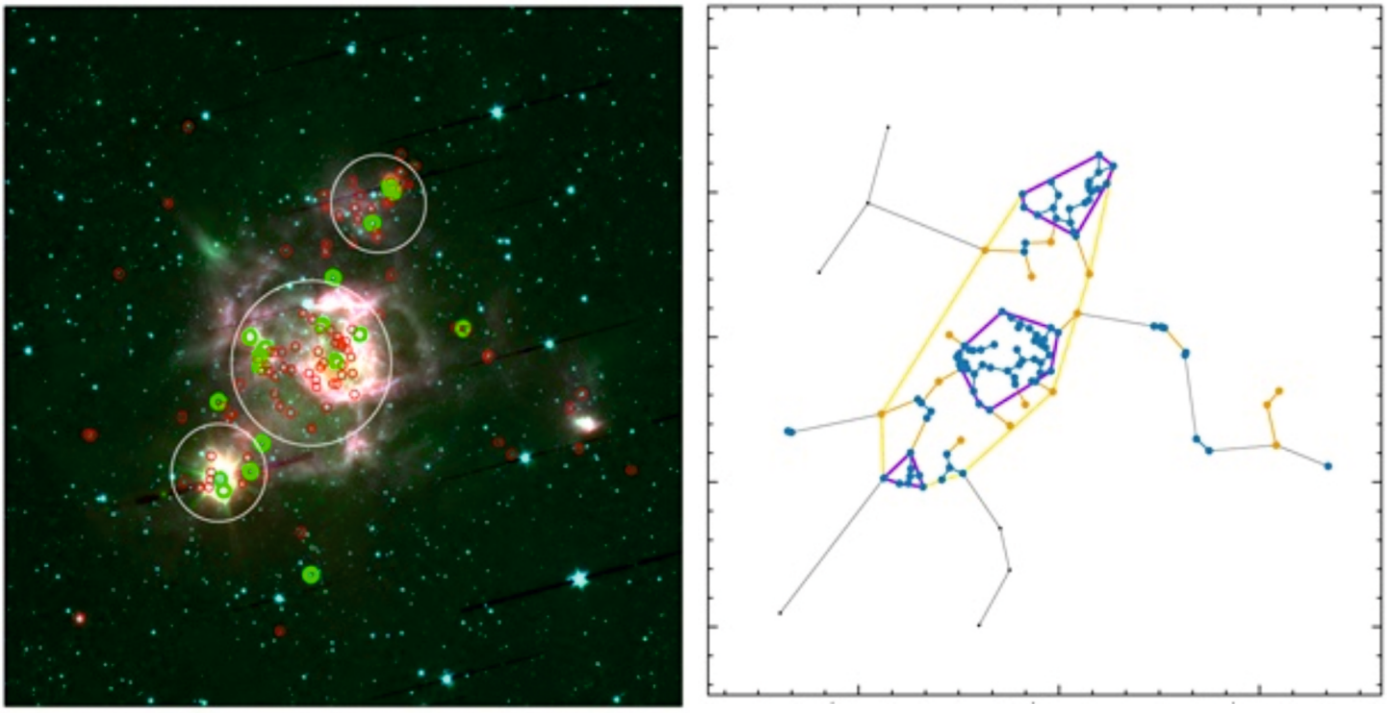


Figure 7. Left panel: Spatial distribution of YSOs superimposed on the ~18'.5×18'. 5 color-composite (red: WISE 12 μm, green: Spitzer 4.5 μm, blue: Spitzer 3.6 μm) image of the Sh 2-305 region. The locations of Class I (green circles) and Class II (red circles) sources are also shown. The white circles represent the three clusters/clumps identified in the present analysis**. Right panel:** Minimal spanning tree (MST) for the identified YSOs in the same region along with the convex hull. The blue dots connected with solid blue lines and yellow dots connected with yellow lines are the branches smaller than the critical length for the cores and the active region, respectively. The identified cores and the active region are encircled by purple and yellow solid lines (i.e., Qhull), respectively.

Large-scale star formation in Auriga region

New observations in the VI bands along with archival data from the 2MASS and WISE surveys have been used to generate a catalogue of young stellar objects (YSOs) covering an area of about 6◦ × 6◦ in the Auriga region centred at l = 173◦ and b = 1.5◦. The nature of the identified YSOs and their spatial distribution are used to study the star formation in the region. The distribution of YSOs along with that of the ionized and molecular gas reveals two ring-like structures stretching over an area of a few degrees each in extent. These structures were named as Auriga Bubbles 1 and 2. The centre of the Bubbles appears to be above the Galactic mid-plane. The majority of Class I YSOs are associated with the Bubbles, whereas the relatively older population, i.e. Class II objects are rather randomly distributed. Using the minimum spanning tree analysis, 26 probable subclusters were found having five or more members. The subclusters are between ~0.5 and ~3 pc in size and are somewhat elongated. The star formation efficiency in most of the subcluster region varies between 5 per cent and 20 per cent indicating that the subclusters could be bound regions. The radii of these subclusters also support it. **[Pandey, A. K., Sharma, S.,** Kobayashi, N., Sarugaku, Y. & Ogura, K. (2020). *Mon. Not. Roy. Astron. Soc.*, *492,* 2446-2467**]**

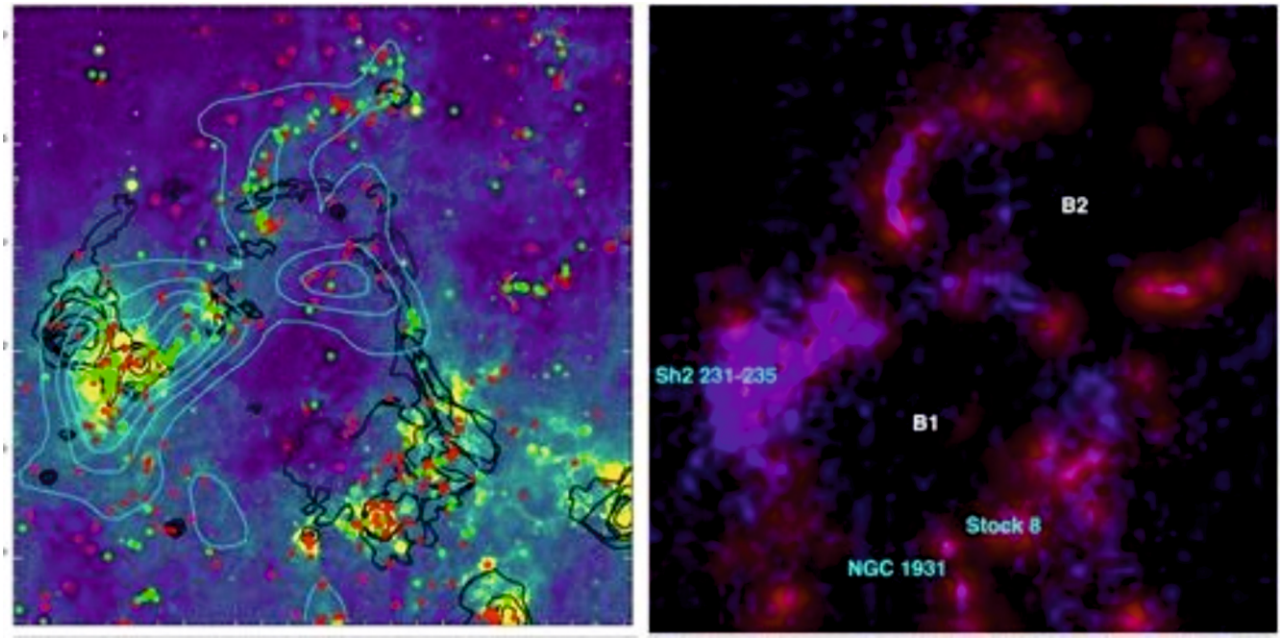


Figure 8: Left panel: Spatial distribution of YSOs superimposed on the 6° × 6° WISE 12 μm image of the Auriga Bubble region. Class I (175) and Class II (535) YSOs are shown by green and red dots, respectively. The cyan and black curves are the 12CO and H I contours taken from Dame et al. (2001) and Furst et al. (1990), respectively. **Right panel:** Extinction map (blue colour) and YSOs density map (red colour) for the Auriga Bubble region smoothed to a resolution of 18 arcmin. B1 and B2 are two bubbles identified in this study.

3. Stellar Evolution

Astrometric and photometric study of NGC 6067, NGC 2506, and IC 4651 open clusters based on wide-field ground and Gaia DR2 data

An analysis of three southern open star clusters NGC 6067, NGC 2506, and IC 4651 was carried out using wide-field photometric and Gaia DR2 astrometric data. They are poorly studied clusters. The synergy between Gaia DR2 high precision astrometric measurements and ground-based wide-field photometry is used to isolate cluster members and further study these clusters. Cluster members were identified using proper motions, parallax and colour-magnitude

diagrams. Mean proper motion of the clusters in $\mu_\alpha \cos\delta$ and μ_δ is estimated as -1.90 ± 0.01 and -2.57 ± 0.01 mas yr^{-1} for NGC 6067, -2.57 ± 0.01, and 3.92 ± 0.01 mas yr^{-1} for NGC 2506 and -2.41 ± 0.01 and -5.05 ± 0.02 mas yr^{-1} for IC 4651. Distances are estimated as 3.01 ± 0.87, 3.88 ± 0.42, and 1.00 ± 0.08 kpc for the clusters NGC 6067, NGC 2506, and IC 4651, respectively, using parallaxes taken from Gaia DR2 catalogue. Galactic orbits are determined for these clusters using Galactic potential models. The clusters were found to have circular orbits. Cluster radii are determined as 10 arcmin for NGC 6067, 12 arcmin for NGC 2506, and 11 arcmin for IC 4651. Ages of the clusters estimated by isochrones fitting are 66 ± 8 Myr, 2.09 ± 0.14 Gyr, and 1.59 ± 0.14 Gyr for NGC 6067, NGC 2506, and IC 4651, respectively. Mass function slope for the entire region of cluster NGC 2506 is found to be comparable with the Salpeter value in the mass range of 0.77-1.54 $M_\odot$. The mass function analysis shows that the slope becomes flat when one goes from halo to core region in all the three clusters. A comparison of dynamical age with cluster's age indicates that NGC 2506 and IC 4651 are dynamically relaxed clusters. **[**Rangwal, G., **Yadav, R. K. S.**, Durgapal, A., Bisht, D. & Nardiello, D. (2019). *Mon. Not. Roy. Astron. Soc., 490*, 1383-1396**]**

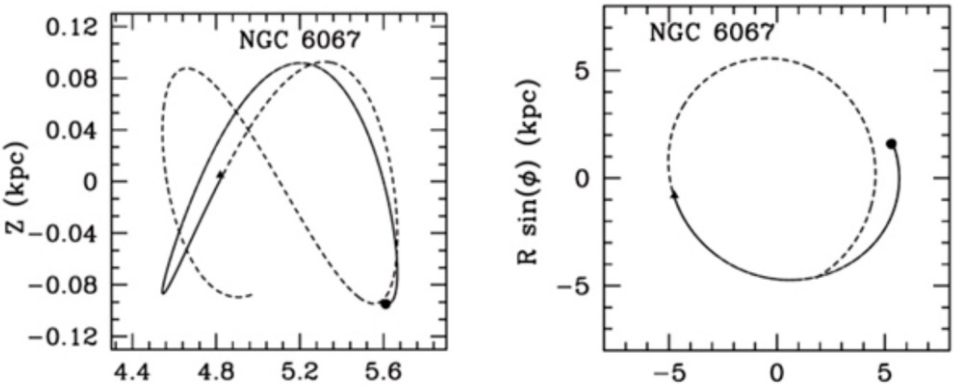


Figure 9: Galactic orbits of the NGC 6067 determined with Galactic potential model described in text. The continuous line represents orbit of cluster in a time interval of age of cluster. The dotted line represents cluster orbit for a time interval of 160 Myr. The left-hand panel shows side picture and right-hand panel shows top view of the orbit. The filled triangle and filled circle denote birth and present day position of cluster in the Galaxy.

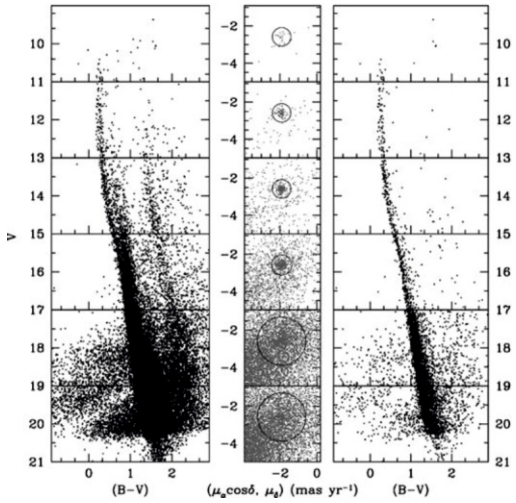


Figure 10: Proper motion VPD (middle panels) in different magnitude bins and calibrated *(B − V)*, V CMD (left-hand and right-hand panels) are shown for the cluster NGC 6067. Left-hand panel shows the entire cluster stars, and the right-hand panel shows stars in VPD within the chosen circle radius.

Extra-Galactic Astronomy

1. GRB and Supernovae

Observation of inverse Compton emission from a long gamma ray burst

On 14-January-2019, following an alert from the Neil Gehrels Swift Observatory and the Fermi satellite, the MAGIC telescopes observed and detected long lasting radiation upto atleast 1 TeV from GRB 190114C. This was the first time that TeV radiation was reported. Owing to the low redshift of GRB 190114C (z=0.4245±0.0005), a comprehensive set of multi-wavelength observations were collected which allows to study the time evolution of GRB emission across 17 orders of magnitude in energy, from 5×10^{-6} to 10^{12} eV. The broadband spectral energy distribution was found to be double peaked, with TeV emission constituting a distinct spectral component with power comparable to the synchrotron component. This TeV component is associated with the afterglow and is satisfactorily explained by inverse Compton up-scattering of synchrotron photons by high energy electrons. The conditions required to account for the observed TeV component are typical for GRBs, supporting the possibility that inverse Compton is commonly produced in GRBs. **[**MAGIC Collaboration, including **Misra, K.** & **Pandey, S. B.** (2019). *Nature, 575*, 459-463**]**

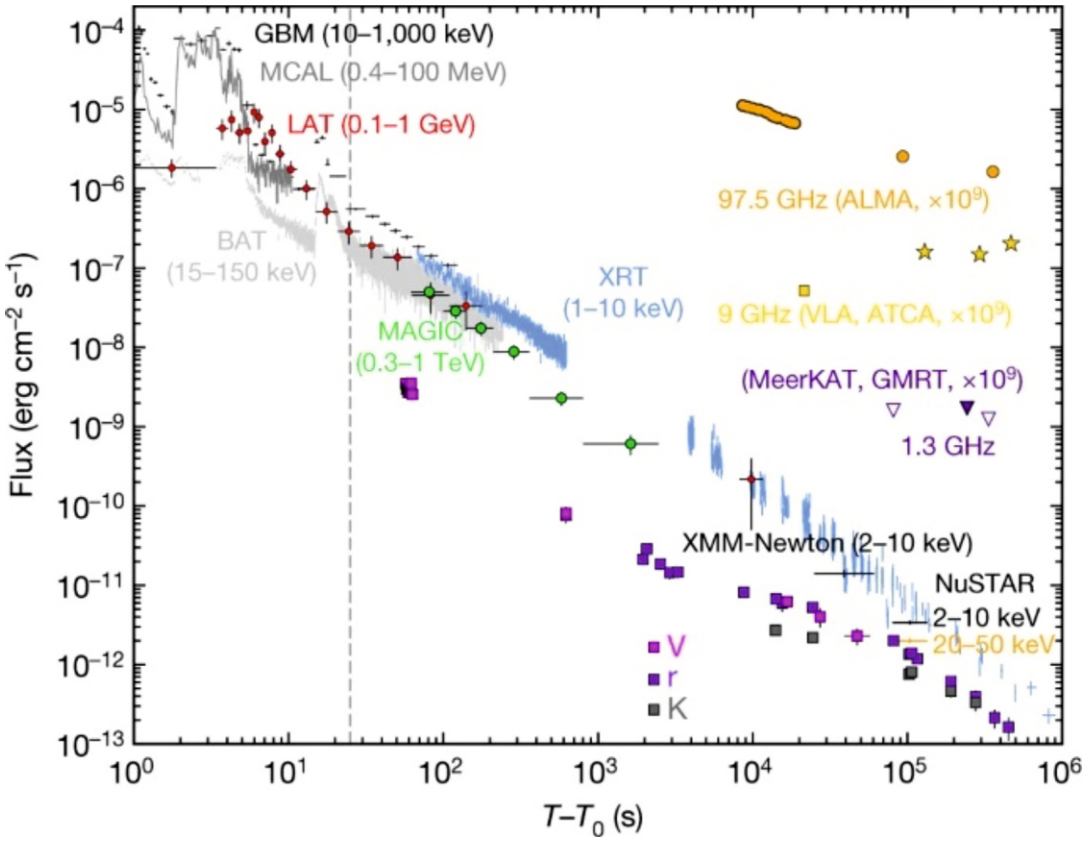


Figure 11: Energy flux at different wavelengths, from radio to γ-rays, versus time after the BAT trigger, at T_0 = 20:57:03.19 universal time (ut) on 14 January 2019. The light curve for the energy range 0.3–1 TeV (green circles) is compared with light curves at lower frequencies. Those for VLA (yellow square), ATCA (yellow stars), ALMA (orange circles), GMRT (purple filled triangle) and MeerKAT (purple open triangles) have been multiplied by 10^9 for clarity. The vertical dashed line marks approximately the end of the prompt-emission phase, identified as the end of the last flaring episode. For the data points, vertical bars show the 1σ errors on the flux, and horizontal bars represent the duration of the observation. The fluxes in the V, r and K filters (pink, purple and grey filled squares, respectively) have been corrected for extinction in the host and in our Galaxy; the contribution from the host galaxy has been subtracted.

SN 2010kd: Photometric and Spectroscopic Analysis of a Slow-decaying Superluminous Supernova

Superluminous SNe are the most luminous SNe, having a mean absolute magnitude of ~ -21.7 mag and are very rare comprising only ~0.01% of the normal population of core collapse SNe. A low redshift (z = 0.101), H-deficient superluminous SN 2010kd is studied using the UV/optical photometric and optical spectroscopic data between -28 to +194 days relative to B band maximum. The B-band light-curve comparison of SN 2010kd with a subset of well-studied superluminous SNe I at comparable redshifts indicates that it is a slow-decayingPTF12dam-like superluminous SN. Analytical light curve modeling favours an ejecta CSM interaction as the powering mechanism in SN 2010kd. SYNAPPS modeling of the early-phase spectra does not identify broad H or He lines, whereas the photospheric-phase spectra are dominated by O I, O II, C II, C IV, and Si II. The nebularphase spectra of SN 2010kd are dominated by O I and Ca II emission lines similar to those seen in other superluminous SNe I. The host of SN 2010kd is a dwarf galaxy with presence of extreme emission lines and a high star formation rate of ~$0.18 \pm 0.04\, M_{\odot}\, \mathrm{yr}^{-1}$. [**Kumar, Amit,** et al. (including **Pandey, S. B., Aryan, A., Dastidar, R., Gangopadhyay, A., Gupta, A., Misra, K. & Kumar, B.)** (2020). *Astrophy. Jr., 892:*28 (23pp)]

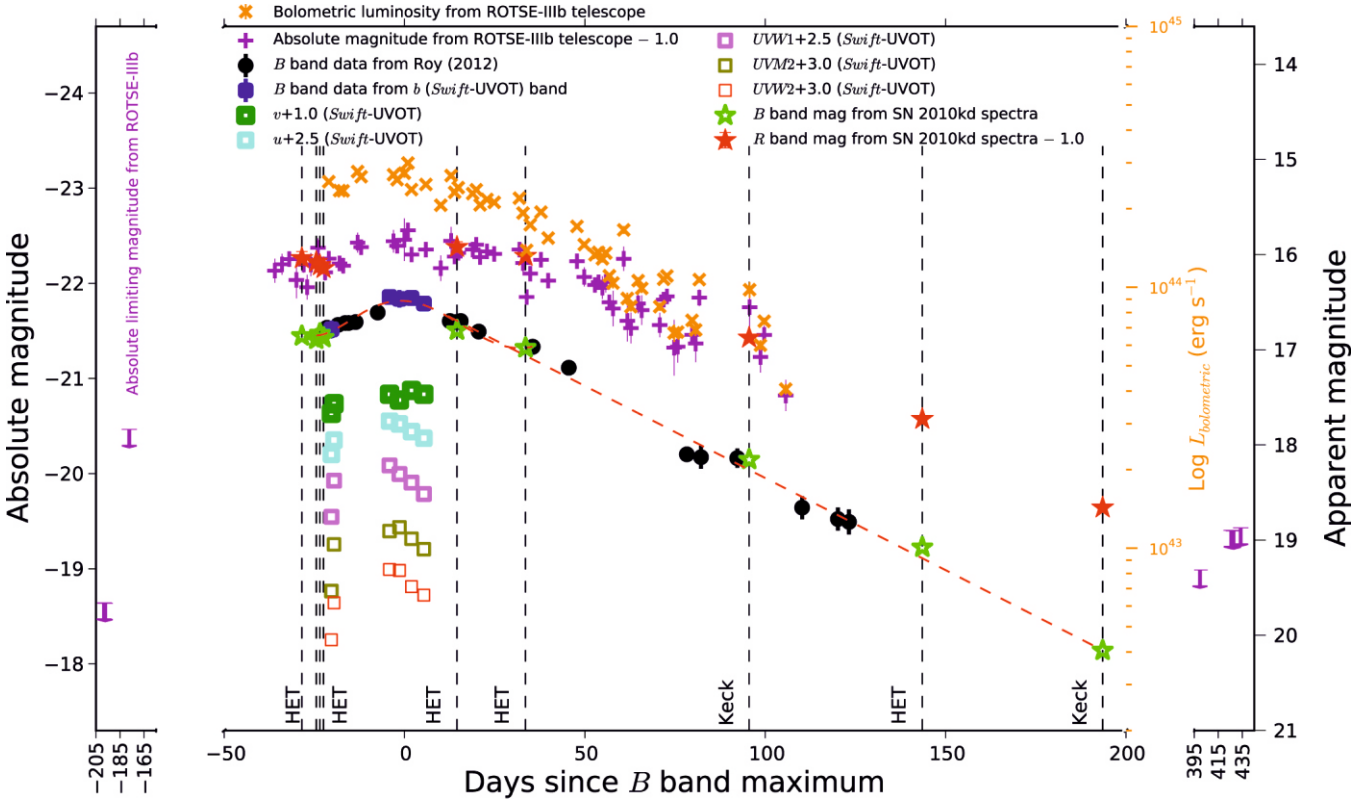


Figure 12: Multiband light curves of SN 2010kd, including the ROTSE-IIIb discovery photometric data in the clear filter (magenta plus signs) along with Swift-UVOT data (squares of different colors), are plotted. The Johnson B-band photometry (in black) was taken from Roy (2012). The magenta arrows represent upper limits obtained by the ROTSE-IIIb at prediscovery and very late epochs. The B- and R-band magnitudes calculated from spectra of SN 2010kd using the sms (Inserra et al. 2018c) code are plotted with star symbols (lime and red, respectively). Around peak brightness, the MB light curve is fitted with a third-order spline function to get the MB, peak and the corresponding MJDB,peak. The postpeak (from peak to +194 days) data points are fitted using a straight line (in red dashed) to estimate the postpeak decay rate. Vertical dashed black lines represent epochs of spectral observations used in the present analysis. The bolometric light curve calculated from ROTSE-IIIb discovery photometry is plotted in orange cross signs, showing a peak at ~$(2.67\pm0.20)\times10^{44}$ erg s^{-1}.

Flash ionisation signatures in the type Ibn supernova SN 2019uo

Sne that are embedded in dense CSM may show short-lived narrow high ionisation emission lines (<10 days) (along with the narrow emission lines produced due to interaction of SNe ejecta with CSM) owing to the recombination of the CSM following the shock breakout flash. These features are known as "flash features" and have been rarely observed. SN 2019uo is the second discovered type Ibn SN, after SN 2010al, with flash ionisation signatures of He II, C III, N III in its early spectra. SN 2019uo displays a rapid post-peak luminosity decline of 0.1 mag day^{-1} similar to most type Ibn SNe, but is fainter (M = -18.30±0.24, V_{max} mag) than a typical SN Ibn and shows a color evolution that places it between SNe Ib and the most extreme SNe Ibn.The bolometric light curve does not support only ^{56}Ni powering mechanism but requires an additional source of energy which is fulfilled by CSM interaction. **[Gangopadhyay, A.,** et al. (including **Misra, K., Dsatidar, R., Kumar, Brajesh, Kumar, B., Pandey, S. B., Sanwal, P.** & **Singh, Mridweeka**) (2020). *Astrophy. Jr., 889:170* (14pp)**]**

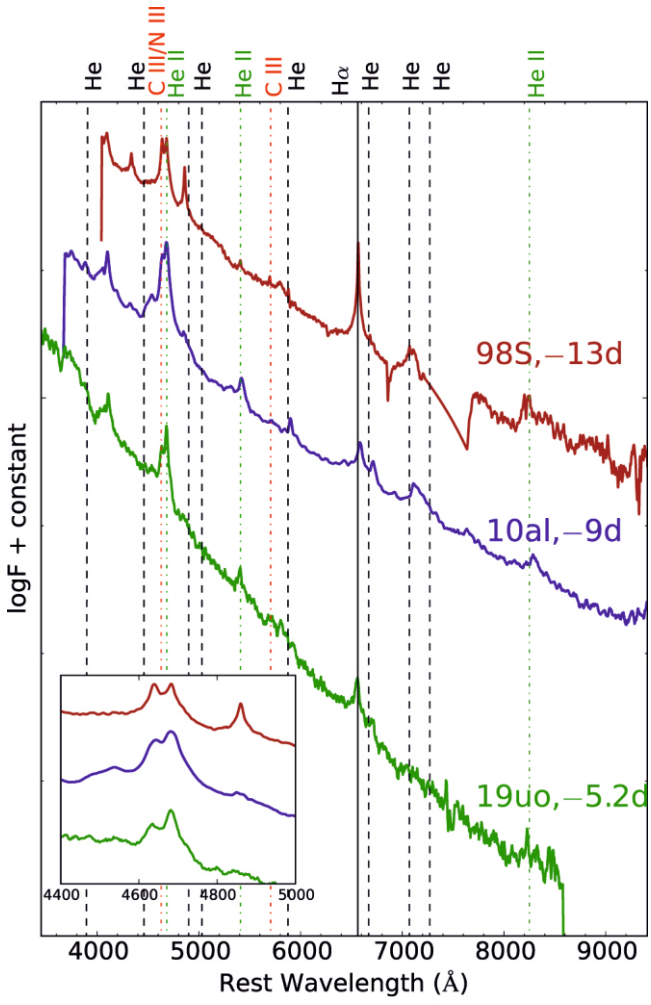


Figure 13: Spectral comparison of SN 2019uo at − 5.2 days to SNe 1998S (Fassia et al. 2001) and 2010al (Pastorello et al. 2015b). Prominent flash ionization features are marked.

A multi-wavelength analysis of a collection of short duration GRBs observed between 2012 and 2015

Using multi-wavelength data, the prompt and afterglow emission properties of a set short GRBs during 2012-2015 are investigated. Five short GRBs which have *INTEGRAL* data between 0.1-10 MeV in the prompt emission phase do not show any signature of the extended emission or precursor activity and their spectral and temporal properties are similar to those seen in case of other short bursts. The afterglow light curve modeling of short GRB 130603B, including new photometric data, puts a constrain on the pre-jet break temporal decay and is broadly consistent with the ISM afterglow model. Modeling of the host galaxies of two short GRBs - 1306063B and 141212A with the LePHARE code supports moderate star formation activity in the burst environment. The availability of late time data allows to put tight constrains on the non-detection of afterglow, host galaxy or any underlying kilonova emission. **[Pandey, S. B.,** et al. (including Kumar, **Amit, Gupta, A., Aryan, A.** & **Kumar, Brajesh**) (2019). *Mon. Not. Roy. Astron. Soc., 485,* 5294-5318**]**

Investigation the properties of core collapse supernovae

The core collapse SNe of type Ib/Ic fall in the category of stripped envelope SNe where the progenitors have stripped off their outer H or He layers via strong stellar winds. Dense photometric and spectroscopic monitoring of these SNe at different stages of evolution serve as an indirect probe to identify the plausible progenitor systems. Rigorous spectroscopic monitoring of

MASTER OT J120451.50+265946.6 (M12045) at 27 epochs upto ~250 days since B_max makes this as one of the best observed type Ib SN. Nebular phase spectra show asymmetry and indicates ~0.90 M_o of O is ejected in the explosion supporting a massive WR progenitor with main sequence mass of ~ 20 M_o.

Core collapse of type II are rich in Hydrogen and show prominent H features in their spectra. Extensively photometric and spectroscopic monitoring are fundamental to characterise the SN and discern the explosion properties. The photometric properties of SN 2015an indicates it to be a normal type IIP SN. However the spectral properties are atypical with low H-α expansion velocity and presence of high velocity component of H-α at early phases indicative of ejecta CSM interaction. Similar high velocity features were also noted in SN 2016B. Although the light curve of SN 2016B exhibits intermediate properties between those of type IIP and IIL SNe. On the other hand SN 2017gmr does not show signs of narrow, high ionisation emission lines in the early optical spectra, yet the optical light curve suggests that an extra energy source from CSM interaction must be present. **[**Singh, Mridweeka, et al. (including **Misra, K., Dastidar, R., Gangopadhyay, A., Kumar, B. & Pandey, S. B.**) (2019). *Mon. Not. Roy. Astron. Soc.*, *485,* 5438-5452; **Dastidar, R.,** et al. (including **Misra, K., Singh, Mridweeka, Gangopadhyay, A., Sanwal, P., Kumar, B. & Pandey, S. B.**) (2019). *Mon. Not. Roy. Astron. Soc.*, *486,* 2850-2872; **Dastidar, R.,** et al. (including **Misra, K., Gangopadhyay, A., Singh, Mridweeka, Kumar, B., Sanwal, P. & Pandey, S. B.** (2019). *Mon. Not. Roy. Astron. Soc.*, *490,* 1605-1619; Andrews, J. E., et al. (including **Dastidar, R., Misra, K., Gangopadhyay, A., Sanwal, P. & Singh, Mridweeka**) (2019). *Astrophy. Jr., 885*:43 (23pp)**]**

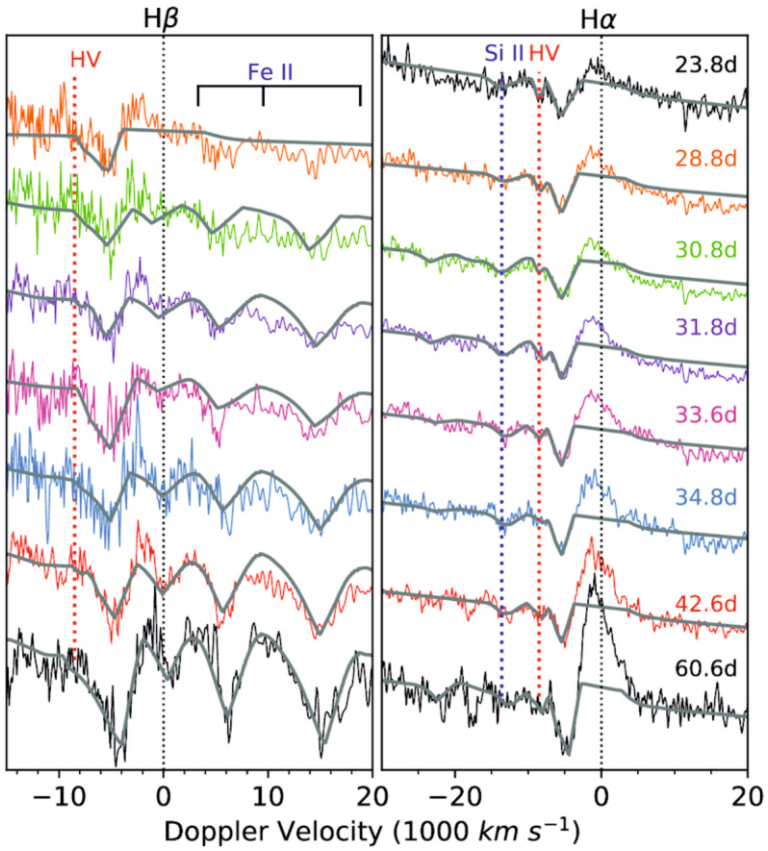


Figure 14: Evolution of H α, H β emission line profiles during the photospheric phase. The SYN++ model fits to the spectra are shown with gray solid lines. The Si II ('B') and high-velocity (HV) features ('A') are conspicuous up to the 50 d spectrum and are shown with dashed lines.

Nature of the unusual transient AT 2018cow from HI observations of its host galaxy

At2018cow, the unusual and poorly understood transient located in the host galaxy CGCG137-068 provides an unparalleled opportunity to learn about both the stellar and galaxy evolution. The HI hyperfine structure line observations of the AT 2018cow host galaxy were conducted with the GMRT. The observations indicate that there is no atomic gas concentration near the position of AT 2018cow. The gas distribution is much more regular than those of GRB/SN hosts. Two faint HI emitters are detected at 100 – 150 kpc away, but at low significance. Continuum emission is detected from AT 2018cow and a star-forming region in the north-eastern part of the bar (away from AT 2018cow). This region hosts a third of the galaxy's SFR. The absence of atomic gas close to AT 2018cow, along with a normal SFR and regular HI velocity field, sets CGCG137-068 apart from GRB/SN hosts studied in HI. The environment of AT 2018cow therefore suggests that its progenitor may not have been a massive star. [Michalowaski, M. J., et al. (including **Misra, K.**) (2019). *Astron. Astrophy., 627*, A106 (8pp)]

2. External Galaxies and AGN

Detection of faint high-redshift radio galaxy from 3.6-m Devasthal Optical Telescope

High sensitivity optical observations of TGSS J1054+5832, a candidate high-redshift (z = 4.8 ± 2) steep-spectrum radio galaxy, were carried out in r and i bands using the faint object spectrograph and camera mounted on the 3.6-m Devasthal Optical Telescope (DOT). The radio source previously detected at 150 MHz from Giant Meterwave Radio Telescope (GMRT), Pune and at 1420 MHz from Very Large Array, USA has a known counterpart in near-infrared bands with K-band magnitude of AB~22. The source was successfully detected in i-band with AB~24.3 ± 0.2 magnitude in the 3.6-m DOT images. An upper limit to (i–K) color is estimated to be ~ 2.3, suggesting youthfulness of the galaxy with active star formation. These observations highlight the importance and potential of the 3.6-m DOT for detections of faint galaxies. [**Omar, A.,** et al. (including **Chand, K., Paswan, A., Kumar, T. S., Krishna Reddy, B. & Pant, J.**) (2019. *Jr. Astrophy. Astron., 40:*9 (6pp)

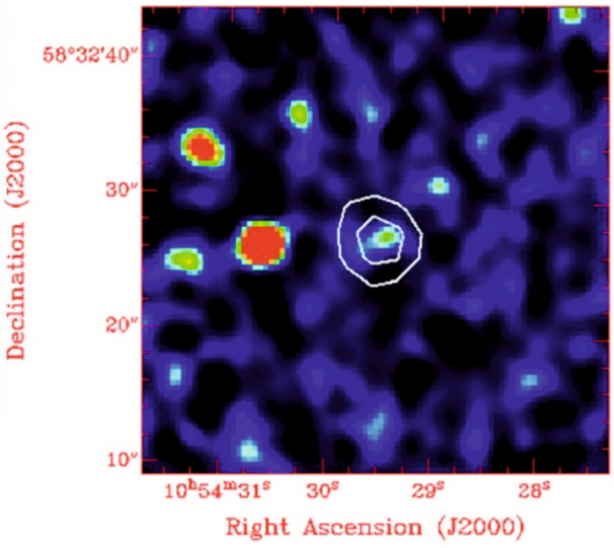


Figure 15: The DOT i-band color-coded image of TGSS J1054+5832, a high redshift radio galaxy, detected with the 3.6-m DOT. The DOT image is overlaid with the 1.4 GHz radio contours at levels of 1 and 2 mJy beam^{-1}.

Outflow properties of radio loud quasars and their M-sigma relation

Quasars are classified as radio loud and radio quiet. Radio loud quasars possess powerful radio jets that extend from sub-pc to well outside the galaxy and sometimes to Mpc scales. The remaining sources are radio quiet, with much weaker radio jets that are mostly confined within the host galaxy when they are detected at all. Although the mechanism of jet formation in radio loud quasars is still under debate, it has been proposed that the jet provides substantial feedback that could affect the circum nuclear environment, at the galaxy scale and even at larger, galaxy cluster, scales. Recent observations show evidence for AGN feedback in the form of massive large scale outflows. The [O III] emission line shows asymmetry and blueshifts, indicating that NLR is undergoing an organized outflow. In order to study outflows in Narrow Line Region (NLR) in radio loud

quasars, we studied a sample of 223 quasars upto a redshift of 0.3. We study the [O III] line properties of these quasars to investigate the origin and properties of blue wings (shift of the profile towards lower wavelengths) and blue outliers (shift of the whole spectroscopic feature). Most of the quasars show blue

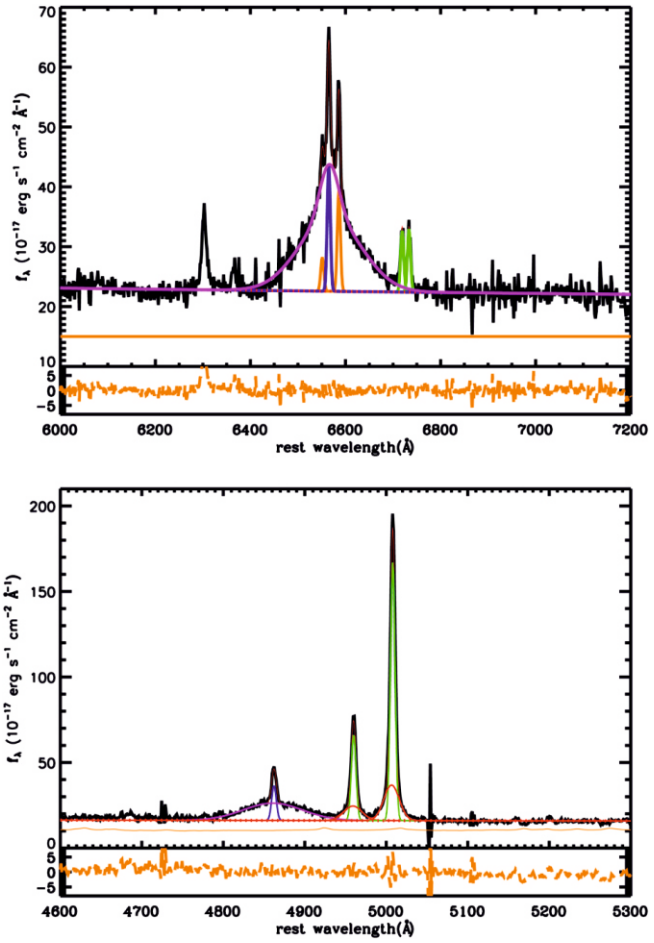


Figure 16: Examples of fits to the spectra in Hα (upper panel) and Hβ regions (lower panel), respectively. Black lines in both panels indicate the observed spectrum, and thick red lines indicate the complete fit to the spectra including all the Gaussian components. The power-law continuum and the Fe II template are shown by red and orange lines, respectively. Broad and narrow Hα are shown in the upper panel by magenta and blue lines, respectively. The [S II] and [N II] lines are shown by green and orange lines, respectively. Broad and narrow Hβ are shown in the lower panel by magenta and blue lines, respectively. The narrow core of [O III] is shown by a green line, and the wing component is represented by a red line. The fit residuals are shown in the lower panels of both panels.

wings with velocities up to 420 km/sec. We find that around 17% of the quasars show outliers with velocities spanning 419 to -315 km/sec. We searched for the possible connection between the NLR and jet interaction leading to such outflows in NLR, but we did not find any significant correlation between them. It is well known that the galaxies having massive bulges contain central Super Massive Black Holes (SMBHs). The studies of the correlation between the mass of the SMBH, and the host stellar velocity dispersion, σ, which is called the MBH − σ relation, is of fundamental importance to understand the galaxy formation and evolution. Earlier studies found a close connection between the black hole mass and bulge stellar velocity dispersion and a close link between the black hole mass and bulge formation and growth. In this work, we revisit the MBH −σ relation of our sample of radio loud quasars using [S II] λ6716, 6731 and [O III] linewidths as surrogates for stellar velocity dispersions, σ, to investigate their location on the MBH −σ relation for quiescent galaxies. Due to strong blending of [S II] with Hα, we could estimate σ[SII] of only 123 quasars. We find that the radio-loud quasars do not show a relationship between MBH and σ [SII] / [OIII] up to a redshift of 0.3, although they cluster around the local relation. We find an overall offset of 0.12 ± 0.05 dex of our sample of radio loud quasars from the MBH − σ relation of quiescent galaxies. Quasars in our highest redshift bin (z=0.25-0.3) show a deviation of ~0.33 ± 0.06 dex with respect to the local relation. **[Gaur, H.,** Gu, M., Ramya, S. & Guo, H. (2019). *Astron. & Astrophy., 631*, A46 (1-11 pp)**]**

Narrowband Hα imaging of star-forming dwarf galaxies

Narrow-band Hα imaging of 13 nearby Wolf–Rayet (WR) galaxies, known as a subset of starburst galaxies, was carried out using the 1.3-m Devasthal fast optical telescope. The Hα images have been used to study morphology of star-forming regions in the galaxies.The images suggest that the studied galaxies have most likely experienced merger or interaction with low luminous dwarf galaxies or H I clouds. The Hα-based star formation rates (SFRs) in galaxies using our Hα observations were derived. These SFRs are found to be well correlated with the SFRs derived using other indicators at far-ultraviolet,

far-infrared, and 1.4-GHz radio wavebands. It is noticed that the infrared excess (IRX) method gives the best SFR estimates, consistent with different models predication. These models also predict that the sample galaxies have probably gone through a continuous star formation at least for 1 Gyr over which the recent star formation has taken place in a WR phase. This study presents main-sequence (MS) relation for nearby WR galaxies for the first time. This derived MS relation is found to be similar to previously known MS relation for normal nearby star-forming galaxies, suggesting that the WR systems evolve in a similar fashion as normal star-forming galaxies evolve. **[**Paswan, A., Saha, K. & **Omar, A.** (2019). *Mon. Not. Roy. Astron. Soc., 490*, 3448-3453**]**

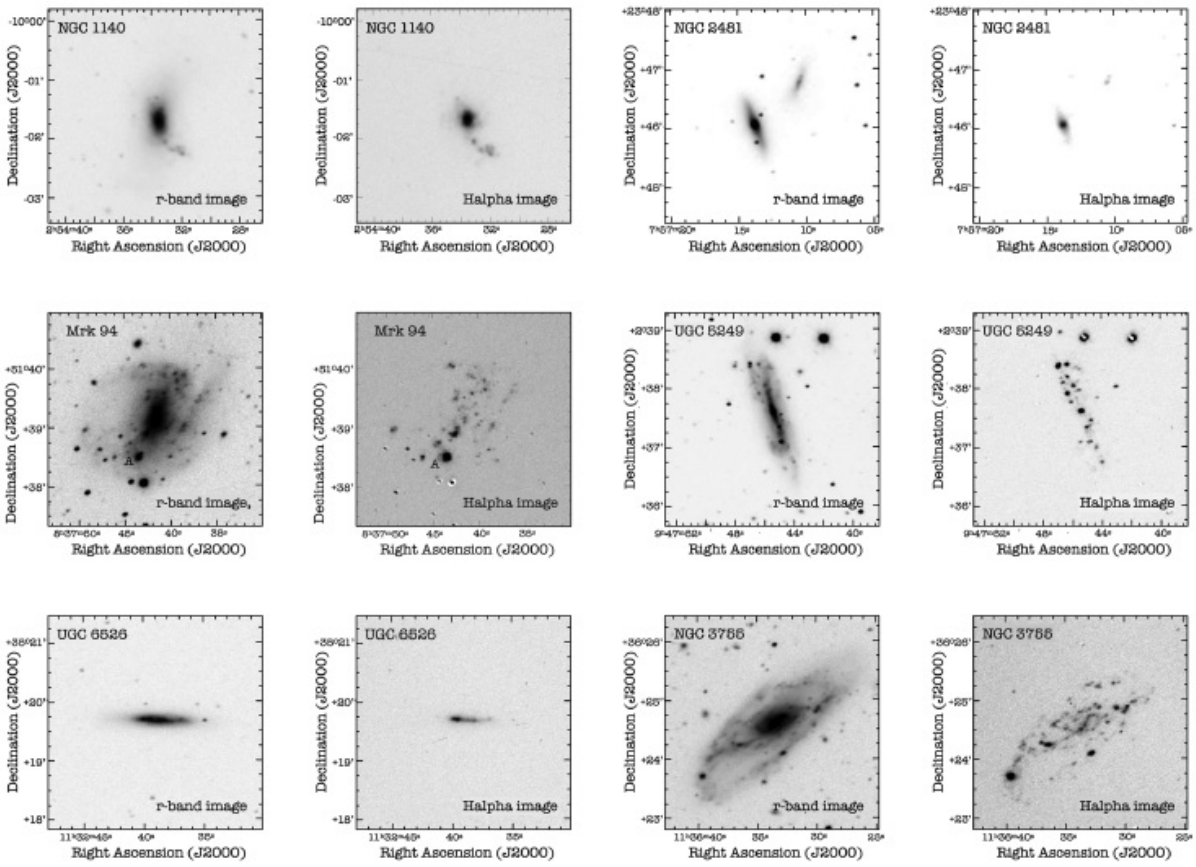


Figure 17: The broad r band (left) and continuum subtracted Hα (right) images of WR galaxies obtained from the 1.3m Devasthal Fast Optical Telescope..

3. Blzars

OJ 287: A unique astrophysical laboratory to explore physics of accretion and jet in supper-massive black holes

Active galaxies are galaxies with a very active central supermassive black hole. One of its subclass called blazars is active galaxies that host a powerful relativistic jet which is roughly aligned with our line of sight. However, contrary to active galaxies where radiation is mainly due to accretion-disk and corona, blazar emission is almost entirely from the jet and spread across the entire electromagnetic spectrum from radio to gamma-rays. OJ 287 belongs to the BL Lacartae subclass of blazar which has very weak or totally absent emission line features. This source shows unique optical outbursts every ~12 years and based on this it is postulated to host a binary

black hole system. The best model which explains and predicts these ~12-yr outbursts claims that the masses of the primary and secondary black holes are 1.83 x 10^{10} $M_{\odot}$ and 1.5 x 10^{8} $M_{\odot}$, respectively and these outbursts are due to impact of secondary on the accretion-disk of the primary. However, no accretion-disk emission was ever observed in this source as required by the model until 2015. In the 2015 outburst, our multi-wavelength study, for the first time, reported the accretion-disk emission from a ~10^{10} $M_{\odot}$ black hole. On further investigation, we found that this emission first appeared in May 2013 and is present since then. Both of these were consistent with the prediction of the model and provided the first independent proof of the model from the spectral domain.

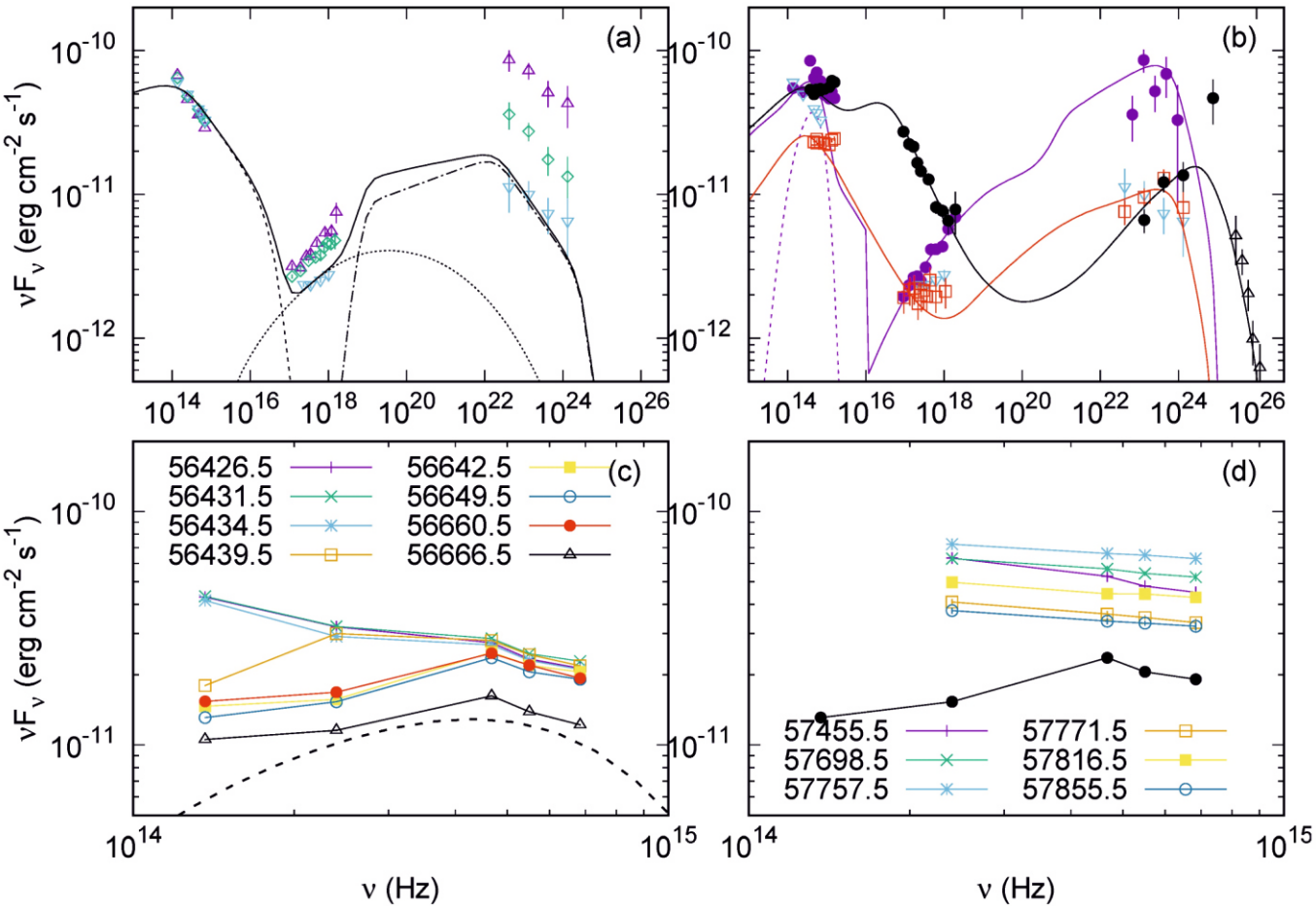


Figure 18: Broadband and optical SEDs showing the spectral phases exhibited by OJ 287 to date. (a) Typical broadband SEDs of OJ 287 from a 2009 observation [28] showing three different flux states: Flare (magenta, MJD: 55124-55131), moderate (green, MJD: 55131-55152) and quiescent (cyan, MJD: 55152-55184) MW emission. The solid curve is the total emission with synchrotron, SSC and EC-IR component shown respectively in dashed, dotted, and dot-dashed curves (see [28], for modeling details). (b) Broadband SEDs of the source in its new spectral phase during 2016–2017 with magenta (MJD: 57359-57363; [60]) showing a flare SED, black (MJD: 57786; [27]) showing a typical SED during the VHE phase and red (MJD: 57871; [27]) showing the quiescent SED state after the VHE activity with the lowest flux across EM spectrum. For reference/comparison, the quiescent SED (cyan) from panel (a) is also shown. The solid curves are the model produced spectrum, while the dotted curve is the standard accretion-disk spectrum of a ~10^{10} $M_{\odot}$ SMBH; (c) NIR-optical spectrum highlighting the timing of tbe appearance of spectral break [60]. The dashed curve is the accretion-disk spectrum drawn again for clarity. (d) NIR-optical SEDs before (MJD 57455.5), during and after the VHE activity of OJ 287, showing return to the typical power-law NIR-optical spectrum. For comparison, one of the SED (black) from (c) is also shown.

In our next work, we further investigated this source at optical to X-ray energies where it has shown the new spectral features. Our investigation of 2015 and 2018 X-ray observations by XMM- Newton satellite showed a significant excess below 2 keV compared to its generally observed power-law spectrum in the X-ray band (0.3 - 10 keV) in 2015 data. By a detailed and systematic study we showed that this excess cannot be due to the extension of the synchrotron emission component to X-rays. Based on broadband optical to X-ray modeling, we found reprocessing of X-ray photons by disk or Comptonization of UV photons as the best candidates but favored the reprocessing scenario based on lagging of UV with respect to X-ray. This explanation was also consistent with the observed accretion disk emission from a 10^{10} M_o supermassive black hole which was present in 2015 but has disappeared in 2018. **[Kushwaha, P.** (2020). *Galaxies, 8*:15, 1-17; Pal, M., **Kushwaha, P.**, Dewangan, G. C. & Pawar, P. K. (2020). *Astrophy. Jr., 890*:47 (9pp)**]**.

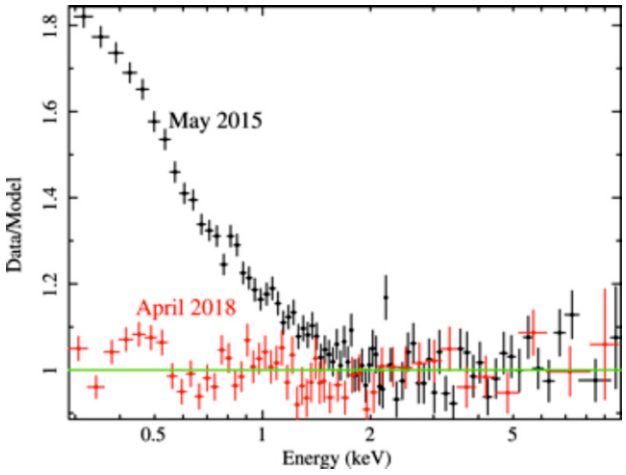


Figure 19. Ratio (Data/Model) plot of absorbed power-law model fitted in 2–10 keV band and then extended to 0.3–2 keV. A clear soft excess is present at low energies in the 2015 May data, while the 2018 data seems consistent with a power-law model.

Signature of Stochastic Acceleration and Cooling Processes in an Outburst Phase of the TeV Blazar ON 231

NASA satellite Swift and ESA (European Space Agency) satellite XMM-Newton operate in multi-wavelengths. A detailed spectral and temporal study is carried out of the intermediate type blazar ON 231 during the TeV outburst phase in 2008 June with observations taken from Swift and XMM-Newton. On day timescale, X-ray flux of the source varied between 27% to 38% while mild variation in optical/UV EM bands flux are noticed. A soft lag of ~ 1 hour between UV and soft X-ray band is detected which gave the magnetic field of the emitting region ~ $5.6\,\delta^{-1/3}$ G. The X-ray spectra in the energy range 0.6 – 10 keV is well fitted by broken power-law model which indicates the presence of both synchrotron and inverse Compton components in the X-ray energy range. The synchrotron part of the spectral energy distributions (SEDs) constructed with simultaneous optical/UV and X-ray data follows a log-parabolic shape. A significantly positive $Ep - \beta$ relation is observed from both SED and time-resolved spectral analyses. The most feasible scenario for the observed trend during the flaring event could be associated with a magnetic-field-driven stochastic process evolving toward an equilibrium energy level. **[**Kalita, N., Sawangwit, U., **Gupta, A. C.** & Wiita, P. J. (2019). *Astrophy. Jr., 880*:19 (14pp)**]**

X-Ray Intraday Variability of the TeV Blazar Mrk 421 with Suzaku

Suzaku was an X-ray astronomy satellite developed jointly by the Institute of Space and Aeronautical Science at JAXA and NASA's Goddard Space Flight Center to probe high energy X-ray sources. During its complete operational duration, the brightest X-ray TeV emitting blazar Mrk 421 had three pointed observations in which the longest one was for 101.3 hours. A detailed X-ray flux and spectral analyses of these three pointed Suzaku observations of Mrk 421 showed large amplitude intraday flux variability in all soft and hard bands in all the light curves. The discrete correction function analysis of the light curves in soft and hard bands peaks on zero lag, showing that the emission in hard and soft bands are cospatial and emitted from the same population of leptons. The hardness ratio plots imply that the source is more variable in the harder bands compared to the softer bands. The source is harder when brighter, following the general behavior of high synchrotron peak blazars. Power spectral densities of all three light curves are red noise dominated, with a range of power spectra slopes. If

the emission originates very close vicinity to the central super massive black hole, its mass is estimated to be ~ 4×10^8 M_o. The possible physical mechanisms most likely responsible for the observed flux and spectral variability are described. **[**Zhang, Z., et al. (including **Gupta. A. C. & Gaur, H.**) (2019). *Astrophy. Jr., 884*:125 (11pp)**]**

Detection of a quasi-periodic oscillation in γ−ray light curve of the high-redshift blazar B2 1520+31

Using NASA (National Aeronautics and Space Administration) γ−ray satellite Fermi and LAT (Large Area Telescope) on board which operates in 0.1 – 300 GeV, a possible ~71 days quasi-periodic oscillation (QPO) detected in the light curve taken between 2008 August 5 and 2012 June 22 of the high redshift blazar B2 1520+31. The QPO in the light curve of the blazar is confirmed by LombScargle periodogram and weighted wavelet Z-transform analyses. Using this QPO period, the central supermassive black hole (SMBH) mass is found in the range between 5.4×10^9 M_o to 3.4×10^{10} M_o. Various radio loud AGN emission models that can produce γ−ray QPOs with such periods in blazars are discussed. **[Gupta , A. C.,** et al. (2019). *Mon. Not. Roy. Astron. Soc.*, *484,* 5785-5790**]]**

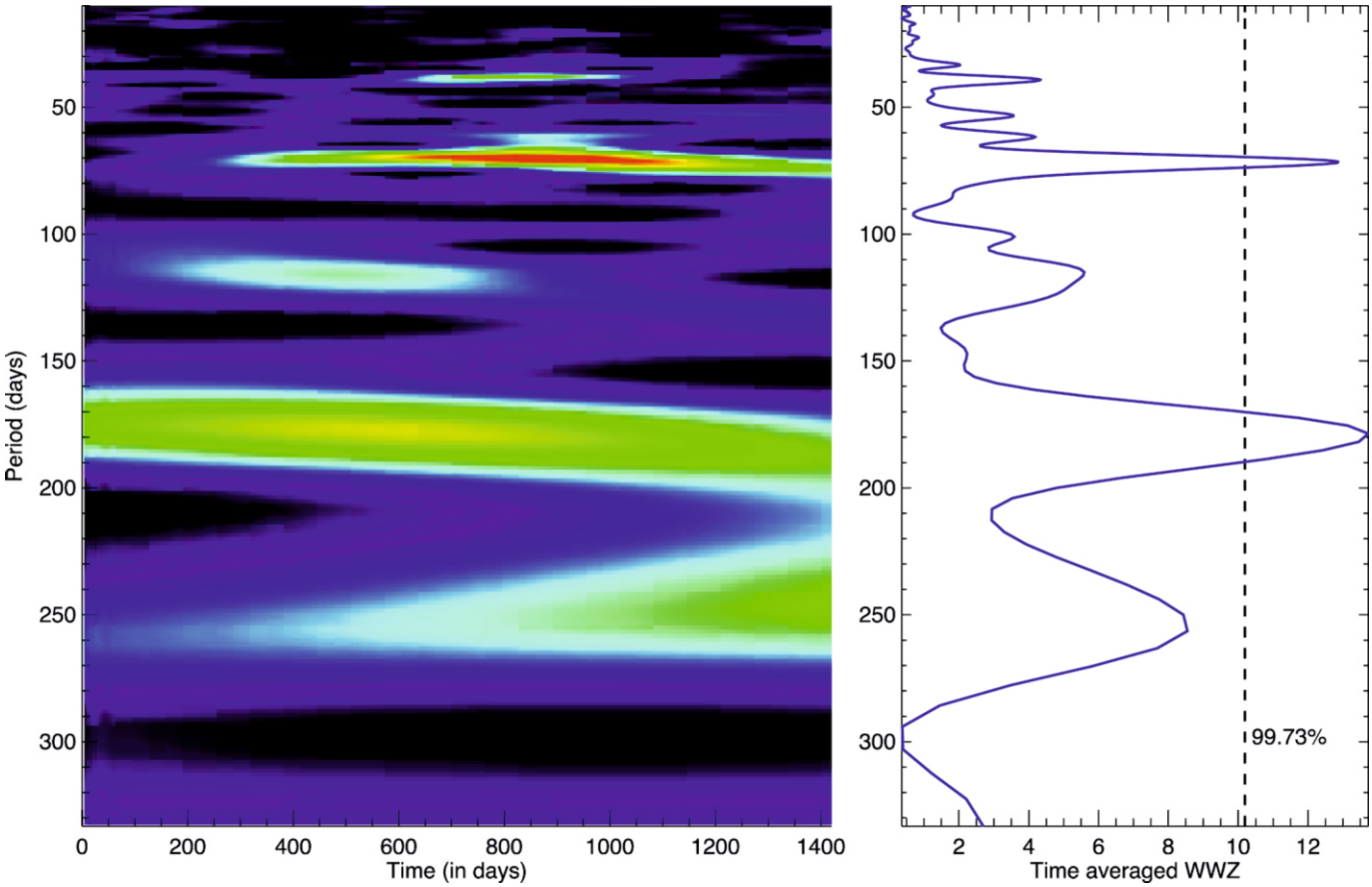


Figure 20. Weighted wavelet Z-transform (WWZ) of the light curve. The left-hand panel shows the distribution of colour-scaled WWZ power (with red most intense and black lowest) in the time–period plane; the right-hand panel shows the time-averaged WWZ power (solid blue curve) as a function of period and the 99.73 per cent global significance (dashed black curve).

Long-term Variability and Correlation Study of the Blazar 3C 454.3 in the Radio, NIR, and Optical Wavebands

The blazar 3C 454.3 is a flat spectrum radio quasar. Its long-term optical (B, V, R bands), infrared (J and K bands), and radio band (15, 22, 37 GHz band) data collected over a period of more than 8 years (MJD 54500 – 57500). The temporal variability, spectral properties, and interwaveband correlations were studied by dividing the available data into smaller segments with more regular sampling. It constrain the size and the relative locations of the emission regions for different wavebands. Spectral analysis of the source revealed the interplay between the accretion disk and jet emission. The source predominantly showed a redder-when-brighter trend, though we observed a bluer-when-brighter trend at high flux levels, which could be a signature of particle acceleration and radiative cooling. Significant correlations with near-zero lag were seen between various optical and infrared bands, indicating that these emission regions are cospatial. Correlations with a time lag of about 10 – 100 days are seen between the optical/infrared and radio bands indicating these emissions arise from different regions. **[**Sarkar, A., et al. (including **Gupta, A. C. & Gaur, H.**) (2019). *Astrophy. Jr., 887*:185 (14pp)**]**

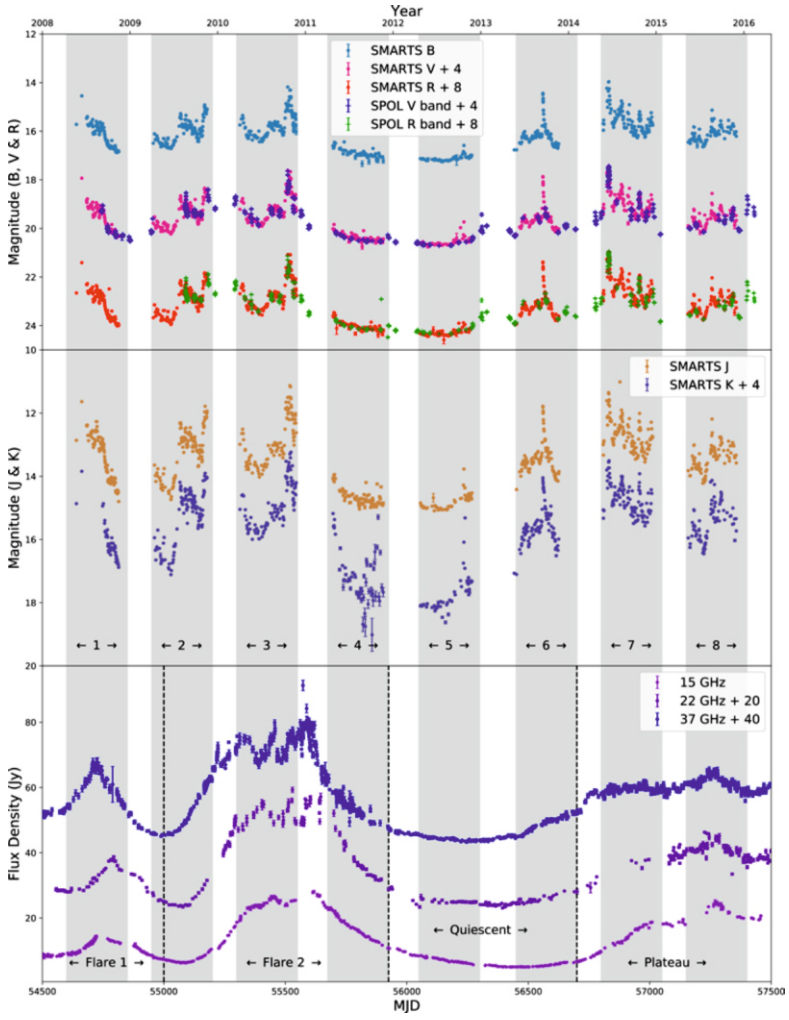


Figure 21. Multiwaveband light curves for 3C 454.3: (top) optical bands; (middle) IR bands; (bottom) radio bands. Curves in different bands are shifted, as indicated in the legends, to improve visibility; and the eight individual segments are shaded gray. In the last panel, the dotted lines separate the radio light curves into four segments where further analyses were performed.

Optical Variability of the TeV Blazar 1ES 0806+524 on Diverse Timescales

Optical (VRI) band photometric observations of the TeV blazar 1ES 0806+524 was carried out on 153 nights during 2011 – 2019 by using seven optical telescopes in Asia and Europe. For the first time, an extensive optical variability study of the blazar was carried out on intra-day and long timescales. Out of 18 intraday light curves for flux and color variations, only on one night a small but significant flux variation was found in both V and R bands light curves while color was non variable on all the nights. Flux density changes of around 80% were seen over the course of these eight years in multiple optical bands. A weighted mean optical spectral index of 0.639±0.002 was determined during our monitoring period by fitting a power law in 23 optical (VRI) spectral energy distributions (SEDs). Different possible mechanisms responsible for blazar variability on diverse timescales were discussed. **[Pandey, Ashwani, Gupta, A. C.** et al. (2020). *Astrpohy. Jr., 890:72* (11pp)**]**

Optical variability of TeV blazars on long time-scales

The results of photometric observations of three TeV blazars, 3C 66A, S5 0954+658 and BL Lacertae, during the period 2013–2017 were presented. An extensive observations were performed in a total of 360 nights which produced ~ 6820 image frames in BVRI bands. The flux and spectral variability of these blazars on these lengthy timescales were studied and also examined the optical Spectral Energy Distributions (SEDs) of these blazars, which are crucial in understanding the emission mechanism of long-term variability in blazars. All three TeV blazars exhibited strong flux variability during the observations. The colour variations are mildly chromatic on long timescales for two of them. The nature of the long-term variability of 3C 66A and S5 0954+658 is consistent with a model of a non-thermal variable component that has a continuous injection of relativistic electrons with power law distributions around 4.3 and 4.6, respectively. However, the long-term flux and colour variability of BL Lac suggests that these can arise from modest changes in velocities or viewing angle toward the emission region, leading to variations in the Doppler boosting of the radiation by a factor ~ 1.2 over the period of these observations. **[Gaur, H.,** et al. (including **Gupta A. C.**) (2019). *Mon. Not. Roy. Astron. Soc., 484,* 5633-5644**]**

Long-term optical spectroscopic variations in blazar 3C 454.3

Ten years of optical spectroscopic data from the Steward Observatory for the blazar 3C 454.3, as well as γ-ray data from the Fermi Large Area Telescope (LAT) is used to characterize the long-term variations in the broad line region in the blazar, where Comptonisation of broad-line emission within a relativistic jet is the standard scenario for production of γ–ray emission that dominates the spectral energy distribution. The optical spectra are dominated by a highly variable non-thermal synchrotron continuum with a prominent Mg II broad emission line. The line flux was obtained by spectral decomposition including significant contribution from the Fe II pseudo-

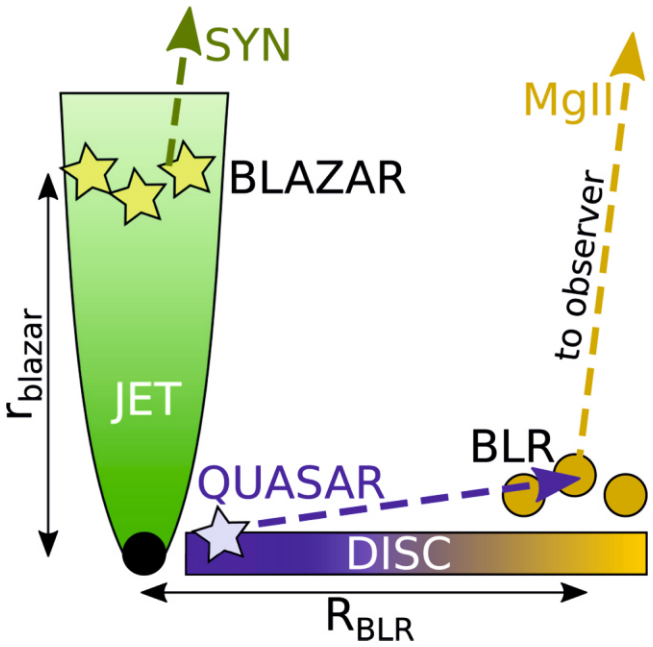


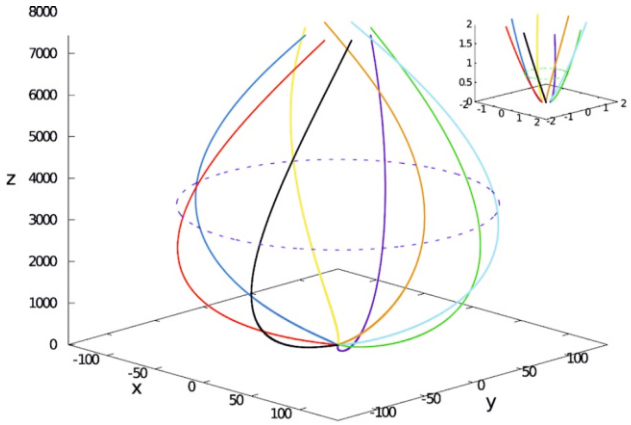
Figure 22. Schematic illustration of an AGN being both a quasar (luminous thermal emission from the accretion disc) and a blazar (even more luminous non-thermal emission from the relativistic jet), i.e. an FSRQ like 3C 454.3. It is assumed here that the BLR is concentrated along the accretion disc plane at characteristic distance R_{BLR} from the SMBH. The optical continuum is dominated by the synchrotron radiation produced in a blazar zone located within the jet at characteristic distance r_{blazar}, and the Mg II BEL is produced in the BLR.

continuum. Three methods were used to characterize variations in the line flux: (1) stacking of the continuum-subtracted spectra, (2) subtracting the running mean light curves calculated for different timescales, and (3) evaluating potential time delays via the discrete correlation function (DCF). The data suggest that the line flux responds to a dramatic change in the blazar activity from a very high state in 2010 to a deep low state in 2012. Two interpretations are possible: either the line flux is anti-correlated with the continuum or the increase in the line luminosity is delayed by ~ 600 days. If this time delay results from the reverberation of poorly constrained accretion disc emission in both the broad-line region (BLR) and the synchrotron emitting blazar zone within a relativistic jet, we would obtain natural estimates for the BLR radius $R_{BLR,MgII} \geqslant 0.28$ pc and mass of the supermassive black hole $M_{SMBH} \sim 8.5 \times 10^8 M_{\odot}$. **[**Nalewajko, K., et al. (including **Gupta, A. C**.).(2019). *Astron. & Astrophy., 631*, A4 (1-8 pp)**]**

4. Theoretical and Numerical Analysis of Astronomical Sources

Study of relativistic magnetized outflows with relativistic equation of state

We study relativistic magnetized outflows using relativistic equation of state having variable adiabatic index (Γ) and composition parameter (ξ).We study the outflow in special relativistic magnetohydrodynamic regime, from sub-Alfvenic to super-fast domain. We showed that, after the solution crosses the fast point, magnetic field collimates the flow and may form a collimation-shock due to magnetic field pinching/ squeezing. Such fast, collimated outflows may be considered as astrophysical jets. Depending on parameters, the terminal Lorentz factors of an electron-proton outflow can comfortably exceed few tens. We showed that due to the transfer of angular momentum from the field to the matter, the azimuthal velocity of the outflow may flip sign. We also study the effect of composition (ξ) on such magnetized outflows. We showed that relativistic outflows are affected by the location of the Alfven point, the polar angle at the Alfven point and also the angle subtended by the field lines with the equatorial plane, but also on the composition of the flow. The pair dominated flow experiences impressive acceleration and is hotter than electron-proton flow.**[Singh, Kuldeep & Chattopadhyay, I.** (2019). *Mon. Not. Roy. Astron. Soc., 488*, 5713-5727**]**.



(a) Streamline side view.

Figure 23. Streamlines of magnetically driven relativistic electron - proton jets. There are two dashed circles, one near to the centre at z ~ 0.73 represents the Aflvén point location and second at z ~ 3500 represents the fast-point location. Here, z is vertical height and x, y are in terms of light cylinder. Inset: Region close to the base is zoomed to show the location of the Alfvén point (dashed circle).

Effect of plasma composition on magnetized outflows

Magnetized winds described by variable adiabatic index equation of state in Paczynski & Wiita pseudo-Newtonian potential were studied. The flow solutions with the parameter space of the flow were identified. We also confirm that the physical wind solution is the one which passes through the slow, Alfven, and fast critical points. We study the dependence of the wind solution on the Bernoulli parameter *E* and the total angular momentum *L*. The adiabatic index, which is a function of temperature and composition, was found to be variable in all the outflow solutions. For the same values of the Bernoulli parameter and the total angular momentum, a wind in strong gravity is more accelerated, compared to a wind in Newtonian gravity. We show that flow variables such as the radial and azimuthal velocity components and temperature all depend on the composition of the flow. Unlike the outflow solutions in hydrodynamic regime, the terminal speed of a magnetically driven wind also depends on the composition parameter. **[Singh, Kuldeep & Chattopadhyay, I.** (2019). *Mon. Not. Roy. Astron. Soc., 486*, 3506-3516**]**.

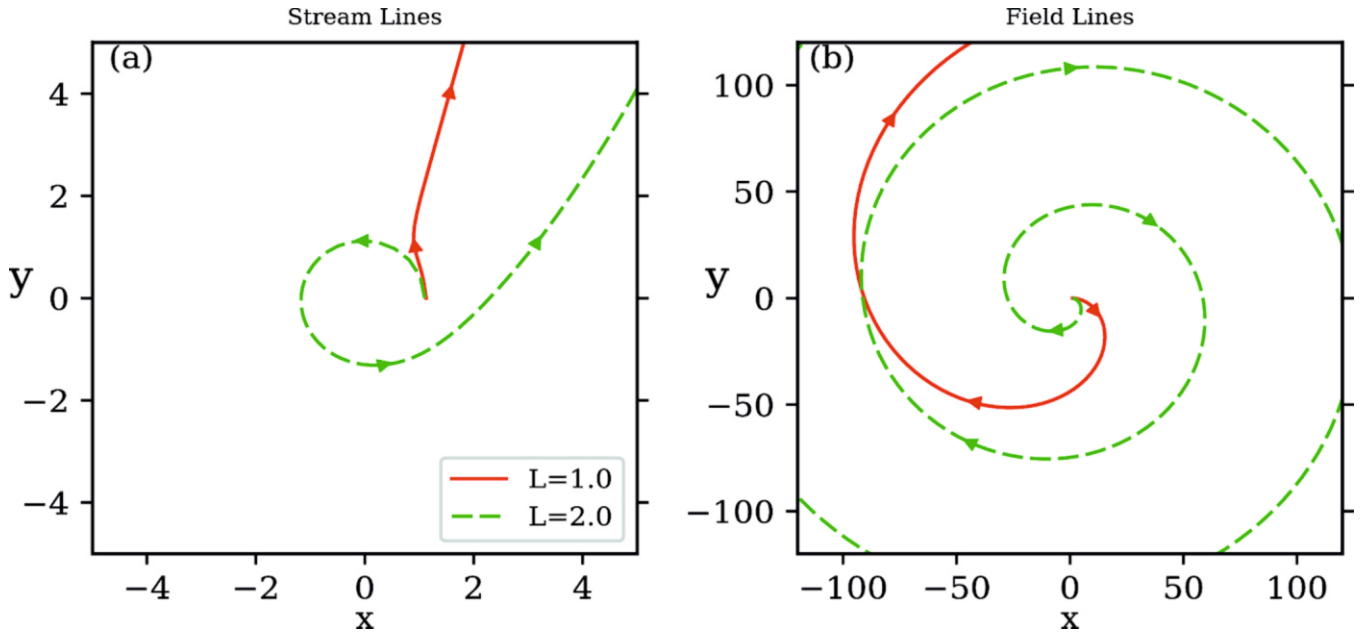


Figure 24. (a) Flow streamlines and (b) magnetic field lines. Each of the curves are for total angular momentum L = 1.0 (solid, red) and L = 2.0 (dashed, green). In both the cases E = 1.030 75.

Research Working Group - II

All the scientists working on the Sun and Atmospheric Sciences are members of WG – II. The group consists of 6 scientists. The solar physics research group (consisting of 2 scientists) is basically concentrated on the observations and modeling of the transients (e.g., flares and associated plasma processes, jets, spicules, etc.), space weather phenomena, and magneto-hydrodyanmic waves in the solar atmosphere. Atmospheric Science group (consisting of 4 scientists) is mainly engaged in the investigation of aerosols, trace gases, dynamics, meteorology etc., of the lower atmosphere. The extracts of the publications made by the members are briefly presented below.

1. Solar Physics

Kinematics and Energetics of the EUV Waves on 11 April 2013

Kinematics and Energetic of the EUV waves on 11 April 2013 In this study, we present the observations of extreme-ultraviolet (EUV) waves associated with an M6.5 flare on 2013 April 11. The event was observed by Solar Dynamics Observatory (SDO) in different EUV channels. The flare was also associated with a halo CME and type II radio bursts. We observed both fast and slow components of the EUV wave. The speed of the fast component, which is identified as a fast-mode MHD wave, varies in the range from 600 to 640 km s^{-1}, whereas the speed of the slow-component is ~140 km s^{-1}. We observed the unusual phenomenon that, as the fast-component EUV wave passes through two successive magnetic quasi-separatrix layers (QSLs), two stationary wave fronts are formed locally. We propose that part of the outward propagating fast mode EUV wave is converted into slow-mode magneto hydrodynamic waves, which are trapped in local magnetic field structures, forming successive stationary fronts. Along the other direction, the fast component EUV wave also creates oscillations in a coronal loop lying ~225 Mm away from the flare site. We have computed the energy of the EUV wave to be of the order of 1020 J. **[**Fulara, A. et al. (including **Uddin, W.**). (2019). *Sol. Phys., 294*: 56 (19pp)**]**

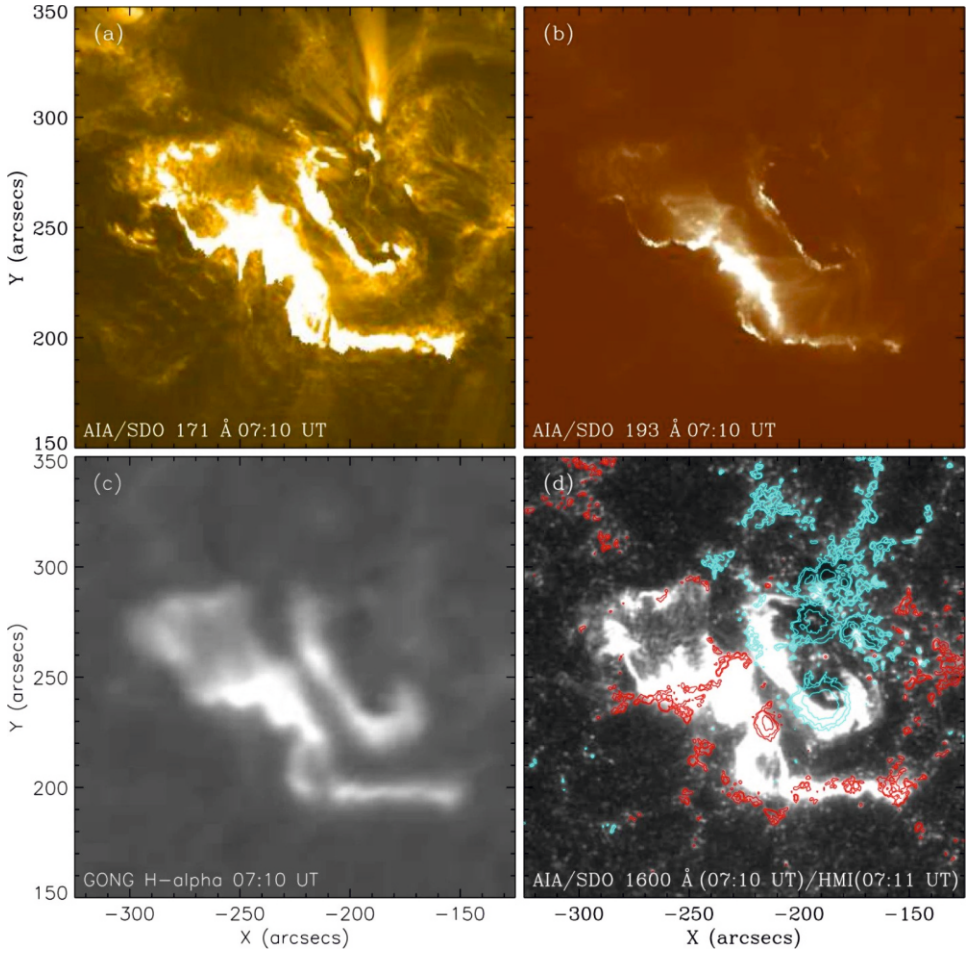


Figure 25. Multiwavelength observations of the flare ribbons in AIA 171, 193, 1600Å and Hα at 07:10 UT where the AIA 1600 Å image is overlaid by HMI contours. Red/cyan colors represent negative/positive magnetic polarities, respectively. The contour levels are ±200, ±400, ±800, ±1600 G.

2. Atmospheric Sciences

Meteorological dynamics associated with emission and transport of dust from the Thar Desert

We examines the atmospheric/meteorological dynamics associated with dust outbreaks from Thar Desert, northwest India and transport along the Indus and Ganges valleys. The dust storms over the region, along with anthropogenic emissions, contribute to deterioration of air quality, leading to PM_{10} concentrations above 1000 μg m^{-3}, and may alter the atmospheric stability and heating rates, thus modulating the Indian summer monsoon rainfall. Furthermore, the deposition of the south-Asian dust over the Himalayan glaciers leads to acceleration of their melting due to decrease in albedo caused by darkening of the snow surface. In June 2018, an intense dust storm facilitated by thermal low and strong density currents associated with the southwest monsoon flow originated from Thar Desert (TD). The dust plume was initially transported to the north and accumulated in the Himalayan foothills at altitudes below 3000 m due to blocking effect and then shifted to the east along the Ganges basin by the dominant northwesterlies. The study uses the synergy of satellite sensors (MODIS, CALIPSO), along with meteorological and aerosol products from re-analysis (MERRA-2, ERA-Interim) and model (Meso-NH) simulations for studying the atmospheric dynamic processes associated with the emissions, uplift, vertical profiles, long-range transport and accumulation of dust.

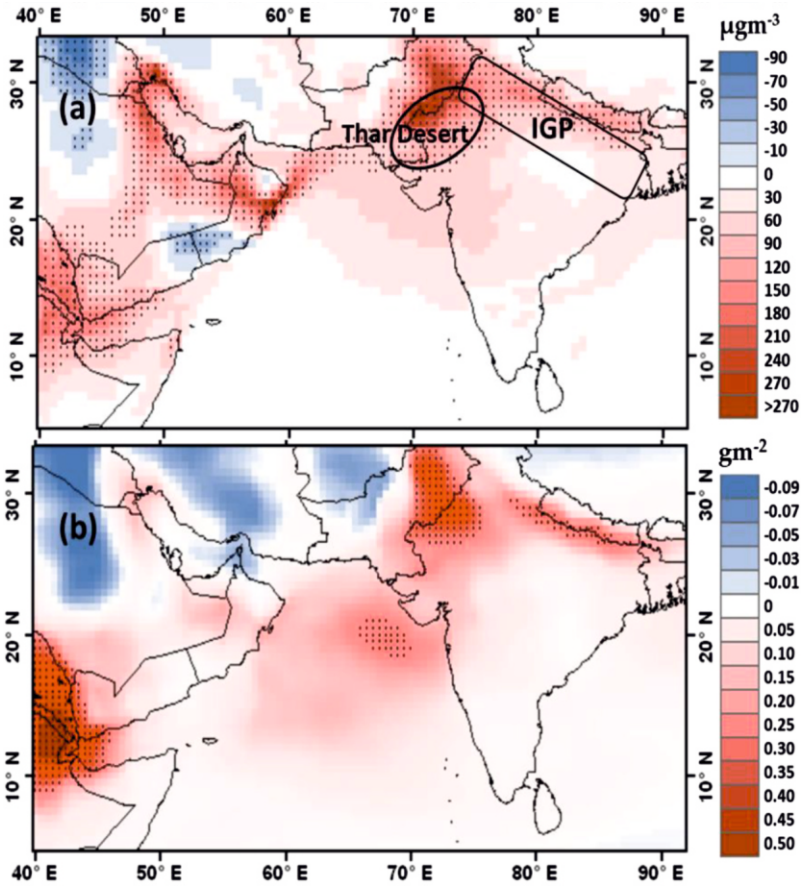


Figure 26. Spatial distribution of the difference (a) dust surface mass concentration and (b) columnar dust mass loading between June 2018 and mean June 91980-2018) according to MERRA-2. The dots represents the statistically significant difference at 95% confidence level.

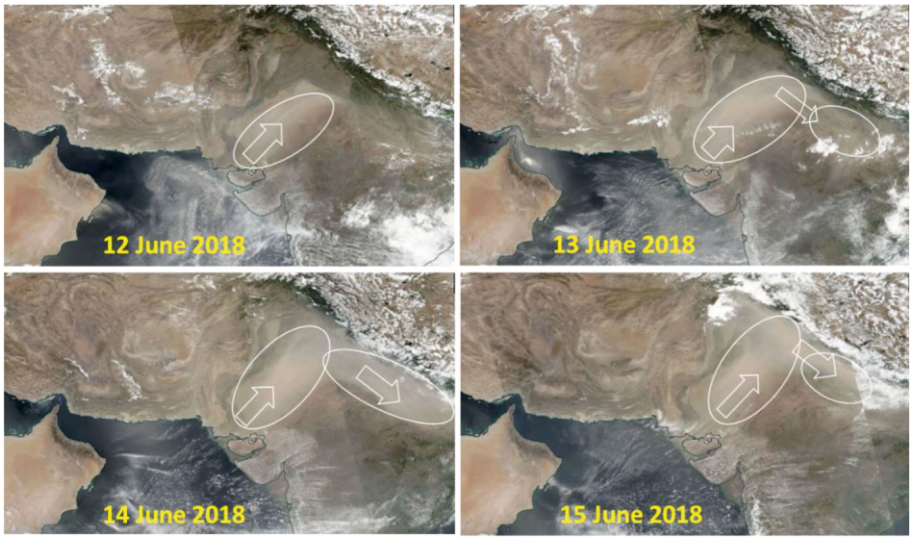


Figure 27. NPP/VIRS true color corrected image for intense dust storm (12-15 June 2018). The circle and arrow shows the main dust plumes and propogation of dust storm.

Dust surface mass concentrations, obtained from MERRA-2 reanalysis, in June 2018 are higher than the June climatological mean (1980-2018), with the largest increases to be detected primarily over the TD and secondarily along the Indo-Gangetic Plain (IGP) **(Figure 26a)**. More specifically, MERRA-2 reveals surface dust concentrations of ~250 μgm^{-3} above the June climatological mean over TD and along the Indian-Pakistan borders, while along the Ganges valley the surface dust concentration was ~100-150 μgm^{-3} above the normal value for June, which is considered as an exceptional increase. Furthermore, the Terra-MODIS AOD_{550} distribution shows increased values in June 2018 compared to mean June (2000-2018) over India, and more specifically, over parts of the IGP and the TD **(Figure 26b)**. Some discrepancies in the spatial distributions of the differences between MODIS and MERRA-2 may be attributed to the different parameters considered as well as to the different climatic periods (1980-2018 for MERRA-2 and 2000-2018 for Terra-MODIS). The large increase in dust aerosols over north India in June 2018 is attributed to an intense and long-lasting dust event (~12 – 16 June). The NPP/VIIRS true-colour imagery detects thick dust plumes over the TD,starting emitted on 12 June 2018, which initially moved to north and then shifted to east along the main axis of the Ganges valley **(Figure 27). [Dumka, U. C.,** et al. (2019). *JGR: Atmosphere, 124,* 197-219**]**

Rossby Wave Breaking Induced Enhancement in the Tropospheric Ozone over the Central Himalayas

An unusual enhancement in the surface and tropospheric ozone concentrations over the central Himalayan region from ground-based and space-borne measurements in the month of December 2010 was reported. The surface ozone levels (~80ppbv) on 18-19 December 2010 is observed to be two-fold higher relative to the seasonal average (December-January-February). The space-borne measurements from Tropospheric Emission Spectrometer (TES) and Ozone Monitoring Instrument (OMI) onboard Aqua satellite also show higher values in the tropospheric column ozone over this region. The plausible reason for this significant enhancement in the surface and tropospheric ozone is found to be associated with the breaking Rossby waves in the upper troposphere. The wave breaking leads to the advection of Potential Vorticity (PV) towards the central Himalayan region from high-latitudes. The vertical component of PV advection shows a deep stratospheric intrusion of high-PV air into the troposphere. The isentropic transport of ozone across the folding tropopause due to the wave breaking is clearly depicted from the satellite and reanalysis datasets. Therefore, the present study has strong implications of upper tropospheric wave dynamics to the tropospheric and surface ozone over the Himalayan regions having complex topography. **[**Kumar, K. N., Sharma, S. K., **Naja, M.** & Phanikumar, D. V. (2020). *Atmos. Envir., 224,* 117356 (11pp)**]**

Water Vapor in the Asian Summer Monsoon Anticyclone: Comparison of Balloon-Borne Measurements and ECMWF Data

Water vapor (H_2O) is the strongest greenhouse gas in our atmosphere. Hence, accurate measurements and a correct representation in global models of H_2O in the upper troposphere/lower stratosphere (UTLS) are important for understanding and projecting climate. Here we compare balloon-borne measurements of UTLS H_2O, performed by Cryogenic Frostpoint Hygrometers (CFH) and meteorological radiosondes (Vaisala RS41) during two intensive field campaigns in the Asian summer monsoon anticyclone region, with humidity data from three products (OPERA, ERA-Interim and ERA5) of the European Centre for Medium-range Weather Forecasts (ECMWF). Taking CFH as a reference, we show that OPERA and ERA5 provide a more accurate representation of UTLS H_2O than ERA-Interim. In particular, OPERA and ERA5 similarly overestimate H_2O mixing ratios by on average 0.7–0.8 ppmv (14–15%) and 0.7–0.9 ppmv (15–17%) at pressures 60–100 hPa, respectively, and both provide a good representation of the observed vertical distribution (including fine structures) and natural variability ofUTLS H_2O. In contrast, ERA-Interim underestimates UTLS H_2O by 0.6–1.7 ppmv (14–30%), and it fails tocapture relevant features of the vertical distribution of UTLS H_2O. At pressures (p) lower than 60 hPa, allthree ECMWF products are in good agreement with CFH. Humidity

measurements by RS41 show an average dry bias of 0.1–0.5 ppmv (3–9%) compared to CFH for 60–100 hPa, and a moist bias increasing with altitude for p < 60 hPa, exceeding 100% for p < 40 hPa. **[**Brunamonti, S., et al. (including **Manish Naja**) (2019), *JGR: Atmospheres, 124*, 7053-7068**]**

Absorption Characteristic of Aerosols over the Central Himalayas and its Adjacent Foothills

The absorption characteristics and sources of aerosols are investigated at Nainital (high altitude site) and Pantnagar (in the adjacent foothill region) using in-situ measurements and model (GEOS-Chem) simulations. The study reveals the significant influence of biomass burning over both the locations during spring, indicating the efficiency of the vertical transport of biomass burning aerosols during the peak of the fire activity period over the northern Indian region. On the other hand, the dominance of fossil fuel emission sources is seen during most part of the year at the mountain site, while biomass/biofuel sources are prevalent at the foothill site. The estimates of BrC are also made at both sites, Nainital and Pantnagar. The seasonal variation in BrC shows significant different seasonal variation in BrC at these sites **(Figure 28)**. The positive BrC contribution (5–12%) is seen during April and May over the Himalayan site, while it is negative in other seasons. The significant positive BrC contribution is seen during all the months at the foothill site in the IGP region. The diurnal variation in BrC is observed to be very prominent at the foothill site as compared to what is observed at the mountain site

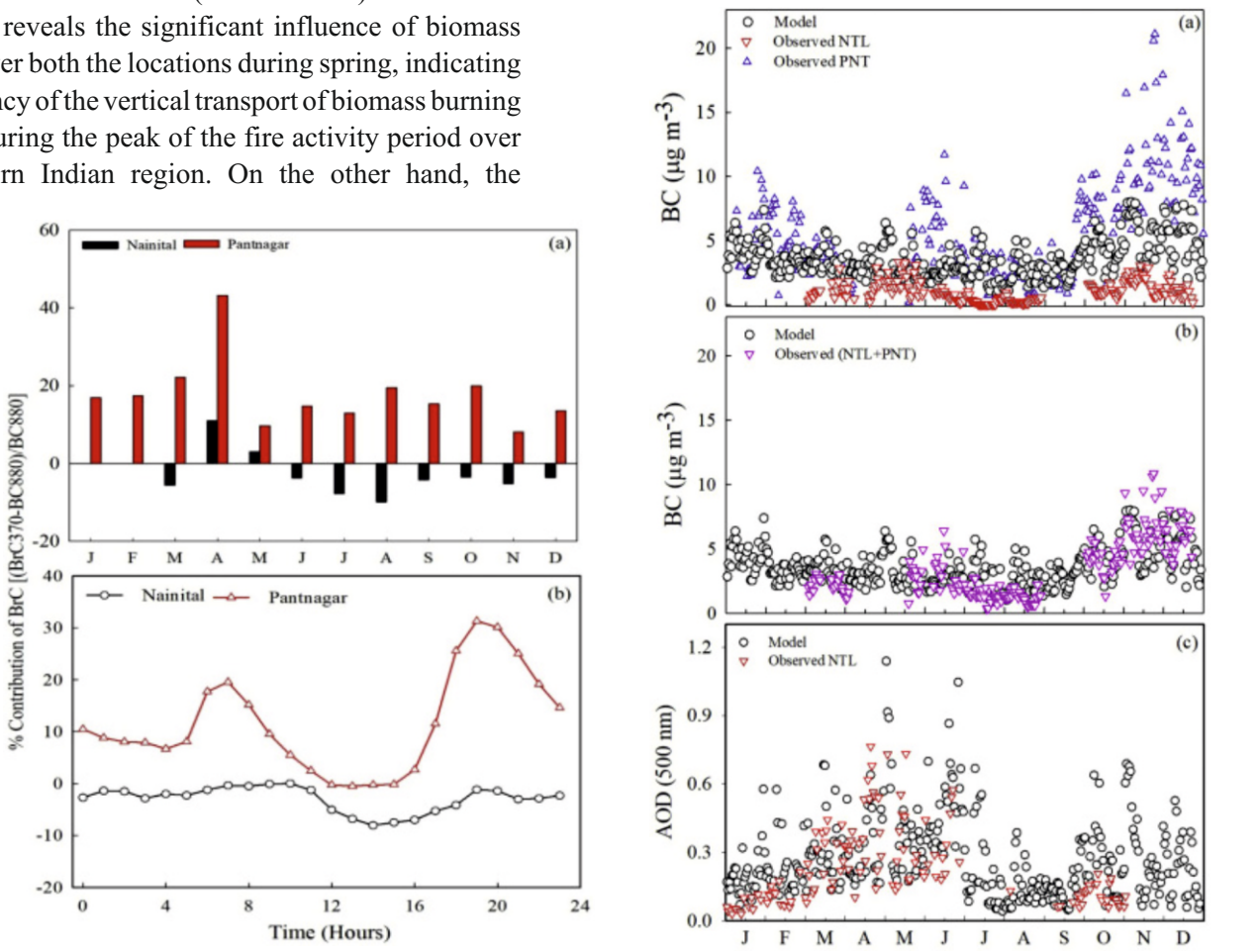


Figure 28. Left panel: The seasonal variation of percentage contribution of BrC at Nainital and Pantnagar. (a) The monthly mean BrC is shown for year 2010-2011. (b) The diurnal variation in annual BrC is also shown. The time mentioned here is the Indian standard time (IST) in hours. **Right panel:** Seasonal variation in BC and AOD (a) The comparison of model simulated BC over the region with the observed BC at Nainital (NTL) and Pantnagar (PNT). (b) Comparison of model simulated BC with the ground-based observation averaged over the region. (c) The comparison of model simulated AOD (500 nm) with the ground based AOD at Nainital for year 2010.

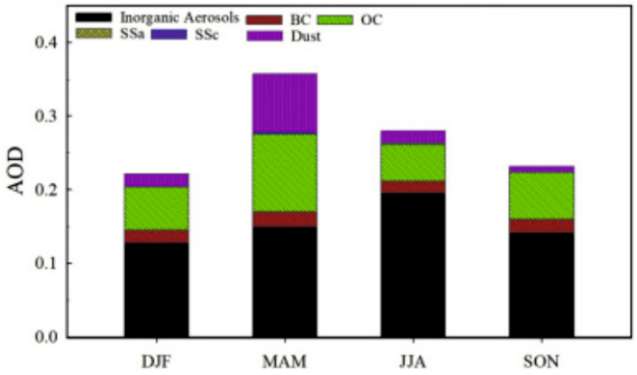


Figure 29. The total contribution of various aerosol components to total aerosol loading during winter (DJF), spring (MAM), summer-monsoon (JJA) and autumn (SON) seasons over the study region.

(Figure 28 Left panel). Model simulated BC mass concentration and AOD show a reasonable comparison with the observations **(Figure 28 Right panel)**. Simulations of different aerosol components in model have revealed that dust aerosols, in addition to carbonaceous aerosols from fossil fuel and biomass burning sources, significantly influence aerosol burden over this region. During spring, the contribution of dust aerosols is as high as 22%, even though inorganic aerosols (42%), organic carbon (29%) play dominant role in modulating aerosol absorption characteristics in the column over this region **(Figure 29)**. This study highlights the importance of absorbing aerosol, BC, organic aerosols of absorbing types and absorbing dust in spring which might provide the better estimates of radiative forcing of aerosols over this region. **[**Joshi, H., **Naja, M.**, David, L. M., Gupta, T., Gogoi, M. M. & Babu, S. S. (2020). *Atmos. Res., 233*, 104718 (1-13pp)**]**

Spatio-temporal distribution of CO_2using the WRF-CO_2 model

A regional air quality model (WRF–CO_2) is set up for simulating atmospheric CO_2 variations over the greater Asia region(68-124°E, 2°S-45°N)for the period 2010–2012. The simulations are compared with observations from nine sites anda global Atmospheric Chemistry Transport Model (ACTM) **(Figure 30)**.WRF-$CO_2$is able to capture large scale features in the observed variabilities. Statistical analysis from monthly mean CO_2 time series shows correlation coefficient and normalised standard deviation are generally equal or better for the WRF-CO_2 than the coarser resolution ACTM. Study of synoptic scale variation shows that the WRF-CO_2 is able to better resolve day time signatures than night time. Analysis of CO_2 signals from individual flux components suggests that ocean flux has least contribution to the CO_2 variation (<10%). CO_2 mixing ratios are found to be maximum in winter over East Asia, while they are maximum in spring over Indian subcontinent. It is shown that the year-to-year variations in seasonal amplitude is highest (~5 ppm) at Nainital.**[Ballav, S., Naja, M.,** Patra, P. K., Machida, T. & Mukai, H. (2020). *Jr. Earth System Science, 129:80* (1-16pp)].

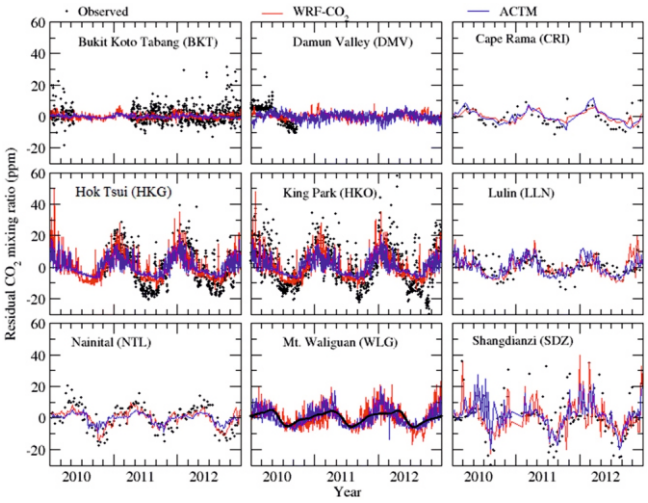


Figure 30. De-trended inter-annual variation of seasonal cycle of CO_2 obtained after removing the secular CO_2 increase rate by digital filtering technique from the model and observed data (2010 – 2012) at different sites.

A satellite perspective on the distribution of precipitation over northern India

Clouds and precipitation are closely associated to each other and a baseline understanding of such meteorological parameters on various scales including their regional climatology is essentially needed. This work deals with the annual and seasonal distribution of different forms of precipitation (liquid, solid and drizzle) and their association with the different cloud types over the northern states of India (NSI). Synergic estimates of precipitation obtained with raDAR-liDAR (DARDAR) and Tropical Rainfall Measuring Mission (TRMM), over

a decade (2007-2016) are used to elucidate the same. The study on different forms of precipitation over NSI region exhibits opposite circulation of its solid (increase) and liquid (decrease) forms in westward or north-westward. The association of deep convective and nimbostratus cloud types with solid precipitation on an annual scale are observed as 1.6 % and 76 % of their total co-occurrences, respectively. On the other hand, their association with liquid precipitation are found to be 98.4 % and 23.7 %, respectively, thereby implying that nimbostratus and deep convectiveclouds are the main contributor of solid and liquid precipitations, respectively over the NSI region during the last decade. **[Singh, N., Kumar, Ashish,** Kumar, Anshumali, **Singh, Jaydeep** & Nath, D. (2020). *Remote Sensing Letter, 11,* 117-126**]**

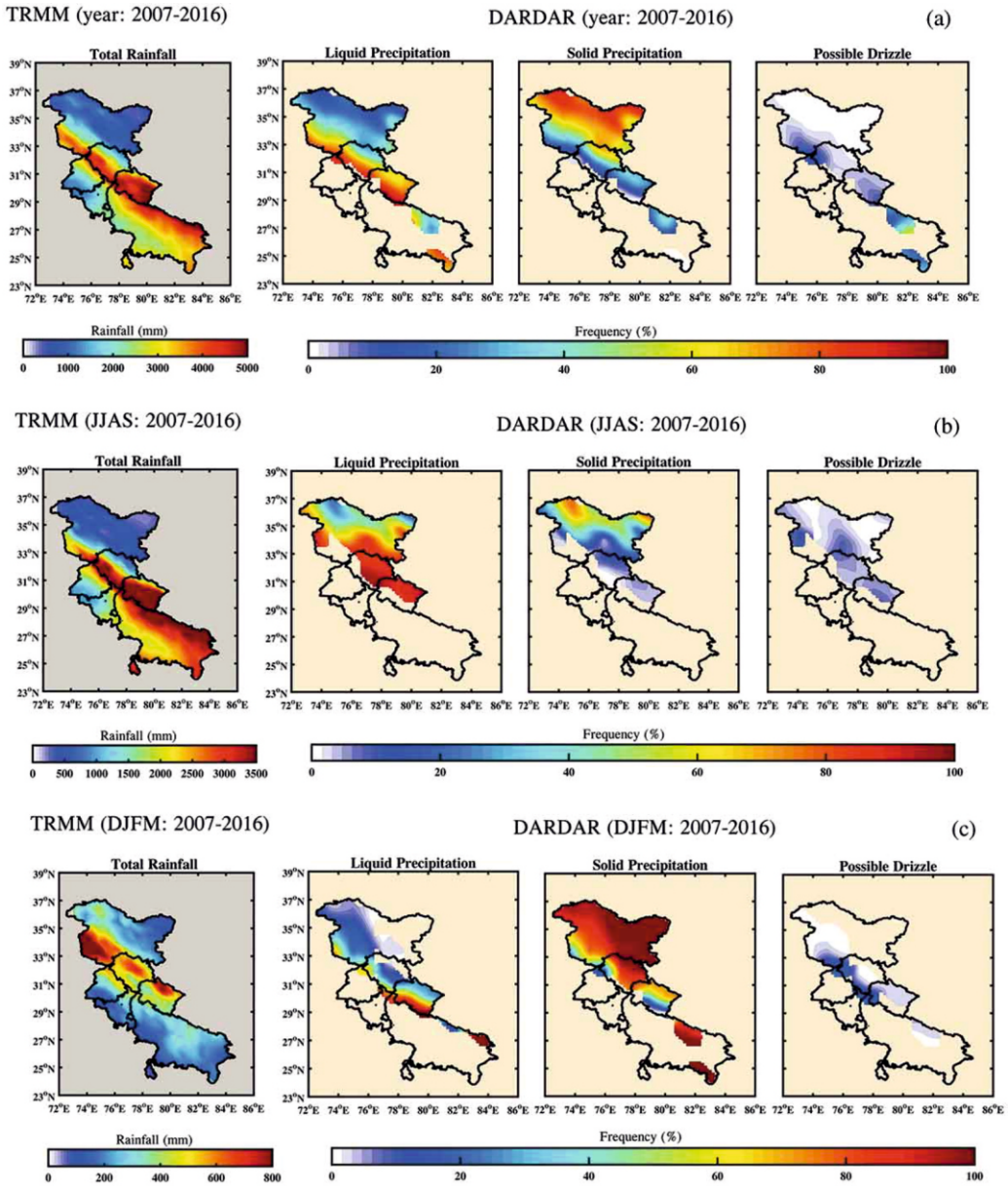


Figure 31. Total rainfall (mm) distribution obtained from TRMM and frequency of liquid precipitation, solid precipitation and possible drizzle derived from DARDAR product during (a) decade 2007–2016, (b) June–September and (c) December–March, over the NSI region.

List of Publications

Refereed Journals

1. Kaskaoutis, D. G., et al. (including **Dumka, U. C**.) (2019). Atmospheric dynamics associated with exceptionally dusty conditions over the eastern Mediterranean and Greece in March 2018. *Atmosph. Res., 218*, 269-284.

2. Kumar, K. N. et al. (including **Phanikumar, D. V.** & **Naja, M.**). (2019). Influence of tropical-extratropical interactions on the dynamics of extreme rainfall event: a case study from Indian region. *Dynamics of Atmos. and Oceans, 85*, 28-40.

3. **Gaur, H.,** et al. (including **Gupta A. C**.) (2019). Optical variability of TeV blazars on ling time-scales. *Mon. Not. Roy. Astron. Soc.*, *484,* 5633-5644.

4. **Gupta , A. C.,** et al. (2019). Detection of a quasi-periodic oscillation in -ray light curve of the high-redshift blazar B2 1520+31, *Mon. Not. Roy. Astron. Soc.*, *484,* 5785-5790.

5. **Kumar, Ashish** (2019). A simple approach for designing a filter on microstrip lines. *Applied Engineering Letters., 4,* 19-23.

6. Kaskaoutis, D. G., et al. (including **Dumka, U. C**.) (2019). Analysis of intense dust storms over the eastern Mediterranean in March 2018: impact on radiative forcing and Athens air quality. *Atmospheric Environment, 209,* 23-39.

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88. Joshi, H., **Naja, M.,** David, L. M., Gupta, T., Gogoi, M. M. & Babu, S. S. (2020). Absorption characteristic of aerosols over the central Himalayas and its adjacent foothills. *Atmospheric Research, 233,* 104718 (1-13pp).

89. Kumar, Amit, et al. (including **Pandey, S. B., Aryan, A., Dastidar, R., Gangopadhyay, A., Gupta, A., Misra, K**. & **Kumar, B.)** (2020). SN 2010kd: photometric and spectroscopic analysis of a slow-decaying superluminous supernova. *Astrophy. Jr., 892:*28 (23pp).

90. Chatterjee, S., Hegde, M., **Banerjee, D.,** Ravindra, B. & Mclntosh, S. W. (2020). Time-latitude distribution of prominences for 10 Solar Cycles: a study using Kodaikanal, Meudon, and Kanzelhohe data. *Earth and Space Sci., 7: 3* (1-16pp).

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Circulars/Bulletins/Conference Proceedings

1. Savanov, I. S., et al. (including **Pandey, J. C.** & **Karmakar, S**.) (2019). Photometric activity cycles of UX Ari. *ASP Conf. Series, 518*, 191-194

2. Kushwaha, P., Pino, E. M. de G. D., **Gupta, A. C.** & Wiita, P. J. (2019). Revealing the nature and location of high energy emission in the candidate binary SMBH system OJ 287. *Proceedings of Science (International Conference on Black Holes as Cosmic Batteries : UHECRs and Multimessenger Astronomy-BHCB2018 held on 12-15 Sept., 2018) , 329,* 1-6.

3. Sarkar, Shilpa & **Chattopadhyay, I.** (2019). Two-temperature advective transonic accretion flows around black holes. *IOP Conf. Series: Journal of Physics: Conf. Series, 1336*, 1-11.

4. Chakraborty, P. (2019). Design, manufacturing and testing of ovality checking gauge for facilitating mechanical inspection and quality control. Proceedings of International conference on sciences engineering & Technology (ICSET) held in Goa, India on 30-31st Dec., 2019, 23-29.

5. Chattopadhyay, I, Vyas, M. K. & **Singh, Kuldeep** (2019). Relativistic jets from black hole accretion disc. *Proceedings of Science, 1-6.*

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7. Joshi, S. & Cat, P. D. (2019). Overview of the BINA activites. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 19-30.

8. Omar, A., Reddy, B. K., Kumar, T. & **Pant, J.** (2019). Global performance and capabilities of the instruments on the 3.6-m Devasthal Optical Tesecope. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 31-42.

9. Pandey, J. C., Pant, J. & **Joshi, Y. C.** (2019). A high-resolution spectrograph for the 3.6-m Devasthal Optical Telescope of ARIES. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 43-54.

10. Sagar, R., Kumar, Brijesh & Subramaniam, A. (2019). Scientific potential of the Indo – Belgian 3.6-m DOT in the field of galactic astronomy. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 70-81.

11. Joshi, Y. C., et al. (including **Panchal, A**. & **Maurya, J**.) (2019). Optical characterization and radial velocity monitoring of expolanet and exlipsing binary candidates. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 81-88.

12. Dutta, S., Mondal, S., **Joshi, S.** & Das, R. (2019). Rotation rates of pre-main sequence stars: role of circumstellar disk. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 103-109.

13. **Gopal-Krishan,** Britzen, S. & Wiita, P. (2019). The diversity of AGN variability: some highlights and challenges. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 132-142.

14. **Joshi, Arti** & **Pandey, J. C.** (2019). Study of an asynchronously rotating polar CD Ind. *Bulletin de la Societe Royale des Sciences de Liege, 87*, 240-247.

15. Nhlapo, D., et al. (including **Joshi, S**.) (2019). Ground-based photometric survey to search for the pulsational variability in Bp, Ap, and Am stars. *Bulletin de la Societe Royale des Sciences de Liege, 88,* 248-25

16. Panja, A., et al. (including **Joshi, S**. & **Lata, S**.) (2019). Characterization of pre-main sequence population in H II region Sh2-242. *Bulletin de la Societe Royale des Sciences de Liege, 87*, 270-274.

17. Ghosh, S., et al. (including **Joshi, S**. & **Lata, S**.) (2019). A search for fast photometric variability in very low mass stars and brown dwarfs. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 275-278.

18. **Panchal, A.** & **Joshi, Y. C.** (2019). Photometric studies of three short-period eclipsing binaries. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 279-282.

19. **Singh, S., Pandey, J. C., Yadav, R. S.**, Medhi, B. J., **Joshi, A.** & **Arora, B.**(2019). Linear polarization towards galactic anticenter direction: the case of alessi 1. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 275-278.

20. **Arora, B., Pandey, J. C., Joshi, A.** & Becker, M. D. (2019). Polarization study of massive binaries with the ARIES 1.04 m telescope. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 287-290.

21. **Maurya, J.** & **Joshi, Y. C.** (2019). Photometric study of the open cluster NGC 381. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 291-294.

22. **Karmakar, S., Pandey, J. C.,** Naik, S., Savanov, I. S. & Raj, A. (2019). Mangnetic activites on active solar-type stars. *Bulletin de la Societe Royale des Sciences de Liege, 88*, 182-189.

Ph.D. Theses

Awarded

1. Spectro-photometric studies of star-forming galaxies, **Abhishek Paswan**, (Supervisor: **Dr. Amitesh Omar**), *Pt. Ravishankar Shukla University,* January, 2018. (Awarded 30 July, 2019)

2. Multi-wavelength study of magnetic cataclysmic variables, **Arti Joshi**, (Supervisor: **Dr. Jeewan C. Pandey** and Prof. H. P. Singh), *Delhi University,* May, 2018. **(Awarded 4 November, 2019)**

3. Astrophysical jets in relativistic regime: thermal and radiative driving, **Mukesh Kumar Vyas**, (Supervisor: **Indranil Chattopadhyay**), *Delhi University,* August, 2018. (Awarded 19-08-2019)

4. Optical studies of hydrogen deficient supernovae, **Mridweeka Singh**, (Supervisor: **Dr. Kuntal Misra**), *Pt. Ravishankar Shukla University,* January, 2019. (Awarded 31-07-2019)

5. Multiwavelength studies of TeV blazars, **Ashwani Pandey**, (Supervisor & Co-Supervisor : **Dr. Alok C. Gupta** and Prof. S. N. Tiwari), *Deen Dayal Upadhyay Gorakhpur University,* April, 2019. (Awarded 1 November, 2019)

6. Atmospheric studies using remote sensing techniques and in-sitr measurements over the Himalayan region, **Ashish Kumar**, (Supervisor & External Supervisor: Dr. Anshumali & **Dr. Narendra Singh**), *Indian Institute of Technology (ISM), Dhanbad,* October, 2019. (Awarded 15-11-2019).

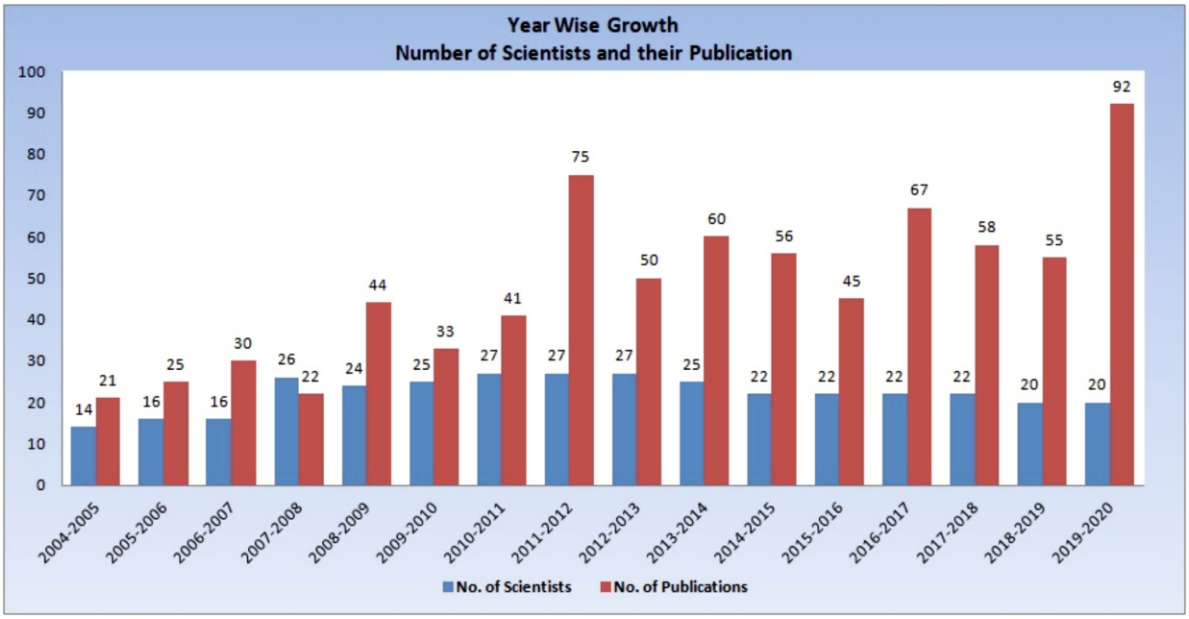
Submitted

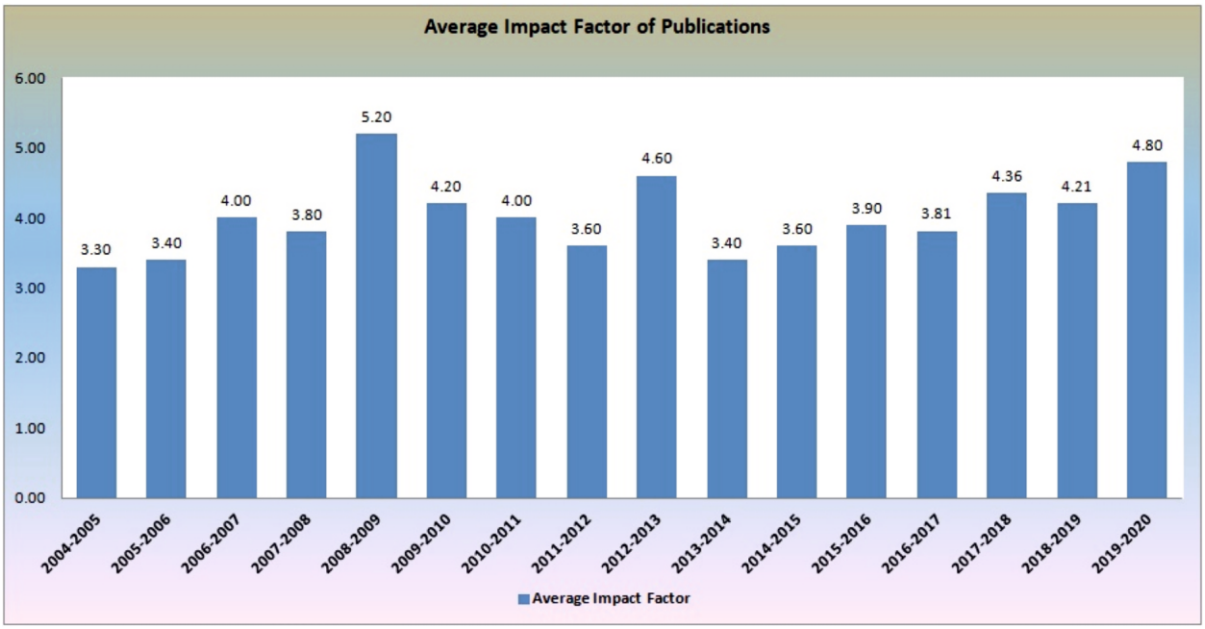
1. Probing the nature of raio-quiet weak emission line quasars, **Parveen Kumar**, (Supervisor: **Dr. Hum Chand**), *Pt. Ravishankar Shukla University,* March, 2019.

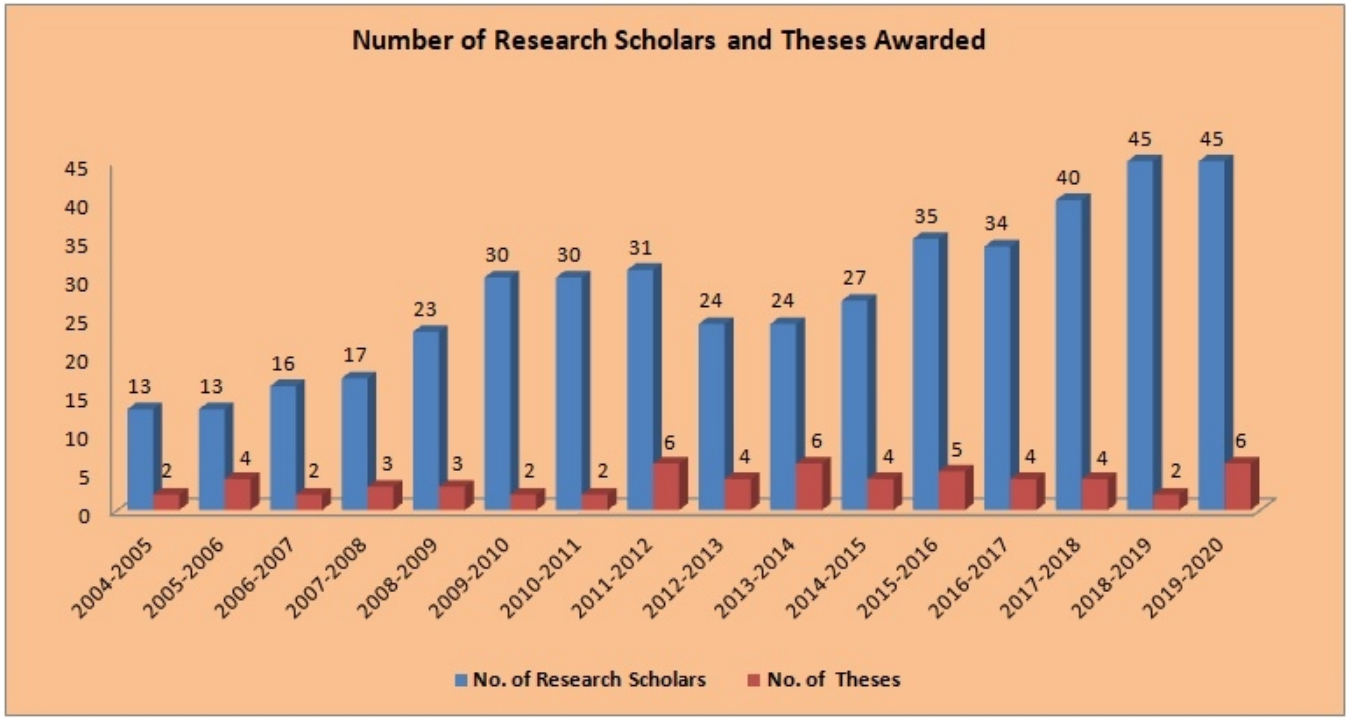
2. Triggering and energy telease mechanism in the solar eruptions, **Aabha Monga**, (Supervisor & Co-Supervisor: **Dr. Wahab Uddin** & Dr. Ramesh Chandra), *Kumaun University,* August, 2019.

3. Observational study of core-collapse supernovae with diminishing hydrogen envelope, **Anjasha Gangopadhyay,** Supervisor: **Dr. Kuntal Misra**), *Pt. Ravishankar Shukla University,* January, 2020.

4. Multi-wavelenght study of narrow-line Seyfert 1 galaxies, **Vineet Ojha**, Supervisor: **Dr. Hum Chand**), *Pt. Ravishankar Shukla University,* February, 2020.







Summary

1.	Total Number of Publications in Refereed Journals	92
2.	Number of Publications in Circulars/Bulletin	22
3.	Ph.D. Theses Awarded	6
4.	Ph.D. Theses Submitted	4

International and National Research Projects

In year 2019-2020 following research projects were ongoing from outside funding agencies.

Name of Project: Observational signature of super massive Black Holes: TeV blazars in multi-wavelength view
PI (ARIES): Alok C. Gupta
PI of the collaborating institute: M. Ostrowski, Astronomical Observatory, Jagiellonian University, Krakow, Poland
Funding Agency: DST, Govt. of India
Project Code: DST/INT/POL/P–19/2016

Name of Project: Indo-Thai Collaboration for Studying Pulsating Variables at Different Evolutionary Stages
Co-PI (ARIES): Santosh Joshi
PI of the Collaborating institute: Aruna Goswami, IIA, Bangalore and David Mkrtichian, NARIT, Thailand
Funding Agency: DST, Govt. of India
Project Code: DST/INT/Thai/P-16/2019

Name of Project: Influence of massive stars on the formation and evolution of low mass stars
PI (ARIES): Dr. Saurabh
PI of the Collaborating institute: Dr. Ramkesh Yadav, NARIT, Thailand
Funding Agency: DST, Govt. of India
Project Code: DST/INT/Thai/P-15/2019

Name of Project: International Liquid Mirror Telescope
PI (ARIES): Hum Chand
PI of the collaborating institute: Jean Surdej, Liege University, Belgium
Funding Agency: ARIES, Belgium and Canada
Project Code: CSNOF-09

Title of Project: Belgo-Indian Network for Astronomy and Astrophysics (BINA)
PI (ARIES): Santosh Joshi
PI of the Collaboration institute: Peter De Cat, Belgium
Funding Agency: DST, Govt. of India
Project Code: DST/INT/Belg/P-02/2014

Name of Project: Flares from F to M-type mass stars.
PI (ARIES): Jeewan C. Pandey
PI of the collaborating institute: Igor S. Savanov, Institute of Astronomy, Moscow, Russia
Funding Agency: DST, Govt. of India
Project Code: INT/RUS/RFBR/P-271

Title of Project: Probing of Hot Jupiters Environmental and Physical Conditions: Numerical Modeling vs Observations.
PI (ARIES): Yogesh C. Joshi
PI of the collaborating institute: Navin Dwivedi, Space Research Institute, Graz, Austria
Funding Agency: DST, Govt. of India
Project Code: INT/AUSTRIA/BMWF/P-14

Name of Project: Probing fundamental characteristics of extreme astrophysical phenomenon.
PI (ARIES): S. B. Pandey
PI of the collaborating institute: IUCAA Pune, IIT Mumbai, IKI Moscow Russia and SAAO and other institutes of South Africa

Funding Agency: DST, Govt. of India and BRICS consortium
Project Code: DST/IMRCD/BRICS/PILOTCALL1/PROFCHEAP/2017G

Name of Project: Fostering of the next generation of scientists for better understanding of air quality in monsoon Asia and Oceania region
Co-PI (ARIES): Manish Naja
PI of the collaborating institute: Hiroshi Tanimoto, NIES, Japan
Funding Agency: Asia-Pacific Network
Project Code: CBA2017-02MY

Name of Project: Physics of radio bright gamma ray burst afterglows.
Co-PI (ARIES): Kuntal Misra
PI of the collaborating institute: Lekshmi Resmi, IIST, Thiruvanthapuram
Funding Agency: DST, Govt. of India
Project Code: EMR/2016/007127

Title of Project: Observations of trace gases at a high altitude site in the Central Himalayas.
PI (ARIES): Manish Naja
Funding Agency: Indian Space Research Organization (ISRO), India.

Title of Project: Study of the aerosol characteristics over central Himalayas.
PI (ARIES): Manish Naja
Co-PI (ARIES): Umesh C. Dumka
Funding Agency: Indian Space Research Organization (ISRO), India.

Title of Project: Atmospheric Boundary Layer Network & Characterization: Network of Observatories for Boundary Layer Experiments (ABLN&C: NOBLE)
PI (ARIES): Narendra Singh
Funding Agency: ISRO, VSSC Trivandrum

Title of Project: Devasthal optical telescope - AGN Reverbera- tion Monitoring (DOT-ARM): Probing AGN black-hole masses and broad line regions.
PI (ARIES): Hum Chand
Co-PI (ARIES): Amitesh Omar
Funding Agency: DST/SERB

Updates on the Major Facilities

ARIES ST Radar (ASTRAD)

ARIES Stratosphere Troposphere Radar (ASTRAD) has been operationalized for regular observations. Its activities during 2019-20 are:

- Radar performance was reviewed during 14-16 May, 2019 at ARIES. During this period, there was an event of a sudden hailstorm on 15th May, 2019 at around 1130 hr. **Figure 32** shows signature of strong precipitation observed by the ARIES ST Radar during this period.

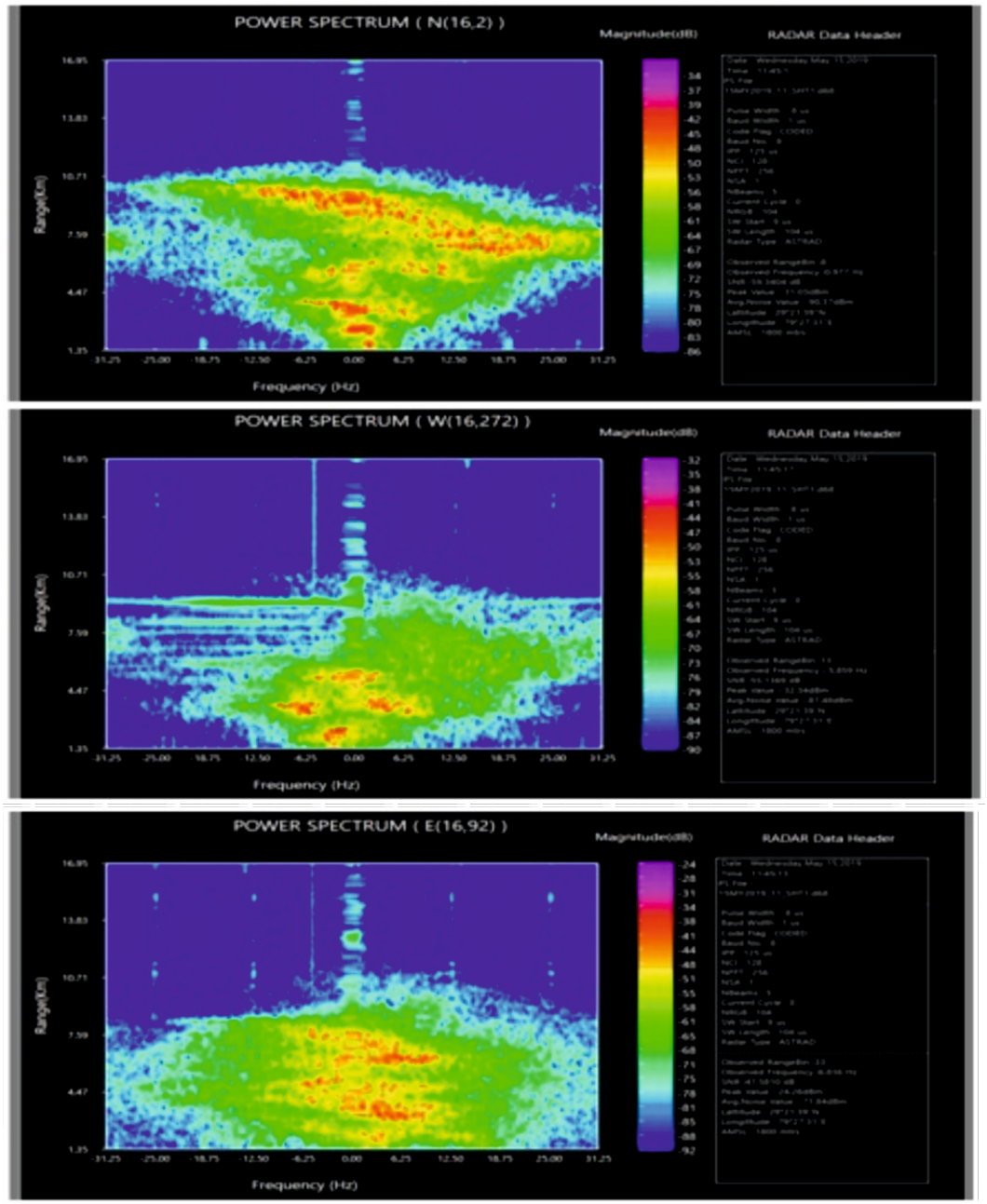


Figure 32. Power spectrum (N, S, E and W) from ARIES ST Radar during event of hailstorm on 15 May 2019.

- All the 12 clusters of ASTRAD have been operationalized successfully at ARIES Nainital **(Figure 33)**. Radar has also been operated continuously for more than 72 hours. During this 72 hours operation, GPS radiosondes were also launched to compare the wind products. Reasonable good agreement are observed between radar winds and winds from GPS radiosonde.

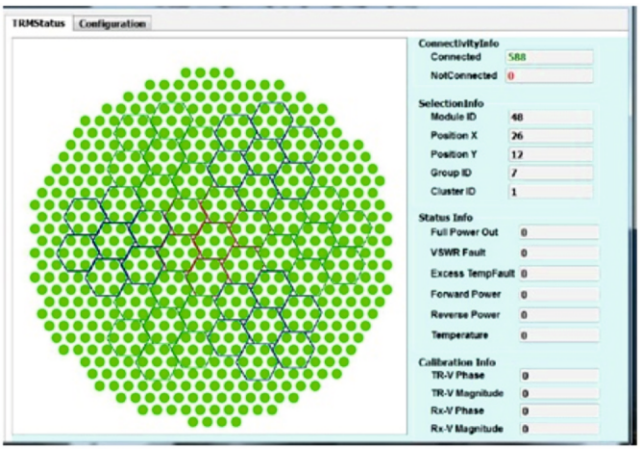


Figure 33. Readiness (green color) of all 12 clusters of ARIES ST Radar. One cluster consists of 49 TRMs and thereby making total 588 TRMs.

- Observations from ARIES ST Radar and GPS radiosonde are being used to estimate C_n^2 and turbulence parameters (**Figure 34**). Preliminary studies indicate that these values are higher over this Himalayan region, when compare to those reported over the southern India.

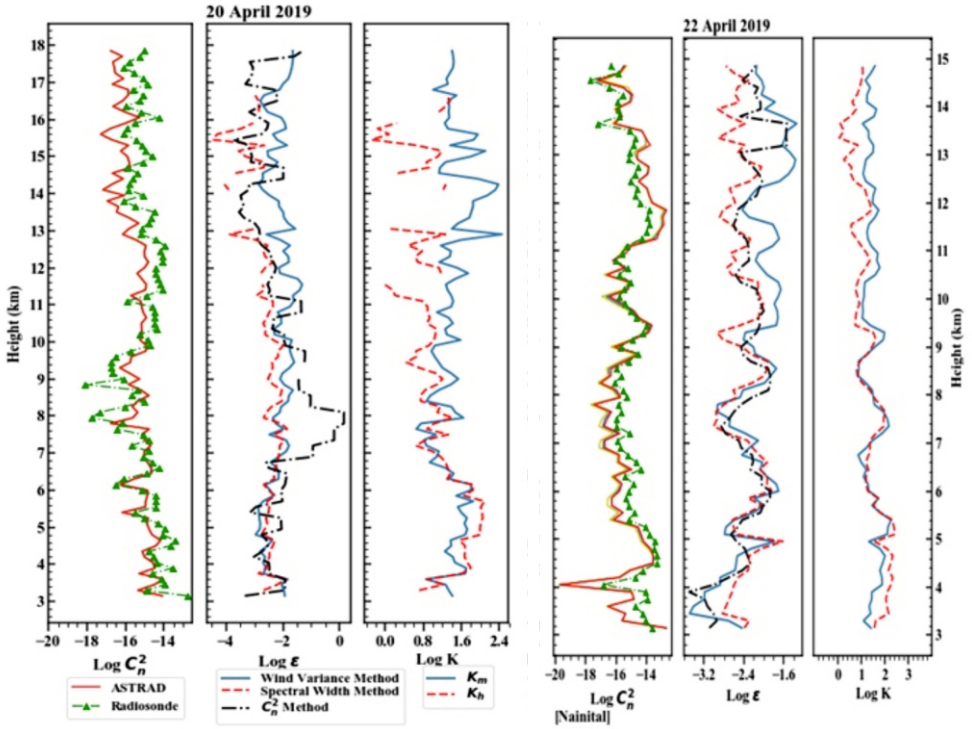


Figure 34. Vertical variations in Cn2 and turbulence parameters on 20 and 22 April, 2019.

- Apart from periodic maintenance of radar, radar calibration was done during bi-annual cycle (November2019 to February2020)of radar calibration and it was made ready for continuous observations.

- As in-house activity, ARIES has made one set of TRM and it has gone through critical performance evaluation. It has achieved required peak power and gain that is sufficient for an element of the active aperture of the Radar system. Evaluation of the thermal dissipation has also been done.

- ARIES has organized a session on ST Radar during URSI Regional Conference on Radio Sciences at IIT BHU (12-14 Feb 2020).

4m International Liquid Mirror Telescope: A Status Report:

The 4.0m International Liquid Mirror Telescope (ILMT) is established in ARIES in collaboration with the Institute of Astrophysics and Geophysics (Liege University), the Canadian Astronomical Institutes from Quebec (Laval University), Montreal (University of Montreal), Toronto (University of Toronto and York University), Vancouver (University of British Columbia) and Victoria (University of Victoria).

The 4.0m ILMT is a dedicated photometric and astrometric variability survey of a narrow strip of sky (about half a degree) passing through the zenith offering best image conditions (atmospheric seeing and extinction). The CCD images recorded each night will be matched to a reference image to detect transient and variable objects. The first light of ILMT is expected during December 2020.

The major milestones achieved in 2019-2020 are as follows:

1. Air-bearing and primary mirror azimuth alignment: During the last attempt for first light in April 2019, it was realised that the horizontality of the air-bearing could be degraded due to its inbuilt heaters. As a remedy, four fans are kept inside the plexiglass insulation box surrounding the air-bearing in order to homogenise the temperature distribution. From **Figure 35**, it is evident that the temperature variation across the air-bearing leading to non uniform thermal expansion has reduced.

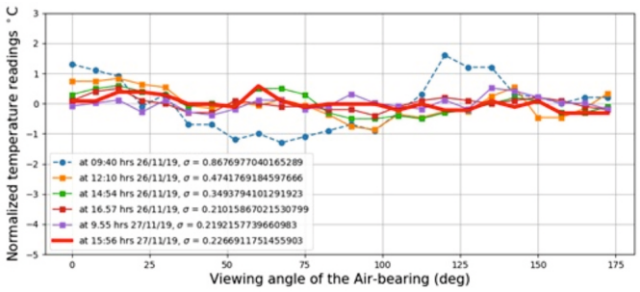


Figure 35. Temperature readings around the air-bearing at different times. The dashed plot represents the readings before the fans inside the insulating box were switched on. The thick continuous line represents the temperature readings after the air-bearing was supplied with clean air while the fans are still active.

The alignment between the primary mirror and the air-bearing was disturbed due to sudden breakings applied during mirror acceleration and deceleration in attempt to form a continuous Hg surface. The alignment was fixed by lifting the whole mirror **(Figure 36)** and placing back at the right orientation. Then the horizontality of the primary mirror was again adjusted followed by its rotation axis alignment with the centre of the corrector lens.

Figure 36. Four car-jacks (two of them are shown) used to lift the mirror to orient it properly with respect to the air-bearing.

After the proper alignment of the air-bearing w.r.t. the bowl, inspection of the orientation of the rotation axis of the mirror was performed. Two spirit levels with accuracies of 2 and 4 arc-seconds, respectively were individually used to estimate the horizontality of the primary mirror. An equilateral triangle shaped Aluminium plate was used as a flat platform to put the spirit level roughly at the center of the 4-m bowl **(Figure 37 a)** and three screws at the edge of the plate were used to make the plate horizontal. The amplitude of the measurements shown in **figure 37 (c)** was found to be 7 arc-seconds. Later on, AMOS mechanical engineers will be consulted and the three point mount of the air-bearing will be adjusted to set the rotation axis along the vertical.

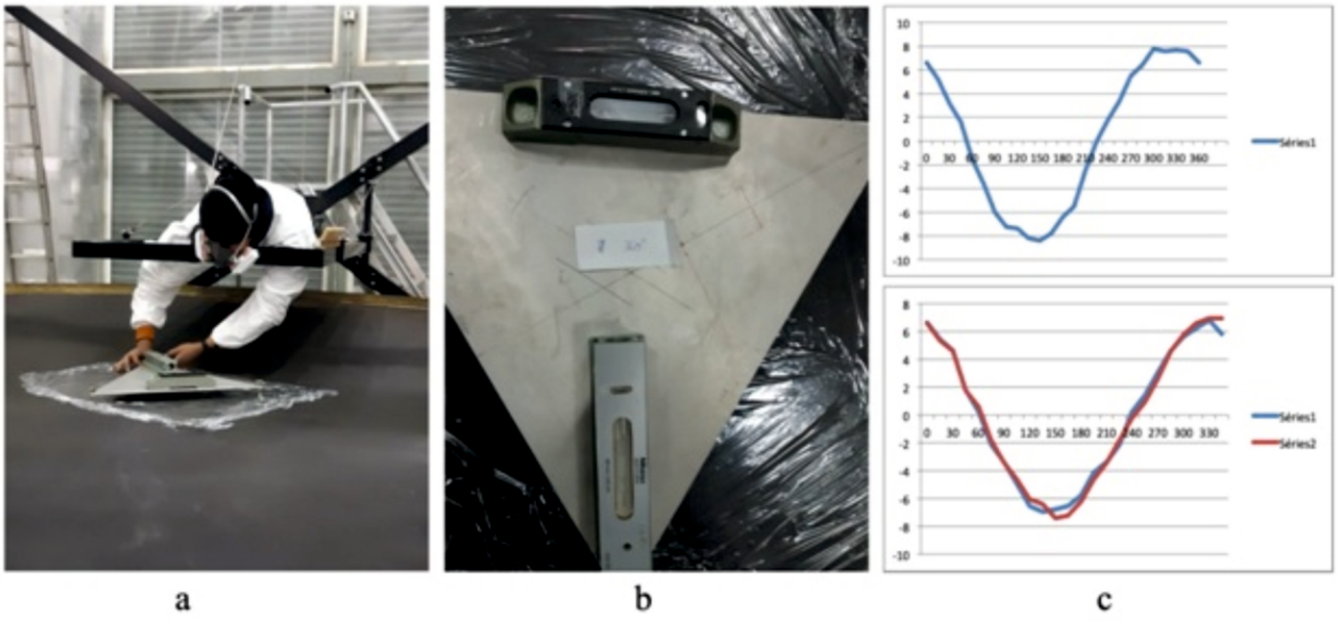


Figure 37. (a) Setting up the spirit level at the center of the primary mirror for its horizontality test. (b) After setting the bubble inside the spirit level roughly at the center, which would swing around it's current position depending on the horizontality of the mirror. (c)Spirit level readings at different angular position of the primary mirror. The x-axis represents the radial location of the mirror viewed from different angles. The y-axis represents the spirit level measurements in arc-seconds. The plots at the top and the bottom are obtained by using 2" and 4" spirit levels, respectively.

2. Vacuum refreshing the CCD camera: The last pressure reading of the ILMT CCD camera was at 1.4 torr. According to the manufacturer's instructions, the ideal pressure should be in the order of 10^{-2} torr. During the last attempt to make vacuum refreshing in April 2019, the vacuum pump broke down due to a leakage in the connection line from the vacuum pump to the CCD camera. This time we used a modified hose sent by Prof. Paul hickson. At first, the hose was connected to the vacuum pump with its other end blocked to check if the hose has any leakage. After we found that there were no leakage, the vacuum pump along with the hose were lifted near to the prime focus with the help of chain pulleys. The pressure inside the CCD could be brought down to 1.2 x 10^{-2} torr within 3 hours. The pressure readings were monitored till the next day and no significant change was noticed.

3. Hg hand-wheel: The Hg hand-wheel along with the linear stage to make Hg pumping possible at the center of the bowl was damaged because of the rust and corrosion due to Hg contamination as well as humidity. A new set of hand-wheel and linear stage has been brought but could not be assembled properly because of a wrong mechanical component (cf. a larger size coupler between the hand-wheel and the linear stage) delivered by the manufacturer. The proper fitting and installation tools for the hand-wheel will be brought soon. However, the functioning of the hand-wheel could be checked also after connecting a NCC limit switch.

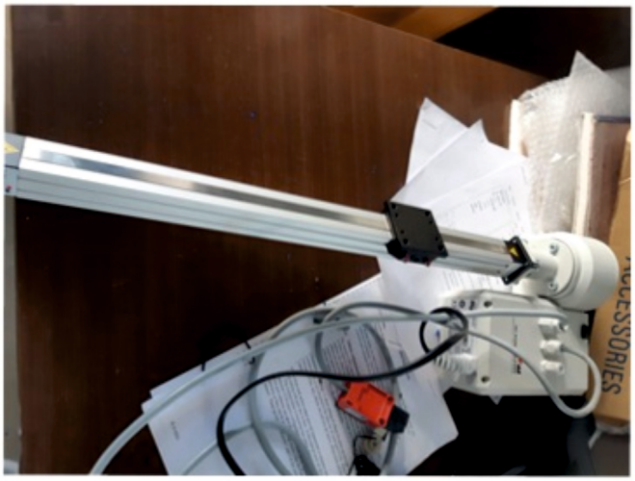


Figure 38. After assembling the linear stage with the hand-wheel and making electrical connections with the limit switch.

4. Mercury purchase: The purchase of excess amount of required mercury (15 L) was initiated by ARIES. During January-February 2019 ARIES team identified local vendors in India who could readily supply the mercury. Three such vendors were identified. The one found reasonable based on the quoted price and delivery time was contacted and the order was placed to M/s Vivid India Pvt. Ltd. The purchase order was released in March 2020 and 15 liters of mercury was dispatched by the vendor on 19-March.With this ILMT is expected to receive first light in December 2020.

Status report on the 3.6m DOT instruments

ARIES-Devasthal Faint object Spectrograph & Camera (AD-FOSC)

AD-FOSC is a low-dispersion (R<2000) slit-spectrograph for astronomy applications and used forthe observations of faint sources in both broad-band/narrow-band imaging and spectroscopy using optical filters, slits, and grisms on the 3.6m Devasthal Optical Telescope (DOT). The AD-FOSC was designed, developed, assembled and tested through in-house R&D efforts at ARIES. Some science publications in reputed journals and a general article for common readership have been published in current science. Presently, SDSS ugrizbroad-band filter set and grisms providing spectral resolution R up to ~2000 are available in the AD-FOSC. AD-FOSC will be released for general science observations for all users from the next cycles on the 3.6m DOT.

The total cost of components of AD-FOSC was about Rs. 4 Crore. If a similar instrument was bought from outside, the cost would have been nearly Rs. 10 Crore. Therefore, cost saving of about 6 Crore was achieved as it was completely designed and developed in ARIES. Moreover, as the full technical know-how of the instrument rests with the scientists and engineers at ARIES, it offers an opportunity to up-grade the instrument to next level with minimum investment of time, manpower and finance. Several up-gradations to include spectro-polarimetry mode, dual-color fast imaging mode, and medium dispersion spectroscopy modes are planned to be included in this instrument. A sub-aperture spectro-polarimetry mode has been included in the AD-FOSC and is being tested using the sky observations. A seeing monitor is also built in the ADFOSC using the DIMM principle.

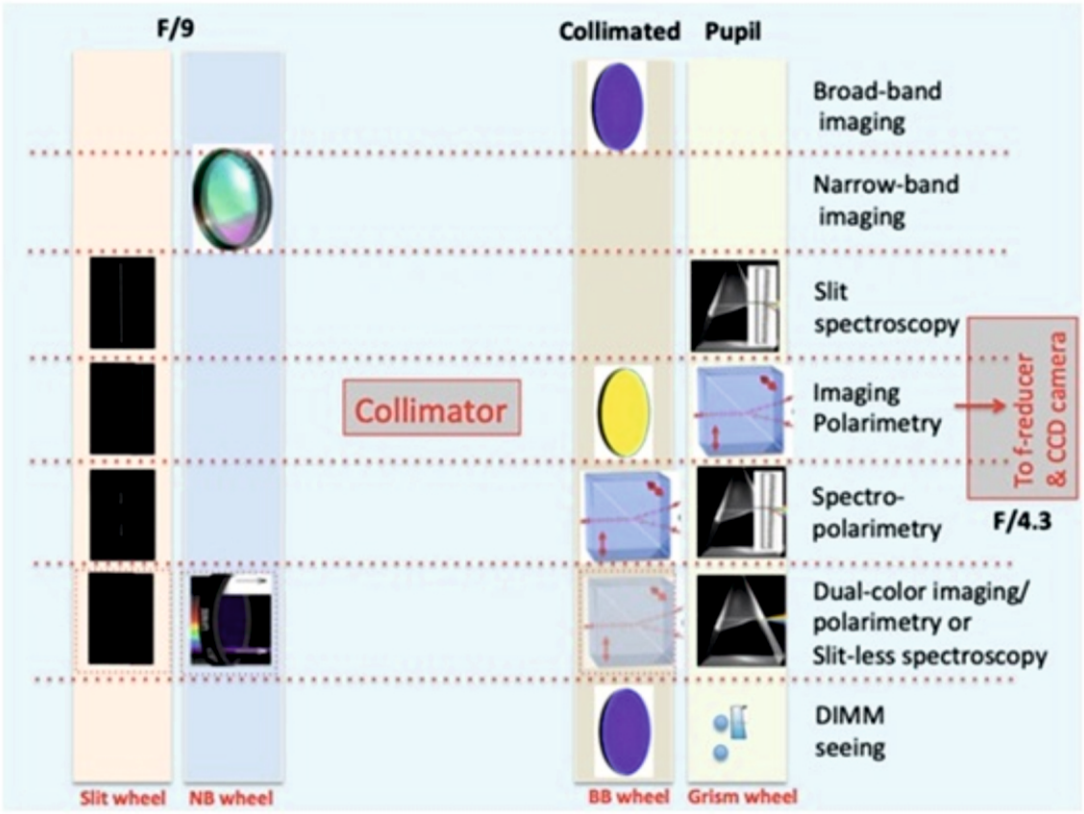


Figure 39. Various commissioned and planned observing modes on the AD-FOSC.

4Kx4K CCD Imager

Earlier during 2019, due to telescope being in maintenance phase, the CCD imager could not be utilized. However, during March 2020, the CCD Imager was mounted at the axial port of the 3.6m DOT and some of the useful observations were acquired for various Galactic and extra-galactic astronomical objects. Performance of the CCD Imager was found to be satisfactory and the instrument was considered to be ready for the upcoming observing cycle. The plans to have a back-up 4Kx4K CCD camera and controller with help of IUCAA, Pune have also been initiated. During the year at least 3 internationally refereed publications came out using the CCD Imager data, one of the first ones ever published using the data taken with the 3.6m DOT. Some of the results are highlighted below along with the recent images taken with the imager. These results show the usefulness of the 3.6m DOT to do deep imaging of faint Galactic and extra-galactic sources.

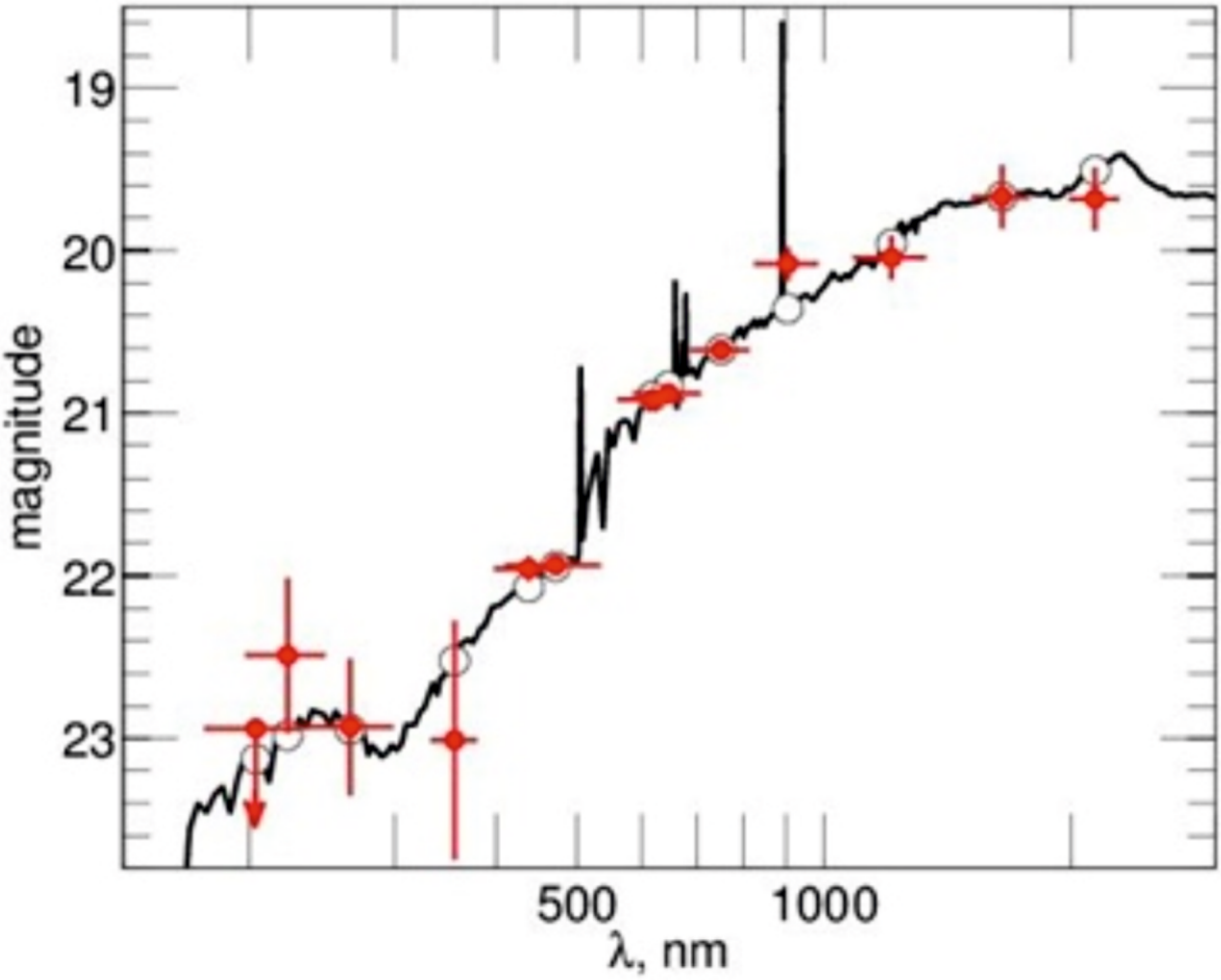


Figure 40. The SED of the host galaxy of GRB 130603B fitted by the LePhare with fixed redshiftz =0.356. Filled red circles depict respectively the data points in the filters uvw2, uvm2,uvw1, U and NIR from literature and data points in *B* and R_c pass-bands were obtained using the 4K×4K CCD Imager mounted at the axial port of the commissioned 3.6m DOT at Nainital India. Open circles represent model magnitudes for each filter. All magnitudes are in AB system.

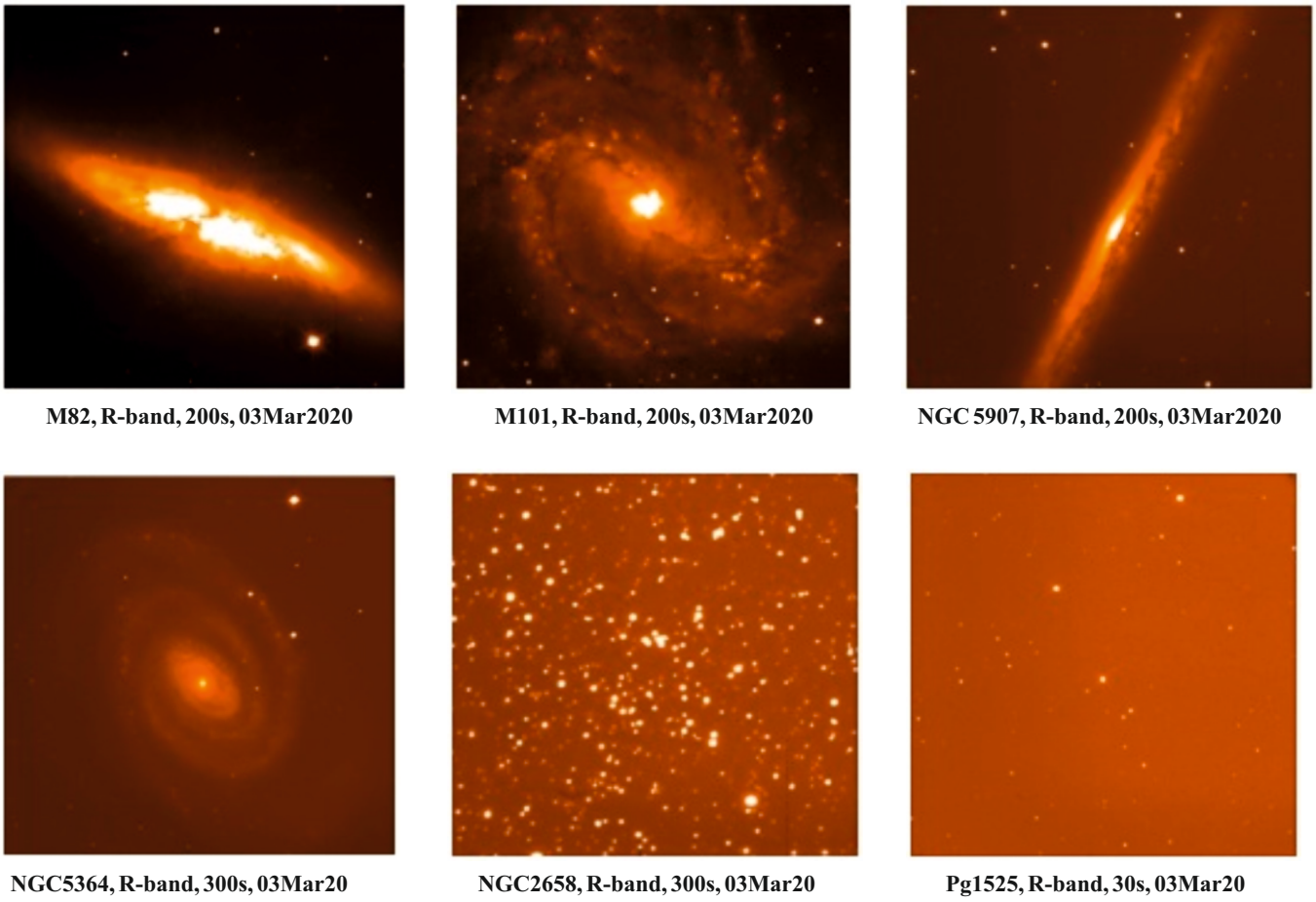


Figure 41. Images taken with the 4Kx4K CCD Imager mounted at the 3.6m DOT on 03 March 2020.

TIFR-ARIES Near Infrared Spectrometer (TANSPEC)

TANSPEC is built in collaboration with ARIES, TIFR and MKIR, Hawaii for the 3.6m Devasthal Optical Telescope (DOT). It is a medium resolution spectrograph (dual mode, R~2750, R-150-350) cum imager having sensitivity in the wavelength range from 550 to 2540 nm. This spectrograph operates in two modes i.e., cross-dispersed mode (R ~ 2750) and prism mode (R ~ 100-350. TANSPEC consists of an independent imaging camera (built-in slit viewer) with a 1k x 1k H1RG detector. The reflected beam from the back of the mirrored slit is imaged to this camera through a filter wheel which consists of broad band r', i', Y, J, H, Ks and narrow band H2 & BrG filters. This camera has a field of view of 1 x 1 arcmin^2, and is used for guiding the telescope (IR guider) as well as imaging field for photometry. It also functions as a pupil viewer for instrument alignment on the telescope. For calibration, a uniform flat field from an integrating sphere outside the dewar as an identical f/9 beam from telescope is imaged. Wavelength calibration is performed by Argon and Neon lamps. Spectroscopy sensitivity (100-σ in 1 hour, 1" seeing) is expected to be 15.4 mag (R ~2000 - 3000), whereas in prism mode (R ~ 100) it would be 17.3 mag in the J-band. TANSPEC will be used for a wide range of studies from local star formation to extra-galactic astronomy. Simultaneous coverage of wavelength from 550 nm to 2540 nm makes TANSPEC a unique instrument and ideal for studies which require simultaneous measurement of lines in optical and near-infrared waveband.

TANSPEC was delivered and mounted on the 3.6m DOT successfully during March - April 2019 and January-February, 2020. TANSPEC was also released for general science community (ARIES+TIFR+Belguim Astronomers, 11 proposals received) during 8-18 February 2020. TANSPEC was used successfully for different science cases and is routinely delivering sub-arcsec images. During the above runs, TANSPEC was used successfully for many commissioning tests. Initial parameters such as array characteristics, wavelength range, resolution etc, were calculated and found to be at par with the design specifications.

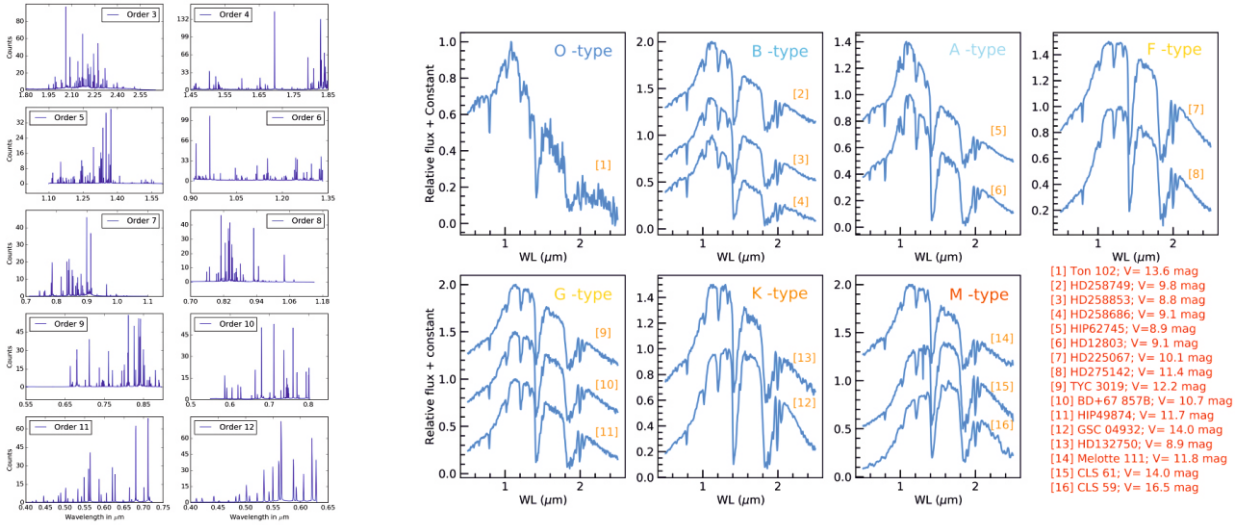


Figure 42. Different order of XD mode lamp spectra (Spectral range = 0.5 – 2.5 micron) (left), Stellar spectra in prism mode of different spectral types (right).

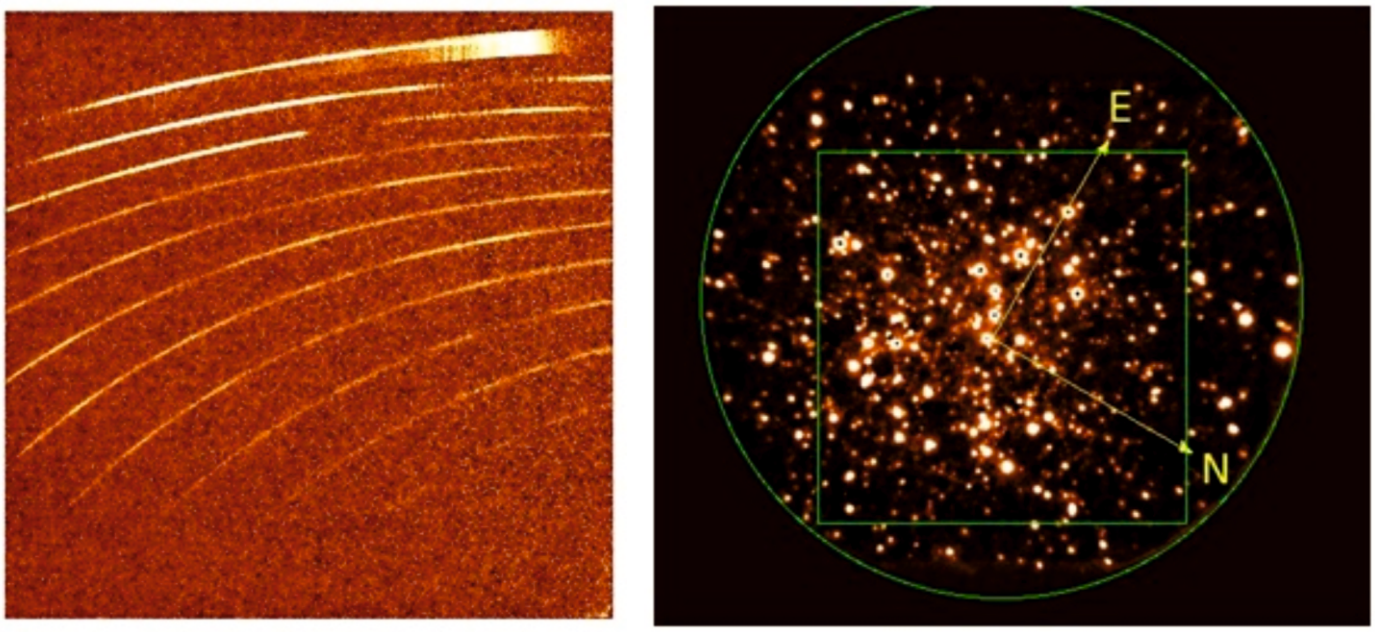


Figure 43. High resolution cross dispersed spectra (left), K-band image of M53 (right).

TIFR Near Infrared Imaging Camera – II (TIRCAM2)

TIFR Near Infrared Imaging Camera-II (TIRCAM2) is a closed-cycle Helium cryo-cooled imaging camera equipped with a Raytheon 512 × 512 pixels InSb Aladdin III Quadrant focal plane array having sensitivity to photons in the 1–5 μm wavelength band. We have used this camera on the 3.6-m Devasthal Optical Telescope (DOT) for near-infrared calibration of the site and scientific observing. After the preliminary characterization, the camera has been released to the Indian and Belgian astronomical community for science observations since 2017 May.

Recently (December 2019), mounting of TIRCAM2 on the side port of 3.6m DOT has been done successfully. Many necessary modifications were carried out on TIRCAM2 structure and mountings by ARIES/TIFR team. The compatibility of TIRCAM2 with the other main port instruments (IMAGER/FOSC) has also been checked successfully.

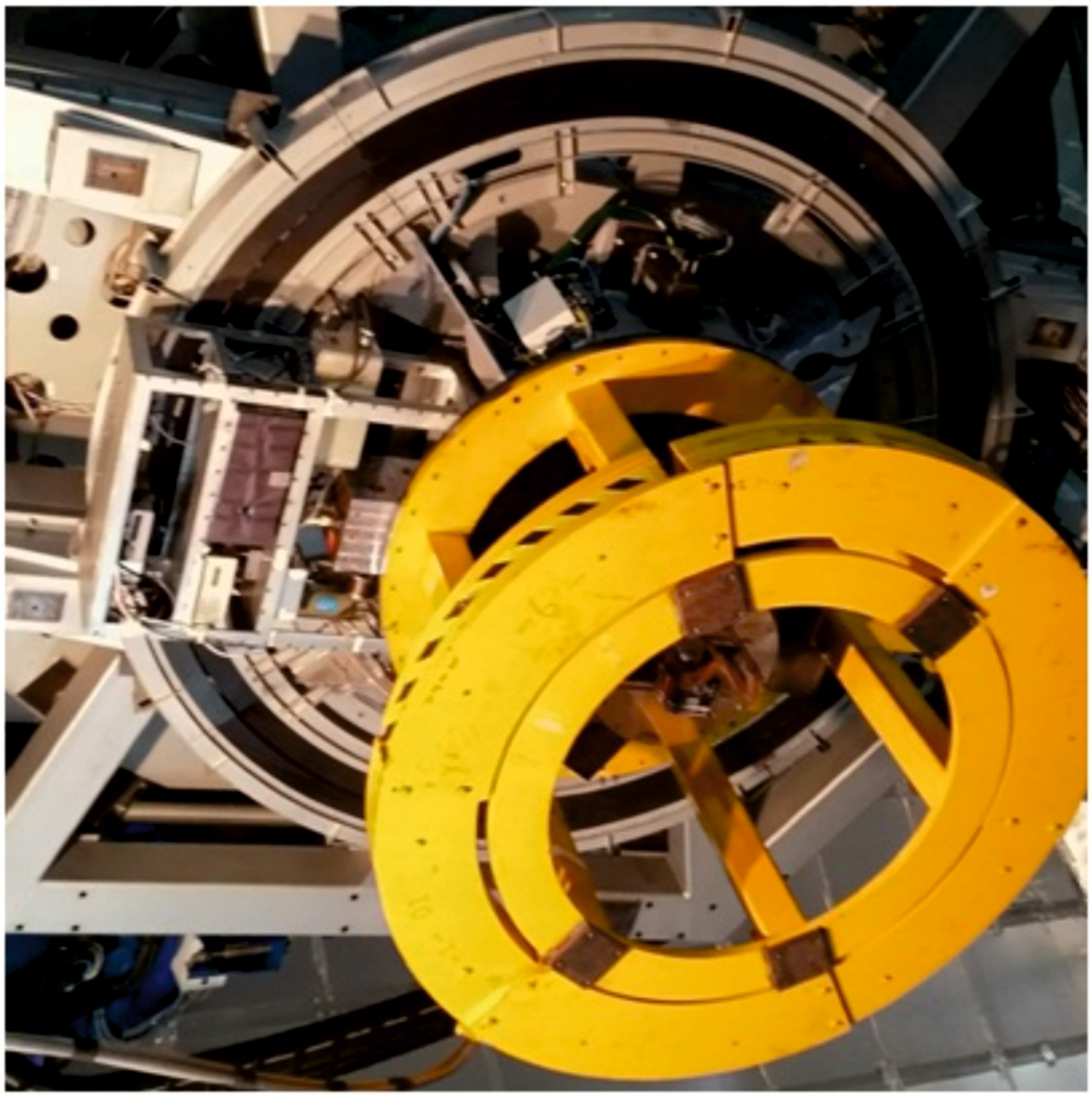


Figure 44. The TIRCAM2 instrument mounted at the sideport of 3.6m DOT. The yellow instrument structure is mounted on main axial port.

Thirty meter telescope – a status report

During the year, apart from participating to SAC, MAC and PMB meetings related to the India-TMT activities, ARIES hosted "I-TMT Science and Instruments Workshop" during 17 - 19 October 2019. This workshop was mainly focused on the ongoing development of the first and second generation instruments. A brief review of the activities related to the workshop is following.

The workshop was hosted at ATI Nainital and was inaugurated by Vice-chancellor Kumaun University Nainital. Around 130 participants from around more than 20 institutions, universities were actively participated during the workshop and discussions were conducted about how India could contribute better towards these ongoing mega-projects particularly towards instrumentation. One of the ideas behind hosting the workshop was to sensitize more and more young mass to understand about the requirements towards the project and to get them know how they could work towards such mega international projects. The workshop was one of the very successful ones conducted recently to discuss about the India-TMT related activities. During the workshop, the participants also visited Devasthal. The print, electronic and social media coverage for this workshop was also done extensively.

Figure 45. A group photograph of "I-TMT Science and Instruments Workshop" during 17 - 19 October 2019.

Report from existing observing facilities

1.04m Sampurnanand Telescope (ST)

The 1.04m Sampurnanand Telescope (ST) situated at Manora Peak is being used as a main observing facility by PhD students and faculty members of ARIES and other Institute since 1972. This telescope is working well. The preventive maintenance is being carried out by the scientist and engineering staff of ARIES.

The major back-end instruments used at 1.04m ST are 4kx4k CCD and ARIES Imaging polarimeter (AIMPOL). 4Kx4k CCD is mainly used for imaging purpose. A PyLon 1300x1340 CCD is also used imaging as well as polarimetric observations. The major scientific programs being carried out includes the study of star clusters, young star forming regions, HII region, optical variability in AGN, optical counterpart of Gamma-ray-burst, Supernovae and X-rays sources and polarimetric study of star forming regions and late type stars.

A total of 193 observing nights were allotted from Oct 2019 to May 2020 for CCD and AIMPOL. 74 nights were clear for observations and data were collected by the observer during those nights. Few nights were also used for instrument and telescope testing. 12 refereed papers and 1 conference proceedings were published during 2019-2020.

Upgradation of AIMPOL

1. Till October 2019, 512x512 CCD was used for polarimetric observations. Acquisition software of 512 CCD was running in Windows 95, a very old system. Therefore, there was a need to replace 512x512 CCD with a new one. In October 2019, we made the mounting of PyLon 1300x1340 CCD to mount with AIMPOL. We tested the whole assembly with the telescope. Now, AIMPOL is running well with PyLon CCD.

2. There is a need to replace the filter assembly of AIMPOL. Presently, a manual filter assembly is used in which filters are mounted in a straight line. Now, we have made a circular filter wheel in our workshop, which will be controlled by a motor and software. All components of the filter assembly have been collected and assembled. Testing is going on in the lab.

Activities related to 1.04m telescope

1. The Right ascension (RA) and Declination (Dec) display system of 1.04m is to be upgraded. We have developed a preliminary software to control the RA and Dec motions of the telescope along with the sidereal clock and tracking. The control software is still under development and testing phase.

2. Coating of primary mirror is in progress.

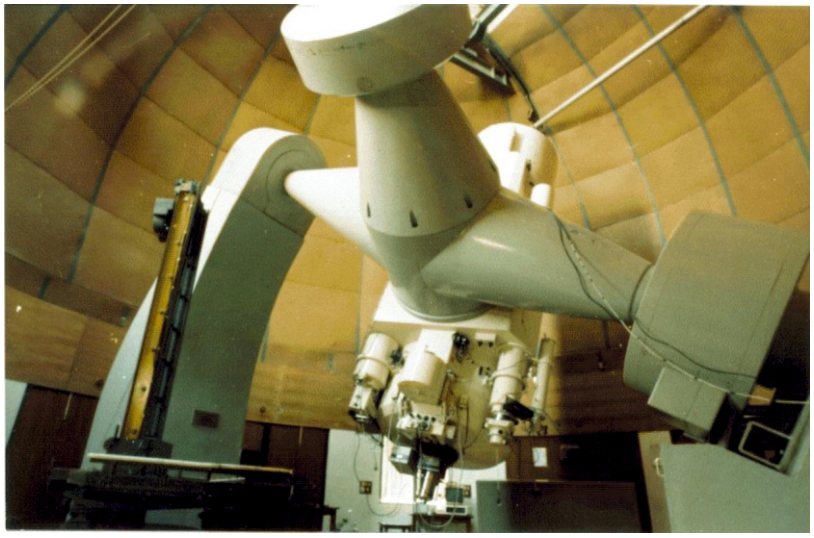


Figure 46. 1.04m Sampurnanand Telescope.

1.3m Devasthal Fast Optical Telescope (DFOT)

Following activities were performed during the year 2019-2020.

1. Online web based cloud storage for data archiving has been created and continuous archiving of the data taken from 1.3m telescope is carried out. The data can be accessed from anywhere inside/outside the ARIES portal with prior notification.

2. Maintenance work: One of the radial pads of primary mirror got unglued, which is necessary to support the primary mirror and carefully balance it in order to avoid any distortion in the mirror support. The radial pad was glued back in September/October 2019 and since then it is working properly. During February 2020 centering of primary mirror in the cell was carried out. For that mirror cell was removed from the telescope and centering procedure was followed. Mirror cell was mounted back to the telescope with proper adjustment in radial and axial counter weights. Coarse alignment of the telescope was carried out using a laser mounted at the primary mirror cell. Further improvement in the image quality was attempted in subsequent weeks during on sky testing. During the testing it was also observed that the thermal emission from the telescope building is contributing a lot to the seeing. It is recommended by the optics engineer that installation of ventilation fans on the windows may help to overcome the thermal effect of the telescope enclosure. In addition to this annual in-situ cleaning of primary mirror of the telescope and reflectivity measurements was also carried out.

3. Observational support: In November 2017, we recruited two observational assistants on a temporary basis along with two permanent scientific assistants to operate the telescope during the 8-months long observing cycles. This has helped us to operate the telescopes quite efficiently and avoided any manhandling by unfamiliar or less experience observers. Due to this initiative, no major malfunctioning was reported on the telescope during the observing cycle October 2017 to 2018. However, in the beginning of the observing cycle in October 2018, one observing assistant has left the institute which has made it difficult for us to provide observing support to 1.3m observers on all of their allocated nights. So, we urgently need at least one more observing assistant for the 1.3m telescope to run the telescope smoothly and efficiently.

In the year 2019-2020 total 252 nights were allotted for observing, out of which 86 nights were lost due to bad weather and 13 nights were lost due to some technical issues. In total 153 nights were used for observation and useful data was collected. This year total 32 papers were published using the data from 1.3m DFOT.

3.6m Devasthal Optical Telescope (DOT)

ARIES operates India's largest 3.6 meter Devasthal Optical Telescope (DOT) as a National Facility. Ninety three percent times on telescope is guaranteed for astronomers from India whereas the remaining seven percent is guaranteed for astronomers from Belgium. The allotment of observing time on 3.6m DOT is done by a six-member National Level Committee, namely D-TAC (DOT Time Allotment Committee) under the Chairmanship of Professor T. P. Prabhu from IIA Bengaluru. The DOT facility consists of a modern 3.6 meter diameter optical telescope with active optics technology, a suite of complex instruments, a mirror coating plant, and a control room. The instruments on 3.6m DOT can provide astronomical observations at optical and near-infrared wavelengths catering to a wide range of astronomical topics related to solar system objects, exo-planets, stars, star-clusters, galaxies and extra-galactic sources. It is being used for follow-up studies of sources identified in the radio region by GMRT and UV/X-ray by ASTROSAT.

3.6m DOT was commissioned in March 2016 and it has been put into regular operation since then. The day-to-day operation, maintenance and up gradation activities related to scientific, technical, and administrative aspect of the facility is executed by the DOT-Team consisting of scientists, engineers and support staff from ARIES and working under overall control and supervision of Astronomer In-charge, DOT (A-DOT) in consultation with Director, ARIES. The A-DOT is assisted by Assistant A-DOT in all the activities. Two engineer-in-

charges take lead in electronics-related and mechanical-related activities of DOT respectively. The internal discussions within the DOT Team and with Director ARIES took place on sixty occasions with one hour each.

A Devasthal Operation and Maintenance Committee (DOMC) with ten members from ARIES has been constituted to review the operation of telescope, to take active part in the enhancement of the facility and to liaison with National and International users of the facility. The DOMC is chaired by A-DOT. During the current period, the DOMC held three lengthy meetings (about 3 hrs duration each) dated 9th April, 5th July and 4th September 2019 to discuss matter related to operation and maintenance of the facility. The Operational Advisory Committee for Devasthal (OACD) has been constituted under chairmanship of Professor S. Ananthakrishnan (NCRA, Pune) and co-chairmanship of Director, ARIES, for advising on operations and maintenance of all the observational facilities at Devasthal. The OACD met on one occasion on 16th May 2019.

The activities performed during the current financial year April 2019 – March 2020 are summarised below.

A- Observations with telescope during April to June 2019: One of the pads of M2 mirror got unglued in the middle of February 2019 and the telescope was under maintenance since then. The TANSPEC instrument reached Devasthal site by middle of March 2019 and subsequently, the telescope was re-aligned by making changes in the software for the unglued pad of M2. The telescope was made ready for mounting and commissioning tests of the TANSPEC instrument on main port of the telescope from 2nd of April 2019. TANSPEC instrument subsequently mounted successfully along with its cryo-genics components during 2nd week of April 2019. First light of the sky observations of the TANSPEC took place on 12th of April 2019. Commissioning tests continued till 15th of May 2019 in seven clear nights. Majority of the nights during this period could not be utilized mainly due to technical issues such as failure of ungluing of M1 mirror pad as well as the bad weather conditions. Despite this, initial commissioning tests and science observations with TANSPEC were done successfully during this period. The sub-arcsec images have been recorded. Initial parameters such as array characteristics, wavelength range, resolution etc, of the instrument were calculated and found to be at par with the design specifications. **Figure 47** shows picture of the instrument on telescope.

The ADFOSC instrument was mounted on axial port of telescope during 16th May to 25th June 2019. Some nights have been utilised for tests and observations from the instrument, however, majority of the nights during this period could not be utilised mainly due to technical issues such as failure of ungluing of M1 mirror pad as well as the bad weather conditions. The ADFOSC was dismounted by 28th June 2019.

B- Upkeep and health of telescope during monsoon: The telescope needs to be protected from high humidity during monsoon period and hence during July to middle of September 2019, the telescope was parked and it was not made available for science observations. The gaps between rotating and non-rotating part is filled with foams and dehumidifiers are installed inside the building. A few parts of the telescope viz azimuth, altitude, rotator, adapter, sensor arm focus and turntable, M2 hexapod, and M1 mirror; need to be moved fortnightly to keep good health of the telescope. The health of telescope was recorded and checked on about half a dozen occasions during the monsoon period.

C- Major repair work during September – December 2019:

C1. Replacement of Azimuth motor: The azimuth motor is malfunctioning since 23rd November 2017. Though the telescope is made functional by reducing acceleration of azimuth motion, it is technically essential to replace the azimuth motor as soon as possible and accordingly, the process of procurement of spare motor and its replacement were started immediately and the order for new azimuth motor was placed in August 2018. The replacement of azimuth motor was very complex process as it involved handling of 22k N torque magnet motors and also this activity has never been done at site. ARIES

took the responsibility to install azimuth motor in the telescope in consultation with engineers from M/s AMOS, Belgium. An expert technical committee under chairmanship of Professor S. N. Tandon was also formed by ARIES to monitor motor manufacturing, acceptance at factory, and its installation at Devasthal site.

The acceptance of motor at factory has been successfully completed during 7-9 August 2019. A team of experts from India visited Germany for this purpose. The motor was transported from the factory in Germany and it reached Devasthal site on 14th September 2019 and after its arrival at site, a detailed plan for the mission was made and the work at site could start thereafter. There was a plan to make telescope ready by 11th November 2019. A team of experts from AMOS for motor alignment also visited Devasthal site during September 2019.

The old azimuth motor was disassembled from the telescope a new motor was assembled. The ungluing of the magnet from the rotor ring of old motor was clearly visible. The new azimuth motor was successfully installed with the telescope by 11th October 2019, The M1 and M2 mirrors were integrated with the telescope and the telescope was made ready for azimuth motor test on 29th October 2019. The tracking performance of telescope was found to be less than 0.02 arcsec on sky and the azimuth motor replacement mission was declared successful. **Figure 48** shows the picture of azimuth motor.

C2. Regluing of M1 and M2 pads: The M1 Mirror Axial Fixed Point (AFP1) invar pad got unglued thrice since year 2016. It unglued for the first time in January 2017 and 2nd time in August 2018. On 4th June 2019, it unglued for the third time. The technical reason for repeated failure of pad-gluing is being investigated. Two M1 Axial Fixed Points (AFP1, AFP3) were unmounted and the same were sent to AMOS, Belgium on 8th August 2019 for a technical investigation. All the three axial fixed points were refurbished during September 2019 and a new M1 integration procedure has been written.

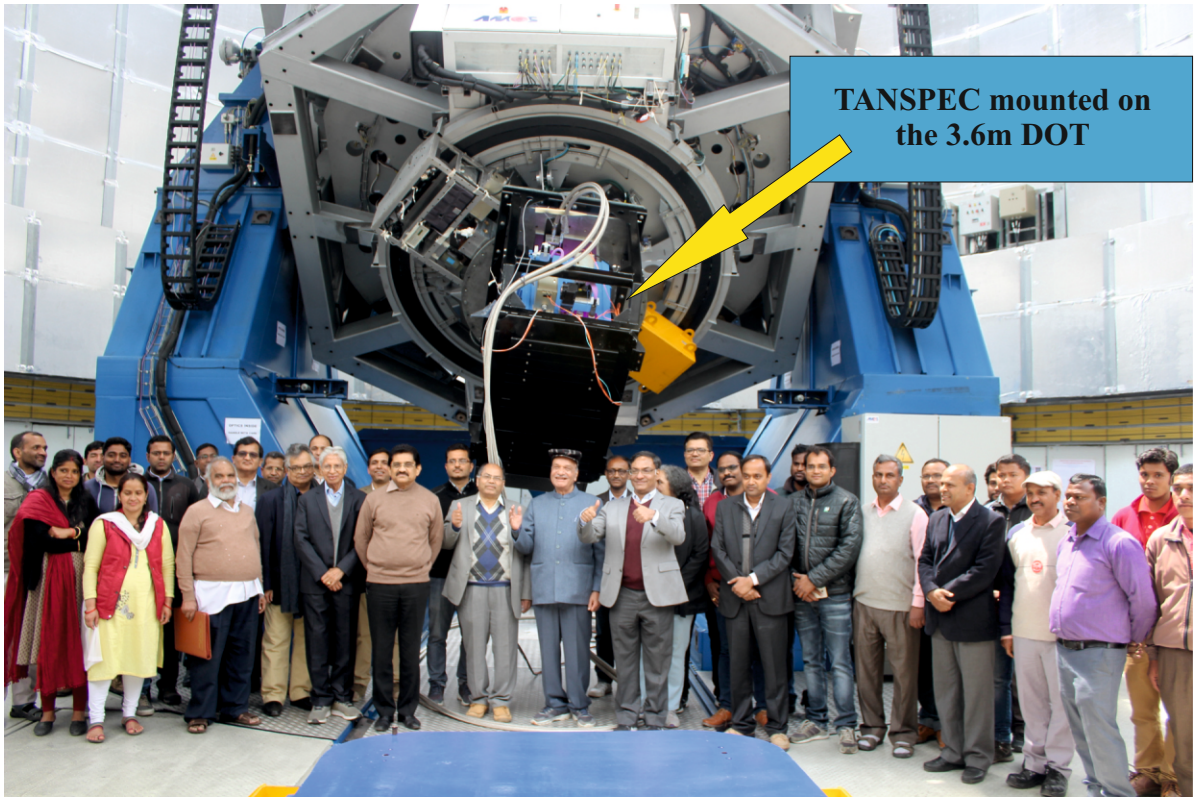


Figure 47. Fully mounted TANSPEC instrument on 3.6m DOT. It was tested on telescope during 21st March to 15th May 2019.

M2 mirror is supported by six axial pads. One of the pads of M2 mirror got unglued in the middle of February 2019 and its re-gluing took place on 23rd September 2019 during recent motor replacement mission and the telescope was made ready for on-sky tests. On 4th November 2019, it was discovered that the same M2 pad got unglued again. The ARIES team unmounted the M2 cell and the regluing of M2 pad was completed jointly by ARIES-AMOS team by 15th November 2019.

During on-sky test, large coma was noticed and after a detailed analysis it was found that the centering of M2 mirror inside its cell is not proper. A minor tilt of M2 mirror in its cell was observed. A remedial measure was thought of by ARIES team and the M2 mirror was integrated in its cell afresh and the telescope was made ready for on-sky tests by last week of December 2019. **Figure 48** shows a picture of the mirror pad.

D - On-sky performance tests of telescope in December 2019: After major repair work, the optical alignment of telescope was completed and on-sky tests were performed during the nights of 26th and 27th December 2019. Pointing model generation worked well. A WFE RMS of 54 nm was achieved during image quality optimisation and it was at par with the original specifications. Star was observed for about 5 minutes on WFS and the resulting Image quality of telescope look stable. A new set of open loop parameters for telescope were generated and implemented in the software. After long efforts by ARIES engineering and scientific team of 3.6m DOT since August 2019 for the major repair work - motor replacement and pad gluing; the telescope could be made ready for testing instruments and making science observations. The telescope was released for back-end instrument tests/observations from night of 28th December 2019. It is however noted that the guider camera of the telescope is still giving some technical issues and it requires to be attended urgently.

E- Successful observations with telescope during January to March 2020: As the telescope could recover from major repairs, it is recommended to monitor health of telescope and use it under close supervision of ARIES engineering team. It was therefore decided not to open telescope time for community and rather to use the telescope during January to June 2020 for instrument characterization. The Astronomers from Belgium were informed about the mode of telescope uses during this period and they were also requested to participate in the instrument test observations. It is important to note that there has been impact of COVID-19 on telescope operation during January to March 2020 and the telescope was operated optimally with less number of operation staff in line with COVID-19 related guidelines.

E1. TANSPEC Instrument: The TANSPEC instrument was mounted with the telescope during 28th December 2019 to 24th February 2020. Several characterization tests on the instruments were performed and the instrument was released to internal users at ARIES for 11 nights during 8th to 18th February 2020. The reports received from observers of instrument indicated that the telescope worked normally during the period. The TANSPEC team made pointing models and the image quality obtained looks at par with specifications. All the sub-system of telescope worked fine during this period and the telescope-cum-instrument delivered sub-arcsec images in visible and near-infrared wavebands. **Figure 49** shows one such image and the PSF-FWHM of stellar images were found to be around 0.5 arcsec.

E2. TIRCAM2 Instrument: This infrared imaging camera was also mounted successfully on the side port of the 3.6m DOT. Infrared Images of sub-arcses FWHM were recorded using this camera. Its compatibility with other instruments on the main port i.e. IMAGER, ADFOSC have also been tested.

E3. IMAGER Instrument: The mounting process of imager instrument could begin on 25th February and after balancing, the instrument team used telescope for instrument characterization tests till end of March 2020. Reports received from observers indicate that the telescope worked normally during this period. **Figure 50** shows an image of 0.6 arcsec PSF-FWHM recorded in R-band of IMAGER.

F – Service upgradation Activities: The old compressor supplied with the telescope was aging and was taking

larger time to attain air pressure. A new compressor was procured and integrated with the telescope system and it is successfully interfaced with the telescope system. An effort was made to indigenously design, manufacture and install a telescope cover structure with dome for protecting telescope from dust and humidity during rainy season. A dummy cover has been tested. The commissioning of a scissor lift with working height around 16m for preventive maintenance activities related to mechanical activities was installed during the financial year. **Figure 51** shows the picture of Scissor Lift.

G- Miscellaneous activities: Update on 3.6m DOT facility was presented at different forums during the financial year. Altogether, about a dozen contributions related to various aspects of the facility appeared in the conference proceedings and refereed Journals during the current year. The work on 3.6m DOT facility was presented at the 38th ASI meeting held at Tirupati during 13-17 February 2020.

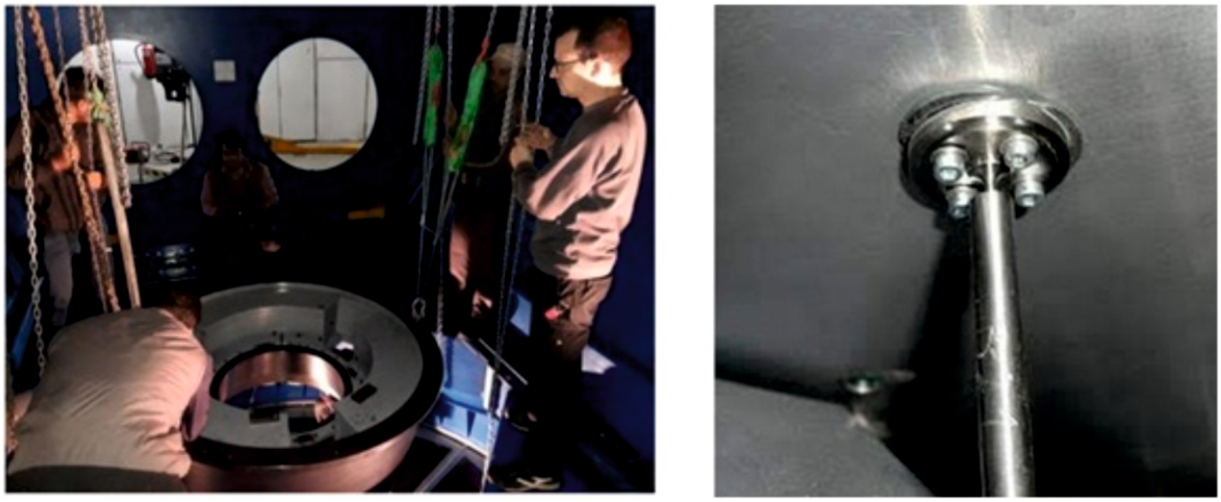


Figure 48. Azimuth motor replacement (left), unglued M2 pad (right).

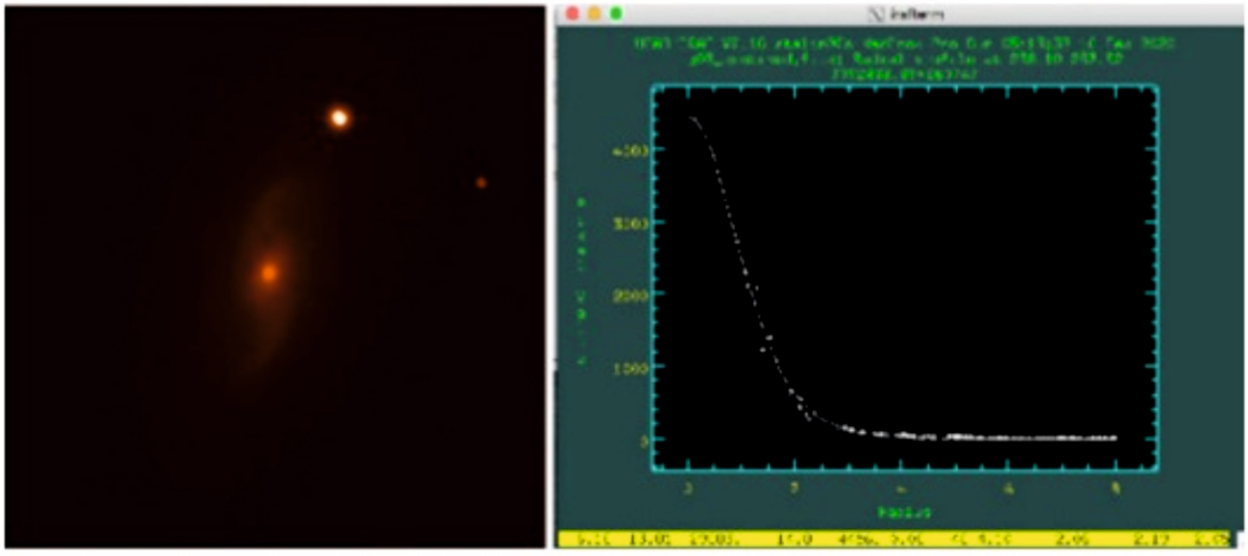


Figure 49. 1×1 arcmin FOV J-band image centered on a galaxy with integrated exposure of 10 min observed with TANSPEC (left); radial profile of the stellar source in the image is measured to be 0. 5 arcsec FWHM.

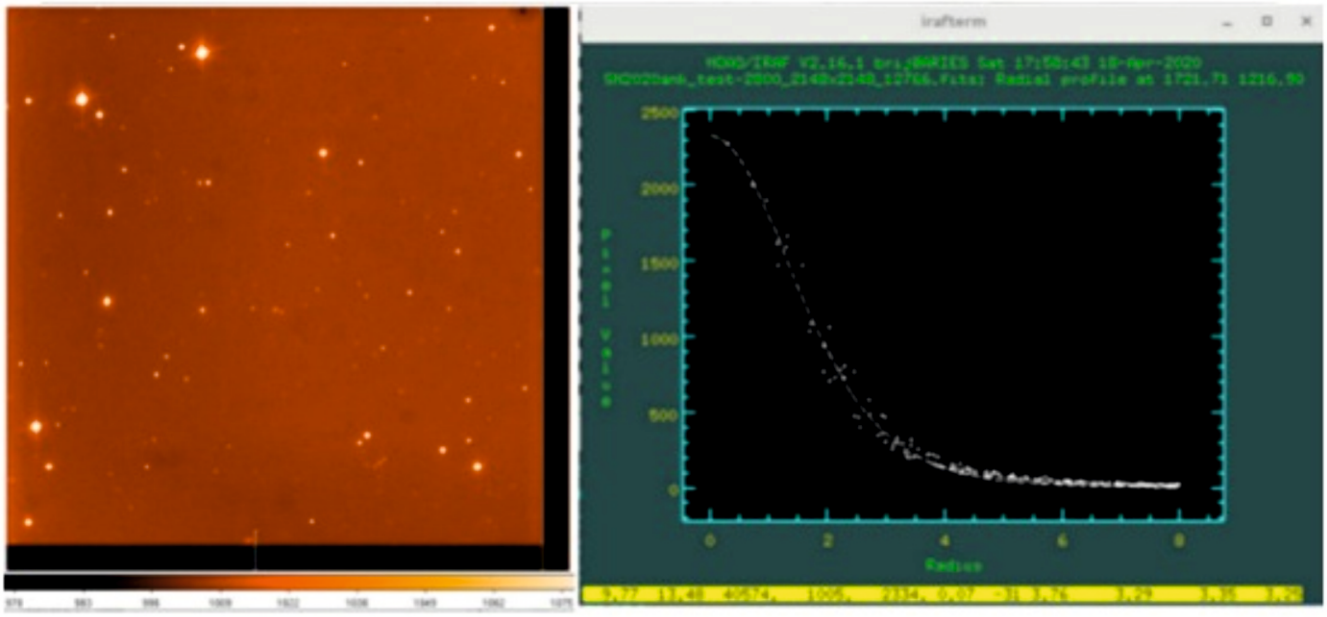


Figure 50. A 30s R-band image of a 6.5 × 6.5 arcmin field centered at SLSN 2020ank using IMAGER with pixel binning of 2 × 2 (left); Image profile of a stellar source of the same field. The PSF FWHM is 3.25 pixels (0. 62 arcsec).

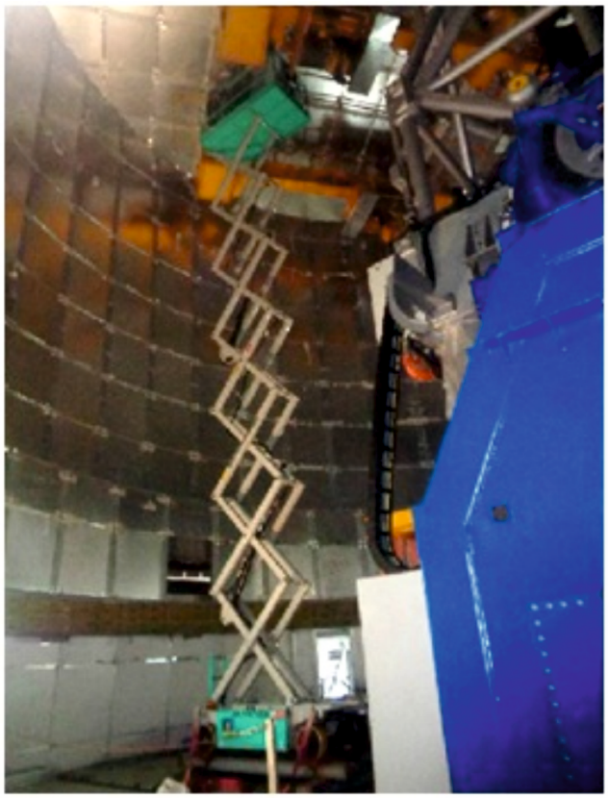


Figure 51. Working of Scissor Lift inside the 3.6m DOT Dome.

15cm Solar Telescope

The main solar observing facility at ARIES is 15cm, f/15 Coude Solar Tower Telescope equipped with Hα filter, and CCD camera (1Kx1K, 13 micron, 16 bit, 10 MHZ read out rate, frame transfer, back illuminated). It has a spatial resolution of 0.58" per pixel. It is an automatic Hα flare patrolling system, which takes fast sequence of images in the flare mode observations. Regular observations of the solar eruptive events (e.g. solar flares, filaments and prominences eruptions, surges etc.) were routinely done with the telescope. The telescope s also equipped with FeX 6374Å, FeXIV 5303Å, FeXI 7892Å filters to observe the corona during total solar eclipse. The telescope is located in a reasonably good site especially during first half of the day. The total clear observing days are approximately 200 per year.

Figure 52. The 15cm Coude solar tower telescope for solar observations.

Report from the Labs

Electronics laboratories

The electronics laboratories at ARIES broadly cater toward instrumentation for observational astronomy and experiments in the field of atmospheric sciences. With the addition of two major facilities, the 3.6 m Devasthal optical telescope (DOT) and the ARIES ST Radar, the need of two separate electronics engineering teams for focused effort arose. However, the development process in all these laboratories follow the same pattern which includes understanding the requirements from the scientific community, technology study and literature survey, discussions and learning from the internal and external experts, simulations, emulations, design, procurement, development, validation and commissioning. The commissioning phase is followed by training, maintenance and upgradation activities. The engineers are also encouraged to upgrade their knowledge by participating in conferences, training programs, teaching activities and to acquire higher qualifications.

The ST Radar electronics engineering group works mostly in the area of radar engineering covering related aspects like radio frequency, antenna, wave guide, signal processing etc. and the laboratory is equipped with specialized tools like spectrum analyzer, RF cabling and related signal generator, measurement and diagnostic tools. The ST Radar laboratory is ESD safe and equipped with modern tools for carrying out the above activities. The same team also caters to the electronics engineering needs of the ARIES atmospheric section and the ARIES solar section under the working group 2 (Wg2).

In the area of telescopes and backend instruments several teams of scientists and engineers are working on different systems, subsystems and modules for different telescopes at ARIES. Here, the design, developmental and experimental activities related to electronics, optoelectronics, electronics, mechatronics, optical and mechanical systems are interrelated, thus have a lot of overlaps both at macro and micro levels. This requires the team members to interact frequently and understand different processes which led to the development of several small electronics laboratories with overlapping facilities. Thus the astronomical instrumentation work is carried out in different laboratories at different phases. Currently, the embedded systems laboratory (**Figure 53**) and the rework laboratory in the 104 cm telescope building is being used for development of electronic

Figure 53. Embedded systems laboratory in the 1.04 m building.

controller and power electronics boards, the fabrication laboratory in the 104 cm telescope building are being utilized for mechatronics and interface development work, one room in the optics building is being used as optoelectronics laboratory. Overall, these laboratories are focused on telescope instrumentation work and have facilities like ESD safe working area, embedded systems, simulation tools, hardware in the loop platform, mixed signal oscilloscopes, function generators, SMD soldering stations, PCB design software, special workshop tools for fine cutting and fine drilling etc. As the nature of the new facilities like the 3.6 m DOT and related instruments and auxiliary facilities are demanding distributed control electronics handling multiple tasks the laboratory is continuously upgraded in phased manner to facilitate development and upgradation activities related to real-time control, CCD controller etc. and also development of low cost controllers for auxiliary control.

The 3.6 m DOT employs sophisticated motion control and mirror control systems. To support the DOT activities which require multidisciplinary skill sets and necessary understanding necessary support environment has been developed in the electronics laboratory **(Figure 54)**. This laboratory is humidity controlled and ESD safe thus suitable for storing, periodically energizing and especially for learning different aspects of the complete range of sophisticated electronics, mechatronics and optoelectronics spares of the 3.6m DOT. In this laboratory, a spare telescope control panel was successfully developed which was utilized for simulating and understanding the azimuth motor "wake-shake" initialization process and low speed control techniques. These activities proved very helpful in the azimuth motor FAT as well as replacement missions.

In addition the DOT laboratory is used for development, testing and initial calibration of the CCD detector system. ARIES students regularly participate in instrument development activities especially related to CCD and backend instruments.

Figure 54. Central electronics laboratory being accommodated with the 3.6m DOT laboratory.

A support laboratory for the 3.6m telescope for repair and maintenance activities is being planned at ARIES, Devasthal base camp. This laboratory will be utilized for activities like maintenance of backend instruments and repair and replacement of the DOT telescope parts. Currently, part of this work is being done in the 3.6m DOT pier and in the 1.3m telescope laboratory.

The electronics engineers also cater towards infrastructure needs of the institute in the ARIES electrical section. The main job function here is to coordinate the electrical maintenance activities including building electrical, power and telephone cabling and distribution in office and residence premises, substation development and maintenance, UPS installation and maintenance and EPABX installation and maintenance. The section is located in the central electronics laboratory building.

1) Summary of existing electronics/electrical laboratory facilities

a) Embedded systems laboratory in the 40 inch telescope building: This facility is extensively used for developing control system (developing control algorithm, interfacing the encoders, other analog and digital sensors, actuators, design of power electronics and drive boards etc.), software, PCB design, simulations and validation.

b) CCD laboratory in the optics building ground floor: This facility is being used for CCD integration, customizing, testing and maintenance.

c) Software and development in the 40 inch telescope building: Necessary software and computers with large/multiple monitors have been installed for professional level multi-layer PCB boards design and development, simulation work and multi-screen control software development (TCS, ICS etc.). Multi-threading control software for controlling various aspects of telescope and run-time plotting have been developed for the Schmidt telescope.

d) Model fabrication laboratory in the 40 inch telescope building: This laboratory is in the ground floor of the 40 inch telescope building and has necessary power tools for developing wooden and aluminium models, test rigs, catering laboratory requirements, developing instrument enclosures etc.

e) ST Radar electronics laboratory: This laboratory is mainly used for working on different aspects of Radar engineering. However, it also supports the instrumentation work related to the atmospheric science section.

f) Experimental laboratory in 22 in telescope building: The atmospheric science experiments are carried out in this laboratory and it has the necessary tools for maintaining these instruments. For larger support help is sought from the ST Radar laboratory.

g) Electrical group: This is mainly established for installation and maintenance of building electrical facilities, central UPS, EPABX and telephone facilities, electrical substations, power distribution in office and residence premises. The electrical group manages installation and maintenance of SCADA based substation both at Manora Peak and Devasthal. There are currently four different substations, two at each of the sites. The substations are equipped with a hierarchy of DG sets and capable of automatic load management, distribution and computerized remote control, monitoring and logging.

2) Summary of upcoming electronics laboratory facilities

a) New electronics laboratory for telescopes and instruments for integrated design and development work: For catering towards multidisciplinary activities including electronics, optoelectronics and mechatronics required for telescopes and instruments and also for learning (programming and validation) and testing the telescope motion controllers, PLCs, active optics control system, understanding the system identification and tuning techniques and also for performing periodic functional tests on the spares we have proposed a full-fledged environment controlled laboratory at Manora Peak site. The dimensions and internal structure were

finalized and soil test was done for evaluating the load bearing capacity. The construction would begin in the next financial year.

b) Devasthal electronics maintenance and support laboratory: The requirements of the laboratory have been finalized and development through CPWD has been initiated. It will be used both for the electronics maintenance of the Devasthal facilities and for remote operation of the Devasthal telescopes.

c) Upgradation of embedded systems laboratory: This laboratory has been upgraded with low cost wireless microcontroller for implementing sensor network mainly for the 3.6m DOT enclosure and FPGA platform with system on chip (SoC) for advanced controller development both for telescopes and backend instruments. Matlab license with Simulink toolbox has been procured for simulating precision real-time motion controllers. Hardware for developing CANopen and EtherCAT has been procured and programming techniques and required knowledge base are being explored.

Optics Section

Optics section is actively involved in various instruments activities related to various existing facilities and new projects. Testing, verification, alignment and images quality testing of various systems and subsystems were carried out using facilities/instruments available in optics laboratory. In addition to that, design section of optics laboratory was actively involved in the optical designing and analysis of various instruments under different projects. The major achievements of optics section in 2019-2020 are:

(A) Re-gluing of primary and secondary mirror pads of 3.6m Devasthal Optical Telescope (DOT):

Primary (M1) and secondary (M2) mirror cells were un-mounted from the 3.6m DOT. Re-gluing of M1 and M2 pads were carried out along with AMOS engineers. Proper mechanical set ups was arranged for gluing of M1 and M2 pads. A close room was created to control humidity and temperature for better curing of glue for M2. Integration and disintegration of M2 with its cell was carried out before and after the re-gluing procedure. Thorough inspection of M2 cell was carried out before integration. M1 pad was glued without removing the M1 from the cell. The axial definers were refurbished by AMOS and the same were installed in the mirror cell and its functioning was inspected. Some of the faulty actuators were replaced by the spare actuators. Needles of the axial definers were inspected to ensure that no bending was occurred.

Figure 55. Secondary mirror un-mounting from the cell (top), Gluing arrangement (bottom).

After installing the primary and secondary mirror cells, the optical alignment of the 3.6m telescope was carried out with the help of wave-front sensor and M2 hexapod. Zernike polynomials were optimized using wave-front sensor in closed loop mode by using the M2 sensitivity parameters. Open loop parameters were updated after the converging the total wave-front error less than 60nm rms. The pointing model was also generated. Telescope was made ready for science observations.

Regular in-situ CO_2 cleaning of primary mirror was also carried out and reflectivity log was maintained.

Figure 56. CO_2 cleaning of 3.6m DOT primary mirror.

(B) 3.6m Devasthal Coating Plant:

This year we received 41 TACTIC (TeV atmospheric Cherenkov telescope with Imaging Camera) mirrors from the Astrophysical Sciences Division of BARC (GOALS Observatory Mt. Abu) for re-aluminisation. For that, a suitable mechanical attachment was designed and fabricated to mount the medium size TACTIC mirrors for coating inside the 3.6m DOT coating chamber. Till March 2020 fifteen out of 41 TACTIC mirrors were re-aluminised using our coating facility. The average reflectivity of the freshly coated mirror was about 85-89% from 365 to 900 nm wavelength range. Besides this, regular health run of the coating plant was carried out and activity log was maintained.

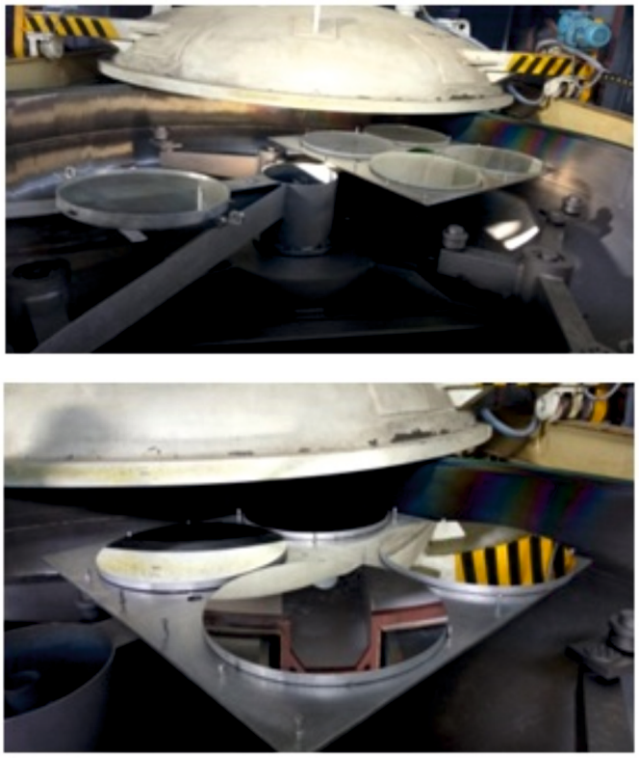


Figure 57. TACTIC mirrors coating set up, before coating (top), after coating (bottom).

(C) Contribution of Optics Team in TANSPEC Instrument:

Opened the TANSPEC dewar after venting it using dry nitrogen gas. Inspected the optics and removed the damaged grating and cleaned the dewar and closed it. Small aperture was assembled to the calibration unit to avoid saturation.

TANSPEC was integrated with 3.6m telescope, evacuated the dewar and started the cooling. It was made ready for observations. Pointing model was generated and some test observations were carried out. It was un-mounted from the telescope after the observations.

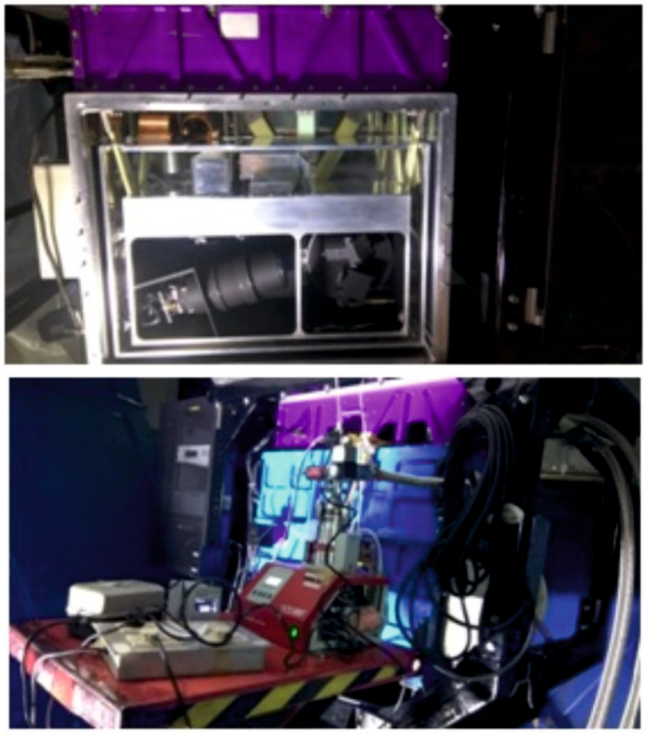


Figure 58. TANSPEC with Dewar opened condition (top), Evacuation of dewar after integrating with DOT.

(D) Contribution in TIRCAM2:

TIRCAM2 was mounted in the side port of the 3.6m telescope. Couple of times it was made ready for observations. It includes dewar evacuation, helium lines connections, cable rooting, cooling and testing the detector before observations. First time it was tested with the side port successfully.

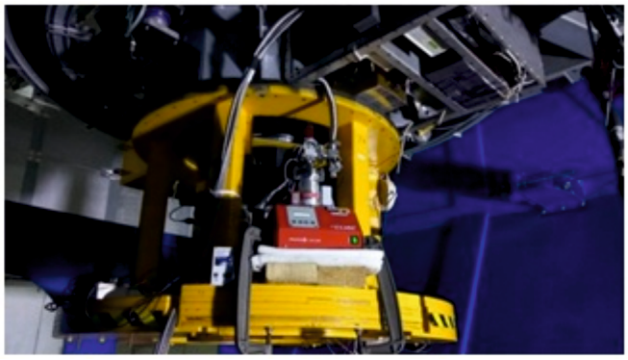


Figure 59. Evacuation TIRCAM2 which was integrated in the side port of 3.6m DOT.

(E) Contribution in 4Kx4K CCD IMAGER:

Bessel and SDSS filter were cleaned. Transmission measurements were carried out in optics lab. All these filters were assembled in the respective slots of filter wheel. Imager is mounted with 3.6m telescope and made ready for observations. It includes dewar evacuation, helium lines connections, cable rooting, cooling and testing the detector before observations. It was un-mounted after the observations; filters were removed and properly stored. Some experiments were carried out to check the unwanted light before un-mounting.

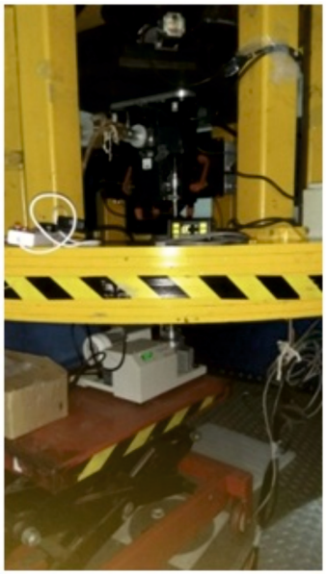


Figure 60. Evacuation of 4k imager after integrated with the DOT.

(F) Contribution in FOSC Instrument:

A quad-beam full-stokes spectro-polarimeter for the 3.6m Devasthal Optical Telescope (DOT) is designed using wedged double-Wollaston prism concepts with FOSC. This design obtains simultaneous measurements at four polarization angles in a single exposure and does not require a half-wave plate for linear polarimetry. Both linear and circular polarimetry observations in imaging and spectroscopy modes will be possible with the proposed augmentation in the FOSC using innovative design for adding a quad-beam spectro-polarimeter mode using double wedged Wollaston prisms in FOSC. The optical design uses only two 60mm x 30mm x 30mm wedged Wollaston prisms made of Quartz crystal without any rotating half-wave plate. A fixed quarter-wave plate is proposed to be mounted in the slit-mask for circular polarimetry. In addition, spectral order-sorting filters are also proposed to be mounted in the slit-mask itself. Both linear and circular polarimetry observations in imaging and spectroscopy mode will be possible with the proposed augmentation in AD-FOSC. In order to validate design ideas, a sub-aperture spectro-polarimeter using two 25-mm Wollaston prisms procured from a small-scale optical manufacturer in India is presently being integrated in the AD-FOSC. This sub-aperture spectro-polarimeter does not require a wedge and the required separation between the four spectrums measuring polarization of light at 0, 90, 45, and 135 degree angles is obtained by placing two Wollaston prisms at a relative angle of 45 degree and rotating this double Wollaston assembly at an angle with respect to the spectrograph's dispersion axis. The optical simulations and analysis is done for the above configurations.

A design of mechanical mounting for two Wollaston prisms was finalised with mechanical team and got it manufactured. Two Wollaston prisms were mounted in the holder and assembled it in the broadband wheel of FOSC. BG-3 filter set up was mounted with narrow band

wheel. KG3 filter transmission measured and embedded with bg-3.

FOSC was mounted with 3.6m telescope and made ready for testing. Previously un-mounted SDSS filters were re-mounted in the broadband wheel. Single Wollaston prism of 38X38mm was also mounted. CCD focusing was carried out. Sky images were taken in all modes which are imaging, spectroscopy, dual band, spectro-polarimetry, imaging polarimetry, low resolution spectroscopy etc. Calibration spectra were also taken. Calibration lamp mounting was replaced with new mounting to avoid the saturation. Optical design and analysis was carried out to get high resolution using VPH grating.

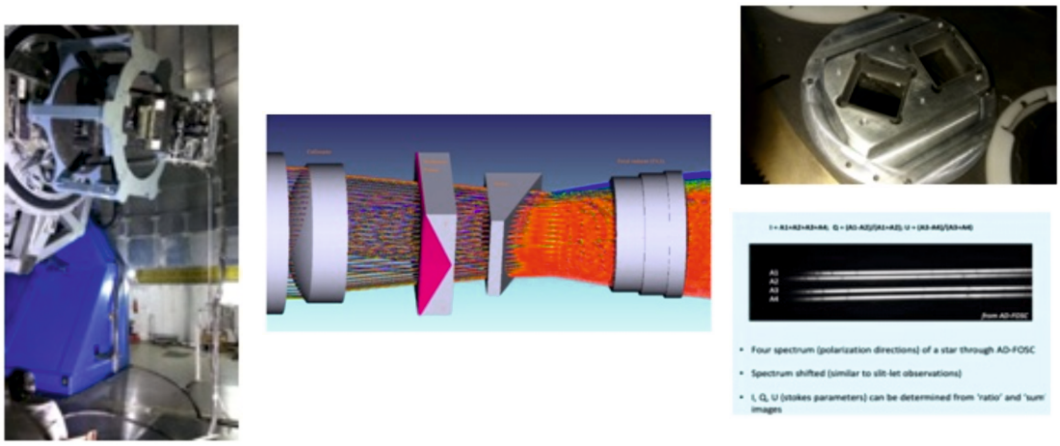


Figure 61. ADFOSC mounted with 3.6m DOT (left), two wollaston prism optical design (middle), wollaston prism assembled in the filter wheel of FOSC and its on sky image (right).

(G) Maintenance activity of 130cm Devasthal Fat Optical Telescope (DFOT) and 104cm Sampurananand Telescope:

Proper in-situ cleaning (without un mounting the M1 cell) of 1.3m primary mirror, filters and corrector was carried out before observing seasons and reflectivity of primary mirror was measured. One of the radial pads of primary mirror of 1.3m telescope was re-glued. M1 of 1.3m telescope was re aligned with its cell by taking down the mirror cell and re-assembled with the telescope after alignment of M1 with the cell. Final alignment was carried out. In-situ cleaning of primary and secondary mirrors of 1.04cm telescope was carried out and reflectivity was measured.

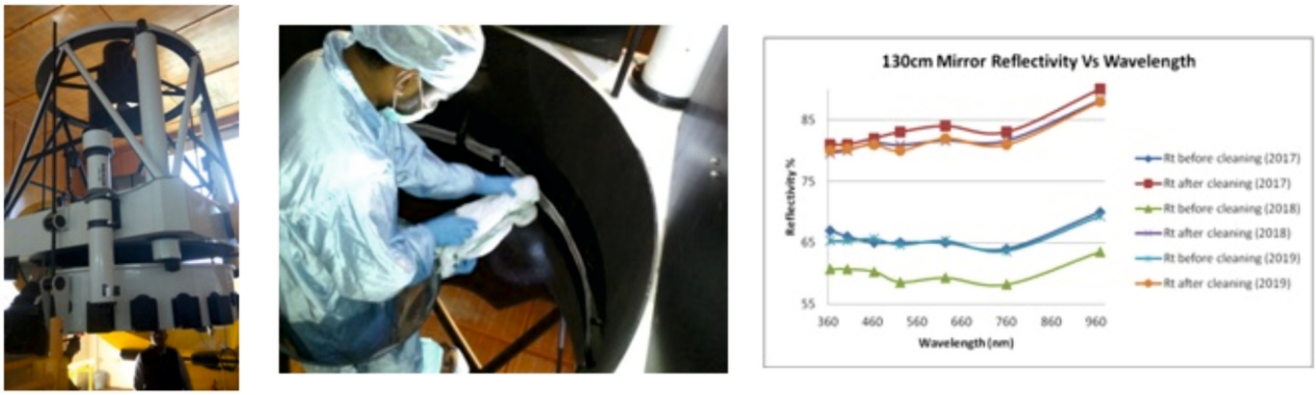


Figure 62. 1.3m telescope M1 cell un-mounting (left), Cleaning process (middle), M1 Reflectivity (right).

Mechanical Engineering Section

The mechanical section is actively participating in design, development and maintenance activities for establishing modernized telescope facilities and instrumentation. We also support in up keeping all observation facilities by regular maintenance and up-gradation of existing technology. The mechanical section is equipped with a vertical machining center CNC and conventional machines such as lathe, milling, radial drilling, surface grinder, mechanical power hacksaw, tool grinder, air compressor, single-phase, three-phase machines, TIG welding machines, etc. Besides, a portable CMM machine is equipped for measuring the geometry of physical objects by sensing discrete points on the surface of the object with a probe. Our Engineers are familiars in Pro E, Unigraphics, Auto Cad, Ansys, and Master cam software for design simulation, and computer-aided manufacturing of critical mechanical systems. Below is a brief description of activities undertaken by mechanical section during 2019-20.

a). Replacement of azimuth motor of 3.6m DOT

The 3.6m telescope azimuth motor is a frameless brushless DC motor and it delivers a peak torque of 25000N at acceleration 2m/sec^2. The technical details required for manufacturing a new motor was provided and verified each stage of manufacturing by going through the technical requirements and discussing with M/s AMOS for finalized the motor replacement procedure because of the criticality of work.

The motor accessibility was narrow and the motor sits beneath GIS, therefore, a special trolley was designed and manufactured in workshop. Once the motor arrived at the site, it was examined properly and the stator tilt problems were successfully rectified by building the special setup from locally available materials at site. To take out old motor a general arrangement was prepared at telescope floor by using chain blocks and slings arrangements. The motor connections are establishing through a central ring, radial bearings and brakes in GIS assembly therefore, all systems need to be properly taken care along with removing the motor for replacing new motor. A systematic procedure prepared and following the procedure, the old motor was taken out from GIS from extensive efforts and precautions.

Once the old motor were taken out from GIS the reference positions marked to install the new motor and aligned in an accuracy of 50 micron before installing back in GIS. Once installation finishes it should again aligned with telescope rotation for establishing proper air gap between stator and rotor of the motor. With this new motor telescope is successfully achieving the accelerations requirements and telescope is used to track an objects while in wind speed up to 10m/sec earlier it was reduced to 5m/sec.

b). SS mirror holder plate is designed for optics department for aluminizing the BARC mirrors. This plate is having a threaded holes of equip space distance to clamp mirrors in aluminizing coating chamber.

c). forced air chiller is been procured for TANSPEC instrument with customizing the features because of low ambient temperature in winters in 3.6m telescope site.

d). Polarimeter filter unit is upgraded with new automated system. The complete set up was designed in-house and manufactured in CNC and integrated drive incorporated for precision shifting of filter positions.

e). TANSPEC instrument Dewar opened by construction dust proof envelope and taken out the damaged grating and set the instrument in low-resolution mode and helium storing lines routed.

f). TIRCAM2 instrument structure was successfully modified by reducing the length of housing structure and redistribution of balance weights in the instrument envelope.

Figure 63. New azimuth motor.

Figure 66. Alignment of new motor in GIS for replacement.

Figure 64. Tilt correction of stator.

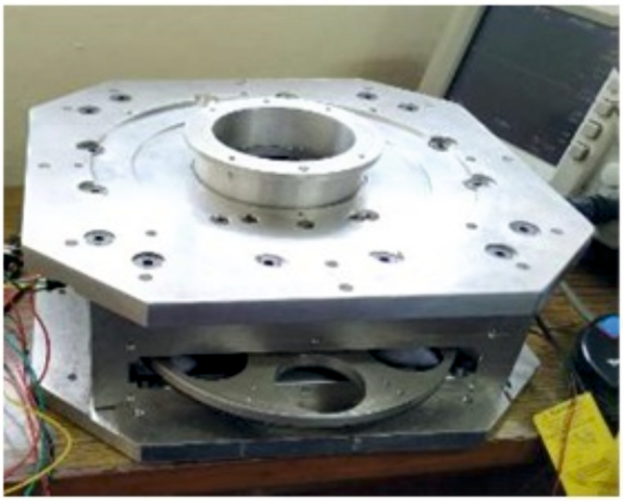


Figure 67. Polarimeter filter wheel assembly.

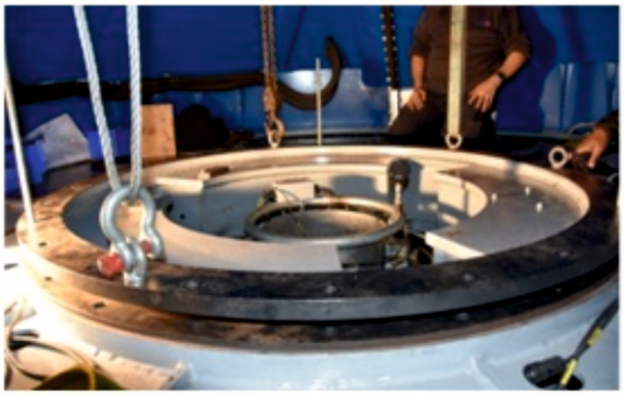


Figure 65. Taking out old motor.

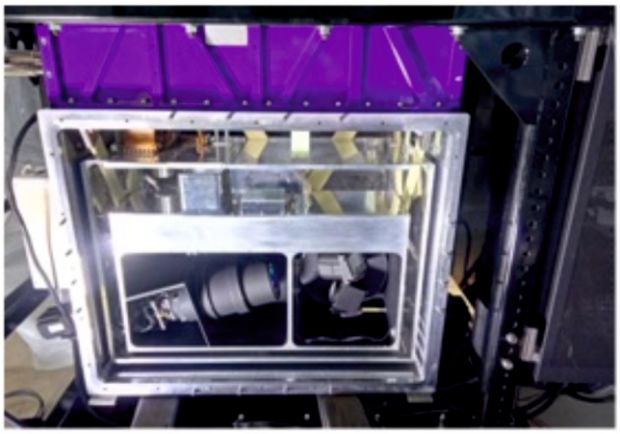


Figure 68. NSPEC Dewar opened for maintenance.

Computer Section

Computer Section is backbone of ARIES which provides various Computing and Network services through Information & Communication Technologies and provides high-end computing, cluster-based computing, and programming supports to various R&D projects of the institute on 24 X 7 basis.

The Division manages Servers, Storage Device, Work Stations, Desktop and Laptop Computers, Printers, Plotters, Scanners, CCTV, Projectors, Audio & Video-Conference, DSLAM, LFD, Software and Network (Wired & Wireless) infrastructure along with setup, maintenance and support. The section also maintains the ISDN-PRI telephone lines from service providers (BSNL), and high-end PBX systems.

The Division also provides secured network services of campus wide LAN/WAN solutions and internet /intranet solutions besides providing computing services to ongoing R&D projects. The IT group has been deploying information technologies to help faculties to be in their chosen area of research/work.

We are also the part of National Knowledge Network (NKN) network through which we are providing dedicated Internet service to the users. We are also maintaining Internet line at Devasthal which is provided by BSNL. Firewalls at Nainital & Devasthal have been upgraded.

Section also focuses on Software development using technologies like .NET (C, C++, C#, ASP.Net, etc.), PHP, Python, MATLAB, LabVIEW, Java, etc. to support the R&D activities of the Institute. Different Software interfaces are designed and developed for various stakeholders of the Institute to facilitate for their needs, on demand.

Technical Activities:

- Wired and Wireless Networking Solutions & Services
- Software/Web Development & Data Base Management
- Windows and Linux Server Administration
- E-Administration Services including Software and Hardware installations, printers, scanners and all other computer related devices
- E-mail Service for ARIES Staff members including Scientists, Engineers, Technical and Administrative Staffs and Students
- Technical support in Online meetings/Video Conferencing / Seminars/ Training Schools/ Scientific Workshop
- Network Security
- Web Services include Website (Website Development, Administration and Maintenance)
- Management of Point to Point link (Microwave link) between Nainital & Devasthal.
- Management of Bio Metric Attendance System at Nainital & Devasthal

Facilities:

- Servers/Workstation for services like Web, Email, DHCP, DNS etc.
- Email services for all Staff and Students
- Wi-Fi Internet Management System
- VPN Network Service Management System

- Centralized Storage System
- Centralized printing facility
- Network Security Management System with Firewalls
- Various advanced and special purpose **software** for users.

Further Plan of Action

- Cluster/A Hyper converge system is planned to provide cost effective server infrastructure to faculties with dynamic compute/storage provision. **Hyper-convergence** is a type of infrastructure system that tightly integrates compute, storage, networking and virtualization resources and other technologies will be combined in a commodity hardware box.
- Upgradation of computational Hardware of students & faculties.
- A new CMS based Website for ARIES is in progress.
- Digitization of old office records.
- Enterprise Resource Planning (ERP) for smooth running of office.
- Installation of Managed AP for network security.

Knowledge Resource Center

The mark of a progressive institution is judged by the strength of its library, which has been aptly termed "Library is a growing organism" fifth law of library science given by Prof. S.R. Ranganathan, an authority on library science. Ever since the inception of the Observatory in 1954, its library has been steadily building up through the years and is now known to be one of the best libraries amongst those belonging to any similar scientific research institutions in the country. Institute has a well stocked automated library which is named as Knowledge Resource Centre (KRC). It is facilitated with Wi-Fi connectivity. The ARIES KRC acquires books and journals mainly related to Astronomy & Astrophysics and Atmospheric Sciences. The KRC also acquires reference books time to time. The ARIES KRC is a member of FORSA (Forum for Resource Sharing in Astronomy and Astrophysics), which was established by Indian Astronomy Librarians in 1979. The ARIES KRC is also a member of National Knowledge Resource Consortium (NKRC). NKRC provides free access of Subscribed Online Databases to DST and CSIR institutions.

KRC Resource Development

During the period 2019 – 2020, the following information resources were added:

Subscription to Journals	:74 (Print + Online) + Full Text Databases
Publications in refereed journals	: 92
Theses awarded	: 06

The collection at the end of the period is

Books	: 11015
Bound volumes of Journals	: 11,205

Apart from books and journals, other materials such as slides, charts, maps, diskettes, CD-ROMs, etc. are also available in the KRC. The new features of Online Catalogue are available at Web-OPAC in ARIES home page. DSpace, an open source software is used for the digital repository of ARIES, where KRC preserves scientific documents, academic reports, photographs of special events, newspaper clippings, etc.

Figure 69. KRC main reading hall.

Academic Programmes of ARIES

The Academic Committee (AC) of ARIES is pursuing to improve the academic environment of the institute. The present members of the committee are:

Dr. Manish Naja (Chariman)

Dr. Sneh Lata

Dr. Narendra Singh

Dr. Yogesh Joshi

Dr. Saurabh

Mr. Ramdayal, secretary to the AC and AC is also assisted by Mr Arjun Singh and Mr. Prashant Kumar.

Major academic activities of 2019-2020 are listed below:

[A] Joint Entrance Screening Examination (JEST):

Academic Committee actively participated in the overall planning of the JEST on the behalf of ARIES. One of the members of AC (Dr. Narendra Singh) took the responsibility of conducting the JEST 2020 examination at Nainital centre and exam was conducted in February, 2020.

[B] PhD entrance interviews:

AC organizes interviews every year to select PhD students as Junior Research Fellows (JRFs) in ARIES. Dr Saurabh and other AC members screened all applications and interviews were conducted during 27-31 May 2019. Students who are MSc in physics/astrophysics and have qualified JEST/ NET/ GATE are invited to appear for the interviews. Candidates who have successfully qualified the interviews are selected as JRFs and are inducted in ARIES to undergo a pre-PhD course work. Seven students have joined ARIES in year 2019. Three more students from IIA have joined ARIES, who have migrated from IIA to ARIES with Prof. Dipankar Banerjee.

[C] Summer Project Students:

The summer project internship is one of the significant programs of the academic committee. In this, we intend to provide training to the Bachelor/Master level students from various universities/institutes and provide glimpses of the cutting-edge research and development activities that are being carried out in the Institute.

[D] Conducting the Course Work of ARIES Post Graduate School:

Academic Committee has made the detailed course work structure in Astronomy/Astrophysics, and Atmospheric Science for the students joining ARIES. Committee conducts the teaching classes in four terms followed by three months project in the specialized area of the basic research.

The extensive course work is followed by rigorous examination. Each instructor takes the examination under the supervision of the AC, and evaluates the students as per the criteria made by the AC. The project related evaluations, commissioning of respective committees and experts, and arrangements of the project talks, are also executed by AC. In 2019-2020, AC conducted the examination and project presentations of the first year batch and following students successfully negotiated the Pre PhD course work, and entered the main PhD programme of ARIES:

[1] Ms. Akanksha Rajput

[2] Mr. Amar Aryan

[3] Ms. Dimple

[4] Mr. Mahendar Chand Rajwar

[5] Ms. Nikita Rawat

[6] Mr. Rahul Gupta

[7] Mr. Raj Kishor Joshi

[8] Mr. Vivek Kumar Jha

[E] PhD Thesis:

Six students of ARIES have awarded their PhD and four have submitted during April 2019-March 2020.

[F] Post Doctoral Fellows/Research Associate:

Five postdocs/RA are at ARIES during 2019-2020:

[G] Conducting the Annual Student/Postdoc Reviews:

Every year around the month of July/August, AC under the guidance of the Director, forms the expert panels, select the examiners, and furnish the details of the Junior and Senior Research Fellows of the Institute to conduct their annual reviews. The recommendations on upgrading their fellowships (JRF to SRF), thesis submissions etc are based on the significant review process organized by the committee.

[H] Orientation Programme 2019:

Every year Academic Committee organizes orientation programme to welcome new students, and distributes pre-PhD course certificates to successful and outgoing first students of ARIES. Orientation programme 2019 was conducted on July 2019.

Figure 70. Group photo with newly joined JRF and pass out JRF of Pre PhD course work during orientation programme conducted on 2019.

Public Outreach Activities

Public Outreach is an ongoing program at ARIES. Among other branches of sciences, Astronomy and Atmospheric sciences are ideal subject area to reach-out general public and students to develop scientific temperament in general. Also, it has been mandated very clearly that disseminating the research outcomes, communicating science and Technology to masses, stimulate scientific and technological temper is our one of the key responsibilities being a public-funded organization. Recently, all these activities are defined as Scientific Social Responsibility (SSR) i.e. the ethical obligation of "giving back" to less endowed stakeholders of science, technology and innovation as well as society at large, some of the benefits that science derives from it.

Nainital and nearby places are full of schools and colleges and are major center for primary education in this part of the country. For this purpose, ARIES has a dedicated science center comprising one lecture hall, equipped with projector and sitting arrangements of about 40 students and an exhibition hall to display the science model and posters. In addition a small 14-inch telescope has been installed to facilitate live night sky visual observation for the general public. Recently, a 5-m planetarium is also made functional at ARIES, playing important role in science popularization. This is used as a virtual sky as well as it shows some full dome astronomical movie to visitors. ARIES also attracts around a dozen of visitors per day and 3-4 educational tours per month and educate them using above mentioned facilities and also arrange popular talks (for educational tours) or full dome planetarium shows (for general visitor). In addition, huge rush is attracted in summer season or on the occasions of popular astronomical events like eclipses and other occasions like national science day. Apart from this, we also make use of print, electronic and social media to communicate information related to astronomical events as and when required as a part of ongoing outreach activities at ARIES. Popular talks in the nearby schools and colleges are also arranged.

In the year 2019-20, about 8200 visitors got benefited during their visits to ARIES science center and related facilities. Out of 8200 visitors, about 60% were students from various schools/colleges from various parts of the country. Students from various colleges and schools in local area are specially invited and entertained to promote science and related activities. Several popular talks were also given occasionally in local schools and colleges for high-school and intermediate students. A brief summary of other major public outreach activities conducted by ARIES during the year are following.

Vigyan Samagam, pushing the frontiers of science: ARIES being part of Thirty Meter Telescope project actively participated to the first of its kind mega-sciences exhibition called "Vigyan Samagam" at Mumbai (May-Jun 2019), Kolkata (Nov-Dec 2019), and Delhi (Feb-Mar 2020) during the year 2019-20. Vigyan Samagam was first of its kind multi-venue mega-science exhibition that attempted to bring several collaborative mega-science projects under one roof. It showcased India's contribution to some of the biggest international collaborations on fundamental science and research, and provided a common interactive platform for mega-science activities, industry, academia and institutions. During the exhibition, it was also presented that how fundamental science and research could be chosen as a strong career options for the youngsters. Several scientists and young students from ARIES actively participated towards this year long exhibition.

Bapu Khogol Mela: ARIES hosted the program organized by Nehru Planetarium Delhi (funded by Ministry of culture Govt. of India) called "Bapu Khagol Mela" during 4-8 May 2019 in places, where Mahatma Gandhi ji visited long back i.e. Takula, Tadikhet, Almora and Kausani in Kumaun hills. During this program, our public outreach team along with team members from Nehru planetarium conducted different types of astronomical activities and sky watching through telescopes in these places for college/school students and general public.

Visit by meritorious students from Aryabhat Foundation: Aryabhat Foundation a social service organization based in Madhya Pradesh, actively involved in the field of Science popularization. It annually organizes state level astronomy quiz for school students in which around 5000 students participate from different

schools across the state to select a few meritorious ones. In 2019, three of those selected students visited ARIES during 18-20 May 2019. These students got a chance to interact with scientist and research scholars and to know more about astronomy and astronomical facilities of ARIES and delivered a presentation.

Participation to HIMWATS's Workshop: HIMWATS is a Champawat-based NGO working in the field of Social, educational and environment issue of Uttarakhand. It annually organizes a workshop for school children, where ARIES provides resource person and materials. This year it was held on 7-8 June 2019 and ARIES public-outreach team participated actively.

Participation to "Destination Uttarakhand": ARIES participated during the exhibition called "Destination Uttarakhand", Dehradun 18-20 July 2019 along with other team members of the outreach section for ARIES and placed a stall showcasing about our research activities. During this program, ARIES own the best exhibition stall award and interacted with more than 1000 local students and general public.

Other similar workshops during the year joined by the public-outreach section of ARIES are:

- "Vision Rajasthan" at Udaipur during 17-19 Sep 2019,
- "Srijan Uttarakhand" at Gairsain during 15-18 December 2019,
- "Rise in UP" at Ghaziabad during 14-16 Feb 2020

Basics of telescopes and astronomy workshop 2019: Upon request of St Joseph's College, Nainital, ARIES organized five day workshop on "Basics of Telescope and Astronomy" during September 2019. Around 25 students of class 11 and 12 participated in this workshop. The workshop consisted a series of lectures, observation through 14-inch telescope, hands-on training of handling and maintenance of Telescopes were organized during the workshop.

Workshop on Astronomy and Sky watching: ARIES participated in one-day educator workshop in Astronomy and Sky-watching at Gurukul Kangri Vishwavidyalay Haridwar on 27th Nov 2019 and series of discussions with under-graduate science students were conducted about astronomy, atmospheric sciences and physics in general.

Annular Solar Eclipse, 26th December 2019: A big outreach program was hosted at ARIES Nainital on 26th December 2019 to observe the partial Solar eclipse passing through Nainital and series of talks and interaction session with public and media briefing was done on the day. Astrophotography of the eclipse was also conducted on this occasion. On this occasion, ARIES in collaboration with District Administration, Nainital organized a one day observation camp at ARIES campus on Thursday 26 December 2019. The main objective of this programme was to develop scientific temperament behind the celestial events like eclipse among General public and specially student. For this programme about 70 student of class IX to XII of Govt. and Private Colleges of nearby area and ARIES campus residents participated.

National Science Day Celebration: This year, the National Science Day celebrations were organized on 28 February 2020 under theme of "Women in Science" as decided by Dept of Science and Technology. In this program about 80 Students were participated and women scientists of ARIES delivered talks about contribution of women scientists in various areas of sciences.

VIP Visits to ARIES: ARIES outreach team coordinated the visit of Her royal highness princess Maha Chakri Sirindhron, Thai Ambassador and other VIP dignitaries during 12-13 February 2020 and earlier since November-December 2019. ARIES visit by Honorable Governor of Uttar Pradesh Mrs. Anandiben Patel and various high officials on 3st Oct 2019 were also coordinated by ARIES outreach team.

Popular talk (extra campus)

- TMT project by Dr. S. B. Pandey at Vigyan Samagam, Kolkata.
- TMT project and Science Using TMT by Dr. S. B. Pandey at Vigyan Samagam, New Delhi.
- Two invited lectures by Dr. S. B. Pandey at Nehru Planetarium Delhi on 01 and 02 July 2019 towards 2 months long "Astronomy Boot Camp" hosted for post-graduate science students.

Figure 71. A discussion session about "Bapu and astronomy" at Anasakti Ashram Kausani with the general public and other dignitaries on 4-5th May 2019 during.

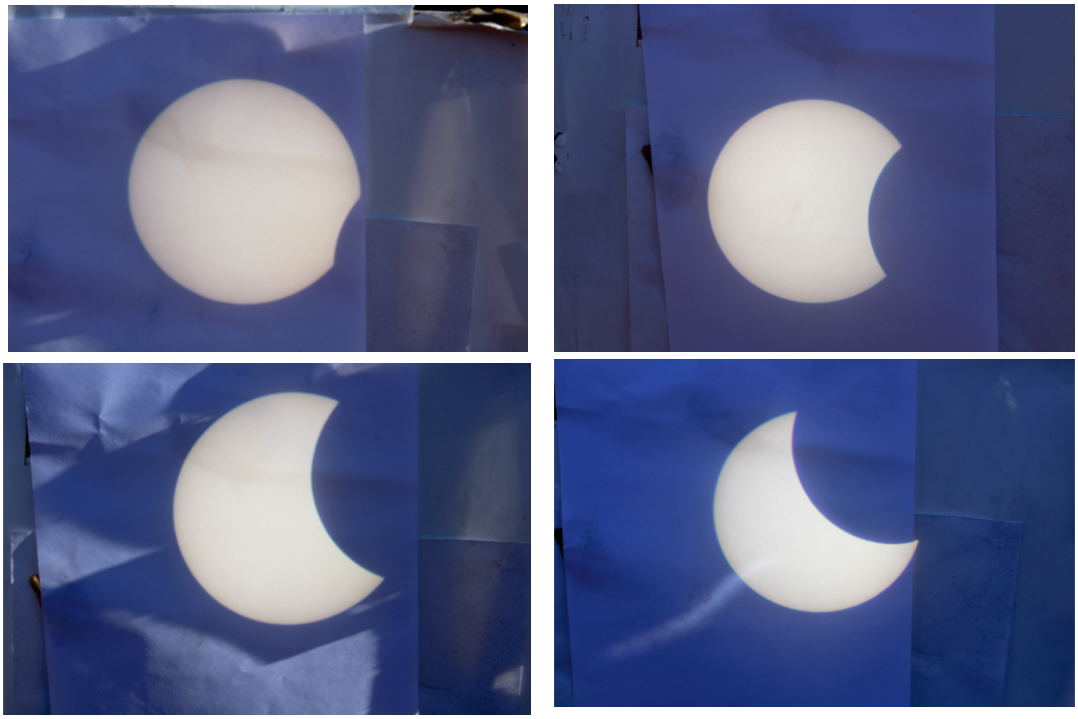


Figure 72. Partial solar eclipse as observed from ARIES on 26th December 2019.

Figure 73. District Magistrate of Nainital along with other delegates visiting the solar facility to observe the event.

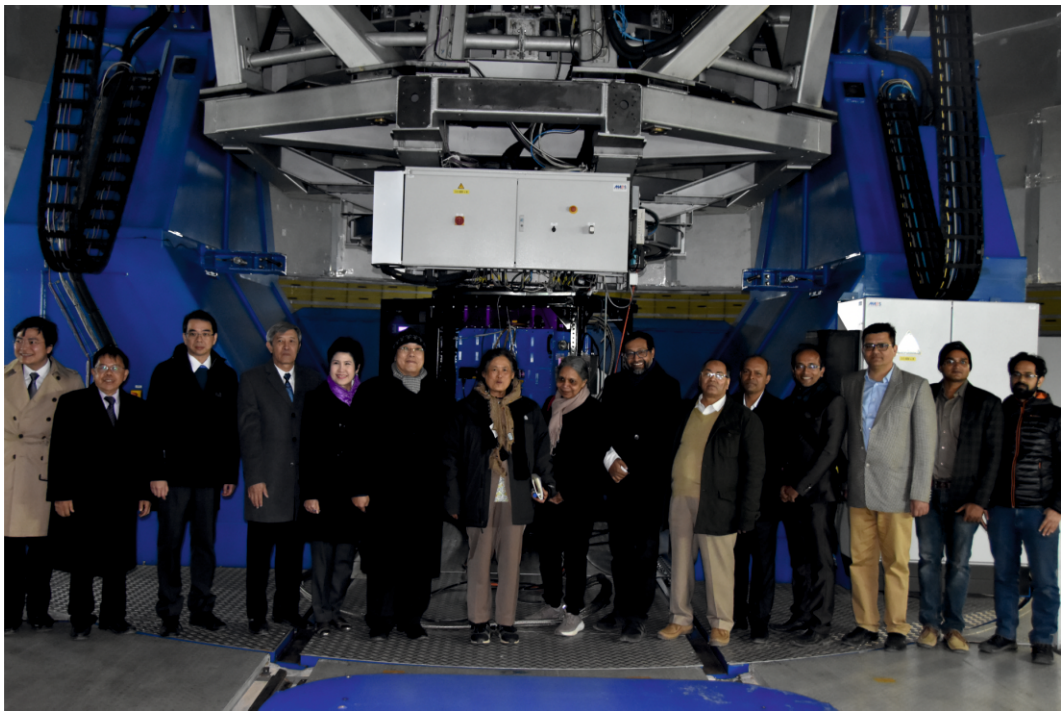


Figure 74. Her royal highness princess Maha Chakri Sirindhron along with thai Ambassador, VIP dignitaries along with Director ARIES and others in the 3.6m Dome.

International Conferences/Workshops

IGAC-MANGO Meeting, Science Workshop, and Training Course

IGAC-MANGO Meeting, Science Workshop, and Training Course was organized by ARIES at Nainital during 28-30 November 2019. Eleven current MANGO committee members, along with twenty-two early career scientists and four invited lectures, from 17 countries (Japan, India, Bangladesh, Singapore, Myanmar, Malaysia, Indonesia, Vietnam, Philippines, Taiwan, Nepal, Sri Lanka, Cambodia, Brunei, Thailand, France, United Kingdom) attend this event. In addition to the meeting, two-day science workshop and training course were organized.

Recent updates and future directions of MANGO including membership, new activities, and funding opportunities were discussed during the one day committee meeting. This was followed by two-day science workshop and training course that included sessions dedicated for science-policy and science communication, as well as a joint MANGO-India scientific session, posters including a 1-mn flash talk, and course for satellite data analysis and low-cost sensors. What is unique about this year's meeting is a video-clip competition by MANGO early career scientists.

The sessions devoted to science-policy and science communication comprise four main components: an invited talk, a panel discussion, a video presentation and a sharing talk on case-study related to science communication. The invited talk entitled "Recurrent Haze in Southern ASEAN: What more can we do to prevent it?" given by Prof. David Koh covered multifaceted elements; it over viewed the recurrent smoke emission from burning peat forest in Southeast Asia, the relevant policies built, the progression and challenges of policy implementation, and evolvement of understandings, as well as technologies of protecting public to minimize exposure to airborne smoke pollutants.

Following the invited talk, a panel discussion was convened where the invited members (Drs. David Koh, Shyam Lal, Candice Lung, MM Sarin, and Hiroshi Tanimoto) shared their individual experiences and insights on the gaps and dos-and-don'ts (for scientists) in effective communication linking science and policies. To provide a balanced view, the panel members encouraged to the early career scientists to concentrate on building solid scientific knowledge and research capabilities. Such endeavor is required to form a solid foundation to contribute to effective science-policy communication during later stages of ones' career development as scientists.

A 20-min video focusing on "What is Science Policy? Why do we want to engage in Science-Policy" made by Drs. Megan Melamed, Erika von Schneidemesser, and Julia Schmale was presented. The session in Science-Policy was concluded by a successful story of how scientific findings led to meaningful policy of protecting the public from being overly exposed to emission of burning incense during religious activities in Taiwan. Dr. Candice Lung detailed local-culture-specific understandings in the mindset of public and policy makers, obstacles encountered and perseverance required to convince policy makers. This was followed with lively Q&A, encouraging all MANGO countries to endeavor dynamic practice.

The MANGO 2019 workshop launched a new initiative on "MANGO Flavored Research-Educational Video Competition". This aims to enhance effective scientific learning & sharing through video literature that demonstrate (a) novel scientific research findings in MANGO region, and/or (b) better explanation & understanding of existing yet challenging scientific concepts related to scope within IGAC. A total of 10 submissions were received and all the MANGO members and invited delegates participated in the viewing and marking of all submitted videos.

Parallel sessions for training course on satellite data handling/visualization and on low cost sensors were also

organized. Dr. Silvia Bucci gave lectures and hands-on training on satellite data retrievals with demonstration of processing GOME-2, Sentinel 5P, and CAMS data. Lectures and hands-on training on low cost sensors were provided on the next day by Drs. Tomoki Nakayama and Iq Mead. "Green-MANGOs" were grouped to perform and present measurements using low-cost sensors at different locations. These sensors were also provided to interested students/scientists for observations in their own countries. As one of the unique events of the workshop was the live onsite launch of ozonesonde and radiosonde by Dr. Manish Naja, a rare experience and highlight of the workshop.

A MANGO-India session on the second day hosted a total of 14 presentations, including two remote presentations, to overview the scientific research carried out in the individual member countries. It has helped in sharing the information on status of air pollution and will contribute in focusing on the themes for future research in Asia. It was reminded that so far, there has been only two major international observational field campaigns (INDOEX and Suskat) in the South Asia. Considering the complexity and intensity of emission sources it is very important to have extensive observations, with open data policy, over this region where Himalayas is on the North and pristine oceanic regions are on the South with a huge human population in between. The event concluded with the distribution of top three posters and top two video clips awards. The meeting was jointly funded by IGAC, NIES, APN and ARIES.

Figure 75. IGAC-MANGO 2019 Participants

Figure 76. Training course, posters and launch of ozonesonde-radiosonde during IGAC-MANGO meeting.

Figure 77. Best posters and video clips awardees during IGAC-MANGO meeting.

Indo-Thai Workshop

ARIES organized a one day Indo-Thai workshop on "Investigating the Stellar Variability and Star Formation" on 02 March 2020.

To setup the cooperation in the fields of Science and Technology, Department of Science and Technology (DST) Government of India and Ministry of Science & Technology of the Kingdom of Thailand sanctioned two joints bilateral programme for the joint research in the area of Astronomy and Astrophysics. The Indian astronomers from Indian Institute of Astrophysics (IIA), Bangalore and ARIES, Nainital in coordination with Thai astronomers from NARIT, Thailand are simulating the research in the area of the space and atmospheric science using the observational facilities available in both the countries.

The main objective behind organizing this one day workshop is strengthen the ongoing collaboration and expand the Indo-Thai cooperation from stellar sources to other areas of astronomy and astrophysics such as extra-galactic astronomy and instrumentation. Such joint ventures help in exchanging the knowledge of the investigators involved in the projects and gives opportunity to train the young researchers as well.

About 60 participants from National Astronomical Research Institute of Thailand (NARIT), Nanjing University China, Indian Institute of Astrophysics (IIA), Kumaun University, Nainital and ARIES, attended this international conference. A total of 14 talks each of 20 min duration were delivered on various topics such as stellar variability, star formation, stellar abundance, transient events and instrumentation by the scientists and students of both the countries. In his welcome address Dr. Santosh Joshi, the convener of the workshop stressed the importance of Indo-Thai collaboration in science and technology and invited the astronomers from India and Thailand for long lived cooperation in space science and instrumentation. Dr. Joshi also presented a glimpse of the ongoing and planned activities under the Indo-Thai collaboration.

The guest speaker Prof. Ram Sagar, the former director of ARIES summarized the importance of bilateral programme supported by the funding agencies of both the countries. The chief guest of the event, Prof. H. C. Chandola, head department of Physics, Kumaun University inaugurated the function and briefed the history of ARIES and NARIT, Thailand and similarity of the Indian and Thai cultures those brings the researchers of both the countries closer. The summary of the workshop and concluding remarks where given by Dr. David Mkrtichian, senior researcher of NARIT, Thailand.

At the end the sponsoring agencies DST, Govt. of India, Ministry of Science & Technology of the Kingdom of Thailand and ARIES were highly acknowledged.

Figure 78. Indo-Thai workshop Participants.

Staff Welfare Measure

Medical Facility:

The institute has its medical reimbursement system through which bills on expenses of both indoor and outdoor treatment for all employees and their dependent family members are reimbursed as per CGHS rates. ARIES has empanelled SAI Hospital, Haldwani (Dist.-Nainital), Brijlal Hospital, Haldwani (Dist. - Nanital) and Krishna Hospital and Research Centre, Haldwani (Dist.-Nainital) on cashless basis through which bills on expenses are reimbursed as per CGHS rates. One doctor is engaged by ARIES who visits the institute twice a week. Facilities like rest bed and pressure machine are readily available in the dispensary.

Canteen Facility:

The institute has a canteen run by ARIES on no loss no benefit basis. In the canteen meals, snacks and beverages are prepared in hygienic condition and are served to employees, students and guests at subsidized rates.

Apart from this, the institute has a departmental store which serves employees and their family members residing in the campus.

Group Insurance:

A Group Insurance Scheme for the employees of the institute is operating in association with the Life Insurance Corporation of India. All the regular employees of the institute are members of the scheme.

Reservation Policy:

The Institute is following post based rosters for affecting the prescribed percentage of reservations to SC/ST/OBC in all its new recruitments as per Government of India rules in this regard.

Official Language Policy:

Proactive efforts are being made to ensure successful implementation of the official language. A nodal officer has been nominated for implementation of official language as per rules and directions issued by Government of India from time to time.

Prevention of Sexual Harassment of Women at Work Place:

Necessary steps and guidlines are laid out in compliance of the instructions on the subject. No complaints have been received during the year.

Implementation of Right to Information Act:

The provisions of RTI Act have been implemented.

Members of ARIES

Academic (20)

Prof. Dipankar Banerjee *(from 12-12-19)*
(Director)

Alok C. Gupta
Amitesh Omar
Brijesh Kumar
D. V. Phanikumar *(till 07-05-19)*
Hum Chand *(till 18-11-19)*
Indranil Chattopadhyay
Jeewan C. Pandey
Kuntal Misra
Manish Naja
Narendra Singh
Neelam Panwar
Ramakant Singh Yadav
Santosh Joshi
Shashi Bhushan Pandey
Saurabh
Snehlata
Umesh C. Dumka
Wahab Uddin
Yogesh C. Joshi

Engineering (12)

Ashish Kumar
B. Krishna Reddy
Chandra Prakash
Jayshreekar Pant
Mohit K. Joshi
Mukeshkumar B. Jaiswar
Nandish Nanjappa
Sanjit Sahu
Samaresh Bhattacharjee
Shobhit Yadava
Tarun Bangia
Tripurari S. Kumar

Administrative and Support (11)

Ravinder Kumar
(Registrar)
Bharat Singh
(Asstt. Registrar)
Abhishek Kumar Sharma
Hansa Karki
Himanshu Vidhyarthi
Mahesh Chandra Pande
Manjay Yadav
Praveen Solanki
Rajeev Kumar Joshi
Rajendra Prasad Joshi
Virendra Kumar Singh

Scientific and Technical (31)

Abhijit Misra
Anant Ram Shukla
Anil Kumar Joshi
Arjun Singh
Ashok Kumar Singh
Babu Ram
Bharat Bhushan *(till 30-06-19)*
C. Arjuna Reddy
Darwan Singh Negi
Girija Nandan Pathak
Harish Chandra Tewari
Hemant Kumar
Javed Alam
Kanhaiya Prasad
Kanti Ram Maithani
Lalit Mohan Dalakoti
Manoj Kumar Mahto
Naveen Chandra Arya
Nitin Pal
Pavan Tiwari
Pradip Chakarborty
Prashant Kumar
Rajdeep Singh
Rajan Pradhan
Rajendra Prasad
Ravindra Kumar Yadav
Sanjay Kumar Singh
Srikant Yadav
Tileshwar Mahto *(till 02-04-19)*
Uday Singh
Vinod Kumar Sah

Laboratory Assistant/Attendants (9)

Ashok
Basant Ballabh Bhatt
Laxman Singh Kanwal
Mohan Singh Rana
Rakesh Kumar
Ramdayal Bhatt
Shyam Giri
Shyam Lal
Suresh Chandra Arya

Post Doctoral Fellows/Research Associate (05)

Manjunath Hegde
Rakesh Majumdar
M. Syed Ibrahim
Pankaj Kushwaha
Srabanti Ballav *(till 16-06-19)*

Research Scholars (46)

Abha Monga *(till 31-07-19)*
Akanksha Rajput
Amit Kumar
Arpan Ghosh
Bharti Arora
Dimple
Jayanand Maurya
Kuldeep Singh
Nitin Vashishtha
Prajjwal Singh Rawat
Rajkishore Joshi
Rakesh Pandey
Sadhana Singh
Shubham Kishore
Vibhore Negi
Vivek Kr. Jha
Aditya Jaiswal
Alaxender Panchal
Anjasha Gangopadhyay
Arvind Kumar
Bhavya
Gurpreet Singh
Jaydeep Singh
Mahendra C. Rajwar
Pankaj Sanwal
Priyanka Jalan
Rahul
Raya Dastidar
Sapna Mishra
Tirthendu Sinha
Vineet Ojha
Aditya Priyadarshi
Amar Aryan
Ankur Ghosh
Ashwini Pandey
Bibhuti Kumar Jha
Gaurav Singh
Krishan Chand
Nikita Rawat
Parveen Kumar
Priyanka Srivastava
Rahul Gupta
Ritesh Patel
Shilpa Sarkar
Tushar Tripathi
Vinit Dhiman

Visits by ARIES Members

International Visits

Ms. Shilpa Sarkar	Platja d'Aro, Girona, Spain	22 – 26 April, 2019
	CEA, Saclay, Paris	28 Apr. – 26 May, 2019
	IAC, Spain	19 – 28 Nov., 2019
Dr. Brijesh Kumar	NARIT, Thailand	05 – 10 May, 2019
	Osterwieck, Germany	06 – 09 Aug., 2019
Dr. Saurabh	NARIT, Thailand	05 – 10 May, 2019
Mr. Gaurav Singh	Bologna, Italy	27 – 31 May, 2019
Dr. Narendra Singh	Hefei, China	24 – 28 June, 2019
Dr. Alok C. Gupta	SAO, Shanghai, China	01 July – 31 Aug., 2019
Dr. Indranil Chattopadhyay	Univ. of Barcelona, Spain	09 – 12 July, 2019
Dr. Wahab Uddin	Osterwieck, Germany	06 – 09 Aug., 2019
Mr. Nandish Nanjappa	Osterwieck, Germany	06 – 09 Aug., 2019
Dr. T. S. Kumar	Osterwieck, Germany	06 – 09 Aug., 2019
Mr. Vivek Kumar Jha	IHEP, Beijing, China	17 – 25 Sept., 2019
Dr. Manish Naja	Mexico	28 - 31 Oct., 2019
	NIES, Japan	01 - 09 Nov., 2019
Dr. Hum Chand	KIAA, China	21 – 25 Oct., 2019
Ms. Priyanka Jalan	Albert Einstein Institute, Hannover, Germany	11 - 13 March 2020
	Univ. of Liege, Belgium	15 - 18 Mar., 2020

National Visits

Dr. Indranil Chattopadhyay	IUCAA, Pune	16-17 April, 2019
	SINP, Kolkata	26 Aug. – 13 Sept., 2019
		06 – 10 Jan., 2020
	ISAC, Bangalore	10 – 13 Nov., 2019
Dr. S. B. Pandey	National Science MUSEUM , Mumbai	07 - 10 May, 2019
	Nehru Planetarium, New Delhi	01- 02 July, 2019
	Dehradun	18 - 20 July, 2019
	Science city, Kolkata	03 - 07 Nov., 2019
	Gurukul Kangri Univ., Haridwar	27 Nov., 2019

	DDU Univ., Gorakhpur	07 - 09 Jan., 2020
		14 - 15 Feb., 2020
	New Delhi	21 Jan., 2020
		05 - 09 Feb., 2020
Dr. Kuntal Misra	ISRO, Bangalore	10 – 13 Nov., 2019
	IISER, Mohali	04 – 07 Feb., 2020
	IISER, Tirupati	14 – 19 Feb., 2020
Dr. Tarun Bangia	IIA, Bangalore	13 – 18 Sept., 2019
	IISER, Tirupati	11 – 19 Feb., 2020
Ms. Shilpa Sarkar	IUCAA, Pune	17 – 20 Apr., 2019
Ms. Priyanka Jalan	IIA, Bangalore	23 – 27 Sept.,2019
Ms. Bharti Arora	IIA, Bangalore	23 – 27 Sept.,2019
	IISER, Tirupati	13 - 17 Feb., 2020
Dr. Saurabh	IUCAA, Pune	21 – 26 Oct., 2019
	DDU Univ., Gorakhpur	21 – 26 Nov., 2019
	IISER, Tirupati	14 – 19 Feb., 2020
Mr. Pradeep Chakroborty	Goa	30 – 31 Dec., 2019
Mr. Gaurav Singh	IIA, Bangalore	31 Dec., 2019–01 Feb., 2020
	TIFR, Mumbai	02 – 08 Feb., 2020
Dr. Yogesh C. Joshi	IIA Bangaluru	19 – 20 Feb., 2020
	TIFR, Mumbai	17 – 21 Dec., 2019
		02 – 08 Feb., 2020
Dr. Santosh Joshi	Delhi Univ., Delhi	04 – 07 Feb., 2020
	BHU, Varanasi	22 – 23 Dec., 2019
	Central Univ., Gaya	24 – 25 Dec., 2019
	HRI, Allahabad	26 – 27 Dec., 2019
Dr. Neelam Panwar	IISER Tirupati	13 - 16 Feb., 2020
	Delhi University	17 - 19 Feb., 2020

Visitors at ARIES

From Abroad

Prof. Jean Surdej	Liegue Univ., Belgium	24 – 29 Apr., 2019
		29 Nov. – 02 Dec., 2019
Mr. Bikram Pradhan	Liegue Univ., Belgium	24 Apr. – 03 May, 2019
		02 – 11 Jan., 2020
Dr. Anupam Bhardwaj	KIAA, Beijing, China	05 - 8 Aug., 2019
Prof. Jurua Edward	Mabarara Univ. S&T, Uganda	10 – 12 July, 2019
Mr. Otto Trust	Mabarara Univ. S&T, Uganda	10 – 12 July, 2019
Dr. Navin Dwivedi	ISRI Graz, Austria	10 – 22 Oct., 2019
Dr. H. Suzuki	Japan	08 Nov., 2019
Prof. Katsuo Ogura	Japan	10 – 12 Nov., 2019
Prof. David Buckley	South Africa	10 - 13 Nov., 2019
Ms. Angel Noel	Krakow, Poland	12 – 26 Jan., 2020
Dr. Mridweka Singh	KASI, South Korea	27 Jan., 2020
		21 Feb. – 14 Mar., 2020
Dr. Ram Kesh Yadav	NARIT, Thailand	19 – 22 Feb, 2020
		26 Feb. – 08 Mar., 2020
Dr. David Mkrtichian	NARIT, Thailand	26 Feb. – 03 Mar., 2020
Dr. Khemsinan Gunsriwiwat	NARIT, Thailand	26 Feb. – 03 Mar., 2020
Prof. Pankaj Kumar	NASA, USA	01 – 07 Mar., 2020
Dr. Ravi Joshi	KIAA, China	03 – 08 Mar., 2020
Dr. Ramkesh Yadav	NARIT, Thailand	18 – 31 Mar., 2020

From other Indian Institutions

Mr. R. K. Sharma	DST, New Delhi	03 – 06 Apr., 2019
Prof. H. Bohidar	JNU, New Delhi	03 – 06 Apr., 2019
Dr. Sujin Jose	MKU, Madurai	03 – 06 Apr., 2019
Prof. S. N. Tiwari	DDU Univ., Gorakhpur	08 – 09 Apr., 2019
Prof. Ashutosh Sharma	DST, New Delhi	19 – 20 Apr., 2019
Mr. B. Anand	DST, New Delhi	19 – 20 Apr., 2019
Prof. S. K. Joshi	NPL, New Delhi	19 – 21 Apr., 2019
Prof. Avinash C. Pandey	IUAC, New Delhi	19 – 21 Apr., 2019

Prof. Sibaji Raha	Bose Institute, Kolkata	19 – 21 Apr., 2019
Prof. P. C. Agrawal	Univ. of Mumbai, Mumbai	19 – 21 Apr., 2019
		15 – 18 Mar., 2020
Prof. V. P. N. Nampoori	Cochin Univ. of S & T, Cochin	19 – 21 Apr., 2019
Ms. Gulapsha Choudhary	Assam Univ., Silchar	07 – 09 May, 2019
		19 – 21 Jan., 2020
Ms. Ayesha M. Mazumdar	Assam Univ., Silchar	07 – 09 May, 2019
Mr. Tanuj Kr. Dhar	Assam Univ., Silchar	07 – 09 May, 2019
		19 – 21 Jan., 2020
Prof. S. Ananthakrishnan	Pune Univ., Pune	14 – 17 May, 2019
		15 – 17 Marc., 2020
Prof. N. K. More	BBA Univ., Lucknow	21 – 23 May, 2019
Ms. Apara Tripathi	DDU Univ., Gorakhpur	23 May – 10 June, 2019
Dr. Abhay Pratap Yada	Govt. Model College, MP	31 May – 12 June, 2019
Mr. Ramesh V. Swami	NCRA, GMRT, Pune	10 – 13 June, 2019
Dr. Amitava Guharay	PRL, Ahmedabad	31 July – 03 Aug., 2019
Dr. Anupam Bhardwaj	New Delhi	04 – 08 Aug., 2019
Prof. S. N. Tandon	IUCAA, Pune	13 – 14 Oct., 2019
		01 – 04 Mar., 2020
Mr. Amit Kr. Singh	DDU Univ., Gorakhpur	15 – 21 Oct., 2019
Mr. Vaibhav Pandey	DDU Univ., Gorakhpur	15 – 21 Oct., 2019
Mr. Vishnu Patel	DDU Univ., Gorakhpur	15 – 21 Oct., 2019
Mr. T. K. Sahu	DDU Univ., Gorakhpur	15 – 21 Oct., 2019
Prof. Nand Kr. Chakradhari	Pt. R. S. Univ., Raipur	16 – 20 Oct., 2019
Mr. C. Dewangan	Pt. R. S. Univ., Raipur	16 – 20 Oct., 2019
Mr. C. Chandravanshi	Pt. R. S. Univ., Raipur	16 – 20 Oct., 2019
Ms. Shrutika Tiwari	Pt. R. S. Univ., Raipur	16 – 20 Oct., 2019
Prof. Umesh Yadav	DDU Univ., Gorakhpur	16 – 20 Oct., 2019
Prof. V. P. Srivastava	St. Andrew College, Gorakhpur	16 – 20 Oct., 2019
Prof. Pankaj Jain	IIT, Kanpur	17 – 20 Oct., 2019
Prof. S. N. Tiwari	DDU Univ., Gorakhpur	18 – 20 Oct., 2019
Prof. Abhijit Chakraborty	PRL, Ahmedabad	19 – 20 Oct., 2019
		17 – 19 Nov., 2019
Dr. Neelam Prasad	PRL, Ahmedabad	20 Oct., 2019

Prof. R. K. Tiwari	DDU Univ., Gorakhpur	20 Oct., 2019
Mr. Shyam Sarkar	ICSP, Kolkata	21 Oct., 2019
Mr. Pabitra Sil	ICSP, Kolkata	21 Oct., 2019
Mr. Ashima Sarkar	ICSP, Kolkata	21 Oct., 2019
		07 – 13 Jan., 2020
Prof. M. P. Rao	SAC, Ahmedabad	17 – 19 Nov., 2019
Prof. K. Nageswara Rao	SAC, Ahmedabad	17 – 19 Nov., 2019
Mr. Abhishek Yadav	IIRS, ISRO, Dehradun	18 – 19 Nov., 2019
Dr. R. Majumdar	NRSC, Hyderabad	21 – 22 Nov., 2019
Dr. Brajesh Kumar	IIA, Bangalore	20 – 23 Nov., 2019
		02 – 05 Mar., 2020
Mr. Arnab Mondal	NPL, New Delhi	27 Nov., 2019
Ms. Subhasmita Pande	CSIR-IIMT, Bhubaneswar	27 Nov., 2019
Ms. Arshini Saikia	Dibrugarh Univ., Assam	27 Nov., 2019
Ms. Sonal Kumari	Dayalbagh Edu. Inst., Agra	27 – 29 Nov., 2019
Mr. Yesobu Yarragunta	IIRS, Dehradun	28 Nov., 2019
Mr. Harshit Sah	TIFR, Mumbai	06 – 07 Dec., 2019
Mr. Rahul Arya	NPL, New Delhi	08 – 10 Dec., 2019
Mr. Supriyo Ghosh	TIFR, Mumbai	14 Dec., 2019
Mr. Dilip Kumar	IIIT, Allahabad	17 – 20 Dec., 2019
Mr. Soujan Ghosh	Kolkata	22 – 29 Dec., 2019
Dr. Main Pal	CTP, New Delhi	30 Dec., 2019 – 04 Jan., 2020
Dr. Pradeep Kr. Thapliyal	SAC, Ahmedabad	30 – 31 Dec., 2019
Dr. Hum Chand	CUHP, Shimla	23 Dec., 2019 – 11 Jan., 2020
Mr. Dipankar Paul	Assam Univ., Silchar	19 – 21 Jan., 2020
Mr. Rakesh Mazumdar	West Bengal	19 – 22 Feb., 2020
Dr. Bhuwan Joshi	Udaipur Univ., Udaipur	20 – 24 Feb., 2020
Mr. Partha P. Goswami	IIA, Bangalore	26 Feb. – 03 Mar., 2020
Prof. Aruna Goswami	IIA, Bangalore	26 Feb. – 03 Mar., 2020
Dr. D. V. Phanikumar	DST, New Delhi	10 – 11 Mar., 2020
Prof. A. K. Gwal	Rabindranath Tagore Univ., Bhopal	14 – 15 Mar., 2020
Prof. Anil Bhardwaj	PRL, Ahmedabad	15 – 16 Mar., 2020
Prof. R. K. Tayal	DST, New Delhi	15 – 16 Mar., 2020

Abbreviations

AC	Academic Committee
ADFOSC	ARIES Devasthal Faint Object Spectrograph & Camera
ADOT	Astronomer In-charge, Devasthal Optical Telescope
AFP	Axial Fixed Points
AGN	Active Galactic Nuclei
AIMPOL	ARIES Imaging Polarimeter
AMOS	Advanced Mechanical and Optical Systems
AOD	Aerosol Optical Depth
ASTRAD	ARIES Stratosphere Troposphere Radar
ATSOA	ARIES Training School in Observational Astronomy
BC	Black Carbon
BrC	Brown Carbon
BSNL	Bharat Sanchar Nigam Limited
CCD	Charged Coupled Device
CCTV	Closed-Circuit Television
CNC	Computerized Numerical Control
DFOT	Devasthal Fast Optical Telescope
DHCP	Dynamic Host Configuration Protocol
DIMM	Differential Image Motion Monitor
DOMC	Devasthal Operation and Maintenance Committee
DOT	Devasthal Optical Telescope
DSLAM	Digital Subscriber Line Access Multiplexer
DTAC	DOT Time Allotment Committee
ESD	Electrostatic Discharge

GATE	Graduate Aptitude Test in Engineering
GMRT	Giant Metrewave Radio Telescope
GPS	Global Positioning System
GRB	Gamma Ray Burst
IGP	Indo-Gangetic Plains
IIA	Indian Institute of Astrophysics
IIT	Indian Institute of Technology
ILMT	International Liquid Mirror Telescope
JEST	Joint Entrance Screening Test
JRF	Junior Research Fellow
KRC	Knowledge Resource Centre
LAN	Local Area Network
LMC	Large Magellanic Cloud
NET	National Eligibility Test
NIC	National Informatics Centre
MKIR	Mauna Kea Infrared
NKN	National Knowledge Network
NuSTAR	Nuclear Spectroscopic Telescope Array
OACD	Operational Advisory Committee for Devasthal
OPAC	Online Public Access Catalogue
PLC	Programmable Logic Controller
PMS	Pre-Main-Sequence
QPO	Quasi-Periodic Oscillation
SAC	Scientific Advisory Committee
SCADA	Supervisory Control and Data Acquisition

SED	Spectral Energy Distribution
SN	Supernova
SRF	Senior Research Fellow
ST	Stratosphere Troposphere (Atmospheric Facility)
ST	Sampurnanand Telescope (Astronomical Facility)
TANSPEC	TIFR-ARIES Near Infrared Spectrometer
TCS	Telescope Control System
TIFR	Tata Institute of Fundamental Research
TIRCAM2	TIFR Near Infrared Imaging Camera – II
TMT	Thirty Meter Telescope
TRM	Transmitting and Receiving Module
TRMM	Tropical Rainfall Measuring Mission
UPS	Uninterruptible Power Supply
UV	Ultraviolet
VHE	Very High-Energy
VOC	Volatile Organic Compound
WAN	Wide Area Network
WFS	Wave Front Sensor
WG	Working Group
WWZ	Weighted Wavelet Z-transform
XMM	X-ray Multi-Mirror Mission
YSO	Young Stellar Object

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENES, (ARIES)

MANORA PEAK,
NAINITAL – 263001 (UTTARAKHAND)

AUDITED FINANCIAL STATEMENTS

2019 – 2020

Audited By:
CA. Mukesh Goel, FCA
MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS
"JHURMUT", POLYSHEET, NAINITAL ROAD
HALDWANI – 263 126
(DISTT- NAINITAL, UTTARAKHAND)

PH: 05946-298920, 9719406671
E-MAIL: mukeshgoel3691@gmail.com

MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS
[CAG Empanelment No – CR2168]

POLYSHEET, NAINITAL ROAD
HALDWANI – 263126 (UK)
PH: (05946) 298920, 9719406671
Email: mukeshgoel3691@gmail.com

INDEPENDENT ADUITOR'S REPORT
FINANCIAL YEAR - 2019-2020

To,
THE REGISRAR,
ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES),
UNDER THE DEPARTMENT OF SCIENCE & TECHNOLOGY (DST),
GOVERNMENT OF INDIA,
MANORA PEAK,
NAINITAL – 263001
[District – Nainital, Uttarakhand]

Dated: September 07, 2020

Report on the Audit of the Financial Statements

Opinion:

We have audited the accompanying Financial Statements of **"ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES), NAINITAL, ("The Institute"),** which comprise the Balance Sheet as at **March 31, 2020**, the Statement of Income & Expenditure and the Statement of Receipt & Payment for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, and to the best of our information and according to the explanations given to us the accompanying financial statements, prepared in all material respects in accordance with the Rules & Regulations of the ARIES duly approved by Department of Science & Technology, Government of India, give a true and fair view of the financial position of the Institute as at March 31, 2020 and its financial performance for the year then ended in accordance with the accounting standards issued by the Institute of Chartered Accountants of India (ICAI).

Basis for Opinion:

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those Standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Institute in accordance with the ethical requirements that are relevant to our audit of the financial statements and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion on the financial statements.

Continued to page -2-

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

Key Audit Matters:

Key Audit Matters are those matters that, in our professional judgment, were of most significance in our audit of the financial statements of the Institute for the year ended March 31, 2020. These matters were addressed in the context of our audit of the financial statements as a whole, and in forming our opinion thereon, and we do not provide a separate opinion on these matters.

We have determined the matters described below to be the Key Audit Matters to be communicated in our report. We have fulfilled the responsibilities described Auditor's Responsibilities for the Audit of the Financial Statements section of our report, including in relation to these matters. Accordingly, our audit included the performance of procedures designed to respond to our assessment of the risks of material misstatement of the financial statements. The results of our audit procedures, including the procedures performed to address the matters below, provide the basis for our audit opinion on the accompanying financial statements.

a) The Institute, though covered u/s 51 of the CGST Act, related to TDS under GST, has not get it registered under the said section of the said Act and thus has not deducted tax as required by the said Act with effect from October 01, 2018. The Institute may be held responsible for non-compliance of GST Laws resulting contingent liability of the Institute in future.

(b) During the year under audit some accounts are written-off and / or adjusted to overcome the previous year's irregularities after management's approval on our suggestions given to them along with our detailed letter of audit findings.

The effects of these written-offs and / or adjustments in the financial statements of the Institute for the FY-2019-20 are as under:-

➢ Reserves & Surplus (Capital) (Cr.)	Rs. 16,376,621.46
➢ Prior Period Expenses (Cr.)	Rs. 321,446.21
➢ Fixed Assets (Dr.)	Rs. 1,864,642.00
➢ GPF Reserves & Surplus (Dr.)	Rs. 954,355.00

(c) The Institute's management did not verify its fixed assets physically as on March 31, 2020 due to "Covid-19" pandemic.

Our opinion is not modified in respect of these matters.

Continued to page -3-

MUKESH GOEL & CO. * Chartered Accountants * HARDWANI M.9[illegible]406671

Responsibilities of Management for the Financial Statements:

The Institute's Management is responsible for the preparation and fair presentation of these financial statements that give a true and fair view of the financial position and financial performance of the Institute in accordance with the accounting principles generally accepted in India and the provisions of Rules & Regulations of the ARIES duly approved by Department of Science & Technology, Government of India.

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

The management is also responsible for overseeing the Institute's financial reporting process.

Auditor's Responsibilities 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 SAs 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.

As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional skepticism throughout the audit.

We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

Continued to page -4-

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.9719406671

- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Institute's internal control.

- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.

- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Institute's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Institute to cease to continue as a going concern.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence and where applicable, related safeguards.

From the matters communicated with those charged with governance, we determine those matters that were of most significance in the audit of the financial statements for the financial year ended March 31, 2020 and are therefore the Key Audit Matters. We describe these matters in our Auditor's Report unless law or regulation precludes public disclosure of these matters.

Other Matter:

Attention is drawn to the fact that the corresponding figures for the year ended March 31, 2019 are based on the previously issued financial statements of the Institute that were audited by the predecessor auditor who expressed an unmodified opinion on those financial statements on September 30, 2019.

Our opinion is not modified in respect of these matters.

Continued to page -5-

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.9719406671

Report on Other Regulatory Requirements:

Further, we report that:-

a) We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit subject to management representation letter;

b) In our opinion, proper books of account have been kept by the Institute so far as it appears from our examination of those books subject to management representation letter; and

c) The Institute's Balance Sheet, the Statement of Income and Expenditure, and the Statement of Receipt & Payment dealt with by this Report are in agreement with the books of account, subject to management representation letter.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]
UDIN: 20073335AAAABD2985

PLACE: HALDWANI
DATED: September 07, 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

BALANCE SHEET AS AT 31st MARCH 2020

(Amount in "Rupees")

S. NO	PARTICULARS	Schedule	Current Year For the year ended 31st March 2020	Previous Year For the year ended 31st March 2019
	CORPUS/ CAPITAL FUND AND LIABILITIES			
1	CORPUS/ CAPITAL FUND	1	1,315,894,823.10	1,429,664,941.62
2	RESERVES AND SURPLUS	2	16,376,621.46	-
3	EARMARKED/ ENDOWMENT FUNDS	3	112,467,190.06	107,581,313.06
4	SECURED LOANS AND BORROWINGS	4	-	-
5	UNSECURED LOANS AND BORROWINGS	5	-	-
6	DEFERRED CREDIT LIABILITIES	6	-	-
7	CURENT LIABILITIES AND PROVISIONS	7	4,392,869.00	38,225,602.28
	TOTAL LIABILITIES		1,449,131,503.62	1,575,471,856.96
	ASSETS			
8	FIXED ASSETS	8	1,187,933,893.70	1,313,424,884.70
9	INVESTMENTS - FROM ENDOWMENT FUNDS	9	28,883,832.00	99,001,664.00
10	INVESTMENTS - OTHERS	10	7,641,349.00	18,564,224.00
11	CURRENT ASSETS, LOANS, ADVANCES ETS.	11	224,672,428.92	144,481,084.26
12	MISCELLANEOUS EXPENDITURE (to the extent not written off or adjusted)		-	-
	TOTAL ASSETS		1,449,131,503.62	1,575,471,856.96
13	SIGNIFICANT ACCOUNTING POLICIES	24		
14	CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our separate Audit Report of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

STATEMENT OF INCOME AND EXPENDITURE FOR THE YEAR ENDED 31st MARCH 2020

(Amount in "Rupees")

S. NO	PARTICULARS	SCH	Current Year For the year ended 31st March 2020	Previous Year For the year ended 31st March 2019
	(A) INCOMES:			
1	Income from Sales/Services	12	-	-
2	Grants/Subsidies	13	185,072,000.00	175,953,000.00
3	Project Grants	13A	6,761,269.00	-
4	Fees/Subscriptions	14	-	-
5	Income from Investments	15	5,124,610.00	-
6	Income from Royalty, Publication etc.	16	-	-
7	Interest Earned	17	5,154,220.54	7,765,333.96
8	Other Income	18	1,993,058.00	1,838,449.28
9	Increase/(decrese) in stock of Finished goods and works-in-progress	19	(721,037.47)	(897,870.34)
	TOTAL (A)		203,384,120.07	184,658,912.90
	(B) EXPENDITURES:			
10	Establishment Expenses	20	122,630,161.00	111,184,089.30
11	Other Administrative Expenses etc.	21	61,680,440.87	60,232,894.31
12	Expenditure on Projects	22	8,688,228.50	7,053,843.96
13	Interest	23	5,146,468.00	-
14	Depreciation (corresponding to Sch 8)		176,701,494.00	180,924,892.26
	TOTAL (B)		374,846,792.37	359,395,719.83
	Balance being excess of Income / (Expenditure) (A - B)		(171,462,672.30)	(174,736,806.93)
15	Prior Period Income / (Expenses)	21A	(321,446.22)	4,931,617.00
16	Transfer to Special Reserve (Specify each)		-	-
17	Transfer to / from General Reserve		-	-
	BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		(171,784,118.52)	(169,805,189.93)
18	SIGNIFICANT ACCOUNTING POLICIES	24		
19	CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our separate Audit Report of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 1 - CORPUS/CAPITAL FUND		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Balance as at the beginning of the year	1,429,664,941.62	1,566,353,017.55
2	Add : Contributions towards Corpus/Capital Fund	58,014,000.00	32,008,000.00
3	Add / (Deduct) : Balance of net Income / -(Expenditure) transferred from the Income and Expenditure Account	(171,784,118.52)	(169,805,189.93)
4	Add / (Deduct) : Unspent Grant	-	1,109,114.00
	BALANCE AS AT THE YEAR - END	1,315,894,823.10	1,429,664,941.62

	SCHEDULE 2 - RESERVES AND SURPLUS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Capital Reserve :		
	As per last Account	-	-
	Addition / (Dedutions) during the year	-	-
2	Revaluation Reserve :		
	As per last Account	-	-
	Addition / (Dedutions) during the year	-	-
3	Special Reserves :		
	As per last Account	-	-
	Addition / (Dedutions) during the year	-	-
4	General Reserve :		
	As per last Account	-	-
	Addition / (Dedutions) during the year	16,376,621.46	-
	TOTAL	16,376,621.46	-

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS					(Amount in Rupees)	
S.NO	PARTICUALRS	Fund Wise Breakup				Current Year Total	Previous Year Total
						For the year ended 31st March 2020	For the year ended 31st March 2019
		GPF Fund	GPF Reserve	Pension Fund	Pension Reserve	(Credit)	(Credit)
A	Opening Balance of Funds	34113425.00	5,833,773.56	44236446.56	23397667.94	107581313.06	143236942.74
	Total (A)	34113425.00	5833773.56	44236446.56	23397667.94	107581313.06	143236942.74
B	Additions :						
	a) Employee's Contributions	6642675.00	-	-	-	6642675.00	8387325.00
	b) Interest Accrued	2890006.00	-	-	-	2890006.00	-
	c) Recoveries of Advances	269150.00	-	-	-	269150.00	313775.00
	d) Transferred from Reserve	954,355.00	-	-	-	-	-
	e) Interest Contribution	-	-	-	-	-	4465850.00
	f) Endowment Surplus	-	-	-	-	-	8477375.78
	g) Pension Payable	-	-	-	-	-	1418396.00
	TOTAL (B)	10756186.00	0.00	0.00	0.00	9801831.00	23062721.78
C	Utilisation/Expenditure :						
	a) Capital Expenditures	-		-	-	-	-
	Transferred to GPF Fund	-	954,355.00	-	-	-	5,833,773.56
	b) Revenue Expenditures	-	-	-	-	-	-
	-Permanent Withdrawls	2340000.00	-	-	-	2340000.00	1535000.00
	-Recoverable Advances	36600.00	-	-	-	36600.00	-
	-Retirement Payment	621858.00	-	-	-	621858.00	14514177.00
	-Advances of Previous yrs	499100.00	-	-	-	499100.00	-
	-Pension Paid	-	-	-	1418396.00	1418396.00	36835400.90
	TOTAL (C)	3497558.00	954355.00	0.00	1418396.00	4915954.00	58718351.46
	NET BALANCE [A + B - C]	41372053.00	4879418.56	44236446.56	21979271.94	112467190.06	107581313.06

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 4 - SECURED LOANS AND BORROWINGS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Central Government	-	-
2	State Government	-	-
3	Financial Institutions		
	a) Term Loans	-	-
	b) Interest accrued and due	-	-
4	Banks:		
	a) Term Loans	-	-
	Interest accrued and due	-	-
	b) Other Loans	-	-
	Interest accrued and due	-	-
5	Other Institutions and Agencies	-	-
6	Debentures and Bonds	-	-
7	Others	-	-
	TOTAL	-	-

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

PLACE : HALDWANI
DATED : 7th September 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 5 - UNSECURED LOANS AND BORROWINGS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Central Government	-	-
2	State Government (Specify)	-	-
3	Financial Institutions	-	-
4	Banks:		
	a) Term Loans	-	-
	b) Other Loans (specify)	-	-
5	Other Institutions and Agencies	-	-
6	Debentures and Bonds	-	-
7	Fixed Deposits	-	-
8	Others (Specify)	-	-
	TOTAL	-	-

	SCHEDULE 6 - DEFERRED CREDIT LIABILITIES		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Acceptances secured by hypothecation of Capital Equipments and other assets	-	-
2	Others	-	-
	TOTAL	-	-

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR)

(DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
		(Credit)	(Credit)	(Credit)	(Credit)
	A. CURRENT LIABILITIES				
1	Acceptances		-		-
2	Sundry Creditors *		1,687,429.00		4,541,991.00
3	Advances Received - Scientific Meeting		6,676.00		113,000.00
4	Interest accrued but not due on:				
	a) Secured Loans /borrowings	-		-	
	b) Unsecured Loans/borrowings	-	-	-	-
5	Statutory Liabilities:				
	a) GST Reverse Charge	-		317,070.00	
	b) Service Tax (2015-16)	-		3,410.00	
	c) NPS (Employee's Contribution)	23,853.00		431,822.00	
	d) NPS (Employer's Contribution)	-		426,915.00	
	e) NPS of R.Kumar (Employee Contb)	402,491.00		262,741.00	
	f) NPS of R.Kumar (Employer Contb)	402,491.00	828,835.00	-	1,441,958.00
6	Other Curent Liabilities				
	a) Earnest Money Deposits	323,115.00		2,051,674.00	
	b) Performance Security Deposits	1,336,807.00		3,177,094.00	
	c) Other Securities	-		87,921.00	
	d) TDS Payable *	195,061.00		931,146.28	
	e) Leave Encashment - Satish Kumar	14,946.00		14,946.00	
	f) Misc. Project Grant	-		19,451,116.00	
	g) Outstanding Expenses	-		6,338,307.00	
	h) DDO DST	-		76,163.00	
	i) ASTROSAT Workshop - IUCAA	-		8,286.00	
	j) Faulad Construction	-		20,000.00	
	k) INDO-UK Seminar (DST)	-	1,869,929.00	(28,000.00)	32,128,653.28
	TOTAL (A)		4,392,869.00		38,225,602.28
	B. PROVISIONS :				
1	Taxation		-		-
2	Gratuity		-		-
3	Accumulated Leave Encashment		-		-
4	Others (Specify)		-		-
	TOTAL (B)		-		-
	TOTAL (A+B)		4,392,869.00		38,225,602.28

* Separate List Attached.

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)

MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

SCHEDULE 8 - FIXED ASSETS

(Amount in Rupees)

S.NO.	DESCRIPTION	Rate	GROSS BLOCK					DEPRECIATION				NET BLOCK	
			Cost/valuation As at beginning of the year (01.04.2019)	Additions During the Year (> 180 days)	Additions During the Year (< 180 days)	Deductions / W-off during the year	Cost/valuation at the year end (31.03.2020)	As at the beginning of the year (01.04.2019)	On [Op. WDV + Additions (> 180 days) - Deductions]	On Additions During the Year (< 180 days)	Total Depreciation up to the year end (31.03.2020)	As at the Current Year end (31.03.2020)	As at the Previous Year end (31.03.2019)
1	FIXED ASSETS:												
A	LAND:	0%											
	LAND		105,850,429.00	-	-	-	105,850,429.00	-	-	-	-	105,850,429.00	105,850,429.00
	TOTAL (A)		105,850,429.00	-	-	-	105,850,429.00	-	-	-	-	105,850,429.00	105,850,429.00
B	BUILDINGS & INFRASTRUCTURES	10%											
	Building 3.60 Telescope		34,428,379.00	12,090.00	161,400.00	-	34,601,869.00	12,034,879.13	2,240,559.00	8,070.00	14,283,508.13	20,318,360.87	22,393,499.87
	Building Non-Res (Devsthal)		8,801,426.00	16,625,700.00	3,099,938.00	-	28,527,064.00	5,450,305.63	1,997,682.00	154,997.00	7,602,984.63	20,924,079.37	3,351,120.37
	Building Non-Res (Manora Peak)		107,627,691.00	-	-	-	107,627,691.00	69,245,491.43	3,838,220.00	-	73,083,711.43	34,543,979.57	38,382,199.57
	Infrastructure Dev. (Dev Sthal)		50,072,786.90	-	-	-	50,072,786.90	19,414,159.29	3,065,863.00	-	22,480,022.29	27,592,764.61	30,658,627.61
	Infrastructure Dev. (Manora Peak)		16,070,946.70	-	-	-	16,070,946.70	7,556,326.60	851,462.00	-	8,407,788.60	7,663,158.10	8,514,620.11
	Roads at Devsthal		22,849,164.00	-	-	-	22,849,164.00	13,080,900.09	976,826.00	-	14,057,726.09	8,791,437.91	9,768,263.92
	TOTAL (B)		239,850,393.60	16,637,790.00	3,261,338.00	-	259,749,521.60	126,782,062.17	12,970,612.00	163,067.00	139,915,741.17	119,833,780.43	113,068,331.45
C	Buildings - Residential	5%											
	Guest House (Devsthal)		1,224,022.00	-	-	-	1,224,022.00	535,790.35	34,412.00	-	570,202.35	653,819.65	688,231.65
	Building Residential (Manora Peak)		30,719,204.60	-	-	-	30,719,204.60	8,783,353.33	1,096,793.00	-	9,880,146.33	20,839,058.27	21,935,851.27
	TOTAL (C)		31,943,226.60	-	-	-	31,943,226.60	9,319,143.68	1,131,205.00	-	10,450,348.68	21,492,877.92	22,624,082.92
D	VEHICLES	15%											
	Vehicle		4,303,716.10	-	-	-	4,303,716.10	2,320,657.03	297,459.00	-	2,618,116.03	1,685,600.07	1,983,059.07
	TOTAL (D)		4,303,716.10	-	-	-	4,303,716.10	2,320,657.03	297,459.00	-	2,618,116.03	1,685,600.07	1,983,059.07
E	FURNITURE AND FIXTURES	10%											
	Furniture & Fixture		9,743,636.70	-	-	-	9,743,636.70	5,691,202.50	405,243.00	-	6,096,445.50	3,647,191.20	4,052,434.20
	TOTAL (E)		9,743,636.70	-	-	-	9,743,636.70	5,691,202.50	405,243.00	-	6,096,445.50	3,647,191.20	4,052,434.20
F	OFFICE EQUIPMENTS	10%											
	Office Equipment		1,729,983.25	-	-	-	1,729,983.25	1,195,824.46	53,416.00	-	1,249,240.46	480,742.79	534,158.79
	TOTAL (F)		1,729,983.25	-	-	-	1,729,983.25	1,195,824.46	53,416.00	-	1,249,240.46	480,742.79	534,158.79
G	COMPUTER/PERIPHERALS	40%											
	Computer & Peripherals		45,247,039.40	239,283.00	1,058,183.00	-	46,544,505.40	39,707,668.12	2,311,462.00	211,636.00	42,230,766.12	4,313,739.28	5,539,372.07
	Computer Software		1,702,794.00	36,299.00	1,425,026.00	-	3,164,119.00	1,461,707.04	110,955.00	285,005.00	1,857,667.04	1,306,451.96	241,086.96
	TOTAL (G)		46,949,833.40	275,582.00	2,483,209.00	-	49,708,624.40	41,169,375.16	2,422,417.00	496,641.00	44,088,433.16	5,620,191.24	5,780,459.03
H	ELECTRIC INSTALLATIONS	15%											
	Electrical (Non-Consumable)		-	1,485,193.00	2,174,056.00	-	3,659,249.00	-	222,779.00	163,054.00	385,833.00	3,273,416.00	-
	Electric Instalation (Devasthal)		4,235,665.00	117,600.00	-	-	4,353,265.00	2,393,943.94	293,898.00	-	2,687,841.94	1,665,423.06	1,841,721.06
	Electric Instalation (Manora Peak)		14,983,909.72	-	-	-	14,983,909.72	4,632,239.93	1,552,750.00	-	6,184,989.93	8,798,919.79	10,351,669.79
	Electronic Section		9,061,449.55	104,790.00	-	-	9,166,239.55	7,830,058.80	200,427.00	-	8,030,485.80	1,135,753.75	1,231,390.75
	Electronic Substation-DOT 3.6 Mt		-	3,938,840.00	-	-	3,938,840.00	-	590,826.00	-	590,826.00	3,348,014.00	-
	Solar Section		8,227.00	-	-	1,846.21	6,380.79	6,380.79	-	-	6,380.79	-	1,846.21
	TOTAL (H)		28,289,251.27	5,646,423.00	2,174,056.00	1,846.21	36,107,884.06	14,862,623.46	2,860,680.00	163,054.00	17,886,357.46	18,221,526.60	13,426,627.81
I	LIBRARY BOOKS	40%											
	Library Books		55,945,384.50	819,682.00	2,923,675.00	-	59,688,741.50	51,556,391.00	2,083,470.00	784,735.00	54,424,596.00	5,264,145.50	4,388,993.50
	TOTAL (I)		55,945,384.50	819,682.00	2,923,675.00	-	59,688,741.50	51,556,391.00	2,083,470.00	784,735.00	54,424,596.00	5,264,145.50	4,388,993.50

MUKESH GOYAL & CO. ★ Chartered Accountants ★ HALDWANI M.9719406671

Continued to page - 2-

S.NO.	DESCRIPTION	Rate	GROSS BLOCK					DEPRECIATION				NET BLOCK	
			Cost/valuation As	Additions During	Additions	Deductions	Cost/valuation at	As at the	On [Op. WDV +	On Additions	Total	As at the Current	As at the Previous
J	PLANT MACHINERY & EQUIPMENT	15%											
	Telescope - DOT 3.6 Mt		1,246,396,920.00	-	-	-	1,246,396,920.00	477,174,799.82	115,383,318.00	-	592,558,117.82	653,838,802.18	769,222,120.18
	Telescope - 1.3 Mt		92,252,249.00	-	-	-	92,252,249.00	59,332,558.47	4,937,954.00	-	64,270,512.47	27,981,736.53	32,919,690.53
	Telescope		7,454,695.55	-	8,582,071.00	-	16,036,766.55	3,376,920.83	611,667.00	643,655.00	4,632,242.83	11,404,523.72	4,077,774.72
	Backend Instrument - Moderenization		68,182,741.00	85,626,304.00	10,366,668.00	-	164,175,713.00	38,990,186.76	17,222,829.00	777,500.00	56,990,515.76	107,185,197.24	29,192,554.24
	Backend Instrumemt - ADFOSC		3,621,201.00	-	-	-	3,621,201.00	2,326,869.59	194,150.00	-	2,521,019.59	1,100,181.41	1,294,331.41
	Instruments		108,625,443.67	-	-	-	108,625,443.67	71,027,695.83	5,639,662.00	-	76,667,357.83	31,958,085.84	37,597,747.84
	Aluminization Plant (Devsthal)		39,523,736.00	-	-	-	39,523,736.00	15,251,221.63	3,640,877.00	-	18,892,098.63	20,631,637.37	24,272,514.37
	LIDAR Project		8,760,465.00	-	-	-	8,760,465.00	6,819,133.50	291,200.00	-	7,110,333.50	1,650,131.50	1,941,331.50
	Optics		454,597.80	-	-	-	454,597.80	55,602.79	59,849.00	-	115,451.79	339,146.01	398,995.00
	Telecscope (Schmidt)		10,738,623.00	-	-	-	10,738,623.00	8,589,753.10	322,330.00	-	8,912,083.10	1,826,539.90	2,148,869.89
	Planetarium (Public Outreach)		3,918,714.00	-	-	-	3,918,714.00	2,440,772.91	221,691.00	-	2,662,463.91	1,256,250.09	1,477,941.08
	Projector (Public Outreach)		105,000.00	-	-	-	105,000.00	73,863.95	4,670.00	-	78,533.95	26,466.05	31,136.05
	Spectrometer		1,062,951.00	-	-	-	1,062,951.00	352,567.56	106,558.00	-	459,125.56	603,825.44	710,383.44
	Telescope (Public Out Reach)		607,295.00	-	-	-	607,295.00	441,812.79	24,822.00	-	466,634.79	140,660.21	165,482.21
	Telescope Solar		1,367,166.00	-	-	-	1,367,166.00	1,126,110.94	36,158.00	-	1,162,268.94	204,897.06	241,055.06
	ST RADAR		-	1,864,642.00	-	-	1,864,642.00	-	279,696.00	-	279,696.00	1,584,946.00	-
	ASTRAD - CSNOF-05		-	5,617,595.00	241,173.00	-	5,858,768.00	-	842,639.00	18,088.00	860,727.00	4,998,041.00	-
	Telescope Enclosure - 3.6 Mt		-	3,353,027.00	8,963,708.00	-	12,316,735.00	-	502,954.00	672,278.00	1,175,232.00	11,141,503.00	-
	TOTAL (J)		1,593,071,798.02	96,461,568.00	28,153,620.00	-	1,717,686,986.02	687,379,870.47	150,323,024.00	2,111,521.00	839,814,415.47	877,872,570.55	905,691,927.52
K	OTHER FIXED ASSETS	15%											
	Aluminising / Anodising		103,357.45	-	-	13,998.78	89,358.67	89,358.67	-	-	89,358.67	-	13,998.78
	Canteen Assets		-	-	35,297.00	-	35,297.00	-	-	2,647.00	2,647.00	32,650.00	-
	CCTV Camera		77,500.00	-	-	-	77,500.00	25,705.78	7,769.00	-	33,474.78	44,025.22	51,794.22
	Library Instrument		9,500.00	-	-	-	9,500.00	3,665.81	875.00	-	4,540.81	4,959.19	5,834.19
	Workshop Assets		273,027.45	11,877.00	25,135.00	-	310,039.45	236,047.46	7,329.00	1,885.00	245,261.46	64,777.99	36,979.99
	Project Assets		-	2,762,966.00	-	-	2,762,966.00	-	414,445.00	-	414,445.00	2,348,521.00	-
	TOTAL (K)		463,384.90	2,774,843.00	60,432.00	13,998.78	3,284,661.12	354,777.72	430,418.00	4,532.00	789,727.72	2,494,933.40	108,607.18
	TOTAL OF CURRENT YEAR (1)		2,118,141,037.34	122,615,888.00	39,056,330.00	15,844.99	2,279,797,410.35	940,631,927.65	172,977,944.00	3,723,550.00	1,117,333,421.65	1,162,463,988.70	1,177,509,109.70
	TOTAL OF PREVIOUS YEAR (1)		2,092,176,117.62	10,591,507.72	15,373,412.00	-	2,118,141,037.34	759,707,034.61	179,094,848.26	1,830,044.00	940,631,926.87	1,177,509,109.70	1,332,469,083.01
2	CAPITAL WORK-IN-PROGRESS												
	International Liquid Mirror Telescope -4 M											25,469,905.00	135,915,775.00
	TOTAL (2)											25,469,905.00	135,915,775.00
	GRAND TOTAL (1 + 2)		2,118,141,037.34	122,615,888.00	39,056,330.00	15,844.99	2,279,797,410.35	940,631,927.65	172,977,944.00	3,723,550.00	1,117,333,421.65	1,187,933,893.70	1,313,424,884.70

NOTE: Balance of W.I.P & Project Assets of previous year 2018-19 Rs. 110445870.00 adjusted in current year as below:-

1- Transferred to Fixed Assets (Addition) Rs. 105,203,142.00 [W.I.P.]
2- Transferred to Indirect Expenses Rs. 1,179,643.00 [Licence Fee (2018-19) - Rs. 754843.00, Building Repair Expenses - Rs. 424800.00]
3- Transferred to Reserves & Surplus (Capital) Rs. 4,063,085.00 [TMT Project Expenses]

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]
PLACE : HALDWANI
DATED : 7th September 2020

MUKESH GOEL & CO. HALDWANI M.9719486671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 9 - INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	In Government Securities	-	-
2	Other approved Securities	-	-
3	Shares	-	-
4	Debentures and Bonds	-	-
5	Subsidiaries and joint Ventures	-	-
6	Others (to be specified):		
	a) FDR (GPF A/C) with Scheduled Bank (SBI)	28,883,832.00	27,404,990.00
	b) FDR (Pension Fund A/C) with Scheduled Bank (UBI)		69,300,000.00
	c) Interest Accrued	-	2,296,674.00
	TOTAL	28,883,832.00	99,001,664.00

	SCHEDULE 10 - INVESTMENTS - OTHERS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	In Government Securities	-	-
2	Other approved Securities	-	-
3	Shares	-	-
4	Debentures and Bonds	-	-
5	Subsidiaries and Joint Ventures	-	-
6	Others (to be specified):		
	a) FDR (ST RADAR Project) with Scheduled Bank (SBI)	6,492,906.00	6,153,606.00
	b) FDR (ISRO Project) with Scheduled Bank (SBI)	1,148,443.00	11,856,024.00
	c) Interest Accrued	-	554,594.00
	TOTAL	7,641,349.00	18,564,224.00

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
		(Debit)	(Debit)	(Debit)	(Debit)
	A. CURRENT ASSETS				
1	Inventories:				
	a) Finished Goods		-		-
	b) Work in Progress		-		-
	c) Consumables				
	-Stores and Spares	2,402,476.56		2,738,999.53	
	-Stationary	473,805.32		551,216.96	
	-Computer Accessories	1,490,472.92		1,942,752.47	
	-Fuel (POL)	297,456.69	4,664,211.49	152,280.00	5,385,248.96
2	Sundry Debtors:				
	a) Debts Outstanding > six months	-		-	
	b) Others	-	-	-	-
3	Cash balances in hand (including cheques/drafts)		18,608.00		-
4	Bank Balances:				
	a) With Scheduled Banks:				
	Current Accounts	-		-	
	Deposit Accounts (LC) *	1,833,052.00		9,899,581.96	
	Savings Account *				
	-Director A/C	155,029,872.06		76,874,712.76	
	-Pension Fund A/C	758,206.72		2,051,825.76	
	-GPF A/C	9,815,230.30		5,029,518.30	
	-Project Bank A/Cs	16,450,245.79	183,886,606.87	8,899,717.29	102,755,356.07
	b) With Non-Scheduled Banks:		-		-
5	Post Office-Savings Accounts		-		-
	TOTAL (A)		188,569,426.36		108,140,605.03

* Separate List Attached.

(Continued..)

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st March 2020

	SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
		(Debit)	(Debit)	(Debit)	(Debit)
	B. Loans, Advances & Other Assets				
1	Loans:				
	a) Staff *	4,371,555.00		4,905,773.00	
	b) Others (specify)	-	4,371,555.00	17,246,487.06	22,152,260.06
2	Advances and other amounts (recoverable in cash or in kind)				
	a) On Capital Accounts *	354,000.00		1,169,294.00	
	b) Prepayments	-		2,043,667.17	
	c) Others *	30,966,403.56	31,320,403.56	10,975,258.00	14,188,219.17
3	Income Accured On:				
	a) Investments - Endowment Funds	-		-	
	i) FDR (GPF A/C)	275,690.00		-	
	ii) FDR (Pension Fund A/C)	-		-	
	b) Investments - Others	-		-	
	i) FDR (ST RADAR Project)	135,354.00		-	
	ii) FDR (ISRO Project)	-		-	
	c) Loans and Advances	-		-	
	d) Others (Specify)	-	411,044.00	-	-
4	Claims Receivable		-		-
	TOTAL (B)		36,103,002.56		36,340,479.23
	TOTAL (A+B)		224,672,428.92		144,481,084.26

*As Per Separate List Attached

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 12 - INCOME FROM SALES/SERVICES		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Income from Sales		
	a) Sale of Finished Goods	-	-
	b) Sale of Raw Material	-	-
	c) Sale of Scraps	-	-
2	Income from Services		
	a) Labour and Processing Charges	-	-
	b) Professional/ Consultancy Services	-	-
	c) Agency Commission and Brokerage	-	-
	d)Maintenance Servies (Equipment/ Property)	-	-
	e) Others (Specify)	-	-
	TOTAL	-	-

	SCHEDULE 13 - GRANTS/SUBSIDIES		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Central Government Grants:		
	-Grant in aid "General"	40,249,000.00	69,703,000.00
	-Grant in aid "Salary"	144,823,000.00	106,250,000.00
2	State Government Grants	-	-
3	Government Agencies	-	-
4	Others (specify)	-	-
	TOTAL	185,072,000.00	175,953,000.00

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

PLACE : HALDWANI
DATED : 7th September 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 13A - PROJECTS GRANTS		(Amount in Rupees)
		Current Year	Previous Year
S.NO	PARTICUALRS	For the year ended 31st March 2020	For the year ended 31st March 2019
		(Credit)	(Credit)
1	Central Government Grants:		
	Project Grants Received:-		
	a) Project Grant - DST / INSPIRE / FELLOWSHIP	421,760.00	-
	b) Project Grant - DST / INT / POL / P-19 / 2016	368,608.00	-
	c) Project Grant - DST / INT / THAI / P-15	255,000.00	-
	d) Project Grant - EMR / 2016 / 001723	600,000.00	-
	e) Project Grant - INT / AUS / BMWF / P-14	433,000.00	-
	f) Project Grant - ISRO GBP	2,000,000.00	-
	g) Project Grant - UCOST	190,000.00	-
	h) Other Project Grants	2,492,901.00	-
	(Separate A/C not opened)		
2	State Government Grants	-	-
3	Government Agencies	-	-
4	Others (specify)	-	-
	TOTAL	6,761,269.00	-

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 14 - FEES/SUBSCRIPTIONS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Credit)	Previous Year For the year ended 31st March 2019 (Credit)
1	Entrance Fees	-	-
2	Annual Fees/ Subscriptions	-	-
3	Seminar/ Programe Fees	-	-
4	Consultancy Fees	-	-
5	Others (Specify)	-	-
	TOTAL	-	-

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

PLACE : HALDWANI
DATED : 7th September 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

SCHEDULE 15 - INCOME FROM INVESTMENTS (Amount in Rupees)

S.NO	PARTICUALRS	Investment from Earmarked Fund				Investment - Others			
		Current Year		Previous Year		Current Year		Previous Year	
		For the year ended 31st March 2020		For the year ended 31st March 2019		For the year ended 31st March 2020		For the year ended 31st March 2019	
		(Credit)	(Credit)	(Credit)	(Credit)	(Credit)	(Credit)	(Credit)	(Credit)
1	Interest		-		-		-		-
2	Dividends:		-		-		-		-
3	Rents		-		-		-		-
4	Others (Specify)								
	-Interest on FDR (GPF A/C)	1,752,415.00		-		-		-	
	-Interest on FDR (Pension Fund A/C)	2,680,137.00		-		-		-	
	-Interest on FDR (ISRO Project A/C)	-		-		298,434.00		-	
	-Interest on FDR (ST RADAR Project)	-	4,432,552.00	-	-	393,624.00	692,058.00	-	-
	TOTAL		4,432,552.00		-		692,058.00		-
	TRANSFFRRED TO INVESTMENTS		4,432,552.00		-		692,058.00		
	TOTAL INCOME FROM INVESTMENTS		5,124,610.00		-				-

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.9719406671

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 16 - INCOME FROM ROYALTY, PUBLICATION ETC.			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
1	Income from Royalty	-	-	-	-
2	Income from Publications	-	-	-	-
3	Others (specify)	-	-	-	-
	TOTAL	-	-	-	-

	SCHEDULE 17 - INTEREST EARNED			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
1	On Term Deposits:				
	a) With Scheduled Banks	-		2,591,945.00	
	b) With Non-Scheduled Banks	-		-	
	c) Others	-	-	-	2,591,945.00
2	On Savings Accounts:				
	a) With Scheduled Banks				
	-GPF A/C (SBI - 300)	239,020.00			
	-Pension Fund A/C (SBI - 311)	2,213.00			
	-Pension Fund A/C (UBI - 535)	96,222.00			
	-Project Bank A/Cs (SBI & UCO Bank)	428,509.50		370,658.00	
	-Director's Bank A/C (SBI - 253)	3,796,504.00		2,245,762.00	
	-LC Bank A/Cs	479,294.04		1,473,708.96	
	b) With Non-Scheduled Banks	-		-	
	c) Others	-	5,041,762.54	-	4,090,128.96
3	On Loans:				
	a) Employees/Staff				
	-HBA Interest	66,660.00		134,470.00	
	-Car Advance Interest	31,000.00		29,000.00	
	-Computer Advance Interest	7,520.00		27,345.00	
	-M.Cycle Advance Interest	7,278.00		15,171.00	
	b) Others - Intt on Income Tax Refund	-	112,458.00	877,274.00	1,083,260.00
	TOTAL		5,154,220.54		7,765,333.96

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. * HALDWANI M.9719406671 * Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 18 - OTHER INCOMES			(Amount in Rupees)	
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020		Previous Year For the year ended 31st March 2019	
		(Credit)	(Credit)	(Credit)	(Credit)
1	Profit on Sale/disposal of Assets		-		-
2	Export Incentives realized		-		-
3	Fees for Miscellaneous Services:				
	a) Electricity Charges	319,621.00		346,108.24	
	b) Telephone Charges	91.00		1,247.00	
	c) Water Charges	85,164.00		86,805.24	
	d) House License Fees	416,731.00	821,607.00	429,352.00	863,512.48
4	Miscellaneous Income:				
	a) Guest House rent	876,903.00		414,060.00	
	b) Hostel/Shop rent	66,500.00		52,680.00	
	c) EMD Security Forfeited	60,000.00		25,882.00	
	d) Project Overhead Charges	125,000.00		396,216.00	
	e) RTI Receipts	1,794.00		874.00	
	f) Notice Period Income	26,823.00		-	
	g) Other Incomes	14,431.00		2,279.80	
	h) Travelling Reimbursements	-	1,171,451.00	82,945.00	974,936.80
	TOTAL		1,993,058.00		1,838,449.28

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 19 - INCREASE/(DECREASE) IN INVENTORIES				(Amount in Rupees)
S.NO	PARTICUALRS	Current Year		Previous Year	
		For the year ended 31st March 2020		For the year ended 31st March 2019	
		(Credit)	(Credit)	(Credit)	(Credit)
1	Closing stock				
	-Finished Goods	-		-	
	-Work-in-progress	-		-	
	-Consumables	4,664,211.49	4,664,211.49	5,385,248.96	5,385,248.96
2	Less: Opening Stock				
	-Finished Goods	-		-	
	-Work-in-progress	-		-	
	-Consumables	5,385,248.96	5,385,248.96	6,283,119.30	6,283,119.30
	NET INCREASE/(DECREASE) [1-2]		(721,037.47)		(897,870.34)

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 20 - ESTABLISHMENT EXPENSES*		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	Salaries and Wages	79,705,160.00	87,394,724.30
2	Allowances and Bonus	17,255,916.00	-
3	Contribution to NPS	5,034,904.00	6,296,500.00
4	Contribution to Other Fund (Old Pension Fund)	-	1,500,000.00
5	Staff Welfare Expenses	-	
6	Others (specify)		
	-Medical Expenses	2,958,422.00	2,375,894.00
	-Fellowship	13,934,804.00	11,032,279.00
	-Leave Encashment	401,683.00	
	-LTC	1,114,977.00	967,547.00
	-Reimbursement of Tuition Fees	2,224,295.00	1,617,145.00
	TOTAL	122,630,161.00	111,184,089.30

*As per separate list attached.

Annexed to the Statement of Income & Expenditure of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

PLACE : HALDWANI
DATED : 7th September 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	Repair & Maintenance (Minor Works) *	2,309,800.00	4,504,702.00
2	Consumable Expenses *	3,311,275.79	6,077,578.04
3	Other Administrative Expenses *	6,269,264.00	
4	Consultancy Fee 3.6 Meter DOT	3,445,942.00	4,954,755.00
5	Contract Employee Salary	571,338.00	-
6	Travelling Expenses	8,032,273.00	6,716,559.00
7	Conveyance Expenses	1,001,840.00	3,063,932.00
8	POL (Fuel) Expenses	2,702,364.00	2,678,151.50
9	Custom Duty / Custom Clearance Charges	856,994.00	105,101.00
10	GST (RCM) on Security Expenses	2,141,773.00	-
11	Meeting Expenses *	1,202,913.00	1,306,253.60
12	Security Expenses	12,242,288.00	18,217,873.05
13	Electricity Expenses (Devasthal)	5,476,837.00	5,055,436.00
14	Legal Fee / Professional Fee/ Consultance Charges	234,089.00	1,305,158.00
15	Library Expenses (Journals)	109,488.00	-
16	Other Services (M/s Biva Securities)	4,041,351.00	-
17	Cleaning Work Expenses	2,063,834.00	2,904,969.23
18	ASTRAD Annual License Fee	721,000.00	1,028,492.00
19	Workshop Expenses	151,830.00	-
20	AMC Expenses	1,295,039.17	-
21	Bank Charges	157,264.70	141,215.71
22	Office Expenses	288,400.21	317,929.18
23	Telephone Expenses	250,678.00	269,483.00
24	Audit Fees	115,168.00	115,168.00
25	Printing & Stationary Expenses	297,927.00	331,829.00
26	Hospitality Expenses	172,192.00	64,510.00
27	Insurance Charges	92,844.00	335,383.00
28	Manpower Expenses	1,007,018.00	-
29	IISF Expo - 2019	604,160.00	500,000.00
30	Training Expenses	58,312.00	238,416.00
31	Hiring Charges - 4.2 ILMT Balaji Cranes	41,300.00	-
32	Hiring Charges - 4.2 ILMT Pedvak Cranes	413,644.00	-
	TOTAL	61,680,440.87	60,232,894.31

*As per separate list attached.

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 21A - PRIOR PERIOD INCOMES / (EXPENDITURES)		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
A	PRIOR PERIOD EXPENDITUTRES: -Adjustments of Previous Years		
1	NPS Employer's Contribution - R.Kumar (till 2018-19)	281,823.00	NA
2	NPS Employee Contribution - R.Kumar (Arrear 2018-19)	19,082.00	NA
3	Project (BRNS) Bank A/C	179,222.00	NA
4	Project (ISRO) Bank A/C	23,600.00	NA
5	Licence Fee-CSNOF-05 (2018-19)	754,843.00	NA
6	Cleaning Expenses (2018-19)	(136,696.00)	NA
7	LC A/C No 2016-04	(312,348.00)	NA
8	Group Inssurance	(12,099.00)	NA
9	TDS - Salary	(16,373.00)	NA
10	TDS - Contractor	(2,053.28)	NA
11	Project (PDF/2016/003848) Bank A/C	(42,984.00)	NA
12	Project (Poland/P-19) Bank A/C	(9,207.50)	NA
13	Project (BRNS) Bank A/C	(1,988.00)	NA
14	Project (U-COST) Bank A/C	(403,375.00)	NA
	TOTAL [Income / (Expenditure)]	(321,446.22)	4,931,617.00

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

PLACE : HALDWANI
DATED : 7th September 2020

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31st March 2020

	SCHEDULE 22 - EXPENDITURE ON PROJECTS		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	Project Exp - ABLN & C	2,929,589.00	NA
2	Project Exp - DST / IMRCD / BRICKS / PILOTCAL 1	823,714.00	NA
3	Project Exp - DST / INSPIRE	509,671.00	NA
4	Project Exp - DST / INSPIRE FACULTY	951,969.00	NA
5	Project Exp - DST / INSPIRE / FELLOWSHIP	168,967.00	NA
6	Project Exp - DST / INT / POL / P-19 / 2016	77,861.95	NA
7	Project Exp - DST / INT / THAI / P-15	49,794.50	NA
8	Project Exp - EMR / 2016 / 001723	366,000.00	NA
9	Project Exp - ILTP Project	27,003.00	NA
10	Project Exp - Indo Autria (Dr A.K.Srivastva)	36,422.00	NA
11	Project Exp - INT / AUS / BMWF / P-14	128,604.50	NA
12	Project Exp - INT / RUS / RFBR / P-271	20,883.00	NA
13	Project Exp - ISRO Environmental Observatory	1,207,879.50	NA
14	Project Exp - ISRO GBP	550,321.00	NA
15	Project Exp - PDF / 2016 / 003032	212,500.00	NA
16	Project Exp - PDF / 2016 / 003848	215,657.75	NA
17	Project Exp - UCOST	411,391.30	NA
	TOTAL	8,688,228.50	7,053,843.96

	SCHEDULE 23 - INTEREST EXPENDITURES		(Amount in Rupees)
S.NO	PARTICUALRS	Current Year For the year ended 31st March 2020 (Debit)	Previous Year For the year ended 31st March 2019 (Debit)
1	On Fixed Loans	-	-
2	On Other Loans (including Bank Charges)	-	-
3	Others (specify)		
	-Interest returned to DST	2,256,462.00	-
	-Interest accrued on GPF A/C	2,890,006.00	-
	TOTAL	5,146,468.00	-

Annexed to the Statement of Income & Expenditure
of even date attached herewith.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 2: STATEMENT OF RESERVES & SURPLUS (CAPITAL) AS ON 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.)		REASON
		DEBIT	CREDIT	
1	Misc. Project Grants	-	18,713,503.00	Project Grants of previous years adjusted
2	Performance Security Deposits	-	1,311,002.00	Old Entries, Op balance adjusted
3	Earnest Money Deposits	-	1,085,302.00	Old Entries, Op balance adjusted
4	Security Deposits	-	178,151.00	Old Entries, Op balance adjusted
5	Retention Money Deposits	-	157,245.00	Old Entries, Op balance adjusted
6	Running Security Deposits	249,475.00	-	Old Entries, Op balance adjusted
7	DDO - DST	-	76,163.00	Old Entries, Op balance adjusted
8	Fualad Constructions	-	20,000.00	Old Entries, Op balance adjusted
9	Service Tax (2015-16)	-	3,410.00	Old Entries, Op balance adjusted
10	Canteen Security	-	2,000.00	Old Entries, Op balance adjusted
11	Custom Duty	19,362.00		A/C Balance differences of 31.03.2019 adjusted
12	INDO - UK Seminar	28,000.00		Old Entries, Op balance adjusted
13	Pension Fund Bank A/C - (SBI-311)	-	2,791.96	Bank balance difference of 31.03.2019 adjusted
14	TMT Project	4,063,085.00	-	Balance of 31.03.2019 under WIP adjusted
15	HBA Advnaces	227,069.00	-	A/C Balance differences of 31.03.2019 adjusted
16	Car Advances	256,726.00	-	A/C Balance differences of 31.03.2019 adjusted
17	Computer Advances	14,300.00	-	A/C Balance differences of 31.03.2019 adjusted
18	M-Cycle Advances	58,840.00	-	A/C Balance differences of 31.03.2019 adjusted
19	Sundry Advances to Employees	224,829.50	-	A/C Balance differences of 31.03.2019 adjusted
20	LTC Advances	4,800.00	-	A/C Balance differences of 31.03.2019 adjusted
21	Advance of Ravinder Kumar	37,000.00	-	A/C Balance differences of 31.03.2019 adjusted
22	Festival Advance	-	10,540.00	A/C Balance differences of 31.03.2019 adjusted
	Totai	5,183,486.50	21,560,107.96	
	Net Balance (Cr) (Credit - Debit)		16,376,621.46	

Annexed to Sch 2 of the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

MUKESH GOEL & CO. HALDWANI M.9[illegible]6671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 7: STATEMENT OF SUNDRY CREDITORS AS ON 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.)
		Debit
1	PRINCETONE INSTRUMENTS	1,390,293.00
2	KUMAUN AUTO SALES	256,923.00
3	SHRI BALAJI CRANE SERVICES	35,400.00
4	DEVKI NANDAN	4,813.00
	Total	1,687,429.00

STATEMENT OF TDS PAYABLE AS ON 31.03.2020
(ANNEXURE OF SCH 7 (6) (d) - OTHER CURRENT LIABILITIES)

S. NO.	PARTICULARS	AMOUNT (Rs.)
		Credit
1	TDS - Consultant	70,889.00
2	TDS - Contractor	52,772.00
3	TDS - Pension	31,650.00
4	TDS - Salary	39,750.00
	Total	195,061.00

Annexed to Schedule 7 of the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.No.719406671

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 11(A): LIST OF BANK ACCOUNTS AS ON 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.) Debit	AMOUNT (Rs.) Debit
1	Director's (SBI) Bank A/C 10860840253		155,029,872.06
2	GPF (SBI) A/C 10860840300		9,815,230.30
3	LC No - 2016-04 (SBI) A/C 35822432563		1,833,052.00
4	Pension Fund A/Cs:		
	Pension Fund (SBI) A/C - 10860840311	65,160.70	
	Pension Fund (UBI) A/C - 534702010000535	693,046.02	758,206.72
5	Project Bank A/Cs		
	SBI PROJECT A/C 30192927780	1,757,208.50	
	SBI PROJECT A/C 30310168038 (ISRO)	10,357,765.00	
	SBI PROJECT A/C 30318931302	552,834.50	
	SBI PROJECT A/C 30357703902 (ST-RADAR)	966,731.00	
	SBI PROJECT A/C 31286509555	258,396.50	
	SBI PROJECT A/C 36065850402	7,175.54	
	SBI PROJECT A/C 37039717963	539,394.50	
	SBI Project A/C 37039721038 (Indo Poland)	300,377.55	
	SBI PROJECT A/C 372665312845	413,214.50	
	SBI PROJECT A/C 37598108567	32,954.50	
	SBI PROJECT A/C 38098705686	296,487.00	
	SBI PROJECT A/C 38532163287 (BMWF PROJECT)	312,501.50	
	SBI PROJECT A/C 38832273131 (THAI PROJECT)	205,640.50	
	SBI PROJECT A/C 39092267684 (FELLOWSHIP)	254,167.00	
	UCO BANK A/C 28720110011577 UCOST PROJECT	195,397.70	16,450,245.79
	Total		183,886,606.87

Annexed to Sch 11(A)(4) of the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES,
Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 11(B): STATEMENT OF ADVANCES & OTHER RECEIVABLES AS ON 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.) Debit	AMOUNT (Rs.) Debit
1	LTC Advances to Employees:		
	LTC Advance (C Arjuna Reddy)	20,000.00	
	LTC Advance (Kanhaiya Prasad)	2,600.00	
	LTC Advance (Pradeep Chakraborty)	23,500.00	46,100.00
2	TA Advances: to Employees		
	TA Advance (Chandra Prakash)	18,000.00	
	TA Advance (Dr Alok C Gupta)	19,800.00	
	TA Advance (H C Tiwari)	18,000.00	
	TA Advance (Mohit Joshi)	20,000.00	
	TA Advance (Nagabhushan S)	50,000.00	125,800.00
3	Other Advances:		
	Advance for Legal Charges	50,000.00	
	Advance - INDO-US Project (Dr. Wahab Uddin)	36,305.00	
	Advance to DST (Excess Interest Paid)	16,195,520.56	
	Advance to Niyaz Ahmed	4,093.00	
	Imprest Adv (A K Sharma) for 3.6Mt Tel.	28,797.00	16,314,715.56
4	Seurities & Deposits:		
	Security for Gas Connection	8,500.00	
	Security with BSNL	5,000.00	
	Security with Electricity	675,617.00	
	Security with Telephone	10,000.00	699,117.00
5	TDS Receivables:		
	TDS - GPF FDR - 2019-20	175,244.00	
	TDS Receivable (Till 2018-19)	1,294,572.00	
	TDS - STRADAR FDR - 2019-20	43,500.00	1,513,316.00
6	Deposit Against Income Tax Demand		6,800,000.00
7	ISRO-Project Cost Receivable		4,025,982.00
8	Advance to Natioanal Institute of Design for LOGO		354,000.00
9	Sundry Advances to Employees		
	Advance (Aditya Jaiswal)	18,000.00	
	Advance (Akanksha Rajput)	17,400.00	
	Advance (A K Sharma)	68,303.00	
	Advance (Alaxender Panchal)	18,900.00	
	Advance (Amitesh Omar)	10,550.00	
	Advance (Amit Kumar)	90,500.00	
	Advance (Anjasha Gangopadhyay)	30,600.00	
	Advance (Ankur Ghosh)	46,800.00	
	Advance (Arpan Ghosh)	9,900.00	
	Advance (Ashwani Pandey)	30,500.00	

Continued to page -2-

MUKESH GOEL & CO. Chartered Accountants HALDWANI M.9[illegible]106671

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 11(B): STATEMENT OF LOANS TO STAFF AS ON 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.) Debit	AMOUNT (Rs.) Debit
1	Car Advance - Staff		
	Car Advance (B.Krishna Reddy)	55,350.00	
	Car Advance (Narender Singh)	64,800.00	
	Car Advance (Sanjit Sahu)	96,000.00	
	Car Advance (Saurabh)	53,760.00	
	Car Advance (U.C.Dumka)	90,000.00	359,910.00
2	Computer Advance - Staff		
	Computer Advance (A.K.Sharma)	39,000.00	
	Computer Advance (D.S.Negi)	33,000.00	
	Computer Advance (Hemant Kumar)	41,000.00	
	Computer Advance (Himanshu)	39,000.00	
	Computer Advance (Mahesh Pandey)	4,500.00	
	Computer Advance (Manjay Yadav)	31,000.00	
	Computer Advance (Naveen C. Arya)	43,000.00	
	Computer Advance (R.D.Bhatt)	31,000.00	
	Computer Advance (R.K.Yadav)	50,000.00	
	Computer Advance (S.K.Singh)	31,000.00	342,500.00
3	HBA Advance - Staff		
	HBA Advance (Bharat Singh)	570,000.00	
	HBA Advance (Chandra Prakash)	123,395.00	
	HBA Advance (Dr. Brijesh Kumar)	504,000.00	
	HBA Advance (Dr. Narendra Singh)	625,000.00	
	HBA Advance (Dr. Saurabh)	976,000.00	
	HBA Advance (M.K.Naza)	303,750.00	
	HBA Advance (Samaresh Bhattacharjee)	546,000.00	3,648,145.00
4	M-Cycle Advance - Staff		
	M-Cycle Advance (S.C.Arya)	5,500.00	
	M-Cycle Advance (V.K.Singh)	15,500.00	21,000.00
	Total		4,371,555.00

Annexed to Sch 11(B)(1) of the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

S. NO.	PARTICULARS	AMOUNT (Rs.) Debit	AMOUNT (Rs.) Debit
	Advance(Bharti Arora)	13,500.00	
	Advance (B Krishna Reddy)	32,000.00	
	Advance (Dimple)	9,000.00	
	Advance (Dr. Kuntal Misra)	48,000.00	
	Advance (Dr. M Naja)	14,500.00	
	Advance (Dr S B Pandey)	13,452.00	
	Advance (Dr Snehlata)	35,504.00	
	Advance (Dr Wahab Uddin)	131,000.00	
	Advance (Gaurav Singh)	90,000.00	
	Advance (I. Chattopadhyay)	9,444.00	
	Advance (Jayanand Maurya)	12,600.00	
	Advance (Krishan Chand)	9,000.00	
	Advance (Mahendar Chand Rajwar)	4,500.00	
	Advance (Mridweeka Singh)	96,300.00	
	Advance (Mukesh Vyas)	10,880.00	
	Advance (Nikita Rawat)	4,500.00	
	Advance (N. Nanjappa)	37,000.00	
	Advance (Pradeep Chakraborty)	33,500.00	
	Advance (Priyanka Jalan)	25,200.00	
	Advance (Raj Kishore Joshi)	4,500.00	
	Advance (Ravindra Kumar Yadav)	35,300.00	
	Advance (Raya Dastidar)	18,000.00	
	Advance (Sadhana Singh)	13,500.00	
	Advance (Sameresh Bhattacharya)	27,424.00	
	Advance (Sapna Mishra)	17,000.00	
	Advance (Shilpa Sarkar)	97,200.00	
	Advance (Syed Ibrahim)	11,700.00	
	Advance (T S Kumar)	122,116.00	
	Advance (Vibhore Negi)	4,500.00	
	Advance (Vineet Ojha)	118,800.00	1,441,373.00
	Total		31,320,403.56

Annexed to **Sch 11(B)(2)** of the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH-20: LIST OF PAY & ALLOWANCES FOR THE YEAR ENDED 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.) DEBIT	AMOUNT (Rs.) DEBIT
1	SALARIES & WAGES:		
	Pay / Salaries - Employees	59,299,632.00	
	Grade Pay	386,918.00	
	Pension	19,699,202.00	
	Special Pay	882.00	
	MACP & Promotion Arrear	76,276.00	
	Honorarium	205,250.00	
	Honorarium (Visiting Scientist)	37,000.00	79,705,160.00
2	ALLOWANCES & BONUS:		
	a) Dearness Allowance		
	Dearness Allowance	11,358,423.00	
	DA Arrear	1,252,236.00	
	DA on TA	419,418.00	
	b) House Rent Allowance	2,082,359.00	
	c) Transport Allowance	2,116,500.00	
	d) Hill Compensation Allowance	19,008.00	
	e) Cash Handling Allowance	7,700.00	
	f) Washing Allowance	272.00	17,255,916.00
3	Employer Contribution - NPS		5,034,904.00
4	OTHERS:		
	a) Medical Expenses		
	Medical Expenses	216,556.00	
	Medical Expenses Brij Lal Hospital	1,257,657.00	
	Medical Expenses (Devasthal)	34,000.00	
	Medical Expenses (Krishna Hospital)	406,657.00	
	Medical Expenses (Sai Hospital)	179,456.00	
	Medical Reimbursement	864,096.00	2,958,422.00
	b) Fellowship		
	Fellowship	12,139,550.00	
	Fellowship Arrear	1,795,254.00	13,934,804.00
	c) Leave Encashment		401,683.00
	d) Leave Travel Concession		1,114,977.00
	e) Reimbursement of Tution Fee		2,224,295.00
	Total		122,630,161.00

Annexed to Schedule 20 of Income & Expenditure of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M 9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH-21: LIST OF OTHER ADMINISTRATIVE EXPENSE FOR THE YEAR ENDED 31.03.2020

S. NO.	PARTICULARS	AMOUNT (Rs.) DEBIT
1	Canteen Expenses	2,212,389.00
2	Internet Charges	2,299,894.00
3	Food Bill Expenses (ARIES Canteen)	300,715.00
4	Pest Control Expenses	186,273.00
5	Water Expenses	847,057.00
6	Return Filing Fees - GST/TDS	80,775.00
7	NPS Service Charges	7,144.00
8	Antivirus Expenses	51,989.00
9	Wages	139,250.00
10	Gardening Expenses	63,972.00
11	Postage Expenses	20,000.00
12	LC Issuance Charges	24,406.00
13	Certification Fee	35,400.00
	Total	6,269,264.00

Annexed to Schedule 21 (3) of the Statement of Income & Expenditure of even date attached.

	ANNEXURE OF SCH 21: LIST OF MEETING EXPENSES FOR THE YEAR ENDED 31.03.2020	
S. NO.	PARTICULARS	AMOUNT (Rs.) DEBIT
1	ASI-2020 Meeting Expenses	200,000.00
2	Asia Solar Physics Meeting Expenses	200,000.00
3	ESC Meeting Expenses	50,983.00
4	G.C. Meeting Expenses	195,625.00
5	Hindi Program Expenses	89,300.00
6	JEST 2020 Meeting Expenses	25,000.00
7	Public Outreach Programme	201,839.00
8	Scientific Meeting Expenses	240,166.00
	Total	1,202,913.00

Annexed to Schedule 21 (11) of the Statement of Income & Expenditure of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

ANNEXURE OF SCH 21: LIST OF REPAIR & MAINTENANCE FOR THE YEAR ENDED 31.03.2020

S. NO.	PARTICULARS		AMOUNT (Rs.) DEBIT
1	Repair & Maintance - Instruments		185,552.00
2	Repair & Maintenance - 3.6M DOT		307,175.00
3	Repair & Maintenance - Building		1,076,748.00
4	Repair & Maintenance - Computer		89,876.00
5	Repair & Maintenance - Electric Items		53,100.00
6	Repair & Maintenance - Fire Alarm		47,355.00
7	Repair & Maintenance - Fire Extinguisher		130,007.00
8	Repair & Maintenance - Internet		8,850.00
9	Repair & Maintenance - Others		165,953.00
10	Repair & Maintenance - Vehicle		245,184.00
	Total		2,309,800.00

Annexed to Sch 21 (1) of the Statement of Income & Expenditure of even date attached.

ANNEXURE OF SCH 21: LIST OF CONSUMABLE EXPENSES FOR THE YEAR ENDED 31.03.2020

S. NO.	PARTICULARS		AMOUNT (Rs.) DEBIT
1	Consumables (3.6mt Telescope)		122,880.00
2	Consumables (4.2 ILMT Project)		450,394.00
3	Consumables (Aluminising / Anodising)		13,998.79
4	Consumables (Computer)		231,995.00
5	Consumables (Electrical)		499,885.00
6	Consumables (Machinical)		40,380.00
7	Consumables (Materials)		796,758.00
8	Consumables (OPTICS)		29,647.00
9	Consumables (Others)		533,462.00
10	Consumables (Workshop)		36,917.00
11	Observational Facilities (Consumable)		402,693.00
12	Observational Facilities (LN2 Gas)		152,266.00
	Total		3,311,275.79

Annexed to Sch 21 (2) of the Statement of Income & Expenditure of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

STATEMENT OF ADJUSTMENTS OF PREVIOUS YEAR WORK IN PROGRESS
IN CURRENT YEAR 2019-20

S. NO.	PARTICULARS	AMOUNT (Rs.)
		Debit
1	Fixed Assets - Building Non-Residential at Devsthal	16,625,700.00
2	Fixed Asets - ASTRAD - CSNOF - 05	5,357,582.00
3	Fixed Assets - Backend Instruments - Modernization	80,456,894.00
4	Fixed Assets - Project Assets till 2018-19	2,762,966.00
5	Prior Period Expenses - ASTRAD Licence Fee of 2018-19	754,843.00
6	Repair & Maintenance - Building (Building (NR) Manora Peak	424,800.00
7	Reserves & Surplus (Capital) - TMT Project Expenses	4,063,085.00
	Total	110,445,870.00

Annexed to the Balance Sheet of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9[illegible]106671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

STATEMENT OF RECEIPT AND PAYMENT FOR THE YEAR ENDED 31ST MARCH 2020

S. NO	RECEIPTS	Current Year		S. NO	PAYMENTS	Current Year	
		2019-2020	2019-2020			2019-2020	2019-2020
I	Opening Balances:			I	Expenses:		
	a) Cash in hand	0.00			a) Establishment Expenses	122630161.00	
	b) Bank Balances:-				b) Administrative Expenses	61680440.87	
	i) Director (SBI) SB A/C	76874712.76			d) Less: Admin Expenses Transferred from FA	15844.99	
	ii) GPF (SBI) SB A/C	5029518.30			d) Less: Prepaid Expenses 2018-19	(2043667.17)	
	iii) Pension (SBI) SB A/C	36605.74			e) Less: Expenses out of Previous Year Advances	(1988597.00)	
	iv) Pension (UBI) SB A/C	2015220.02			f) Less: TDS Payable 2019-20	(195061.00)	
	v) LC (SBI) SB A/C	9665685.00			g) Less: Expenses from Previous year WIP	(424800.00)	179674321.69
	vi) Projects (SBI) SB A/C	8899717.29	102521459.11	II	Project Expenses:		
II	Grants Received:				a) Expenses on Various Sponsored Project	8688228.50	
	a) From Government of India:-				b) Less: Expenses out of Previous Year Advances	(256285.45)	8431943.05
	i) Salary Grant	144823000.00		III	Investments and deposits:		
	ii) General Grant	40249000.00			a) Out of Earmarked / Endowment funds	0.00	
	iii) Capital Grant	58014000.00			b) Out of Own Funds (Other Investments)	0.00	0.00
	iv) Project Grant	6761269.00		IV	Expenditures on Fixed Assets & W.I.P.:		
	Less: Grant Recd in 2018-19	(433000.00)			a) Purchase / Construction of Fixed Assets	56469076.00	
	b) From State Government	0.00	249414269.00		b) Expenditure on Capital Work-in-progress	0.00	
					c) Less: Expenses out of Previous Year Advances	(1993104.00)	54475972.00
III	Income on Investments:			V	Refund of surplus money/Loans :		
	a) Earmarked / Endowment Funds	0.00			a) To the Government of India	0.00	
	b) Own Funds (Other Investment)	0.00	0.00		b) To the State Government	0.00	0.00
				VI	Finance Charges (Interest)		
IV	Interest Received:				- Interest returned to DST	2256462.00	2256462.00
	a) On Bank deposits	5041762.54		VII	Other Payments:		
	b) On Loans & Advances	112458.00	5154220.54		a) Outstanding Expenses of 2018-19	7493363.00	
					b) Earnest Money Deposits paid	630257.00	
V	Other Incomes:				c) Performance Security Deposits paid	1240369.00	
	As per Income & Expenditure	1993058.00			d) Staff Advances	1822377.00	
	Less: EMD Forfeited	(60000.00)	1933058.00		e) ISRO Project Advance	4025982.00	
					f) HBA Loan to Staff	1000000.00	
VI	Amount Borrowed	0.00	0.00		g) Computer Loan to staff	100000.00	
					h) TA Advance	107800.00	
VII	Any Other Receipts:				i) LTC Advance	46100.00	
	a) Earnest Money Deposits	47000.00			l) TDS of 2018-19	912720.00	
	b) Performance Security Deposits	711084.00			k) Advance (Meeting) of Previous Year paid	106324.00	
	c) ISRO FDR Matured	11436079.00			l) Less: NPS Employee's share payable	(23853.00)	17461439.00
	d) M-Cycle Advance	12000.00		VIII	Closing Balances		
	e) Computer Advance	97500.00			a) Cash in hand	18608.00	
	f) Car Advance	132880.00			b) Bank Balances:-		
	g) HBA Advance	409265.00			i) Director (SBI) SB A/C	155029872.06	
	h) LTC Advance	1478.00			ii) GPF (SBI) SB A/C	9815230.30	
	i) TA Advance	1743.00			iii) Pension (SBI) SB A/C	65160.70	
	j) FDR (Pension) Matured	74099450.00			iv) Pension (UBI) SB A/C	693046.02	
	k) LC Bank Interest 2018-19	233866.96	87182345.96		v) LC (SBI) SB A/C	1833052.00	
					iii) Projects (SBI) SB A/C	16450245.79	183905214.87
	GRAND TOTAL		446205352.61		GRAND TOTAL		446205352.61

As per our separate Audit Report of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

For and on behalf of ARIES, Nainital

(REGISTRAR) DIRECTOR

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2020

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 the **CASH** method of accounting.

2. INVENTORY VALUATION

2.1 Stores and Spares (including machinery spares) are valued at cost.

2.2 Raw materials, semi-finished goods and finished goods are valued at lower of cost and net realizable value. The costs are based on weighted average cost. Cost of finished goods and semi-finished goods is determined by considering material, labour and related overheads.

3. INVESTEMNTS

3.1 Investments classified as "long term investments" are carried at cost. Provision for decline, other than temporary, is made in carrying cost of such investments.

3.2 Investments classified as "Current" are carried at lower of cost and fair value. Provision for shortfall on the value of such investments is made for each investment considered individually and not on a global basis.

3.3 Cost includes acquisition expenses like brokerage, transfer stamps etc.

4. FIXED ASSETS

4.1 Fixed assets are stated at cost of acquisition inclusive of inward freight, duties and taxes and incidental and direct expenses related to acquisition. In respect of projects involving constructions, related pre-operational expenses (including interest on loans for specific project prior to its completion), form part of the value of the assets capitalized.

4.2 Fixed assets received by way of non-monetary grants, (other than towards the Corpus Fund), are capitalized at values stated by corresponding credit to Capital Reserve.

5. DEPRECIATION

5.1 Depreciation is provided on **"written down value"** method as per rates specifies in the Income-tax Act, 1961 except depreciation on cost adjustments arising on account of conversion of foreign currency liabilities for acquisition of fixed assets, which is amortized over the residual life of the respective assets.

5.2 In respect of additions to/deductions from fixed assets during the year, depreciation is considered on pro-rata basis.

5.3 Assets costing Rs. 5,000.00 or less each are fully provided.

Continued to page -2-

6. **MISCELLANEOUS EXPENDITURE**

Deferred revenue expenditure is written off over a period of 5 years from the year it is incurred.

7. **GOVERNMENT GRANTS/SUBSIDIES**

7.1 Government grants of the nature of contribution towards capital cost of setting up projects are treated as Capital Reserve.

7.2 Grants in respect of specific fixed assets acquired are shown as a deduction from the cost of the related fixed assets.

7.3 Government grants/subsidies are accounted on realization basis.

8. **FOREIGN CURRENCY TRANSACTIONS**

8.1 Transactions denominated in foreign currency are accounted at the exchanged rate prevailing at the date of the transaction.

8.2 Current asset, foreign currency loans and current liabilities are converted at the exchanged rate prevailing as at the year end and the resultant gain/loss is adjusted to cost of fixed assets, if the foreign currency liability relates to fixed assets, and in other cases is considered to revenue.

9. **RETIREMENT BENEFITS**

9.1 Liability towards gratuity payable on death/retirement of employees is accrued and paid based on actuarial valuation.

9.2 Provision for accumulated leave encashment benefit to the employees is accrued and computed on the assumption that employees are entitles to receive the benefit as at each year end.

10. **LEASE**

Lease rentals are expensed with reference to lease terms.

PLACE: ARIES, NAINITAL
DATED: 07/09/2020

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.9[illegible]0406671

REGISTRAR
ARIES, NAINITAL

D. Banerjee

DIRECTOR
ARIES, NAINITAL

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2020

SCHEDULE 25 – CONTINGENT LIABILITES AND NOTES ON ACCOUNTS:

1. CONTINGENT LIABILITIES

1.1 Claims against the Entity not acknowledged as debts	Rs. NIL	(Previous year Rs. NIL)
1.2 In respect of:-		
-Bank guarantees given by/on behalf of the Entity	Rs. NIL	(Previous year Rs. NIL)
-Letters of Credit opened by Bank on behalf of the Entity	Rs. NIL	(Previous year Rs. NIL)
-Bills discounted with Banks	Rs. NIL	(Previous year Rs. NIL)
1.3 Disputed demands in respect of:		
Income Tax	Rs. NIL	(Previous year Rs. NIL)
Sales Tax/VAT/GST	Rs. NIL	(Previous year Rs. NIL)
Municipal Taxes	Rs. NIL	(Previous year Rs. NIL)

2. CAPITAL COMMITMENTS

Estimated value of contracts remaining to be executed on capital account and not provided for (Net of advances) Rs. NIL (Previous year Rs. NIL)

3. LEASE OBLIGATIONS

Future obligations for rentals under finance lease arrangements
For plant and machinery amount to Rs. NIL (Previous year Rs. NIL)

4. CURRENT ASSETS, LOANS AND ADVANCES

In the opinion of the Management, the current assets, loans and advances have a value on realization in t ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

5. TAXATION

In view of there being no taxable income under Income-tax Act 1961, no provision for Income tax has been considered necessary.

Continued to page -2-

6. FOREIGN CURRENCY TRANSACTIONS

	Current Year	(Amount-Rs.) Previous Year
6.1 Value of Imports Calculated on C.I.F Basis:		
-Purchase of finished Goods		
-Raw Materials & Components (Including in transit)		
-Capital Goods	Rs. 2,65,24,359.00/-	Rs. 20,31,860/-
-Stores, Spares and Consumables, Library Books/Journals	Rs. 46,39,008.00/-	Rs. 35,55,895/-
6.2 Expenditure in foreign currency:		
a) Travel	Rs. 11,07,197/-	Rs. 7,63,669/-
b) Remittances and Interest payments		
c) Royalty		
d) Know-how Expenses		
e) Professional Consultancy Fee	Rs. 1,05,23,897/-	Rs. 15,71,412/-
f) Other expenditure:		
-Commission on Sales	Rs. NIL	(Previous year Rs. NIL)
-Legal and Professional Expenses	Rs. NIL	(Previous year Rs. NIL)
-Miscellaneous Expenses	Rs. NIL	(Previous year Rs. NIL)
6.3 Earnings:		
-Value of Exports on FOB basis	Rs. NIL	(Previous year Rs. NIL)

7. PAYMENT TO AUDITORS:

	Current Year	(Amount-Rs.) Previous Year
A. As statutory auditors	Rs. 62,500/-	Rs. 1,15,168/-
B. As advisor or in other capacity in respect of:		
i) Taxation matters	NIL	NIL
ii) Management Services	NIL	NIL
iii)Certification	Rs. 10,000/-	Rs. 35,400/-
C. Any other matter	NIL	NIL

8. Contingent Liabilities not provided for

9. Corresponding figures for the previous year have been regrouped/ rearranged, wherever necessary.

10. Schedules 1 to 25 are annexed to and form an integral part of the Balance Sheet as at 31st March 2020 and the Income and Expenditure Account for the year ended on that date.

PLACE: ARIES, NAINITAL
DATED: 07/09/2020

MUKESH GOEL & CO. Chartered Accountants HARDWANI M.9719406671

REGISTRAR
ARIES, NAINITAL

D. Banerjee

DIRECTOR
ARIES, NAINITAL

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)
MANORA PEAK, NAINITAL

BALANCE SHEET OF ENDOWMENT FUND AS AT 31st MARCH 2020

LIABILITIES	Amount (in Rs.) 2019-2020	Amount (in Rs.) 2018-2019	ASSETS	Amount (in Rs.) 2019-2020	Amount (in Rs.) 2018-2019
CORPUS FUND:			INVESTMENTS		
A. GPF FUND:			FDR (SBI) - GPF	28,883,832.00	27,404,990.00
OPENING BALANCE	34,113,425.00	44,329,425.56	ACCRUED INTEREST (GPF)	275,690.00	177,361.00
ADD: EMPLOYEE'S CONTRIBUTION	6,642,675.00	8,387,325.00	FDR (UBI) - PENSION FUND	-	69,300,000.00
ADD: RECOVERY OF ADVANCES	269,150.00	313,775.00	ACCRUED INTEREST (PENSION)	-	2,119,313.00
ADD: INTEREST ACCRUED ON GPF	2,890,006.00	2,965,850.00			
LESS: OPENING ADVANCES	(499,100.00)	-			
LESS: PAYMENTS FROM GPF	(2,998,458.00)	(16,049,177.00)			
LESS: TRANSFERRED FROM/TO RESERVES	954,355.00	(5,833,773.56)			
TOTAL (A)	41,372,053.00	34,113,425.00			
B. PENSION FUND:			CURRENT ASSETS :		
OPENING BALANCE	44,236,446.56	79,571,847.46	BANK BALANCE (SBI) A/C 300	9,815,230.30	5,029,518.30
LESS: PENSION PAID	-	(36,835,400.90)	BANK BALANCE (SBI) A/C 311	65,160.70	36,605.74
Add: Pension Received	-	1,500,000.00	BANK BALANCE (UBI) A/C 253	693,046.02	2,015,220.02
TOTAL (B)	44,236,446.56	44,236,446.56			
TOTAL CORPUS FUIND (A + B)	85,608,499.56	78,349,871.56	LOANS & ADVANCES:		
			TDS - GPF RECEIVABLE (OP)	365,880.00	365,880.00
RESERVES & SURPLUS:			TDS - GPF RECEIVABLE (CURRENT)	175,244.00	-
GPF FUND	4,879,418.56	5,833,773.56			
PENSION FUND	21,979,271.94	18,119,997.72	GPF FUND RECEIVABLE	-	633,325.00
			ADVANCE - GPF	-	499,100.00
EXCESS OF INCOME / (EXPENDITURE)	1,874,692.96	3,859,274.22	ADVANCE - ARIES		
			-FDR Maturity of Pension Fund	74,099,450.00	-
CURRENT LIABILITIES:					
PENSION PAYABLE	-	1,394,846.00			
TDS PAYABLE	31,650.00	23,550.00			
TOTAL	114,373,533.02	107,581,313.06	TOTAL	114,373,533.02	107,581,313.06

As per our separate Audit Report of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

MUKESH GOEL & CO. HALDWANI M.9719406671 Chartered Accountants

PLACE : HALDWANI
DATED : 7th September 2020

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (ARIES)

MANORA PEAK, NAINITAL

STATEMENT OF INCOME & EXPENDITURE OF ENDOWMENT FUND FOR THE YEAR ENDING 31st MARCH 2020

EXPENDITURES	Amount (in Rs.) 2019-2020	Amount (in Rs.) 2018-2019	INCOMES	Amount (in Rs.) 2019-2020	Amount (in Rs.) 2018-2019
TO INTEREST ACCRUED (GPF)	2,890,006.00	2,965,850.00	BY FDR INTEREST (GPF)	1,476,725.00	2,167,739.00
			BY FDR INTEREST ACCRUED (GPF)	275,690.00	-
TO BANK EXPENSES	8,100.00	652.78	BY FDR INTEREST (PENSION)	2,680,137.00	2,119,313.00
			BY FDR INTEREST ACCRUED (PENSION)	-	-
			BY BANK INTEREST-SBI-300 (GPF)	239,020.00	188,033.00
			BY BANK INTEREST-UBI-535 (PENSION)	96,222.00	2,350,355.00
			BY BANK INTEREST-SBI-311 (PENSION)	2,213.00	337.00
TO EXCESS OF INCOME / (EXPENDITURES)	1,874,692.96	3,859,274.22	BY OPENING BANK BALANCE DIFF.	2,791.96	-
TOTAL	4,772,798.96	6,825,777.00	TOTAL	4,772,798.96	6,825,777.00

As per our separate Audit Report of even date attached.

For MUKESH GOEL & CO.
CHARTERED ACCOUNTANTS

CA. MUKESH GOEL, FCA
PROPRIETOR
[FRN - 006150C]
[MRN - 073335]

PLACE : HALDWANI
DATED : 7th September 2020

MUKESH GOEL & CO. * Chartered Accountants * HALDWANI M.9719406671

For and on behalf of ARIES, Nainital

(REGISTRAR) (DIRECTOR)