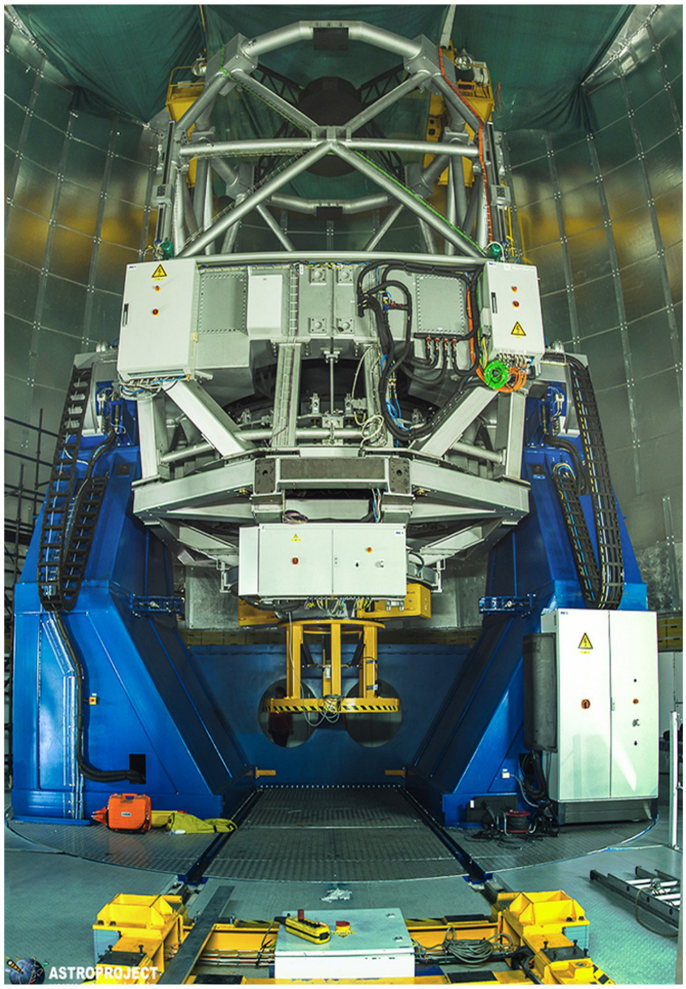
ARIES Aryabhatta Research Institute of Observational Sciences



Annual Report 2015 - 16

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES

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

Manora Peak, Nainital - 263 002, India

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Front Cover:

Top Left: Remote Technical Activation of India's largest 3.6 meter Devasthal Optical Telescope by the Hon'ble Prime Minister of India Shri Narendra Modi and Hon'ble Prime Minister of Belgium Mr. Charles Michel from Brussels, Belgium on 30th of March, 2016.

Bottom Left: Dr. Harsh Vardhan (Hon'ble Cabinet Minister Science & Technology and Earth Science), Dr. Wahab Uddin (Acting Director, ARIES), Dr. Brijesh Kumar (Project Manger, 3.6m DOT) along with some school children witnessing the Remote Technical Activation of 3.6m DOT at Devasthal.

Right: 3.6m DOT as completely installed at Devasthal.

Back Cover:

Optical image (6.5 x 6.5 $arcmin^2$) of the M101 (Spiral Galaxy) taken by the 4Kx4K CCD Imager mounted at the focal plane of the 3.6m Devasthal Optical Telescope, ARIES, Nainital on 17th March 2016.

September, 2016

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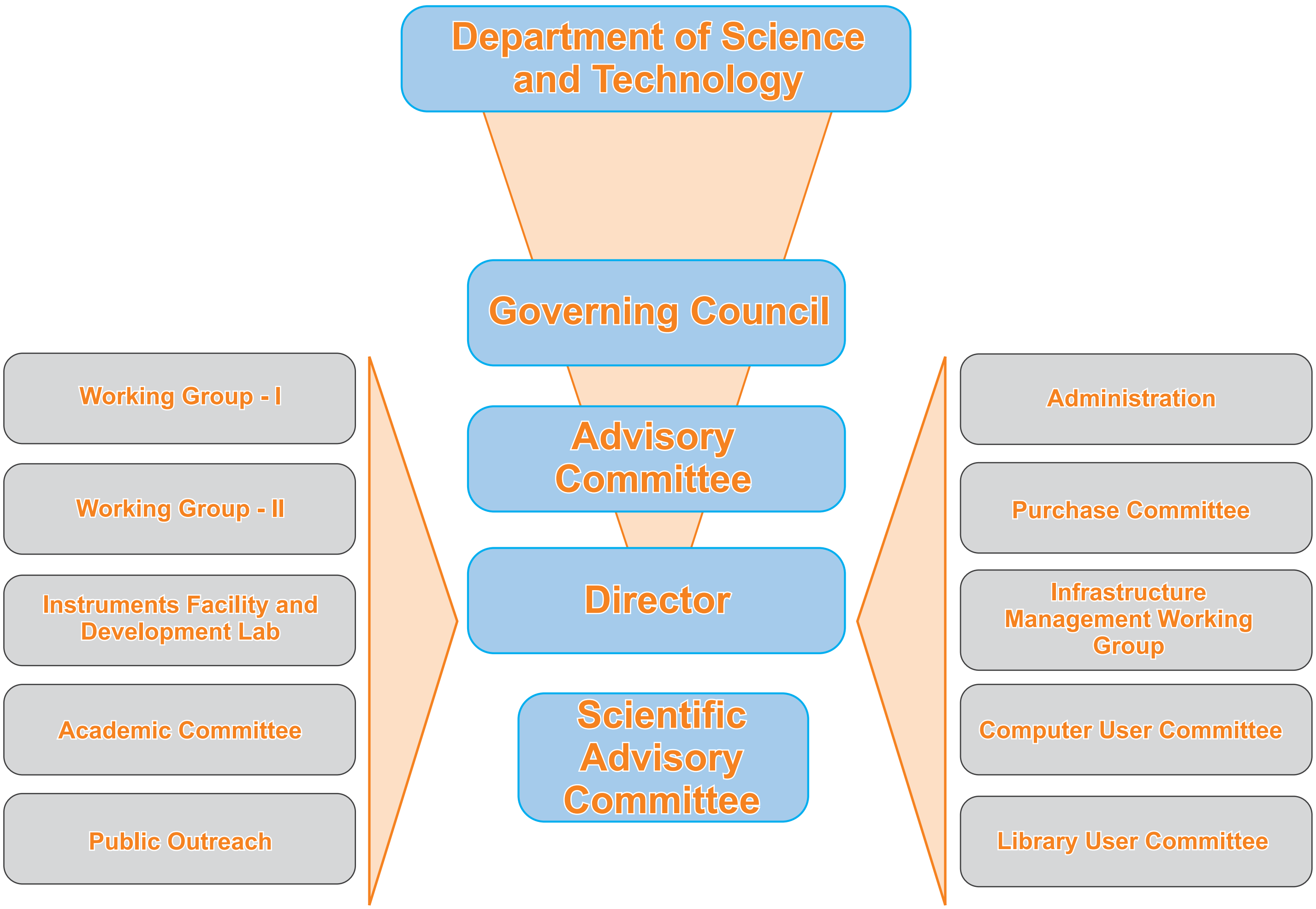

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From Director's Desk

The financial year 2015-16 was a milestone year for the institute. It is indeed of great pride that the Devasthal Optical telescope has been technically activated on 30th March 2016 jointly by Honorable Prime Minister of India, Shri Narendra Modi and Honorable Prime Minister of Belgium, Mr. Charles Michel, remotely from Brussels, and in the gracious presence of the Honorable Minister of Science and Technology and Earth Sciences, Government of India Dr. Harshvardhan at Devasthal. Now the onus lies with the scientist of ARIES and other national institutes to make best use of this wonderful and sophisticated instrument to carryout research in the forefront areas of Astronomy & Astrophysics. Here I present the 12th Annual Report of ARIES which highlights some of the progresses we made in research, human resource development, development of new facilities, involvement in the national and international projects, science popularization etc., over the past one year.

In ARIES, scientists are mainly engaged in carrying out frontline research in the fields of Astronomy & Astrophysics, Solar Physics and Atmospheric Sciences in collaboration with the scientists of national and international institutions and Universities. We are also involved in the popularization of Astronomy and Atmospheric sciences not only to disseminate the knowledge gathered by us to the general public but also to attract young talents to take up research as their career. The engineers are deeply involved in the development of new instruments and software for various national and international projects. There are **23** scientists, **13** engineers, **15** administrative and support staffs, **38** scientific and technical staffs, **13** laboratory assistants, **10** post doctoral fellow/research associates and **35** research scholars. In the year 2015, 8 new research scholars joined the institute. This is indeed a very heartening sign especially when the institute now has a world class facility like 3.6m DOT which requires involvement from younger people.

ARIES has three main research and development groups – Working Group – I (WGI), Working Group – II (WGII) and Instruments and Facility Design Laboratory (IFDL). The members of the respective groups have collectively published a total of 45 papers in refereed journals mostly in those with relatively high impact factor. Five of our research scholars have been awarded PhD degree this year and Four research scholars have submitted their thesis. There are eight national and international research projects that are being carried out with funds provided mostly either by the Department of Science and Technology or by the Indian Space Research Organization.

A good progress has been made in the development of back-end instruments for the 3.6-m DOT. A new CCD imager, used as the first instrument for the DOT, is ready for its regular use with the telescope. The progress of the TANSPEC, a near infrared spectrograph, which is being built in collaboration with the TIFR, Mumbai, is on schedule. The fabrication and assembly of ARIES Devasthal faint object spectrograph and camera is complete and testing with the telescope is in progress. The other telescope facilities like 1.3-m FOT and the 1.04-m Sampurnanand Telescope is functioning well and is producing good scientific results. A near DSP system has been installed in ST Radar and its tests are in progress. An Electro Static Discharge (ESD) lab has been setup for maintenance and development of different equipments related with ST Radar. Different instruments, including balloon-borne experiments, in atmospheric science group are working well and leading to good scientific outputs.

The scientists of ARIES are also actively involved in the popularization of Science and in particular the topics related to the Astronomy and Atmospheric sciences among general public especially to the students from various schools in Nainital district and elsewhere in the country. Various workshops and events have been organized as a part of the public outreach program. Visitors are allowed to various facilities of the institute to show them the activities carried out by the scientists and engineers.

Continuous efforts are being put to implement the official language in the day to day administrative work. We have taken special steps in keeping our office and premises *swachh.* All efforts are being taken to provide a constructive and essential role in building an equitable work environment by safeguarding the interests of the schedule casts and schedule tribes as well as women. All the necessary steps have been taken to maintain the national integration in the institute and implemented all the important schemes as directed by the Government of India.

Dr. Wahab Uddin

Acting Director

Research Highlights

The scientists of ARIES carry out research mainly on topics related to Astronomy and Astrophysics, Atmospheric Sciences and Instrumentation related to both the above fields. The research activities of the institute are classified into three working groups. The groups are

1. Working Group – I (WG I) – Galactic & Extragalactic Astronomy
2. Working Group – II (WG II) – Solar Physics & Atmospheric Sciences
3. Instruments Facility and Design Laboratory (IFDL)

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 account of the scientific and instrument related achievements of the institute, during the period of 2015-16, are presented.

Research Working Group – I

All the scientists working on the topics related to the Galactic and Extragalactic astronomy are the members of WG – I. The group consists of 17 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, LMC, quasars, supernovae and numerical simulations. The extracts of the publications made by the members are briefly presented below.

Astronomy & Astrophysics

1. Near Earth Objects

Imaging polarimetry of comets C/2013 V1 (Boattini) and 290P/Jager before and after perihelion

The authors presented the results obtained from the optical polarimetric study of the light scattered by comets C/2013 V1 (Boattini) and 290P/Jager at lower phase angles. The polarimetric observations of two comets have been performed with the 1.04-m Sampurnanand telescope of ARIES on 2013 December 4 (shown in the figure) and 5, and on 2014 April 24 using R photometric band (λ = 630 nm, Δλ = 120 nm). They covered the observations in both the pre- and post-perihelion passage of comets C/2013 V1 (Boattini) and 290P/Jager at two phase angles ~ 13° and 27°. The degree of polarization changed from (-1.4 ± 0.3) to (+2.8 ± 0.5) per cent for comet C/2013 V1 (Boattini) and (-1.6 ± 0.5) to (+2.5 ± 0.5) per cent for comet 290P/Jager at phase angles ˜13° and 27°, respectively. The change in the physical properties of cometary dust is being well

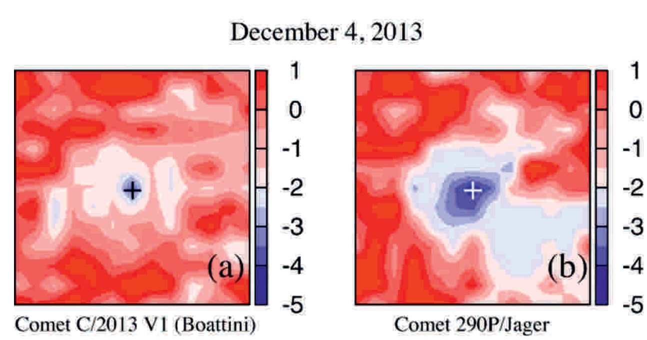

Figure 1. The polarization maps of (a) comet C/2013 V1 (Boattini) at 12.8 degree and (b) comet 290P/Jager at 13.1 degree phase angle. The '+' mark denotes the photocentre of the comet. The field of view is about 23 000 × 23 000 km.

studied from the polarization maps obtained for both the period of observations. It is found that the aperture polarization values are comparable to those of other comets. The variation in the brightness profile of both the comets from the standard canonical nature is also being observed in both the solar and antisolar direction during this phase which suggests the various physical evolutions influencing the cometary comae.[Deb Roy, et. al. (including **Medhi, B. J.).** (2015). *Mon. Not. Roy. Astron. Soc., 450,* 1770-1776]

2. Molecular Clouds and Star Formation

First Optical and Near-infrared Polarimetry of a Molecular Cloud Forming a Proto-brown Dwarf Candidate

LDN 328 is cited as an example of a fairly isolated clump contracting to form multiple sub-cores, possibly through gravitational fragmentation. In one of these sub-cores, a proto-brown dwarf (L328-IRS) candidate is in the process of formation through the self-gravitating contraction, similar to the formation scenario of a low-mass star. In this work, authors have presented the results of their optical and near-infrared polarization observations of regions toward LDN 328. This is the first observational attempt to map the magnetic field geometry of a cloud harboring a proto-brown dwarf candidate associated with a sub-parsec-scale molecular outflow. On a parsec scale, the magnetic field is found to follow the curved structure of the cloud showing a head-tail morphology. The magnetic field is found to be well ordered over a 0.02-0.2 pc scale around L328-IRS. Taking into account the uncertainties in the determination of position angles, the projected angular offset between the magnetic field direction and the outflow axis is found to be in the range of 0°-70°.

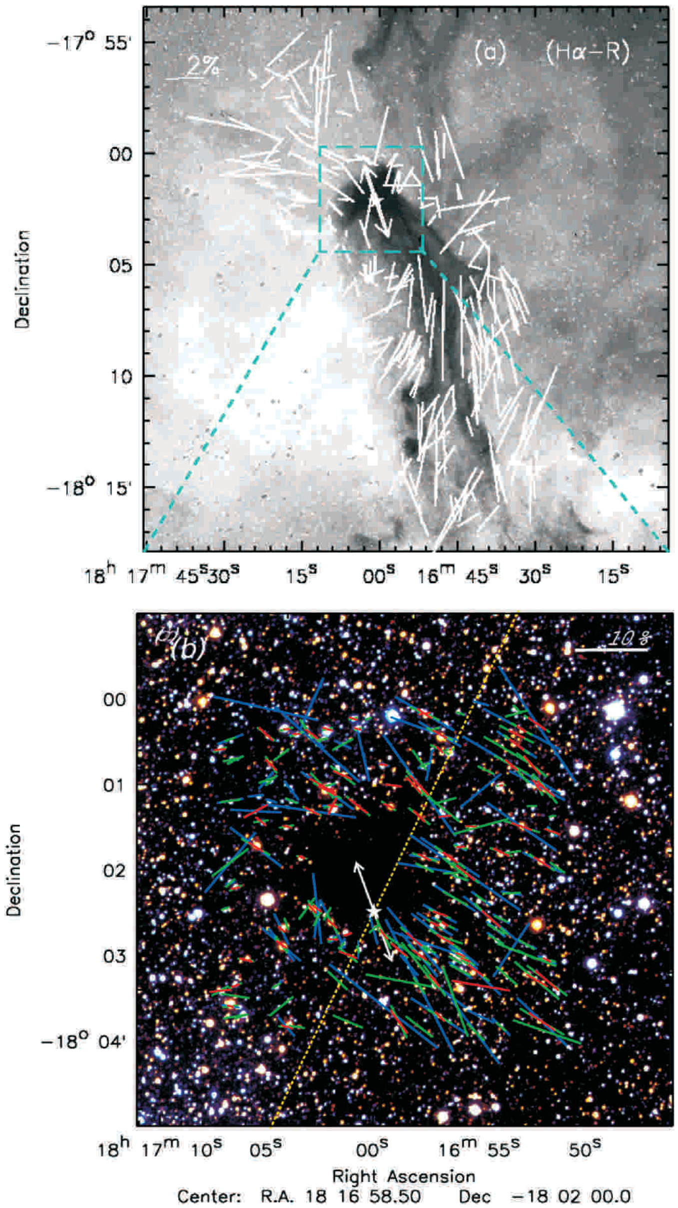

Figure 2. Upper panel: the *R*-band polarization vectors, representing *B*-field geometry, are over-plotted on the continuum subtracted Hα image of the L328 region. Lower panel: the polarization vectors are overplotted on the color-composite image shown in blue (*J*), green (*H*), and red (*Ks*), respectively. L328-IRS (star symbol) and the outflow direction (double-headed arrow) are also shown. The dotted yellow line demarcates the regions with relatively high and low dispersion in position angles.

Considering outflow to be the proxy for the rotation axis, the result obtained in this study implies that the rotation axis in L328 is preferably parallel to the local magnetic field. The magnetic field strength estimated in the close vicinity of L328-IRS is ˜20 μG. Results from the present study suggest that the magnetic field may be playing a vital role even in the cores that are forming sub-stellar sources. **[Soam, A.,** et. al. (including **Maheswar, G.).**(2015). *The Astrophysical Journal Letters, 803,* L20(5pp)]

Star formation in the filament of S254-S258 OB complex: a cluster in the process of being created

Infrared dark clouds are ideal laboratories for studying the initial processes of high-mass star and star-cluster formation. The authors investigated the star formation activity of an unexplored filamentary dark cloud (size ~5.7 pc × 1.9 pc), which itself is a part of a large filament (~20 pc) located in the S254-S258 OB complex at a distance of 2.5 kpc. Using Multi-band Imaging Photometer (MIPS) Spitzer 24 μm data, they uncovered 49 sources with signal-to-noise ratios greater than 5. They identified 45 sources as candidate young stellar objects (YSOs) of Class I, flat-spectrum, and Class II natures. Additional 17 candidate YSOs (9 Class I and 8 Class II) are also identified using JHK and Wide-field Infrared Survey Explorer (WISE) photometry. They found that the protostar-to-Class II sources ratio (~2) and the protostar fraction (~70%) of the region are high. Comparison of the protostar fraction to other young clusters suggests that the star formation in the dark cloud possibly started only 1 Myr ago. Combining the near-infrared photometry of the YSO candidates with the theoretical evolutionary models, they inferred that most of the candidate YSOs formed in the dark cloud are low-mass (<2 $M_\odot$). They further examined the spatial distribution of the YSOs and found that majority of them are linearly aligned along the highest column density line ($N(H_2)$~1×10^{22} cm^{-2}) of the dark cloud along its long axis at the mean nearest-neighbour separation of ~0.2 pc. Using the observed properties of the YSOs, physical conditions of the cloud and a simple cylindrical model, they explored the possible star formation process of this filamentary dark cloud and suggested that gravitational fragmentation within the filament should have played a dominant role in the formation of the YSOs. From the total mass of the YSOs, the gaseous mass associated with the dark cloud, and the surrounding environment, they inferred that the region is presently forming stars at an efficiency of ~3% and a rate ~30 $M_\odot$ Myr^{-1}, and it may emerge in a richer cluster. [Samal, M. R. et. al. (including **Pandey, A. K.**) (2015). *Astron. & Astrophy., 581*, A5]

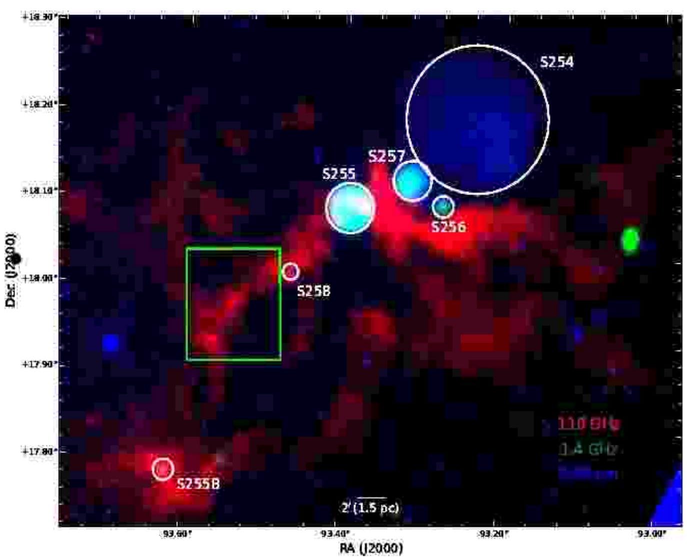

Figure 3. Colour composite image of the complex obtained using the ^{13}CO (110 GHz) column density map in red (from Chavarría et al. 2008), radio emission in green (from NVSS survey at 1.4 GHz; Condon et al. 1998) and optical emission in blue (from DSS2 survey). The abscissa (RA) and ordinate (Dec) are in the J2000 epoch. North is up and east is left. The H II regions discussed in this work are marked in white circles. The rectangular box represents the area studied in this work.

Variable stars in young open star cluster NGC 7380

The authors presented time series photometry of 57 variable stars in the cluster region NGC 7380 in this work. The association of these variable stars with the cluster NGC 7380 has been established on the basis of two colour diagrams and colour-magnitude diagrams. 17 stars are found to be main-sequence variables, which are mainly B-type stars and are classified as slowly pulsating B stars, β Cep or δ Scuti stars. Some of them may belong to new class variables as discussed by Mowlavi et al. and Lata et al. Present sample also contains 14 pre-main-sequence stars, whose ages and masses are found to be mostly ≲5 Myr and range $0.60 \lesssim M/M_{\odot} \lesssim 2.30$ and hence should be T-Tauri stars. About half of the weak-line T-Tauri stars are found to be fast rotators with a period of ≲2 d as compared to the classical T-Tauri stars. Some of the variables belong to the field star population. **[Lata, S.** et. al. (including **Pandey, A. K.** and **Pandey, J. C.**). (2016). *Mon. Not. Roy. Astron. Soc., 456,* 2505-2517.]

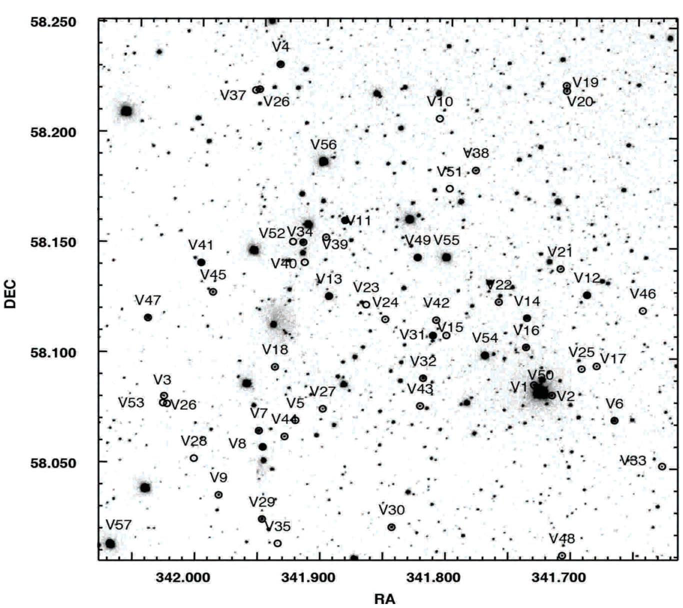

Figure 4. The observed region of NGC 7380 in the *V* band. The variable candidates detected in this work are encircled and labeled with numbers. The epoch of equatorial coordinates RA and Dec. is J2000.0.

3. Galactic Open Clusters

Complex stellar system ESO65SC03: Open cluster or remnant?

The comprehensive study of the Open Star Clusters and their basic parameters provide a fundamental database to understand the Galactic evolution process. However, it is difficult to study poorly populated open clusters as their photometric and structural properties are similar to those of Asterisms which sometime creates conflicting classifications. In order to understand the difference between sparse clusters and asterisms, we studied a poorly populated stellar system ESO65SC03 using infrared archival data. A detailed study of the system

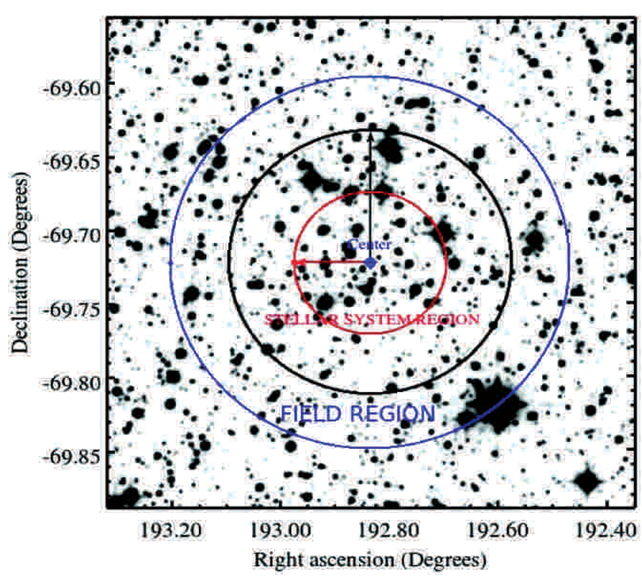

Figure 5. The finding chart (20arcmin×20arcmin) of stellar system ESO65SC03 in W 1band of WISE taken from IRSA webportal. The field region starts after the radial distance of 5.36 arcmin (shown in black circle) and ends in 7.58 arcmin (shown in blue circle).

ESO65SC03 gives a core and cluster radii of 1.10±0.63 and 5.36± 0.24 arcmins, respectively although the surface number density profile does not show any clear enhancement of the surface stellar number density between the stars of the system and the field regions. Using the statistically cleaned CMDs, we find the distance modulus, $(m - M)_0$, and reddening, E(B − V), of the system to be 11.8±0.2 mag and 0.45 mag, respectively. The mean proper motion of this system is estimated to be −5.37±0.81 mas/yr and 0.31±0.40 in RA and DEC directions, respectively. The mean proper motion of this system is found to be almost similar to the field region. The mass function for the brighter stars is found to be too high for the system to be an open cluster. These combined results place strong constraints on whether stellar system ESO65SC03 is a possible open star cluster remnant or an Asterism. Our understanding is that the ESO65SC03 is in a stage of open star remnant by losing their main sequence stars in the dynamic evolution processes. [Joshi, G. C. et. al. (including **Joshi, Y. C.** and **Joshi, S.**).(2015). *Pub. of the Astron. Soc. of Australia, 32,* e022 (18pp)]

Photometric study of open star clusters in II quadrant: Teutsch 1 and Riddle 4

The authors conducted broad band *UBVI* CCD photometry in the region of two open star clusters Teutsch 1 and Riddle 4 located in the second Galactic quadrant. The optical CCD data for these clusters are obtained for the first time. Radii of the clusters are estimated as 3′.5 for both the clusters. Using two color (U−B) versus (B−V) diagram we determined the reddening as E (B - V) = 0.40 ± 0.05 mag for Teutsch 1 and 1.10 ± 0.05 mag for Riddle 4. Using 2MASS *JHK* and optical data, we estimated E (J - K) = 0.24 ± 0.05 mag and E (V - K) = 1.40 ± 0.05 mag for Teutsch 1 and E (J - K) = 0.47 ± 0.06 mag and E (V - K) = 2.80 ± 0.06 mag for Riddle 4. Color-excess ratio indicates normal interstellar extinction law in the direction of both the clusters. We estimated distance as 4.3 ± 0.5 Kpc for Teutsch 1 and 2.8 ± 0.2 Kpc for Riddle 4 by comparing the color-magnitude diagram of the clusters with theoretical isochrones. The age of the clusters has been estimated as 200 ± 20 Myr for Teutsch 1 and 40 ± 10 Myr for Riddle 4 using the stellar isochrones of metallicity Z=0.02. The Mass function slope has been derived 1.89 ± 0.43 and 1.41 ± 0.70 for Teutsch 1 and Riddle 4 respectively. Our analysis

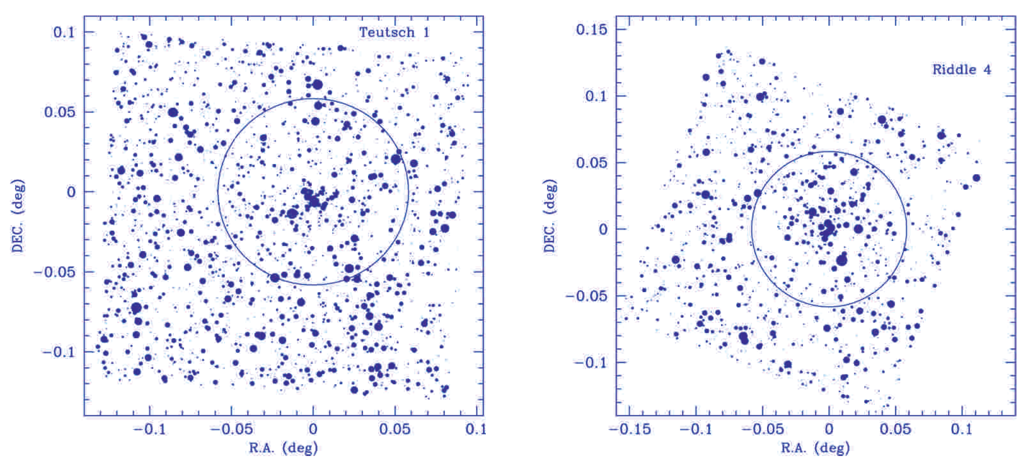

Figure 6. Finding chart of the stars in the cluster and field regions of Teutsch 1 and Riddle 4. North is up and East in the right direction. Circle represents the extent of the clusters. The smallest size denotes star of *V* ~ 21 mag.

indicates that both the clusters are dynamically relaxed. A slight bend of Galactic disc towards the southern latitude is found in the longitude range l= 130–180°. [Bisht, D., **Yadav, R. K. S.** & Durgapal, A. K. (2016). *New Astronomy, 42,* 66-77]

Basic parameters of open star clusters DOLIDZE 14 and NGC 110 in infrared bands

The study of Galactic open star clusters is important for understanding the history of star formation and the nature of the parent star clusters. These systems are used to test stellar models and are vital for our understanding of stellar evolution. The authors have studied two open cluster NGC 110 and DOLIDZE 14 using the data from the PPMXL and WISE catalogues. The center coordinates of NGC 110 and DOLIDZE 14 are found as (00:27:22.4, +71:23:56.6) and (04:06:26.7, +27:22:26.7), respectively. The radius of each cluster has been estimated using the King's empirical model on their stellar density profile and found to be 5.2+/-0.4 arcmin and 9.6+/-0.2 arcmin, respectively. The mean-proper motion of NGC 110 and DOLIDZE 14 in the RA and DEC directions were estimated as 4.03+/-0.29 and 2.53+/-0.23 mas/yr and -0.15+/-0.34 and 7.79+/-0.41 mas/yr, respectively. The reddening, E(B-V), is estimated as 0.42 mag for NGC 110 and 0.32 mag for DOLIDZE 14. The best fit theoretical isochrone on JHK catalogue of NGC 110 yielded a distance of 1.29 kpc for the cluster, while it is estimated as 1.67 kpc for DOLIDZE 14. The various colour-excesses, such as E(J-H), E(H-K) and E(W1-W2), have been estimated using the best fit of the theoretical isochrone on (J-H)/H, (H-K)/H and (W1-W2)/H CMDs respectively. The ratios among that of various infrared colours of each cluster are obtained through two colour diagrams. The spatial, kinematic and spatio-kinematic probabilities of stars of each cluster have been determined and used to identify the most probable members within them. The co-relation between E(H-K) and E(W1-W2) is also established. [Joshi, G. C., **Joshi, Y. C.**, **Joshi, S.** & Tyagi, R. K. (2015). *New Astronomy, 40,* 68-77]

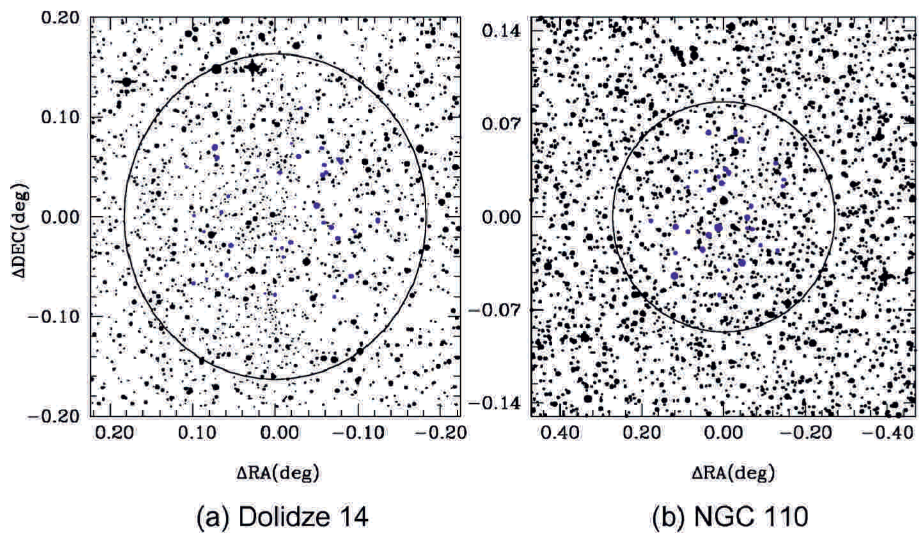

Figure 7. The finding charts of stars in, (a) DOLIDZE 14, and (b) NGC 110. The biggest size dots represent 10th magnitude star and smallest size dots represent stars fainter than 18 mag. The blue dots are identified as most probable members (MPMs) within the cluster region.

4. Globular cluster systems

Proper motions and membership probabilities of stars in the region of globular cluster NGC 6366

NGC 6366 is a metal-rich globular cluster that is relatively unstudied. It is a kinematically interesting cluster, reported as belonging to the slowly rotating halo system, which is unusual given its metallicity and spatial location in the Galaxy. The purpose of this research was to determine the relative proper motion and membership probability of the stars in the region of globular cluster NGC 6366. To target cluster members reliably during spectroscopic surveys without including field stars, a good proper motion and membership probability catalogue of NGC 6366 was needed. To derive relative proper motions, the archival data from the Wide Field Imager mounted on the ESO 2.2 m telescope have been reduced using a high precision astrometric software. The images used were in the *B,V,* and *I* photometric bands with an epoch gap of ~3.2 yr. The calibrated *BVI* magnitudes have been determined using recent data for secondary standard stars. The authors determined relative proper motions and cluster membership probabilities for 2530 stars in the field of globular cluster NGC 6366. The median proper motion rms errors for stars brighter than $V\sim$ 18 mag is ~2 mas yr^{-1}, which gradually increases to ~5 mas yr^{-1} for stars having magnitudes $V\sim$ 20 mag. Based on the membership catalogue, they checked the membership status of the X-ray sources and variable stars of NGC 6366 mentioned in the literature. They also provide the astronomical community with an electronic catalogue that includes *B*, *V*, and *I* magnitudes; relative proper motions; and membership probabilities of the stars in the region of NGC 6366. **[Sariya, D. P.** & **Yadav, R. K. S.** (2015). *Astron. & Astrophy., 584,* A59 (8pp)]

5. Active Galactic Nuclei

Intra-night Optical Variability of Radio-Quiet Weak Emission Line Quasars-III

Three years ago, the authors have started a programme using ARIES 1.3m telescope, to search for the elusive radio-quiet BL Lacs, by carrying out a systematic search for intranight optical variability (INOV) in a subset of weak emission line quasars which are already designated as high-confidence BL Lac candidate and are also known to be radio quiet. Here in continuation of this programme they presented the INOV observations taken in 13 sessions of duration >3.5 hours each, for new 7 such radio-quiet weak-line quasars (RQWLQs). Combining these data with their previously published INOV monitoring of RQWLQs in 29 sessions yields a set of INOV observations of 19 RQWLQs monitored in 42 sessions, each lasting more than 3.5 hours. The 42 differential light curves, thus obtained for the 19 RQWLQs, were subjected to a statistical analysis using the F−test, and the deduced INOV characteristics of the RQWLQs are then compared with those published recently for several prominent AGN classes, also using the F−test. From our existing INOV observations, there is a hint that RQWLQs in their sample show a significantly higher INOV duty cycle than radio-quiet quasars and radio lobe-dominated quasars. Three sessions when they have detected rather strong (blazar-like) INOV for RQWLQs are pointed out (e.g see DLCs figure), and all these three RQWLQs are therefore the best known candidates for radio-quiet BL Lacs, deserving to be pursued. For a proper comparison with INOV properties of other AGN classes, it would be very interesting to check if a factor of 2 − 3 improvement in INOV detection threshold for the RQWLQs would lead to a significantly higher estimate for their INOV duty cycle. Since a major goal of our program is to characterise the INOV properties of RQWLQs, it is also desirable to extend this programme in future to monitor RQWLQ samples selected from different catalogs, given that individual catalogs are expected to suffer from different sets of systematic and hence rare objects, such as WLQs, picked up in them may not represent identical populations. **[Kumar, Praveen**, Gopal-Krishna & **Chand, H**. (2015). *Mon. Not. Roy. Astron. Soc., 448,* 1463-1470]

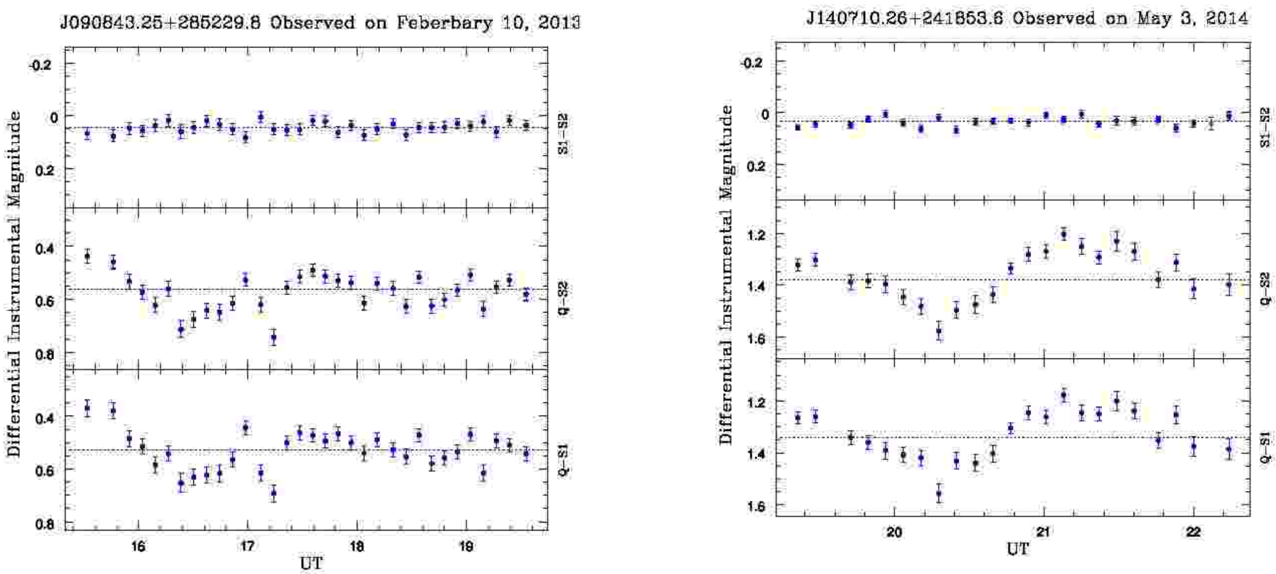

Figure 8. Differential light curves (DLCs) for the 2 RQWLQs from our sample. The name of the RQWLQ together with the date and duration of its monitoring are given at the top of each panel. In each panel the upper DLC is derived using the two non-varying comparison stars, while the lower two DLCs are the quasar-star DLCs, as defined in the labels on the right side.

Multi-wavelength Studies of Blazars

A small subset of Radio Loud AGNs called Blazars show rapid variability at almost all wavelengths of the EM spectrum with the emission being strongly polarized. BL Lacs (BLLs) and flat spectrum radio quasars (FSRQs) are collectively known as Blazars. BLLs show featureless optical continua (no prominent emission or absorption lines) while FSRQs show prominent emission lines in their optical spectra. The radiation from blazars is dominated by non-thermal emission at all wavelengths, consisting of two broad spectral bumps: A low-frequency component from radio to the UV/X-rays, generally agreed to be due to synchrotron radiation from relativistic electrons in the jet, and a high-frequency component from X-rays to gamma-rays, which can be either due to Compton scattering of lower-frequency radiation by the same relativistic electrons (leptonic models) or due to interactions of ultrarelativistic protons in the jet (hadronic models), either via proton synchrotron radiation or via secondary emission from photo-pion and photo-pair production process.

Blazars Variability in Radio to Optical bands on Diverse Time Scales (Ground Based Observations)

Multiband optical behaviour of the BLL, S5 0716+714, during its outburst state from 2014 November to 2015 March have been reported by the authors based on the quasi-simultaneous observations in B, V, R, and I bands. The data were taken on 23 nights from 3 telescopes (1 in ARIES, India and 2 in Bulgaria). Source was detected in the flaring state during their observations. Multiband optical fluxes, colour, and spectral variations for this blazar on intraday and short time-scales are studied. They recorded the brightest flux state of the source on 2015 January 18, which is the brightest value ever recorded for S5 0716+714. The amplitude of variation tends to increase with increasing frequency with a maximum of ~ 22% seen during flaring states in B band. A mild trend of larger variability amplitude as the source brightens was also found. They found the duty cycle of the source during the analysed period to be ~90%. Day to day spectral energy distribution of S5 0716+714 was also investigated using B, V, R, and I data points for 21 nights of observations.

In another study of the same source, the spectral energy distribution was investigated in optical/NIR bands using data taken in B, V, R, I, J and K passbands for 7 nights of observations. Physical mechanisms which are likely to be responsible for its

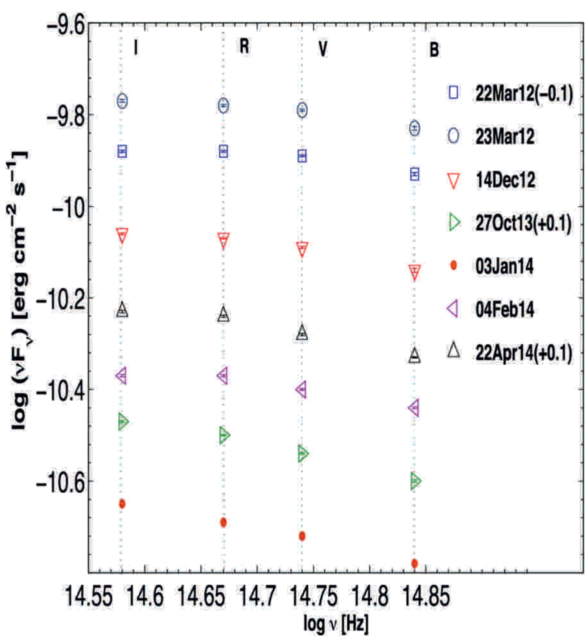

Figure 9. SED results for S5 0716+714 in optical frequencies.

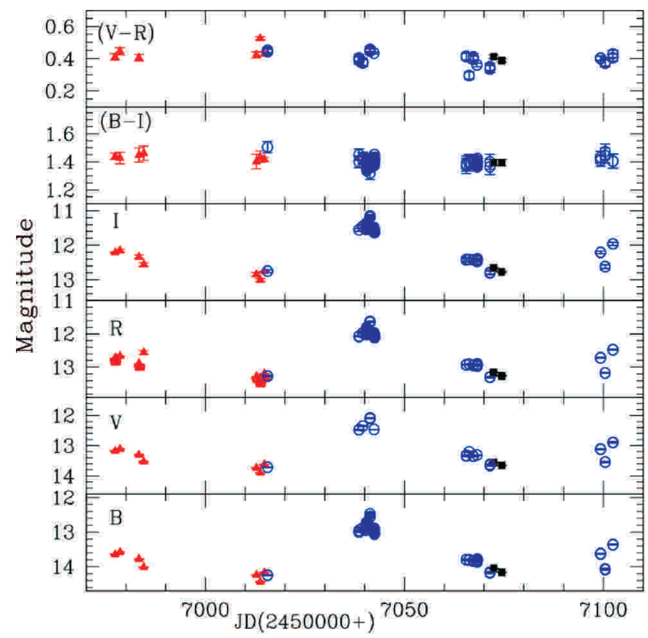

Figure 10. LCs for S5 0716+71 covering full monitoring period; different colours denote data from different observatories: red denotes telescope A; blue denotes telescope B; black denotes telescope C. *Y*-axis is the magnitude while *X*-axis is Julian Date (JD). Top two panels represent (*V* − *R*) and (*B* − *I*) colour variation.

flux and spectral variations were given. [**Agarwal, A.,** et al. (including **Gupta, A. C.**) (2015). *Mon. Not. Roy. Astron. Soc., 451,* 3882-3897 and **Agarwal, A.,** et al. (including **Gupta, A. C.**) (2015). *Mon. Not. Roy. Astron. Soc., 455,* 680-690]

BL Lacerate was extensively observed in 2010 - 2013 (optical and radio bands) using about a dozen telescopes in India, Europe and USA. Some published data were also used. They detected several prominent outbursts. Many optical “mini-flares” on short timescales were detected. Variations on longer term timescales were mildly chromatic with the superposition of many strong optical outbursts. In radio bands, the amplitude of variability is frequency dependent. Flux variations at higher radio frequencies lead the lower frequencies by days or weeks. Significant cross-correlations

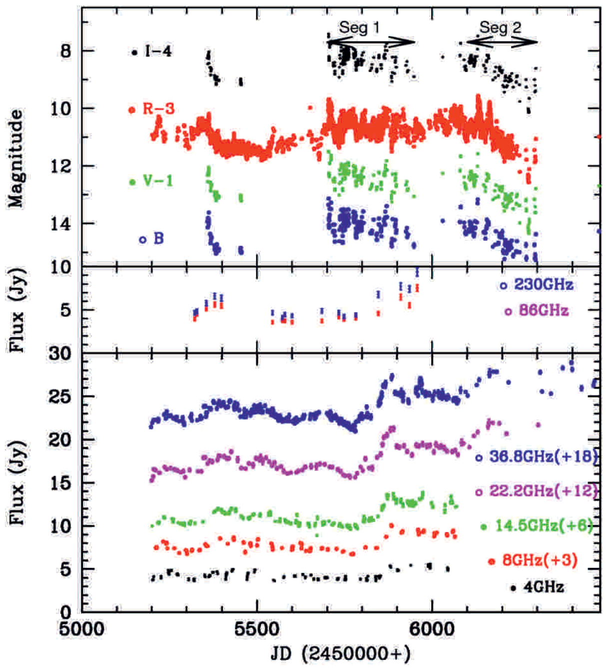

Figure 11. Entire timeline of the observations in optical B, V, R, and I-bands (upper panel), the radio bands at 230 and 86 GHz (middle panel) and at 36.8 (and 37.0), 22.2, 14.5, 8.0, and 4.8 GHz frequencies (lower panel). The individual light curves and their offsets are labeled.

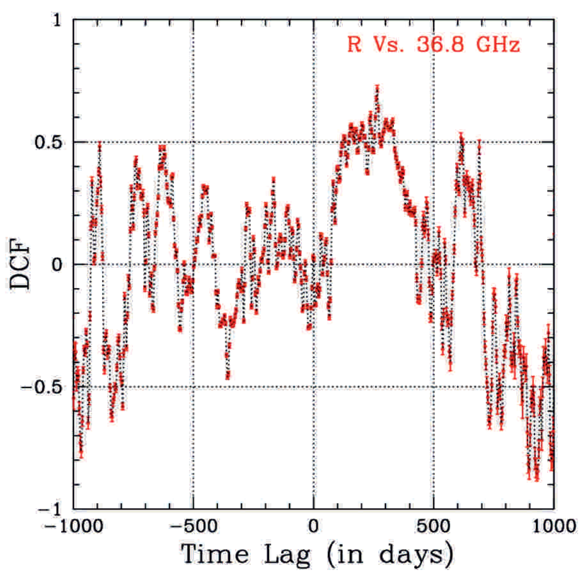

Figure 12. DCF between optical R-band versus radio frequency at 36.8 GHz.

between optical and radio bands were found in their observations with a delay of cm-fluxes with respect to optical bands of ~250 days. The optical and radio light curves do not show any significant timescales of variability. The optical variations are consistent with being dominated by a geometric scenario where a region of emitting plasma moves along a helical path in a relativistic jet. The frequency dependence of the variability amplitude supports an origin of the observed variations intrinsic to the source. [Gaur, H., et al. (including **Gupta, A. C.** & **Agarwal, A.**) (2015). *Astron. & Astrophy., 582*, A103]

In a very active phase of BL Lacertae during 2010–2012, authors did extensive multiband intranight optical monitoring using half a dozen telescopes in India, Europe and USA. They observed it for a total for 38 nights; on 26 of them, observations were done quasi-simultaneously in B, V, R and I bands (totalling 113 light curves). The authors did not find any evidence for periodicities or characteristic variability time-scales in the light curves. The intranight variability amplitude is generally greater at higher frequencies and decreases as the source flux increases. They found spectral variations in BL Lacertae in the sense that the optical spectrum becomes flatter as the flux

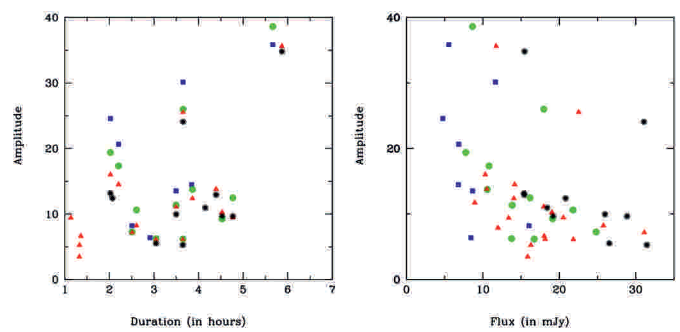

Figure 13. Dependence of amplitude of variability on duration (left-hand panel) and flux (right-hand panel) of the observations. Here, the B band is represented by squares (blue), V by solid circles (green), R by triangles (red) and I by starred symbols (black).

increases but in several flaring states, deviates from the linear trend suggesting different jet components contributing to the emission at different times. [Gaur, H., et al. (including **Gupta, A. C**.) (2015). *Mon. Not. Roy. Astron. Soc., 452,* 4263-4273]

The authors monitored BL Lacertae for 13 nights in optical B, V, R, and I bands during 2014 October and November including quasi-simultaneous observations in V and R bands using two optical telescopes (1.04m and 1.3m) of ARIES, India. They have studied multiband optical flux variations, colour variation and spectral changes in this blazar. It was found to be active during the whole monitoring period and showed significant intraday variability. From the colour–magnitude analysis of the source, authors found that the spectra of the target get flatter as it becomes brighter on intranight time-scale. Spectral energy distribution of the target generated using the B, V, R, and I data sets for all 13 nights helped them to investigate the physical process responsible for the observed variations in BL Lacertae. [**Agarwal, A.** and **Gupta, A. C.** (2015). *Mon. Not. Roy. Astron. Soc., 450,* 541-551]

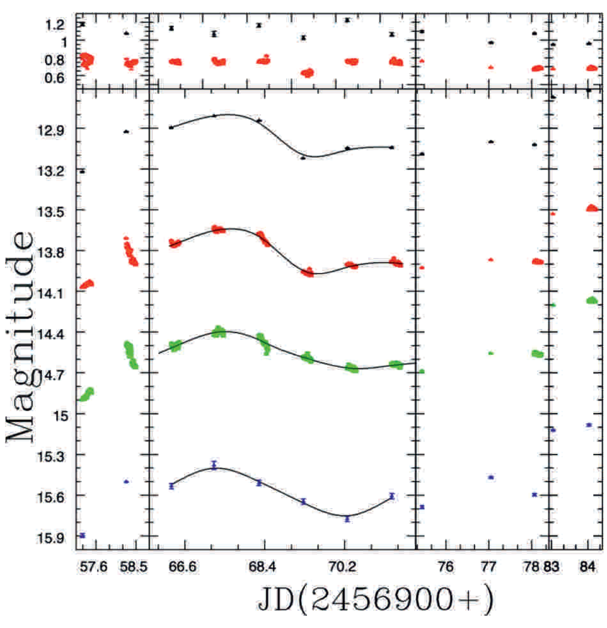

Figure 14. Light curves for BL Lacertae covering full monitoring period; blue denotes *B* filter; green denotes *V* filter; red, *R* filter; and black, *I* filter. *y*-axis is the magnitude while *x*-axis is Julian Date (JD). In the top panel, red colour represents *(V − R)* colour variation while black is for *(B − I)* − 1.7 colour. Offset of 1.7 is used with *(B − I)* plot to avoid its eclipsing with *(V − R)* plot. Solid line represents a cubic spline interpolation during the continuous six nights monitoring in *B, V, R,* and *I* filters.

New optical observations during 2011 - 2014 over 100 nights were made using 7 telescopes: 4 in Bulgaria, 1 in Greece, and 2 in India to study optical variability of two blazars FSRQs 3C 279 and 3C 454.3 on a wide range of time-scales. Authors measured multiband optical flux and colour variations on diverse time-scales. Discrete correlation functions were used to compute among B, V, R, and I observations, to search for any time delays. They found weak correlations in some cases

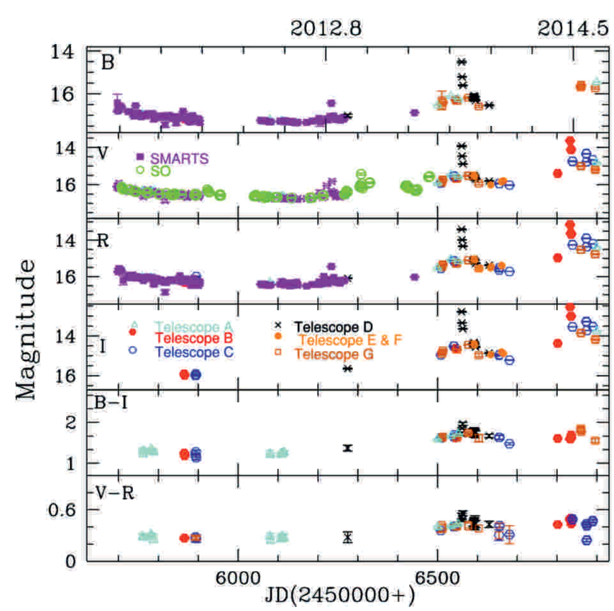

Figure 15. Short/long-term variability LCs and colour indices of 3C 454.3 in the *B, V, R,* and *I* bands and *(B−I)* and *(V−R)* colours. Different colours denote data from different observatories: cyan = telescope A, red = telescope B, blue = telescope C, black = telescope D, dark orange = telescopes E and F, chocolate = telescope G, magenta = SMARTS, green = SO.

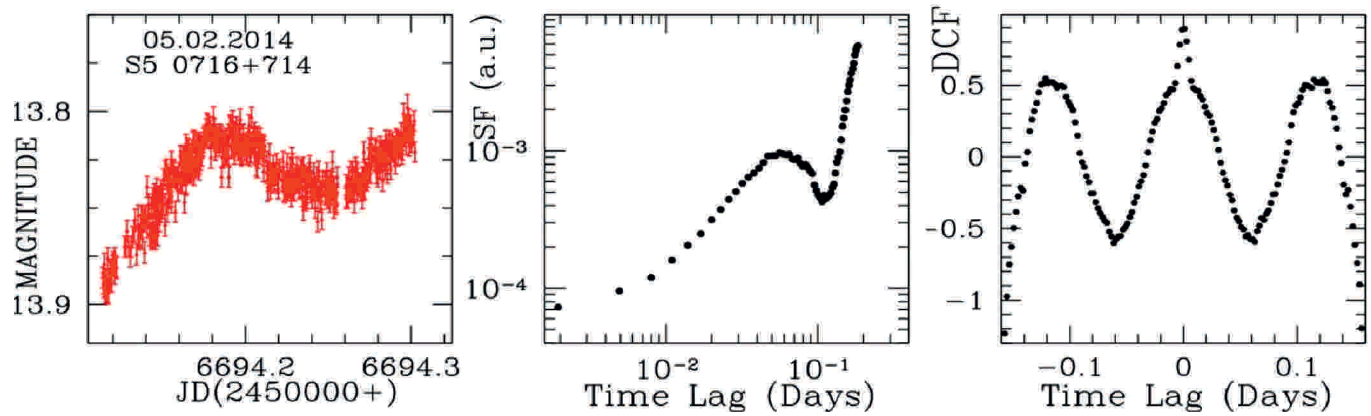

Figure 16. R-band optical IDV LC of the blazar S5 0716+714 and their respective SFs and DCFs. The remainder of these observations and analyses are presented as online-only material.

with no significant time lags. The structure function method was used to estimate any characteristic time-scales of variability. They also investigated the spectral energy distribution of the these blazars using B, V, R, I, J, and K passband data. They found that the sources almost always follow a bluer-when-brighter trend. They discussed possible physical causes of the observed spectral variability. [**Agarwal, A.,** et al. (including **Gupta, A. C.**) (2015). *Mon. Not. Roy. Astron. Soc., 451,* 3882-3897]

Frequency-dependent core shifts and parameter estimation for the blazars

Recently the authors have started a pilot project based on long term (~40 - 50 years) radio data of balazars. This was their first study under the project in which they studied the blazar 3C 454.3. Data in 5 radio frequencies 4.8, 8.0, 14.5, 22.2, and 36.8 GHz were collected starting from year 1966 to 2013. Three radio single dish telescopes located at University of Michigan Radio Astronomical Observatory (UMRAO), USA; Crimean Astrophysical Observatory, and Aalto University Metsahovi Radio Observatory in Finland. They developed an automated way to fit peacewise Gaussian fit to multiple flares in long timeseries data. Using peacewise Gaussian fit to the long term radio light curves, cross-correlation in different frequencies, and Fourier periodogram analysis yield spectral indicies based on peak amplitude, time lags, and power-law slop in periodogram, respectively. With the help of the above analysis, they estimated spectral index in the range of -024 to 1.52, magnetic field at the core is 46+-16 mG, core

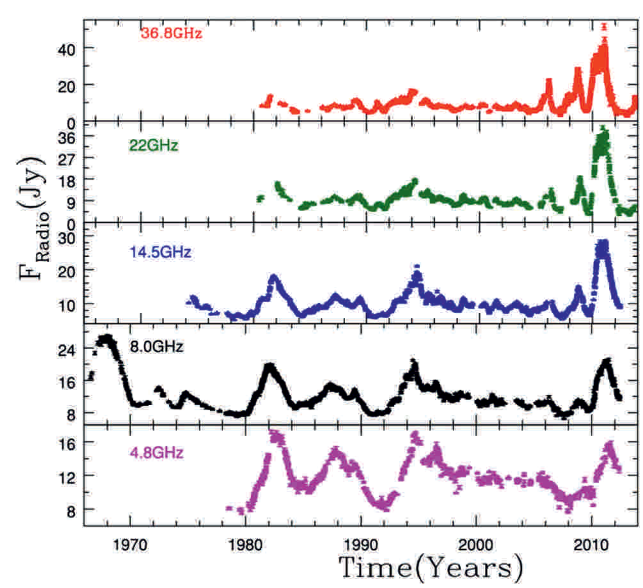

Figure 17. Long-term variability light curves of 3C 454.3 in the 4.8 –36.8 GHz frequency range. Colour figure in online version.

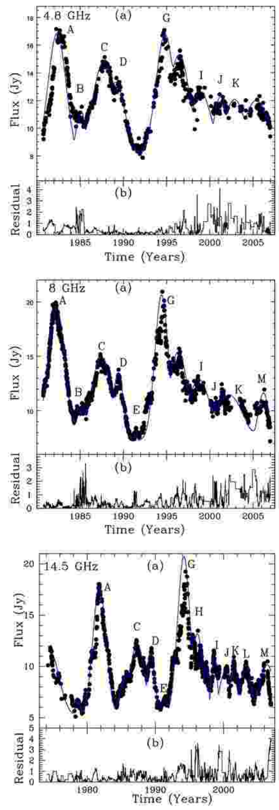

Figure 18. Segment 1(beginning of observations to ~2007.0) of the 4.8, 8.0 and 14.5 GHz light-curve flares fit with a piecewise Gaussian function. The residual in the lower panels are calculated as $[y(A_i, m_i, \sigma_i) - x_i(t_i)]$/Standard Deviation $(x_i(t_i))$.

position offset is 6.4+-2.8 pc, power-law slope range -1.6 to -3.5 describing the power spectral density shape and gives bend timescales in the range 0.52 - 0.66 yr. Important objectives met in their study include: the demonstration of the computational efficiency and statistical basis of the piecewise Gaussian fit; consistency with previously reported results; evidence for the core shift dependence on observation frequency and its utility in jet diagnostics in the region close to the resolving limit of very long baseline interferometry observations. [Mohan, P. et al. (including **Agarwal, A.** & **Gupta, A. C.**) (2015). *Mon. Not. Roy. Astron. Soc., 452,* 2004-2017]

Multi-wavelength Blazars studies with Space Based Observations

The authors have studied near simultaneous optical/UV and X-ray study of the FSRQ, 3C 273 using data available from the XMM–Newton satellite mission from 2000 June to 2012 July. They focused on the multi-wavelength flux variability on both intra-day and long time-scales. They found high flux variability over long time-scales in all bands for which observations were made. The optical/UV variability amplitude was more than twice than that in the X-ray bands. There is some frequency dependence of the variability in optical/UV bands in the sense that the variability amplitude increases with increasing frequency; however, the X-ray emissions disagree with this trend as the variability amplitude decreases from soft to hard X-ray bands. On intra-day time-scales 3C 273 showed small amplitude variability in X-ray bands. A hardness

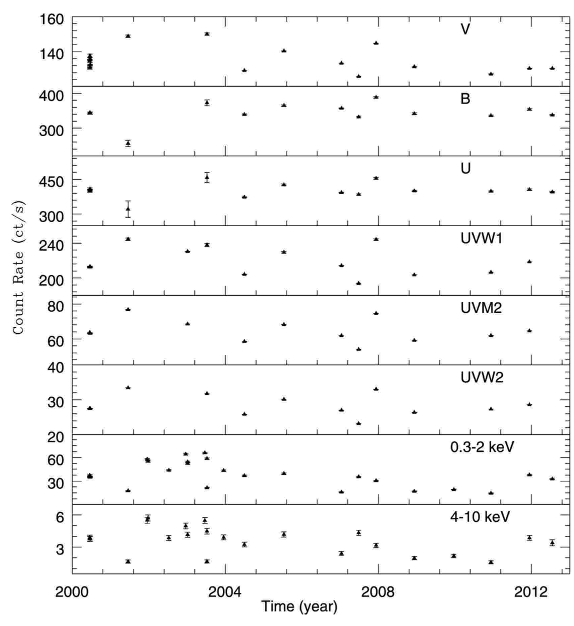

Figure 19. Optical/UV and X-ray long-term variability (2000–2012). The lower panel shows two X-ray bands, hard and soft, respectively from the bottom. Three UV bands with increasing wavelength are plotted just above X-ray bands and in the upper panel, optical U, B and V bands are shown.

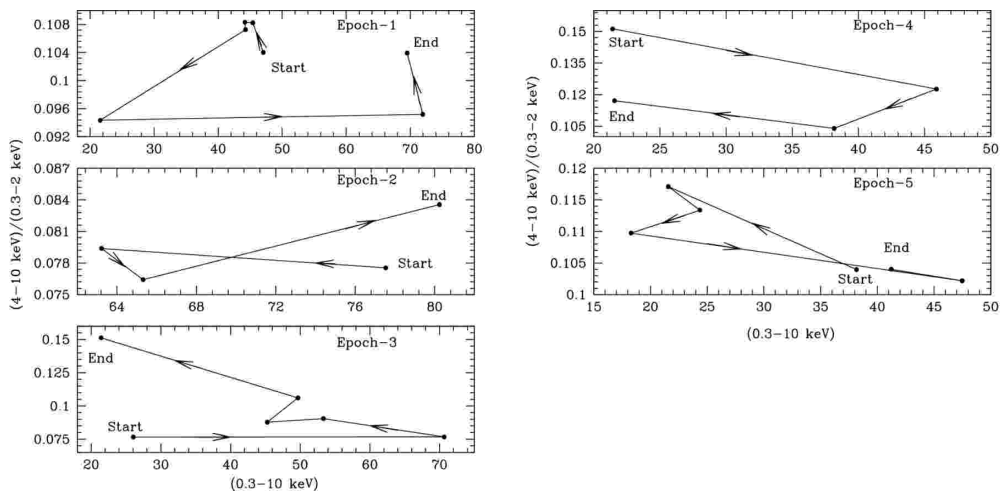

Figure 20. Spectral evolution of 3C 273 in different epochs. Arrows indicate the directions of the loops. Here, the term epoch in the plots represent different time intervals during which the data were acquired for each corresponding loop: Epoch-1 = 13.06.2000–22.12.2001; Epoch-2 = 17.12.2002–18.06.2003; Epoch-3 = 07.07.2003–12.01.2007; Epoch-4 = 12.01.2007– 09.12.2008; Epoch-5 = 06.12.2007–16.07.2012. The clockwise and anti-clockwise loops are distinct and closed or nearly so, presenting a clear evidence of alternate acceleration and cooling mechanism.

ratio analysis in the X-ray regime indicates that the particle acceleration mechanism dominates the cooling mechanism during most of the ~12 yr span of these observations. [Kalita, N.**, Gupta, A. C.,** Witta, P. J., **Bhagwan, J.** & Duorach, K. (2015). *Mon. Not. Roy. Astron. Soc., 451,* 1356-1365]

The long term (~ 1.6 years) Kepler satellite optical data of the blazar W2R 1926+42 indicates a variety of variability properties during different intervals of observations. The normalized excess variance ranges from 1.8% in the quiescent phase and 43.3% in the outburst phase. Time series analysis using the Fourier power spectrum and the wavelet analysis methods give characteristic time-scales and statistically significant quasi-periodic oscillations (QPOs). The authors obtained a black hole mass of (1.5 - 5.9) * 10^7 $M_\odot$ for the first time for the blazar. A possible QPO peaked at 9.1 day and lasting 3.4 cycles. They argued that the observed variability and the weak and short duration QPO could be due to jet based processes including orbital features in a relativistic helical jet and others such as shocks and turbulence. [Mohan, P., **Gupta, A. C.,** Bachev, R. & Strigachev, A. (2016). *Mon. Not. Roy. Astron. Soc., 456,* 654-664]

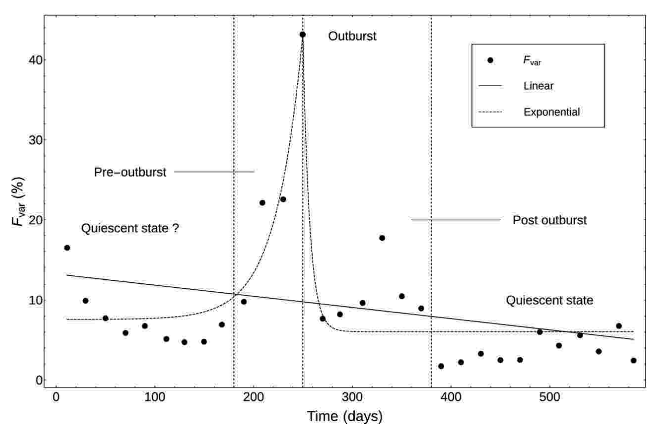

Figure 21. F_{var} as a function of observation time. The measured values follow the variability pattern of the light curve in the figure and indicate the following distinct regions: a possible quiescent phase (0–180 d), a pre-outburst phase (180–250 d), an outburst at 250 d, a post-outburst phase (250–380 d) containing a smaller outburst at ~ 330 d, followed by a quiescent phase (380–589 d) with F_{var} ranging between 1.8 and 43.3 per cent. For specific details of F_{var} ranges during each phase and the fits carried out, refer to text.

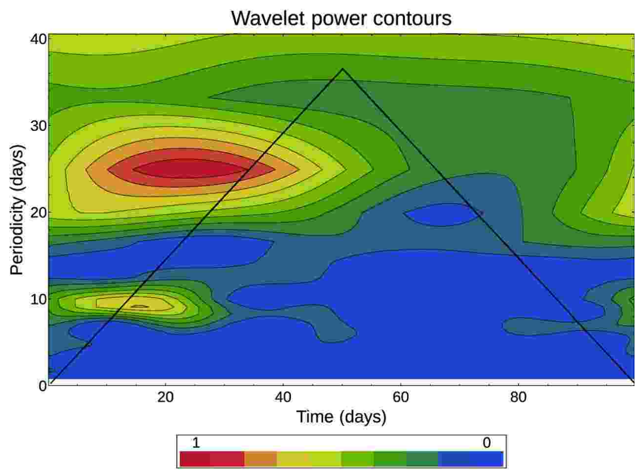

Figure 22. Wavelet analysis of segment 1 light curve (0–100 d) showing strong QPO features peaked at 9.1 d and 24.1 d. Red contours are highly significant levels in the power spectrum and blue contours correspond to the average background power. The power spectrum peaks outside the cone of influence (black triangle shaped region) could be affected by edge effects due to the cyclic nature of the sampling wavelet process.

6. Core-collapse supernovae

Core collapse supernovae are the magnificent explosions that mark the violent end of massive stars. These events are the most energetic explosions in the cosmos, releasing energy of order 10^{53} erg at the staggering rate of 10^{45-46} watts. Elements heavier than helium (through the iron group) are synthesized during the course of stellar evolution, and via supernovae, are delivered back into the interstellar medium to be reprocessed later in new stars, solar systems, and other astrophysical systems. Core collapse supernovae occur when the iron core of a massive star collapses under its own gravity. Once the density in the core exceeds that of nuclear matter, the core rebounds generating pressure waves that propagate outward. At the sonic point (the point at which the velocity of the infalling material exceeds the velocity of sound) the pressure waves become a shock wave that propagates toward the surface of the iron core. A shock generated by this process, collapse and bounce, lacks the energy needed to overcome dissipation due to iron dissociation and neutrino losses and will stall before reaching this surface. Majority of the core-collapse supernova are classified as Type II SNe, which show presence of hydrogen lines in their spectra and their progenitors are thought to have retained enough hydrogen until the time of explosion. About 90% of all Type II are sub-classified as Type IIP, which displays plateau of about hundred days in the V-band light curves. On the other hand, Type Ibc events are commonly referred as stripped-envelope supernovae, as their outer layers of hydrogen and/or helium are stripped off before the explosion.

SN 2013ab: a normal Type IIP supernova in NGC 5669

The nature of progenitor system for supernovae explosions remains fairly uncertain. The ultraviolet-optical photometric and low-resolution optical spectroscopic observations of the Type IIP supernova 2013ab in the nearby (about 24 Mpc) galaxy NGC 5669, from 2 to 190 days after the explosion have been collected and studied. The light curve and spectra suggest that the supernova is a normal Type IIP event with a plateau duration of about 80 days with mid-plateau absolute visual magnitude of −16.7, although with a steeper decline during the plateau (0.92 mag per 100 day in V band) relative to other archetypal SNe of similar brightness. The velocity profile of SN 2013ab shows striking resemblance with those of SNe 1999em and 2012aw. Following the theoretical prescriptions, the initial temperature evolution of the SN emission allows us to estimate the progenitor radius to be about 800 Solar radius indicating that the SN originated from a red supergiant star. General relativistic, radiation hydrodynamical modeling of the SN infers an explosion energy of 0.35×10^{51} erg, a progenitor mass (at the time of explosion) of about

9 Solar mass and an initial radius of about 600 Solar-radius. **[Bose, S.**, et al. (including **Misra, K., Kumar, Brijesh, Kumar, Brajesh** & **Pandey, S. B.**) (2015). *Mon. Not. Roy. Astron. Soc., 450,* 2373-2392]

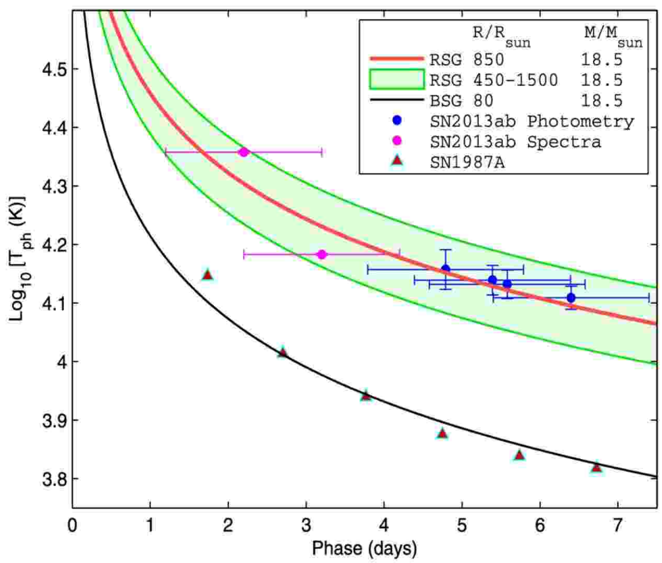

Figure 23. Constraining radius of progenitor star. The red solid line is the best fit for RGS of 850 $R_{\odot}$ for SN 2013ab temperatures and the black solid line is for BSG of 80 $R_{\odot}$ for SN 1987A temperatures.

SN 2013ej: A Type IIL Supernova with Weak Signs of Interaction

The interactions of SN ejecta with the circumstellar medium is least understood and so far the observation evidence is found only for a few supernovae. Here the authors present optical photometric and spectroscopic observations of SN 2013ej. It was one of the brightest Type II supernovae (SNe II) exploded in a nearby (~ 10 Mpc) galaxy, NGC 628. The light-curve characteristics are similar to SNe II, but with a relatively shorter (about 85 days) and steeper (about 1.7 mag per 100 days in V) plateau phase. The SN 2013ej shows a large drop of 2.4 mag in V-band brightness during the plateau-to-nebular transition. The absolute ultraviolet (UV) light curves are identical to SN 2012aw, showing a similar UV-plateau trend extending up to 85 days. The radioactive 56Ni mass estimated from the tail luminosity is 0.02 Solar-mass, which is significantly lower than typical SNe IIP. The characteristics of spectral features and evolution of line velocities indicate that SN 2013ej is a Type II event. However, light-curve characteristics and some spectroscopic features provide strong support in classifying it as a Type IIL event. A detailed SYNOW modeling of spectra indicates the presence of some high-velocity components in Hα and Hβ profiles

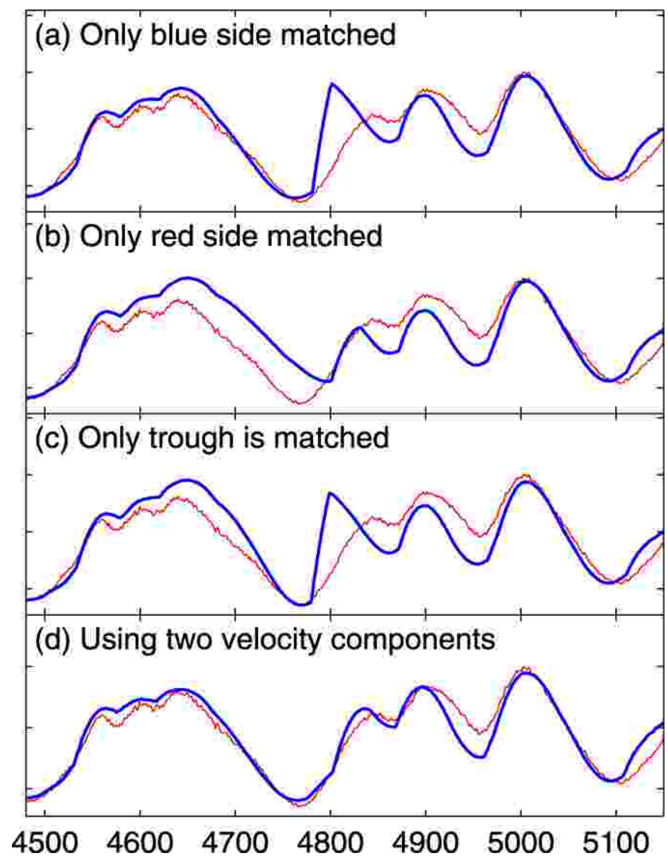

Figure 24. For the 68-day spectrum, the Hβ profile is fitted using SYNOW with various velocity components:(a) fit only with a single HV component to match the blue wing of the absorption dip, (b) with a single low-velocity component to match the red wing, (c) with a single velocity to only fit the trough, (d) with two velocity components to fit the entire absorption profile.

(Figure 24), implying a possible ejecta –circumstellar medium interaction. The nebular phase spectrum shows an unusual notch in the Hα emission, which may indicate bipolar distribution of 56Ni. Modeling of the bolometric light curve yields a progenitor mass of about14 Solar-mass and a radius of about 450 Solar-radius, with a total explosion energy of about 2.3 x 10^{51} erg. **[Bose, S.,** et al. (including **Kumar, Brijesh, Misra, K.** & **Singh, M.** (2015). *Astrophy. Jr., 806,* 160 (18pp)]

Photometric and polarimetric observations of fast declining Type II supernovae 2013hj and 2014G

The Supernova events with rare features provide opportunity to test critical elements of theoretical assumptions. The broad-band photometric and polarimetric observations of two Type II supernovae (SNe) 2013hj and 2014G, were investigated. SN 2014G is a spectroscopically classified Type IIL event, which the authors have also confirmed photometrically because its light curve shows characteristic features – a plateau slope of 2.55 mag per 100 days in the V band and a duration of about 77 days of a generic Type IIL SN. However, SN 2013hj also shows a high plateau decline rate of 1.5 mag per 100 days in the V band, similar to SNe IIL, but marginally lower than SNe IIL template light curves. Their high cadence photometric observations of SNe 2013hj and 2014G enables them to cover all characteristic phases up to the radioactive tail of optical light curves. Broad-band polarimetric observations reveal some polarization in SN 2013hj with subtle enhancement as the SN evolves towards the plateau end. However, the polarization angle remains constant throughout the evolution (**Figure 25**). This characteristic is consistent with the idea that the evolving SN with recombining hydrogen envelope is slowly revealing a more asymmetric central region of explosion. Modelling of the bolometric light curve yielded a progenitor mass of ~11M with a radius of about 700 R for SN 2013hj, while for the SN 2014G model estimated progenitor mass is about 9 Solar-mass with a radius of about 630 Solar-radius, both having a typical energy budget of about 2 x10^{51} erg. **[Bose, S.** et al. (including **Kumar, Brijesh, Misra, K., Kumar, Brajesh** and **Singh, Mridweeka**) (2016). *Mon. Not. Roy. Astron. Soc., 455,* 2712-2730]

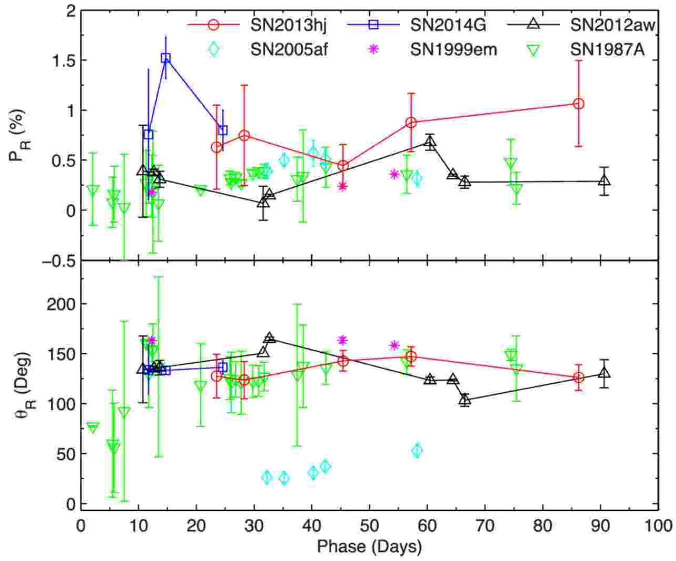

Figure 25. Broad-band polarimetric evolution of SNe 2013hj and 2014G are compared with other SNe IIP.

Broad-band polarimetric investigation of the type II-plateau supernova 2013ej

The authors present results based on follow-up observations of the Type II-plateau supernova (II-P SN) 2013ej at six epochs spanning a total duration of ˜37 d. The R_C-band linear polarimetric observations were carried out between the end of the plateau and the beginning of the nebular phase, as demarcated in the photometric light-curve. The contribution arising from interstellar polarization (ISP) was constrained using two approaches, namely based on observations of foreground stars lying within a 5-arcmin and a 10° radius of the SN location, and by investigating the extinction arising from the Milky Way and host galaxy in the direction of the SN. Our analysis revealed that in general the intrinsic polarization of the SN was higher than the polarization values for the foreground stars and exhibited an increasing trend during our observations. After correcting for the ISP of ˜0.6 per cent,the maximum intrinsic polarization of SN 2013ej was found to be 2.14 ± 0.57 per cent. Such a strong polarization has rarely been seen in II-P SNe. If this procedure is justified (i.e. the `polarization bias' effect is indeed negligible) the polarization could be caused by the asymmetry of the inner ejecta of the SN, because the ISP towards the SN location is estimated to be, at most, 0.6 per cent. **[Kumar, Brajesh, Pandey, S. B.**, Eswaraiah, C. & Kawabata, K. S. (2016). *Mon. Not. Roy. Astron. Soc., 456,* 3157-3167]

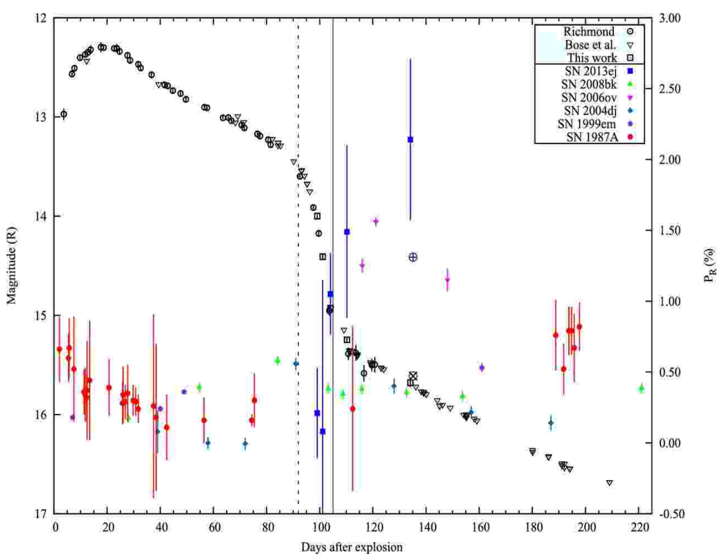

Figure 26. Photometric and polarimetric evolution of SN 2013ej. The calibrated R_C-band photometric light-curve from Richmond (2014), Bose et al. (2015) and estimated from the AIMPOL observations in the present study are shown with different symbols (in the cyan-shaded upper portion of the legend). The intrinsic polarization values of various Type II-P SNe (indicated in the legend) along with SN 2013ej are over-plotted for comparison. The two vertical lines, dotted (black) and continuous (grey), respectively, indicate the end of the plateau and the beginning of the nebular. The encircled (brown) plus and cross symbols represent the limiting polarization and limiting photometric magnitude, respectively.

Broadband observations of the gamma-ray emitting narrow line Seyfert 1 galaxy SBS 0846+513

The results of a broadband study of the γ-ray emitting narrow line Seyfert 1 (NLSy1) galaxy SBS 0846+513 (z = 0.585) are presented by the authors. This includes multiband flux variations, γ-ray spectral analysis, broadband spectral energy distribution (SED) modeling, and intranight optical variability (INOV) observations carried out over six nights between 2012 November and 2013 March using the 2 meter Himalayan Chandra Telescope and the 1.3 meter telescope at Devasthal, India. Multiple episodes of flaring activity are seen in the γ-ray light curve of the source which are also reflected in the observations at lower frequencies. A statistically significant curvature is noticed in the seven years averaged γ-ray spectrum, thus indicating its similarity with powerful flat spectrum radio quasars (FSRQs). Modeling the SEDs with a one-zone leptonic emission model hints that the optical UV spectrum is dominated by synchrotron radiation, whereas inverse Compton scattering of broad line region photons reproduces the γ-ray part of the SEDs. The source was found to be variable on all the six nights of optical observations with a variation of ~0.3 mag within a single night, coinciding with a high γ-ray activity state. The observed large amplitude INOV clearly indicates the presence of a closely aligned beamed relativistic jet in SBS 0846+513. Our broadband study supports the recent claims in literature that γ-ray emitting NLSy1 galaxies are similar to blazars and constitute the low black hole mass counterparts to FSRQs. [Paliya, V. S., Rajput, B., Stalin, C. S. & **Pandey, S. B.** (2016). *Astroph. Jr., 819*: 121 (8pp.)]

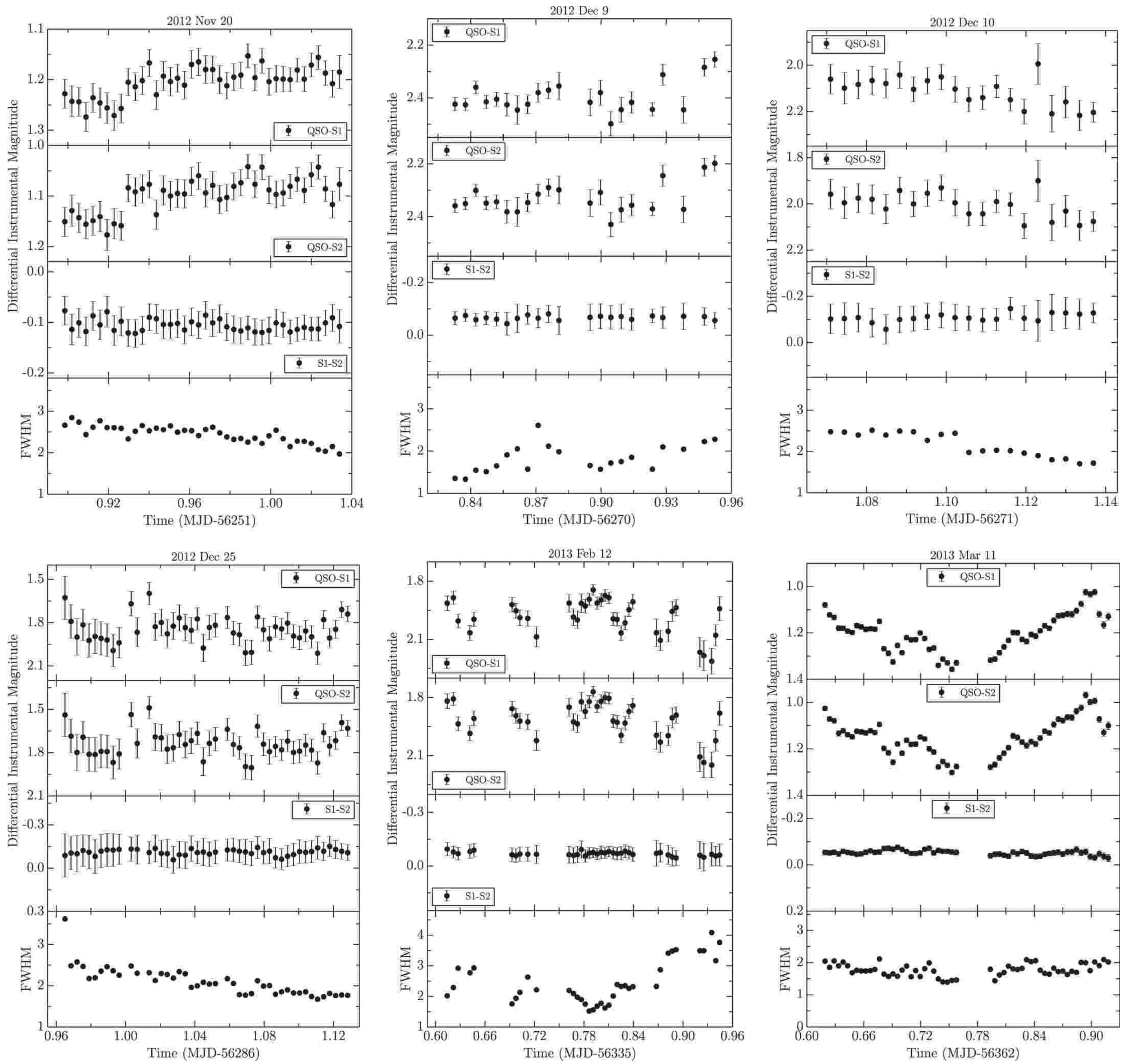

Figure 27. Intranight differential light curves of SBS 0846+513. The bottom panel of each plot shows the variations of the FWHM of the stellar images during the night. QSO refers to the source SBS 0846+513, while S1 and S2 denote the two comparison stars selected to generate the differential light curves.

7. Numerical Studies

Radiatively driven relativistic jets with variable adiabatic index equation of state

Astrophysical jets are ubiquitous, as they are associated with many classes of astrophysical objects such as active galactic nuclei (AGN e.g. M87), young stellar objects (e.g. HH 30, HH 34), X-ray binaries (e.g. SS433, Cyg X-3, GRS 1915+105, GRO 1655−40) etc. However, only jets around X-ray binaries like GRS1915+105 and AGN like 3C273, 3C345, M87 are relativistic. In this work the authors have concentrated on relativistic jets where they investigated a fluid jet driven by radiation from a shocked accretion disc around a non-rotating black hole approximated by Paczyński–Wiita potential. The sub-Keplerian and Keplerian accretion rates control the shock location and therefore, the radiation field around the accretion disc. They computed the radiative moments with full special relativistic transformation. The effect of a fraction of radiation absorbed by the black hole has been approximated, over and above the special relativistic transformations. They showed that the radiative moments around a supermassive black hole are different compared to those around a stellar mass black hole. They showed that the terminal speed of jets increases with the mass accretion rates, synchrotron emission of the accretion disc, and reduction of proton fraction of the flow composition. To obtain relativistic terminal velocities of jets, both thermal and radiative driving are important. They showed that for very high accretion rates and pair dominated flow, jets around supermassive black holes are truly ultrarelativistic, while for jets around stellar mass black holes, terminal Lorentz factor of about 10 is achievable. [**Vyas, M. K., Kumar, Rajiv,** Mandal, S. & **Chattopadhyay, I.** (2015). *Mon. Not. Roy. Astron. Soc., 453,* 2992-3014]

Research Working Group – II

All the scientists working on the Sun and Atmospheric Sciences are members of WG – II. The group consists of 5 scientists. The solar physics research group (consisting of one 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.

Solar Physics

Formation of a rotating jet during the filament eruption on 2013 April 10 – 11

Among the different types of plasma motions observed during solar eruptive events in the corona and chromosphere, there are apparently linear collimated plasma flows, which are presumably guided by magnetic fields, usually referred to as jets. The authors have analysed multiwavelength and multiviewpoint observations of a helically twisted plasma jet formed during a confined filament eruption on 2013 April 10 – 11. Given a rather large-scale event with its high spatial and temporal resolution observations, it allowed them to clearly understand some new physical details about the formation and triggering mechanism of twisting jet. They identified a pre-existing flux rope associated with a sinistral filament, which was observed several days before the event. The confined eruption of the filament within a null-point topology, also known as an Eiffel tower (or inverted-Y) magnetic field configuration results in the formation of a twisted jet after the magnetic reconnection near a null point. The sign of helicity in the jet is found to be the same as that of the sign of helicity in the filament. Untwisting motion of the reconnected magnetic field lines gives rise to the accelerating plasma along the jet axis. The event clearly showed the twist injection from the pre-eruptive magnetic field to the jet. [Filippov, B., et al. (including **Uddin, W.**) (2015). *Mon. Not. Roy. Astron. Soc, 451,* 1117-1129]

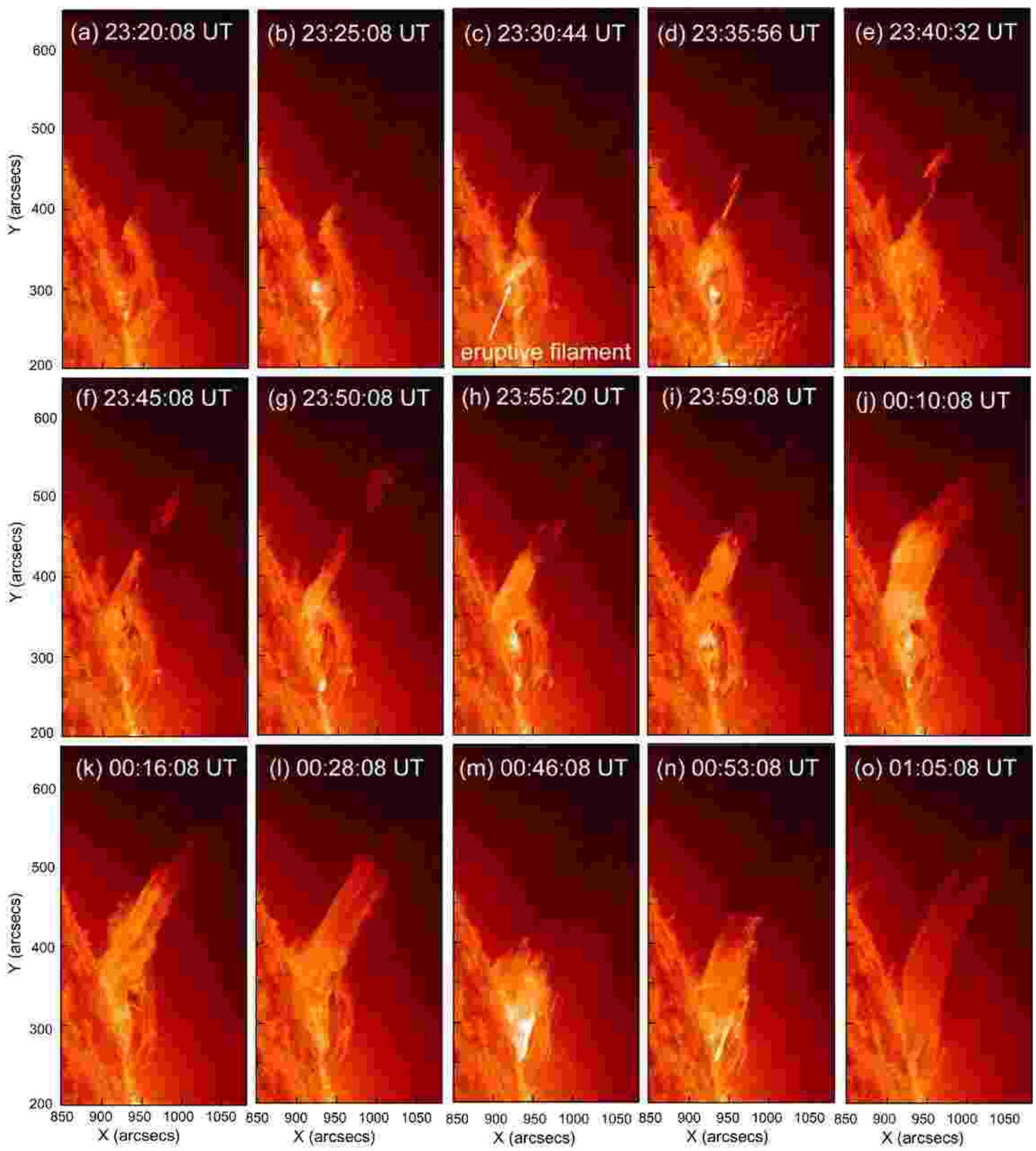

Figure 28. Sequence of selected SDO/AIA 304 Å images showing a filament eruption and formation of a set of three successive helically twisted jets.

Atmospheric Sciences

Investigation of aerosol optical, physical, and radiative characteristics of a severe dust storm observed over UAE

In this work, a comprehensive analysis has been performed for the first time of the dynamical processes triggering the occurrence of the two heavy dust storms occurred in March 2012 over the Middle East region. The dynamics of this event are related to the coupling of subtropical jet and polar jet over the Saudi Arabia region, resulting in massive dust storm generation and dust transport through Rub' al Khali and the Persian Gulf to the UAE region **(Figure 29)**. AOD and PM10 values showed a fourfold increase during the event and also the spatial extent of the dust storm is evident from the extremely high concentration of MODIS AOD and OMI aerosol index covering the entire Middle East region. Moreover, surface temperature showed a decrease of almost 15 °C during the event signifying the intensity of the dust storm. ARF estimates showed huge increase during the dust storm and present study evidences that the dust layer caused an additional warming of ~150 Wm^{-2} in the atmosphere over the Middle East region. The present event showcases the importance of dust storm induced aerosol optical and physical processes, and associated atmospheric dynamics over UAE as well as other affected regions. [Basha, G., **Phanikumar, D. V.**, Kumar, K. N., Ouarda, T. B. M. J. & Marpu, P. R. (2015). *Remote Sens. Envi., 169*, 404-417]

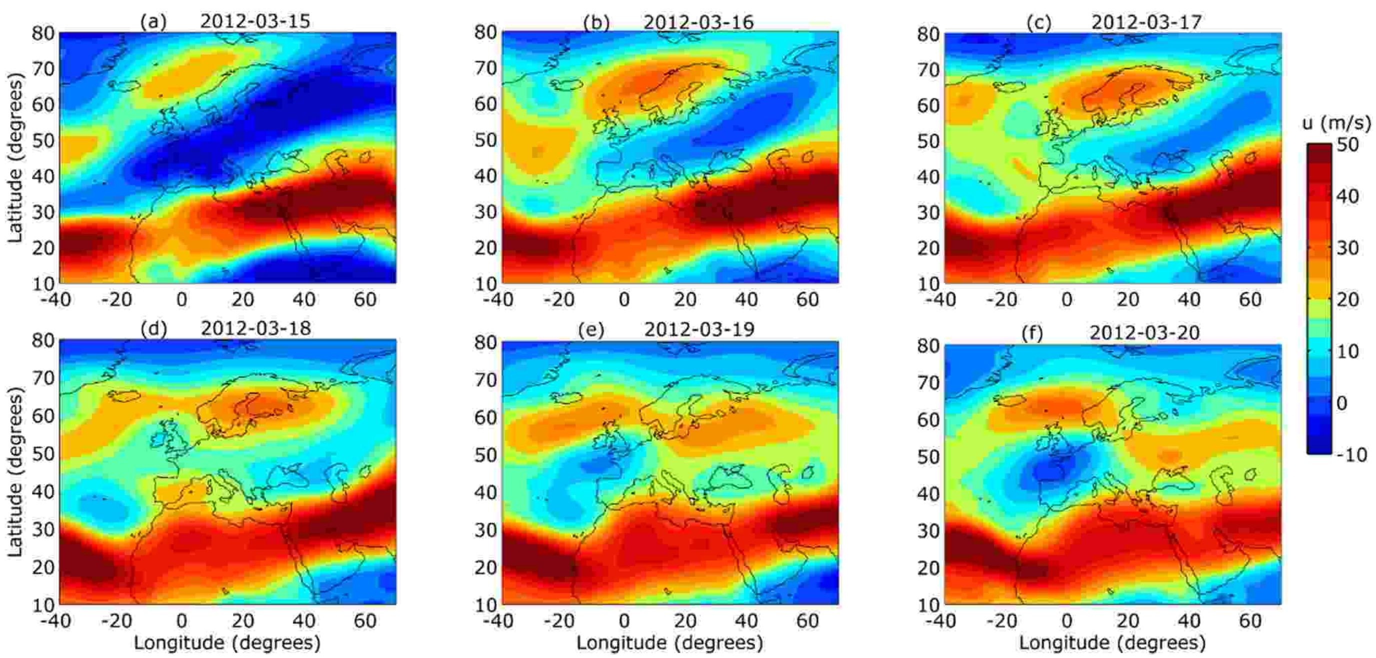

Figure 29. a–f. Zonal wind speed from ERA-interim reanalysis data at 150 hPa from 15 to 20 March 2012.

Modulation of surface meteorological parameters by extratropical planetary-scale Rossby wave

In the study, the main focus of the authors was to examine the link between upper tropospheric planetary-scale Rossby waves and surface meteorological parameters for the first time at an extra-tropical site over Central Himalayan region. The spectral analysis showed the dominant periodicities of around 8 days in the upper troposphere wind fields during the observational period. Moreover, 200 hPa meridional wind (v200 hPa) anomalies from the MERRA reanalysis dataset shows distinct Rossby-wave-like structures characterized by zonal wave number 6.

Interestingly, amplification of Rossby wave packets over the site leads to persistent sub-tropical jet stream (STJ) patterns further affecting the surface weather conditions (see fig below). It is evident that propagating Rossby waves in the upper troposphere along with the undulations in the STJ create convergence and divergence regions in the mid-troposphere. Therefore, the surface meteorological parameters such as the relative humidity, wind speeds, and temperature are synchronized with the phase of the propagating Rossby waves. The present study finds important implications for medium-range forecasting through the upper-level Rossby waves over the study region. [Kumar, K. N., **Phanikumar, D. V.,** Ouarda, T. B. M. J., Rajeevan, M., **Naja, M.** & **Shukla, K. K.** (2016). *Ann. Geophy., 34*, 123-132

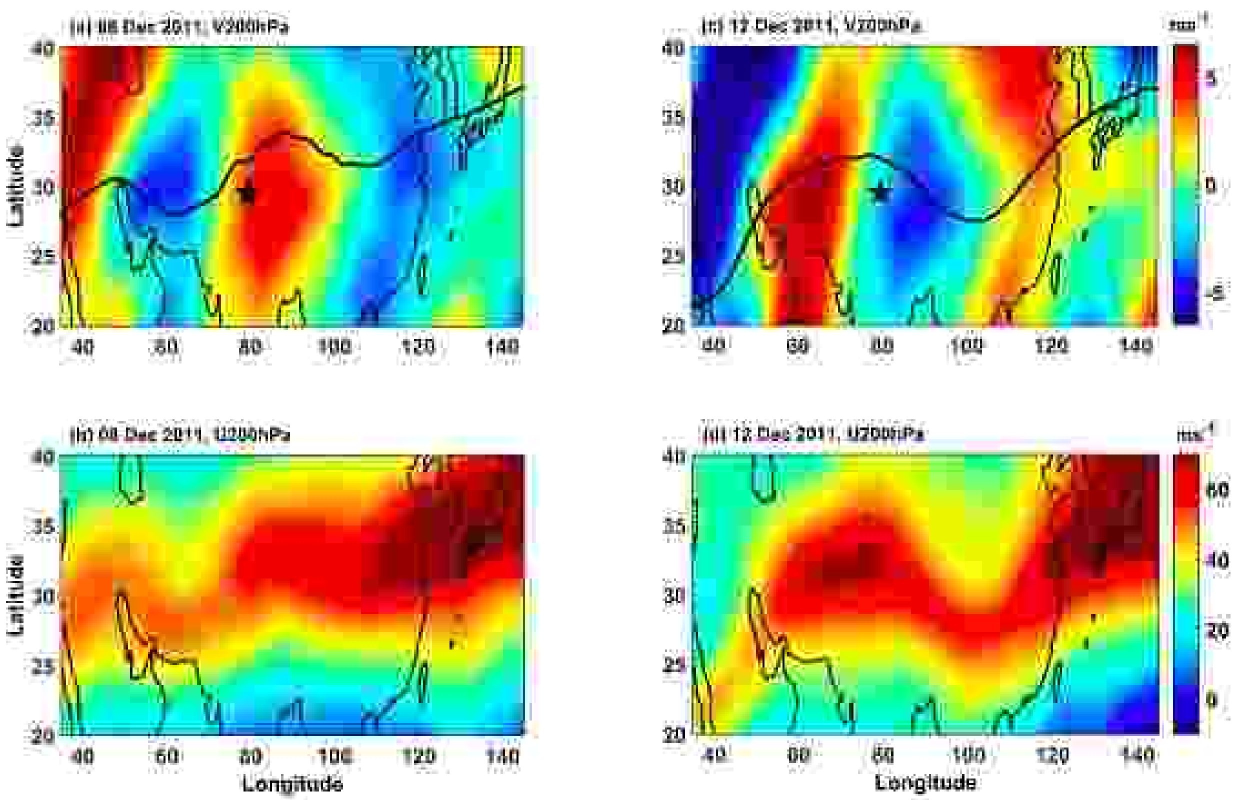

Figure 30. Meridional wind anomalies (a) at 200 hPa pressure level (v200 hPa) overlaid with the position of subtropical jet stream (thick solid black line) and zonal wind (b) at 200 hPa pressure level on 8 December 2011 obtained from MERRA reanalysis. (c) and (d) same as (a) and (b) except on 12 December 2011. The location of ARIES, Nainital (29.45° N, 79.5° E), is also indicated by the star in (a) and (c).

Effect of diurnal variation of aerosols on surface reaching solar radiation

In this report, the authors have attempted to quantify direct aerosol radiative forcing over central Himalayan region by considering the diurnal variation of aerosols and this study is first of its kind over the study region. The measured daytime aerosol optical depth (AOD) values are higher by a small magnitude ~15% during forenoon and reached as high as ~ 90% by late afternoon when compare to nighttime AOD. The above observations hint us about the transport of regional polluted aerosols to the observational site. Their results also showed 10 (16) % increment in the atmospheric radiative forcing due to diurnal variation of aerosols instead of average aerosols during winter (post-monsoon) season is quite significant. However, they surmised that it is extremely important to choose appropriate parameters like vertical distribution of different types of aerosol mass concentrations, aerosol optical properties, surface reflectance, mixing state of aerosols etc for reasonable assessment of aerosol radiative forcing especially over a high altitude sites where the diurnal variation of aerosols are significant. [Reddy, K., **Phanikumar, D. V., Joshi, H.,** Ahammed, Y. Z. & **Naja, M.** (2015). *Jr. Atmosph. Solar-Terr. Phy., 129,* 62-68

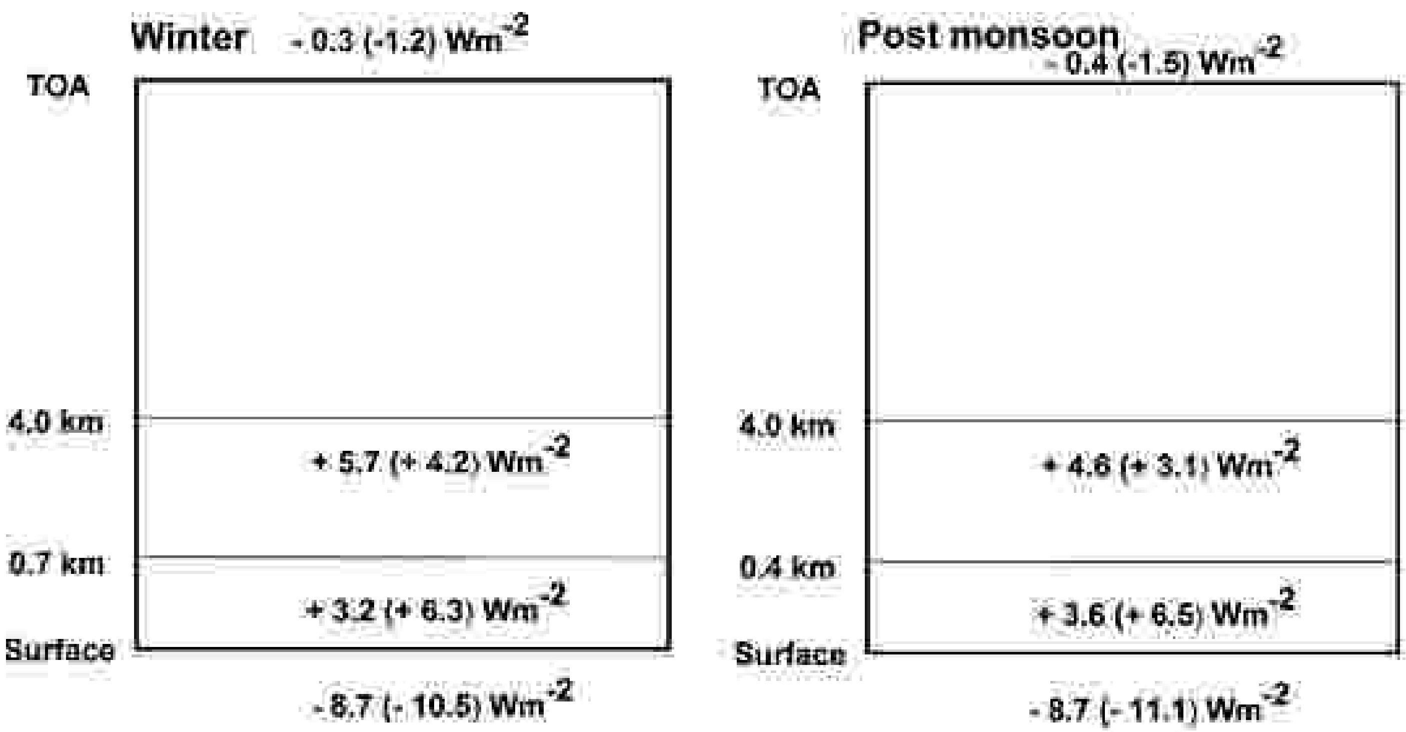

Figure 31. Derived aerosol radiative forcing (Wm^{-2}) at top of atmosphere (TOA), surface and in the atmosphere (AF) for winter and post-monsoon seasons. Radiative forcing values for the instantaneous properties of aerosol cases represent insides the brackets.

Time-variability of surface-layer characteristics over a mountain ridge in the central Himalayas during the spring season

Over homogeneous flat surfaces, diurnal evolution of Atmospheric Boundary Layer (ABL) is primarily controlled by the variations in net radiation balance, energy fluxes, surface characteristics (including vegetation and soil moisture), and the background meteorological conditions. In contrast, the diurnal evolution of ABL meteorological parameters, energy and momentum fluxes and circulation over mountainous region are further substantially modulated by topography and the associated land cover heterogeneities. Strength of the large-scale prevailing wind and its orientation with the orography as well as the sheltering effects produced by the mountain and trees further add to the complexities in evolution of ABL over mountainous terrain. Knowledge of the diurnal variations of meteorological parameters and surface-layer characteristics is essential for improving the understanding of mountain meteorology, assessment of the impact of topography in regulating ABL processes, as well as the accurate parametrization of the ABL processes, in order to improve the performance of atmospheric circulation models. Diurnal variations in the surface-layer characteristics and mountain circulation play vital role in regulating the transport or trapping of pollutants from valleys and is a decisive factor in the occurrence of atmospheric pollution episodes in the Himalayan region.

A micrometeorological laboratory has been established at ARIES, under the NOBLE (Network of Observatories for Boundary Layer Experiment) project of Indian Space Research Organization's Geosphere-Biosphere Program (ISRO-GBP). The laboratory is equipped with a 27 m meteorological tower equipped with two ultrasonic anemometers (mounted at 12 and 27 m level) providing fast response (25 Hz) measurements of the three orthogonal wind components and acoustic temperature. Focussing primarily on the diurnal evolution of ABL in fair weather conditions, in this study for the period of March-May 2013, 46 mostly cloud-free days (except for the ABL clouds) were selected, discarding the days with significant cloudiness or precipitation. Since the measurements for this study has been take over sloping terrain, the tilt corrections have been applied to sonic anemometer data using the planar-fit method, thus making the measurements comparable to those over other sites. After the application of planar fit method on the data set, the surface layer parameters are estimated over averaging time of 30- min. The turbulence intensity is quantified through the magnitudes of *e*, whereas the exchange of energy and momentum fluxes are quantified through sensible heat flux (*H*) and vertical momentum flux (τ) respectively. The results are summarized below:

- Strong seasonal mean winds (6-10 m s^{-1}) in terms of synoptic scales are observed during spring season; the observational site being located at the northern fringe of this strong north-westerly wind regime. The wind speed generally increases from a minimum (< 3 m s^{-1}) at ≈ 0900 IST to maximize (> 6 m s^{-1}) around the evening and early night. The wind shear is quite significant during the evening and night, with its phase similar to the wind speed; the peak wind shear increases from March (typically ≈ 0.06 m $s^{-1}m^{-1}$) to April-May (typically 0.2 m $s^{-1}m^{-1}$). In general, the wind direction is mostly within a cone of 285° to 315° during the night-time and forenoon, while the occurrence of westerly winds (265-305°) increases during the afternoon as depicted by **Figure 32.**

- Monthly mean diurnal variations of *e*, *H*, τ and *z/L* derived from the tower-based fast-response sonic anemometer measurements at the 27-m level during March, April, and May are shown in **Figure 33**. Diurnal variation of *H* is highly prominent; it increases systematically after ≈ 0800 IST, attains peak values during 1200-1400 IST and decreases to negative night-time values by ≈ 1800 IST. The peak value of *H* is the largest (353±147 W m^{-2}) in May and the least (222±46 W m^{-2}) in March.

- The diurnal variation of *e* **(Figure 33 (b))** during March is quite small, while the values of *e* show an enhancement in the afternoon (especially during 1500-1600 IST) during April-May. These afternoon peak values of *e* observed during April-May are almost 30-50 % larger than the corresponding values observed during the night-time, indicating the magnitude of the increase in the turbulence strength during the afternoon.

- Diurnal variation of *z/L* **(Figure 33 d)** shows the development of instability during the daytime while the nocturnal surface-layer is generally stable or neutral. Analysis shows that during the daytime unstable conditions prevail for 85 % of the time, while the frequency of occurrence of stable conditions is 14 % at 27-m level. In contrast 10 % of the night-time is either unstable or neutral and stable conditions prevail only for about 90 % of the time at 27-m level. The significant occurrence of night-time neutral or unstable conditions is associated with the large wind shear during the early night, which leads to mixing of the surface-layer air mass.

This study provides rare experimental evidence (first of its kind over the Himalayan terrain) to show that the parameterization of surface layer turbulence characteristics over complex terrain is similar to those over flat homogeneous terrain, at least for the limited wind conditions. [**Solanki, R.** et. al. (including **Singh, N.)** (2016). *Boundary Layer Meteorology, 158*, 453-471]

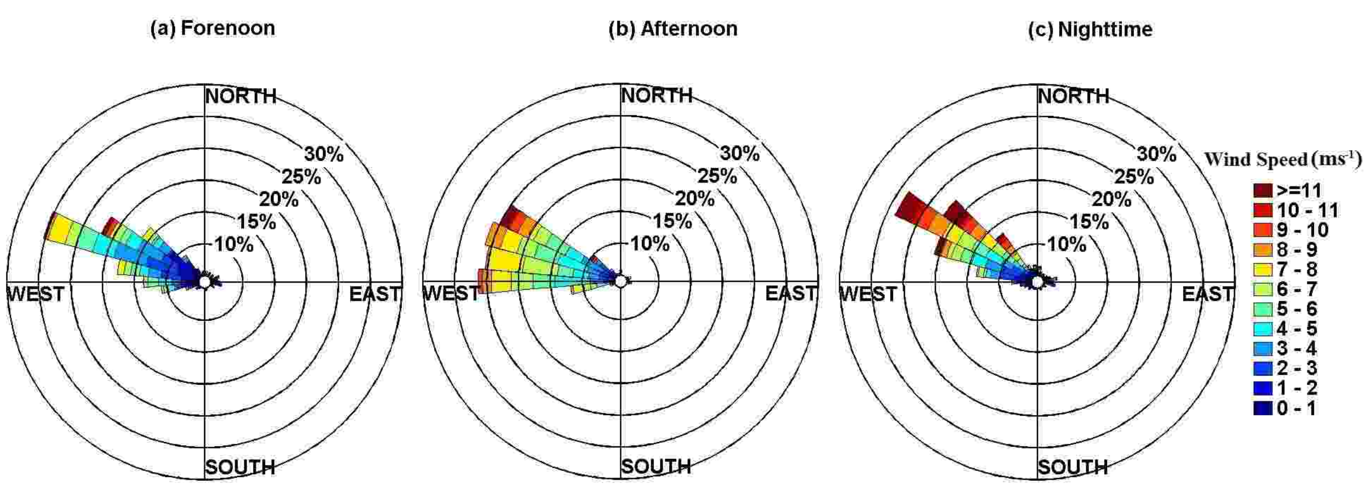

Figure 32. Wind roses at the 27-m level for (a) forenoon (0700-1200 IST), (b) afternoon (1300-1800 IST) and (c) night (1900-0600 IST) during the spring season of 2013.

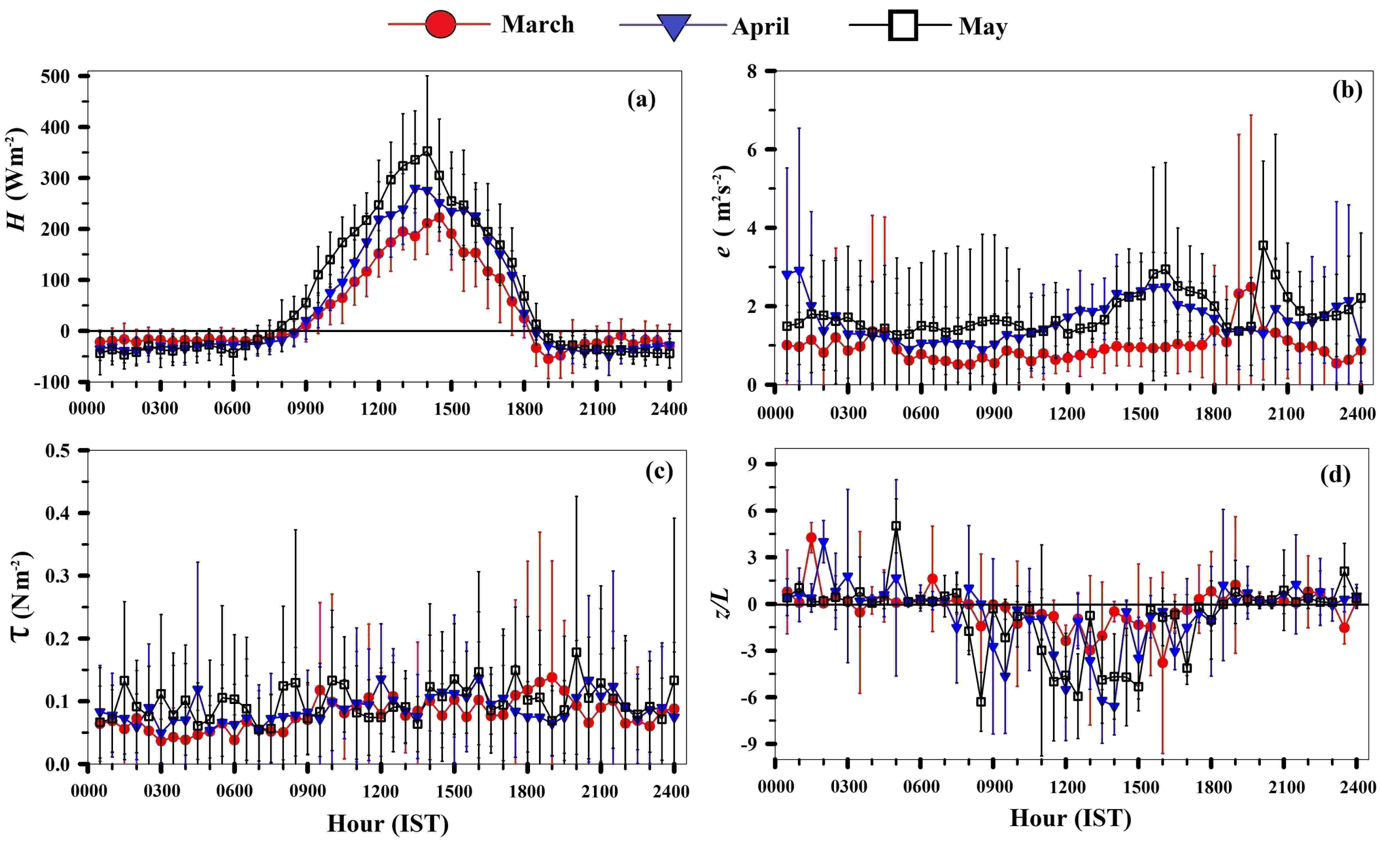

Figure 33. Monthly mean diurnal variations of (a) sensible heat flux (*H*), (b) turbulent kinetic energy (*e*), (c) momentum flux (*τ*) and (d) stability parameter (*z/L*) during March, April, and May of 2013. The vertical bars represent the standard deviations.

Carbonaceous aerosols and pollutants over Delhi urban environment: temporal evolution, source apportionment and radiative forcing

A year long samples of $PM_{2.5}$ were collected over Delhi, India during January to December 2012 and analysed for carbonaceous aerosols and inorganic ions (SO_4^{2-} and NO_3^-) to examine variations in atmospheric chemistry, combustion sources and influence of long-range transport. In addition to this, continuous (online) measurements of $PM_{2.5}$, black carbon (BC) mass concentration and carbon monoxide are also carried out. $PM_{2.5}$ (online) range from 18.2 to 500.6 μg m^{-3} (124.6 ± 87.9 μg m^{-3}) exhibiting higher night-time (129.4 μg m^{-3}) than daytime (103.8 μg m^{-3}) concentrations. The online concentrations are 38% and 28% lower than the offline during night and day, respectively. In general, larger night-time concentrations are found for the BC, OC, NO_3^- and SO_4^{2-}, which are seasonally dependent with larger differences during late post-monsoon and winter. The high correlation (R^2 = 0.74) between OC and EC along with the OC/EC of 7.09 (day time) and 4.55 (night-time), suggest significant influence of biomass-burning emissions (burning of wood and agricultural waste) as well as secondary organic aerosol formation during daytime. The Concentrated weighted trajectory (CWT) analysis reveals that the potential sources for the carbonaceous aerosols and pollutants are local emissions within the urban environment and transported smoke from agricultural burning in northwest India during post-monsoon. The BC radiative forcing estimates result in very high atmospheric heating rates (~1.8-2.0 K day^{-1}) due to agricultural burning effects during the 2012 post-monsoon season. [Bisht, D. S., et al. (including **Dumka, U. C.**). (2015). *Science of the Total Environment, 521-522,* 431-445]

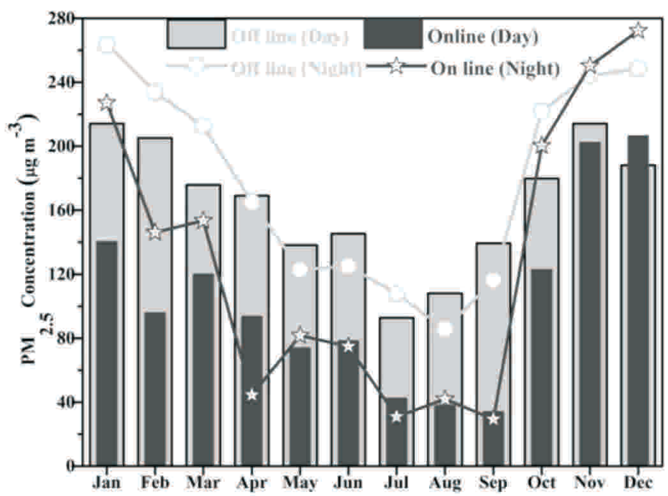

Figure 34. Monthly-mean variation of online and offline $PM_{2.5}$ mass concentrations during day and night.

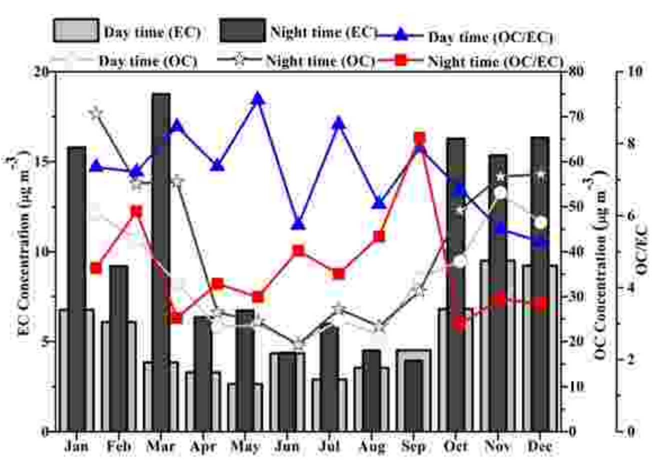

Figure 35. Monthly-mean variation of EC, OC and OC/EC during day and night obtained via offline measurements.

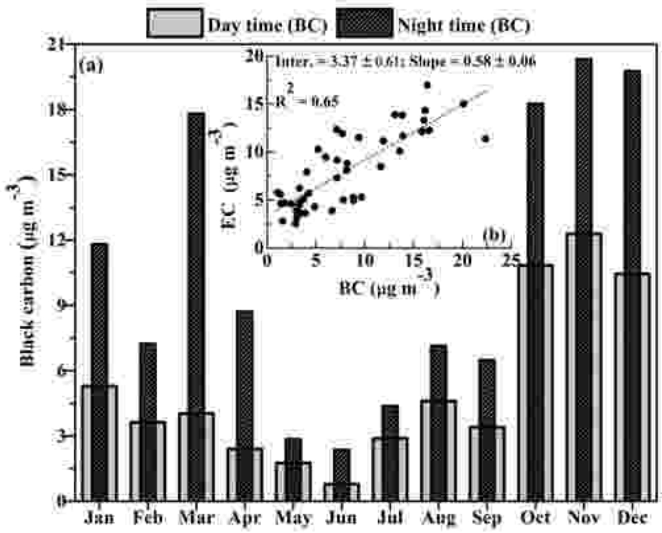

Figure 36. Monthly-mean variation of BC mass concentration (online measurements) during day and night and correlation with EC (inset graph).

Aerosol chemical characterization and role of carbonaceous aerosol on radiative effect over Varanasi in central Indo-Gangetic Plain

The chemical composition of PM_{10} aerosols at Varanasi located in the central Indo-Gangetic Plain (IGP) during April to July 2011, with emphasis on examining the contribution of elemental carbon (EC) to the estimates of direct aerosol radiative effect (DARE) is presented. The PM_{10} aerosol samples was analysed for the carbonaceous aerosols (Organic Carbon, OC and EC) along with water-soluble ionic species (WSIS: Cl^-, SO_4^{2-}, NO_3^-, PO_4^{2-} NH_4^+, Na^+, K^+, Mg^{2+} and Ca^{2+}). In addition to this, several diagnostic ratios (OC/EC, K^+/EC, etc) have been also used for studying the aerosol sources at Varanasi. The PM_{10} mass concentration varies between 53 and 310 μg m^{-3} (mean of 168 ± 73 μg m^{-3}), which is much higher than the National and International air quality standards. The OC mass concentration varies from 6 μg m^{-3} to 24 μg m^{-3} (mean of 12 ± 5 μg m^{-3}; 7% of PM_{10} mass), whereas EC ranges between 1.0 and 14.3 μg m^{-3} (4.4 ± 3.9 μg m^{-3}; ~3% of PM_{10} mass). The relative low OC/EC of 3.9 ± 2.0 and strong correlation (R^2 = 0.82) between them suggest the dominance of primary carbonaceous aerosols. The contribution of WSIS to PM_{10} is found to be ~12%, out of which ~57% and 43% are anions and cations, respectively. Using the SBDART radiative transfer model in conjunction with OPAC model the composite DARE and atmospheric heating rate was estimated. The estimated DARE reveal significant radiative effect and atmospheric heating rates (0.9 to 2.3 K day^{-1}). Although the EC contributes only ~3% to the PM_{10} mass, its contribution to the surface and atmospheric forcing is significantly high (37-63% and 54-77%, respectively), thus playing a major role in climate implications over Varanasi. [Tiwari, S., et al. (including **Dumka, U. C.)** (2016). *Atmospheric Envi., 125,* 437-449]

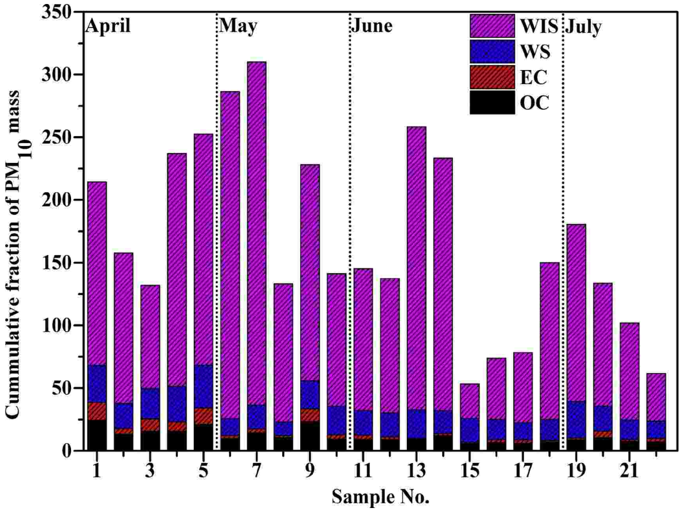

Figure 37. Cumulative fraction of PM_{10} samples collected at Varanasi during April – July 2011. The PM_{10} mass was separated for water soluble (WS), OC, EC and water insoluble/unidentified (WIS) aerosol.

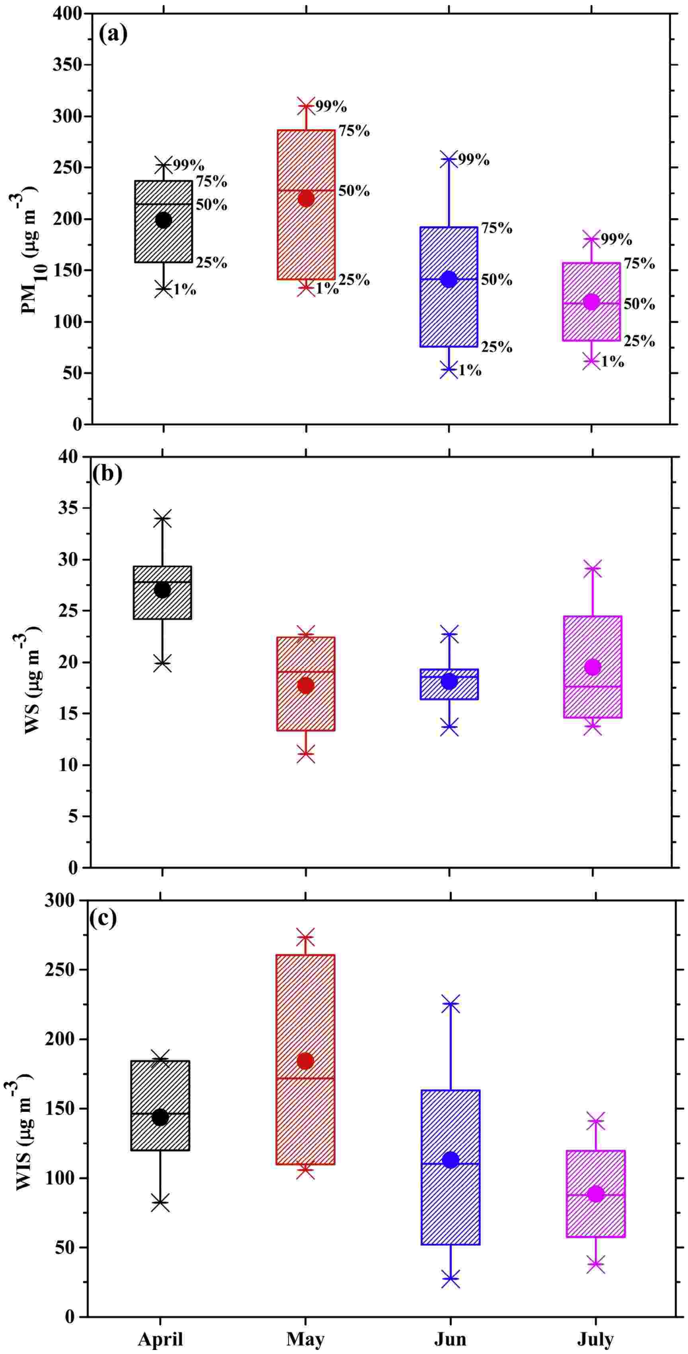

Figure 38. Monthly variation of PM_{10} (a), water soluble (WS) (b) and water insoluble/unidentified (WIS) (c) aerosol in Varanasi during April – July 2011. The circle in the box stands for mean and the horizontal line for median.

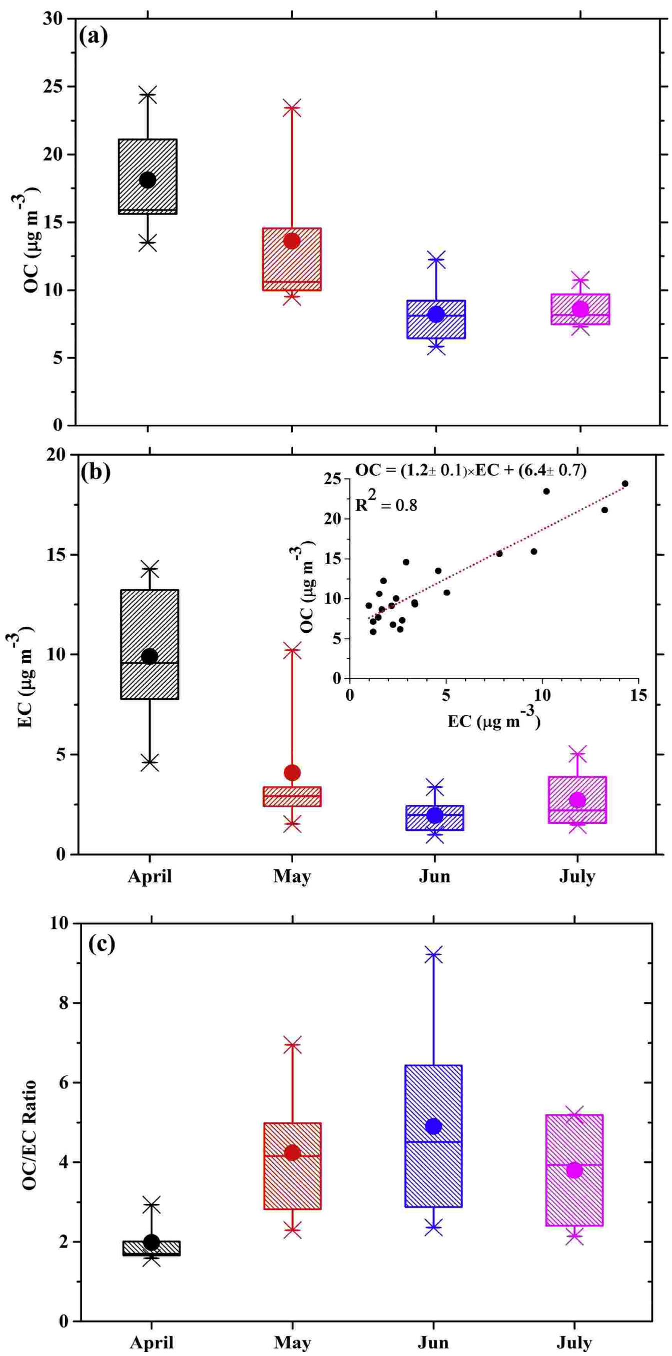

Figure 39. Monthly variation of mass concentrations of OC (a), EC (b) and their ratio (OC/EC) (c) in Varanasi during April – July 2011. The circle in the box stands for mean and the horizontal line for median. The inset graph shows the relationship between OC and EC.

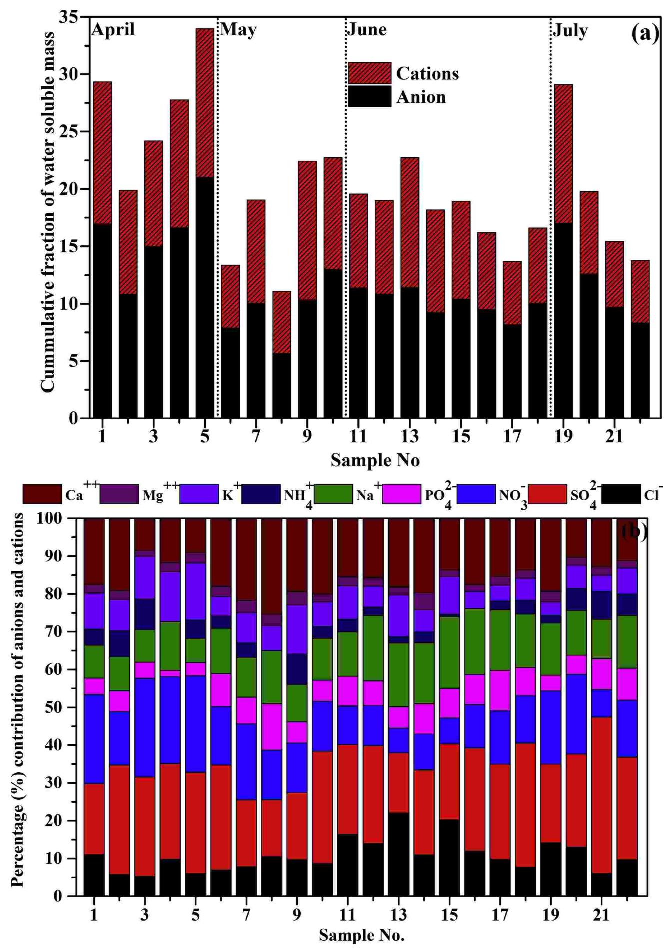

Figure 40. Cumulative fraction of anions and cations in the WS aerosol mass (a) and percentage (%) contribution of various ionic species on WS mass (b) in Varanasi during April – July 2011.

Variabilities in the biomass burning activities and pollution loading over South Asia

Satellite data of active fire, AOD and tropospheric column NO_2 are used to understand the effects of biomass burning on the tropospheric pollution loadings during 2003–2013. Biomass burning emission estimates from Global Fire Emission Database (GFED) and Global Fire Assimilation System (GFAS) are also used to quantify uncertainties and regional discrepancies in the emissions of carbon monoxide (CO) **(Figure 41),** nitrogen oxide (NO_x), and black carbon (BC) due to biomass burning in South Asia. It is shown that in the Asian continent, the frequency of fire activity is highest over Southeast Asia, followed by South Asia and East Asia. The annual biomass burning activity in north, central, and south regions shows an increasing tendency, particularly after 2008, while a decrease is seen in northeast region during 2003–2013. The increase in fire counts over the north and central regions contributes 24% of the net enhancement in fire counts over South Asia. MODIS AOD and OMI tropospheric column NO_2 retrievals are classified into high and low fire activity periods and show that biomass burning leads to significant enhancement in tropospheric pollution loading over both the cropland and forest regions. The enhancement is much higher (110–176 %) over the forest region compared to the cropland (34–62 %)

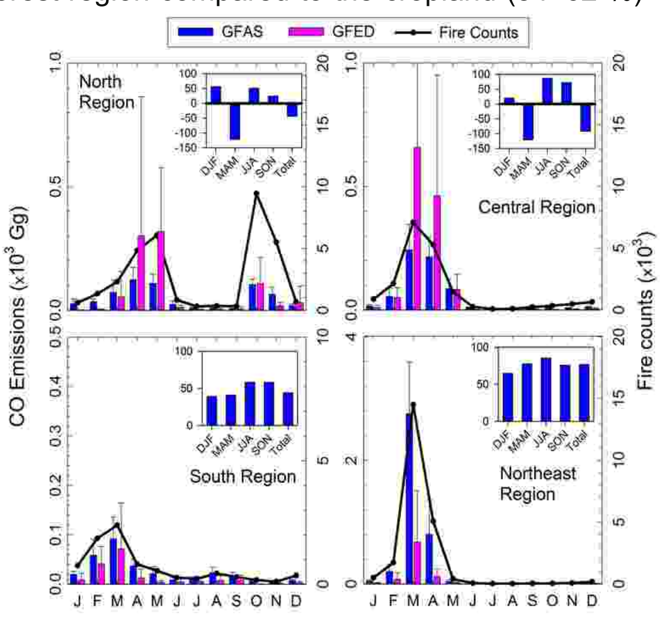

Figure 41. Seasonal variations in CO from biomass burning emissions using GFAS v1.0 and GFED v3.1 emission inventories for eight years (2003-2010). CO emissions are in 10^3 Giga-grams (10^9 grams) per month. Over plotted are the seasonal variations fire counts without 80% confidence condition applied. Inset, figures are showing % deviation in GFAS emissions with respect to GFED emissions.

region.[**Bhardwaj, P., Naja, M.,** Kumar, R. & Chandola, H. C. (2016).*Environ. Sci. Pollut. Res., 23,* 4397-4410]

First observations of light non-methane hydrocarbons (C_2–C_5) over the central Himalayas

Ozone production potential is significantly high for non-methane hydrocarbons (NMHCs), however its observation are not available over the Himalayan region. Here, for the first time, observations of light NMHCs are made in the central Himalayas with a complete seasonal cycle. The whole air samples collected with a frequency of 3 samples per week during April 2009-December 2011 and are analyzed

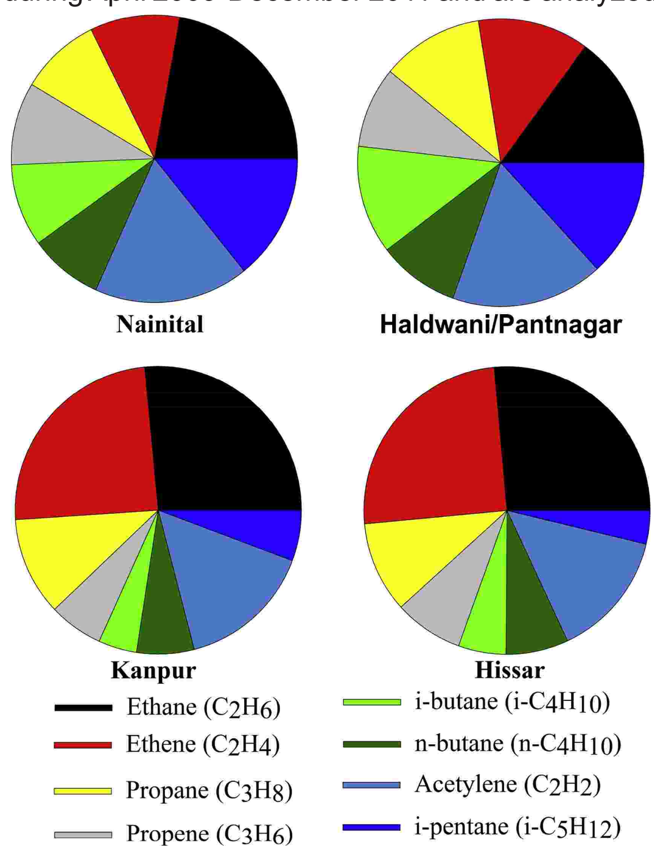

Figure 42. Contribution of different light NMHCs to their total at Nainital and Haldwani/Pantanagar and a comparison with other two urbanized sites in the IGP region in December.

using a Gas Chromatograph equipped with Flame Ionization Detector (GC-FID). CH_4 and NMHCs show a distinct seasonal cycle over this region with higher levels during winter and late autumn and lower levels during summer-monsoon. Regional differences in seasonal variations are shown, when compared with those over other sites in India **(Figure 42)**. Different NMHCs exhibit better correlations during autumn/winter as compared to summer-monsoon. The seasonal cycle of CH_4 at Nainital is found to be similar to other global high altitude sites (Jungfraujoch and Mauna Loa) but somewhat different than at a high altitude site Mt. Abu in India. NMHCs, other than ethane and propane, are found to be higher over this central Himalayan region than other sites. Additionally, composition of NMHCs is shown to be different over the study region when compared with other sites in the IGP region. A correlation study between ln((n-butane)/(ethane)) and ln((i-butane)/(ethane)) showed that oxidation by the OH radical is the main removal mechanism of these species over the central Himalaya and dilution maintains the ratios of these species. The lowest slope of propane and acetylene with CO during summer and spring are indicating absence of fresh air mass over this region. [**Sarangi, T.** et. al. (including **Naja, M., Bhardwaj, P., Ojha**, **N.** (2016). *Atmospheric Environment, 125*, 450–460]

Black carbon observations at a semi-urban site in the IGP region

Observations of black carbon (BC) from a semi-urban site (Pantnagar) near the Himalayan foothill showed two peaks (morning and evening) in the diurnal variations those are arising from the combined effects of the atmospheric boundary layer (ABL) dynamics and local emissions. The diurnal amplitudes as well as the rates of diurnal evolution are observed to be highest in winter season, followed by autumn, and the lowest in summer-monsoon **(Figure 43)**. BC exhibits nearly an inverse relation with mixing layer depth in all seasons; being strongest in winter (R^2=0.89) and weakest (R^2=0.33) in monsoon (July-August). Unlike BC, co-located aerosol optical depths (AOD) and aerosol absorption are highest in spring over IGP, probably due to the presence of higher abundances of aerosols (including dust) above the ABL. AOD (500 nm) showed annual peak (>0.6) in May-June, dominated by coarse mode, while fine mode aerosols dominated in late autumn and early winter. Aerosols profiles from CALIPSO show highest values close to the surface in winter/autumn, similar to the feature seen in surface BC, whereas at altitudes > 2 km, the extinction is maximum in spring/summer. The WRF-Chem model captures most of the important features of the diurnal and seasonal variations but significantly underestimated the observed BC levels, suggesting improvements in diurnal and seasonal varying BC emissions apart from the boundary layer processes. [**Joshi, H.** et. al. (including **Naja**, **M.**, **Bhardwaj, P.**, (2016). *Atmospheric Environment*, *125,* 346-359

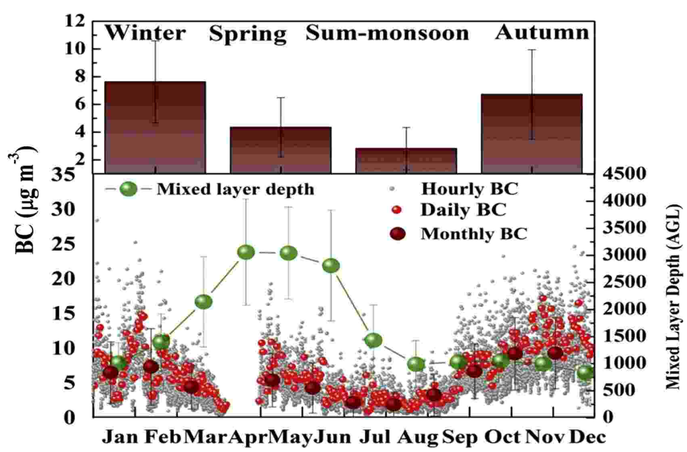

Figure 43. Monthly variations in hourly and daily average BC during 2009-2012. Noontime average monthly mixing layer depth estimated during 2009-2012 is also shown. BC during four seasons is shown in upper panel.

Influences of regional pollution and long range transport: Ozone from MOZAIC and back-air trajectory

Ozone data from MOZAIC (Measurements of OZone and water vapor by Airbus In-Service airCraft) are analyzed usingback-air trajectories and contribution from regional pollution and long-range transport are assessed over a southern Indian airport region during years 2005-2011. Ozone data are grouped and analysed according to the air-mass residence time over the central India,marine region and Africa/Middle East regions. Ozone showed a linear dependence on air-mass residencetime over the central India region for about six days. Rate of ozone increase is found to be maximum during summer(boundary layer 6.8 ± 0.9 ppbv/day, lower free troposphere 2.4 ± 0.4 ppbv/day) and minimum duringwinter (boundary layer 1.5 ± 0.2 ppbv/day, lower free troposphere 0.8 ± 0.7 ppbv/day). The backgroundozone is estimated to besignificantly lower during summer/monsoon (15.8 ± 2.4 ppbv) within the boundary layer due to influenceof marine air-mass. Simultaneous investigation of fire counts and potential source contributionfunction analysis confirms that IGP outflow has a significant contribution in ozoneenhancement over even at this southern region throughout the year except in summer-monsoon season.The ozone in regionally polluted air masses influenced by the central Indian region is found to be higherthan average ozone by 6-15% within the boundary layer and by 5-9% in the lower troposphere duringdifferent seasons. Role of long-range transport from Africa/Middle East is found to be significant in thelower troposphere and shows 4.4 ppbv and 9 ppbv higher ozone mixing ratio during summer andautumn, respectively. [Srivastava, A., **Naja, M.** & Thouret, V. (2015). *Atmo. Envi., 117,* 135]

List of Publications

Refereed Journals

1. Singh, K. K., et al. (including **Bhagwan, J.** & **Gupta, A. C.**) (2015). Search for TeV -ray emission from blazer 1Es1218+304 with TACTIC telescope during March- April 2013. *New Atronomy, 36,* 1-8.

2. **Kumar, Praveen**, Gopal-Krishna & **Chand, H**. (2015). Intranight optical variability of radio-quiet weak emission line quasars – III. *Mon. Not. Roy. Astron. Soc., 448,* 1463-1470.

3. Pasquale, M. D., et al. (including **Pandey, S. B.**). (2015). The optical rebrightening of GRB 100814A: an interplay of forward and reverse shocks?. *Mon. Not. Roy. Astron. Soc., 449,* 1024-1042.

4. Singh, S., et al. (including **Dumka, U. C.)** (2015). Intra-seasonal variability of black carbon aerosols over a coal field area at Dhanbad, India. *Atmospheric Research, 161-162,* 25-35.

5. Bisht, D. S., et al. (including **Dumka, U. C.**). (2015). Carbonaceous aerosols and pollutants over Delhi urban environment: Temporal evolution, source apportionment and radiative forcing. *Science of the Total Environment, 521-522,* 431-445.

6. **Soam, A.,** Kwon. J., **Maheswar, G.,** Tamura, M. and Lee, C. W. (2015). First optical and near-infrared polarimetry of a molecular cloud forming a proto-brown dwarf candidate. *The Astrophysical Journal Letters, 803,* L20(5pp).

7. **Agarwal, A.,** & **Gupta, A. C.** (2015). Multiband optical variability studies of BL Lacertae. *Mon. Not. Roy. Astron. Soc., 450,* 541-551.

8. Joshi, G. C., **Joshi, Y. C., Joshi, S.** & Tyagi, R. K. (2015). Basic parameters open star clusters DOLIDGE 14 and NGC 110 in infrared bands. *New Astronomy, 40,* 68-77.

9. Deb Roy, P., Halder, P., Das, H. S. & **Medhi, B. J.** (2015). Imaging polarimetry of comets C/2013 V1 (Boattini) and 290P/Jager before and after perihelion. *Mon. Not. Roy. Astron. Soc., 450,* 1770-1776.

10. **Kalita, N., Gupta, A. C.,** Witta, P. J., **Bhagwan, J.** & Duorach, K. (2015). Multiband variability in the blazar 3C 273 with *XMM–Newton, Mon. Not. Roy. Astron. Soc., 451,* 1356-1365.

11. Joshi, G. C., **Joshi, Y. C., Joshi, S.,** Chowdhury, S. & Tyagi, R. K. (2015). Complex Stellar System ESO65SC03: Open Cluster or Remnant?. *Pub. of the Astronomical Society of Australia, 32,* e022 (18pp).

12. **Bose, S.,** et al. (including **Kumar, Brijesh, Misra, K.** & **Singh, Mridweeka** (2015). SN 2013ej: A type IIL supernova with weak signs of interaction. *Astrophy. Jr., 806,* 160 (18pp).

13. **Agarwal, A.,** et al. (including **Gupta, A. C.**) (2015). Multiband optical–NIR variability of blazars on diverse time-scales. *Mon. Not. Roy. Astron. Soc., 451,* 3882-3897.

14. Hayashida, M., et al. (including **Agarwal, A.** & **Gupta, A. C.**) (2015). Rapid variability of blazar 3C 279 during flaring states in 2013−2014 with joint fermi-lat, Nustar, swift, and ground-based multi-wavelength observations. *Astrophy. Jr., 807,* 79 (18pp).

15. Kaskaovtis, D. G., Rashki, A., Francois, P., **Dumka, U. C.,** Houssos, E. E. & Legrand, M.

(2015). Meteorological regimes modulating dust outbreaks in southwest Asia: The role of pressure anomaly and Inter-Tropical Convergence Zone on the 1–3 July 2014 case. *Aeolian Research, 18,* 83-97.

16. Mohan, P. et al. (including **Agarwal, A.** & **Gupta, A. C.**) (2015). Frequency-dependent core shifts and parameter estimation for the blazar 3C 454.3. *Mon. Not. Roy. Astron. Soc., 452,* 2004-2017.

17. Gaur, H., et al. (including **Gupta, A. C**.) (2015). Nature of intranight optical variability of BL lacerate. *Mon. Not. Roy. Astron. Soc., 452,* 4263-4273.

18. Filippov, B., et al. (including **Uddin, W.**) (2015). Formation of a rotating jet during the filament eruption on 2013 April 10-11. *Mon. Not. Roy. Astron. Soc, 451,* 1117-1129.

19. Sagar, R., Dumka, U. C., Naja, M., Singh, N. & **Phanikumar, D. V.** (2015). ARIES, Nainital: a strategically important location for climate change studies in the Central Gangetic Himalayan region. *Current Science, 109,* 703-715.

20. Vyas, M. K., Kumar, Rajiv, Mandal, S. & **Chattopadhyay, I.** (2015). Radiatively driven relativistic jets with variable adiabatic index equation of state. *Mon. Not. Roy. Astron. Soc., 453,* 2992-3014.

21. Shukla, K. K., et al. (including **Phanikumar, D. V.**) (2015). Wave like signatures in aerosol optical depth and associated radiative impacts over the central Himalayan region. *Jr. Atmos. Solar Terr. Phy., 133,* 62-66.

22. Gaur, H., et al. (including **Gupta, A. C.** & **Agarwal, A**.) (2015). Optical and radio variability of BL lacerate. *Astron. & Astrophy., 582,* A103.

23. Reddy, K., **Phanikumar, D. V., Joshi, H.,** Ahammed, Y. Z. & **Naja, M.** (2015). Effect of diurnal variation of aerosols on surface reaching solar radiation. *Jr. Atmosph. Solar-Terr. Phy., 129,* 62-68.

24. Agarwal, A., et al. (including **Gupta, A. C.**) (2015). Multiband optical variability of the blazer S5 0716+714 in outburst state during 2014-2015. *Mon. Not. Roy. Astron. Soc., 455,* 680-690.

25. Bose, S., et al. (including **Misra, K., Kumar, Brijesh, Kumar, Brajesh** & **Pandey, S. B.**) (2015). SN 2013ab: a normal type IIP supernova in NGC 5669. *Mon. Not. Roy. Astron. Soc., 450,* 2373-2392.

26. Sariya, D. P. & **Yadav, R. K. S.** (2015). Proper motions and membership probabilities of stars in the region of globular cluster NGC 6366. *Astron. & Astrophy., 584,* A59 (8pp).

27. Singh, B. P., et al (including **Dumka, U. C.)** (2015). Seasonal in homogeneity of soot particles over the Central Indo-Gangetic plains, India: influence of meteorology. *Jr. of Meteorological Research, 29,* 935-949.

28. Samal, M. R. et. al. (including **Pandey, A. K.**) (2015). Star formation in the filament of S254-S258 OB complex: a cluster in the process of being created. *Astron. & Astrophy., 581,* A5.

29. Srivastava, A., **Naja, M.** & Thouret, V. (2015). Influence of regional pollution and long range transport over Hyderabad using ozone data from MOZAIC. *Atmo. Envi., 117,* 135.

30. Basha, G., **Phanikumar, D. V.**, Kumar, K. N., Ouarda, T. B. M. J. & Marpu, P. R. (2015). Investigation of aerosol optical, physical, and radiative characteristics of a severe dust storm observed over UAE. *Remote Sens. Envi., 169*, 404-417.

31. Skidmore, W. et. al. (including **Pandey, S. B.**). (2015). Thirty Meter Telescope detailed science case: 2015. *Res. Astron. & Astrophy., 15 (12),* 1945-2140.

32. Tiwari, S., et al. (including **Dumka, U. C.)** (2016). Aerosol chemical characterization and role of carbonaceous aerosol on radiative effect over Varanasi in central Indo-Gangetic Plain. *Atmospheric Envi., 125,* 437-449.

33. Mohan, P., **Gupta, A. C.,** Bachev, R. & Strigachev, A. (2016). Kepler light-curve analysis of the balzar W2R 1962+42. . *Mon. Not. Roy. Astron. Soc., 456,* 654-664.

34. **Kumar, Brajesh, Pandey, S. B**., Eswaraiah, C. & Kawabata, K. S. (2016). Broad-band polarimetric investigation of the type II-plateau supernova 2013ej. *Mon. Not. Roy. Astron. Soc., 456,* 3157-3167.

35. Kumar, K. N., **Phanikumar, D. V.,** Ouarda, T. B. M. J., Rajeevan, M., **Naja, M.** & **Shukla, K. K.** (2016). Modulation of surface meteorological parameters by extratropical planetary-scale Rossby waves. *Ann. Geophy., 34*, 123-132.

36. **Bhardwaj, P., Naja, M.,** Kumar, R. & Chandola, H. C. (2016). Seasonal, interannual and long-term variabilities in biomass buring activity over South *Asia. Environ. Sci. Pollut. Res., 23,* 4397-4410.

37. Bisht, D., **Yadav, R. K. S.** & Durgapal, A. K. (2016). Photometric study of open star clusters in II quadrant: Teutsch 1 and Riddle 4. *New Astronomy, 42,* 66-77.

38. **Bose, S.** et al. (including **Kumar, Brijesh, Misra, K., Kumar, Brajesh** and **Singh, Mridweeka**) (2016). Photometric and polarimetric observations of fast declining Type II supernovae 2013hj and 2014G. *Mon. Not. Roy. Astron. Soc., 455,* 2712-2730.

39. **Lata, S.** et. al. (including **Pandey, A. K.** and **Pandey, J. C.**). (2016) Variable stars in young open star cluster NGC 7380. *Mon. Not. Roy. Astron. Soc., 456,* 2505-2517.

40. Valtonen, M. J. et. al. (including **Gopinathan, M., Joshi, A.** and **Pandy, J. C.**) (2016). Primary black hole spin in OJ 287 as determined by the general relativity centenary flare. *Astroph. Jr. Lett., 819*:L37 (6pp.).

41. Lipunov, V. M. et. al. (including **Pandy, S. B.**) (2016). The optical identification of events with poorly defined locations: the case of the Fermi GBM GRB 140801A. *Mon. Not. Roy. Astron. Soc., 455*, 712-724.

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43. **Joshi, H., Naja, M.**, Singh, K. P., Kumar, R., **Bhardwaj, P.**, Babu, S. S., Satheesh, S. K., Moorthy, K. K. & Chandola, H. C. (2016). Investigations of aerosol black carbon from a semi-urban site in the Indo-Gangetic Plain region. *Atmospheric Environment*, *125,* 346-359.

44. **Sarangi, T., Naja, M.**, Lal, S., Venkataramani, S., **Bhardwaj, P., Ojha, N.**, Kumar, R. & Chandola, H. C. (2016). First observations of light non-methane hydrocarbons (C2–C5) overahigh altitude site in the central Himalayas. *Atmospheric Environment, 125*, 450–460.

45. **Solanki, R., Singh, N.**, Kiran Kumar, N V P, Rajeev, K., Dhaka, S. K. (2016). Time variability of surface-layer characteristics over a mountain ridge in the central Himalayas during the spring season. *Boundary Layer Meteorology, 158*, 453-471.

Editorial:

1. Zheng, W. et. al. (including **S. B. Pandey**) (2015). Gamma-ray burst in Swift and Fermi era. *Advances in Astronomy, 2015.*

Circulars/Bulletins/Conference Proceedinga

1. **Joshi, S.,** Semenko, E., Moiseeva, A., Joshi, G. C., **Joshi, Y. C.** & Sachkov, M. (2015). Photometric and Spectroscopic Analysis of CP Stars Under Indo-Russian Collaboration. *ASP Conference Series on Physics and Evolution of Magnetic and Related Stars, 494,* 210-219.

2. **Gupta, A. C.** (2015). Optical and X-ray variability blazars. *ASI Conf. Series, 12,* 77-78.

3. **Pandey, S. B.** (2015). Short duration gamma-ray bursts. *ASI Conf. Series, 12,* 153-157.

4. **Kumar, P., Chand, H.,** Gopal-Krishna & Joshi, R. (2015). A search for the elusive radio-quiet BL Lacs. *ASI Conf. Series, 12,* 133-134.

5. **Agarwal, A.** & **Gupta, A. C.** (2015). Optical-NIR variability of blazars on diverse timescales. *ASI Conf. Series, 12,* 141-142.

6. **Vyas, M. K., Kumar, Rajiv,** Mandal, S. & **Chattopadhyay, I.** (2015). Study of radiatively driven outflows around black holes under hydrodynamic and relativistic regime. *ASI Conf. Series, 12,* 109-110.

7. **Kumar, Rajiv** & **Chattopadhyay, I.** (2015). Self-consistent accretion-ejection solutions from general relativistic viscous discs. *ASI Conf. Series, 12,* 93-94.

8. Nandi, A., Mandal, S., Das, S. & **Chattopadhyay, I.** (2015). 'Q' factors in galactic black hole sources- a case study of 1999 outburst of XTE J1859+226. *ASI Conf. Series, 12,* 69-72.

9. **Chattopadhyay, I.** (2015). Simulations of relativistic astrophysical jets. *ASI Conf. Series, 12,* 131-132.

10. **Bose, S., Kumar, Brijesh** & **Misra, K.** (2015). Core-collapse supernovae and its progenitors. *ASI Conf. Series, 12,* 83-84.

11. **Joshi, A.** & **Pandey, J. C.** (2015). PALOMA: a magnetic CV between Polars and intermediate polars. *ASI Conf. Series, 12,* 127-128.

12. **Sharma, S.** & **Shekhar, S.** (2015). The 130 cm telescope at Devashtal. *ASI Conf. Series, 12,* 147-148.

13. **Chand, H.** & **Joshi, R.** (2015). Probing AGN central engine and its environment based on their photometry and spectroscopy. *ASI Conf. Series, 12*, 79-80.

14. Anche, R. M. et. al. (including **S. B. Pandey**). (2015). Analytical modeling of Thirty Meter Telescope optics polarization. *Proc. Of SPIE, 9654*, 965408-1.

15. **Kumar, Brijesh** et. al. (including **S. B. Pandey**). (2015). Study of core-collapse supernovae with the upcoming 4m international liquid mirror telescope at Devasthal, Nainital. *ASI Conf. Series, 12,* 149-150.

Ph.D. Theses

Awarded

1. Astrometric and photometric studies of star clusters, **Devesh P. Sariya**, Supervisor: **R. S. Yadav**), *Pt. Ravishankar Shukla University,* July, 2014. (June, 2015 Awarded)

2. Probing central engine and environments of active galactic nuclei, **Ravi Joshi,** (Supervisor : **Hum Chand**), *Pt. Ravishankar Shukla University,* July, 2014. (June, 2015 Awarded)

3. Study of transients and waves in the solar atmosphere, **P. K. Kayshap,** (Supervisor : **A. K. Srivastava**), *Pt. Ravishankar Shukla University,* August, 2014. **(June, 2015, Awarded)**

4. Investigation of star forming regions land young stellar objects, **Archana Soam** (Supervisor **M. Gopinathan**), *Pt. Ravishankar Shukla University,* March, 2015. (30 December, 2015).

5. Theoretical and numerical investigations of accretion-ejection mechanism around compact objects, **Rajiv Kumar,** (Supervisor: **I. Chattopadhaya**), *Pt. Ravishankar Shukla University,* (11 March, 2016).

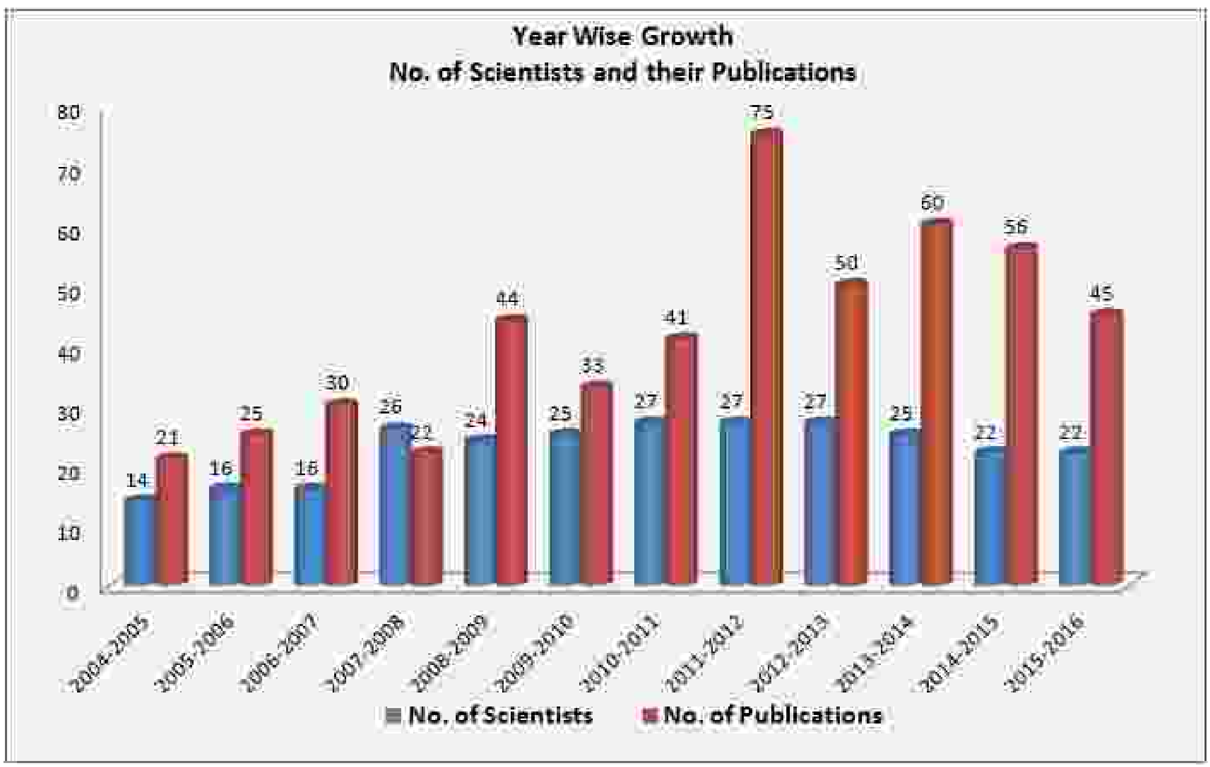
Submitted

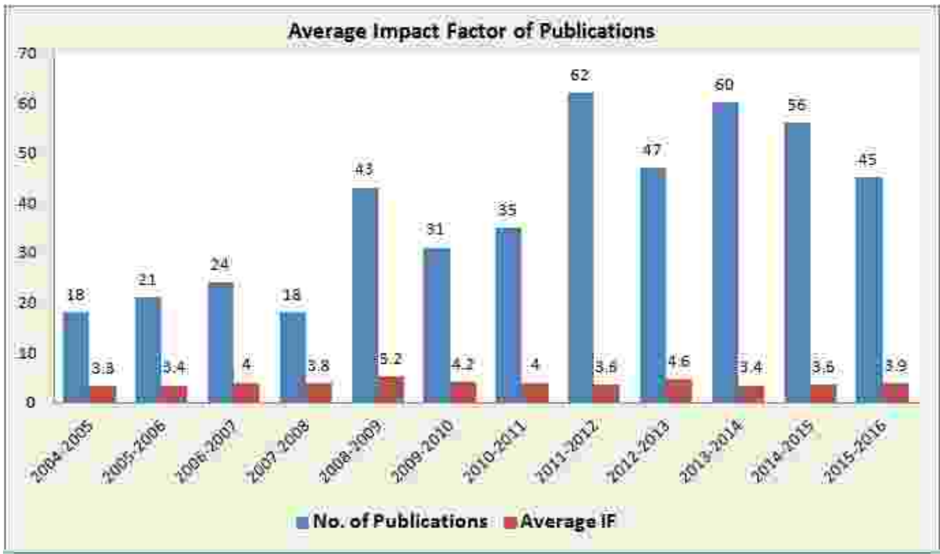
1. Study of aerosols characteristics over Central Himalayas, **Hema Joshi,** (Supervisor & Co-Supervisor: **M. Naja** and H. C. Chandola), *Kumaun University,* July, 2015.

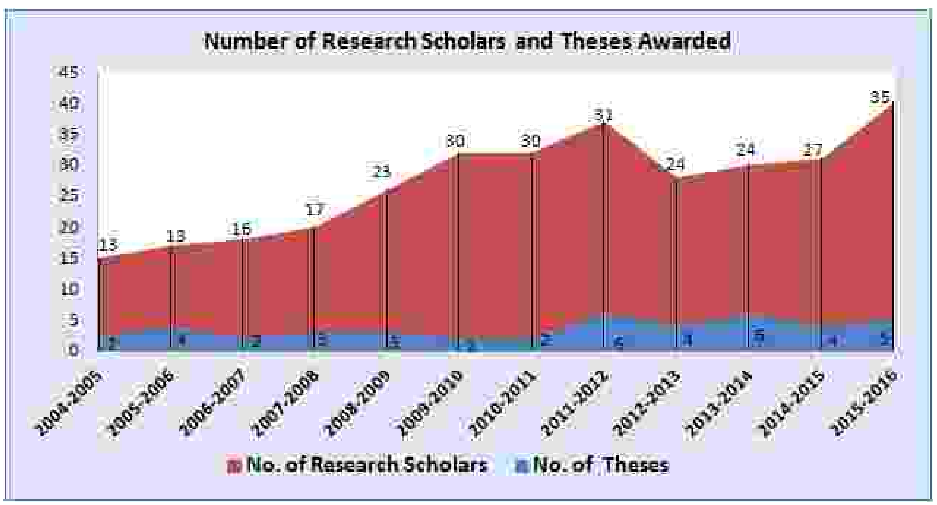
2. Multiwavelength investigation of core-collapse supernovae, **Subhash Bosh**, (Supervisor & Co-Supervisor: **Brijish Kumar** and H. C. Chandola), *Kumaun University,* August, 2015.

3. A study of dynamical aspects of aerosols over the central Himalayan region, **Krishna Kumar Shukla,** (Supervisor : **D. V. Phanikumar**), *Pt. Ravishankar Shukla University,* December, 2015.

4. Multi-wavelength studies of active galactic nuclei, **Jai Bhagwan**, Supervisor : **Alok C. Gupta**), *Pt. Ravishankar Shukla University,* March, 2016.







Summary

1.	Total Number of Publications in Refereed Journals	45
2.	Number of Publications in Circulars/Bulletin	15
3.	Ph.D. Theses Awarded	5
4.	Ph.D. Theses Submitted	4

International and National Research Projects

During the year 2015-2016 following research projects were funded from outside agencies.

1. **Title of Project:** Observations and analysis of stars in the Kepler field
   PI (ARIES): Yogesh Chandra Joshi
   PI (South Africa): C. A. Engelbrecht
   Funding Agency: DST, New Delhi
   Project Code: DST/INT/SA/P-02
   Duration: 01-04-2014 to 31-03-2017

2. **Title of Project:** Investigation of the structure and kinematics of the young population of the Galactic disk in the solar neighborhood
   PI (ARIES): Yogesh Chandra Joshi
   PI (Russia): A. K. Dambis
   Funding Agency: DST, New Delhi
   Project Code: INT/RUS/RFBR/P-219
   Duration: 01-04-2015 to 31-03-2017

3. **Title of Project:** Magnetic activities in low mass stars
   PI (ARIES): Jeewan Chandra Pandey
   PI (Russia): Igor Savanov
   Funding Agency: DST, New Delhi
   Project Code: DST/RUS/RFBR/P-167
   Duration: 01-02-2014 to 01-03-2016

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

5. **Title of Project:** Surface observations of ozone at a rural location in Pantnagar.
   P.I.: Manish Naja
   Funding Agency: Indian Space Research Organization (ISRO), India.

6. **Title of Project**: Vertical Distribution of Ozone and Meteorological Parameters in the Central Himalayas.
   P.I.: Manish Naja
   Funding Agency: Indian Space Research Organization (ISRO), India.

7. **Title of Project:** Study of the aerosol characteristics over central Himalayas.
   P.I.: Manish Naja
   Funding Agency: Indian Space Research Organization (ISRO), India.

8. **Title of Project**: Atmospheric boundary layer network and characterization (ABLN&C): ISROGBP-NOBLE.
   P.I.: Narendra Singh
   Funding Agency: Indian Space Research Organization (ISRO), India.

Important Highlights of International and National Projects

Title: Observations and analysis of stars in the Kepler field.

Name of the PI: Yogesh Chandra Joshi, ARIES, Nainital and C. A. Engelbrecht Univ. of Johanesburg, South Africa.

In 2014, we started a collaboration between India and South Africa on the spectroscopic study of Kepler stars in the anticipation of low-resolution spectrograph ADFOSC to be mounted on the 3.6-m telescope. However, in absence of ADFOSC, we continued our program with the low-resolution spectrograph HFOSC mounted on 2-m Himalayan Chandra Telescope (HCT) while high-resolution spectra were obtained using the MSS spectrograph attached to the 6-m telescope at the Special Astrophysical Observatory. A detailed spectroscopic analysis of the spectra were carried out using UlySS software, which was also be used for the determination of the stellar atmospheric parameters. In the study on the Kepler stars, we identified two new classes of pulsating stars. One is the hot Gamma-Dor variables which have multiple low frequencies, but no high frequencies. These stars lie between the red edge of the SPB and the blue edge of the Gamma-Dor instability strip. Other is the Maia variables which have multiple high frequencies and lie between the red edge of the Cepheid instability strip and the blue edge of the delta-Sct instability strip. Current models are unable to account for pulsations in either of these two classes, adding to the problems of pulsation in the upper main sequence. Our study confirmed their anomalous nature. Two Maia candidates were also identified in our study which were earlier found to exist theoretically. **Figure 44** shows the observed and fitted spectra of three stars taken with HFOSC.

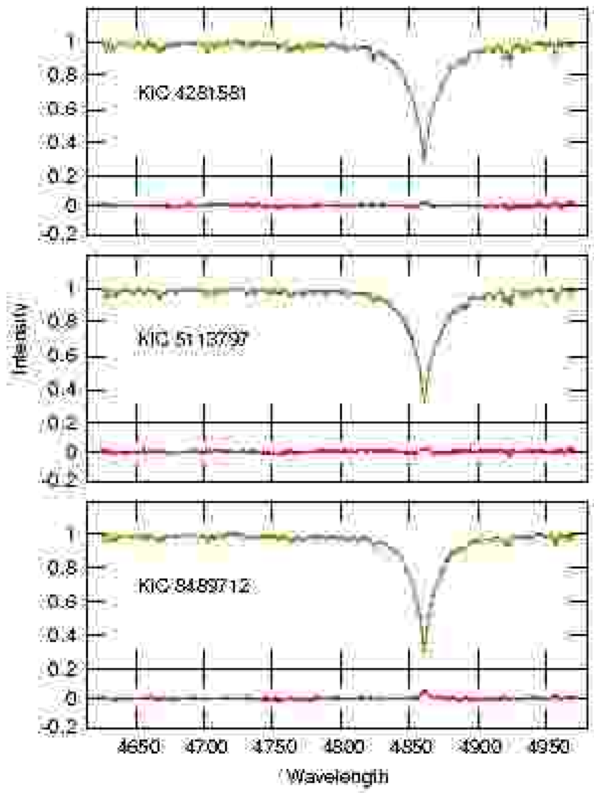


Figure 44. Observed and fitted spectra of three stars taken with HFOSC.

Title: Investigation of the structure and kinematics of the young population of the Galactic disk in the solar neighborhood.

Name of the PI: Yogesh Chandra Joshi, ARIES, Nainital and A. K. Dambis, MSU, Moscow, Russia.

In 2015, we started a collaboration between India and Russia in the field of open star clusters and Galactic structure and under the project entitled " Investigation of the structure and kinematics of the young population of the Galactic disk in the solar neighborhood" . The aim of the project is to study young open clusters in the broad solar neighborhood (within 3 kpc of the Sun) using both published multi-color photometry and our own UBVI-band CCD observations of several dozen poorly investigated open clusters. We have already observed few star clusters from the observing facilities at ARIES, Nainital for which data reduction and analysis is in progress. However, using an almost complete sample of 1241 open star clusters within 1.8 kpc of the Sun from archival MWSC catalogue, we studied the general properties of the open cluster system in the Galaxy and probed the Galactic structure. We determine several parameters like average scale height, solar offset, local and surface mass densities. and found the linear mass-radius and mass-age relations in the open clusters. Figure shows the X-Y distribution of the young, intermediate and old age clusters as projected on the Galactic plane. The dependence of the spatial distribution of clusters on their age points to a complex interplay between cluster formation and survivability within the Galaxy. The geometrical characteristics of a significant number of clusters enabled us to understand large-scale spatial properties of the cluster systems within the Galaxy. The structural and physical parameters of clusters allowed us to check mutual correlations between the individual parameters.

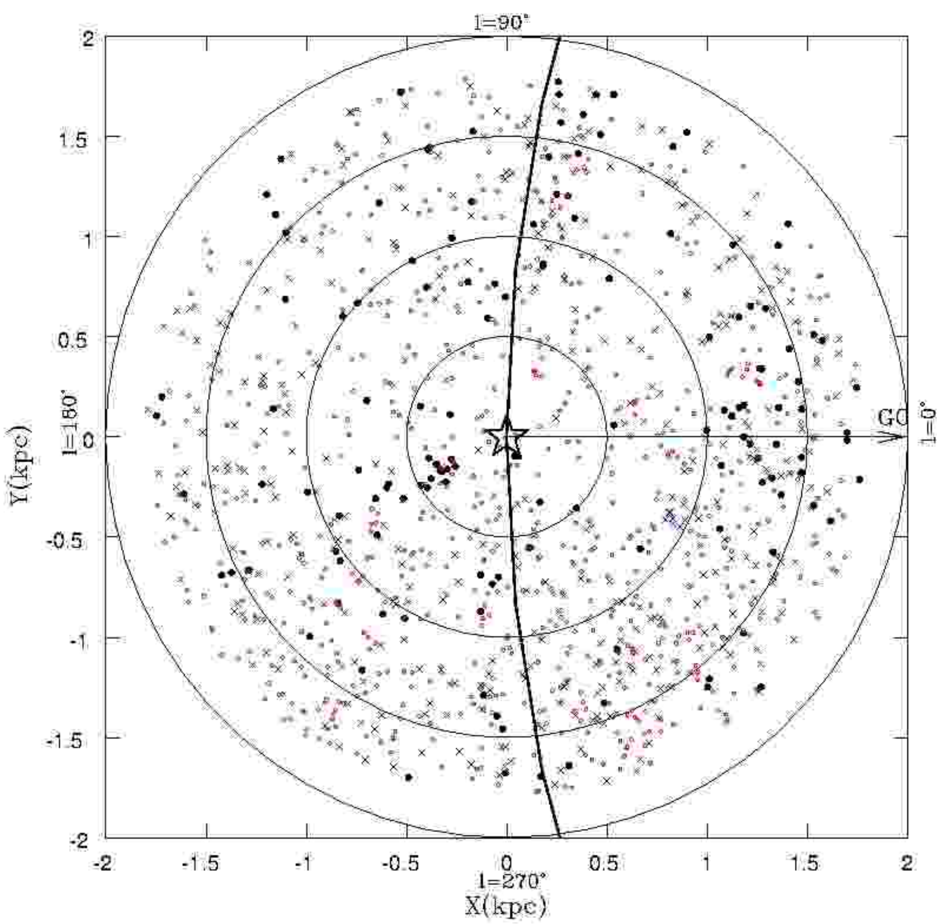


Figure 45. X-Y distribution of the young, intermediate and old age clusters as projected on the Galactic plane.

Title: Magnetic activities in low mass stars.

Name of the PI: Jeewan Chandra Pandey, ARIES, Nainital and Igor Savanov, Russia.

Research output of the project with highlights:

X-ray flares are common phenomena in late-type stars and it is believed that they are produced by the same mechanism as solar flares, namely magnetic reconnection. However, stellar flares show very high temperatures and an extremely large total energy. Observationally, stellar flares are defined as a sudden enhancement of an intensity followed by a gradual decay. The study of stellar flares is a valuable tool for understanding stellar coronae as these are dynamical events that consist of different information than quiescent state observations For the present study, we have chosen a poorly known early F-type main sequence stellar system 47 Cas and an G-type active solar-type star π^1 UMa. It is supposed that the 47 Cas system consists of an unseen companion, 47 Cas B, which has been detected only in the radio wavelength by Güdel et al. (1998) and for which no optical characterization is available thus far. Whereas, π^1 UMa is nearby (dist. = 14.3 pc), G1.5V-type star with a rotation period of 4.2 days and V-band magnitude of 5.6. It is a single solar-type star that has high levels of chromospheric and coronal X-ray emissions (Gaidos 1998).

The properties of the quiescent and flaring coronae of both the active solar-type star 47 Cas and π^1 Uma were investigated using XMM–Newton observation. The luminosity of 47 Cas at the peak of the flare is found to be 3.54 × 10^{30} erg s^{-1}, which is ~ 2 times higher than that at a quiescent state. The quiescent state corona of 47 Cas can be represented by two temperature plasma: 3.7 and 11.0 MK. The time-resolved X-ray spectroscopy of the flare show the variable nature of the temperature, the emission measure, and the abundance. The maximum temperature during the flare is derived as 72.8 MK. We infer the length of a flaring loop to be 3.3 × 10^{10} cm using a hydrodynamic loop model. Using the RGS spectra, the density during the flare is estimated as 4.0 × 10^{10} cm^{-3}. The loop scaling laws are also applied when deriving physical parameters of the flaring plasma.

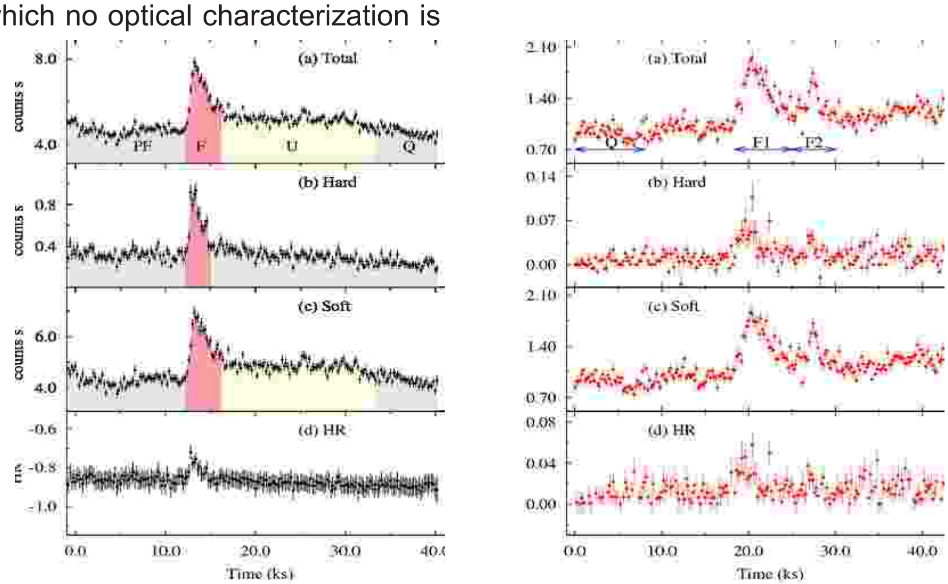
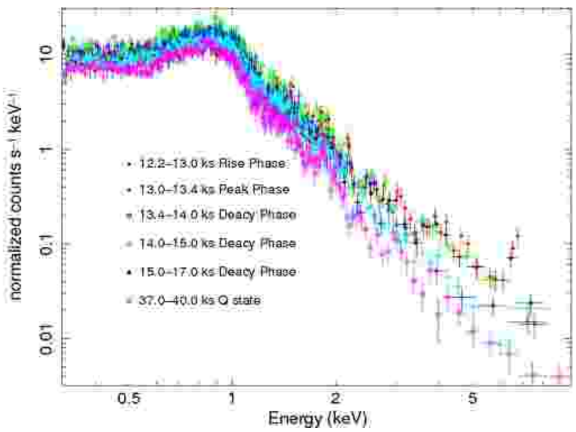


Figure 46. X-ray light curve of 47 Cas (left) and π^1 Uma(right) in soft, hard and total energy bands. The hardness ratio (HR) curve is shown in the bottom panel; where the HR is defined as ratio hard band count rates to the soft band count rates.



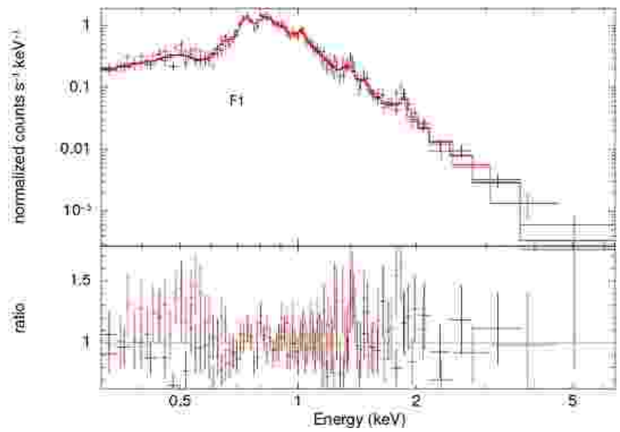


Figure 47. (left) X-ray spectral evolution of 47 Cas during the flare with respect to quiescent state. (Right) The MOS spectra of π^1 UMa during the flare 'F1' with the best fit two temperature plasma models apec. The residual in terms of ratio is also shown in bottom panel of each plot.

The present data show that the quiescent state coronae of π^1 UMa consist of two temperatures 4.7 and 7.9 MK and it has an X-ray luminosity of 7.4 × 10^{28} erg s^{-1} in 0.3-10.0 keV energy band. Two flares with X-ray luminosities of 1.2 × 10^{29} and 1.1 × 10^{29} erg s^{-1} were detected during the observation, where temperature corresponding to hot component are increased to 11.3 and 9.6 MK, respectively. The loop length is estimated of the order of 10^{10} cm for both flares. We have also derived other physical parameters of flaring plasma using the loop scaling laws. The spectral parameters derived during both the flare is shown in Table 1.

The parameters derived from the present analyses indicate that the X-ray flare on 47 Cas is similar to a solar impulsive flare whose height (L /π) is only 15% of the stellar radius, whereas the flares F1 and F2 on π^1 UMa were only 5-9 % of the stellar radius.

Details of Paper publish on/by the project

1. An X-ray flares from 47 Cas, (J. C. Pandey & S. Karmakar, AJ, 2015, 149,47)

2. Flares from π^1 UMa (J. C. Pandey, ASPC, 494,203)

3. Broad band polarization in late-type active dwarfs (M. K. Patel, J. C. Pandey, S. Karmakar, D. C. Srivastava, I. S. Savanov, MNRAS, 2016 in press)

4.Long-term spot topography and multi-band flare analysis of active ultra-fast rotator LO Peg (Pandey, S. B.; Pandey, J. C.; Karmakar, S.; Savanov, I. S., proceeding of scinece, 2014, 155)

Table 1: Peak flare parameters as obtained from spectral fitting.

Star	Flare	Z ($Z_\odot$)	T (10^6 °K)	EM (10^{52} cm^{-3})	L_X (10^{30} erg s^{-1})	χ^2_ν	DOF
47 Cas	F	$0.20^{+0.01}_{-0.01}$	73^{+13}_{-13}	$9.7^{+0.8}_{-0.6}$	$3.54^{+0.08}_{-0.08}$	1.11	203
π^1 UMa	F1	$0.28^{+0.04}_{-0.03}$	$11.3^{+0.6}_{-0.5}$	$3.7^{+0.6}_{-0.5}$	$1.20^{+0.02}_{-0.02}$	1.04	159
	F2	$0.24^{+0.06}_{-0.05}$	$9.6^{+1.3}_{-1.3}$	$3.9^{+1.5}_{-1.7}$	$1.13^{+0.04}_{-0.04}$	1.22	79

Updates on the Major Facilities

3.6-m Devasthal Optical Telescope

ARIES is establishing a national facility in optical astronomy at Devasthal to fulfill the major aspirations of the Indian astronomical community. This facility consists of a modern 3.6 meter optical new technology telescope, a suite of instruments, an observatory with a coating plant, a control room and a data center. The 3.6m Devasthal Optical Telescope (DOT) will have a number of instruments providing high resolution spectral and imaging capabilities at visible and near-infrared bands. In addition to optical studies of a wide variety of astronomical topics, it will be used for follow-up studies of sources identified in the radio region by GMRT and UV/X-ray by ASTROSAT.

The 3.6m DOT project is monitored and advised periodically by a nine member Project Management Board (PMB) chaired by Professor P.C. Agrawal. The day-to-day activities related to scientific, technical and financial aspect of the project is executed by a project implementation team (PIT) and eight project working groups (PWG) under the guidance and supervision of the Project Director and Project Manager. The PMB met at three occasions (2 Sep 2015, 28 Nov 2015, and 1 Feb 2016) during the financial year. The PIT and PWGs met at several occasions to monitor the progress of the project.

During the previous financial year, the optical, mechanical and electrical integration of telescope was completed, the telescope was completely mounted and made operational; the first engineering light was achieved on 22nd March 2015 and the images of stars, Saturn and Jupiter were recorded. During the current financial year Apr 2015 – Mar 2016, following milestones were achieved.

On-site tests and performance verification of telescope : Several on-sky tests were performed by AMOS during Apr-May 2015, to verify the performance of telescope at system and sub-system level. During April 2015, a preliminary alignment of the telescope was done successfully, and the active optics functionalities of both the Mirrors were checked and verified. The pointing model were generated for both the main port and the AGU. The image quality characteristics of telescope optics was verified using test and AGU wavefront sensors. On the night of 20th April 2015, the FWHM of 0.6 arcsec was obtained for a star on AGU Camera. The alignment of telescope optics was further fine-tuned during May 2015. The aberrations characteristics were recorded and studied in detail. The ARIES team participated actively during April and May 2015 in various verification activities. The procedures to check the health of telescope was learnt by the team. The synchronisation of telescope motion with that of dome is absolutely necessary while making test observations with telescope. This synchronization task was the responsibility of ARIES and it has been successfully achieved.

The health verification of telescope was performed regularly during Monsoon-2015 period. During October 2015, the remaining activities related to Side-Port-Fold-Mirror (SPFM) was performed. The technical issue of SPFM was resolved at site. A committee under chairmanship of Prof. S. Anathakrishnan was constituted to look into the technical activities of the telescope. Some reparations activities were also performed. A preventive maintenance training was imparted to ARIES engineering team. During Nov-Dec 2015, tests were performed to check the tracking and pointing performances of telescope at side-port1, side-port2 and the main-port. The image quality performance of telescope was verified with and without corrector at main-port. The image quality performance was also verified independently by ARIES team A set of mutually agreed acceptance tests were carried out during December 2015 jointly by ARIES and AMOS team. The first ARIES science instrument was mounted on the last day of acceptance Mission on 10th December 2015 and few images of celestial objects were recorded. Overall, the on-sky performance of telescope was found satisfactory. The binary stars with separation down to 0.4 arc sec have been clearly resolved in one of the nights and it implies that seeing at site is close to what was expected during site characterizations. **Reference Figure 48.**

Acceptance of telescope : A committee was constituted under Chairmanship of Professor S. N. Tandon for acceptance of 3.6m Devasthal optical telescope. The committee made critical assessment of the tests performed and the results obtained for acceptance of telescope viz. Pointing accuracy, the tracking accuracy, the optical image quality and the sensitivity of the acquisition and guiding unit (AGU) guider camera. The 3.6m acceptance committee recommended the telescope for acceptance. However, the committee also recommended to doubly ensure the functionality of active-optics loop at low elevations. Hence further tests were carried out to confirm performance at lower elevations. The list of tests were mutually agreed by ARIES and AMOS. The tests were carried out in the night of 16-17 February 2016. The acceptance committee and the PMB re-examined the low-elevation performance and they unanimously recommended the acceptance of telescope and hence the completion of last milestone of on-site installation and testing for the project. The telescope was formally accepted by ARIES on 29th February 2016.

Technical activation of telescope :Considering the global importance of 3.6m aperture telescope at an excellent site, the Belgian government participated in the project financially with the objective to get benefited by achieving science goals from the state-of-the art optical telescope and also by building back-end instruments with specific goals and using it with the telescope. It is indeed of great pride that the Devasthal Optical telescope has been technically activated on 30th March 2016 jointly by Honorable Prime Minister of India, Shri Narendra Modi and Honorable Prime Minister of Belgium, Mr. Charles Michel, remotely from Brussels, and in the gracious presence of the Honorable Minister of Science and Technology and Earth Sciences, Government of India Dr. Harshvardhan at Devasthal. India now has a world-class 3.6-m optical telescope at Devasthal in Uttarakhand ready to explore the deep celestial sky. **Reference Figures 49, 50 and 51.**

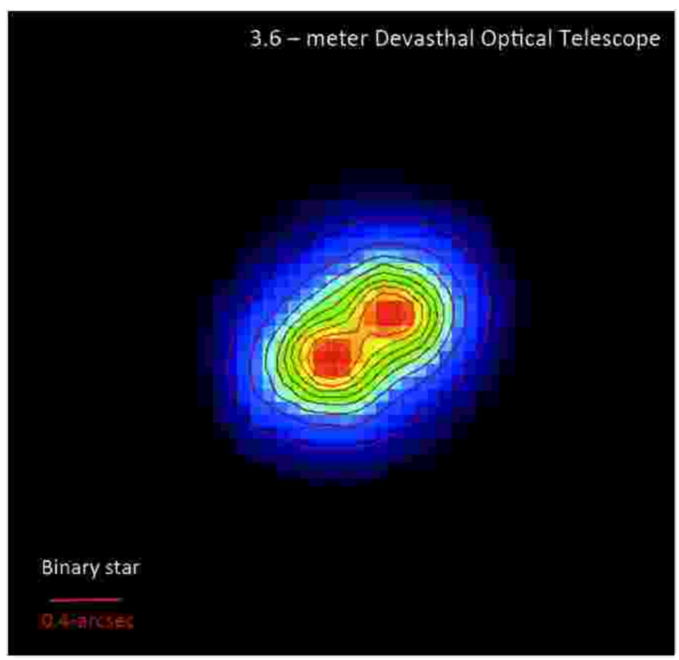


Figure 48. Picture of a binary star HIP 25060 with known separation of 0.37 arcsec taken with 3.6m telescope using a test camera. The exposure time is one second.

Figure 49. The remote technical activation of telescope on 30th March from Brussels.

Figure 50. The remote technical activation of 3.6m DOT, the team present at Devasthal.

Figure 51. The opening of 3.6m Dome slit during technical activation event.

Activities in ARIES ST Radar (ASTRAD) project:

Installation and interfacing of new Digital Signal Processing (DSP) system and Radar Controller (RC) was carried out as a major activity in the ARIES ST Radar (ASTRAD) project, during the last financial year. Despite several modifications, earlier system was not achieving intended performances and its instability was causing a delay in commissioning the ASTRAD. After installing the new DSP system, the performance of radar was critically examined by an external committee (review meetings on 28th May 2015) formed by the Governing Council (GC) of ARIES. The summary of major activities in FY 2015-16 connections to ASTRAD project are listed below.

(I) M/s ECIL, Hyderabad has installed new Digital Signal Processing (DSP)system& Radar Controller (RC) and interfaced them with active aperture of ASTRAD in July 2015.ARIES played an active role in the installation work and validates the basic communication and digital processing schemes with new one which was found stable and improved than earlier. The new setup was operated with three and sometime seven clusters and it was noted that wind data obtained from new DSP system required fine tuning to match with winds from balloon data. A sample wind profile using three clusters operated on September 2015 is shown in **figure 52**.

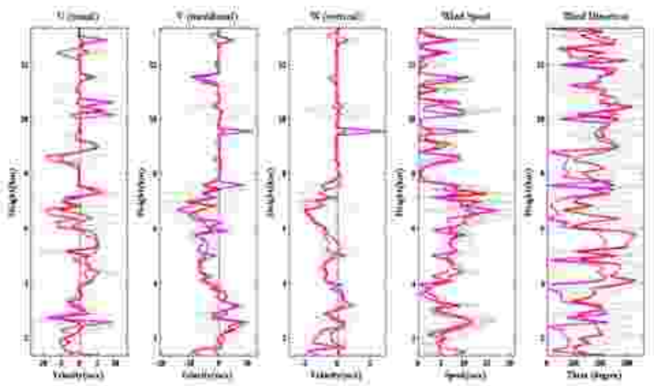


Figure 52. Wind data from ARIES ST Radar obtained from re-engineered sub-systems and using seven clusters in September, 2015.

(II) After achieving the initial milestone of interfacing with new DSP system, aninvestigation by a joint team of ARIES and ECIL was initiated to understand the source of appearance of strong center patch on the spectral domain which was also present with earlier DSP unit .This strong patchmasks the low power atmospheric returns and results ambiguous Doppler detection from a particular height. The investigation was also attempted with earlier DSP system but instability and other technical problems with earlier system made it difficult to probe the source of the patch.

(III) Meanwhile, during visit (3rd August 2015) of Secretary, SERB, DST Prof T. Chandrashekar a detailed presentation was given on the results obtained after installing the new DSP system and briefed him about the road-map on completion of the installation of the radar.

(IV) To strengthen and to monitor the work being carried out by ARIES and ECIL, the ARIES Governing Council (GC) formed a Technical Review Committee (TRC) where ShriRangaRao (Sci/Engg-H, Retd Deputy Director, ISRO,) was nominated as its chairman, following a meeting at SERB, DST, New Delhi, on 28 October, 2015. The members of the committee was chosen from SAMEER, Mumbai and NARL, Gadanki .This committee had two meetings (10-13 Dec, 2015 and 2-4 Feb, 2016) at ARIES and carried out experiments on each sub system as standalone and integrated condition. Though the committee did not noticed any major technical hitch in the design and installation of the ASTRAD but suggested few modifications in original design of the system for improving the performance and sensitivity of the system. The committee also strongly recommended performinga test of ASTRAD Transmit Receive Module (TRM) at CUSAT, Cochi for verifying its performance and confirming any role behind the appearance of the strong center patch.

(V) Following the recommendation of the TRC committee, ARIES carried out a test of ASTRAD TRM with CUSAT wind profiler system at Cochinduring 25-27 January 2016. Despite a complete different design of two systems, a joint team of ARIES and CUSAT succeeded to interface the ASTRAD TRM with CUSAT system and radiated maximum possible power with CUSAT three element Yagi-Udaantennas. Unfortunately, ECIL did not join this exercise. The return echoes were process by the CUSAT system. Unlike at ASTRAD, no strong center patch was observed at CUSAT which confirmed that the ASTRAD TRM has not contributing anything in generating the patch and role of TRM behind the matter can be ruled out. The result was presented in the second meeting of TRC (2-4 Feb, 2016).

(VI) A state of art ESD safe lab was installed at ASTRAD to facilitate in-house maintenance and development activities with RF instrument and devices prone to Electro Static Discharge (ESD) damage **(Figure 53)**.

Figure 53. ESD safe lab at ASTRAD facility.

(VII) To validate the wind data obtained from the radar , balloon lunch was carried on regular basis

(VIII) Few RF measuring instruments purchased to cater in house lab activities.

(IX) Like past, this year also several students from different engineering colleges did project using ASTRAD system and became familiar with basic operation of the wind profiler radar and RF circuit troubleshooting using high end measuring instruments. This training is the part of human resource development in the area of doing research using wind profile radar.

(X) Honorable union minster for Science and Technology and Earth Sciences, Dr. Harsh Vardhan visited the ARIES ST Radar site **(Figure 54)** on 30th March 2016. Honorable minister also released a balloon-borne meteorological sensor **(Figure 55)**.

Figure 54. Visit by Dr. Harsh Vardhan, Honorable union minster to ARIES ST Radar site, Transmit and Receiver module area.

Figure 55. Release of a balloon-borne meteorological sensor by Dr. Harsh Vardhan, Honorable union minster from ARIES ST Radar site.

Status report on the upcoming instruments

4Kx4K CCD Imager project:

The 4KX4K CCD imager i.e. the first light instrument was mounted at 1.3m telescope during 8-10 Dec 2015 for the characterization purposes. Some of the observations were found useful to verify the photon transfer curve at various gain/speed values. Bias stability were checked and the gain and read out noise values were verified using the sky flats in consultation with PMB members using photon transfer curves.

On 10-11th Dec 2015 the fully assembled Imager along with the 4KX4K CCD Camera was mounted at 3.6m telescope for the first time in presence with the AMOS team and hands-on experiences were gained about mounting the camera and balancing the telescope.

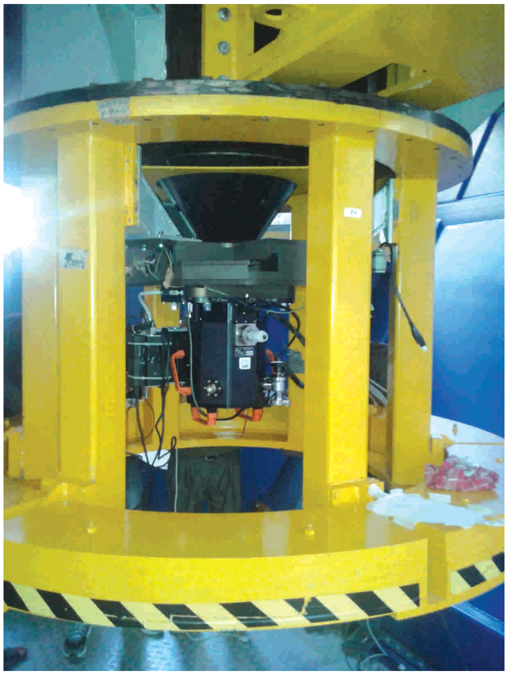


Figure 56. The fully assembled Imager set-up along with the 4KX4K CCD camera as mounted at the axial port on 11th Dec 2015 for the first time in presence of AMOS team.

Previously, it was planned that Imager team will spend two effective days with AMOS team which could not happen due to some technical constraints and weather being not supportive. Several on-sky images (see figure below for the Crab Nebula) were taken in R and V bands in passing cloud conditions.

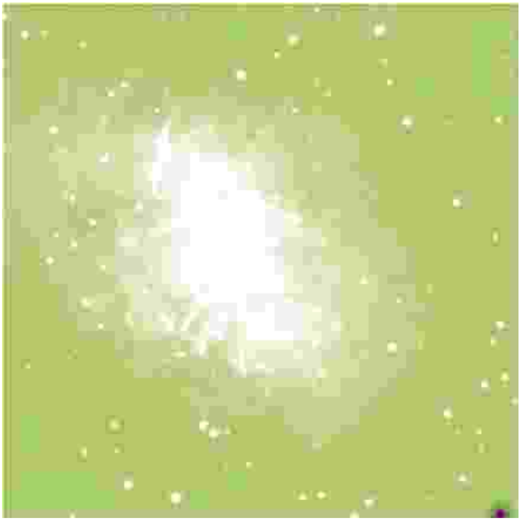


Figure 57. The very first scientific image taken by the 4KX4K CCD Imager on 11th December 2015 in R-band with a given exposure time of 180 sec covering around ~6.5x6.5 arcmin centered around a supernova remnant called 'Crab Nebula'.

The images were analyzed to check for the circularity, radial profile, guassianity etc. The parameters derived using IRAF software looks fine. More observations in clear sky conditions are required to conclude some of the desired numbers. All other aspects of the imager like filter movement control etc. was working OK. It was the first time when we had such an experience with the 4Kx4K Imager, many more nights are required to get a certain level of confidence. However, since the telescope was not accepted officially we were asked by the AMOS team to un-mount the CCD imager on the same night i.e. 11th Dec 2015.

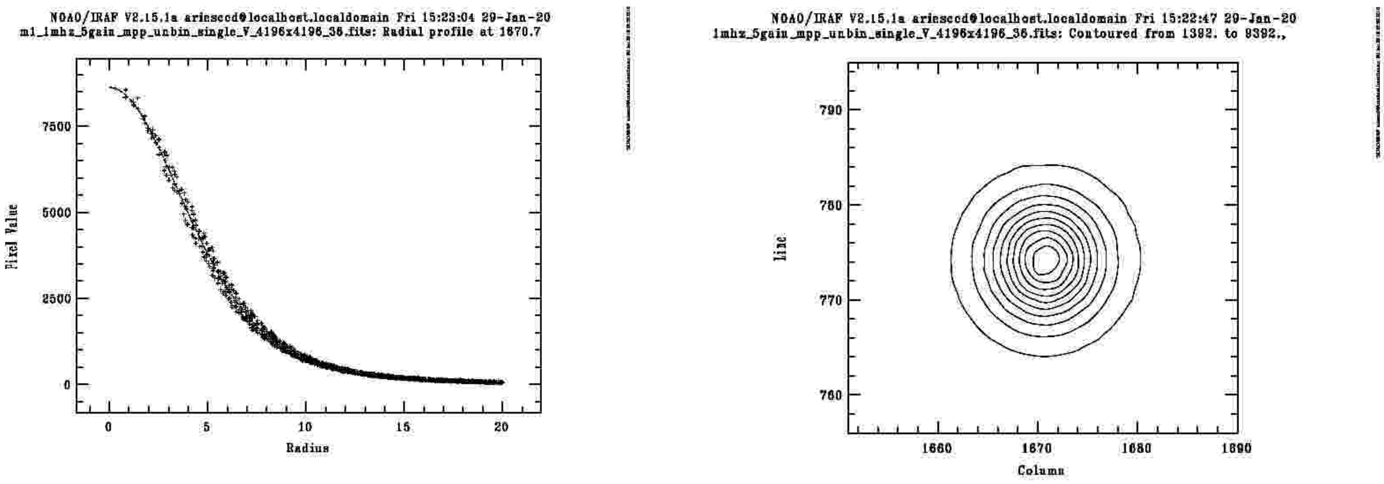


Figure 58. The radial profile (left panel) and the contour profile of a typical star in the field of `Crab Nebula' as observed using the 4KX4K CCD Camera.

The CCD Imager was again mounted at the 3.6m Telescope on 16-17th March 2016 for a week time for calibration purposes and to acquire some of the images for galaxies and bright objected for the scheduled program of the Prime Minister of India to activate the telescope technically remotely from Belgium. Due to poor sky conditions not many useful observations could be performed however many images for nearby bright spiral galaxies like M101, M104, M 106 etc. were obtained in different broad-band filters.

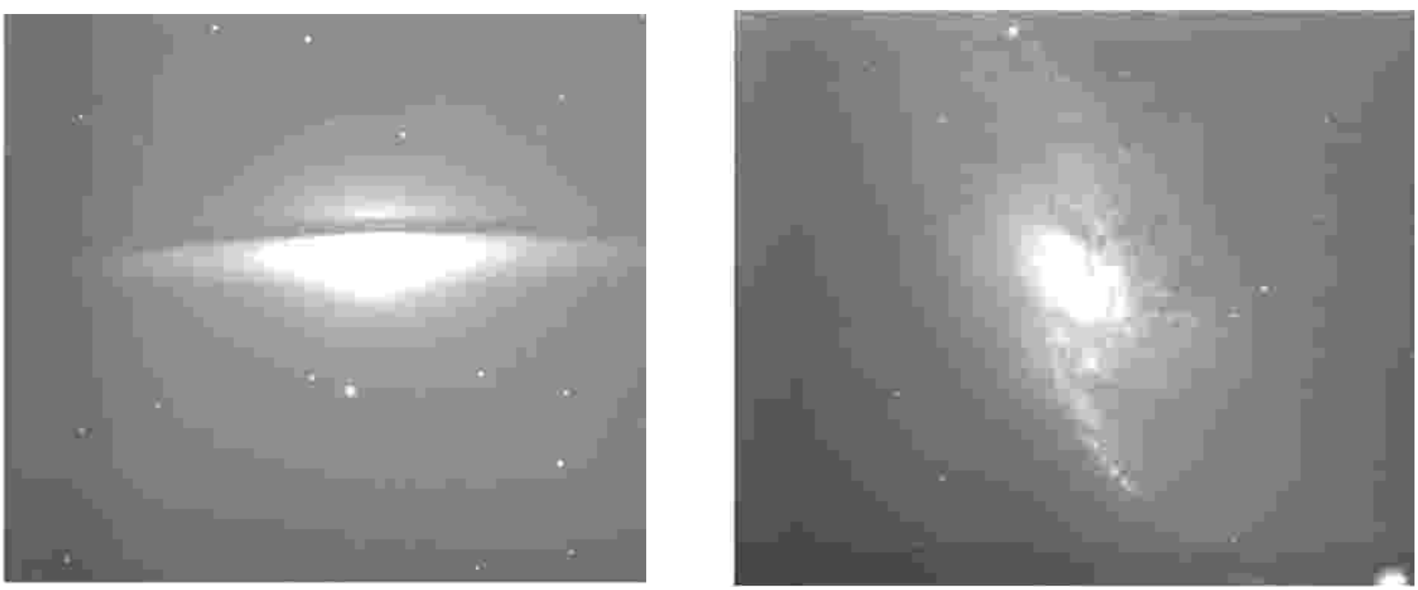


Figure 59. R-band image taken by the 4KX4K CCD Imager for the spiral galaxy M104 (left panel) and the M106 (right panel) with an exposure time o 300-sec. The radial profile (left panel) and the contour profile of a typical star in the field of `Crab Nebula' as observed using the 4KX4K CCD Camera.

During the technical activation of the 3.6m telescope, the 4kX4K CCD Imager was mounted at the axial port during 29-31st March 2016. On 31st March we could acquire some useful observations of the Landolt standard field PG 0918 as well as the open star cluster field NGC 2682 in rather poor sky conditions. Using standard procedures and IRAF, we were able to calibrate the field at rather brighter end i.e. < 22 mag in UBVRI filters. It seems that primary mirror reflectivity could be lower than normal. Analysis is going on to constrain the value of the reflectivity to re-coat the primary mirror during post-Monsoon period. It is planned to mount the CCD Imager some time during late 2016 to acquire new set of images for calibration and characterization purposes.

Faint Object Spectrograph & Camera (FOSC)

The FOSC is a low-resolution (~2000) optical spectrograph-cum-imager instrument for the 3.6-meter Devasthal optical telescope. The instrument was designed and assembled at ARIES. The instrument's main optics consists of a collimator and a focal reducer. Various filters, slits, and dispersing elements (viz., prism, grisms) can be inserted in the collimated beam through a motorized filter wheel. The FOSC will be using a 4kx4k (15 micron) CCD camera (close-cycle cryo-cooled), being developed at ARIES. The final focal-ratio will be nearly f/4, covering field of view of nearly 14'. The slits were developed in collaboration with ARCI, Hyderabad. The mechanical structure was manufactured in India.

The FOSC was mounted on the 3.6-meter telescope on 22-April-2016, and some preliminary tests were carried out. A small front-illuminated thermo-electrically cooled (-35° C) CCD (peak Q.E. 60%) was mounted at the focal plane of FOSC, covering 4'x3' sky.Tests were carried out in the month of May, 2016. Only limited tests were possible during April-May 2016. More comprehensive tests are planned in the coming observing season (October 2016 onwards) to test full performance and capabilities of the instrument. The first images appear nicely circular and seeing limited. The spectral performance also appears satisfactory. In future, various other observing modes such as polarimeter, prism, multi-slit, VPH grisms along with fast milli-second observing capabilities with EM-frame transfer CCD are planned.

First light image from FOSC (near zenith) :

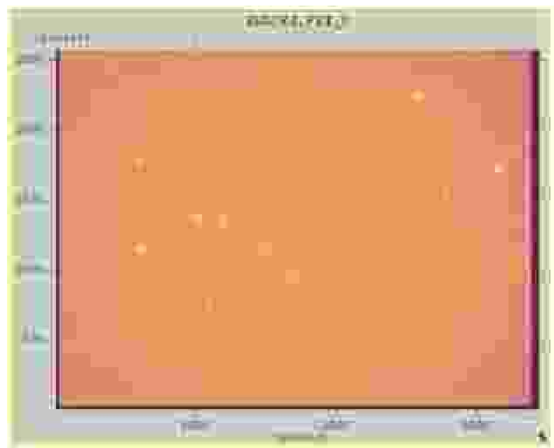


Figure 60. The image taken using FOSC on 3.6 meter DOT covering a field on view of 4'x 3' image.

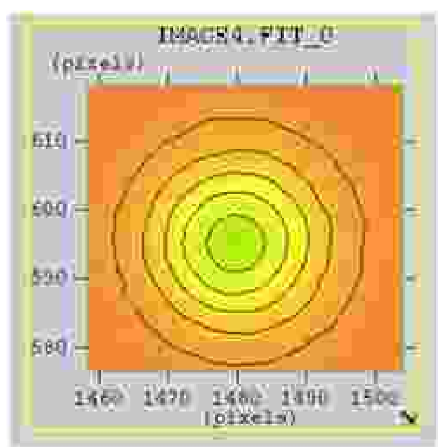


Figure 61. Close up image of a star. The FWHM is ~ 1.0 arcsec and the date of observation is 16-17 May, 2016.

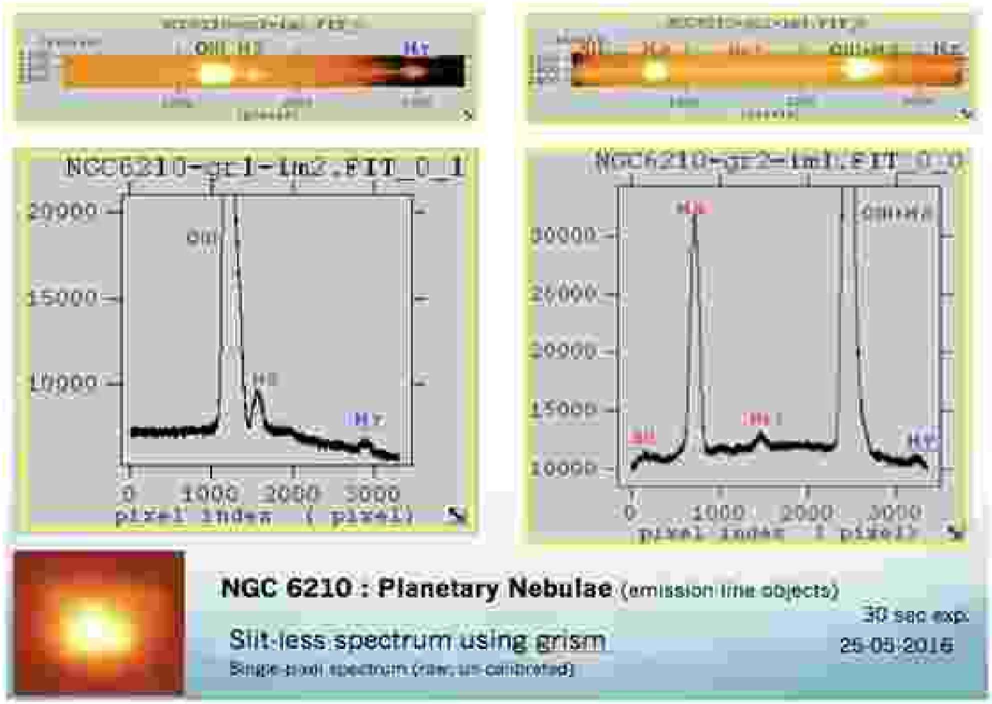


Figure 62. The slit-less spectrum of NGC 6210 (planetary nebulae) taken with FOSC in a total exposure time of 30-sec. Important emission lines are marked in the spectrum.

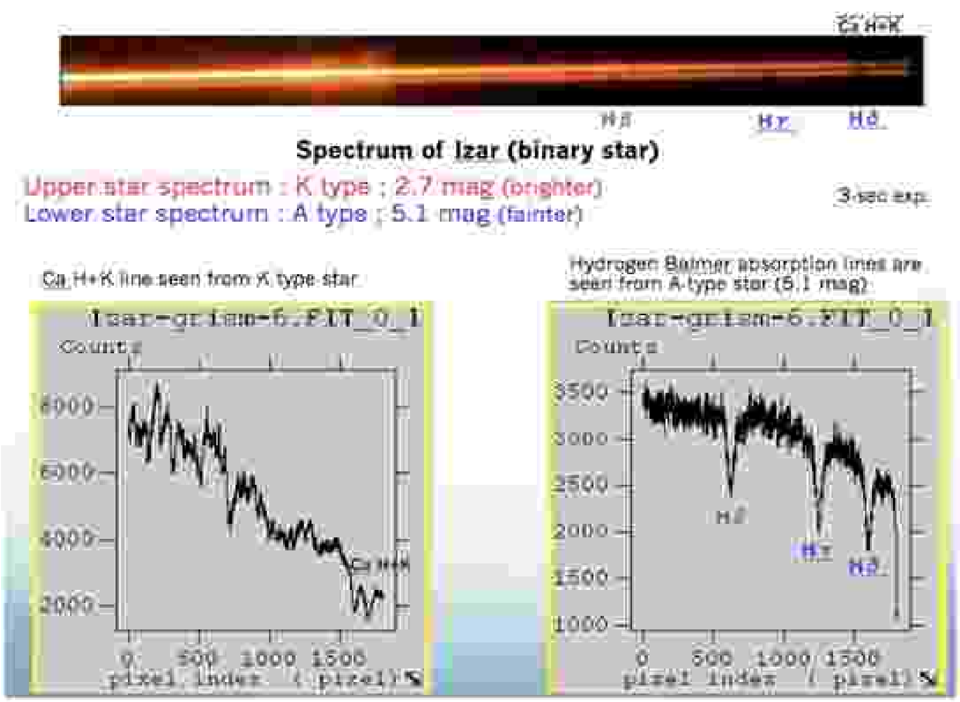


Figure 63. The spectrum of the K-A type binary star Izar taken using FOSC over 3-sec integration. The spectral lines typical of K and A type stars were seen.

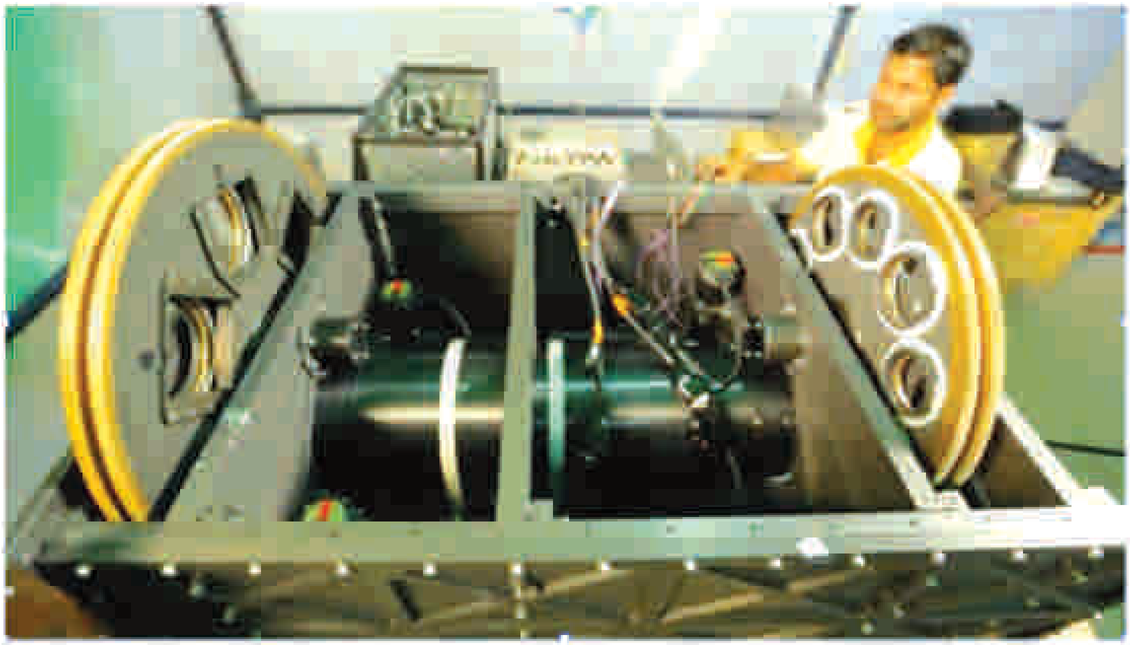


Figure 64. The assembled view of FOSC in the lab in ARIES.

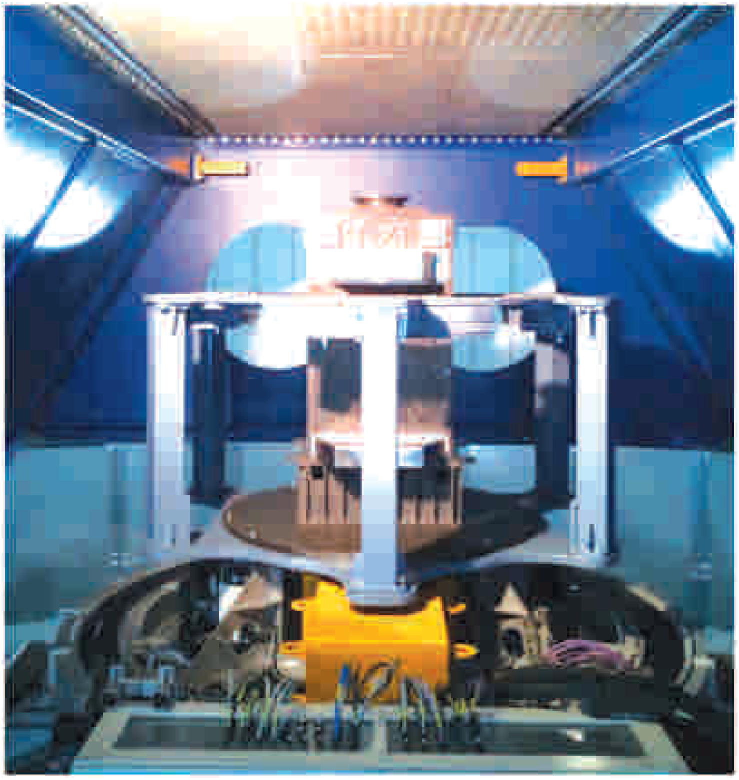


Figure 65. The FOSC as mounted on the 3.6 meter telescope.

Progress on the TIFR - ARIES Near Infrared Spectrometer (TANSPEC)

As a result of a growing demand for the NIR studies of star forming regions/brown dwarfs/AGNs active galaxies etc for which the NIR observations play an crucial role, building of a new spectrometer was initiated. Spectroscopic in NIR wavelengths are practically negligible in our country due to its complexity in instrumentation. A team of scientists and engineers from both the Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Mumbai, India (DAA-TIFR), Mumbai and ARIES have started developing an Infrared medium resolution Spectrometer for the 3.6m Devasthal Optical Telescope. This instrument will be developed under a collaborative program between DAA-TIFR and ARIES. The project is planned to be completed in three years and two month comprised of approximately one year of design and finalization of optical components, electronics and mechanical parts and two years and two month of building and testing. Development of the new competitive 0.6-2.5 micron medium resolution spectrograph/imager would give enormous in-house instrumentation development opportunity and manpower development in India as well as high class data which would be very useful for the various astronomical studies. This spectrograph will be a national facility for the observation of astronomical objects. It will be a simultaneous Optical / NIR Spectrograph/Imager in 0.6-2.5 micron wavelength range and can be used in medium resolution (R~2700) 0.6-2.5 micron in cross-dispersed (XD) mode and (R~100-350) 0.6-2.5 micron prism mode. The guider array will be used for imaging 1x1 arcmin square field of view also. The Detectors will be 2048x2048 HgCdTe Hawaii-2 (H2RG) and 1024x1024 HgCdTe Hawaii-1 (H1RG) spectrometer arrays, 0.6-2.5 micron response range, pixel size = 18 micron square, 0.25 arcsec/pixel plate scale.

The work on this instrument is still in progress. Approval of the project from DAE was taken in November, 2012. An MoU was signed between ARIES and TIFR on 26th of August, 2013. A public tender for designing, building and installation of TANSPEC was floated and PO was released to Mauna Kea Infrared (MKIR) on 22nd August, 2014. The project got started in September, 2014. Major milestones and the current status of the project is given below.

Sr. No.	Milestone	Weeks from start of project	Actual Completion date
1	Sign of Contract and START	0	Sept. 2014
2	Completion of Optical Designs	29	Nov. 2014
3	Preliminary Design Review	52	July 2015
4	Critical Design Review	65	Sept. 2015
5	Ordering Optical Components	69	Nov. 2015
6	Ordering Hardware Components	78	Dec. 2015
7	Delivery of Vacuum Jacket	89	Feb. 2016
8	Ordering Science Array	92	March 2016
9	Warm tests on Electronics and ROIC	105	August 2016
10	First Cool down tests	130	September 2016
11	Installation and Acceptance	163	
12	End of Project (after completion of warranty)	189	

Yellow: Completed, Green: On time, blue: Stage not arrived

The verification of the design suitability, testing and qualifying the spectrometer will be done jointly by DAA-TIFR and ARIES. In addition to the above written responsibilities, ARIES will coordinate the following work packages:

(I) All hardware, software, and operational specifications and requirements related to the telescope and the observatory.

(II) Integration of the instrument control and data acquisition system with the telescope and observatory control system.

(III) Operation and routine maintenance of the instrument.

(IV) Power, network, electrical, mechanical and optical interfaces on the telescope and observatory side.

Last year, a significant progress was made by the project team. Two major milestones i.e. PDR and CDR of the project were concluded successfully in July and September 2015, respectively. A brief detail is given below.

The documents for the PDR of the TANSPEC were made available by MKIR, Hawaii, USA, on 30th June 2015. The documents were circulated to a few experts within India as well as worldwide for their comments. The comments of the reviewers were received on July 15, 2015 and these were compiled as a questionnaire and sent to M/s. MKIR in advance. The PDR meeting was held at ARIES, Nainital, India, from July 20, 2015 to July 24, 2015 along with a visit to 3.6m telescope at Devsthal. Besides the Scientists and Engineers from TIFR, Mumbai, and ARIES, Nainital, national /international experts were invited to review the designs of TANSPEC at the PDR meeting held at ARIES, Nainital. The feedback and comments of the reviewers and the others present at the meeting were compiled and sent to MKIR for further action.

The documents for the CDR of the TANSPEC were made available by MKIR, Hawaii, USA, on September 1, 2015. The documents were circulated to a few experts within India as well as worldwide their comments. The comments of the reviewers were received by September 14, 2015 and these were compiled as a questionnaire and sent to M/s. MKIR in advance. CDR meeting was held through Video conferencing equipment with participation from Scientists and Engineers of TIFR, Mumbai, Scientists and Engineers of ARIES, Nainital and M/s. MKIR represented by Mr. Douglas Toomey on September 15, 2015. Mr. Douglas Toomey of M/s. MKIR, Hawaii, presented the changes that had been made to the TANSPEC Mechanical, Optical and Electrical designs as a result of the recommendations of the PDR Committee. The questions posed by the reviewers were answered satisfactorily and the decisions regarding additional items and changes to specifications was conveyed to M/s. MKIR and were taken into account by them.

After the successful review of the TANSPEC design and its modification, ordering of the optical/hardware components and Science Arrays has been made. The radiation shield and cold structure are ready and warm tests on the electronics and ROIC has been successfully done. At present, preparation of the first cool down tests are under way.

Figure 66. TANSPEC Mechanical design.

Thirty Meter Telescope: a status report

ARIES as one of the founder PI institutes, is involved towards the project since very beginning of the project. ARIES has been granted Rs. 8. crores as a part of its core-grant in 2011 along with 8.0 cores to IIA Bangalore. The aim to award this seed money was to initiate some GSMT-related R&D and prototyping work with the aim of deciding upon possible in-kind contributions to the TMT project from the Indian side and also to gain experience with generic GSMT technologies which would build capacity in the country irrespective of India's participation in the TMT project. Activities going on at ARIES related to the TMT project were presented in detail during 29th GC meeting of ARIES.

During last few months, the major mile stone achieved by ARIES is the successful completion of the contract with the two firms (M/s Godrej Mumbai and Avasarala Bangalore) to manufacture the prototypes of 6 sets of segment support assemblies.

(a) Prototyping of Segment Support Assemblies (SSAs): Under the technology demonstration and development program as mentioned above, ARIES engaged two separate vendors in the execution of this work, i.e. "Fabrication and delivery of 6 version-3 segment support assemblies, assembly tooling and test-bed hardware" each vendor performing approximately half of the work. The Vendor(s) is expected to fabricate, assemble and deliver hardware including six SSAs, various tooling and other hardware for the purpose of supply chain development & vendor qualification by the beginning of 2015. ITCC and the TMT project office shall provide all of the drawings, specifications, and assembly procedures, making this primarily a build-to-print effort. Because this work-scope includes supply chain development and cost estimating for the production program (580 SSAs), it was necessary that the respondents either have the existing capability for performing the production

Figure 67. First set of Indian SSAs as assembled by M/s Godrej on 14 July 2015. In the background staff from Godrej, project office and ITCC.

work, or a credible plan for performing the production work, in order to be qualified for this work.

On 14th of July 2015, the first set of SSAs were assembled by M/s Godrej satisfactorily as per the contract and after a series of extensions to both the firms with due approval, remaining 5 sets were manufactured and shipped to the project office in Pasadena through ITCC by the end of March 2016. Experiences learnt during this ongoing work-package will lead ARIES and other Indian institutes working towards manufacturing of full set of 580 SSAs for the TMT project. Also, this manufacturing WP will be one of the major In-kind contributions from India as proposed.

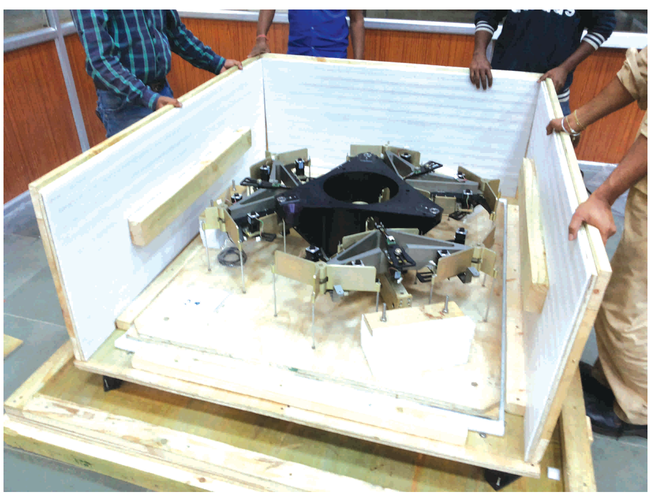


Figure 68. Sixth set of Indian SSAs as assembled by M/s Avasarala on 15th March 2016 at ITCC office Bangaluru before dispatching to the TMTPO Pasadena.

Apart, ARIES was involved and contributed towards other work-packages as well. The summary of these contributions are given below.

(b) Work Package: Prototyping of Leaf Springs for SSAs: The primary mirror ("M1") of the Thirty Meter Telescope (TMT) is comprised of 492 hexagonal mirror Segments. Each mirror segment is 1.44 meters in diameter. These segments need to be maintained at the required surface accuracy and stability, against structural deformations caused by temperature, gravity, wind and seismic vibrations. For this, each segment is actively controlled by three actuators with 21 warping harness leaf springs and passively controlled by the Segment Support Assemblies (SSAs). As a part of free supply item towards the prototypes of SSAs, L-shaped and straight warping harness leaf springs were supposed to be provided by ARIES to the two firms working towards manufacturing of prototypes of SSAs. These required leaf springs were tendered by ARIES (AO 136/TMT/GSMT/14-15) and were manufactured by IPA Bangaluru and have been supplied to IIA-ITCC Bangalure on their request as a part of the ongoing activities by India-TMT. The set of manufactured leaf springs were used during the assembling process of the first set of SSAs. Additional 20 straight and L-shaped leaf springs as required by the project office has also been recently ordered to fulfill the requirements.

(c) Work Package: Participation in the management of I-TMT activities: ARIES has actively participated during weekly Monday core-group I-TMT meeting along with bi-weekly video-conferencing with the project office in Pasadena and institutes participating in India. Also, Director ARIES also participate during regular face-to-face meeting along with Directors of other two institutes and the program director and deputy program director to discuss and decide about several issues including the major ones to run activities related to India-TMT. The decisions of such meetings are minuted and signed for reference and further execution.

(d) I-TMT SAC related activities: The Science Advisory Committee (SAC) is a committee of the Thirty-Meter Telescope International Observatory LLC (TIO) Board of Directors. The SAC is an advisory committee, representing the scientific interests of the TIO Members, including making recommendations to the Board regarding science priorities and instrumentation. India has a team of scientists representing the SAC and Dr. S. B. Pandey is one of the member from ARIES. Since 2011 itself India-SAC has contributed significantly towards the SAC activities hosting regular SAC meetings in different parts of the world and India and have revised the detailed possible science cases to be performed using TMT (**http://arxiv.org/abs/1505.01195**). The detailed about SAC responsibilities are outlined at http://www.tmt.org/about-tmt/science-advisory-committee. SAC has also recommended to form International Science Developmental Teams (ISDTs) throughout the world to work and develop different science cases.

As a part of SAC activity, a science and instrumentation meeting-III was organized using ARIES GSMT budget and was hosted at University of Tezpur Gauhati during 01-03 December 2015. Many scientists and engineers from various institutes and universities of the country participated to this meeting.

Figure 69. A group photograph of science and instrumentation meeting-III hosted at University of Tezpur Gauhati during 01-03 December 2015.

Report on the Existing Observing Facilities

Telescopes for Astronomy

A. The 104-cm Sampurnanand Telescope

The 104-cm ST is still utilized as a main observing facility in the optical domain by the students and scientists of ARIES. The preventive maintenance and the telescope image quality tests were carried out regularly by the scientists and the engineering staff of the ST. There were a number of major telescope problems encountered during the year 2015-2016, related to image quality, telescope pointing, reflectivity etc. All the problems were rectified locally up to a satisfactory level. So far, the total research output of the ST reaches nearly 355 scientific publications in different refereed journals and 49 PhD Thesis over the period of its use. The major back-end instruments like; Wright 2K CCD, Tek 1K CCD and ARIES Imaging Polarimeter (AIMPOL) were working fine. But due a leakage in the dewar of the Wright 2K CCD, it is not working since October, 2015.

Different scientific programs such as; study of star-clusters, young star-forming regions, HII regions, AGN and brown dwarfs, optical counterpart of Gamma-raybursts(GRBs), supernovae and X-ray sources, polarimetric studies of open clusters, star-forming regions and late type stars were carried out with this observing facility. Joint Time Allocation Committee (JTAC) alloted nearly 50% time for CCD imaging, nearly 40% time for imaging polarimetry and 10% time reserve for Target Of Opportunity. During the period of 2015 – 2016, Out of 274 alloted nights we got nearly 150 clear nights. During the last monsoon the primary and secondary mirror of the Sampurnanand telescope were cleaned properly, applying our own innovative idea using warm optical grade tissue paper and a high end vacuum cleaner. After completion of the mirror cleaning, the ST team has successfully done the optical alignment of the telescope and achieved a very good image quality (FWHM of the stellar image up to 1.4 arc sec). The team has initiated the following developmental projects to upgrade the facility without halting the operation of the Telescope; 1. Synchronization of the Dome 2. Automation of Telescope control 3. Replacement of old 1k and 2k CCD The Dome synchronization project is about to be completed and nearly sixty percent of work is completed in telescope automation project. Purchase order of 1k and 2k CCD will be send very shortly.

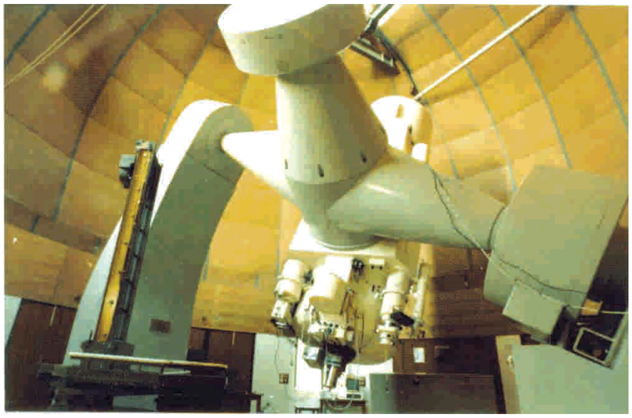


Figure 70. 104-cm Sampurnanand Telescope.

B. 1.3m Fast Optical Telescope (FOT)

Due to heavy monsoon, high humidity, frequent lightening, open truff structure of the telescope and ongoing construction work, the FOT team has to take extra care to protect the telescope. Before the start of observing cycles, the team perform cleaning of the primary mirror, regular checkup of the telescope and the related cameras/instruments. The team also carry out rectification and maintenance activities of the 1.3m telescope housing periodically. The 2K/512 CCD cameras having some problem with their working were send to ANDOR, Ireland for repair. These cameras along with auto-guider/all sky camera/weather station has been repaired and working properly. The team also purchased backups for auto-guider/all sky camera/weather station this year. Several infrastructural steps has been taken such as creation of office/lab space, purchase of furniture's and other necessary items, improving the facilities of the rest rooms/kitchen etc. have been taken to improve the observing through 1.3m telescope.

Apart from above works, the team also maintain online web portal for weather and all sky monitoring which were created to have weather parameters and graphical information's online. These are integrated with the all sky camera to see the weather update and sky view at Devsthal through the dedicated web page. The team maintains a data archive system which can be accessible on the internet so that we can download the data taken from 1.3 m telescope, based on our search criteria such as object name, their coordinates, observer name etc., from any where remotely accessibly by internet. The team also maintain a website of 1.3 m telescope which contains all the necessary information regarding the telescope, its publications, its build, its operation as well as the details of various cameras which are being used on the telescope. Web based interfaces such as online observation logs, online list of publications /documents, online observed nights, online feedback/maintenance facility, online weather station, online documentation etc were also updated routinely to keep observing details of 1.3m telescope.

Papers published based on the data obtained using 1.3m telescope: **Total = 35**

Refereed:http://aries.res.in/~1.3m/publication/publication.php: 28

GCN:http://aries.res.in/~1.3m/publication/gcn/index.php: 7

The FOT team is planning a set of new instruments which will exploit the capability of the telescope fully once they are ready for use, for example, planning to acquire a 4 K CCD camera which can observe a field of view of 26x26 arcmin square which is suitable for wide field studies of star cluster/star forming regions etc. and to develop indigenously a polarimeter for interstellar medium studies having FOV of 20x20 arcmin square.

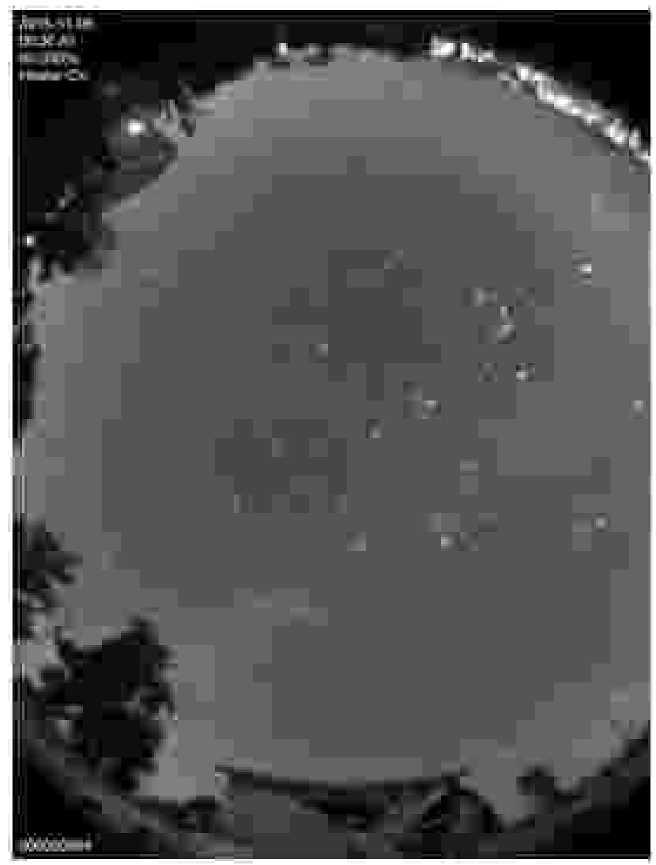


Figure 71. Night-SKY as seen from 1.3m all sky camera.

Reports from the Labs

Optics Lab

Optics section is actively involved in the instrumentation activities related to various projects. Testing, verification of various systems/subsystems was carried out using facilities/instruments available in optics laboratory.

(1). 4K X 4K CCD Testing for Optical Imager Project: The clean room facility of optics laboratory was used for testing of 4K X 4K CCD. CCD was evacuated by using Edward's Turbo molecular pump to a pressure below 5mTorr. CCD was cooled to -120°C by using liquid nitrogen. Flat field and bias images were taken in the laboratory. A screen was placed at sufficient distance from CCD and was illuminated by six diffused sources to produce a uniform diffused illumination for flat fielding. Later on CCD was mounted on 130cm telescope and 360cm Telescope and images were taken.

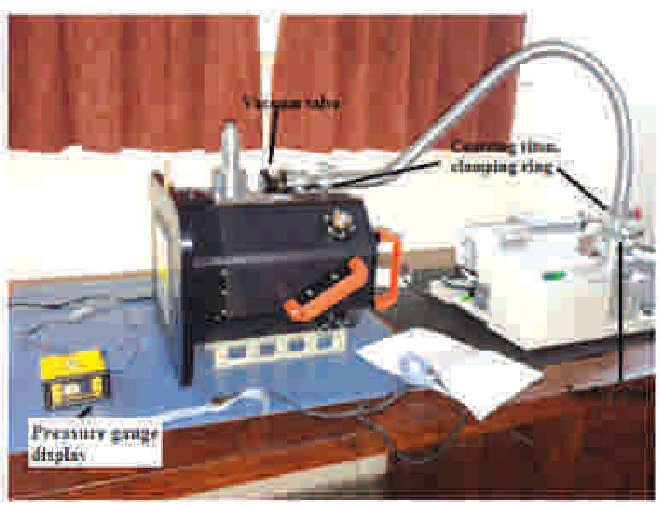


Figure 72. 4K x4K CCD evacuation.

(2). Faint Object Spectrograph and Camera (FOSC): Optics team is actively involved in assembly, testing and verification of different systems/subsystems of the instrument.

(A) Aperture slit was inspected for their slit width and edge accuracy by using optical profiler instrument. These slits are about 80 mm long and having width of 80 micron to 320 micron. Since the slits are only 100 micron thick they were glued precisely on a support bracket and inspected at our laboratory.

(B) Different parts of the FOSC mechanical assembly has been measured by using a coordinate measurement machine. Axial alignment of the assembly was carried out by using a laser system.

(C) Collimator and camera optics has been integrated to the mechanical assembly. Precise alignment of the whole system has been carried out. Further testing and fine tuning in the alignment will be carried out.

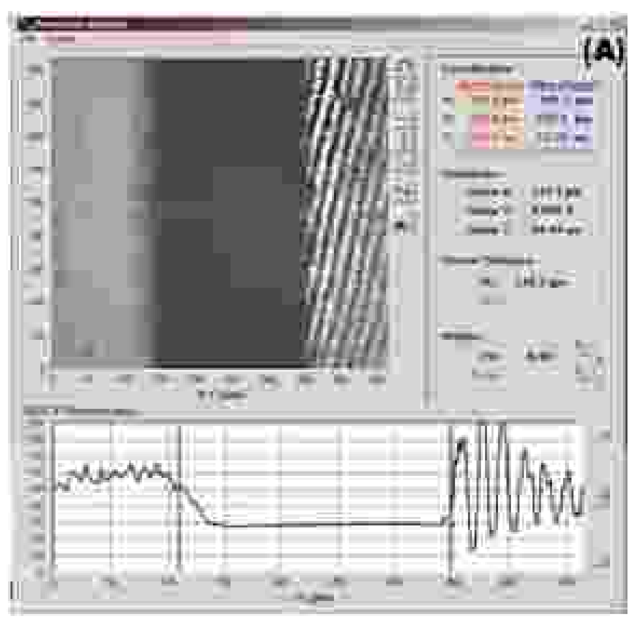


Figure 73. (A) Aperture slit image from optical profiler.

Figure 74. (B) FOSC assembly with collimator and camera.

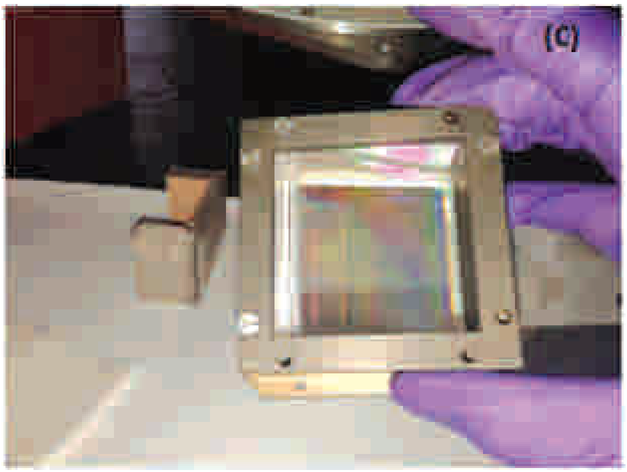


Figure 75. (C) grism in grism holder.

Figure 76. (D) vacuum testing of FOSC CCD Dewar.

Figure 77. (E) camera barrel alignment.

Figure 78. (F) field corrector lens.

(D) Field corrector lens has been integrated to the CCD mounting plate and testing for CCD evacuation is going on.

(E) Optical design analysis of FOSC, using Zemax software is carried out to find the correct order sorting filter, to prevent overlapping of different orders in spectroscopy mode.

(3). Vacuum leakage test for 1K X 1K CCD was carried out and o-ring was replaced at our clean room facility.

Figure 79. (A) 1K X1K CCD placed at clean room facility.

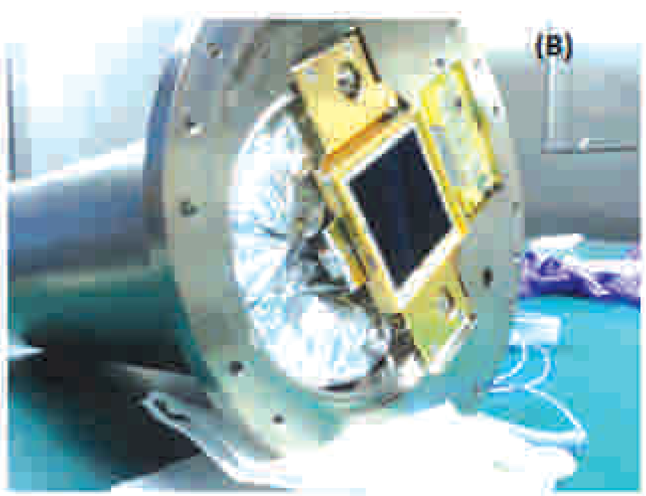


Figure 80. (B) CCD mounting plate has been opened to replace o-ring.

(4). Self pressuring cryo vessel and compatible trolley has been procured for liquid nitrogen filling in 4K x 4K CCD Dewar. Vacuum pump accessories have been procured for FOSC CCD evacuation. In addition to that procurement of SDSS filters, narrow band filters, reflection probe, fiber connectors etc are also in process.

(5). Two 22 inch mirror has been aluminized using the coating facility at Manora Peak.

(6). Zemax tolerance analysis for optical imager for position/tip-tilt of focal plane.

(7). Optical design verification of near infrared spectrograph at PDR and CDR stage.

(8). Guide port folding mirror has been procured. This mirror will be integrated at the guiding unit of 130 cm telescope.

Electronics Lab

Development Activities at Electronics Lab of ASTRAD

Last year, an ESD safe electronics laboratory **(Figure 81)** at ASTRAD facility has been commissioned to cater the need of in-house design, development and testing of various high end modules functioning in radio frequency (VHF) and digital domain. The laboratory is equipped with ESD safe workbenches, tools/tackles, and advanced test & measuring instruments like spectrum and network analyzers, oscilloscopes, power meters, soldering/re-work stations for BGA and SMD components.

The major developmental activities carried out in this laboratory (2015-16) besides routine maintenance

Figure 81. ESD safe electronics laboratory.

jobs are summarized below:

(a) Dual-channel 16-bit front-end receiver

Generally, Doppler detection in backscattered echoes of wind-profiler radar like ASTRAD is accomplished through time & frequency domain processing on in-phase (I) and quad-phase (Q) signal after down-conversion. This function of Doppler detection has been demonstrated by designing and developing a prototype unit comprising of four sub-units - dual channel RF-to-IF section, filtering blocks, digitally-controlled gain block providing gain up to 33dB at 0.5dB steps and 16-bit I & Q digitizer. This prototype has achieved wide dynamic range of ~80dB at 30MHz IF and can perform sampling at maximum 250 MSPS with SFDR and SNR levels of ~88dB and ~75dB, respectively.**(Figure 82 & 83)**.

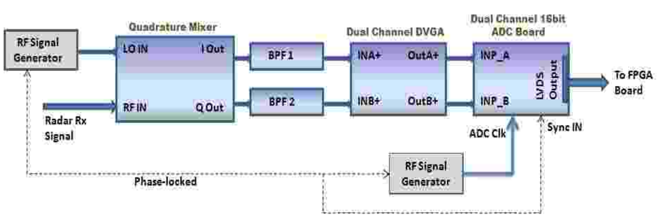


Figure 82. Operational block diagram of Dual Channel 16 bit front and receiver

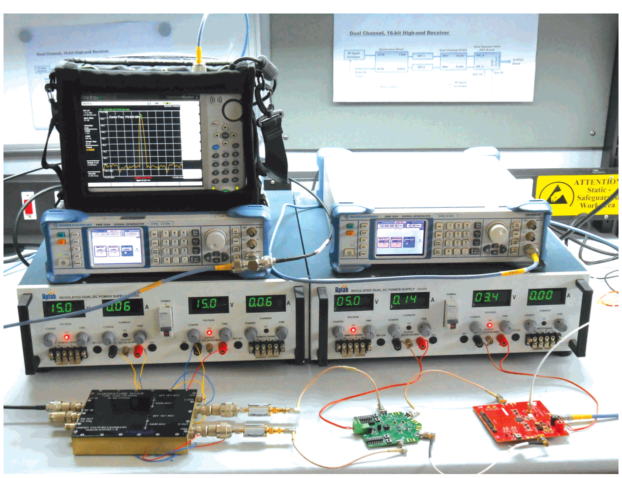


Figure 83. Test setup of the front and receiver.

(b) High power duplexer

In a mono-static pulsed doppler radar like ASTRAD the transmission and reception are controlled and routed by a high speed duplexer. A prototype of the duplexer has been designed and fabricated which can operate in VHF frequency band from 204-209 MHz and can handle 450 watt peak power at maximum 13% duty cycle with insertion loss of 1.5dB.The switching speed and isolation between Tx/Rxachieved 4us and 40dB,respectively. **(Figure 84)**

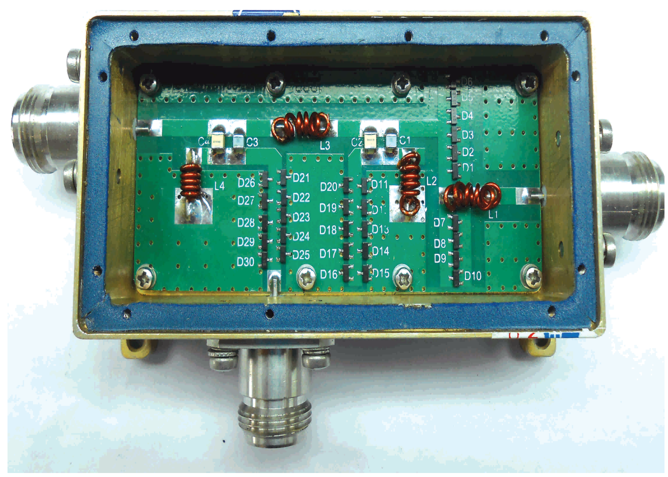


Figure 84. High power duplexer

(c) 4-1/2 digits, quad-digital display panels for transmit-receive modules (TRMs)

ASTRAD system contains 588 TRMs which are powered by +32V and +5V DC power supplies. The level of peak power radiated by a TRM can be monitored by observing the current drawn from the DC power supplied. The existing power supply units are not equipped with any displays for voltage/ currents. Last year an attempt has been made to design and develop quad-display panels in-house for 49 TRMs as a pilot project which can be integrated without much modification in existing power supply units. The production of 49 panels was completed and installation is underway. **(Figure 85)**

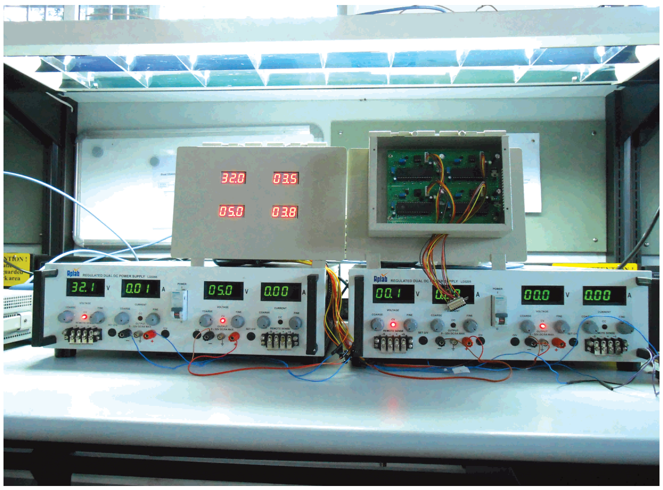


Figure 85. Lab testing of the digital display panel.

Activities of Computer section during 2015-16

1. Devasthal campus is now connected with OFC. A new 10 Mbps leased line (1:1) has been implemented successfully. This is working fine .

2. We have implemented Centralized Storage system at ARIES, before this data was kept in different locations and it was very difficult to manage the data efficiently. Now using centralized storage, data is being saved at a central location. Now it is very easy to manage this data efficiently for scientific purpose. This system supports Automatic volume management, Disk array enclosure, disk processor enclosure, Fibre channel, fibre channel over Ethernet, SAS etc.

3. Two new Video conference system (One at Devasthal , another at Nainital) are installed and these systems are working fine.

4. 30 new desktops, 30 new laptops, 5 new workstation are procured and installed. They are working properly.

5. The 3.6M DOT building is connected through ARIES network, Both wired & wireless networks are working fine.

6. Computer section has successfully handled the event of remote technical activation of 3.M DOT. The technical activation of the 3.6M DOT was done by Hon'ble Prime Minister of India.

7. Portal for collecting Report (Publication, Visits, Project, Lectures) from Scientists and Engineers have been designed.

8. Proposal Submission System for 104cm Telescope and 130cm Telescope has been updated.Which is available at

   www.aries.res.in/~40inch/104cm .

9. 3.6m Telescope Building Indoor weather data logger software developed.

10. Web portal for PhD Online application submissions have been developed for the year 2016 using PHP and MySQL.

Knowledge Resource Centre (KRC)/Library

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 at 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 2015 – 2016, the following information resources were added:-

Books :49

Subscription to Journals :74 (Print + Online) + Full Text Databases

Publications in refereed journals : 45

Theses awarded : 05

The collection at the end of the period is Books : 10,880

Bound volumes of Journals : 11,205

Apart from books and journals, non-book 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 on 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 86. 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 (effective from 28 January 2016) members of the committee are:

- Dr. Manish Naja (Chariman)
- Dr. S. B. Pandey
- Dr. Biman J Medhi
- Dr. Saurabh
- Dr. Sneh Lata
- Dr. J. C. Pandey
- Dr. Narendra Singh

Mr. Ramdayal, secretary to the AC

Drs. Maheswer Gopinathan and Hum Chand were also member of AC, prior to 28 January 2016.

Major academic activities of 2015-2016 are listed below:

[A] Joint Entrance Screening Examination (JEST):

One of the members of AC (Dr. Narendra Singh) took the responsibility of conducting the JEST 2016 examination at Nainital centre. AC also actively participated in the over planning of the JEST on the behalf of ARIES.

[B] PhD entrance interviews:

AC organizes interviews every year to select PhD students as Junior Research Fellows (JRFs) in ARIES. Dr J. C. Pandey/Dr Hum Chand and other AC members screened all applications and interviews was conducted during 29 June – 3 July, 2015. 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. In the year 2015, 8 students have jointed ARIES as JRFs.

[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 and provides 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 the ARIES. Committee conducts the trimester pattern 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 evaluate 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 2015-2016, AC conducted the examination and project presentations of the first year batch 2014-15. Following students successfully negotiated the Pre PhD course work, and entered the main PhD programme of ARIES:

- Ms Anjasha Gangopadhay
- Ms Ekta Sharma
- Mr Pankaj
- Ms Raya Dastidar
- Mr Vineet Ojha
- Mr Ashsini Pandey
- Mr Kuldeep Singh
- Ms Piyali Saha
- Ms Sapna Mishra

[E] PhD Thesis awarded:

As many as five students of ARIES defended their PhD thesis during April 2015-March 2016. And they are:

- Dr Archana Soam
- Dr. P K Kayshap
- Dr. Ravi Joshi
- Dr Rajiv Kumar
- Dr. Devesh Path Saria

Apart from these, four students submitted their PhD thesis.

- Ms Hema Joshi
- Mr Jay Bhaghvan
- Mr K K Shukla
- Mr Subhas Bose

Drs. Archana Soam, Devesh Path Saria, P K Kayshap and Ravi Joshi left ARIES and joined post doctoral positions elsewhere.

[F] Conducting/Managing Post Doctoral Fellows:

All the applications related to postdoctoral fellows are processed by Dr Maheswar Gopinathan/Dr J C Pandey. Under the guidance of the Director, the AC arranges the expert committee for the post doctoral position and the interview cum presentation of the applicants. AC also manages the annual reviews of the post-doctoral fellows. The list of Postdocs at ARIES are:

- Ms Alka Mishra
- Mr. K K Shukla
- Ms Srabanti Ballav
- Mr Subhas Bose

[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 review process. The recommendations on upgrading their fellowships, thesis submissions etc are based on the significant review process organized by the committee. In 2015 the following students have been promoted to SRF after the review process:

- Ms. Mridweeka Singh
- Mr. Mukesh Vyas

[H] Orientation Programme 2015

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 2015 was conducted on 10th August 2015 **(Figure 87)**.

Figure 87. Group photo with newly joined JRF and pass out JRF of Pre PhD course work during orientation programme conducted on 10th August 2015.

Public Outreach Programmes

Public Outreach is an ongoing program at ARIES. Department of Science and Technology (DST) also supports these activities to increase general awareness about astronomy and basic sciences among common people. 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 made a science center comprising one lecture hall, equipped with projector and sitting arrangements of about 40 students and a 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 5m planetarium is also made functional at ARIES. Such planatarium plays an important role in astronomy popularisation. This is used as a virtual sky as well as to show many full dome astronomical movies to the visitors.

Because of observatory attraction, we also entertain on regular basis dozen of visitors per day and 3-4 educational tour per month, and shows them ARIES facility and give popular talks (for educational tour) or have slide shows (for general visitor). In addition, huge rush used to be in summer or on the occasions of popular astronomical events like eclipses and other planetary event. On the occasions of such major astronomical events, special arrangements are made to provide related information to the visitors and the sky-watching programs using the telescopes. Apart from this, we also make use of print and electronic media to communicate information related to astronomical events as and when required as a part of the public outreach activities. Popular talks in the nearby schools and colleges are also arranged.

Popular science Programme

ARIES apart from its main hardcore research, consistently engaged in dissemination of Science and Technology to general public, particularly Astronomy. Related to this, last year we organised five popular science programme as described briefly below.

Motivational summer workshop on observational Astronomy:

ARIES in association with 'South Howrah citizens Forum' have organizing a 8 days program for 11 well selected senior school students from different schools in the vicinity of Birbhum Institute of Engineering and Technology (BIET), *Suri*, India. These students have been selected through a written test among the 130 students of class 11, who attended the DST INSPIRE Science and night Observation Programme held at BIET, Suri from 5 to 9 January, 2015. The main goal of this program was to motivate young talented school students to the excitements of astronomy and Astrophysics, beside giving them flavour of existing and upcoming observational facilities in national as well as international levels.

Astronomical Telescope Making Workshop:

Astronomical Telescope Making workshop (ATMW) was an initiative of Vigyan Prasar, and ARIES was also a partner of this programme. The second ATMW has been organised at Jalandhar, where about 22 team participated from across the country during 05-16 October 2015. The workshop was primarily aimed to attract professionals, amateurs and enthusiasts who were give training to make their own five inch (5”) Dobsonian Telescope from locally available material. For that workshp ARIES provided free aluminizing facility as well as resource person. The program was a grand success.

Science Day Celebration:

This programme has been organised on 28 February 2015 on the occasion of National Science Day under theme of "Make in India". In this programme about 30 Students of class 10-12 from Nainital and its nearby place were invited. The programme began with a lecture on the topic "Raman Effect and structure in the universe". Beside that a popular lecture on basic Astronomy was given along with a planetarium show and facility visit.

Dr. A. P. J. Abdul Kalam's Birthday Celebration:

This programme has been organised on 15 October 2015 on the occasion of Dr A. P. J. Kalam Birthday. In this programme about 30 students of class 10-12 from Nainital and its nearby place were invited. The programme began with a lecture on the topic "Life and idea of Dr. Kalam" which is followed by Popular science talk and Quiz based on Dr. Kalam works. The programme was ended with a visit to our facilities and a Planetarium show.

ARIES Training School of Observational Astronomy (ATSOA):

ARIES training school in Observational Astronomy (ATSOA) is our annual programme, where about 30-40 post graduate science students from different universities/institution participate to get training about observational Astronomy. This year it was held between February 29-March 10 2016. The main motivation for this school was that our current understanding of the Universe depends not only on continuous growth of observation facilities, but also on the number of peoples utilizing them. Recently there has been seen serge in upcoming observatories, not only national wise but also in the international scenario. Given these developments, the need for more researchers to exploit the enormous volume of available and upcoming scientific data, both by analysing these data and interpreting them, is pressing. In this context, 6^{th} annual ATSOA was held from 29 March 2016 until 10 March 2016 at ARIES, Manora Peak Nainital to provide MSc final year or Fresh Ph.D students the necessary expertise/skill to independently conduct data-analysis relating to observational astrophysics especially in optical domain.

About 40 participants from various university /college and institute participated in this school. The focus was on hand on experience on observational Astronomy using 1m-ARIES telescope. There was about two dozen of lecture by ARIES faculty and small project supervised by ARIES research scholar to give first hand experience in dealing with real astronomical data. To give finishing touch on the projects, a small presentation was also given by participants on the project work carried during the school.

In addition, scientist from our outreach program give 3-4 popular talk about every month to the educational tour visiting observatory as well as travel other places in the country as invited speaker on various such occasions related to science outreach activity.

Other outside campus activites in the field of Science Popularisation:

Participation in Exhibition.

ARIES participated in four exhibition in different of part of country to showcase our facility and different activity including Indian Science Congress at Mysore, International Trade Fair at Delhi, India, International Science Festival at IIT Delhi and Grand mela at Simouni-Banda.

In addition, ARIES outreach team also contributed , "Cosmos from my terrace" which is a programme of Vigyan Prasar, where Vigyan Prasar provides its telescope to schools for a year. With this students carry out small observational projects. ARIES also play a vital role in this programme by providing resource persons.

This year about 7500 visitor got benefited by their visit to our science centre, among them about 60% were students from various schools/colleges.

Figure 88. Act. Director ARIES addressing students during Dr. Kalam Birthday Celebration.

Figure 89. Quiz Competition During Dr. Kalam Birthday Celebration.

Figure 90. Group photo of participants and speakers of Dr. Kalam Birthday Celebration.

Figure 91. Dr. Sheshadri (Delhi University) giving his lecture on National Science Day Celebration.

Figure 92. National Science Day Group Photo.

Figure 93. ATSOA lecture in progress.

Figure 96. ATSOA group photo.

Figure 94. ATSOA Participant's visit to 40inch Telescope.

Figure 97. ATSOA Participant's visit to 3.6m Devsthal Optical Telescope.

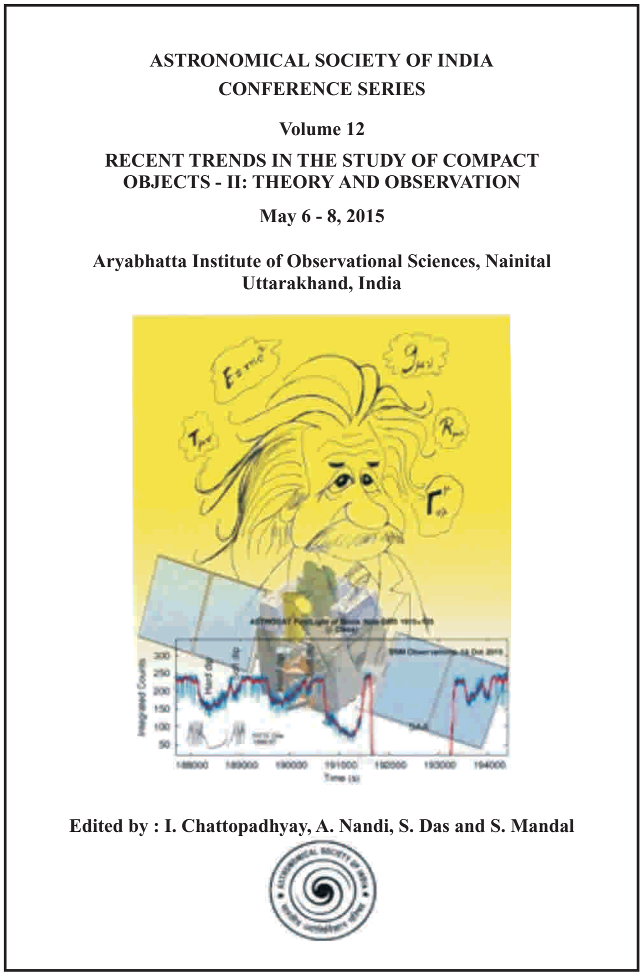
Figure 95. ATSOA Participant's visit to 15cm Solar Telescope.

Figure 98. ATSOA Participant's visit to S T Radar for Baloon Flight.

Figure 99. India International Science Festival

Figure 100. Act. Director Presenting a souvenir to Dr. Harsh Vardhan, Central Minister (S&T)

Report on a National Level Conference held at ARIES



(http://www.astron-soc.in/bulletin/asics_vol012/)

A National level conference (May 6-8, 2015) called `**RE**cent **T**rends in the studies of **C**ompact **O**bjects (RETCO): Theory and Observation' – II, was organized and funded by ARIES.

RETCO is a series of conference initially envisaged to extend the advances in research in high energy astrophysics to the students of north-eastern India. In keeping with this spirit the first edition was held in IIT-Guwhati in 2013. The tremendous response from the entire community of scientists, broadly related to the research in and around compact objects like black holes, neutron stars and white dwarfs, encouraged us to spread the horizon and scope of this meeting. With this back ground in mind and the happy confluence of the launching of Astrosat, installation of 3.6 meter Devasthal optical telescope and the centenary year of general theory of relativity, encouraged us to hold the conference in ARIES.

Research in compact object has passed from the sedentary stage to cutting edge stage over the last three decades. From tentative analysis of Cygnus-X1 and suggestion of the existence of black holes, to constructing catalogues of detailed feeding and ejection behavior of black holes. From unification of AGNs to establishing clear correlation of X-ray binaries and AGNs. From observing the death of the stars, to establishing the connection between supernovae and gamma-ray bursts. From being satisfied with approximate analytical solutions of accretion, jets, blast waves, to constructing state of the art numerical simulation codes of hydrodynamic and magneto-hydrodynamic flow in strong gravity, astrophysics around compact object has made advances of cosmic proportion. RETCO in its second edition has initiated to draw the balance-sheet of latest progress in this field, and what has been India's contribution in this progress.

About sixty participants from all over the country participated. Experts in radio, optical and X-ray astronomy locked horns with experts on theory and numerical simulations for three days, in order to understand intriguing observations. ARIES by funding this conference exposed its students to the wider community, while showcased its array of observational facilities to the astronomy community of the country. The meeting ended with an excursion to Devasthal telescope site.

Proceedings of the conference was published online in Astronomical Society of India, Conference Series (ASICS), and was edited by I. Chattopadhyay (ARIES), A. Nandi (ISAC-ISRO), S. Das (IIT-Guwahati), S. Mandal (IIST).

RETCO-II was conducted under the aegis of a National Advisory Committee, Organizing Committee and the Local Organizing Committee.

National Advisory Committee: A. R. Rao, B. Paul, D. Bhattacharya, D. J. Saikia, I. Chattopadhyay, K. P. Singh, P. Subramanian, S. K. Chakrabarti, S. Seetha, W. Uddin.

Organizing Committee: I. Chattopadhyay, A. Nandi, S. Das, S. Mandal, G. Dewangan, S. Bhattacharya, A. Gupta, J. C. Pandey, H. Chand.

Local Organizing Committee: I. Chattopadhyay, J. C. Pandey, H. Chand, S. Bose, R. Kumar, A. Sharma, M. Vyas, P. Kumar, Purushottam, V. K. Singh.

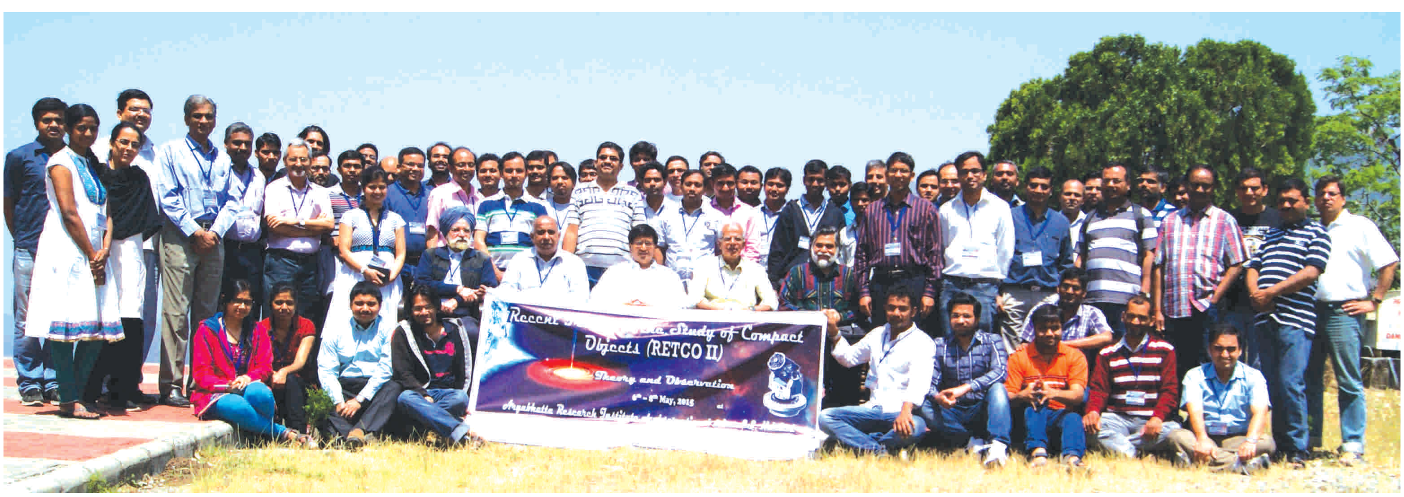


Figure 101. Conference Group Photo

Figure 102. Inaugaration by Dr. W. Uddin.

Figure 103. Welcome on behalf of the organizers.

Figure 104. Scientific sessions

Figure 105. Scientific sessions

Figure 106. Reflecting on the day's progress

Staff Welfare Measure

Medical Facility:

The Institute has its medical reimbursement system through which bills on expenses of both indoor and outdoor treatment in respect of all employees and their dependent family members are reimbursed as per CGHS rates. ARIES also made tie-up with SAI Hospital, Haldwani (Dist.- Nainital) on Cashless basis and with Brijlal Hospital, Haldwani (Dist. - Nanital) through which bills on expenses are reimbursed as per CGHS rates. One doctor is engaged by the ARIES who pays visit to the institute once in a week. Facilities like rest bed and pressure machine are readily available in the doctor's chamber. The institute has made tie up with some of the renowned hospitals of Haldwani (District - Nainital) as per CGHS rates to provide medical facilities to employees and their dependent family members.

Canteen Facility:

The institute is having a canteen run by ARIES itself 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 is also having a departmental store which serves employees and their family members who are living 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 Govt. of India from time to time.

Prevention of Sexual Harassment of Women at Work Place:

Necessary mechanisms have been placed 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.

Remote Technical Activation of the 3.6m Devasthal Optical Telescope (DOT) on 30th March, 2016

Figure 107. Arrival of Dr. Harsh Vardhan for the Telescope Activation Function.

Figure 108. The Technical Activation Function.

Figure 109. Welcome of Dr. Harsh Vardhan

Figure 110. Address of Dr. Harsh Vardhan at Technical Activation Function.

Figure 111. Interaction with media by Dr. Harsh Vardhan.

Figure 112. Dr. Wahab Uddin presenting the picture of Crab Nebula captured using 3.6m DOT and newly installed 4K x 4K CCD Imager.

Figure 113. Presence of Dr. Harsh Vardhan and Dr. Wahab Uddin at 11m floor, Devasthal during Technical Activation.

Figure 114. Presence of Hon'ble Prime Minister Shri Narendra Modi at Brussels, Belgium for Technical Activation event of 3.6m DOT at Devasthal, Nainital.

Members of ARIES

Academic (23)

Wahab Uddin
(Acting Director)
Alok C. GUpta
Biman J. Medhi
Hum Chand
Kuntal Mishra
Manish Naja
Santosh Joshi
Snehlata
Satish Kumar
(Information Scientist)
Amitesh Omar
Brijesh Kumar
Indranil Chattopadhyay
Mahendra Singh
Narendra Singh
Shashi Bhushan Pandey
Umesh C. Dumka
Anil K. Pandey
D. V. Phanikumar
Jeewan C. Pandey
Maheswar Gopinathan
Ramakant Singh Yadav
Saurabh
Yogesh C. Joshi

Engineering (13)

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

Administrative and Support (15)

Ravinder Kumar
(Registrar)
Abhishek Kumar Sharma
Diwan Ram
Manjay Yadav
Rajeev Kumar Joshi
Virendra Kumar Singh
Bharat Singh
(Asstt. Registrar)
Anand Singh Bisht
Hansa Karki
Mohan Singh Bisht
Rajendra Prasad Joshi
Bhuwan Chandra Arya
Mahesh Chandra Pande
Praveen Solanki
Vijay Kumar Meena

Scientific and Technical (38)

Abhijit Misra
Arjun Singh
Bharat Bhushan
Darwan Singh Negi
Girish Kumar
Ishwari Dutt Joshi
Kanti Ram Maithani
Naveen Chandra Arya
Pawan Tiwari
Rajdeep Singh
Ram Lal *(till 30-06-2015)*
Anant Ram Shukla
Ashok Kumar Singh
Bipin Chandra Pant
Girija Nandan Pathak
Harish Chandra Tewari
Javed Alam
Lalit Mohan Dalakoti
Nitin Pal
Pradip Chakarborty
Rajan Pradhan
Ravindra Kumar Yadav
Anil Kumar Joshi
Babu Ram
C. Arjuna Reddy
Girish Chandra Giri
Hemant Kumar
Kanhaiya Prasad
Manoj Kumar Mahato
Parmatma Saran Yadav
Prashant Kumar
Rajendra Prasad
Sanjay Kumar Singh

Members of ARIES

Shashank Shekhar *(till 18-09-2015)*
Srikant Yadav
Tileshwar Mahato
Uday Singh
Vinod Kumar Sah

Laboratory Assistant/Attendants (13)

Ashok
Basant Ballabh Bhatt
Girish Chandra Badhani
Harish Chandra Arya
Lalit Lal Sah
Laxman Singh Kanwal
Mohan Singh Rana
Rakesh Kumar
Ram Ashish Ram
Ramdayal Bhatt
Shyam Giri
Shyam Lal
Suresh Chandra Arya

Post Doctoral Fellows/Research Associate (10)

Mrs Alka Mishra *(from 11-05-2015)*
Mrs. A. Soam *(till 10-12-2015)*
Mr. Brajesh Kumar *(till 21-07-2015)*
Mr. D. P. Sariya *(till 21-08-2015)*
Mrs. H. Joshi *(from 21-09-2015)*
Mr. K. K. Shukla *(from 01-01-2016)*
Dr. P. Mohan *(till 17-09-2015)*
Mr. Rajiv Kumar *(from 06-04-2015)*
Mr. Subhash Bose *(from 11-09-2015)*
Dr. S. Ballav *(from 18-06-2015)*

Research Scholars (35)

Ms. Abha Monga
Mr. Abhishek Paswan
Ms. Aditi Agarwal
Ms. Anjasha Gangopadhyay
Mrs. Archana Soam
Ms. Arti Joshi
Mr. Ashwini Pandey
Ms. Ekta Sharma
Ms. Hema Joshi
Mr. Krishna K. Shukla
Mr. Kuldeep Singh
Ms. Mridweeka Singh
Mr. Mukesh K. Vyas
Ms. Neha Sharma
Mr. Pankaj Sanwal
Mr. Parveen Kumar
Ms. Piyali Sah
Mr. Piyush Bhardwaj
Mr. Rajiv Kumar
Mr. Raman Solanki
Ms. Raya Dastidar
Ms. Sapna Mishra
Mr. Subhajeet Karmakar
Mr. Subhash Bose
Mr. Sumit K. Jaiswal
Ms. Vidhushi (till 24-07-2015)
Mr. Vineet Ojha
Mr. Rakesh Pandey
Mr. T. Sinha
Ms. Priyanka Jalan
Ms. Shilpa Sarkar
Mr. Jayanand Maurya
Mr. Surendra V. Singh
Mr. Gaurav Singh
Ms. Bharti Arora

Visits made by ARIES Members

International Visits:

Dr. Manish Naja	Bangkok, Thailand Potsdam, Germany Academic Sinica, Taiwan	11-12 June, 2015 28 Sept. - 01 Oct., 2015 29 Feb. - 1 Mar., 2016
Dr. Santosh Joshi	Teaxas, USA University of Texas, Arlington University of Florida SAO, Russia; SAI, Moscow and INASAN, Moscow	15 - 18 June 2015 19 - 23 June, 2015 24 - 27 June, 2015 13 - 30 Oct., 2015 27 - 29 March, 2016 28 Mar. - 10 April, 2016
Dr. A. C. Gupta	SHAO, CAS, Sanghai, China	07 June - 06 July, 2015
Dr. Amitesh Omar	Dwingeloo, Netherlands	31 Aug. - 04 Sept. 2015
Dr. S. B. Pandey	Granada, Malaga, Spain	27 Sept. - 10 Oct. 2015
Dr. D. V. Phanikumar	KASI, South Korea	27 Oct. - 06 Nov. 2015
Dr U. C. Dumka	Nanjing University, China	15 Nov. – 07 Dec. 2015
Dr. A. K. Pandey	NARIT, Thailand SAO, Russia; SAI and Moscow, Russia	11 - 22 Jan., 2016 28 Mar. - 10 April, 2016
Dr. Yogesh Chandra Joshi	SAO, Russia, and SAI and Moscow, Russia	 28 Mar. - 10 April, 2016

National Visits:

Dr. U. C. Dumka	IITM, New Delhi DST PAC Meeting MPCST, Bhopal IIFM, Bhopal IIRS Dehradun	07 Jan. - 10 Apr. 2015 19 January, 2016 08 - 12 February, 2016 24 - 28 August, 2015
Dr. Santosh Joshi	G. G. I. C. and NVS, Champawat Delhi University, Delhi	07 - 09 May, 2015 14-19 February, 2016
Mr. Satish Kumar	INFLIBNET, Gandhinagar IIT, Roorkee	15 - 20 June, 2015 24 - 25 August, 2015

Dr. Brijesh Kumar	IIA Bangalore	06 July 2015
	DST, Delhi	01 - 02 Sep., 2015
		20 - 23 Sep., 2015
		27 - 29 Sep., 2015
		31 Jan. - 2 Feb., 2016
		20 - 24 Feb., 2016
		17 - 18 Mar., 2016
	NCRA, Pune	18 - 20 Aug., 2015
Dr. Hum Chand	IUCAA, Pune	02 - 14 August, 2015
	ICTS, Karnataka	11 - 20 October, 2015
	INSA, New Delhi	18 - 21 March, 2016
	IIT, Delhi	03 - 04 December, 2015
Dr. Narendra Singh	NCRA, Pune	18 - 20 Aug., 2015
	IMD, Delhi & JNU Delhi	28 Aug., 2015
	University of Delhi	4 - 6 Jan., 2015
	VSSC Trivandrum	08 - 13 Feb., 2016
Dr. A. C. Gupta	Delhi Univ., Delhi	24 - 25 Aug., 2015
	BARC, Mumbai	23 - 27 Sept., 2015
	IIA, Bangalore	06 - 11 Jan., 2016
	TIFR Balloon Facility, Hyderabad	12 - 15 Jan., 2016
	IUCAA, Pune	16 - 19 Jan., 2016
	TIFR, Mumbai	20 - 23 Jan., 2016
Dr. Saurabh Sharma	TIFR Mumbai	31 Aug.- 12 Sept. 2015
	CREST, Bangalore	31 Jan. - 02 Feb 2016
Mr. Raman Solanki	NESAC, Umiam, Shillong	5 - 14 Sept., 2015
	IIT Delhi	4 - 8 Dec. , 2015
	University of Delhi	4 - 6 Jan., 2016
	VSSC, Trivandrum	08 - 13 Feb., 2016
Dr. Indranil Chattopadhyay	SINP, Kolkata, India	12 -17 Oct. 2015
	Pt. Ravishankar Shukla, Univ. Raipur	25 Nov. - 04 Dec. 2015
	TFIR, Mumbai	20 - 23 January, 2016
	SINP, Kolkata, India	28 - 11 February, 2016
Dr. A. K. Pandey	Dibrugarh University, Assam	02 - 11 Nov. 2015
Dr. Tarun Bangia	GMRT, Pune	23 Feb., 2016
	IUCAA, Pune	24 - 26 Feb., 2016
Mr. Samaresh Bhattacharjee	CUSAT, Cochin	23 - 29 Jan, 2016
	Pune University, Pune	20 - 23 Mar. 2016
Mr. Ashish Kumar	Pune University, Pune	20 - 23 Mar. 2016

Visitors at ARIES

From Abroad

Prof. Jean Surdej	Liege University, Belgium	12 - 20 May, 2015
		27 May - 10 June, 2015
Dr. Douglas T.	USA	20 - 24 July, 2015
Dr. Charles Z.	USA	20 - 24 July, 2015
Prof. N. Kobayashi	IOA University of Tokyo	20 - 25 July, 2015
Prof. Shashi K. Kanbur	SUNYO, Osyogo, USA	08 - 12 Aug., 2015
Mr. Iteven Peare	Canada	26 Sept.- 5 Oct., 2015
Dr. Martin Sahultz	FZ Julich, Germany	23 - 25 Oct., 2015
Dr. Boris Filippov	Troitsk Moscow, Russia	7 - 18 Nov., 2015
Prof. Krishna Kumar	Howard University, USA	27 - 28 Dec., 2015
Dr. Anil P.	PDA, USA	27 - 28 Dec., 2015
Dr. D. Buckcey	SAAO Observatory, South Africa	28 - 31 Jan., 2016

From Other Indian Institution

Mr. Anil Kumar Yadav	GBPIHED, Almora	17 - 18 April, 2015
Prof. U. C. Joshi	PRL, Ahmedabad	30 April - 05 May, 2015
Dr. C. S. Stalin	IIA, Bangalore	05 - 08 May, 2015
Dr. Aarthy E.	PRL, Ahmedabad	05 - 09 May, 2015
Dr. P. S. Pal	S. N. Bose, Kolkata	05 - 08 May, 2015
Dr. B. G. Dutta	R. B. C. College, Kolkata	05 - 08 May, 2015
Prof.. S. K. Chakrabarti	S. N. Bose, Kolkata	05 - 08 May, 2015

Mr. D. Bandhyopadhyay	SINP, Kolkata	05 - 08 May, 2015
Dr. B. C. Joshi	NCRA, Pune	05 - 08 May, 2015
Dr. P. Dasgupta	University of Delhi, Delhi	05 - 08 May, 2015
Dr. A. Ghosh	S. N. Bose, Kolkata	05 - 08 May, 2015
Dr. Varun Bhalerao	IUCCA Pune	05 - 08 May, 2015
Dr. Rajeev Misra	IUCCA, Pune	05 - 09 May, 2015
Dr. Anuj Nandi	ISAC, ISRO, Bangalore	05 - 09 May, 2015
Dr. Samir Mandal	ISAC, ISRO, Bangalore	05 - 09 May, 2015
Dr. S. Das	ISAC, ISRO, Bangalore	05 - 09 May, 2015
Dr. S. Pal	ICSP, West Bangal	05 - 09 May, 2015
Dr. D. Debnath	ICSP, West Bangal	05 - 09 May, 2015
Dr. K. S. Baliyan	PRL, Ahmedabad	05 - 09 May, 2015
Dr. S. Mondal	ICSP, West Bangal	05 - 09 May, 2015
Mr. Santosh	PRL, Ahmedabad	05 - 10 May, 2015
Dr. G. C. Devangan	IUCCA, Pune	05 - 12 May, 2015
Dr. B. Paul	RRI, Bangalore	06 - 07 May, 2015
Dr. D. Mitra	NCRA, Pune	06 - 08 May, 2015
Dr. A. R. Rao	TIFR, Mumbai	06 - 08 May, 2015
Dr. K. P. Singh	TIFR, Mumbai	06 - 09 May, 2015
Dr. Prasad S.	IISER, Pune	08 - 10 May, 2015
Dr. K. D. Purohit	HNB G University, Srinagar	10 - 16 May, 2015
Dr. M. Ponraj	IIGM, New Mumbai	11 - 12 May, 2015
Dr. Vijay Kumar K	IIGM, New Mumbai	11 - 12 May, 2015
Dr. A. Jayaraman	NAPL, Tirupati	27 - 29 May, 2015

Dr. K. Krishnamurthy	ISRO, Bangalore	27 - 29 May, 2015
Dr. J. Rukmini	Osmania University Hyderabad	08 - 20 June, 2015
Prof. Binay Patra	IIT, Roorkee	10 - 17 June, 2015
Prof. P. P. Pathak	GKU, Haridwar	17 - 19 June, 2015
Prof. P. C. Agrawal	University of Mumbai	20 - 23, June, 2015
		28 - 29 Nov., 2015
		27 - 28 Dec., 2015
		29 Mar. - 01 April, 2016
Dr. S. S. Gosh	SPL, VSSC, Trivendrum	21 - 23 June, 2015
Prof. A.N. Ramprakash	IUCAA Pune	21 - 23 June, 2015
		27 - 29 Dec., 2015
Mr. R. Sharma	Delhi University, Delhi	25 June - 04 July, 2015
Mr. T. R. Seshadv	University of Delhi, Delhi	25 June - 04 July, 2015
Dr. Manoj P.	TIFR, Mumbai	20 - 25 July, 2015
Prof. S. N. Tandon	IUCAA, Pune	20 - 23 July, 2015
		28 - 29 Oct., 2015
		27 - 29 Nov., 2015
Prof. D. K. Ojha	TIFR, Mumbai	20 - 24 July, 2015
		27 - 29 Dec., 2015
Dr. M. B. Naik	TIFR, Mumbai	20 - 25 July, 2015
Dr. J. P. Ninan	TIFR, Mumbai	20 - 25 July, 2015
Prof. T. P. Prabhu	IIA, Bangalore	20 - 25 July, 2015
Dr. S. L. D. Costa	TIFR, Mumbai	20 - 25 July, 2015
Mr. Kausal Sharma	Delhi Univ., North Cam.,New Delhi	08 – 12 Aug., 2015

Prof. R. Gupta	IUCAA Pune	18 - 22 Aust. 2015
Dr. G. B. Pant	IITM, Pune	11 - 12 Sept., 2015
Prof. Dipankar Bhattacharya	IUCAA, Pune	23 - 26 Nov., 2015
Dr. Gajendra Pandey	IIA, Bangalore	22 - 26 Nov., 2015
Prof. R. Srinivasan	VIT, Bangalore	22 - 29 Nov., 2015
Prof. S. Ananthakrishnan	Pune University, Pune	22 - 29 Nov., 2015
Prof. T. P. Prabhu	IIA, Bangalore	22 - 29 Nov., 2015
		05 - 06 Dec., 2015
Dr. N. M. Ashok	PRL, Ahmedabad	27 - 29 Dec., 2015
Prof. T. R. Seshadri	Delhi University, Delhi	26 - 28 Feb., 2016
Dr. Binita Pathak	Dibrugarh University, Assam	13 - 16 Mar., 2016
Dr. Jaya Tanwar	ISRO, Hyderabad	13 - 16 Mar., 2016
Dr. M. A. Paul	ISRO, Bangalore	14 - 16 Mar., 2016
Dr. S. K. Sharma	PRL, Ahmedabd	14 - 17 Mar., 2016
Dr. S. Venkateshwarm	PRL, Ahmedabd	14 - 17 Mar., 2016
Prof. S. Shyamlal	PRL, Ahmedabd	14 - 16 Mar., 2016
		18 - 20 Mar., 2016
Prof. Kuldip Yadav	BARC, Mumbai	30 Mar. - 01 April, 2016

Abbreviations

2MASS	Two Micron All-Sky Survey
ABL	Atmospheric Boundary Layer
AC	Academic Committee
ADFOSC	ARIES Devasthal Faint Object Spectrograph and Camera
AF	Atmosphere
AGN	Active Galactic Nuclei
AGU	Acquisition and Guiding Unit
AOD	Aerosols Optical Depth
ATSOA	ARIES Training school in Observational Astronomy
BC	Black Carbon
BL Lac	BL Lacertae
BVRI	Blue Violet Red Infrared
CALIPSO	Cloud Aerosol Lidar and Infrared Path finder Satellite Observations
CCD	Charged Coupled Device
CMDs	Center Meridian Distances
CWT	Concentrated Weighted Trajectory
DARE	Direct Aerosol Radiative Effect
DOLIDZE	Dzimselejsvili open clusters catalogue
DOT	Devasthal Optical Telescope
DSP	Digital Signal Processing
EC	Elemental Carbon
ESD	Electro Static Discharge
FORSA	Forum for Resource Sharing in Astronomy and Astrophysics
FOSC	Faint Object Spectrograph and Camera
FOT	Fast Optical Telescope
FSRQs	Flat Spectrum Radio Quasars
GHz	Giga Hertz
GFED	Global Fire Emission Database
GFAS	Global Fire Assimilation System
GRB	Gamma-Ray Burst
GVAX	Ganges Valley Aerosol Experiment

HCT	Himalayan Chandra Telescope
IGP	Indo-Gangetic Plane
INOV	Intranight Optical Variability
ISDT	International Science Development Teams
ISP	Interstellar Polarization
ISRO-GBP	Indian Space Research Organization's Geosphere-Biosphere Program
IST	Indian Standard Time
JTAC	Joint Time Allocation Committee
kpc	kiloparsec
KRC	Knowledge Resource Centre
LDN	Lynds Dark Nebula
LMC	Large Magellanic Cloud
MERRA	Modern-Era Retrospective Analysis For Research And Applications
MKIR	Mauna Kea Infrared
MODIS	Moderate Resolution Imaging Spectroradiometer
MOZAIC	Measurements of OZone and water vapor
Mpc	Million parsecs
MWSC	Milky Way Star Clusters
Myr	Million Years
NGC	New General Catalog
NKRC	National Knowledge Resource Consortium
NLSy1	Narrow Line Seyfert 1
nm	nano meter
NMHCs	Non-Methane Hydrocarbons
NOBLE	Network of Observatories for Boundary Layer Experiment
NVSS	NRAO VLA Sky Survey
OFC	Optical Fiber Cable
OMI	Ozone Monitoring Instrument
OPAC Model	Optical Properties of Aerosols and Clouds model
OPAC	Online Public Access Catalogue
PIT	Project Implementation Team
QPOs	Quasi-Periodic Oscillations
RAWEX	Regional Aerosol Warming Experiment

RETCO	Recent Trends in the Studies of Compact Objects
RQWLQs	Radio-Quiet Weak Line Quasars
SAC	Scientific Advisory Committee
SBDART	Santa Barbara DISTORT Atmospheric Radiative Transfer
SED	Spectral Energy Distribution
SPFM	Side Port Fold Mirror
SSAs	Segment Support Assemblies
ST Radar	Stratosphere Troposphere Radar
STJ	Sub-Tropical Jet Stream
TANSPEC	TIFR – ARIES Near Infrared Spectrometer
TIFR	Tata Institute of Fundamental Research
TIO	Telescope International Observatory
TMT	Thirty Meter Telescope
TOA	Top of Atmosphere
TRC	Technical Review Committee
TRM	Transmit Receive Module
UBVI	Ultraviolet-Blue-Visual-Infrared
UBVRI	Ultraviolet-Blue-Visual-Red-Infrared
UV	Ultra Violet
W-Uma	W Ursae Majoris
YSO	Young Stellar Object

Audited Statements of Account

(2014-2015)

Membership No: 009741
Firm Regn No : 00106C

BANGA & Co.
Chartered Accountants

BANGA HOUSE,
Mohan Park Compound, Mallital, Nainital
Ph. 05942-235439, (M) 9837506755

INDEPENDENT AUDITOR'S REPORT

To The Director,
"ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES,(ARIES), NAINITAL
We have audited the accompanying Balance sheet of ARIES for the year ended 31st March 2016 and the related Income & Expenditure Account and the Receipt and Payment account.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of the financial statement. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation of the financial statement that are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

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

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error.

In making those risk assessments, the auditor considers internal control relevant to the Society's preparation and fair presentation of the financial statement in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the overall presentation of the financial statements.

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

Unqualified opinion :

In our opinion and to the best of our information and according to the explanations given to us, the financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India

(a) in the case of the Balance Sheet, of the state of affairs of ARIES as at March 31, 2016

(b) in the case of the Income and Expenditure account, of the surplus for the year ended on that date; and

(c) in the case of the Receipts and Payments accounts, of receipt and payments reflected therein.

BANGA & CO. NAINITAL Chartered Accountants

Other matter

1 Rs. 57, 18,112.00 is lying in mis. project grant head from last year, It seems that no work in progress towards misc. grant received.

2. We have not dealt with the issue of imposition of penalty or liquidated damages on contractors in cases of delay in completion of contracts because it has been represented by ARIES that the decision of imposing the damages falls within the purview of the Governing Council.

3. Fixed assets have not been physically verified by the management and no proper fixed asset register is maintained.

4. Value of consumable stocks has been taken as verified and certified by management.

5. A litigation is going on before sole Arbitrator Mr. S. B. Sinha, Retired Judge (SC), New Delhi against claims made by M/s Vidyavati Constructions, Allabhadad for Rs. 1251.00 lakhs.

No agreement for fee etc. was produced before us. However, payment to Advocates are being made without any prior settelement and are on the very high side not supported by any documentary evidence. The payment made are as under for the year 2015 – 16 :-

(a) Advocate Sumit Sen	Rs. 10,85,000.00
(b) Advocate Sidhartha Sah	Rs. 4,60,000.00

The matter needs to be looked into and investigated.

6. The Income Tax returns has not been filed within due date for Ay 2013 – 14 resulting of withholding Income Tax refund of the Institute.

Our opinion is not qualified in respect of the other matters specified above.

Place : Nainital
Date : September 26, 2016
27

BANGA & Co
Chartered Accountants

BANGA & CO. NAINITAL Chartered Accountants

(P L BANGA) 27/3/16
Prop.
Membership No: 009741
Firm Regn No: 00106C

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

BALANCE SHEET AS ON 31st MARCH 2016

PARTICULARS	SCH. NO.	CURRENT YEAR F. Y. 2015-16 (Amount in Rs.)	PREVIOUS YEAR F. Y. 2014-15 (Amount in Rs.)
CAPITAL FUNDS AND LIABILITIES			
Capital Funds	1	18709,83,950.15	16872,19,120.57
Deferred Government Grant	1-A	34,74,109.04	395,04,683.22
EARMARKED FUNDS	1-B	1166,83,576.62	870,12,026.62
CURRENT LIABILITIES & PROVISIONS			
Other Current Liabilities	2	193,19,044.00	175,20,228.50
TOTAL		**20104,60,679.81**	**18312,56,058.91**
ASSETS			
NON CURRENT ASSETS			
(a) Fixed Assets			
(i) Tangible assets	3	3935,90,592.18	3779,47,070.03
(ii) Capital work in progress	3A	13712,43,989.00	12827,46,822.00
(b) Non current investments	4	1324,59,485.35	712,77,005.00
(c) Long term loans and advances	5	60,29,463.00	58,70,739.00
CURRENT ASSETS			
(a) Inventories	6	30,39,118.23	37,11,227.67
(b) Cash and bank balances	7	845,68,693.55	813,42,575.21
(c) Loans and Advances	8	195,29,338.50	83,60,620.00
TOTAL		**20104,60,679.81**	**18312,56,058.91**
		-	
Significant accounting policies and notes to accounts	15		-

In terms of our report of even date annexed hereto

For Aryabhatt Research Institute of Observational Sciences

Ravinder Kumar 27-9-16
Registrar

Wahab Uddin 27-9-16
Acting Director

Bharat Singh
Asstt. Registrar

Vijay Meena
LDC

for Banga & Co., Chartered Accountants
Nainital

(CA, P L Banga)
Membership Number : 009741
FRN No. : 106C
Dated 26 September, 2016

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31ST MARCH, 2016

PARTICULARS	SCH. NO.	CURRENT YEAR F. Y. 2015-16 (Amount In Rs.)	PREVIOUS YEAR F. Y. 2014-15 (Amount In Rs.)
INCOME			
Inventories Decreased/Increased (-/+)	6-A	(6,72,109.44)	4,21,029.28
Grants / Subsidies	9	3505,35,946.00	2832,31,000.00
Interest Earned	10	35,55,799.00	30,75,501.00
Other Income	11	11,48,166.00	10,29,785.00
TOTAL (A)		**3545,67,801.56**	**2877,57,315.28**
EXPENDITURE			
Establishment Expenses	12	1122,29,941.00	1010,79,988.17
Other Administrative Expenses etc.	13	479,43,572.31	365,08,283.00
Depreciation	3	475,25,124.85	470,90,914.99
TOTAL (B)		2076,98,638.16	1846,79,186.16
Balance being surplus i.e. (B-A)		1468,69,163.40	1030,78,129.12
Prior Period Expenses/Income(-/+) (TDS From Bank Interest FY 2014-15)		8,65,092.00	0
Balance being Surplus		**1477,34,255.40**	**1030,78,129.12**
BALANCE CARRIED TO CAPITAL FUND		**1477,34,255.40**	**1030,78,129.12**

Significant accounting policies and notes to accounts 15 of our report of even date annexed hereto

For Aryabhatt Research Institute of Observational Sciences

27-9-16 27-9-16

Ravinder Kumar
Registrar

Wahab Uddin
Acting Director

Bharat Singh
Asstt. Registrar

Vijay Meena
LDC

for Banga & Co., Chartered Accountants
Nainital

(CA, P L Banga)
Membership Number : 009741
FRN No. : 106C
Dated 26 September, 2016

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

Receipts and Payment Account for year ended March 31, 2016

Receipts	Amount - (Rs)	
I Opening Balances		
Cash in hand	6,443.00	
Cash in bank	784,76,132.21	
Amount in L C Account (SBI)	28,60,000.00	813,42,575.21
II Grant-in-aid received during the year	3505,35,946.00	3505,35,946.00
	0.00	-
III Indirect/Other Income Received		
Computer Adv Intt. (ARIES)	33,196.00	
Electricity Receipts	3,26,287.00	
Guest House Rent	3,54,730.00	
Shop Rent	6,000.00	
House Licence Fee	2,94,545.00	
Intrest Receipts	24,09,836.00	
Car Advance Intt.	4,900.00	
OMCA Intt. Receipts	2,700.00	
R T I Receipts	1,062.00	
Hostel Rent	51,194.00	
Sundry Receipts	4,980.00	
Telephone Receipts	3,202.00	
Tender Receipts	20,099.00	
Water Receipts	85,924.00	35,98,655.00
Vehicle dispossed off		2,91,551.00
		4357,68,727.21

Payments	Amount - (Rs)	
I Expenditure		
Salary and Allowance	682,68,504.00	
Computer Accessories	32,819.00	
Consumable (Computer)	13,42,572.00	
Consumable Expensess (Elec. & Works)	21,52,806.00	
Employer Contribution Towards NPS	35,46,318.00	
Fellowship	105,91,795.00	
Honorarium	2,14,800.00	
Internet Maintence Charges	19,78,110.00	
JEST	1,48,935.00	
Leagal Expensess (TAX)	23,790.00	
Leagal Expensess	31,56,502.00	
Medical Expensess	9,15,826.00	
Dispensary	3,45,806.00	
Meeting Governing Council/FC Expensess	2,69,186.00	
Observational Facilities of (Consumable)	7,48,358.00	
Observational Facilities of (LN2 Gas)	1,26,709.00	
Contigencies Exp.	166,40,211.31	
Other Scientific Meeting Expensess	23,10,078.00	
Other Scientific Meeting Expensess (Foreign)	8,58,294.00	
PMB Meeting	8,37,855.00	
Public Outreach Programme	15,32,266.00	
Repair & Maintenance Instruments/AMC	13,74,719.00	
Repair & Maintenance of Buildings	62,56,035.00	
Repair & Maintenance of Others	8,779.00	
Repair & Maintenance of Vehicle	1,46,710.00	
ATSOA Programme	3,79,689.00	
Telephone Exp	4,29,221.00	
Travelling Expensess	16,09,492.00	
Convayance Expensess	22,73,124.00	
Water Expensess	4,20,616.00	1289,39,925.31
	-	
	-	-
Payment to Creditors	77,17,525.00	77,17,525.00
Loans and Advances	50,91,114.00	50,91,114.00
Fixed Assets Purschesd	1518,98,858.00	1518,98,858.00
(Work in Progress)		
Closing Balances		
Cash in hand	31,861.00	
FDR in SBI	575,52,611.35	
Cash in bank	612,50,548.55	
L C with bank(SBI)	232,86,284.00	1421,21,304.90
		4357,68,727.21

27-9-16 27-9-16

Ravinder Kumar
Registrar

Wahab Uddin
Acting Director

Bharat Singh
Asstt. Registrar

Vijay Meena
LDC

for Banga & Co., Chartered Accountants
Nainital

(CA P L Banga, FCA)
Membership Number : 009741
FRN No. : 106C
Dated 26 September, 2016

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31st MARCH 2016

	BANK BALANCES		**ANNEXURE - 1**
	PARTICULARS	**PREVIOUS YEAR 2014-2015**	**CURRENT YEAR 2015-2016**
	Bank Balances with scheduled Banks		
	b) On savings Accounts		
	(i) Director Account - SBI , Nainital - 10860840253	578,02,686.35	221,76,438.69
	(ii) GPF Account - SBI , Nainital - 10860840300	49,32,052.80	103,32,690.80
	(iv) Pension Account (Old) - SBI, Nainital -10860840311	146,48,110.06	276,03,967.06
	(v) Pension Account (New) - SBI, Nainital -10860840322 (Closed)	-	-
	(vi) Union Bank of India, Nainital -535	10,93,283.00	11,37,452.00
	TOTAL	**784,76,132.21**	**612,50,548.55**
	LOAN / ADVANCE TO STAFF		**ANNEXURE - 2**
	PARTICULARS	**PREVIOUS YEAR 2014-2015**	**CURRENT YEAR 2015-2016**
	(i) Motor Car	14,62,086.00	12,00,226.00
	(ii) Motor Cycle	1,28,840.00	1,84,340.00
	(iii) Computer	1,16,050.00	2,42,800.00
	(iv) House Building/Others	28,87,840.00	40,21,597.00
	(v) Festival	69,000.00	94,200.00
	(vi) LTC	63,100.00	2,86,300.00
	TOTAL	**47,26,916.00**	**60,29,463.00**
	ADVANCES - OTHERS		**ANNEXURE - 3**
S NO.	**PARTICULARS**	**PREVIOUS YEAR F. Y. 2014-15**	**CURRENT YEAR 2015-2016**
1	Advance for Scientific Meeting	1,95,784.00	2,15,684.00
2	Travelling Advance	89,000.00	3,50,000.00
3	Sundry Advance	32,500.00	3,60,139.50
	Advances to staff (A)	**3,17,284.00**	**9,25,823.50**
1	Interest Accrued Electricty Board	-	49,015.00
2	Security Deposits	4,92,243.00	5,01,573.00
3	BSNL Broadband Security	7,03,655.00	11,80,781.00
4	Advance for ILTP Project	27,003.00	27,003.00
5	Indo Austria Project (Dr A.K.Srivastava)	36,422.00	36,422.00
6	Advance to Uttrakhand Power Corporation	15,00,004.00	15,00,004.00
7	TDS Receivable	25,28,221.00	44,19,899.00
8	Interest Receivable	-	76,85,186.00
9	Other advances/ST Radar/Custom duty	25,87,251.00	31,17,327.00
10	Advance legal fees	50,000.00	50,000.00
11	INDO-US Project (Dr Wahab Uddin)	1,18,537.00	36,305.00
	Advances and security deposits (B)	**80,43,336.00**	**186,03,515.00**
	Total (A+B)	**83,60,620.00**	**195,29,338.50**

27.9.16
(Ravinder Kumar)
Registrar

27-9-16
(Wahab Uddin)
Acting Director

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31st MARCH 2016

Schedule 1 : Capital Fund				
Particulars	PREVIOUS YEAR		CURRENT YEAR	
	F. Y. 2014-15		F. Y. 2015-16	
	(Amount in Rs.)	(Amount in Rs.)	(Amount in Rs.)	(Amount in Rs.)
Balance as at the beginning of the year		15481,10,417.27		16872,19,120.57
Grant received during the year		2832,31,000.00		2700,00,000.00
Grant received TMT/GSMT		-		805,35,946.00
Deferred Government Grant adjusted		360,30,574.18		360,30,574.18
Surplus transferred from the Income and Expenditure Account less Grant Received during the year		(1801,52,870.22)		(2028,01,690.60)
TOTAL		**16872,19,121.23**		**18709,83,950.15**
Schedule 1A : Deferred Government Grant				
Grant received for asset creation	755,35,257.40		395,04,683.22	
Less : Transferred to Income and Expenditure Account	(360,30,574.18)	360,30,574.18	360,30,574.18	
		395,04,683.22		**34,74,109.04**
Schedule - 1B - Earmarked Funds				
Particulars				
Superannuation / Pension				
a) New Pension Scheme Fund Account		-		-
b) Old Pension Fund Account		592,05,885.06		721,61,742.06
c) GPF Fund Account		278,06,141.56		368,36,648.56
d) Interest Suspense Account		-		76,85,186.00
TOTAL		**870,12,026.62**		**1166,83,576.62**
Schedule 2 : Current Liabilities				
Particulars				
		-		-
Schedule 3 :				
A. Other Current Liabilities				
a) Security and earnest deposits		15,80,854.00		20,50,849.00
b) JIC PAR Research Project		52,650.00		52,650.00
c) Retention and performance security deposits		99,66,889.00		111,57,041.00
d) Vat Collection		(0.50)		-
e) Money received on account of other projects		57,18,112.00		57,18,112.00
f) Faulad Constraction		20,000.00		20,000.00
g) INDO-UK Seminar (DST)		(28,000.00)		(28,000.00)
h) Women Secientific Scheme (WOS-A)		1,99,463.00		3,05,573.00
g) Leave Encashment Payable		-		14,946.00
i) GIS Payable		(194.00)		(239.00)
j) TDS Papable		14,555.00		5,355.00
k) VAT Payable		-		3,410.00
l) Mission Butter Fayable		(4,100.00)		(4,100.00)
m) Motor Cy Advance Intt.(UT)		-		23,447.00
TOTAL (A)		**175,20,228.50**		**193,19,044.00**

27-9-16

BANGA & CO. NAINITAL Chartered Accountants

Schedule - 4 - Non current investments				
Particulars		PREVIOUS YEAR		CURRENT YEAR
Investment in FDR's in Scheduled Banks (GPF A/c)		196,13,571.00		196,13,571.00
Investment in UBI FDR's (Old Pension)		480,47,291.00		480,47,291.00
FDR No: 34482716294				575,52,611.35
Total		**676,60,862.00**		**1252,13,473.35**
Interset accrued on non current investments				
Interest accrued on SBI FDR's (GPF A/c)		16,70,778.00		41,52,983.00
Interest accrued on UBI FDR's (GPF A/c)		19,45,365.00		30,93,029.00
Total accrued interest		36,16,143.00		72,46,012.00
Total non current investments including accrued interest		**712,77,005.00**		**1324,59,485.35**
Schedule 5: Long term loans and advances				
(a) Advance for capital items - fixed assets				
For ADFOSC				
Material Advance (M/s Vidhyawati)	6,36,899.00		6,36,899.00	
For 1.3 mt. Telescope				
Advance for 3.60 Mtr telescope	1,24,262.00		1,24,262.00	
Advance to suppliers	2,662.00		2,662.00	
Advance custom duty	3,80,000.00	11,43,823.00	13,04,278.00	20,68,101.00
(b) Advances to staff recoverable from salary (as per annexure 2)		47,26,916.00		39,61,362.00
Total		**58,70,739.00**		**60,29,463.00**
Schedule 6 :Inventories : Spares and consumable stocks				
Particulars				
i. Consumable Stock		17,72,380.72		16,15,888.51
ii. Stationery Stock		2,03,594.06		1,85,187.67
iii. Computer Accessories Stock		16,47,268.80		11,50,057.98
iv. Fuel (POL)		87,984.09		87,984.07
Total		**37,11,227.67**		**30,39,118.23**
Schedule 7 : Cash and bank balances				
Particulars				
Cash on hand		6,443.00		31,861.00
Bank Balances :				
On Saving Accounts(As per Annexure-1)		784,76,132.21		612,50,548.55
Total bank balances		**784,76,132.21**		**612,50,548.55**
Other bank balances				
Amounts held as margin money against letters of credit opened for import of equipments.		28,60,000.00		232,86,284.00
TOTAL (A)		**813,42,575.21**		**845,68,693.55**
Schedule 8 : Loans and advances				
Particulars				
1. Advances and other amounts recoverable in cash or in kind or for value to be received : (annexure -3)		83,60,620.00		195,29,338.50
TOTAL (A+B)		**83,60,620.00**		**195,29,338.50**

27-09-16

27-9-16

BANGA & CO. NAINITAL Chartered Accountants

Particulars	PREVIOUS YEAR			CURRENT YEAR
SCHEDULE - 9 -Grants				
1. From Central Government for asset creation		2832,31,000.00		3505,35,946.00
2. From Central Government for purposes other than asset creation				
3. Less/Add Transfer to Expensess Accounts				
TOTAL		**2832,31,000.00**		**3505,35,946.00**
Particulars				
Schedule 10 : Interest earned				
1.On Term Deposits & Savings Accounts :		30,36,828.00		34,85,437.00
2. On Loans :				
a) Employees / Staff (Interest on Advances)				
Computer Advance Intt. (ARIES)	8,754.00		33,196.00	
HBA Intt. (ARIES)	2,000.00			
Car Adv. Intt. (ARIES)			34,466.00	
OMCA Intt. (ARIES)	27,919.00	38,673.00	2,700.00	70,362.00
TOTAL		**30,75,501.00**		**35,55,799.00**
Schedule - 11 - Other Income				
PARTICULARS				
Registration Fee		6,100.00		
Residential Buildings / Hostels		2,61,359.00		2,94,545.00
Water Charges		88,603.00		85,924.00
Telephone Charges		3,195.00		3,202.00
Electricity / Meter Charges		2,86,217.00		3,26,430.00
Guest House Rent		3,80,280.00		3,54,730.00
Tender Fee		1,750.00		20,549.00
Misc Receipts		1,235.00		4,530.00
RTI Receipts		1,046.00		1,062.00
House/Shop Rent				57,194.00
TOTAL		**10,29,785.00**		**11,48,166.00**

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BANGA & CO. NAINITAL Chartered Accountants

SCHEDULE - 12 - ESTABLISHMENT EXPENSES	PREVIOUS YEAR		CURRENT YEAR	
Pay & Allowances				
Salary Expenses	594,38,987.50		645,72,017.00	
Honorarium A/c	1,46,948.00		1,58,000.00	
Honorarium Visiting Scientist	59,000.00		56,800.00	
Bonus	2,27,964.00		2,21,056.00	
Leave Travel Concession	11,93,576.00		7,24,201.00	
Employer Contribution towards NPS and interest	35,53,842.67		35,46,318.00	
Employer Contribution towards Old Pension Fund	260,89,253.00		256,98,424.00	
Employer Contribution to GPF Interest	58,779.00		26,00,980.00	
Leave Encashment	12,05,416.00		9,00,969.00	
Over Time	22,172.00		21,115.00	
Medical Reimbursements	9,65,637.00		17,89,832.00	
Dispensary Expenses	2,92,884.00		3,26,484.00	
Fellowship	66,74,320.00		105,88,795.00	
Liveries	44,650.00		7,350.00	
Reimbursement of Tution Fee	9,26,559.00		10,10,700.00	
Stipend /Training	1,80,000.00	1010,79,988.17	6,900.00	1122,29,941.00
TOTAL		-		-
		1010,79,988.17		

SCHEDULE - 13 - OTHER ADMINISTRATIVE EXPENSES ETC.	PREVIOUS YEAR		CURRENT YEAR	
Advertisement	9,71,468.00		10,83,885.00	
ATSOA-2016	61,543.00		3,79,689.00	
Auditor's remuneration	46,652.00		42,000.00	
Bank Charges	5,450.00		5,238.31	
Building Repair	59,88,212.00		62,56,035.00	
Canteen Expenses	16,19,819.00		18,91,143.00	
Cleaning Work	11,27,805.00		16,22,077.00	
Computer Accessories	1,31,195.00		13,78,391.00	
Consumables Assessories	19,76,571.00		23,12,402.00	
Conveyance	23,53,599.00		22,73,124.00	
Electricty	34,48,543.00		35,42,136.00	
Fuel (POL)	19,49,042.00		12,92,042.00	
Gardening Exp	4,28,031.00		4,21,923.00	
Hospitality	42,402.00		60,780.00	
Insurance	56,249.00		81,660.00	
JEST	1,00,000.00		1,48,935.00	
Legal	15,86,526.00		32,25,292.00	
Meeting of Governing Council	12,31,091.00		3,10,599.00	
Meeting of Other Scientific Bodies	23,35,188.00		38,99,406.00	
Observational Facilities	5,28,203.00		8,23,627.00	
Postage	56,610.00		1,05,888.00	
Printing & Stationery	3,16,875.00		4,70,866.00	
Public Outreach Programme	1,98,692.00		15,32,266.00	
Registration	2,95,009.00		1,47,015.00	
Repair and Maintainence - instrument	2,79,031.00		14,38,309.00	
Repair and Maintainence - others	90,000.00		8,275.00	
Repair and Maintainence - Vehicles	2,37,611.00		1,46,710.00	
Security	21,55,079.00		46,07,444.00	
Sundry Expenditure	1,10,715.00		41,747.00	
Telephone and Communication Charges	41,52,238.00		52,55,863.00	
Travel - domestic	9,01,917.00		15,90,913.00	
Travel - Foreign	11,48,381.00		11,27,276.00	
Water	5,78,536.00	365,08,283.00	4,20,616.00	479,43,572.31
TOTAL		**365,08,283.00**		**479,43,572.31**

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BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH, 2016

Fixed Assets

(Amount in Rs.)
Schedule 3 - Fixed Assets

S. NO.	NAME OF ASSETS	GROSS-BLOCK				Depreciation for the year			NET BLOCK		RATE (%)
		OP. BAL. AS ON 01/04./2015	ADDITION	Dispose off	CL. BAL AS ON 31-03-2016	OP. BAL. AS ON 01/04./2015	DEP FOR THE YEAR	CL. BAL AS ON 31-03-2016	WDV AS ON 31-03-2016	WDV AS ON 31-03-2015	
1	Land	1058,50,429.00			1058,50,429.00	-	-	-	1058,50,429.00	1058,50,429.00	
2	Buildings	-			-						
	(i) Residential - Manora Peak	293,61,839.60	-		293,61,839.60	39,34,374.33	12,71,373.29	52,05,747.62	241,56,091.98	254,27,465.27	5%
	(ii) Non Residential - Manora Peak	1076,27,691.00	-		1076,27,691.00	491,27,158.20	58,50,053.28	549,77,211.48	52650479.52	585,00,532.80	10%
	(iii) Residential - Devsthal (Guest House)	12,24,022.00	-		12,24,022.00	3,79,054.08	42,248.40	4,21,302.48	8,02,719.52	8,44,967.92	5%
	(iv) Non Residential - Devsthal	88,01,426.00	-		88,01,426.00	36,93,789.40	5,10,763.66	42,04,553.06	45,96,872.94	51,07,636.60	10%
3	Infrastructure Dev. (Manora Peak)	93,67,352.70	2,07,661.00		95,75,013.70	43,83,236.45	5,19,177.73	49,02,414.18	46,72,599.53	49,84,116.25	10%
4	Infrastructure Dev. (Devsthal)	137,37,518.90	360,82,787.00		498,20,305.90	33,78,061.89	46,44,224.40	80,22,286.29	417,98,019.61	103,59,457.01	10%
5	Road at Devsthal	194,48,327.00	34,00,837.00		228,49,164.00	79,60,787.36	14,88,837.66	94,49,625.02	133,99,538.98	114,87,539.64	10%
6	Furniture & Fixture	85,83,150.70	2,98,233.00		88,81,383.70	37,24,769.61	5,15,661.41	42,40,431.02	46,40,952.68	48,58,381.09	10%
7	Office Equipment	17,16,513.25	-		17,16,513.25	9,14,191.01	80,232.22	9,94,423.23	7,22,090.02	8,02,322.24	10%
8	Instruments And Equipments	-	-		-			-			
	(i) Telescope	10,45,247.55	-		10,45,247.55	7,74,039.17	40,681.26	8,14,720.43	2,30,527.12	2,71,208.38	15%
	(ii) Telescope (Solar)	13,67,166.00	-		13,67,166.00	9,05,380.24	69,267.86	9,74,648.10	3,92,517.90	4,61,785.76	15%
	(iiia) 1.3 Mt. Telescope	770,16,439.00	-		770,16,439.00	368,07,270.95	60,31,375.21	428,38,646.16	341,77,792.84	402,09,168.05	15%
	(iv)Public Outreach Telescope	6,07,295.00	-		6,07,295.00	2,90,283.06	47,551.79	3,37,834.85	2,69,460.15	3,17,011.94	15%
	(v) Schmidt Telescope	107,38,623.00	-		107,38,623.00	66,22,063.29	6,17,483.96	72,39,547.25	34,99,075.75	41,16,559.71	15%
	(vi) Electronic Section	90,55,749.55	-		90,55,749.55	67,06,073.18	3,52,451.46	70,58,524.64	19,97,224.91	23,49,676.37	15%
	(vii) Work Shop	2,73,027.45	-		2,73,027.45	2,02,185.40	10,626.31	2,12,811.71	60,215.74	70,842.05	15%
	(viii) Aluminising / Anodising	1,03,357.45	-		1,03,357.45	76,540.18	4,022.59	80,562.77	22,794.68	26,817.27	15%
	(ix) Optics	27,240.80	-		27,240.80	20,172.34	1,060.27	21,232.61	6,008.19	7,068.46	15%
	(x) Instruments	973,81,776.67	87,91,907.00		1061,73,683.67	373,67,625.33	103,20,908.75	476,88,534.08	584,85,149.59	600,14,151.34	15%
	(xi) Modernisation of Instruments	441,68,538.00	61,96,857.00		503,65,395.00	181,83,393.34	48,27,300.25	230,10,693.59	273,54,701.41	259,85,144.66	15%
	(xii) LIDAR	87,60,465.00	-		87,60,465.00	50,41,483.67	5,57,847.20	55,99,330.87	31,61,134.13	37,18,981.33	15%
	(xiii) ADFOSC (Backend Instrument)	33,13,267.00	-		33,13,267.00	13,05,317.58	3,01,192.41	16,06,509.99	17,06,757.01	20,07,949.42	15%
	(xiv)Solar Section	8,227.00	-		8,227.00	4,690.25	530.51	5,220.76	3,006.24	3,536.75	15%
	(Xv)Projector(Public Outreach)	1,05,000.00	-		1,05,000.00	45,353.11	8,947.03	54,300.14	50,699.86	59,646.89	15%
	(Xvi)Planetarium(Public Outreach)	39,18,714.00	-		39,18,714.00	10,87,443.14	4,24,690.63	15,12,133.77	24,06,580.23	28,31,270.87	15%
9	Vehicles	29,04,288.10	50,740.00	2,91,551.00	26,63,477.10	14,83,963.96	2,20,659.62	17,04,623.58	9,58,853.52	14,20,324.14	15%
10	Electric Installation (Manora Peak)	35,63,920.00	-		35,63,920.00	15,33,525.07	3,04,559.24	18,38,084.31	17,25,835.69	20,30,394.93	15%
11	Electric Installation (Devsthal)	29,22,165.00	-		29,22,165.00	17,21,540.37	1,80,093.69	19,01,634.06	10,20,530.94	12,00,624.63	15%
12	Computer	294,17,381.40	43,07,772.00		337,25,153.40	268,78,586.64	41,07,940.06	309,86,526.70	27,38,626.70	25,38,794.76	60%
13	Computer Software	14,05,432.00	-		14,05,432.00	13,22,167.49	49,958.71	13,72,126.20	33,305.80	83,264.51	60%
14	Library Books	392,54,311.50	41,23,404.00		433,77,715.50	392,54,311.50	41,23,404.00	433,77,715.50	-	-	100%
	Total	6430,75,901.62	634,60,198.00	2,91,551.00	7062,44,548.62	2651,28,831.59	475,25,124.85	3126,53,956.44	3935,90,592.18	3779,47,070.04	

27.9.16
Ravinder Kumar
Registrar

27-9-16
Wahab Uddin
Acting Director

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH, 2016

Schedule 3A : Fixed Assets work in progress as on 31.03.2016

Sl.	Description of assets	Opening balance on April 1, 2015	Addition during year		Assets completed	Balance as on March 31, 2016
1	Building (Dev Sthal)	-	-		0.00	-
2	Building (3.60 Telescope)	34406873	-		34406873	-
3	3.60 Mtr Telescope	1175169762.00	771,73,449.00			12523,43,211.00
4	Alumunising Plant (Devsthal)	395,23,736.00	-			395,23,736.00
5	4.00 Mt. International Liquid Mirror Telesco	67,71,649.00	47,69,294.00			115,40,943.00
6	Medium Resolution NIR Spectrograph	268,74,802.00	391,00,146.00			659,74,948.00
7	TMT/GSMT	-	18,61,151.00			18,61,151.00
	TOTAL	12827,46,822.00	1229,04,040.00		344,06,873.00	13712,43,989.00

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Ravinder Kumar, Registrar

Wahab Uddin, Acting Director

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH, 2016

Schedule of consumption of consumables

Financial Year 2015-2016 as on 31.03.2016

Schedule 6 (Annexure)

S. NO.	PARTICULARS	OP STOCK 01.04.2015	PURCHASE	TOTAL	CONSUMPTION	CL STOCK 31.03.2016	Increased /Decreased
1	2	3	4	5=(3+4)	6	7=(5-6)	8
1	CONSUMABLE ACCESSORIES	17,72,380.72	21,52,806.00	39,25,186.72	23,09,298.21	16,15,888.51	(1,56,492.21)
2	STATIONERY STOCK	2,03,594.06	4,70,866.00	6,74,460.06	4,89,272.39	1,85,187.67	(18,406.39)
3	COMPUTER ACCESSORIES	16,47,268.80	13,42,572.00	29,89,840.80	18,39,782.82	11,50,057.98	(4,97,210.82)
4	FUEL	87,984.09	12,92,042.00	13,80,026.09	12,92,042.02	87,984.07	(0.02)
	TOTAL	37,11,227.67	52,58,286.00	89,69,513.67	59,30,395.44	30,39,118.23	(6,72,109.44)

27-9-16
Ravinder Kumar
Registrar

27-9-16
Wahab Uddin
Acting Director

BANGAR NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERRVATIONAL SCIENCES (ARIES)
NANITAL - 263002

Schedule - 15

SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS ANNEXED TO AND FORMING PART OF FINANCIAL STATEMENTS FOR THE YEAR ENDING 31ST MARCH 2016.

SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS:

(1). Basis of preparation of financial statements:

a) The financial statements have been prepared under historical cost convention by following cash basis of accounting.

b) The accompanying final statements have been prepared by following going concern concept and conform to generally accepted accounting policies, except stated otherwise.

(2). REVENUE RECOGNITION:

a) The institute has received Grants-in-Aid from the Deptt of Science and Technology, Government of India. Since grant was given for development of fixed assets and also for revenue expenditure without specific allocation between capital items and non capital items, the entire amount of grant in aid has been treated as income.

b) Except for interest on fixed deposits with banks earmarked for retirement benefits of employee, which is accounted for on accrual basis, Interest income has been accounted for on cash basis.

(3). EXPENDITURE:

All expenditure is accounted for on cash basis. Sums given as advance on account of expenditure are treated as advance until finally settled and accordingly reckoned as expenditure on the date of adjustment of advance.

(4). RETIREMENT BENEFITS TO EMPLOYEES:

a) The Institute maintains a separate Bank Account for contribution / subscription (Employer's & Employee's) towards General Provident Fund. Advance to employees and refunds thereof are accounted for on actual payment/receipts basis. Interest payable to employees on balances standing to their credit in G.P.F. A/cs have been accounted for on accrual basis. Provision for interest for the current financial year have been shown as current liability. Fixed Deposits / Investments made out of G.P.F. A/cs have been separately reflected in the Financial Statements.

b) Gratuity: Liability towards Gratuity payable on death / retirement is accounted for on " Pay as you go method " i.e. on payment basis.

c) Pension: Liability on account of Pension is accounted for on cash basis.

(5). FIXED ASSETS:

Fixed Assets are stated at values determined on the basis of consolidated list of Assets prepared by the Uttar Pradesh State Observatory on the advice of Expert Committee on conversion of Uttar Pradesh State Observatory into ARIES.

BANGA & CO. NAINITAL Chartered Accountants

27-9-16

Depreciation: For assets acquired in the financial year earlier to the year in which ARIES was accorded registration as a charitable organization under the provisions of the Income tax Act, 1961 have been depreciated at rates shown in the fixed asset schedule; for subsequent years the assets have been considered as income applied for charitable purpose for the computation of income tax liability.

(6). Charged to revenue in full with Banks: Investment in fixed deposits have been recorded at their face value.

(7). FOREIGN CURRENCY TRANSACTIONS:

Transactions denominated in foreign currency are accounted for at the exchange rate prevailing at the date of the transactions. The exchange rate differences arising on foreign currency transactions are recognized as gain / loss in the period in which they arise except the gain / loss relating to the fixed assets which have been adjusted to cost thereof.

(8) TREATMENT OF FIXED ASSETS FOR INCOME TAX COMPLIANCE: For the purpose of computing the Assets acquired during the year are considered as income applied for charitable assets.

(9) Contingent liability to the extend not provided for
(a) claim against the ARIES and not admitted at Rs. 1251.00 Lakhs approximate due to dispute under Arbitration, made by M/s Vidhyawati Construction, Allahabad for civil construction at Devasthal for 3.6 mtr. Telescope same as per last year note.
(b) Liability for Capital commitments not provided for amount payable to supplier M/s AMOS, Belgium for 3.6 mtr. Telescope amounting to Rs. 600.00 Lakhs.
(c) There is contingent liability for Rs. 3970820.00 plus interest against TDS demand created by Additional CIT (TDS), Dehradun which is not admitted but matter is being contested by the Institute.

(10) Misce. Grants received during the year amounting to Rs. 36,64,800.00 which had been paid to scientists for projects development for which separate accounts has been maintained by the respective scientists/Project Officers. This has not been incorporated in the accounts of ARIES as per past practice.

(11) Separate accounts for GPF of employees has not been maintained but incorporated and mixed up in the accounts of ARIES.

(12) Taxation : The income of the Institute is said to be exempt being non-profitable organization. The source of income is Grant-in-aid from Govt. of India, Ministry of Science & Technology, therefore, no provision for income tax has been made in the accounts and NIL return has been filed.

(13) Tax deducted at source on interest from Banks has been accounted for as per form No. 26 AS for the year 2014-15 at Rs. 83,93,639.00 and for the year 2015-16 at Rs. 1,01,76,049.00 which is subject to refund. The return of income tax for Ay 2013-14 could not be filed on due dates.
The assessment for Ay 2013 – 14, 2014 – 15 and 2015 – 16 are pending and refund of income tax (TDS) is awaited.

(14) Previous years figures have been re-arranged, regrouped where ever considered necessary.

27.09.16
Ravinder Kumar
Registrar

27-9-16
Wahab Uddin
Acting Director

BANGA & CO. NAINITAL Chartered Accountants

Date: 26.09.2016