ARIES

Aryabhatta Research Institute of Observational Sciences

Annual Report 2014 - 15

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES

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

Manora Peak, Nainital - 263 002, India

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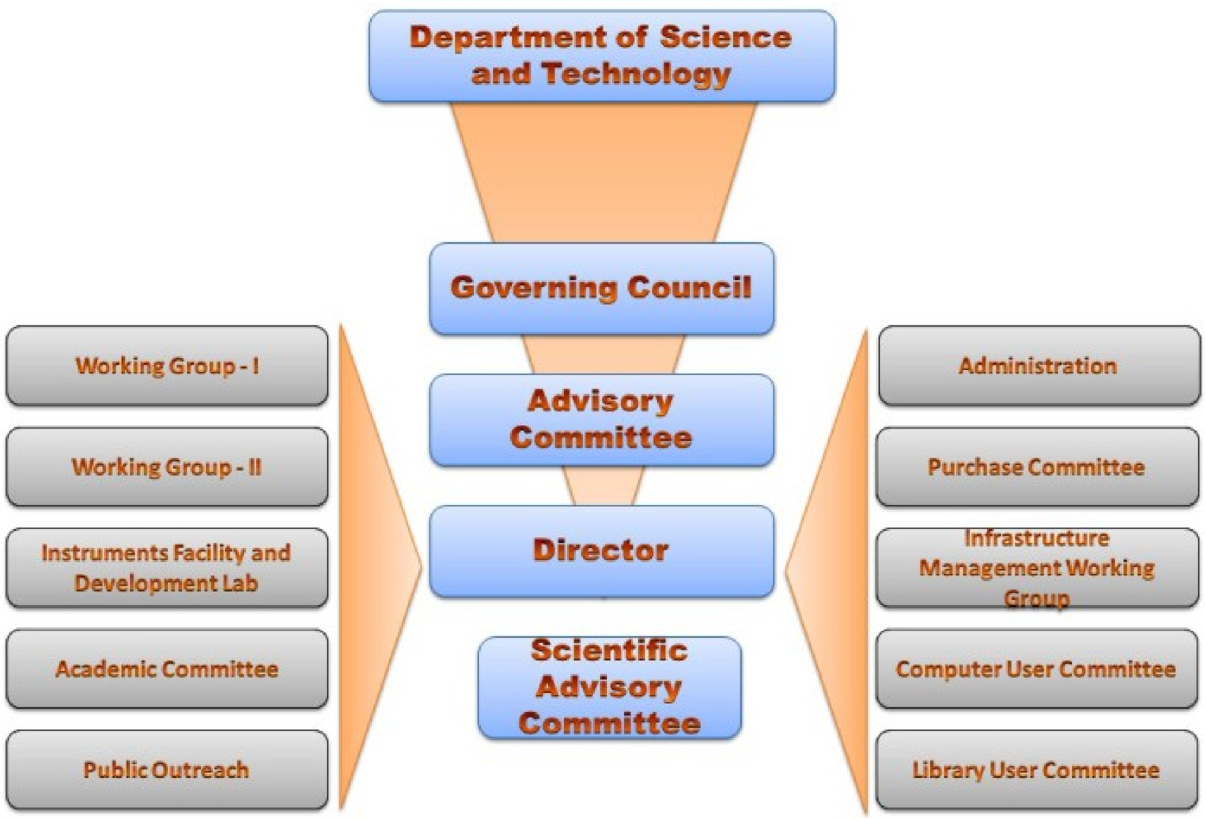

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From Director's Desk

The financial year, 2014-15, was a significant one for ARIES. The mechanical and optical assembly of 3.6m Devasthal Optical Telescope (DOT) has been completed. Whilst this is a positive achievement, we still have many challenges ahead to reach to the final goal of having a fully functional telescope. Here I present the 11th Annual Report of ARIES which highlights some of the progresses we made in research, human resource development and setting up of observing facilities for national and international communities.

In ARIES, scientists are primarily 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 institutes. 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 22 scientists, 13 engineers, 17 administrative and support staffs, 39 scientific and technical staffs, 14 laboratory assistants, 7 post doctoral fellow/research associates and 32 research scholars. In the year 2014, 10 new research scholars joined the institute. This is indeed a very heartening sign especially when the institute is about to complete the setting up of world class facilities like 3.6m DOT and ST-Radar.

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 64 papers in refereed journals mostly in those with relatively high impact factor. Four of our research scholars have been awarded PhD degree this year and five research scholars have submitted their thesis. There are eleven 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.

The enclosure building for the 3.6m DOT was commissioned in July 2014. The completed enclosure building includes a control room, a technical room, pier of the telescope, the rotating dome structure and the cranes. The dome was made ready to meet the clean environment required for the installation of various sensitive components of the telescope. Two single girder cranes of 10 ton capacity were installed inside the dome so that various parts of the telescope could be lifted up for the assembly. The cranes were commissioned in May, 2014.

The transportation of the boxes containing components of the telescope from the base camp to the site located at about 1.5 km uphill was quite a challenging one. The components which were stored in the base camp were brought to the telescope building sites using specialized hydraulic carriers. This activity was done jointly by the teams from ARIES and AMOS.

The primary mirror of the telescope was not coated when it was transported from AMOS factory, Belgium. For the purpose of coating of the mirror, a coating plant was installed inside the extension building. The coating plant was commissioned in January, 2015. Before the coating of the mirror, it was washed thoroughly by the ARIES team with the help of personals from Indian Institute of Astrophysics. The coating of the mirror was completed on 9th of February, 2015 and handed over to AMOS for its integration with the telescope structure. The assembly of the telescope began on 28th of October, 2014 and completed on 23rd of February, 2015. The fully assembled telescope inside the telescope enclosure building is shown below.

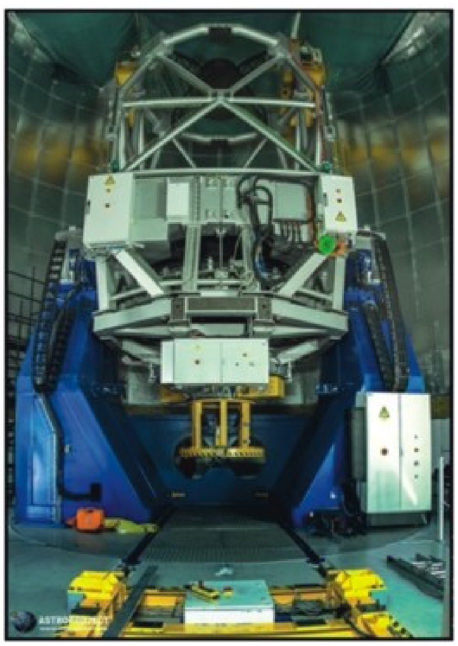

Figure. Fully assembled telescope housed inside the telescope enclosure.

I congratulate the entire ARIES team for achieving this milestone. I also express my sincere gratitude, on behalf of the entire ARIES team, to the 3.6m DOT Project Management Board Chairman, Prof. P. C. Agrawal, and to the entire Board Members for their constant support and timely guidance given for the successful completion of the assembly of the telescope. The Governing Council Chairman, Prof. S. K. Joshi, along with all other members who has also constantly stood by the entire ARIES team giving much needed support and encouragement. The Chairman has made visits to the telescope site to access the progress of the project personally. Dr. T. Ramasami, Former Secretary, DST, also extended his consistent support to this project. I express my sincere thanks to the DST for their support for the project.

The Stratosphere Troposphere (ST) Radar which is getting installed in our Manora Peak campus is going to provide continuous vertical profile of winds with high temporal and spatial (vertical) resolution. This would be a unique facility to come-up in the Himalayan region. The installation of all the hardware related to 12 clusters, (588 TRMs, 588 power supplies and 588 antennae) are complete now. Testing of the system with one of the seven clusters got completed. Currently testing with all the seven clusters are in progress.

Another major achievement for the institute during this period was the approval given by the Cabinet to participate in the Thirty Meter Telescope Project. ARIES is one of the three institutes from India participating in this Mega Project. ARIES has taken the responsibility of coordinating with two of the Indian firms for the fabrication and delivery of six version-3 Segment Support Assemblies along with the assembly tools and test-bed hardware.

The scientists of ARIES are also actively involved in the popularization of Astronomy and Atmospheric sciences among general public especially to the boys and girls from various schools in Nainital district. Various workshops and events have been organized as a part of the public outreach program. Large influx of public to participate in these events is very much encouraging.

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 Castes 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.

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 2014-15, 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 Comet C/2012 L2 (LINEAR)

Comet C/2012 L2 (LINEAR) was discovered by the Lincoln Near Earth Asteroid Research (LINEAR) Survey on 1st June, 2012. The perihelion and aphelion distance of the comet are about 1.51 AU (1 AU = 1.5×10^{13} cm, distance of the earth from the sun) and 1166.64 AU, respectively from the Sun. The Comet C/2012 L2 (LINEAR) may belong to inner Oort-cloud family since the inner Oort-cloud extends as close as 1000 au. The comet came close to the

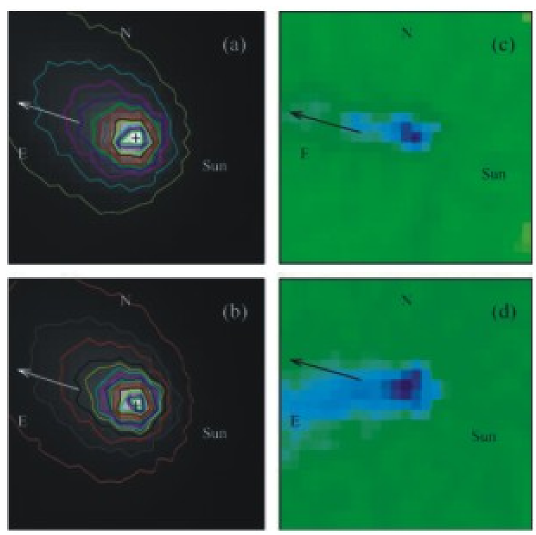

Figure 1. Intensity map with contours for (a) 11th March and (b) 12th March, 2013. The false color rotational gradient treated image for (c) 11th March and (d) 12th March, 2013. The '+' mark denotes the photocenter of the comet. The arrow shows the position angle of the Sun–comet radius vector which is 67°.8 and 68°.1 on 11th and 12th March respectively. Scale: 60,000 km × 60,000 km.

Earth (1.74 Au) on the 26th of January, 2013. The visual magnitudes of the comet were 13.65 and 13.64 on 11 and 12 March, 2013 respectively.

In this study, authors presented the linear polarimetric study of the comet C/2012 L2 (LINEAR) observed at 31.1° phase angle before perihelion passage. The polarimetric observations of the comet were carried out using ARIES Imaging Polarimeter mounted on the 104-cm Sampurnanand telescope on 11th and 12th of March, 2013 using R photometric band. The radial surface brightness profile of the comet C/2012 L2 (LINEAR) was found to be canonical in nature on both the nights of observations with a slope of -1. The asymmetric coma of the comet shows a significant variation in the intensity as well as the polarization profile in all the considered directions which suggest the various physical evolution of the dust grains. The elongation of the coma is prominent along the Sun-Comet position angle. The polarization of comet C/2012 L2 (LINEAR) do not show the radial dependance on the aperture size during both the nights of observations. A prominent jet is well observed in the anti-solar direction on both nights at position angle of 73°. In particular, the degree of polarization obtained in their study was compared with the polarization value obtained by other investigators for the dusty comets 1P/Halley, 22P/Kopff and C/2009 P1 (Garradd) at similar phase angle. **[**P. Deb Roy, H. S. Das, **Biman J. Medhi,** *Icarus, Volume 245, pp. 241-246***]**.

2. Study of Individual Stars

An X-Ray Flare from 47 CAS

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 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.

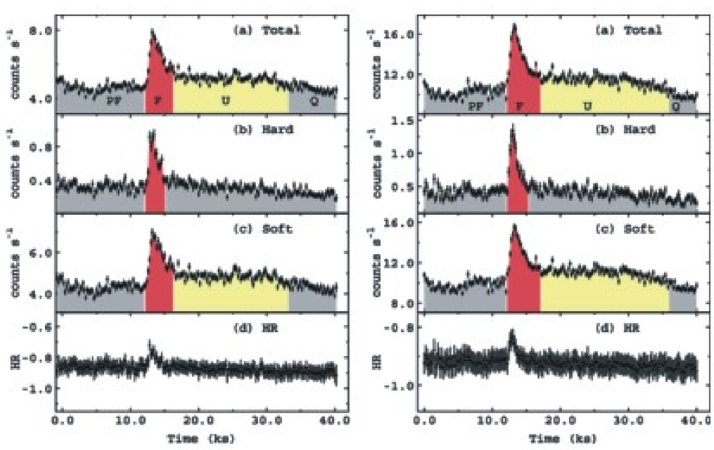

Figure 2. X-ray light curves of the 47 Cas system in three different energy bands along with the hardness ratio curve. The hardness ratio is defined as *(H-S)/(H+S)*. The pre-flare state, flaring state, heightened post-flare emission and quiescent state are marked by PF, F, U, and Q, respectively.

2.75 ± 0.06 keV throughout an orbital cycle, where the cooler plasma could be due to small scale shocks in a radiation-driven outflow and the high temperature plasma could be due to the collision of winds. The column density varied with the orbital phase and was found to be maximum after the periastron passage, when the WN star is in front of the O star. The abundances of WR 25 were found to be non-solar. Optical V-band data of WR 25 also show the phase-locked variability, being at maximum near periastron passage. The results based on the present analysis indicate that WR 25 is a colliding wind binary where the presence of soft X-rays is attributed to individual components; however, hard X-rays are due to the collision of winds. **[J. C. Pandey, S. B. Pandey** and **Subhajeet Karmakar,** *The Astrophysical Journal, Volume 788, Issue 1, p. 84***].**

Photometric and polarimetric studies of three W UMa-type binaries: FZ Ori, V407 Peg and LP Uma

W Ursae Majoris (W UMa)-type variable stars are over-contact eclipsing binary stars whose light curves show strongly curved maxima and minima that are nearly equal in depth. Earlier studies have divided EW stars into two sub-classes which are called A-types and W-types. In the A-type systems the larger component has the higher temperature whereas in the W-type systems the smaller component has the higher temperature.

In this study, authors have analyzed new optical photometric observations of three W UMa-type contact binaries FZ Ori, V407 Peg and LP UMa. Results from the first polarimetric observations of the FZ Ori and V407 Peg were also presented. The periods of FZ Ori, V407 Peg and LP UMa were derived and found to be 0.399986, 0.636884 and 0.309898 day, respectively. The O-C analyses indicates that the orbital periods of FZ Ori and LP UMa have increased with the rate of 2.28 x 10^{-8} and 1.25 x 10^{-6} day yr^{-1}, respectively and is explained by the transfer of mass between the components. In addition to the secularly increasing rate of orbital period, it was found that the period of FZ Ori has varied in sinusoidal way with oscillation period of ~30.1 yr. The period of oscillations are most likely to be explained by the light-time effect due to the presence of a tertiary companion. Small asymmetries have been seen around the primary and secondary maxima of light curves of all three systems, which is probably due to the presence of cool/hot spots on the components. The light curves of all three systems are analysed by using Wilson-Devinney code (WD) and the fundamental parameters of these systems have been derived. The present analyses shows that FZ Ori is a W-subtype, and V407 Peg and LP UMa are A-subtype of the W UMa-type contact binary systems.The polarimetric observations in B, V, R and I bands, yielded average values of polarization to be

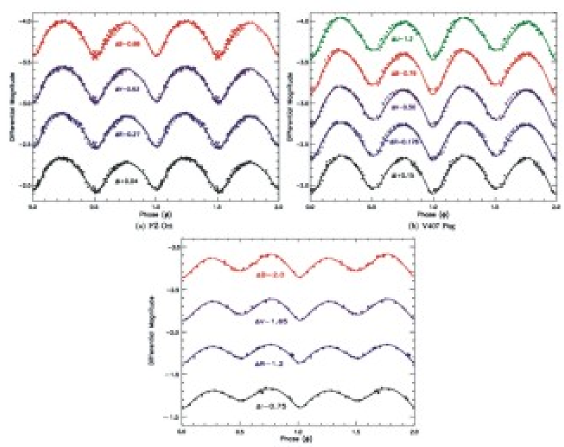

Figure 4. Phased light curves of the (**a**) FZ Ori, (**b**) V407 Peg and (**c**) LP UMa in *B*, *V*, *R* and *I* broad bands along with the phased light curve in *U* band only for V407 Peg (*Open circles* denote the observational data points. *The continuous line* is the synthetic light curves computed from the WD light curve modeling technique considering the case as presence of spot on the primary component of FZ Ori, V407 Peg and LP UMa, respectively).

0.26±0.03, 0.22±0.02, 0.22±0.03 and 0.22±0.05 per cent for FZ Ori and 0.21±0.02, 0.29±0.03, 0.31±0.01 and 0.31±0.04 per cent for V407 Peg. [Vinod Prasad, **J. C. Pandey**, M. K. Patel and D. C. Srivastava, *Astrophysics and Space Science, Volume 353, Issue 2, pp.575-594*].

Asteroseismology of Pulsating Stars

The success of helioseismology is due to its capability of measuring *p*-mode oscillations in the Sun. This allows to extract information on the internal structure and rotation of the Sun from the surface to the core. Similarly, asteroseismology is the study of the internal structure of the stars as derived from stellar oscillations. In this review the authors highlight the progress in the observational asteroseismology, including some basic theoretical aspects. In particular, they discussed their contributions to the asteroseismology through the study of chemically peculiar stars under the 'Nainital-Cape Survey' project which is being conducted at ARIES, Nainital, since 1999. This survey aims to detect new rapidly-pulsating Ap (roAp) stars in the northern hemisphere. They also discuss the contribution of ARIES towards the asteroseismic study of the compact pulsating variables. They also presented the future prospects of the project in the light of the new 3.6m Devasthal Optical Telescope which is getting installed at Devasthal (ARIES). Finally, they presented a preliminary optical design of the high-speed imaging photometers for the 3.6m DOT. [**S. Joshi** and **Y. C. Joshi**, *JAA, Volume 36, pp. 33-80*]

3. Molecular Clouds and Star Formation

Magnetic field structure around cores with very low luminosity objects

Optical polarimetry of five dense cores, (IRAM 04191, L1521F, L328, L673-7, and L1014) which are found to harbour very low luminosity objects (VeLLOs; $L_{int} \lesssim 0.1\, L_{\odot}$) were carried out using ARIES Imaging Polarimeter attached with the 104-cm Sampurnanand Telescope. This study was conducted mainly to understand the role played by the magnetic field in the formation of very low and sub-stellar mass range objects.

Starlight while passing through the dust grains that are somehow aligned with their short axis parallel to an external magnetic field, becomes linearly polarised. The polarisation position angles measured for the stars can provide the plane-of-the sky magnetic field geometry. Because the light in the optical wavelength range is most efficiently polarised by the dust grains typically found at the outer layers of the molecular clouds, optical polarimetry mostly traces the magnetic field orientation of the core envelope.

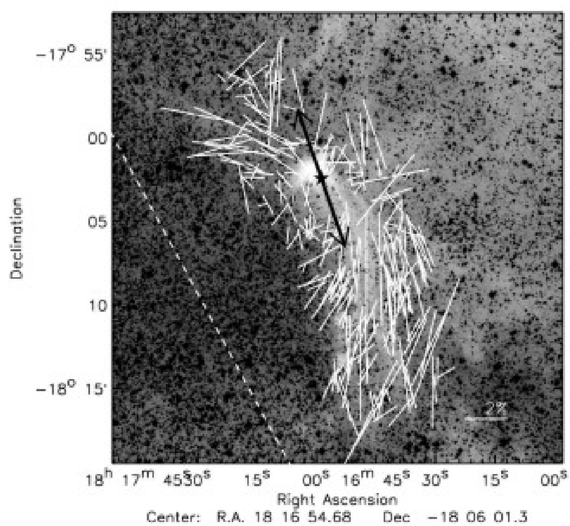

Figure 5. Optical polarisation vectors over-plotted on the R-band DSS image containing L328. The position of L328-IRS is shown by a black star. The outflow orientation is shown as a solid line with double arrow head and the Galactic plane at the latitude of the cloud is represented by a broken line. A vector corresponding to 2% polarisation is shown as reference.

The polarisation observations of stars projected on the five dense cores were obtained in the *R*-band and those of L1521F were obtained in the *V*-band. The angular offsets between the envelope magnetic field direction (inferred from optical polarisation measurements) and the outflow position angles from the VeLLOs in IRAM 04191, L1521F, L328, L673-7, and L1014 were found to be 84°, 53°, 24°, 08°, and 15°, respectively. The mean value of the offsets for all the five clouds is ~ 37°. If IRAM 04191 is excluded, the mean value reduces to become ~ 25°. In IRAM 04191, the offset between the projected envelope and the inner magnetic field (inferred from the submillimetre data obtained using SCUBA-POL) was found to be ~ 68°. The inner magnetic field, however, was found to be nearly aligned with the projected position angles of the minor axis, the rotation axis of the cloud, and the outflow from the IRAM 04191-IRS. A possible explanation for the nearly perpendicular orientation between the envelope and core scale magnetic fields in IRAM 04191 is discussed. The angular offset between the envelope magnetic field direction and the minor axis of IRAM 04191, L1521F, L673-7, and L1014 are 82°, 60°, 47°, and 55°, respectively. The mean value of the offsets between the envelope magnetic field and the minor axis position angles for the four cores was found to be ~ 60°.The results obtained from this study on the limited sample of five cores with VeLLOs show that the outflows in three of them tend to nearly align with the envelope magnetic field which has profound implications on our understanding of star formation process. **[A. Soam, G. Maheswar**, Chang Won Lee, Sami Dib, H. C. Bhatt, Motohide Tamura, Gwanjeong Kim, *Astronomy & Astrophysics, Volume 573, p. A34***]**.

Young stellar population of bright-rimmed clouds BRC 5, BRC 7 and BRC 39

The immense stellar winds and ultraviolet (UV) radiation from massive stars present in a star-forming region have dramatic impact on their immediate vicinity. The propagating ionization fronts can either stop star formation by dispersing surrounding gas or can induce secondary star formation. It is proposed that the expanding ionization front plays a constructive role in inciting a sequence of star formation activities in the neighbourhood of massive stars.

Bright-rimmed clouds (BRCs), illuminated and shaped by nearby OB stars, are potential sites of recent/ongoing star formation. In this work, authors present an optical and infrared photometric study of

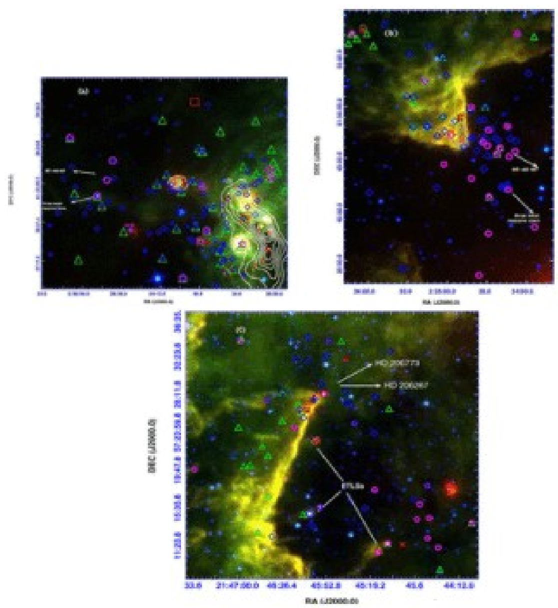

Figure 6. Spatial distribution of the identified YSOs in (a) BRC 5, (b) BRC 7, (c) BRC 39 over-plotted on the *WISE* three-colour composite image at 22 μm (in red), 12 μm (in green) and 3.4 μm (in blue). Open triangles represent NIR excess sources from 2MASS, squares and diamonds represent the IRAC Class I and Class II sources, respectively. Class I and Class II sources selected based on the *WISE* colours are shown as crosses and open circles, respectively. The contours represent the 1.1 mm emission obtained from the CSO BOLOCAM images. The elephant trunk-like structures (ETLSs) seen towards BRC 39 are marked.

three BRCs: BRC 5, BRC 7 and BRC 39 to obtain a census of the young stellar population, thereby inferring the star formation scenario, in these regions. In each BRC, the Class I sources are found to be located mostly near the bright rim or inside the cloud, whereas the Class II sources are preferentially outside, with younger sources closer to the rim [*Young stellar objects are usually classified using criteria based on the slope of their spectral energy distribution, introduced by Lada C.J. in 1987. He proposed three classes (I, II and III), based on the values of intervals of spectral index*]. The spatial distribution of these sources provides strong support to sequential star formation triggered by radiation-driven implosion due to the ultraviolet radiation. Moreover, each BRC contains a small group of young stars that are being revealed at its head, as the next-generation stars. In particular, the young stars at the heads of BRC 5 and BRC 7 are found to be intermediate-/high-mass stars, which, under proper conditions, may themselves trigger star formation in future, thereby propagating the star formation out to long distances. **[**N. Panwar, W. P. Chen**, A. K. Pandey, M. R. Samal,** K. Ogura, D. K. Ojha, J. Jose and B. C. Bhatt**,** *MNRAS, Volume 443, pp. 1614-1628***].**

NGC 7538: multiwavelength study of stellar cluster regions associated with IRS 1-3 and IRS 9 sources

In this work authors present deep near infrared imaging observations of the NGC 7538 IRS 1–3 region (centred on α_{2000} = 23^{h}13^{m}43^s, δ_{2000} = +61°28′22″) in *J* (λ = 1.25 μm), *H*(λ = 1.64 μm), and *K* (λ = 2.21 μm) bands, and the NGC 7538 IRS 9 region (centred on α_{2000} = 23^{h}13^{m}58^s, δ_{2000} = +61°27′ 26″) in *H* and *K* bands. The observations were obtained on 2005 August 19, using the Cooled Infrared Spectrograph and Camera for OHS (CISCO) mounted at the Cassegrain focus of the 8.2 m Subaru telescope.

The NIR analysis is complemented with Giant Metrewave Radio Telescope low-frequency observations at 325, 610, and 1280 MHz, molecular line observations of $H^{13}CO^+$ (J=1-0), and archival Chandra X-ray observations. Using the 'J - H/H - K' diagram, 144 Class II and 24 Class I young stellar object candidates are identified in the IRS 1-3 region. Further analysis using 'K/H - K' diagram yielded 145 and 96 red sources in the IRS 1-3 and IRS 9 regions, respectively. A total of 27 sources were found to have X-ray counterparts. The mass function (MF) of YSOs, constructed using a theoretical mass-luminosity relation, shows peaks at substellar (~0.08-0.18 $M_\odot$) and intermediate (~1-1.78 $M_\odot$) mass ranges for the IRS 1-3 region. The MF can be fitted by a power law in the low-mass regime with a slope of Gamma ~0.54-0.75, which is much shallower than the Salpeter value of 1.35. An upper limit of 10.2 is obtained for the star to brown dwarf ratio in the IRS 1-3 region. GMRT maps show a compact H II region associated with the IRS 1-3 sources, whose spectral index of 0.87 ± 0.11 suggests optical thickness. This compact region is resolved into three separate peaks in higher resolution 1280 MHz map, and the `east' subpeak coincides with the IRS 2 source. $H^{13}CO^+$ (J=1-0) emission reveals peaks in both IRS 1-3 and IRS 9 regions, none of which are coincident with visible nebular emission, suggesting the presence of dense cloud nearby. The virial masses are approximately of the order of 1000 and 500 $M_\odot$ for the clumps in IRS 1-3 and IRS 9 regions, respectively. **[**K. K. Mallick et. al. (Including **A. K. Pandey**), *MNRAS, Volume 443, Issue 4, p.3218-3237***].**

Pre-main-sequence population in NGC 1893 region: X-ray properties

Pre-main sequence stars having masses ≤ 3 $M_\odot$ are called T-Tauri stars (TTSs). The TTSs are sub-divided into weak line TTSs (WTTSs) and classical

TTSs (CTTSs). The Hα and near infrared excess signatures in CTTSs suggest the existence of a well-developed circumstellar disk actively interacting with the central star. Strong Hα emission (EW > 10 Å) in CTTSs is attributed to the magnetospheric accretion of the innermost disk matter onto the central star. On the other hand, the weak Hα emission (EW < 10 Å) in WTTSs, which lack disks (or, at least inner disks), is believed to be due to the chromospheric activity. Both CTTSs and WTTSs are strong emitters in the X-ray part of the electromagnetic spectrum. In fact X-ray emission is used as a tool to identify young sources associated with a star forming region.

In this work, authors have made a comprehensive multi-wavelength study of a relatively young open cluster, NGC 1893. A series of work has already been carried out by the group on this cluster.The main aim of the present study was to characterize

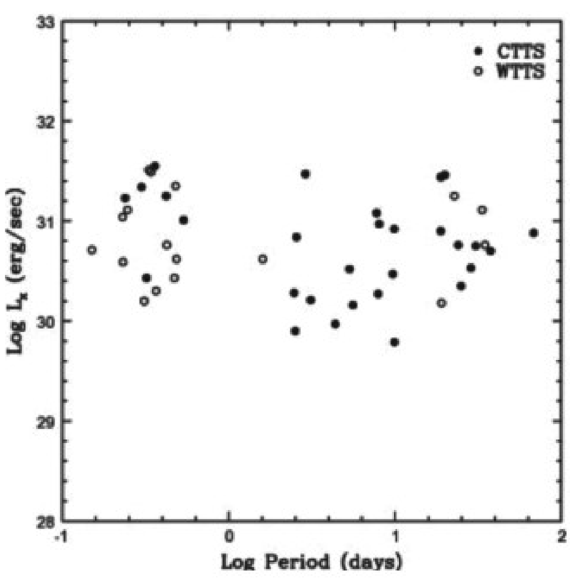

Figure 7. Plot of X-ray luminosity versus rotation period for TTSs having masses in the range 0.2–2.0 $M_{\odot}$.

the X-ray properties of T-Tauri Stars (TTSs) in the NGC 1893 region. They found a correlation between the X-ray luminosity and the stellar mass (in the range 0.2-2.0 $M_{\odot}$) of TTSs in the NGC 1893 region, similar to those reported in some other young clusters, however the value of the power-law slope obtained in the present study (~0.9) for NGC 1893 is smaller than those (~1.4-3.6) reported in the case of TMC, ONC, IC 348 and Chameleon star forming regions. However, the slope in the case of Class III sources (Weak line TTSs) is found to be comparable to that reported in the case of, for example, NGC 6611 (~1.1). It is found that the presence of circumstellar disks has no influence on the X-ray emission. The X-ray luminosity for both CTTSs and WTTSs is found to decrease systematically with the age (in the range ~0.4-5 Myr). The decrease of the X-ray luminosity of TTSs (slope ~ -0.6) in the case of NGC 1893 seems to be faster than those observed in the case of other star-forming regions (slope -0.2 to -0.5). There is indication that the sources having relatively large near infrared excess have relatively lower X-ray luminosity values. TTSs in NGC 1893 do not follow the well established X-ray activity - rotation relation as in the case of main-sequence stars. **[A. K. Pandey, M. R. Samal, Ram Kesh Yadav**, Andrea Richichi, **SnehLata, J. C. Pandey**, D. K. Ojha, W. P. Chen, *New Astronomy, Volume 29, p. 18-24*].

The molecular complex associated with the Galactic H II region Sh2-90: a possible site of triggered star formation

The Sh2-90 complex, located at α_{2000} = 19^{h}49^{m}11^s, δ_{2000} = + 26°51′36″ (l = 63°.16, b = 0°.40), is an optically visible irregularly shaped H II region. This H II region is a part of the Vulpecula OB association. The most commonly adopted distances to the H II region are between 1.6 kpc and 2.5 kpc. The Sh2-90 molecular cloud complex contains several kinds of sources. **Figure 8** displays the color-composite image made with the *R*-band (DSS2 survey) in blue, the emission at 3.6 μm in green and the 8.0 μm emission in red (*Spitzer*-GLIMPSE survey). Various sources studied in the present work are marked in Figure 8. The sources N133 and N132 are identified as bubbles in the *Spitzer* 8.0 μm band.

In this region, the authors investigated the star formation activity in the molecular complex associated with Sh2-90. Radio observations suggest that it is an evolved H II region with an electron density ~144 cm^{-3}, emission measure ~ 6.7 × 10^4 cm^{-6} pc and an ionized mass ~55 $M_{\odot}$. From Herschel and CO (J = 3 - 2) observations they found that the H II region is part of an elongated extended molecular cloud (H_2 column density >= 3 × 10^{21} cm^{-2} and dust temperature 18-27 K) of total mass >= 1 ×

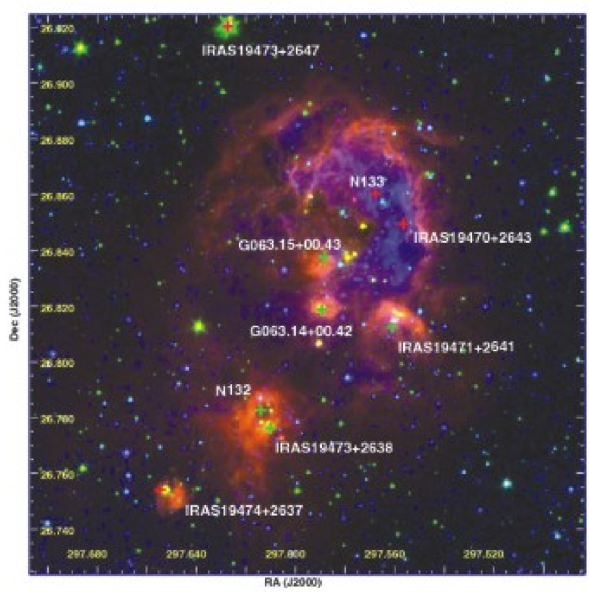

Figure 8. Color-composite image of the Sh2-90 complex. Spitzer-IRAC 8.0 μm (red) and 3.6 μm (green) images have been combined with the DSS2 R-band (blue) image. The different sources associated with the region (see the text) are marked. The field size is 12'.0 (E-W) × 12'.0 (N-S), centered at $\alpha2000 = 19^h49^m18^s$, δ_{2000} = + 26°49'29". North is up and east is to the left.

10^4 $M_{\odot}$. They identified the ionizing cluster of Sh2-90, the main exciting star being an O8-O9 V star. Five cold dust clumps, four mid-IR blobs around B stars, and a compact H ii region are found at the edge of the bubble. The velocity information derived from CO data cubes suggests that most of them are associated with the Sh2-90 region. One hundred and twenty-nine low mass (<=3 $M_{\odot}$) YSOs have been identified, and they are found to be distributed mostly in the regions of high column density. Four candidate Class 0/I MYSOs have been found. They suggested that multi-generation star formation is present in the complex. From the evidence of interaction, time scales involved, and evolutionary status of stellar/protostellarsources, they argued that the star formation at the edges of Sh2-90 might have been triggered. However, several young sources in this complex would have been formed by some other processes also. **[**M. R. Samal et. al. (Including **A. K. Pandey**), *Astronomy & Astrophysics, Volume 566, p..A122***]**.

Investigation of the stellar content in the western part of the Carina nebula

The Carina nebula (NGC 3372) region, which hosts several young star clusters made of very massive stars along with YSOs, provides an ideal laboratory for studying the ongoing star formation. The CO survey of this region demonstrates that the Carina nebula is on the edge of a giant molecular cloud extending over ~130 pc and has a mass in excess of 5 × 10^5 $M_{\odot}$. It contains ~200 OB stars, more than ~60 massive O stars, and three late type Wolf-Rayet stars.

The low obscuration and proximity of the Carina nebula make it an ideal place to study the ongoing star formation process and impact of massive stars on low-mass stars in their surroundings. To investigate this process, authors generated a new catalog of the pre-main-sequence stars in the

Carina west (CrW) region and studied their nature and spatial distribution. They also determined various parameters (reddening, reddening law, age, mass), which are used further to estimate the initial mass function and K-band luminosity function for the region under study. Deep UBVRI Hα photometric data of the field situated to the west of the main Carina nebula and centered on WR 22 were obtained. Medium-resolution optical spectroscopy of a subsample of X-ray selected objects along with archival data sets from Chandra, XMM-Newton and 2MASS surveys were used for the present study. Different sets of color-color and

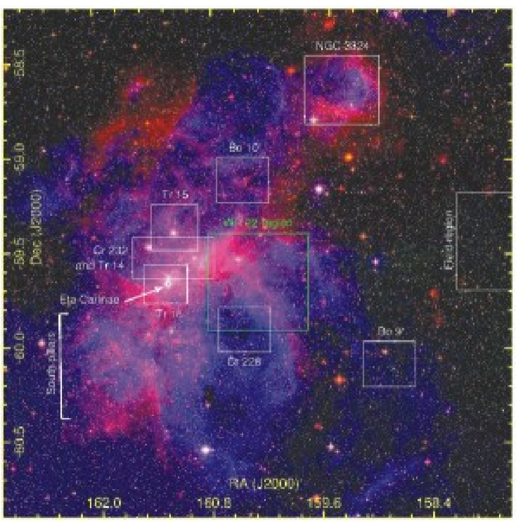

Figure 9. Color composite image of the large (2.7° × 2.7°) area containing the Carina nebula and centered at α(J2000) = $10^h41^m17^s.5$ and δ(J2000) = -59°40'36".9. This RGB image was made using the WISE 4.6 μm (red), 2MASS K_s band (green), and DSS *R* band (blue) images. Approximate locations of different star clusters (Tr 14, 15, 16; Bo 9, 10; Cr 228, 232, and NGC 3324) are denoted by white boxes. η Carinae is marked by an arrow and in the lower left part of the image, south pillar are shown. The region covered in the present study is shown by the green box. Part of the selected field region can be seen in the extreme western part of the image. North is up and east is to the left.

color-magnitude diagrams were used to determine reddening for the region and to identify young stellar objects and estimate their age and mass. Our spectroscopic results indicate that the majority of the X-ray sources are late spectral type stars. The region shows a large amount of differential reddening with minimum and maximum values of E (B - V) as 0.25 and 1.1 mag, respectively. Our analysis reveals that the total-to-selective absorption ratio R_V is ~3.7 ± 0.1, suggesting an abnormal grain size in the observed region. They identified 467 YSOs and studied their characteristics. The ages and masses of the 241 optically identified YSOs range from ~0.1 to 10 Myr and ~0.3 to 4.8 $M_\odot$, respectively. However, the majority of them are younger than 1 Myr and have masses below 2 $M_\odot$. The high mass star, WR 22, does not seem to have contributed to the formation of YSOs in the CrW region. The initial mass function slope, (Gamma), in this region is found to be -1.13 ± 0.20 in the mass range of 0.5 < $M/M_\odot$< 4.8. The K-band luminosity function slope (alpha) is also estimated as 0.31 ± 0.01. They also performed minimum spanning tree analysis of the YSOs in this region, which revealed that there are at least ten YSO cores associated with the molecular cloud, and that leads to an average core radius of 0.43 pc and a median branch length of 0.28 pc. **[Brajesh Kumar, Saurabh Sharma**, Jean Manfroid, Eric Gosset, Gregor Rauw, Yael Naze and **Ram Kesh Yadav,** *Astronomy & Astrophysics, Volume 567, p. A109*].

Deep optical survey of the stellar content of Sh2-311 region

The HII region Sh2-311 (α_{2000} = $07^h52^m26^s$,δ_{2000}= - 26°26'12"; l = 243°.2, b = 0°.4), also known as NGC 2467, is a part of the Puppis OB association. The region is located in "Puppis Window" in the third quadrant of the Milky Way. The interstellar extinction towards the direction of Puppis Window is relatively low, hence the spiral arm structure as well as star formation activities at large distances can be studied. The region is also interesting because it contains a number of young open clusters and nebular entities.

In this work the stellar content in and around Sh2-311 region has been studied using the deep optical observations as well as near-infrared data from the Two micron all sky survey. The region contains three clusters, viz. NGC 2467, Haffner 18 and Haffner 19. The authors have made an attempt to distinguish the stellar content of these individual regions as well as to re-determine their fundamental parameters such as distance, reddening, age, onto the basis of a new and more extended optical and infrared photometric data set. NGC 2467 and Haffner 19 are

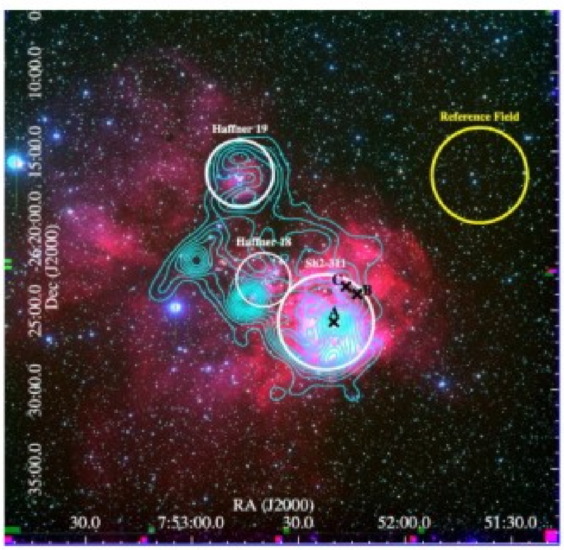

Figure 10. The 34 × 33 $arcmin^2$ color composite image obtained by using *B* (blue), *V* (green) and Hα (red) filter images. The circles represent the estimated boundary of the clusters. The area marked by the yellow circle near the upper-right side of the image is the reference field for the optical data. The stars having spectroscopic observations are marked with crosses. *MSX* A-band contours are also overplotted. The isophot contour levels at 8.28 μm are 80, 75, 65, 60, 50, 40, 30, 25, 15 and 1 percent of the peak value.

found to be located in the Perseus arm at the distances of 5.0 ± 0.4 kpc and 5.7 ± 0.4 kpc, respectively, whereas Haffner 18 is located at a distance of 11.2 ± 1.0 kpc. The clusters NGC 2467 and Haffner 19 might have formed from the same molecular cloud, whereas the cluster Haffner 18 is located in the outer galactic arm, i.e. the Norma-Cygnus arm. They identified 8 class II young stellar objects (YSOs) using the near infrared (J-H)/(H-K) two colour diagram. They estimated the age and mass of the young stellar objects identified in the present work and those by Snider et al. (2009) using the V/(V-I) colour-magnitude diagram. The estimated ages and mass range of the majority of the YSOs are ≲1 Myr and ~0.4-3.5 $M_{\odot}$, respectively, indicating that these sources could be T-Tauri stars or their siblings. Spatial distribution of the YSOs shows that some of the YSOs are distributed around the HII region Sh2-311, suggesting a triggered star formation at its periphery. **[Ram Kesh Yadav, A. K. Pandey, Saurabh Sharma**, J. Jose, K. Ogura, N. Kobayashi, M. R. Samal, **C. Eswaraiah**, H. C. Chandola, *New Astronomy, Volume 34, p. 27-40*]**.**

4. Study of Open Clusters

Main-sequence variable stars in young open cluster NGC 1893

In this work, authors present the time series photometry of 104 variable stars in the young open cluster, NGC 1893. The association of the present variable candidates to the cluster NGC 1893 has been determined by using (U – B)/(B - V) and (J - H)/(H - K) two colour diagrams, and V/(V - I) colour-magnitude diagram. In total, 45 stars were found to be main-sequence variables and these could be B-type variable stars associated with the cluster. They classified these objects as beta Cep, slowly pulsating B stars and new-class variables as discussed by Mowlavi et al. These variable candidates show ~0.005 to ~0.02 mag brightness variations with periods of <1.0 day. The seventeen new-class variables are located in the H - R diagram between the slowly pulsating B stars and delta Scuti variables. Pulsation could be one of the causes for the periodic brightness variations in these stars. The X-ray emission of the main-sequence variables associated with the cluster lies in the saturated region of X-ray luminosity versus period diagram and follows the general trend by Pizzolato et al. **[S. Lata, Ram Kesh Yadav, A. K. Pandey**, Andrea Richichi, **C. Eswaraiah, Brajesh Kumar**, Norbert Kappelmann and **Saurabh Sharma,** *MNRAS, Volume 442, pp. 273-284***].**

5. Study of Globular cluster systems

Globular cluster system of NGC 1316

The merger remnant NGC 1316 (Fornax A) is an important object to study merger-related processes. The kinematical properties of the globular cluster system in comparison with the diffuse stellar light might give more insight into the formation of NGC 1316. Of particular interest is the dark matter content. The authors performed multi object spectroscopy using VLT/FORS2 and MXU with the aim to set radial velocities of the globular clusters. Out of 562 slits, they extracted radial velocities for 177 globular clusters. The GC sample based on radial velocities confirms the colour peaks already found in their photometric study. The bright clusters, which probably have their origin in a 2 Gyr old starburst and younger star formation events, avoid the systemic velocity. The velocity distribution of clusters shows a pronounced peak at 1600 km/s, **see Figure 11** . The central dark matter density of the present model resembles a giant elliptical galaxy. This contradicts population properties which indicate spiral galaxies as pre-merger components. Modified Newtonian dynamics (MOND) would provide a solution, but the kinematical complexity of NGC 1316 does not allow a really firm conclusion. However, NGC 1316 might anyway be a problem for a cold dark matter scenario, if the high dark matter density in the inner region is confirmed in future studies. **[**T. Richtler, M. Hilker, **Brijesh Kumar**, L. P. Bassino, M. Gomez and B. Dirsch, *Astronomy & Astrophysics, Volume 569, id.A41, 18 pp***].**

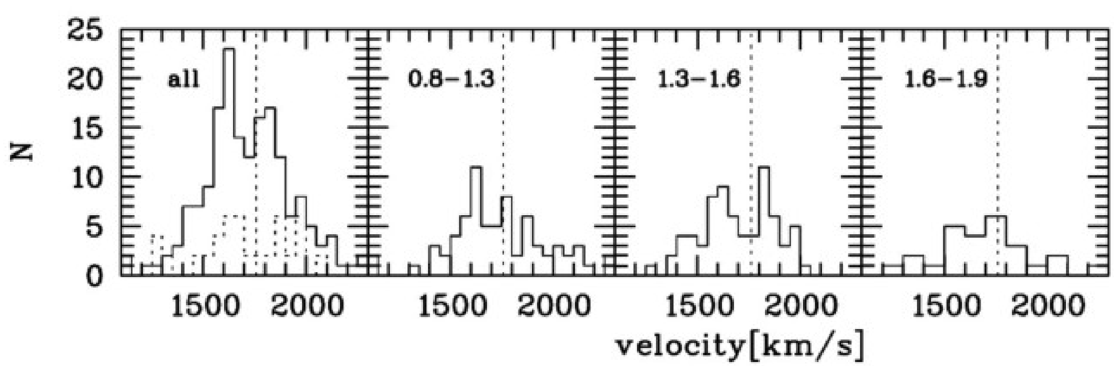

Figure 11. Radial velocity histograms for different color (C-R in mag) intervals, corresponding to different cluster populations. Typical uncertainties in velocities are of the of order 50–80 km/s. The vertical dotted line indicates the systemic velocity of the galaxy. The dotted histogram in the left panel is the velocity histogram from literature, where the two velocity peaks already are discernible. The peak of 1800 km/s is interpreted as the expected peak at the systemic velocity. The peak at 1600 km/s is caused by a dominance of clusters with this velocity in the western part of NGC 1316.

6. Normal Galaxies and Active Galactic Nuclei

Active galactic nuclei (AGN) are galaxies that have very energetic central regions, due to either the presence of a black hole or star formation activity at the core of the galaxy. Three main types of AGN are quasars, ("quasi-stellar objects" or QSOs), which are very compact objects that resemble stars in optical images; Seyfert galaxies, characterized by fluctuations in brightness at their cores; and radio galaxies, which emit massive jets of gas powered by black holes at their cores.

Discovery of a red quasar with recurrent activity

It is well established that many AGNs may go through two or more cycles of episodic activity. This is most clearly seen in extended radio galaxies and quasars, where there may be a new pair of radio lobes with well-defined hot spots closer to the nucleus, in addition to the more distant and diffuse, extended lobes from an earlier cycle of activity. The sources with a second pair of lobes have been classified as double–double radio galaxies (DDRGs).

The authors report a new double–double radio quasar (DDRQ) J0746+4526 which exhibits two cycles of episodic activity. From radio continuum observations at 607 MHz using the Giant Metrewave Radio Telescope and 1400 MHz from the Faint Images of the Radio Sky at Twenty-cm survey they confirmed the episodic nature of the source. They further examined the Sloan Digital Sky Survey (SDSS) optical spectrum and estimated the black hole mass to be $(8.2 \pm 0.3)\times10^7 M_\odot$ from its observed Mg II emission line, and the Eddington ratio to be 0.03. The black hole mass is significantly smaller than that for the other reported DDRQ, J0935+0204, while the Eddington ratios are comparable. The SDSS spectrum is significantly red-continuum-dominated, suggesting that it is highly obscured with $E(B-V)_{host}$= 0.70±0.16 mag. This high obscuration further indicates the existence of a large quantity of dust and gas along the line of sight, which may have a key role in triggering the

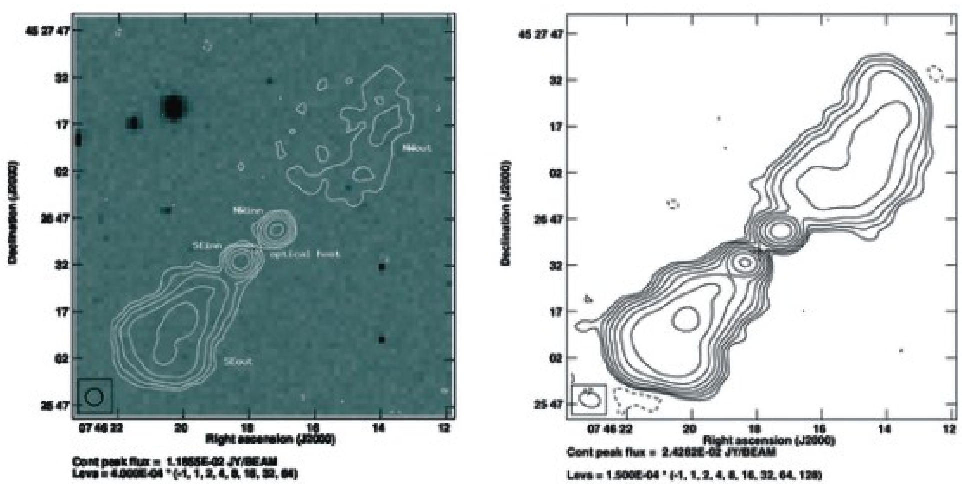

Figure 12. Left panel: the FIRST image at 1400 MHz overlaid on the optical field from the SDSS. The optical host and both the outer and inner doubles (NW_{out}, SE_{out}, NW_{inn}, SE_{inn}) are marked in the same image. Right panel: the GMRT image at 607 MHz. The + sign represents the host position.

recurrent jet activity in such objects. **[S. Nandi, R. Roy**, D.J. Saikia, **M. Singh**, H.C. Chandola, M. Baes**, R. Joshi**, G. Gentile and M. Patori, *The Astrophysical Journal, Volume 789, Issue 1, article id. 16, 5 pp. (2014)***].**

C IV absorption-line variability in X-ray-bright broad absorption-line quasi-stellar objects

Outflows play an important role in controlling the growth of the central massive black hole in QSOs, the evolution of the host galaxy and the chemical enrichment of the intergalactic medium. The strong blue shifted broad absorption lines with velocity widths greater than 2000 km s^{-1} and typical outflow velocities of 1000–30000 km s^{-1} found in about 10–20 per cent of QSO population is interpreted as a signature of outflows from accretion discs.

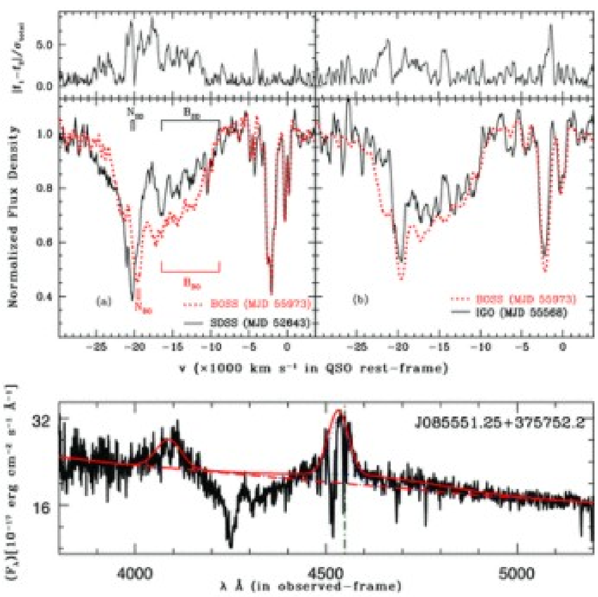

Figure 13. Lower panel: the final continuum fit (smooth curve), comprising a power law, a lower order polynomial (dashed curve) and the multi-Gaussian components (dotted curve), for the SDSS (MJD 52643) spectrum. Middle panel: two-epoch absorption-line variation in continuum-normalized SDSS, BOSS and IGO spectra for SDSS J085551+375752 on a velocity scale, with $v = 0$ km s^{-1}corresponding to a QSO emission redshift of z_{em} = 1.936. Upper panel: the ratio of absolute deviation to the total error bars.

In this work authors report the kinematic shift and strength variability of the C IV broad absorption-line (BAL) trough in two high-ionization X-ray-bright QSOs : SDSS J085551+375752 (at Z_{em} ~ 1.936) and SDSS J091127+055054 (at Z_{em} ~ 2.793). Both these QSOs have shown a combination of profile shifts and the appearance and disappearance of absorption components belonging to a single BAL trough. The observed average kinematic shift of the whole BAL profile resulted in an average deceleration of ~ -0.7 ± 0.1, -2.0 ± 0.1 cm s^{-2} over rest-frame time-spans of 3.11 and 2.34 yr for SDSS J085551+375752 and SDSS J091127+055054, respectively. To their knowledge, these are the largest kinematic shifts known, exceeding by factors of about 2.8 and 7.8 the highest deceleration reported in the literature; this makes both the objects potential candidates to investigate outflows using multi-wavelength monitoring of their line and continuum variability. Various possible mechanisms have been explored to understand the observed profile variations. Outflow models involving many small self-shielded clouds, probably moving in a curved path, provide the simplest explanation for the C IV BAL strength and velocity variations, along with the X-ray-bright nature of these sources. **[Ravi Joshi, Hum Chand**, Raghunathan Srianand, Jhilik Majumdar, *MNRAS, Volume 442, Issue 1, p.862-869***].**

Intranight optical variability of radio-quiet weak emission line quasars - II

This work is a continuation of the search for the elusive radio-quiet blazars, by carrying out a systematic program to detect intranight optical variability (INOV) in a subset of weak-line quasars which are designated as high-confidence BL Lac candidates and are known to be radio-quiet. For 10 such radio-quiet weak-line quasars (RQWLQs), the authors present the INOV observations taken in 16 sessions of durations ≥ 3.5 hour each. Combining these data with their previously published INOV monitoring of RQWLQs in 13 sessions gives a set of INOV observations of 15 RQWLQs monitored in 29 sessions, each lasting more than 3.5 hour. The 29 differential light curves, thus obtained for the 15 RQWLQs, were subjected to a statistical analysis using the F-test, and the deduced INOV characteristics of the RQWLQs are compared with those published recently for several prominent AGN classes, also using the F-test. However, since the RQWLQs are generally 1-2 mag fainter, a rigorous comparison has to wait for somewhat more sensitive INOV observations than those presented here. Based on their existing INOV observations, it seems that RQWLQs in their sample show a significantly higher INOV duty cycle than radio-quiet quasars and radio lobe-dominated quasars. Two sessions when they detected rather strong (blazar-like) INOV for RQWLQs are pointed out, and both these RQWLQs are therefore candidates for radio-quiet BL Lacs. [**Hum Chand**, **Parveen Kumar** and Gopal-Krishna, *MNRAS, Volume 441, pp. 726-732*]

Unveiling the nature of an X-ray flare from 3XMM* J014528.9+610729: a candidate spiral galaxy

The X-ray emission from normal galaxies is mainly associated with bright high-mass X-ray binaries (HMXBs), supernova remnants, O-type stars and hot gas heated by energy originated in supernova explosions. Authors in this work report serendipitous detection of X-ray flare from 3XMM J014528.9+610729 during their observations of an open star cluster NGC 663. The colour-colour space technique using optical and infrared data reveals the X-ray source as a candidate spiral galaxy. The flare shows fast rise and exponential decay shape with a

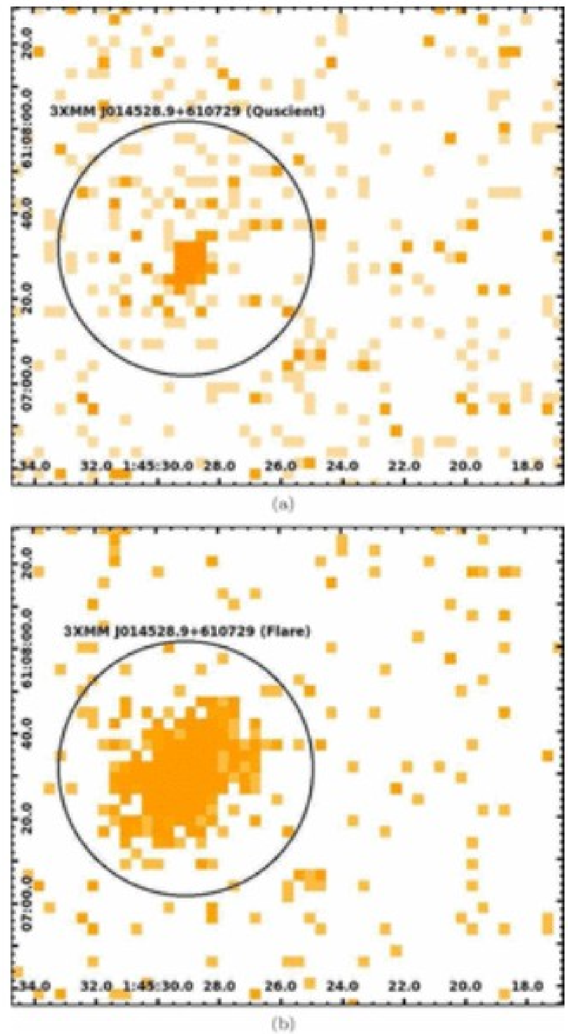

Figure 14. X-ray image of 3XMM J014528.9+610729. (a) Before the flaring event and (b) during the flaring event. *x*-axis and *y*-axis are representing RA(J2000) and Dec.(J2000), respectively.

ratio of the peak and the quiescent count rates of ~60 and duration of ~5.4 ks. The spectrum during the flaring state is well fitted with a combination of thermal (APEC) model with a plasma temperature of 1.3 ± 0.1 keV and non-thermal (POWERLAW) model with power-law index of 1.9 ± 0.2. However, no firm conclusion can be made for the spectrum during the quiescent state. The temporal behaviour, plasma temperature and spectral evolution during flare suggest that the flare from 3XMM J014528.9+610729 cannot be associated with tidal disruption events. [Himali Bhatt, Subir Bhattacharyya, Nilay Bhatt, **J. C. Pandey**, *MNRAS, Volume 444, Issue 3, pp.2270-2279*].

7. Numerical Studies

Dissipative advective accretion disc solutions with variable adiabatic index

Observations of electromagnetic spectra and mass outflow in the form of jets from microquasars and active galactic nuclei (AGN) are better explained as a consequence of conversion of gravitational energy released from matter falling into extreme compact objects like black holes. AGN are supposed to harbour 10^{6-9} $M_\odot$ (where $M_\odot$ is solar mass) black holes at the centre, and microquasarsharbour black holes of mass $\sim 10\ M_\odot$ at the centre.

In this work, authors have investigated accretion on to black holes in the presence of viscosity and cooling, by employing an equation of state with variable adiabatic index and multi-species fluid. They obtained the expression of generalized Bernoulli parameter which is a constant of motion for an accretion flow in the presence of viscosity and cooling. They obtained all possible transonic solutions for a variety of boundary conditions, viscosity parameters and accretion rates. They identified the solutions with their positions in the parameter space of generalized Bernoulli parameter and the angular momentum on the horizon. It was shown that a shocked solution is more luminous than a shock-free one. For particular energies and viscosity parameters, they obtained accretion disc luminosities in the range of 10^{-4} to 1.2 times Eddington luminosity, and the radiative efficiency seemed to increase with the mass accretion rate too. They found steady state shock solutions even for high-viscosity parameters, high accretion rates and for wide range of composition of the flow, starting from purely electron-proton to lepton-dominated accretion flow. However, similar to earlier studies of inviscid flow, accretion shock was not obtained for electron–positron pair plasma.

In this work they consider stationary, viscous, rotating and axisymmetric accretion disc around a Schwarzschild black hole. For mathematical simplicity, space–time around the black hole was described by the Paczyński–Wiita (PW) pseudo-

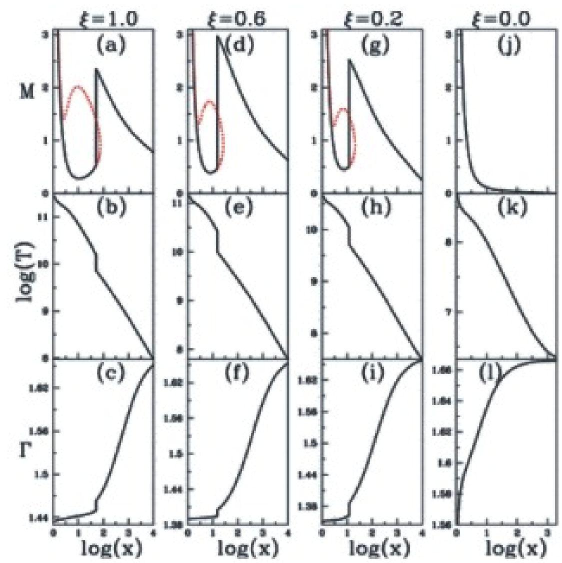

Figure 15. Variation of Mach number *M* (a, d, g, j), log (*T*) (b, e, h, k) and adiabatic index Γ (c, f, i, l) with radial distance log (*x*). These solutions are plotted with disc parameters, $\varepsilon = 1.000001$, $\lambda_0 = 1.63$, $\alpha = 0.01$, $\beta = 0.01$, accretion rete=0.001 and $\xi = 1.0$ (a–c), 0.6 (d–f), 0.2 (g–i), 0.0 (j–l). The plots with ξ = 1.0, 0.6 and 0.2 having shock locations at x_s = 51.82, 15.43 and 12.06, respectively. For $0 \le \xi \le 0.157$, shock solution does not exist for these parameters.

Newtonian potential. PW potential simplified their calculations while retaining all the essential qualitative features of strong gravity, and thus made easier to incorporate more complicated physics in the pseudo-Newtonian scheme. **[Rajiv Kumar** and **Indranil Chattopadhyay,** *MNRAS, Volume 443, Issue 4, pp.3444-3462*]

On the possibilities of mass loss from an advective accretion disc around stationary black holes

In this work authors have studied the coupled disc-jet system around the black hole where the outflow solutions are obtained in terms of the inflow parameters. They found that an advective accretion disc can eject outflows/jets for wide range of viscosity parameter. However, such possibility is reduced if the cooling is active as the energy dissipative process inside the disc. For mass outflow, they obtained the parameter space spanned by the inflow angular momentum and the viscosity in terms of cooling and quantify the limits of viscosity parameter. [Santabrata Das, **Indranil Chattopadhyay**, Anuj Nandi and Biplob Sarkar *BASI, Volume 42, pp. 39-45*].

Periodic mass loss from viscous accretion flows around black holes

The behaviour of low angular momentum viscous accretion flows around black holes using smooth particle hydrodynamics method was investigated in this work. Earlier, it has been observed that in a significant part of the energy and angular momentum parameter space, rotating transonic accretion flow undergoes shock transition before entering in to the black hole and a part of the post-shock matter is ejected as bipolar outflows, which are supposed to be the precursor of relativistic jets. In this work, the authors simulated accretion flows having injection parameters from the inviscid shock parameter space, and studied the response of viscosity on them. With the increase of viscosity, shock becomes time dependent and starts to oscillate when the viscosity parameter crosses its critical value. As a result, the in-falling matter inside the post-shock region exhibits quasi-periodic variations and causes periodic ejection of matter from the inner disc as outflows. In addition, the same hot and dense post-shock matter emits high energy radiation and the emanating photon flux also modulates quasi-periodically. Assuming a 10 M_{o}; black hole, the corresponding power density spectrum peaks at the fundamental frequency of few Hz followed by multiple harmonics. This feature is very common in several outbursting black hole candidates. They discussed the implications of such periodic variations. [Santabrata Das, **Indranil Chattopadhyay**, Anuj Nandi and Diego Molteni, *MNRAS, Volume 442, pp. 251-258*].

Interaction of a galactic wind with halo gas and the origin of multiphase extraplanar material

Disc galaxies contain a substantial amount of baryonic matter outside the disc and this extraplanar material has become an important topic for many observational and theoretical studies. The extraplanar gas and its different phases appear in the literature under different names like hot halo gas, galactic wind, outflowing cold/warm clouds, high-velocity clouds, circumgalactic medium etc.

In this study the interaction of a galactic wind with hot halo gas using hydrodynamical simulations has been carried out by the authors. They found that the outcome of this interaction depends crucially on the wind injection density and velocity. Various phases of extraplanar media such as infalling clouds, outflowing clouds and O VI regions can originate in the interaction zones of wind with the halo gas, depending on the injection velocity and density. In their simulations, the size of the clouds is of the order of 100 pc. The total mass contained in the clouds is 10^5-$10^7 M_\odot$; and they have a normal distribution of velocities in the galactic standard of rest frame. For high injection density and velocity, a significant number of clouds move outwards and resemble the case of cold neutral outflows. Furthermore, a 10^5-10^6 K phase is formed in our simulations, which has a column density ~10^{18} cm^{-2} and resembles the observed O VI regions. The injection velocity and density are linked with the mass-loading factor of the outflow, efficiency of energy injection due to supernovae and star-formation rate. Comparison of the predicted morphology of extraplanar gas with observations can serve as a useful diagnostic for constraining the feedback efficiency of outflows. [Mahavir Sharma, Biman B. Nath, **Indranil Chattopadhyay** and Yuri Shchekinov, *MNRAS, Volume 441, pp. 431-441*].

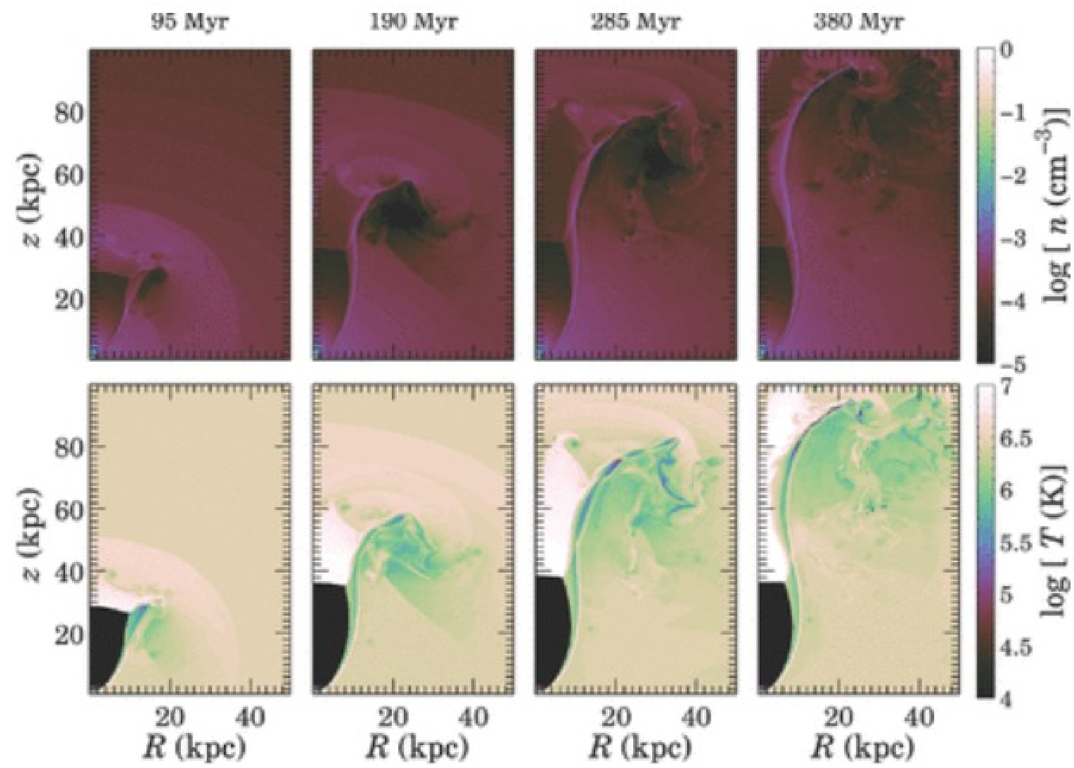

Figure 16. Time evolution of log density (upper panel) and log temperature (lower panel) in the run *MG5 (shown here just for illustration)*.

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

Homologous flare–CME events and their metric type II radio burst association

Solar flares that occur at the same locations in the same active region within a certain time interval are called recurrent flares. When the observed properties have many similarities in space and time, they are called homologous flares. The homologous flares and the associated coronal mass ejections (CMEs) have been investigated to understand the energy buildup, the triggering mechanism, and the flare–CME relationship. There is a general consensus that type II radio bursts are a signature of shock waves propagating away from the Sun. It has been established that shocks driven by CMEs are responsible for interplanetary type II bursts observed at decameter-hectometric (DH) wavelengths and kilometric wavelengths.

Active region NOAA 11158 produced many flares during its disk passage. At least two of these flares are considered as homologous: the C6.6 flare at 06:51 UT and C9.4 flare at 12:41 UT on February 14, 2011. Both flares occurred at the same location (eastern edge of the active region) and have a similar decay of the GOES soft X-ray light curve. The associated CMEs were slow (334 and 337 km/s) and of similar apparent widths (43° and 44°), but they had different radio signatures. The second event was associated with a metric type II burst while the first one was not. The COR1 coronagraphs on board the STEREO spacecraft clearly showed that the second CME propagated into the preceding

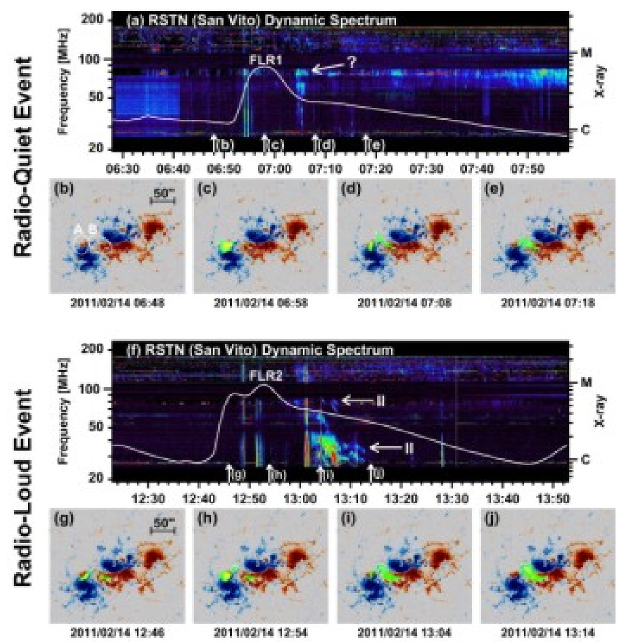

Figure 17. (a, f) Radio dynamic spectrum observed by the San Vito Solar Observatory of the Radio Solar Telescope Network (RSTN). The observed frequency range is from 25 to 180 MHz. The white curve shows the GOES X-ray intensity in the long-wavelength band. The peak X-ray intensity was C6.6 for the first flare (FLR1) and C9.4 for the second flare (FLR2). (b–e, g–j) Magnetogram images observed by SDO/HMI. Red and blue colors correspond to positive and negative polarities. The overlaid green images were the SDO/AIA 94 Å observations, indicating the location of FLR1 and FLR2.

CME that occurred 50 min before. The results from the present study suggest that CME–CME interaction might be a key process in exciting the type II radio emission by slow CMEs. [S. Yashiro, N. Gopalswamy, P. Mäkelä, S. Akiyama, **W. Uddin** and 11 coauthors, *Advances in Space Research, Volume 54, Issue 9, p. 1941-1948*].

Confined Partial Filament Eruption and its Reformation within a Stable Magnetic Flux Rope

Filaments/prominences are relatively cooler and denser plasma structures imbedded in the hot ambient corona. These magnetic structures show up as dark curtains (filaments) on the bright solar disk and as bright features on the limb against the dark background (i.e., prominences). Filaments generally exist in the equilibrium state because of the balance between the upward magnetic pressure and the downward magnetic tension forces and gravity.

In this work, authors present observations of a confined partial eruption of a filament on 2012 August 4, which restores its initial shape within ≈ 2 hr after eruption. From the Global Oscillation Network Group Hα observations, they found that the filament plasma turns into dynamic motion at around 11:20 UT from the middle part of the filament toward the northwest direction with an average speed of ≈ 105 km s^{-1}. A little brightening underneath the filament possibly shows the signature of low-altitude reconnection below the filament eruptive part. In *Solar Dynamics Observatory*/Atmospheric Imaging Assembly 171 Å images, they observed an activation of right-handed helically twisted magnetic flux rope that contains the filament material and confines it during its dynamical motion. The motion of cool filament plasma stops after traveling a distance of ≈ 215 Mm toward the northwest from the point of eruption. The plasma moves partly toward the right foot point of the flux rope, while most of the plasma returns after 12:20 UT toward the left foot point with an average speed of ≈ 60 km s^{-1} to reform the filament within the same stable magnetic structure. On the basis of the filament internal fine structure and its position relative to the photospheric magnetic fields, they found filament chirality to be sinistral, while the activated enveloping flux rope shows a clear right-handed twist. Thus, this dynamic event is an apparent example of one-to-one correspondence between the filament chirality (sinistral) and the enveloping flux rope helicity (positive). From the coronal magnetic field decay index, *n*, calculation near the flux rope axis, it is evident that the whole filament axis lies within the domain of stability (i.e., $n < 1$), which provides the filament stability despite strong disturbances at its eastern foot point. **[N. C. Joshi… et. al. (Including A. K. Srivastava, Pradeep Kayshap and W. Uddin),** *The Astrophysical Journal, Volume 787, Issue 1, article id. 11, 13 pp. (2014)*]

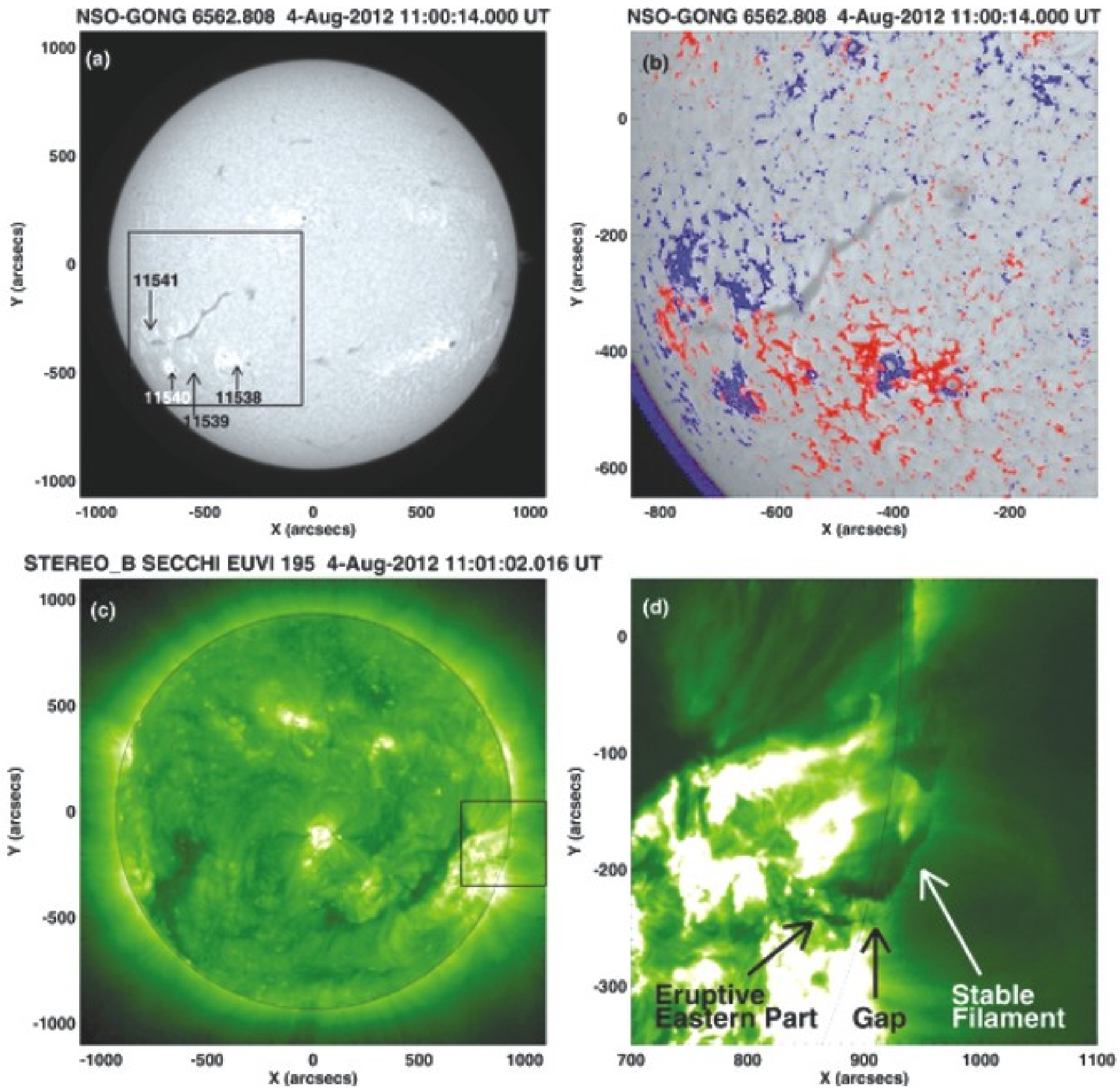

Figure 18. (a) Full disk Hα image from the Global Oscillation Network Group (GONG) in which the box shows the location of the filament. (b) Selected area of the GONG-Hα network showing the filament on the disk. In the panels (b), the contours are the HMI magnetogram contours at ±50, ±100, ±200, ±300, and ±400 G. The red (blue) contour shows positive (negative) polarity regions. (c) Full disk *STEREO*/EUVI 195 Å images in which the box shows the location of the filament over the limb. (d) Zoomed view of the filament corresponding to the box in panel 1(c).

Atmospheric Sciences

Atmospheric sciences encompass the study of different physical, chemical and dynamical processes occurring within the Earth's atmosphere. Within this broad field the scientists seek to understand the state of the Earth's atmosphere where we live in.

LiDAR observations of the vertical distribution of aerosols in free troposphere: Comparison with CALIPSO level-2 data over the central Himalayas

The quantification of the effects of aerosols on climate is quite challenging due to their large spatial and temporal variations in density, various physical and chemical properties, or complex mechanisms of their interaction with radiation and clouds etc.

In this work, authors present a detailed analysis on the vertical distribution of aerosols over the central Himalayan region is carried out during different seasons. The main aim was to elucidates the seasonality in aerosol vertical profiles acquired using LiDAR measurements and compares it with the CALIPSO level-2 data products over central Himalayas. They presented intermittent observations that were made over Manora Peak (29.36° N, 79.45° E, 1951 m, AMSL) Nainital, during March 2012 to May 2013 amounting to a total of 360 h of LiDAR operation, out of which 57 suitable cases were subjected to further analysis. Aerosol loading in the vertical column was found to be highest with 3.40 $(Mm\ sr)^{-1}$ at 3.3 km during the spring and summer seasons (MAMJ-2012), and the lowest with 0.48 $(Mm\ sr)^{-1}$ at 2.5 km, during winter season (DJF 2012-13). The aerosol layer reaches to the maximum altitude of 5.6 km in the period of MAMJ-2012 and a minimum at 2.8 km in the winter (DJF). The highest value (124 Mm^{-1}) of extinction coefficient was found at 3.3 km, during MAMJ- 2012 and minimum (7 Mm^{-1}) at 2.5 km during the winter season. A comparison of ground

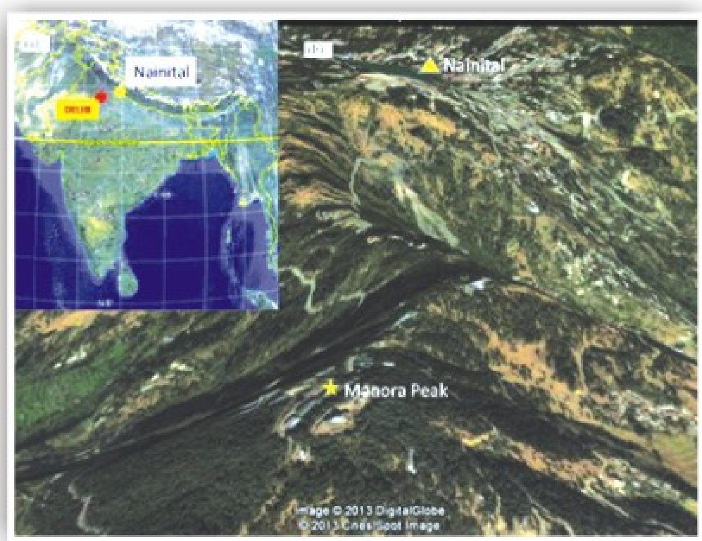

Figure 19. (a) Geographical location (marked by yellow star) of observation site at Nainital and nearest megacity Delhi (marked by red star), on the map of India (b) The topography around observation site Manora Peak, and the city of Nainital, in the Google earth imagery.

based LiDAR observations with the CALIPSO satellite derived aerosol backscatter profiles has been carried out for 37 suitable cases and a representative profile is given in **Figure 20**.To determine the LiDAR ratio, AOD measurements from MODIS were used as constrain. The mean percent bias for different seasons is found to be +18 ± 42%, +22 ± 28%, +32 ± 36% and +18 ± 51% for MAMJ-2012, SON-2012, DJF-2012-13 and MAM-2013 respectively. **[Raman Solanki** and **Narendra Singh**, *Atmospheric Environment, Volume 99, pp. 227-238***]**.

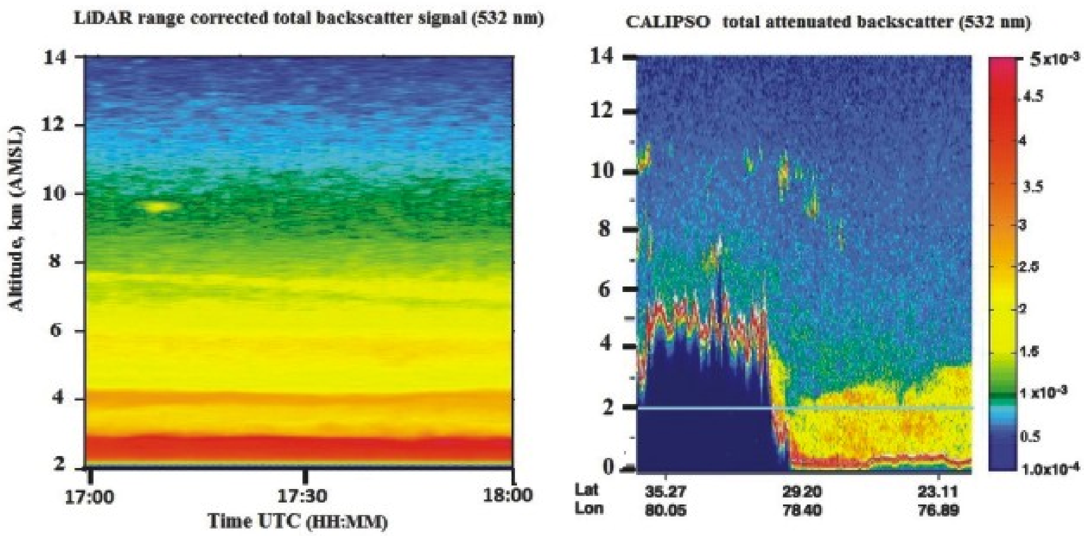

Figure 20. Range-Time-Intensity plot for the comparison of range corrected LiDAR-backscatter (integration time 120 s) and CALIPSO-total attenuated backscatter (version 3.02), on 24 Mar 2012. The signal intensity observed with both Lidar and CALIPSO is in the same order of magnitude.

Scattering and absorption properties of near-surface aerosol over Gangetic-Himalayan region: the role of boundary-layer dynamics and long-range transport

Light scattering and absorption properties of atmospheric aerosols are of vital importance for evaluating their types, sources and radiative forcing. This is of particular interest over the Gangetic-Himalayan (GH) region due to uplift of aerosol from the plains to the Himalayan range, causing serious effects on atmospheric heating, glaciology and monsoon circulation. In this respect, the Ganges Valley Aerosol Experiment (GVAX) was initiated in Nainital from June 2011 to March 2012 with the aim of examining the aerosol properties, source regions, uplift mechanisms and aerosol-radiation-cloud interactions. The present study examines the temporal (diurnal, monthly, seasonal) evolution of scattering (σ_{sp}) and absorption (σ_{ap}) coefficients, their wavelength dependence, and the role of the Indo-Gangetic plains (IGP), boundary-layer dynamics (BLD) and longrange transport (LRT) in aerosol evolution via the Atmospheric Radiation Measurement Mobile Facility. The analysis is separated for particles < 10 μm and < 1 μm in diameter in order to examine the influence of particle size on optical properties. The σ_{sp} and σ_{ap} exhibit a pronounced seasonal variation between the monsoon low and post-monsoon (November) high, while the scattering wavelength exponent exhibits higher values during the monsoon, in contrast to the absorption Ångström exponent which maximizes in December–March. The elevated-background measuring site provides the advantage of examining the LRT of natural and anthropogenic aerosols from the IGP and southwest Asia and the role of BLD in the aerosol lifting processes. The results reveal higher aerosol concentrations at noontime along with an increase in mixing height, suggesting influence from IGP. The locally emitted aerosols present higher wavelength dependence of the absorption in October–March compared to the rather well-mixed and aged transported aerosols. Monsoon rainfall and seasonally changing air masses contribute to the alteration of the extensive and intensive aerosol properties (Dumka et. al. 2015a). **[U. C. Dumka**, D. G. Kaskaoutis, M. K. Srivastava, and P. C. S. Devara, *Atmospheric Chemistry Physics, Volume 15, pp. 1555-1572*].

Seasonal inhomogeneity in cloud precursors over Gangetic Himalayan region during GVAX campaign

Atmospheric aerosols are key elements in cloud microphysics, the hydrological cycle and climate by serving as cloud condensation nuclei (CCN). The present work analyzes simultaneous measurements of number concentration of CCN (N_{CCN}) and condensation nuclei (N_{CN}) obtained at Nainital, in the Gangetic-Himalayan (GH) region, during the frameworks of Ganges Valley Aerosol Experiment (GVAX), June 2011 to March 2012. The N_{CCN}, N_{CN} and activation (AR = N_{CCN}/N_{CN}) at 0.31–0.33% S (supersaturation ratio), exhibit significant daily, monthly and seasonal variations within a range of 684–2065 cm^{-3} for N_{CCN}, 1606–4124 cm^{-3} for N_{CN}, and 0.38–0.60 for AR, suggesting large inhomogeneity in aerosol properties, types and sources, which control the degree of aerosol potential activation. Thus, transported aerosols from the Ganges valley and abroad, the boundary-layer dynamics and atmospheric modification processes play an important role in aerosol–cloud interactions over the GH region. The N_{CN} and N_{CCN} show monthly-dependent diurnal variations with afternoon maxima due to transported aerosols from the Ganges valley up to the Himalayan foothills, while the AR is lower during these hours implying lower hygroscopicities or smaller sizes of the transported aerosols. The dependence of N_{CCN} on S is highest during Dec–Mar and lowest during monsoon (Jun–Sep), suggesting different aerosol chemical composition. Comparison between Nainital and Kanpur shows that N_{CN} and N_{CCN} are much lower at Nainital, while the similarity in AR suggests aerosols of similar type, source and chemical composition uplifted from the Ganges

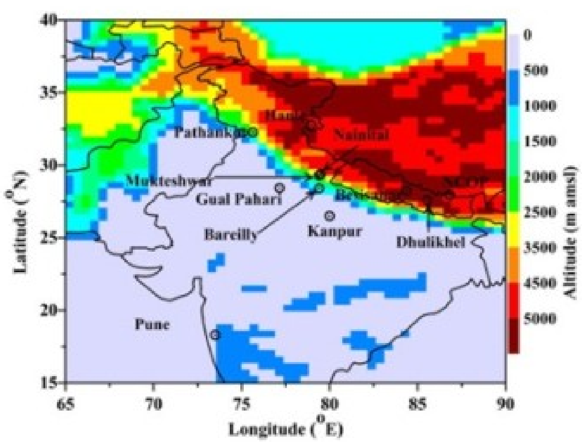

Figure 21. Topography map with measuring sites referred in the text (Dumka et. al. 2015b).

valley to the Himalayan foothills. **[U. C. Dumka**, Deepika Bhattu, S. N. Tripathi, D. G. Kaskaoutis and B. L. Madhavan, *Atmopheric Research, Volume 155, pp. 158-175***]**.

In-situ measurements of aerosol properties and estimates of radiative forcing efficiency over Gangetic-Himalayan region during the GVAX field campaign

Regular near-surface measurements of aerosol scattering and absorbing coefficients, along with other aerosol and meteorological parameters, were performed during June 2011 to March 2012 at Nainital, central Himalayas in the frameworks of GVAX. The spectral scattering (0.45, 0.55 and 0.70 µm) and absorption (0.467, 0.53 and 0.66 µm) coefficients exhibit increased values in November, mostly affected by the biomass-burning aerosols in Indo-Gangetic Plains. Both parameters were considered for fine (D < 1 µm) and sub-10 µm particles (D < 10 µm) revealing the influence of particle size in aerosol properties. Furthermore, estimations of spectral (0.467, 0.55 and 0.66 µm) single scattering albedo (SSA) and aerosol radiative forcing efficiency (ARFE) at 0.55 µm were performed focusing on determination of the role of particle size in spectral SSA and climate implications. The results show relatively high SSA values ranging from 0.90 (±0.09) to 0.95 (±0.01) for D < 10 µm, and from 0.87 (±0.10) to 0.93 (±0.02) for D < 1 µm particles, on monthly basis, suggesting large heterogeneity in the aerosol sources. The SSA for the sub-micron aerosols decreases with wavelength in the majority of the cases, in contrast to the increase for the super-micron particles suggesting different source apportionment for the particle groups. The ARFE at the top of the atmosphere was found to range from -3 to -20 W m^{-2} with a mean of ~ -17 W m^{-2} for both particle-size groups; however, during the June-October period, the ARFE for the sub-10 µm particles was found to be more negative than that for the fine aerosols. **[U. C. Dumka** and D.G. Kaskaoutis, *Atmospheric Environment., Volume 94,pp. 96-105***]**.

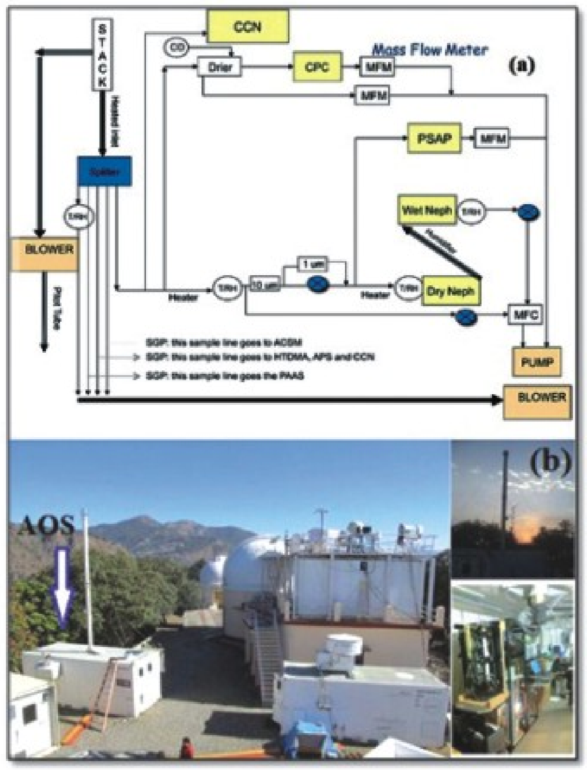

Figure 22. The schematic diagram of AOS (Aerosol Observing System) and ARM AOS installed at GVAX site ARIES, Nainital (Dumka and Kaskaoutis 2014).

Latitudinal variation of aerosol properties from Indo Gangetic Plain to central Himalayan foothills during TIGERZ campaign

The Himalayan region includes some part of the northern India which includes the densely populated the Indo-Gangetic Plain (IGP) region with high pollution levels. The aerosols in the IGP can be lifted to higher altitudes and may impact the radiation budget of the climatically sensitive region of Himalayas. The simultaneous observations of aerosol properties are sparsely characterized over the IGP and Gangetic-Himalayan (GH) region. Towards achieving the simultaneous aerosol data set from central IGP through foothills, the TIGERZ program was conducted during the pre-monsoon (April to June) of 2008 and 2009 in the northern India. The basic aim of the TIGERZ program was to carry out the spatial and temporal characterization of columnar aerosol optical, microphysical, and absorption properties during the pre-monsoon season in the IGP and GH regions.

As part of TIGERZ campaign, latitudinal variation of aerosol optical properties was analyzed over IGP to central Himalayas during pre-monsoon of 2008 and 2009. Measurements of aerosol optical depth (AOD) were performed using Aerosol Robotic Network Sun photometer at four sites with different aerosol environments. The AOD increases from Nainital located in the central Himalayan region to Kanpur located in IGP region. Further, aerosol size varies spatially with dominance of coarse-mode aerosols at Kanpur compared to fine-mode aerosols dominated at Nainital. Spectral variation of single-scattering albedo suggests that during pre-monsoon, dust is the dominant species in the IGP with exception of Pantnagar, where absorbing aerosols were dominant. The optical properties of aerosols were calculated, and shortwave clear-sky aerosol radiative forcing (ARF) was estimated. An insignificant difference is found in columnar ARF and columnar heating rate (HR) when vertical profiles of aerosols were included in the radiative transfer models. Over Nainital, the average ARF was estimated to be -7.61, -45.75, and 38.14 Wm^{-2} at top of atmosphere (TOA), surface (SUR), and in the atmosphere (ATM), respectively. Average ARF was less negative at Kanpur compared to Pantnagar and Bareilly with values -17.63, -73.06, and 55.43 $W m^{-2}$ at TOA, SUR, and ATM, respectively. ARF shows positive gradient from the highlands to the IGP sites; larger TOA and SUR cooling were observed at the three sites compared to the highland site. This translates into large columnar HR with estimated average values as 1.07, 1.41, 1.58, and 1.56 K d^{-1} for Nainital, Pantnagar, Bareilly, and Kanpur, respectively. **[U. C. Dumka**, S. N. Tripathi, Amit Misra, D. M. Giles, T. F. Eck, Ram Sagar, and B. N. Holben, *JGR: Atmosphere, Volume 119,pp. 1-20***]**.

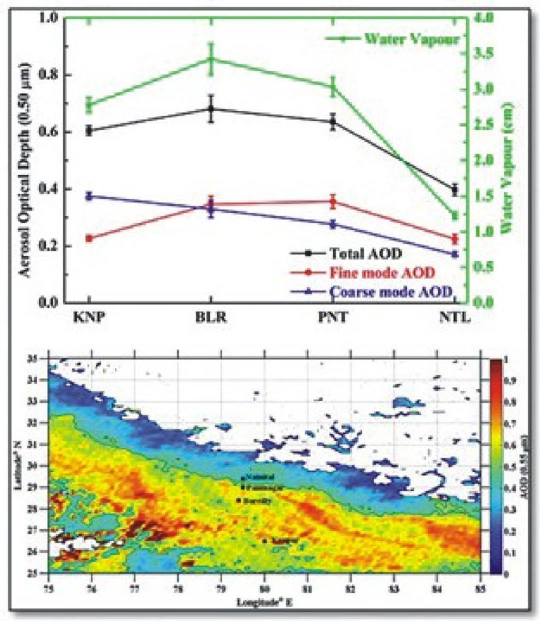

Figure 23. Top: Latitudinal variation of mean total, fine, and coarse-mode aerosol optical depth (AOD) using the ground-based AERONET measurement (primary "*y* axis") and columnar precipitable water vapor in secondary "*y* axis" of same plot. The solid points and vertical bars through them are the mean and standard error in the estimation of mean. There are 46, 49, 40, and 150 days data which are averaged at Nainital, Pantnagar, Bareilly, and Kanpur, respectively, for the estimation of mean during the period under study. Bottom: MODIS level 2 AOD for the period of April to June of years 2008 and 2009. The location of the observational sites is marked in the bottom panel (Dumka el. al. 2014).

Low-mid latitude D region ionospheric perturbations associated with 22 July 2009 total solar eclipse: Wave-like signatures inferred from VLF observations

The solar eclipses (SEs) are of great scientific interest as they provide a unique opportunity to study photochemical, optical, and radio-physical processes in the Earth's environment under the sudden reduced solar radiation conditions. There are several investigations on the Earth's atmospheric and ionospheric effects of SEs. Apart from wide range of implications of SEs on the near Earth's atmosphere and ionosphere, the two most important consequences of SEs are ionospheric variability due to sudden cutoff of solar radiation for a short duration and generation of gravity waves. The 22 July 2009 total SE was the longest SE of the century. The totality was seen in a narrow belt of ~230 km wide but partial eclipse was seen in much wider path in East and South Asian region.

In this work, authors presented the first reporting ofthe periodic wave-like signatures (WLS) in the D region ionosphere during 22 July 2009 total solar eclipse using JJI, Japan, very low frequency (VLF) navigational transmitter signal (22.2 kHz) observations at stations, Allahabad, Varanasi and Nainital in Indian Sector, Busan in Korea, and Suva in Fiji. The signal amplitude increased on 22 July by about 6 and 7 dB at Allahabad and Varanasi and decreased by about 2.7, 3.5, and 0.5 dB at Nainital, Busan, and Suva, respectively, as compared to 24 July 2009 (normal day). The increase/decrease in the amplitude could be understood in terms of modal interference at the sites of modes converted at the discontinuity created by the eclipse intercepting the different transmitter-receiver great circle paths. The wavelet analysis showed the presence of WLS of period ~16–40 min at stations under total eclipse and of period ~30–80min at stations under partial eclipse (~85–54% totality) with delay times between ~50 and 100min at different stations. The intensity of WLS was maximum for paths in the partially eclipsed region and minimum in the fully eclipsed region. The features of WLS on eclipse day seem almost similar to WLS observed in the nighttime of normal days (e.g., 24 July 2009). The WLS could be generated by sudden cutoff of the photo-ionization creating nighttime like conditions in the D region ionosphere and solar eclipse induced gravity waves coming to ionosphere from below and above. The present observations shed additional light on the current understanding of gravity waves induced D region ionospheric perturbations. [Ajeet K. Maurya…et. al. (Including **D. V. Phanikumar**), *JGR: Space Physics., Volume 119,pp. 1-12*]

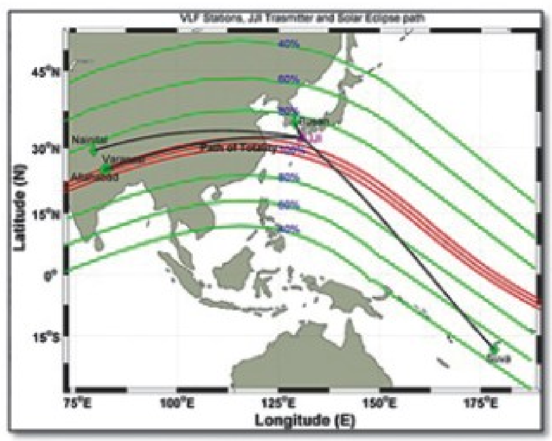

Figure 24. The 22 July 2009 solar eclipse totality path in the Indian and Asia-Oceania regions. The locations of very low frequency (VLF) receiving sites (Allahabad, Varanasi, Nainital, Busan, and Suva) are represented by green diamond and location of JJI transmitter by pink triangle.

Characteristics of the E- and F- region field-aligned-irregularities in middle latitudes: Initial results obtained from the Daejeon 40.8 MHz VHF radar in South Korea

The preliminary results of the observations of the field-aligned-irregularities (FAIs) in the *E* and *F* regions during the solar minimum (2009 - 2010) using the 40.8 MHz coherent backscatter radar at Daejeon (36.18°N, 127.14°E, 26.7°N dip latitude) in South Korea were presented in this work. The radar, which consists of 24 Yagi antennas, observed the FAIs using a single beam with a peak power of 24 kW. The radar has been continuously operated since December 2009. Depending on the manner of occurrence of the backscatter echoes, the *E*-region echoes were largely divided into two types: quasi-periodic (QP) and continuous echoes. Their observations showed that the QP echoes occur frequently above an altitude of 105 km in the post-sunset period and continuous echoes occur preferentially around an altitude of 105 km in the post-sunrise period. QP echoes appear as striated discrete echoes for a period of about 10 - 20 min. The QP-type echoes occured more frequently than the continuoustype echoes do and the echo intensity of the QP type is stronger than that of the continuous type. In the *F* region, the FAIs occur at night at an altitude interval of 250 - 450 km. As time proceeded, the occurrence height of the FAIs gradually increased until early in the morning and then decreased. The duration of the *F*-region FAIs was typically a few hours at night, although, in rare cases, FAIs persist throughout the night or appear even after sunrise. They discussed the similarities and differences of the FAIs observed by the Daejeon radar in comparison with other radar observations. [Young-SilKwak…at. al. (Including **D. V. Phanikumar**), *Jr. Astron. Space Sci., Volume 31, pp. 15-23*].

Response of the mid-latitude D-region ionosphere to the total solar eclipse of 22 July 2009 studied using VLF signals in South Korean peninsula

In this work, the authors analyzed VLF signals received at Busan to study the the D-region changes linked with the solar eclipse event of 22 July 2009 for very short (~390 km) transmitter–receiver great circle path (TRGCP) during local noon time 00:36–03:13 UT (09:36–12:13 KST). The eclipse crossed south of Busan with a maximum obscuration of ~84%. Observations clearly showed a reduction of ~6.2 dB in the VLF signal strength at the time of maximum solar obscuration (84% at 01:53 UT) as compared to those observed on the control days. Estimated values of change in Wait ionospheric parameters: reflection height (h') in km and inverse scale height parameter (β) in km^{-1} from Long Wave Propagation Capability (LWPC) model during the maximum eclipse phase as compared to unperturbed ionosphere were 7 km and 0.055 km^{-1}, respectively. Moreover, the D-region electron density estimated from model computation shows 95% depletion in electron density at the height of ~71 km. The reflection height is found to increase by ~7 km in the D-region during the eclipse as compared to those on the control days, implying a depletion in the Lyman-a flux by a factor of ~7. The present observations were discussed in the light of current understanding

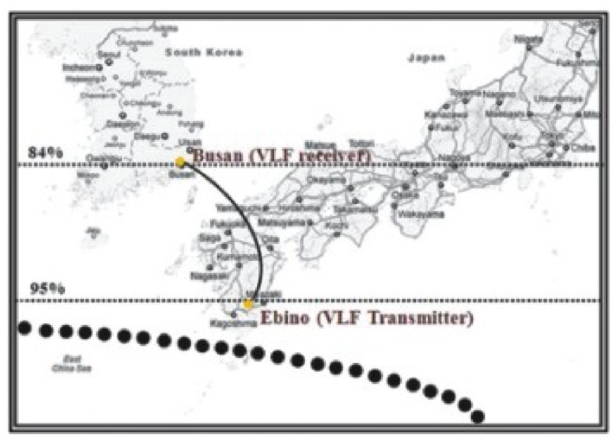

Figure 25. Solar eclipse path of VLF transmitter located at Ebino, Japan and VLF receiver located at Busan, South Korea. Percentages of Solar obscuration at those locations are indicated in black dotted lines. Filled black circles are the path of solar eclipse.

on the solar eclipse induced D-region dynamics. **[D. V. Phanikumar**, Y.-S. Kwak, A. K. Patra, A. K. Maurya, Rajesh Singh, S.M. Park, *Adv. Space Research, Volume 54,pp. 961-968***]**.

Solar flares induced D-region ionospheric and geomagnetic perturbations

The D-region ionospheric perturbations caused by solar flares which occurred during January 2010–February 2011, a low solar activity period of current solar cycle 24, have been examined on NWC transmitter signal (19.8 kHz) recorded at an Indian low latitude station, Allahabad (Geographic lat. 25.75°N, long. 81.85°E). A total of 41 solar flares, including 21 C-class, 19 M-class and 01 X-class, occurred during the daylight part of the NWC-Allahabad transmitter receiver great circle path. The local time dependence of solar flare effects on the change in the VLF amplitude, time delay between VLF peak amplitude and X-ray flux peak have been studied during morning, noon and evening periods of local daytime. Using the Long Wave Propagation Capability code V 2.1 the D-region reference height (H') and sharpness factor (β) for each class of solar flare (C, M and X) have been estimated. It is found that Dregionionospheric parameters (H', β) strongly depend on the local time of flare's occurrence and their classes. The flare time electron density estimated by using H' and β shows maximum increase in the electron density of the order of ~80 times as compared to the normal day values. The electron density was found to increase exponentially with increase in the solar flux intensity. The solar flare effect on horizontal component (H) of the Earth's magnetic field over an equatorial station, Tirunelveli (Geographic lat., 8.7°N, long., 77.8°E, dip lat., 0.4°N), showed a maximum increase in H of ~8.5% for M class solar flares. The increase in H was due to the additional magnetic field produced by the ionospheric electrojet over the equatorial station. **[**R. Selvakumaran...et. al., (Including **D. V. Phanikumar**), *Jr. Atmosph. Solar-Terres. Phy., Volume 123, pp. 102-112***]**.

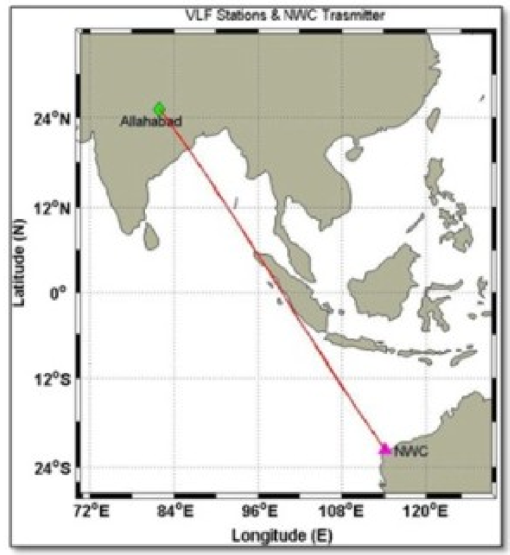

Figure 26. Great Circle path between VLF transmitter NWC (pink triangle) and low latitude receiving stations in India Allahabad (green diamond).

Signatures of ultra fast Kelvin waves in low latitude ionospheric TEC during January 2009 stratospheric warming event

In this study, authors report for the first time, the planetary wave signatures in ionospheric Total Electron Content (TEC) retrieved from global positioning service (GPS),mesospheric wind and temperature at low latitude station identified during January–February 2009. Their investigations revealed that planetary waves with 3–5 days periodicity characterized as ultra fast Kelvin (UFK) waves caused by stratospheric warming event during January 2009.The UFK waves were observed to be propagated from lower atmosphere to ionosphere.The UFK perturbations during SSW event are discussed in the light of current understanding of role of nonlinear interaction of planetary waves to modulate low latitude ionosphere. **[D.V. Phanikumar**, K. Niranjan Kumar, Sanjay Kumar, *Jr. Atmos. & Terr. Phy., Volume 117, pp. 48-53***]**

SO_2 observations over the central Himalayas

Continuous measurements of a climatically important gas (SO_2) were made over Nainital, using a highly sensitive instrument for the first time. SO_2 levels are found to be mostly in the pptv range with higher values during pre-monsoon (~345 pptv) compared to those in winter (~71 pptv). Higher values during pre-monsoon are attributed to the transport of air masses from regions viz. Indo-Gangetic Plain (IGP), northern India and north-East Pakistan, which are dotted with numerous industries and power plants, where coal burning occurs. Transport from the polluted regions is evinced from good correlations of SO_2 with wind speed, NOy and UV aerosol index during these periods. Daytime elevations in SO_2 levels, influenced by 'valley winds' and boundary layer evolution, is a persistent feature at Nainital. The oxidation losses and wet scavenging processes also contribute to the lower SO_2 during monsoon period. Despite this, SO_2/NOy slopes are high (>0.4) both during pre-monsoon and monsoon, indicating impacts of point sources. The SO_2 levels during winter are lower as the measurement site is cut off from the plains due to boundary layer dynamics. Further, the SO_2 levels during winter nights are the lowest (lesser than 50 pptv) and resemble free tropospheric conditions. MOZART-4 simulations more-or-less agree with SO_2 observations over Nainital for most of the months. The model fails to reproduce the peak concentrations in April, probably because of its coarse resolution. These measurements are expected to provide insight into the sulfur cycle, cloud processes and the climate response to their concentration changes at large, for the Himalayan and South Asian region. [**Manish Naja**, C Mallik, **T. Sarangi,** V. Sheel, S. Lal, *Atmos. Envir., Volume. 99, pp. 392-402*]

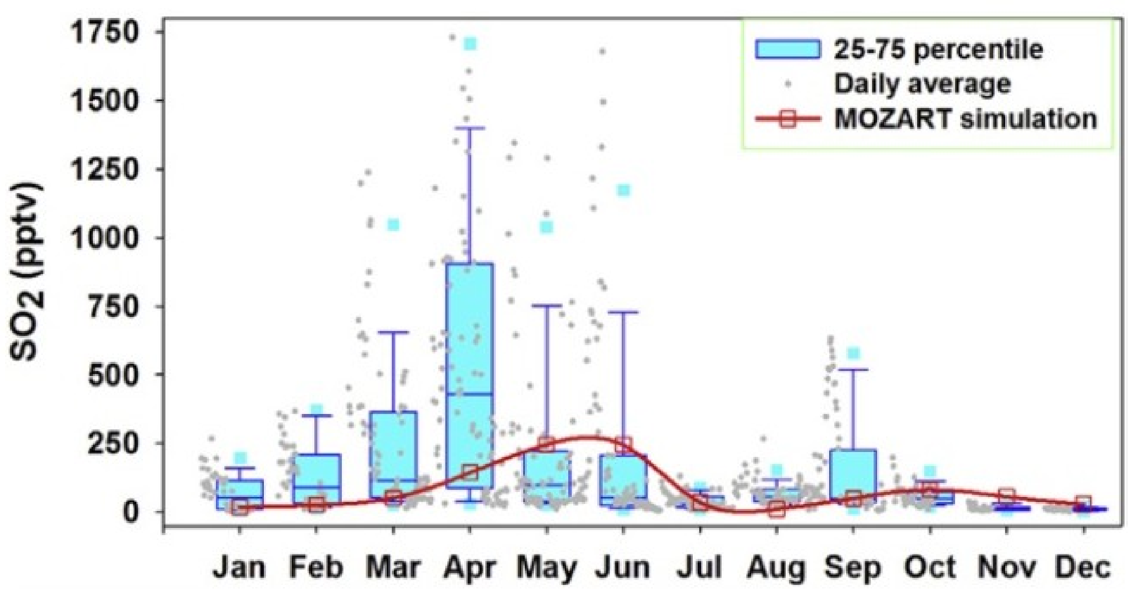

Figure 27. Average daily and monthly variations in surface SO2 during 2009-2011 at Nainital.

Vertical ozone distribution: Role of transport

Balloon-borne observations of ozone were made using electrochemical concentration cell (ECC) sensors and transport processes responsible for the observed vertical ozone distribution are studied using FLEXPART Lagrangian particle dispersion model. The FLEXPART retroplume results show that the free tropospheric vertical ozone distribution is affected by long-range transport from the direction of North Africa and North America. Lowest ozone (~20 ppbv) is observed near the surface during September at the end of the Asian summer monsoon season. Average midtropospheric ozone is greatest (70–75 ppbv) during April–June and lowest (40–50 ppbv) during winter. Ozone variability is greatest in the upper troposphere with higher ozone during March–May. Ozone levels are also affected by transport from the stratosphere particularly during March–April. The lower tropospheric ozone distribution during the Asian summer monsoon is affected by transport from the Indian Ocean via the east coast of Africa and the Arabian Sea. Influence from deep convection in the upper troposphere confined over central Asia has been simulated by FLEXPART. Lower ozone levels are observed during August–November than in any other season at 10–14 km above sea level. These in situ observations are in contrast to other studies based on satellite data which show that the lowest ozone values at these altitudes occur during the Asian summer monsoon. [S. Lal, S. Venkataramani, N. Chandra, O. R. Cooper, J. Brioude, and **Manish Naja**, *JGR: Atmospheres, Volume 119, pp. 10012-10026*].

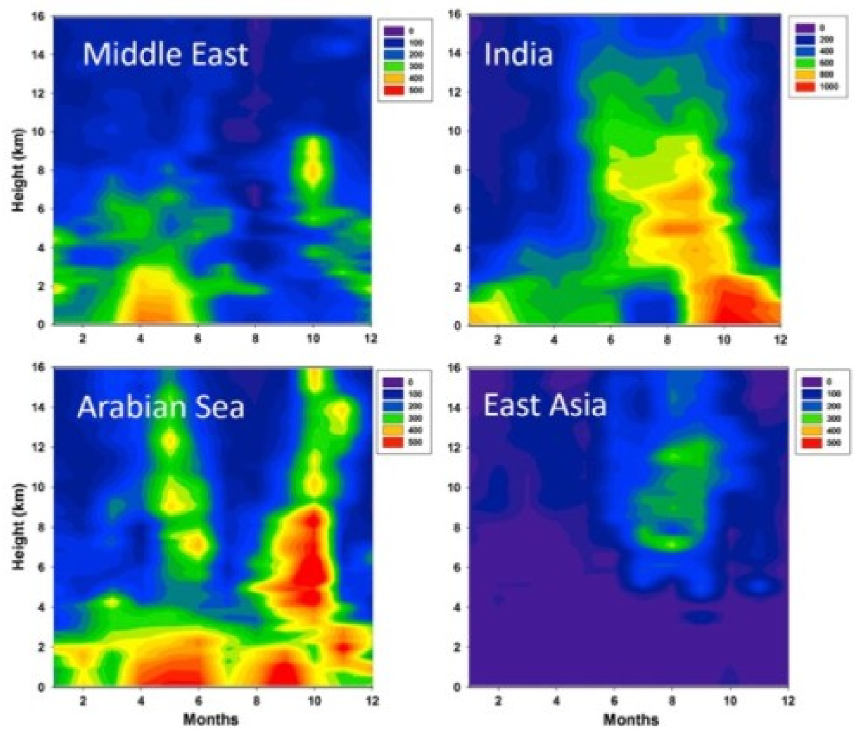

Figure 28. Average residence times (k sec) over India, Middle East, Arabian Sea and East Asia using the FLEXPART model results for all the balloon flights.

Long-term changes in NOx and ozone

Long-term changes in tropospheric NO2 are studied over South India using ground-based observations, and GOME and OMI satellite data. Unlike urban regions, the region between Eastern and Western Ghat mountain ranges experiences statistically significant decreasing trend. There are few ground-based observatories to verify satellite based trends for rural regions. However, using a past study and recent measurements we show a statistically significant decrease in NOX and O3 mixing ratio over a rural location in South India. In the ground-based records of surface NOx, the concentration during 2010–11 is found to be lower by 0.9 ppbv which is nearly 60 % of the values observed during 1994–95. Small but statistically significant decrease in noon-time peak ozone concentration is also observed. Noon-time peak ozone concentration has decreased from 34±13 ppbv during 1993–96 to 30±15 ppbv during 2010–11. NOx mixing ratios are very low over Gadanki. In spite of low NOx values (0.5 to 2 ppbv during 2010–11), ozone mixing ratios are not significantly low compared to many cities with high NOx. The monthly mean ozone mixing ratio varies from 9 ppbv to 37 ppbv with high values during Spring and low values during late Summer. Using a box-model, we show that presence of VOCs is also very important in addition to NOX in determining ozone levels in rural environment and to explain its seasonal cycle. [K. Renuka, Harish Gadhavi, A Jayaraman, Shyam Lal, **Manish Naja**, S.V. BhaskaraRao, Jr. Atmos. Chem., *Volume 71, pp. 95-112*].

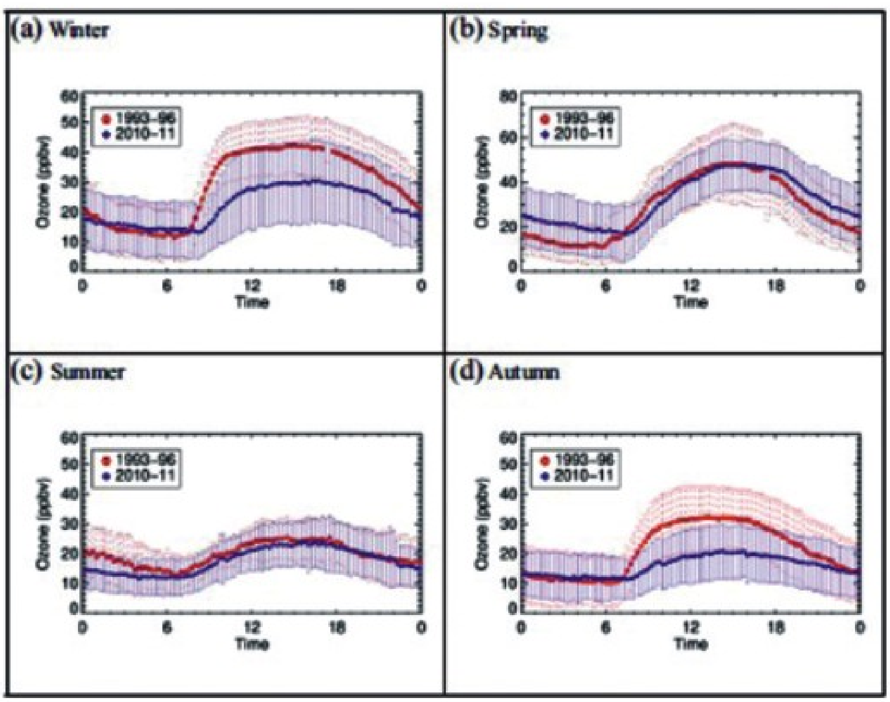

Figure 29. Comparison of surface ozone levels over Gadanki between the periods 1993-96 and 2010-2011.

CCN over the central Himalayas during GVAX

Nearly year-round measurements (June 2011 to March 2012) were carried out during Ganges Valley Aerosol Experiment (GVAX) - Regional Aerosol Warming Experiment (RAWEX) using the first Atmospheric Radiation Measurement mobile facility. The seasonality and mutual dependence of aerosol optical properties and cloud condensation nuclei (CCN) activity under varying meteorological conditions were examined. The results from collocated measurements provided enhanced aerosol scattering and absorption coefficients, CCN concentrations, and total condensation nuclei concentrations during the dry autumn and winter. The CCN concentration was higher during the periods of high aerosol absorption (single scattering albedo (SSA)<0.80) than during the periods of high aerosol scattering (SSA>0.85), indicating that the aerosol composition seasonally changes and influences the CCN activity. The monthly mean CCN activation ratio was highest (>0.7) in late autumn (November); this finding is attributed to the contribution of biomass-burning aerosols to CCN formation at high supersaturation conditions. [Mukunda M. Gogoi, S. Suresh Babu, V. Jayachandran, K. Krishna Moorthy, S. K. Satheesh, **Manish Naja**, V. R. Kotamarthi, *JGR: Atmospheres, Volume 120,pp. 2453-2469*].

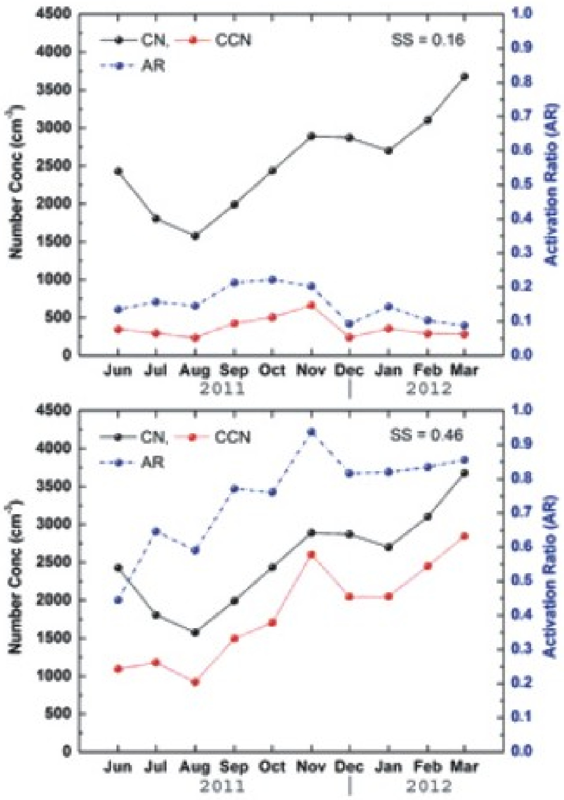

Figure 30. Monthly average variations in CN and CCN at SS=0.16 and SS=0.46. Monthly average values of CCN activation ratio (AR) is also shown at SS=0.46.

List of Publications

Refereed Journals

1. **Joshi, Y. C.** & **Joshi**, **S.** (2014)**.** Population I Cepheids and star formation history of the Large Magellanic Cloud. *New Astron. 28,* 27-34.

2. Vereshchagin, S. V., Chupina , N. V., **Sariya, Devesh P., Yadav, R. K. S. & Kumar, Brijesh** (2014). Apex determination and detection of stellar clumps in the open cluster M 67. *New Astronomy, 31,* 43-50.

3. **Ojha, N., Naja, M., Sarangi, T.,** Kumar, R., **Bhardwaj**, **P.,** Lal, S., Venkataramani, S., **Sagar, R.,** Kumar, A. & Chandola, H.C. (2014). On the processes influencing the vertical distribution of ozone over the central Himalayas: Analysis of yearlong ozonesonde observations. *Atmo. Envi., 88*, 201-211.

4. **Dumka**, **U. C.,** et al. (including **Sagar, R.**) (2014). Latitudinal variation of aerosol properties from Indo- Gangetic Plain to central Himalayan foothills during TIGERZ campaign, *JGR: Atmosphere, 119,* 1-20.

5. Sharma, M., Nath, B. B., **Chattopadhyay, I.** & Shchekinov, Y. (2014). Interaction of a galactic wind with halo gas and the origin of multiphase extraplanar material. *Mon. Not. Roy. Astron. Soc., 441,* 431-441.

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7. **Pandey, J. C., Pandey, S. B.** & **Karmakar**, **S.** (2014). Phase-resolved XMM-Newton and swift observations of WR 25. *Astrophy. Jr., 788:84* (11pp).

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11. Das, S., **Chattopadhyay, I.** Nandi, A. & Molteni, D.(2014). Periodic mass loss from viscous accretion flows around black holes. *Mon. Not. Roy. Astron. Soc., 442,* 251-258.

12. **Phanikumar**, **D. V.,** Kumar, K. N. & Kumar, S. (2014). Signatures of ultra fast Kelvin waves in low latitude ionospheric TEC during January 2009 stratospheric warming event. *Jr. Atmos. & Terr. Phy., 117,* 48-53.

13. Nandi, S., et al. (including **Singh**, **M.** & **Joshi, R.**) (2014). Discovery of a red quasar with recurrent activity, Astrophy. Jr., 789:16 (5pp).

14. Kumar, R., et al. (including **Naja, M., Ojha, N.** & **Sarangi, T.**) (2014). Effects of dust aerosols on tropospheric chemistry during a typical pre-monsoon season dust storm in northern India, *Atmos. Chem. Phys., 14,* 6813-6834.

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51. Pandey, J. C. & **Karmakar, S.** (2015). An x-ray flare from 47CAS, *Astronomical Jr., 149*, 47 (6pp).

52. Dumka, U. C., Kaskaoutis, D. G., Srivastava, M. K. & Devara, P. C. S. (2015). Scattering and absorption properties of near-surface aerosol over Gangetic–Himalayan region: the role of boundary-layer dynamics and long-range transport. *Atmos. Chem. Phys., 15,* 1555-1572.

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B. Accepted Papers (Refereed Journals/Conference Proceedings etc.) (in Press)

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.*

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

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.*

4. 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.*

5. **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.*

6. **Agarwal, A.,** & **Gupta, A. C.** (2015). Multiband optical variability studies of BL Lacertae**.** *Mon. Not. Roy. Astron. Soc.*

7. 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.*

8. 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.*

CIRCULARS/BULLETINS/CONFERENCE PROCEEDINGS

1. Maurya, A. K., Singh, R., Kumar, S., **Phanikumar, D. V.** & Veenadhari, B. (2014). Waves-like Signatures in the D-region ionosphere generated by solar flares. *IEEE Proceeding on General Assembly and Scientific Symposium (URSI GASS), 2014 XXXIth URSI, held on 16-23 Aug., 2014 at Beijing* , 1-4.

2. **Joshi, S.,** Joshi, G. C., **Joshi, Y. C.** & Aggrawal, R. (2014). Time resolved photometric and spectroscopic analysis of chemically peculiar stars. *Proceedings of the IAU Symposium, 307,* 218-219.

3. **Dumka, U. C.,** Kaskaoutis, D. G., Srivastava, M. K. & Devara, P. C. S. (2014). Diurnal Variation of Aerosol Optical Depth over Central Himalayan Region. *Proceeding of Indian Aerosol Science and Technology Association, 21,* 122-124.

4. **Dumka, U. C.,** et al. (2014). Temporal variability in black carbon mass concentration over Gangetic Himalayan region. *Proceeding of Indian Aerosol Science and Technology Association, 21,* 125-127.

5. **Dumka, U. C.,** Kaskaoutis, D. G., Srivastava, M. K. & Devara, P. C. S. (2014). Light scattering enhancement factor over an elevated site in Central Himalayan region. *Proceeding of Indian Aerosol Science and Technology Association, 21,* 128-130.

6. Kaskaoutis, D. G., Houssos, E. E., Rashki, A., **Dumka, U. C.** & Bartzokas, A. (2014). Sistan dust storms and influence over Arabian Sea and Indian subcontinent. *Proceeding of Indian Aerosol Science and Technology Association, 21,* 200-2002.

7. **Dumka, U. C.,** et al. (including **Sagar, R.)** (2014). Vertical distribution of aerosol extinction over astronomical sites in India. *Proceeding of Indian Aerosol Science and Technology Association, 21,* 433-434.

8. **Joshi, S.,** Joshi, G. C., **Joshi, Y. C.** & **Aggrawal, R.** (2014). Time resolved photometric and spectroscopic analysis of chemically peculiar stars. *Proceedings IAU Symposium, 307,* 218-219.

9. **Sagar, R., Naja, M., Maheswar, G.** & Srivastava, A. K. (2014). Science at hight-altitude sites of ARIES- astrophysics and atmospheric sciences. *Proc. Indian Natn. Sci. Acad., 80,* 759-790.

10. **Pandey, J. C.** (2015). Observations of x-ray flares on π^1 UMa. *ASP Conference Series, 494,* 203-209.

Ph.D. THESES

Awarded

1. Study of ozone and other trace gases distribution in the lower atmosphere, **N. Ojha**, (Supervisors: **M. Naja** and H. C. Chandola), *Kumaun University,* May, 2013. (April, 2014)

2. Variabilities in surface ozone and precursors at Nainital, **Tapaswini Sarangi,** (Supervisor & Co-Supervisor: M. Naja and H. C. Chandola), *Kumaun University,* March, 2014. (2014, Awarded)

3. Multiwavelength studies of star forming regions, **Ram Kesh Yadav**, (Supervisor: **A. K. Pandey**), *Kumaun University,* August, 2014. (Feb., 2015)

4. Study of supernovae and massive sars and prospects with the 4m International Liquid Mirror Telescope, **Brajesh Kumar,** (Supervisors**: S. B. Pandey** & Prof. Jean Surdej), University of Liege, November, 2014. (24th November, 2014),

Submitted

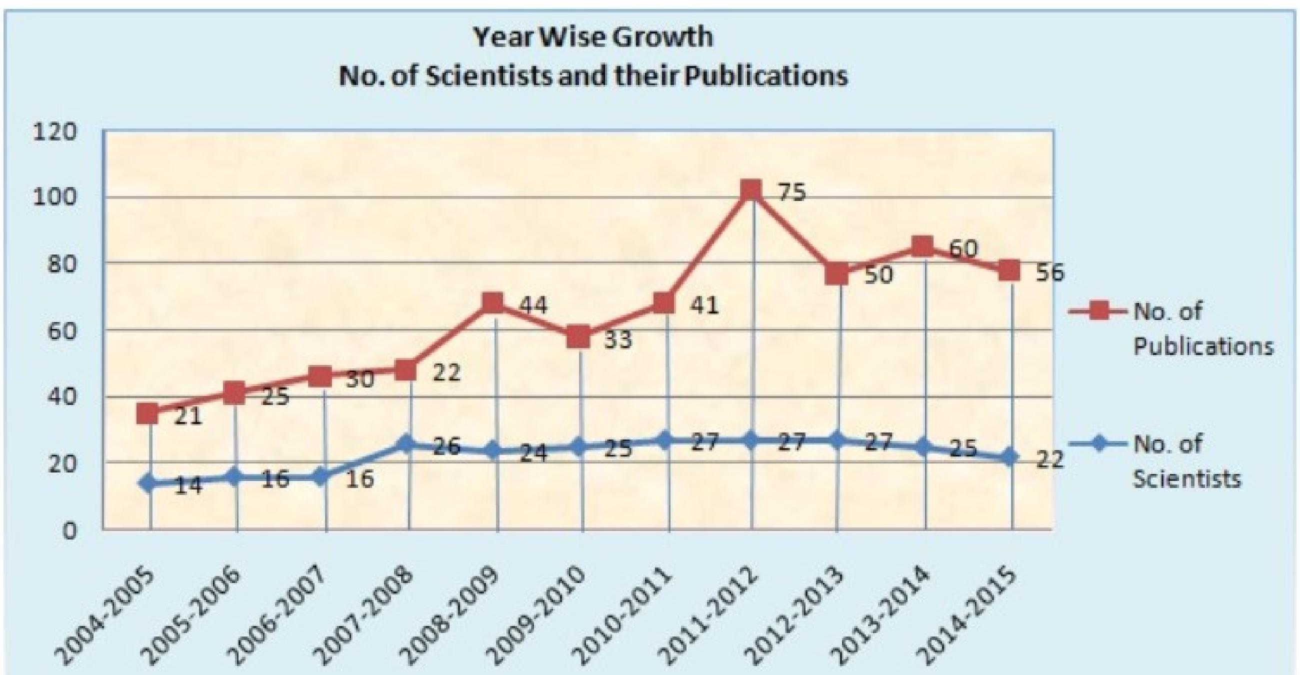
1. Astrometric and photometric studies of star clusters, **Devesh P. Sariya**, Supervisor: **R. S. Yadav**), *Pt. Ravishankar Shukla University,* July, 2014.

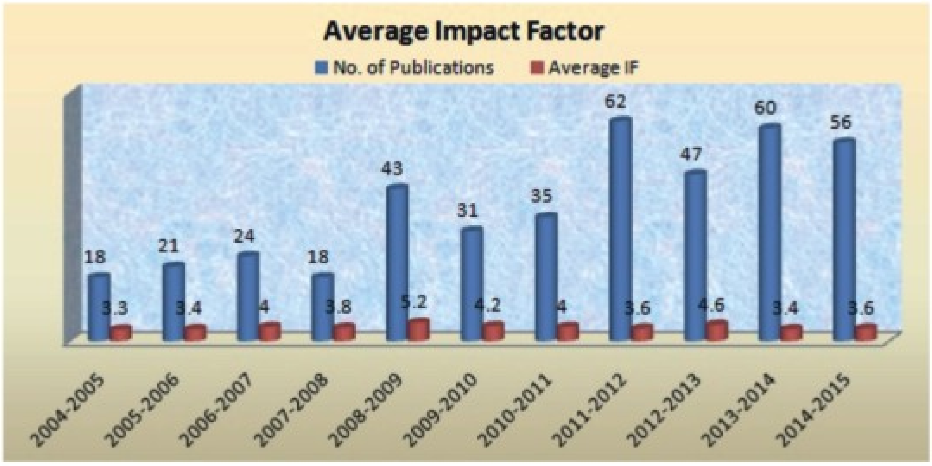
2. Probing central engine and environments of active galactic nuclei, **Ravi Joshi,** (Supervisor : **Hum Chand**), *Pt. Ravishankar Shukla University,* July, 2014.

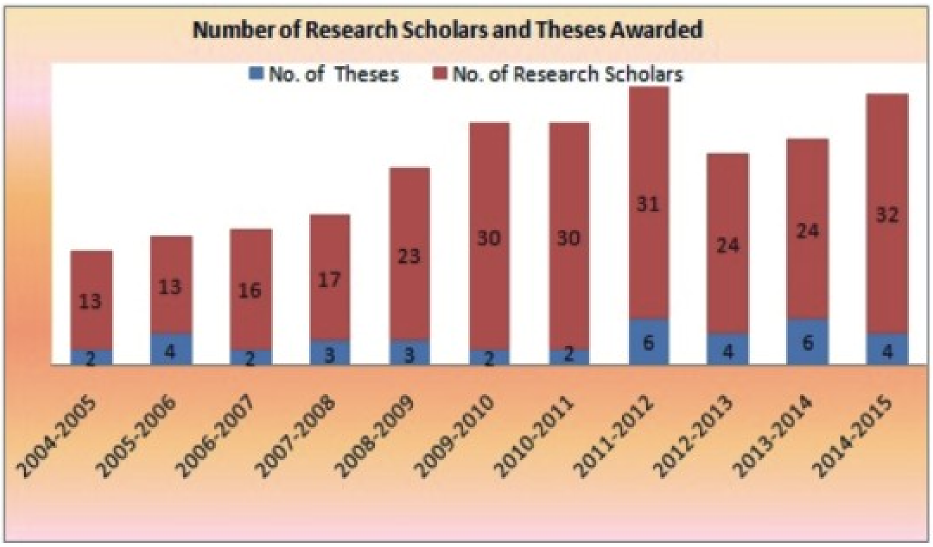
3. Study of transients and waves in the solar atmosphere, **P. K. Kayshap,** (Supervisor : **A. K. Srivastava**), *Pt. Ravishankar Shukla University,* August, 2014.

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

5. Theoretical and numerical investigations of accretion-ejection mechanism around compact objects, **Rajiv Kumar,** (Supervisor: **I. Chattopadhaya**), *Pt. Ravishankar Shukla University,* March, 2015.







Summary

1.	Total Number of Publications in Refereed Journals	56
2.	Total Number of Publications in Press	8
3.	Number of Publications in Circulars/Bulletin	10
4.	Ph.D. Theses Awarded	4
5.	Ph.D. Theses Submitted	5

International and National Research Projects

During the year 2014-2015 following research projects were funded from outside agencies.

1. **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

2. **Title of Project:** Observations and analysis of stars in the Kepler field
   PI (ARIES): Yogesh Chandra Joshi
   PI (South Africa): Chris Engelbrecht
   Funding Agency: DST, New Delhi
   Project Code: DST/INT/SA/P-02
   Duration: 03-06-2014 to 02-06-2017

3. **Title of Project:** Time-resolved photometric and spectroscopic analysis of CP stars
   PI (ARIES): Santosh Joshi
   PI (Russia): Eugene Semenko
   Funding Agency: DST, New Delhi
   Project Code: INT/RFBR/P-118
   Duration: 07-03-2013 to 07-03-2015

4. **Title of Project:** Star formation history of OB associations and characterization of global properties of young open clusters.
   PI (ARIES): Anil K. Pandey
   PI (Japan): N. Kobayashi
   Funding Agency: DST, New Delhi
   Project Code: DST/INT/JSPS/P-168/2013
   Duration: 01-04-2013 to 31-03-2015

5. **Title of Project**: Study of the role of magnetic fields in the flaring and eruptive regions of the solar atmosphere.
   P.I.(India): Wahab Uddin
   P.I.(Russia): Boris P. Filippov
   Funding Agency: DST-RFBR

6. **Title of Project:** Multiwavelength observations of blazars
   P.I.: Alok C. Gupta
   Funding Agency: DST, New Delhi
   Project Code: INT/UKR/2012/P-02

7. **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.

8. **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.

9. **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.

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

11. **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.

Title: Time Resolved Photometric and Spectroscopic Study of the Chemically Peculiar A-type Stars

Name of the P.I.: Santosh Joshi, ARIES, Nainital-India and Evgeny Semenko, SAO, RAS, Russia

This project was sanctioned jointly by the Department of Science and Technology, Govt of India and Russian Foundation for Basic Research (RFBR), Russian Academy of Sciences (RAS), Russia on March, 2013.

The aim of this Indo-Russian bilateral project was to study the chemical peculiar stars using the observational facilities at ARIES and the Special Astrophysical Observatory (SAO). The photometric data of the samples were collected using 1.3-m and 1.04-m telescopes of ARIES aiming to refine the pulsation period of the known pulsating variables. To estimate the basic physical parameters such as effective temperature, surface gravity, rotational velocity, abundance analysis etc. the high-resolution Echelle spectra and polarimetric data of the stars under study were carried out from 6.0-m Russian telescope. The combined photometric and spectroscopic analysis of these stars are prepared for the publication in refereed journal. A report on the major achievements of the project are given below.

Under the Indo-Russian RFBR project a Junior Research Fellow joined in December 2013. Training was given to him to carry out photometric observations using 1.3-m and 1.04-m telescopes of ARIES. Training in data reduction was also given to him. Dr. Yogesh Joshi, a co-investigator of the project, visited Russia from 28 March to 08 April 2014. During the visit, Dr. Joshi made discussions with the Russian investigators, Dr. Evegny Sermanko and Dr. Mikhail Sachkov, and detailed the plan for the forthcoming observational programs, both at ARIES and with the 6-m SAO, Russia.

Under this project, at ARIES, a time-series CCD photometer was designed for the side port of the 3.6-m telescope at Devasthal. One of our engineers, Krishna Reddy, visited INASAN, Russia and SAO Russia from 28-03-14 to 08-04-14 to review the optical design of this instrument. During this visit he presented the overview of the optical design of the proposed photometer and received the valuable comments from the experts. A detailed report was made after incorporating their suggestions.

The first scientific result of the project was presented in the meeting of International Astronomical Union held at Geneva Switzerland from 23-27 June 2014 (the manuscript is enclosed) (Joshi et al. 2015a).

The second result of this project was presented in an International Conference entitle "Physics and Evolution of Magnetic and Related Stars" held at SAO, Nizhnii Arkhyz, Russia. In this conference, the current status of the scientific work done under the bilateral programme and the results were presented (Joshi et al. 2015b).

During the recent visit to SAO, the PI also explored some new areas for possible collaborations. One of the identified areas is "Search for Planets in white dwarf system using photometric and spectroscopic technique". This project was initiated by carrying out observations of some of the sources from ARIES and SAO. The data analysis of the data sets is in progress.

In the collaboration with the Russian astronomers the PI and the co-I jointly submitted an observing proposal at SAO and ARIES for the time-series photometric and spectroscopic observations of HD73045. The data analysis is in progress. The investigators were also worked on a paper aiming to check the pulsational variability based on the existing data observed from 1.04-m telescope. The work done on this subject is submitted for publication in an international journal (Joshi et al. 2015c). An effort to study the photometric variability from space, the investigators extracted the time-series data from the Kepler space mission archive. They found many interesting results and the work carried out under this project is also communicated for publication in an international journal (Chowdhury et al. 2015d). Some of the above results obtained under Indo-Russian project were also presented in the ASI-2015 meeting held at Pune from 17-20 February 2015 and in an international workshop at ARIES, Nainital (Joshi & Joshi 2015e).

Publications resulted from the project:

1. Joshi, Santosh; Joshi, Gireesh C.; Joshi, Y. C.; Aggrawal, Rahul, 2015a, IAU, 307, 218

2. Joshi, S., Semenko, E., Moiseeva, A., Joshi, G. C., Joshi, Y. C., Sachkov, M., 2015b, ASP Conference Series, edit by Kudryavtsev, D. O.; Balega, Yu. Yu.; Romanyuk, I. I. ,494, 210220

3. Joshi S. & Joshi, Y. C., 2015e, Journal of Astrophysics and Astronomy, 36, 33

4. Joshi, G. C, Joshi, Y. C.; Joshi S., Chowdhury, S., Tyagi, R. K, Publication of Astronomical Society of Australia, 2015f, PASA, 32, 22.

Title: Star formation history of OB associations and characterization of global properties of young open clusters

Name of the P.I.: Anil K. Pandey, ARIES, Nainital and N. Kobayashi, University of Tokyo, Japan

At present in India CCD cameras having 2K x 2K pixels chip are available with 104- cm telescope of ARIES (Nainital) and 200-cm telescope at HANLE, which covers a field of about 12 arc-minute square. This field of view is insufficient to study the star formation scenario in a star-forming region which usually spread over 2-3 square degree field. Hence the wide field CCD photometry of star forming regions and around young open clusters/ OB associations is not practical with the telescopes available in India as it will require a very large amount of observing time. The amazingly wide field of view (2.1deg by 2.1deg) of KWFC of the Kiso Schmidt (Japan) is extremely powerful in making wide field photometry of star forming regions and open clusters/OB associations, without which we have to cover the peripheries by combining them by many small fields of view of ordinary telescopes. The single frame of the Kiso Schmidt is equal to 100 frames of the telescopes available in India.

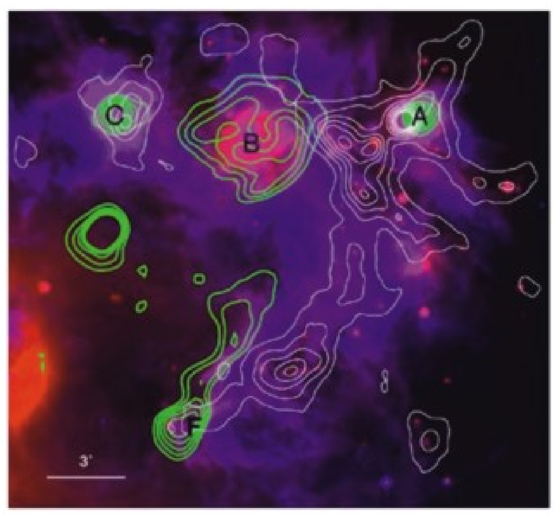


Figure 32. Colour composite image of the western half of Sh2-252 made from the 8.0 and 24 μm bands along with the 1.1 mm dust continuum emission map (white; contour levels at 0.06, 0.21, 0.37, 0.52, 0.68, 0.83, 0.99, 1.14 and 1.30 Jy beam^{-1}) and the low-resolution radio continuum map at 1280 MHz (green; contour levels at 0.25, 0.44, 0.63, 0.82, 1.02 mJy beam^{-1}). The subregions are marked in the figure. North is up and east is to the left. For further detail refer the paper, 2013, MNRAS, 432, 3445.

The cooperation between the Japanese and Indian scientists brings together observations from different facilities and expertise of Indian and Japanese scientists. Since Prof. N. Kobayashi has a long experience in instrumentation (e.g., one of the main instruments Infrared Camera and Spectrograph for 8.2- m Subaru Telescope), his expertise will be extremely useful to develop near-infrared instruments for the upcoming 3.6-m telescope at Devasthal. Prof. N. Kobayashi is one of the members of the expert committee constituted to review the progress of an instrument – TANSPEC.

Publications:

1. Deep optical survey of the stellar content of Sh2-311, Yadav, R. K., Pandey, A. K., Sharma, S., Jose, J., Ogura, K.. Kobayashi, N. et al., 2015, New Astr., 34, 27.

2. Young stellar population and ongoing star formation in the H II complex Sh2-252; Jose, J., Pandey, A. K., Samal, M. R., Ojha, D. K., Ogura, K., Kim, J. S., Kobayashi, N. et al., 2013, MNRAS, 432, 3445.

Title: Multi-wavelength diagnostics of the precursor and main phases of an M1.8 flare on 2011 April 22

Name of P.I.: Wahab Uddin, ARIES, Nainital and N. Gopalswamy, NASA, USA

The work was carried out with the support of IUSSTF/JC-Solar Eruptive Phenomena/99-2010/2011–2012 project on 'Multiwavelength Study of Solar Eruptive Phenomena and Their Interplanetary Responses'.

The temporal, spatial and spectral evolution of the M1.8 flare, which occurred in the active region 11195 (S17E31) on 2011 April 22 was studied in detail to understand underlying physics using multi-wavelength study. The source morphology using the composite images in 131 Å wavelength observed by the Solar Dynamics Observatory/Atmospheric Imaging Assembly and 6–14 keV [from the *Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI)*] revealed a multi-loop system that destabilized systematically during the precursor and main phases. In contrast, hard X-ray emission (20–50 keV) was absent during the precursor phase, appearing only from the onset of the impulsive phase in the form of foot-points of emitting loops. This study also revealed the heated loop-top prior to the loop emission, although no accompanying foot-point sources were observed during the precursor phase. Various plasma parameters were estimated using the data obtained.

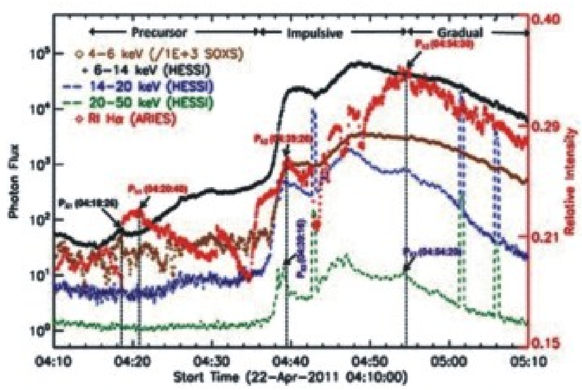


Figure 33. Temporal evolution of multiwavelength emission during M1.8 flare on 2011 April 22. Relative intensity estimated from Hα observations from ARIES/Nainital is plotted by the red coloured symbol. 4–6 keV emission observed by *SOXS* as well as 6–14, 14–20 and 20–50 keV emission by *RHESSI* are shown by the brown, black, blue and green symbols, respectively. $P_{x1,2,3}$ and $P_{h1,2,3}$ represent the corresponding peaks during precursor, impulsive and gradual phases in X-ray and Hα, respectively.

Updates on the Major Facilities

(1) 3.6m 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 two occasions (26-27 Sep 2014 and 18-19 Mar 2015) during the financial year. The PIT and PWGs met at several occasions to monitor the progress of the project.

During the financial year Apr 2014 – Mar 2015, several important milestones were achieved successfully, as described below.

(i) Completion of the enclosure building:

The 3.6m Telescope Enclosure building is a custom-built system of great complexity. Based on design input parameters from ARIES, the enclosure was designed by M/s PPS Pune and its manufacture and erection is done by M/s Pedvak, Hyderabad. The 3.6m telescope enclosure involves structural (steel and concrete), mechanical and electrical engineering. The enclosure is divided into three parts – extension building structure, dome support structure and dome structure.

Extension building : The extension building has size of 24m x 12.25m and it is designed to house an aluminium coating plant. Total structure weighs about 120 Ton. Dome support structure : The stationary dome support structure of the telescope building has shape of a cylinder with inner diameter of 16.5m and a height of 15 m. Total structure weighs about 150T including a lift and staircase. Dome structure : The rotating dome of the 3.6m telescope building is a circular steel structure of 16.5m diameter and 13.9 meter heigh. The rotating dome weighs around 200 Ton and it is the most critical part of the building. It also houses 4.2m wide slit doors and a wind screed.

During the previous financial year, the structural, mechanical and electrical installations of the extension building and the dome support structure was completed at hundred percent level whereas the dome work was completed only at ninety percent level. During current financial year, the remaining work for dome structure, which included mounting of insulation and the erection of remaining dome roof was completed. The entire building was declared completed by end of June 2014. Thereafter, the performance guarantee test was successfully conducted to confirm the design and operational parameters of each and every equipment/sub-system of the 3.6m telescope building. The operational test revealed that the performance meets guaranteed parameters set at the time of

Figure 34: Picture of as-built 3.6m Telescope Enclosure building taken in July 2014. The dome has been completed during the financial year. The dome slit is open and the wind-screen (blue) can be seen.

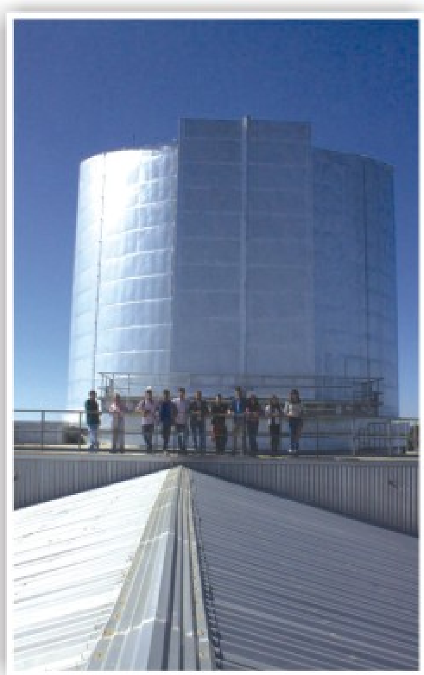


Figure 35 : Picture of Dome of 3.6m telescope taken on 9th November 2014.

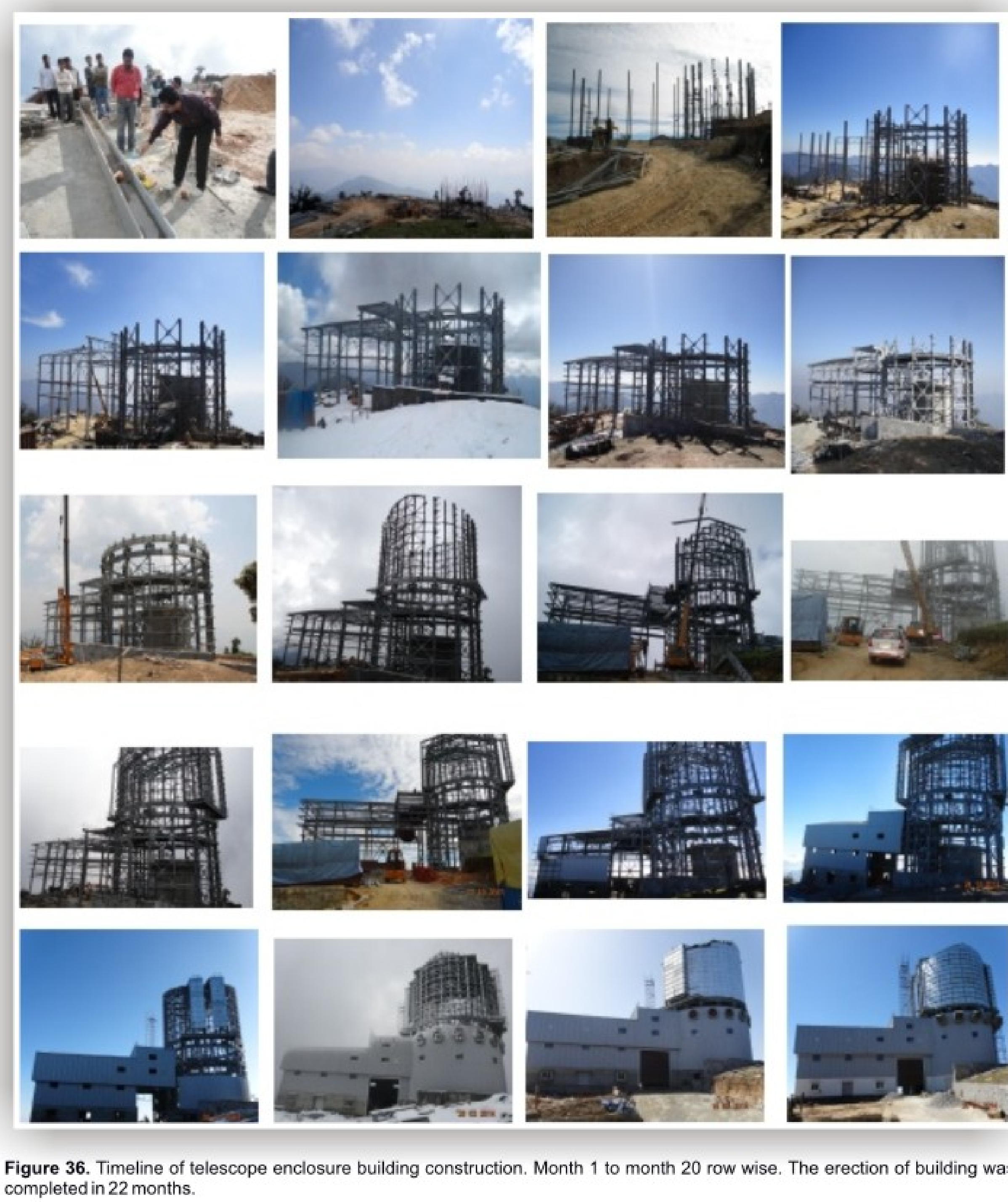


Figure 36. Timeline of telescope enclosure building construction. Month 1 to month 20 row wise. The erection of building was completed in 22 months.

design in 2009. The enclosure building was commissioned in July 2014 and it has been put for regular use.

As-built picture of 3.6m telescope building is given in **Figure 34**. The picture of dome is shown in **Figure 35**. The time-line of enclosure construction is shown in **Figure 36**.

(ii) The Overhead Cranes:

In order to lift and handle parts of 3.6m telescope inside the enclosure building during telescope integration at Devasthal site, there was a requirement of two single girder cranes of 10T capacity each in the extension building and two under-slung cranes of 10T capacity each in the dome of 3.6m enclosure building. These cranes are custom-built and are designed to lift the components of 3.6m telescope with speed of about a few millimeter per second. Based on design inputs from ARIES, the design of cranes have been done by M/s PPS Pune and the crane was manufactured by M/s IMT Govindgarh. During the financial year, the erection of all the four overhead cranes in the enclosure building has been completed. The performance test results are in line with the design specifications. The cranes were commissioned in May 2014 and since then, it has been put for regular use.

As-built pictures of single girder crane in extension building and the under-slung crane in dome are given in **Figure 37** and **Figure 38** respectively.

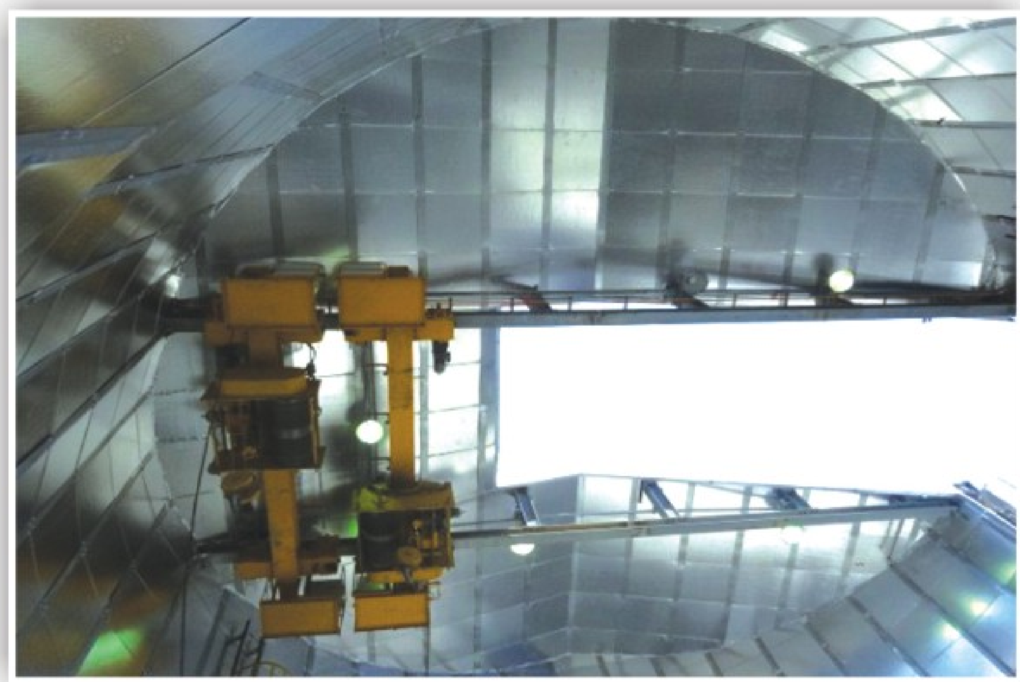


Figure 37 : Both the under-slung cranes of 10T capacity are seen in yellow. These are installed in the dome of 3.6m telescope enclosure building.

Figure 38 : Both the single-girder cranes of 10T capacity each are seen in yellow. These are installed in the extension building of 3.6m telescope enclosure.

(iii) The Aluminium Coating plant :

In order to coat the 3.7m diameter primary mirror of 3.6m telescope as well as other smaller size mirrors, a coating plant has been established in the 3.6m telescope enclosure building. In order to meet science goals of telescope, a highly-customized coating plant with the specification to coat the mirror with uniformity of about a few nanometer was required. The design, manufacturing and installation of the coating plant is done by M/s HHV bangalore. During the financial year, the erection of coating plant at devasthal has been completed. Several tests were carried out to verify the performance of coating plant and the coating plant was commissioned in January 2015. This is the only coating facility available in India, which can aluminise astronomical glass mirrors up to size of 3.7m diameter. The as-built picture of the coating plant is shown in **Figure 39**.

The task of cleaning and coating of primary mirror has been accomplished by ARIES. Before aluminising the actual mirror, it was necessary to rehearse the procedure using a dummy mirror of same size and weight. The mechnaical design of such a dummy mirror was done by M/s PPS Pune and the fabrication was completed by M/S ACT, Ghaziabad. The dummy mirror was delivered at Devasthal site by end of November 2014. A thorough rehearsal using metal dummy mirror of 3.7m diameter were carried out by ARIES team.

The washing and coating of actual mirror was achieved successfully by ARIES during 6th to 9th February 2015. The aluminium coating on sample as well as mirror was characterized and the average reflectivity value of 86 percent and the coating thickness variation of about 3 nanometer was achieved. The picture of coated primary mirror is shown in **Figure 40**.

Figure 39 : The as-built picture of 3.7m diameter Aluminium coating plant at Devasthal. This facility has been installed in the extension building of 3.6m telescope enclosure. A portion of mirror washing unit is also seen in the foreground.

Figure 40 : The picture of freshly coated 3.7m diameter primary mirror of 3.6m devasthal optical telescope.

(iv) The Assembly, Integration and verification of 3.6m telescope

During the current financial year, the assembly and integration of the 3.6m telescope has been completed. All the mechanical, electrical and optical components have been integrated using overhead cranes of telescope enclosure.

The telescope was stored at the base-camp in eighteen crates. Out of these, eleven have been transported by AMOS from the base-camp to the site of telescope during 24-28 Jun 2014, whereas the remaining boxes were transported to the telescope site in the second week of November 2014.

In order to inspect readiness of 3.6m telescope building for installation of telescope, a two-member team from AMOS visited Devasthal and a meeting was held between representatives from both M/s AMOS, Belgium and ARIES, at devasthal during 28-30 Aug 2014. The building was declared fit by AMOS team and subsequently, the AIV of 3.6m Devasthal Optical telescope started on 28th October 2014.

The necessary equipment (such as fork-lift, cranes) and helpers asked by AMOS were made available on time by ARIES AIV team. Necessary support was provided to AMOS team regarding arrangements for their logistics, and transport. Daily coordination with AMOS team was maintained by ARIES team for timely completion of the assembly and integration of the telescope. ARIES AIV members also prepared daily AIV report giving a pictorial summary of technical activities carried out in the day.

The AMOS team completed the assembly and integration of the telescope in three missions over a period of 11 weeks, and now the verification is going on in their fourth mission since 8th March, 2015 at Devasthal. During the first mission (28 Oct-18 Nov) – grouting of telescope foundation bolts on pier, mounting of pier interface plate and azimuth stator, preliminary alighnment of stator and unpacking of a few crates was accomplished. During the second mission (19th Nov – 09th Dec) – final alignment of stator, placement of rotor, installation of fork-base and lateral forks, testing of M1 actuators and unpacking of M1 handling tools were completed. The tasks completed during third mission (21st Jan – 23rd Feb 2015) included cleaning and coating of primary mirror, integration of ARISS and M2 cell. The telescope assembly and integration was completed after the third mission. The ARIES team prepared newsletters versions 1, 2, 3, 4 dated November 11, 2014; December 04, 2014; December 13, 2014; and February 18, 2015 respectively.

As-built picture of 3.6m telescope is shown in **Figure 41**.

Figure 41 : The picture of as-built 3.6m Devasthal optical telescope taken on 11th March, 2015.

(2) ARIES Stratosphere Troposphere Radar (@ 206.5 MHz)

The Stratosphere Troposphere (ST) Radar being established at ARIES, Nainital to provide continuous vertical profile of winds with high temporal and spatial (vertical) resolution, under all weather conditions, in the central Himalayan region. The radar system is configured as an active phased array using state-of-art solid state Transmit Receive Module (TRM) and Digital Signal Processing (DSP) techniques **(Figure 42)** to obtain the end product. This system has an array of 588 Yagi (3-elements) in a circular aperture on equilateral triangular grid arrangement with the inter element spacing of 0.7'λ. This radar system is indigenously developed in India and antennae array is installed on a roof top for the first time.

All the hardware related to 12 clusters, (588 TRMs, 588 power supplies and 588 antennae) are installed at ARIES. Test profiles are completed with one cluster (49 array elements) and now tests with seven clusters (343 array elements) are in progress. Figure 42 shows a comparison of winds from mini wind profiler (ST Radar) at ARIES and radiosonde wind from balloon-borne observations at ARIES.

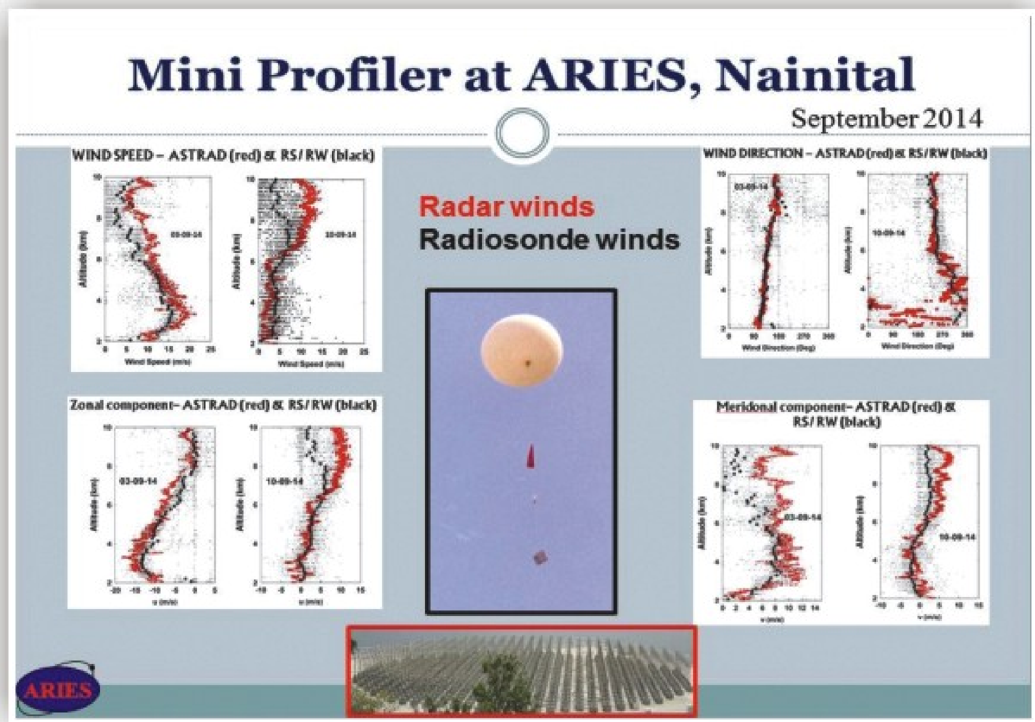
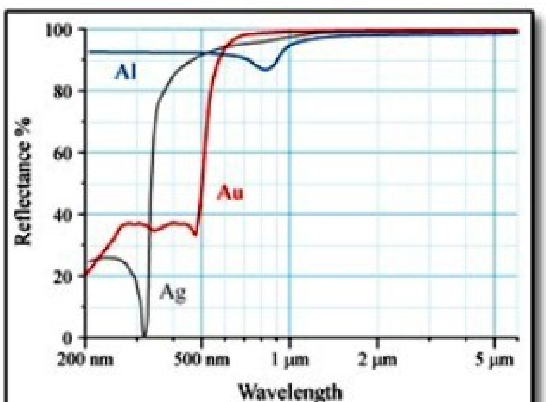


Figure 42. Comparison of winds from mini wind profiler (ST Radar) at ARIES and radiosonde wind from balloon-borne observations at ARIES.

A mirror for the DOT - Coating of the Primary mirror

A highly reflective mirror is desirable in any optical telescope in order to maximize the amount of light reaching the science instruments. Ideally, a coating should reflect as close to 100% of the light that strikes it. Aluminum, Gold and Silver are the material usually used to coat the mirrors. The reflectance of these three elements are shown below. As can be seen from the plot, a surface coated with the aluminum gives more than 90% reflectance over the entire wavelength region except for a small range between ~700 nm to ~1 μm. From ~600 nm and to longer wavelength regime, surfaces coated with the silver give higher reflectance. However, silver coated mirror surfaces tarnish when exposed to the air. Hence require regular polishing which is not plausible in the case of a telescope mirror.



The primary mirror of a telescope is always exposed to the air and moisture during observations of the celestial objects and hence the mirror needs to be coated regularly. Therefore, the coating process has to be cost effective also.

For the purpose of coating the primary glass blank (M1) of the Devasthal optical telescope, it was decided to install a coating plant in the extension building. Two cranes were installed in the extension building to move M1 from the telescope building to the coating.

The coating plant

The coating plant was installed by the Hind High Vacuum, a company based in Bangaluru. The 4000 mm diameter x 1700 mm height chamber is made of stainless steel SS 304L. The chamber and the sub assemblies are welded using Tig welding technique for leak proof joints. The chamber surface is polished for low outgassing rates. The chamber is supported on a tubular support structure in order to take care of the total weight of the chamber. A water cooled rectangular magnetron source is used to hold the aluminum target of size 320 mm (width) x 1878 mm (length). The aluminum used is having purity of 99.999%. The chamber is powered through DC power supply of 16 kw rating.

Figure 43. The coating chamber just after it got installed in the extension building and before the pumps and other gadgets were attached to it.

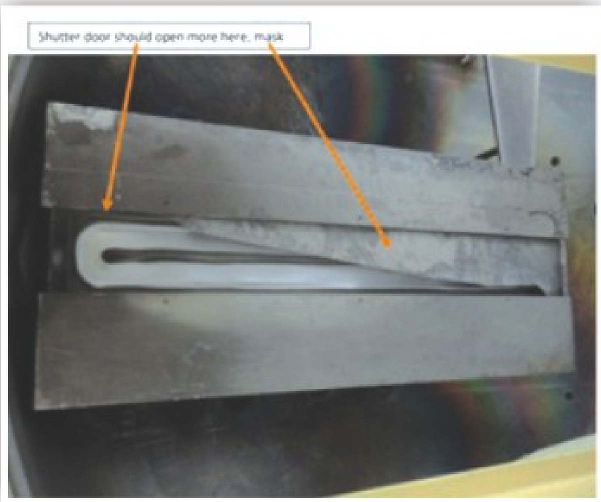


Figure 44. Magnetron Assembly with shutter door and the mask.

The vacuum pumping system consists of Rotary piston pump with a displacement capacity of 510 m^3/hr and a mechanical booster pump with a displacement capacity of 2590 m3/hr. Pneumatically operated isolation valve is used to provide as a roughing valve between the booster pump and the chamber. The vacuum pumping system also consists of two Cryo pumps with displacement capacities of 7100 ltrs/sec each. Pneumatically operated gate valves are used between the cryo pumps and the chamber. One of the high vacuum valves of the cryo pump is programmed to open in a partial mode to maintain the required partial pressure with the Argon gas inside the chamber during the sputtering operation. Two rotary vacuum pumps with displacement capacities of 43 m^3/hr are used for regeneration. The vacuum pipe lines used to connect the rotary vacuum pump, mechanical booster pump with chamber are made of stainless steel SS 304.

Pirani sensors, capacitance gauge and a cold cathode sensor are used to measure the vacuum in the range of 1000 m.bar to 10^{-6} m.bar. The ultimate vacuum that the chamber is designed to achieve is 1×10^{-6} m.bar which can be obtained in about 6 hours of operation time in clean, cold, empty degassed condition.

Inside the chamber, the M1 sits on nine pads attached to a whiffletree arrangement. There is a sample glass piece holder on which test glass pieces can be placed to test and calibrate the coating before performing the coating on the actual glass blank.

Figure 45. The chamber with the top lid open to show the nine pads and the sample holder arm.

Figure 46. Loading of the sample glass on the sample holder for coating.

The M1 mirror handling tool and the dummy mirror

The M1 mirror handling is done using a specialized handling tool of dimensions of 3970X3520X1480 (length, width, height in mm). The weight of the handling tool is 2073 kg and is designed for a carrying capacity of 5000 kg.

Before putting the actual mirror inside the coating chamber, the entire procedure of the mirror handling with the tools was practiced with a dummy mirror made of steel with the dimensions and the weight of the actual mirror.

Figure 47. Rehearsals for lifting the mirror using the handling tool are being carried out using the dummy mirror.

Figure 48. The mirror washing unit is getting examined using the dummy mirror.

Washing and cleaning of the glass blank

It is absolutely essential to remove any oil patches, greasy stains, dust particles and any unwanted dirt from the surface of the glass before performing the coating. An absolutely cleaned glass surface would increase the adhesion between the coated layer and the glass surface. Rehearsals were made with the dummy mirror kept on a customized washing unit designed for the cleaning of the M1 on 3rd of February, 2015. A team of people from ARIES was made to perform the cleaning of the M1. Mr. Nirmal Kumaran from Indian Institute of Astrophysics and Mr. Fransis Gabriel helped the ARIES team during the entire cleaning process. The M1 surface was cleaned with acetone, soap, KOH and HNO_3 solutions and distilled water in a standard manner. Then the glass surface was properly dried using fresh lint-free cloths before placing it inside the chamber for coating.

The coating began at 14:00 hrs on 07th February. After the coating, the mirror was left inside the chamber for 24 hrs. On 09th February, 10:48 hrs, we opened the chamber and inspected the quality of the coating.

Figure 49. Inspection of the primary glass blank before washing and cleaning.

Figure 50. Cleaning of the primary glass blank.

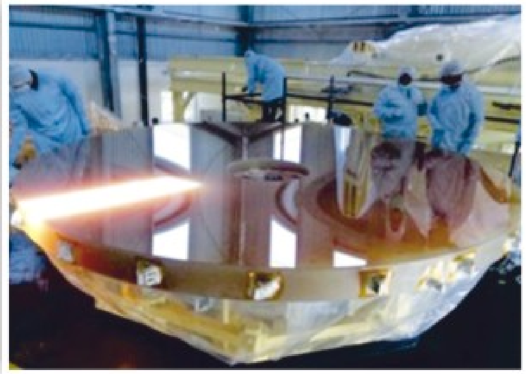


Figure 52. The glass blank after cleaning.

Figure 51. A team member of AMOS inspecting the coated mirror inside the chamber.

Journey of the coated mirror from coating chamber to M1 cell

After inspecting the coated mirror and making the reflectivity measurements, the mirror was lifted using the M1 handling tool and integrated it with the M1 cell.

Figure 53. The mirror is getting lifted using the mirror handling tool.

Figure 54. The mirror lifted from the coating chamber.

Figure 57. After placing the mirror onto the M1 cell, the handling tool is being removed.

Figure 55. Balancing of the mirror cell is in progress. This was carried out by the AMOS.

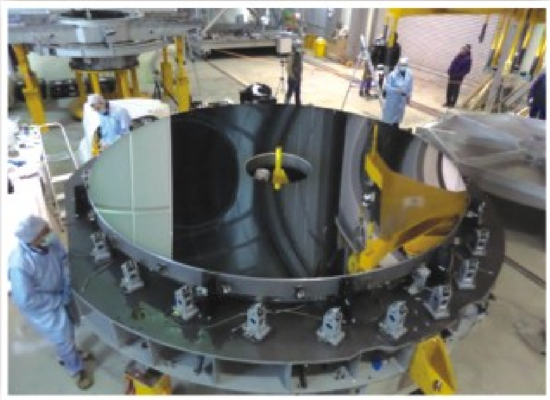


Figure 58. AMOS people are examining the coating quality.

Figure 56. The mirror is being lowered onto the M1 cell.

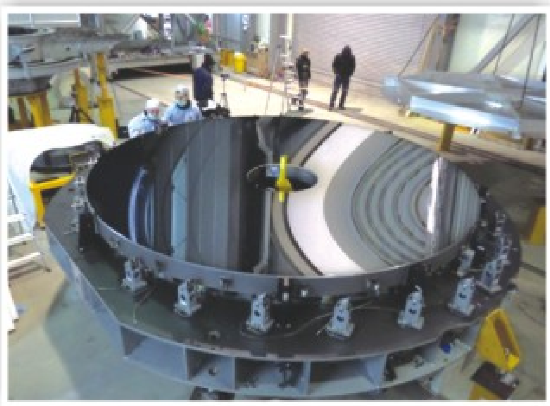


Figure 59. Another view of the coated mirror sitting inside the extension building at Devasthal ready for its integration with the telescope structure.

An algorithm to synchronize the dome with the 3.6m DOT

Most of the optical telescopes are housed within a dome or similar structure, to protect the delicate instruments from the elements. At the same time, a telescope housing should provide maximum amount of space for the telescope maneuver at minimum of the material used for the construction and hence the cost. Therefore wall of a dome is usually made thin. One more advantage is that a thin walled dome is lighter in weight and hence easy to operate. Telescope domes have a slit or other opening in the roof that can be opened during observations of celestial objects, and closed when the telescope is not in use. In most cases, the entire upper portion of the telescope dome can be rotated to allow the instrument to observe different sections of the night sky.

Traditionally, telescopes housings have round or hemispherical (almost) shaped domes. A sphere is still the most efficient space to surround a telescope, so a spherical dome will occupy less volume than, say, a cylindrical one for a telescope of the same size. Equatorially-mounted telescopes swing around a lot, so they required domes that are quite large in proportion to the size or aperture of the telescopes they house. The one disadvantage with a traditional round dome with only one slit is that any wind tends to swirl around inside the dome, which is not good for maintaining a good dome "seeing."

Fluid dynamics modeling of various shapes of the dome using supercomputers and wind tunnel experiments showed that a cylindrical dome with vents that can be opened or closed as and when required can make the air flow smooth providing a better seeing condition inside the dome. The 3.6m DOT has a cylindrical dome with a tapered roof to allow the snow to slide off from the dome roof easily. The dome and the telescope rotate independently. The telescope is sitting on a pier structure which is structurally isolated from the telescope housing. Isolated meaning, any transfer of vibration generated during the operation of the dome movement to the telescope is minimal. This would impart almost negligible disturbance to the very accurate motion of the telescope that is required for tracking the celestial objects.

Figure 60. The cylindrical dome structure with tapering roof. The slit of the dome is kept open. Fan operated vents are seen on the dome structure. View of these vents from inside the dome is shown below.

Figure 61. View of the dome slit.

Figure 62. View of the vents from inside the dome housing before the telescope was installed.

While observing a celestial object through the telescope, the dome slit opening should be suitably positioned so that unobstructed view of the portion of the sky is always available to the telescope.

The height of the dome of the DOT is 9.6 m. The height of the housing is measured from the level of the primary mirror. There is an added complication to the telescope-dome geometry. The telescope is located at a distance of 1.85 m from the dome centre making an angle of 255° with respect to the celestial north. The slit-width of the dome is 4.4 m. Given the declination of a star (δ), the latitude of the place (φ) and the hour angle (HA), we can estimate the telescope altitude and azimuth (ψ_T) of the star using standard equations.

The altitude and the azimuth thus obtained define the line-of-sight (LOS) to that star which is same as the optical axis of the telescope. The dome is said to be synchronized with the telescope when this LOS or the optical axis of the telescope intersects the center line of the slit at a point defined by the dome azimuth (ψ_D) and the telescope elevation. This is true when the telescope and the dome centres coincide. In the case of 3.6 m DOT, because the telescope is off centred towards the south-west of the dome center, the LOS do not coincide. Therefore the dome azimuth corresponding to the telescope azimuth needs to be calculated taking into account the offset.

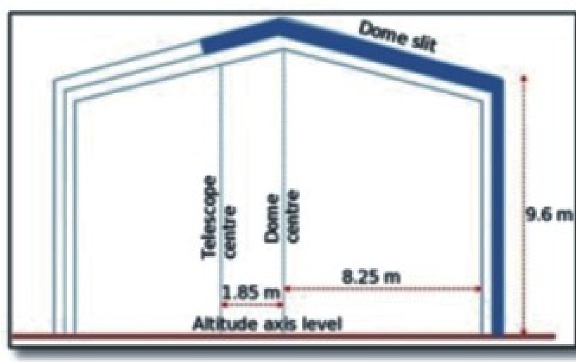


Figure 63. Schematic representation of the dome-telescope offset.

The dome and the telescope positions are shown below. The complexity in the geometry is apparent from the figure. Not only do we need to take into account the offset between the telescope and the dome, but, whether the line of sight is passing through the cylindrical or the roof part of the dome is also needs to be considered.

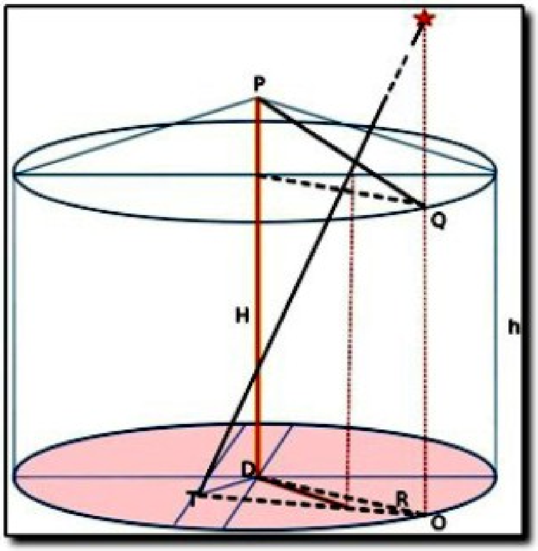


Figure 64. Schematic view of the telescope and dome positions when the line of sight is passing through the cylindrical part of the dome.

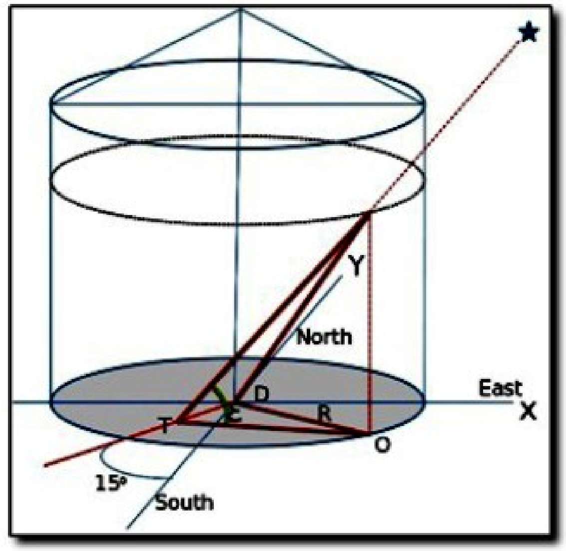


Figure 65. Schematic view of the telescope and dome positions when the line of sight is passing through the roof part of the dome.

When the line of sight is passing through the curved surface of the cylindrical walls, the expression used to calculate the dome azimuth is given by

$$\Psi_D = \psi_T + \sin^{-1}[(d/R)\sin(\psi_T - 255)]$$

where *d* is the distance between the dome center and the telescope center positions and *R* is the radius of the dome measured in meters.

When the line of sight is passing through the roof of the dome building, the dome azimuth is calculated using a set of parametric equations with the solutions considered in the true range of the dome radius. The above two conditions are combined to get the complete path of the telescope as a function of the hour angle. In figure below, the path of the stars with positive and negative declinations are shown. The curves in green and blue in the upper panel show the respective paths followed by the dome and the telescope for sources with positive declinations. As can be seen that this dome makes the transit from east to west almost an hour earlier than the telescope due to the offset. The paths followed by the dome and the telescope while tracking stars with the negative declinations are given in the lower panel.

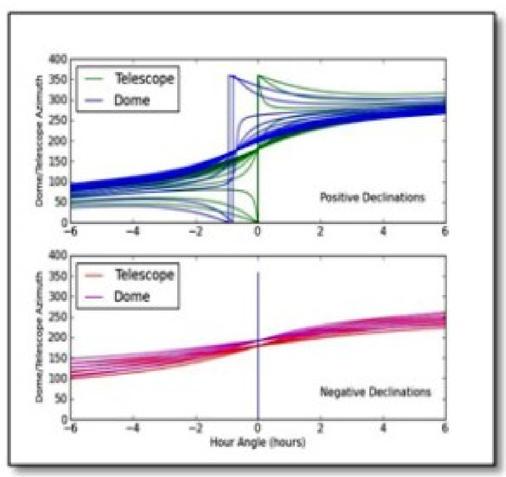


Figure 66. Paths followed by the Dome and the Telescope for the sources with positive declinations (upper panel) and negative declinations (lower panel).

Thirty Meter Telescope: a status report

GSMT/TMT related activities and Prototyping of SSAs:

Department of Science and Technology issued the financial sanction letter of Rs. 1299.9 Crore for the TMT project followed by the cabinet approval back in September 2014. ARIES is one of the three main institutes who have been involved towards the project at the level of 10%.

A national workshop titled 'planning for science with TMT: Challenges and capabilities' was hosted at ARIES during 05-06 November 2014. Apart from participants from ARIES, IUCAA and IIA many other participants from different parts of the country were also participated during the workshop. Participation from non-DST funded institutes like TIFR, BARC, PRL was also there in this workshop. During the workshop, discussions were conducted both on science and instrumentation aspects of the project in the light of India's contribution towards the project.

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). ARIES, one of the participating institutes to India-TMT Co-ordination Center (ITCC) in collaboration with the TMT head-office, has 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. This prototyping work is in quite advanced stage and we hope to get these prototypes manufactured very soon.

As a part of free supply item towards the prototypes of SSAs, L-shpaed 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 (AO136/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 figure below is one of the set of leaf springs as manufactured.

Report on the Existing Observing Facilities

Telescopes for Astronomy

1. The 104-cm Sampurnanand Telescope

Since 1972, the 104-cm Sampurnanand Telescope (ST) located at ARIES, Manora Peak, Nainital continued to be utilized as the 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 2014-2015, related to image quality and telescope pointing. All the problems were rectified and regular observations were carried out.

Figure 69. 104-cm Sampurnanand Telescope building.

The major back-end instruments are Wright 2K x 2K CCD, Tek 1Kx1k CCD and ARIES Imaging Polarimeter (AIMPOL). Different scientific programs viz; study of star-clusters, young star-forming regions, H-II regions, AGN and brown dwarfs, optical counterpart of Gamma-ray-bursts (GRBs), Supernovae and X-ray sources, polarimetric studies of open clusters, star-forming regions and late type stars were carried out using these observing facilities.

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 (ToO). During the period of 2014 – 2015, out of 273 alloted nights, nearly 165 nights were clear. There were 10 publications in refereed journals based on the data taken from ST.

Figure 70. 104-cm Sampurnanand Telescope building.

(2) The 130-cm Fast Optical Telescope

The 130-cm diameter optical telescope was installed in December 2010 at Devasthal, Nainital in the central Himalayan region. The main objective of setting up of a 130 cm optical telescope at Devasthal was to meet the observational requirements for the institute's scientific programs, which were so far being carried out using nearly 40 year old 104-cm Sampurnanand telestcope. The institute's main scientific programs such as monitoring of transients (Gamma Ray Bursts; GRB, Supernovae explosions), variability of stars in the Milky-way and of active nucleus in external galaxies required an automated telescope for efficient observations. Other programs such as imaging of star clusters require wide field imaging capabilities. The installed 130-cm telescope at Devasthal is able to fulfill most of these requirements. The telescope has been fabricated and installed by DFM Engineering Inc. USA. The telescope uses a modified Ritchey-Chretien Cassegrain design and the focal length to diameter ratio (focal-ratio) of the overall optics was kept at 4 making it a very fast system providing 40 arcsec view of the sky in 1 mm scale at the focal plane. A single element corrector provides a nearly flat field view of the sky up to 66 arcmin in diameter. The tube of the 130-cm telescope is of open truss allowing the telescope to cool faster in the ambient. The telescope mount is of fork-equatorial type. The telescope can be pointed to a celestial object with an accuracy of 10 arcsec rms. The mechanical system provides a tracking accuracy at nearly 0.5 arcsec rms over 10-min without any external guider. The images obtained with the telescope show best FWHM at nearly 1 arcsec. The atmospheric extinction at Devasthal is measured as 0.24 mag in B (Blue), 0.14 mag in V (Visual), and 0.08 mag in R (Red) band on the first week of December, 2010. The sky brightness is measured as 21.2 mag/arcsec2 in the V band in moonless night.

Several additional features were added to the telescope facilitiy. Some of these are:

a) Online web portal for the 1.3m weather station has been created giving graphical information about the weather parameters. It has been integrated with the all sky camera. Now the weather update at Devsthal can be viewed through the dedicated web page.

b) Observatory Control System: Observatory Control System (OCS) simplifies the observations taken through three interfaces ie. Telescope Control System (TCS), Instrument interface and filter interface and puts necessary information in the image header. OCS is being developed indigenously and is operational.

c) New mechanical/electrical trolley has been acquired.

d) Purchase of higher specification Workstation for data archiving and data handling for the observes has been done.

Observations

Total scheduled nights 170

Observed nights 80

Testing Nights 18 (including 5 axis testing)

Bad weather 21

Technical issues 53

Currently the the ANDOR 2K and 512 CCDs are under repair since 12 Feb 2015, the observation is currently stoped and will resume after the repair of these CCDs.

4KX4K CCD Imager: The 4kX4K CCD Camera and the associated control-electronics, shutter, filters etc. were received at ARIES by 1st June 2013 **(Figure 70)** from STA Arizona USA. It was planned earlier to test the camera during June 2013 but could not be done as the weather conditions in Devasthal were not favorable and also that the filter automation and procuring some of the required motors to move the wheels were little delayed due to several reasons. During the rainy season (July-September) the mechanical set-up was assembled in the workshop and all the motors and required electronics for the filer-wheels (two filter wheels , each one for the 5 sets of UBVRI and ugriz) automation were demonstrated successfully after couple of tests. Recently, the full mechanical set-up fo the Imager was taken to 1.3m telescope at Devasthal and has been mounted as per the requirements.

Figure 71. The full imager set-up was mounted at 1.3m telescope on 12 March 2015

It was realized that existing turbo-pump at 40-inch (used to maintain the vacuum level of the CCD Dewars) has certain issues to connect to the new Camera. Most impotently, the existing pump is not completely oil free and chances are there for the Dewar contamination. STA has strictly recommended to use a turbo-pump which is completely oil-free. The pump was delivered at ARIES in June 2014. Using the new pump, the vacuum level of the camera seems doing well. The fully assembled imager was again tested in ARIES optics lab and the full set-up seems doing well. We also has video-con with STA during February mid to test the camera s/w and operations along with the PMC team and other concerned engineers. Some small modifications as required are to be incorporated in the s/w and display successfully. The open sky test of the 4kx4k CCD camera and was done on 12th March 2015 with the 1.3m telescope at Devasthal.

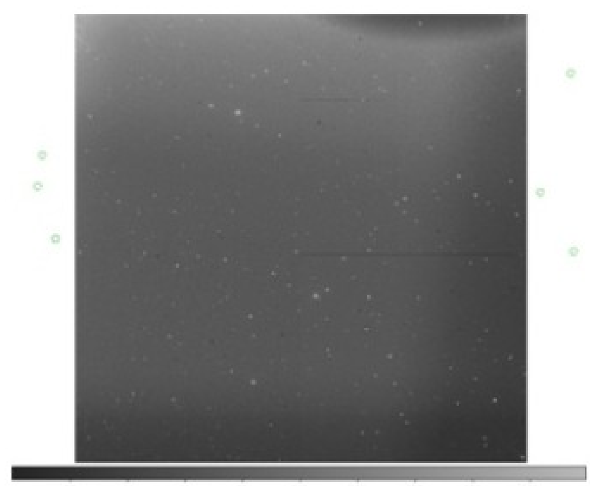


Figure 72. Flat-fielded PG 1659 frame in V-band, exposure time 100 sec with 1.3m telescope.

(3) The 15 inch Solar Telescope

The main solar observing facility at ARIES is 15-cm, f/15 Coudé Solar Tower Telescope equipped with Hα filter, and CCD camera (1K×1K, 13 μ2, 16 bit, 10 MHz read out rate, frame transfer, back Illuminated). It has a spatial resolution of 0.58" per pixel. It is an automatic Hα flare patrolling system, which takes fast sequence of images in the flare mode observations. The main objective of the group is to observe the solar eruptive events (e.g., solar flares, filaments and prominences eruptions, surges etc.).

The group also has FeX 6374 Å, FeXIV 5303 Å, FeXI 7892 Å filters to observe the corona during total solar eclipse. The space based advanced data acquisition and analysis environments are also available to pursue solar research.

The Manora Peak site where the telescope is commissioned, is a reasonable site with good observing conditions especially in first half of the day. The total clear observing days are approx. 110 per year.

Figure 73. 15-cm Coude Solar tower telescope for solar observations.

(4) Atmospheric Sciences Observing facilities

Observations using various instruments to study the Earth's lower atmosphere have been carried out for the past few years. For example, observations of various trace gases, optical and physical properties of aerosols, meteorological parameters and balloon-borne vertical profiling of ozone etc. Apart from these, nephelometer and aerodynamic particle sizer have also been installed at ARIES recently.

Aerodynamic Particle Sizer Spectrometer (APS) measures size distribution of aerosols having aerodynamic diameter between 0.3 – 20 µm. Aerodynamic diameters is one of the important size parameter because it determines the airborne behaviour of the particles. Basically this instrument (**Figure 74**) is a time-of-flight spectrometer that measures the velocity of particles in an accelerating air flow through a nozzle.

Figure 74. Photograph of Aerodynamic Particle Sizer Spectrometer operational at ARIES.

The integrating Nephelometer **(Figure 75)** measures scattered light from aerosols. The three wavelength model measures the scattered light in red (700 nm), green (550 nm) and blue (450 nm) wavelength. Also, it measures the back-scattered light at these three wavelengths. These measurements help us in estimating the forward scattered light by subtracting the back-scattered light from the total scattered light.

Figure 75. Photograph of three wavelength Integrating Nephelometer operational at ARIES.

Optics Lab

Optics section is actively involved in the instrumentation activities related to various projects. Testing, verification of various instruments was carried out in the laboratory. Optical alignment of instruments/ telescopes image quality testing was also carried out. In addition to that, design section of optics laboratory was actively involved in the optical designing of various instruments under different projects. Some of the achievements are listed below:

1. Optical design of Fast Photometer

Preliminary optical design of fast photometer instrument was completed. This instrument will be attached to one of the two side ports of 3.6 m DOT. The preliminary opto-mechnical design review of the instrument is planned in comming months.

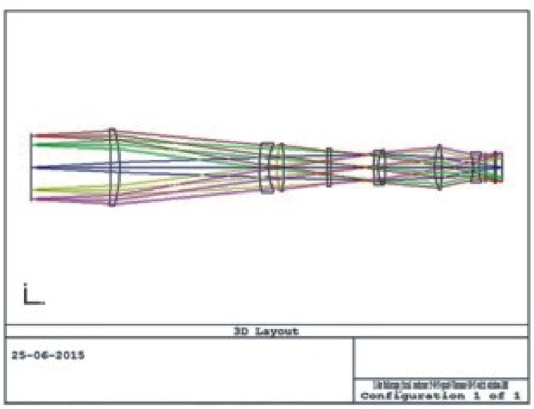


Figure 76. Optical layout of fast photometer.

2. Polarization of light from Thirty Meter Telescope

Zemax analysis was carried out to estimate instrumental polarization of Thirty Meter Telescope. This analysis was carried out by including the primary, secondary, tertiary mirrors and NFIRAOS and IRIS as the backend instruments. Different coatings e.g. like aluminium, protective aluminium, Silver, protective silver and GEMEINI coating were considered during the analysis. The investigation was carried out for different wavelengths as well.

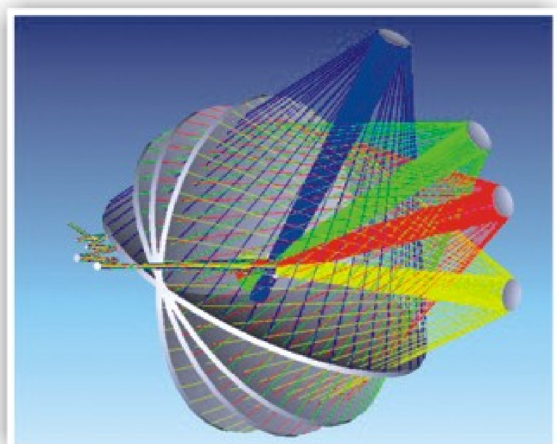


Figure 77. Optical system of TMT at different zenith angles

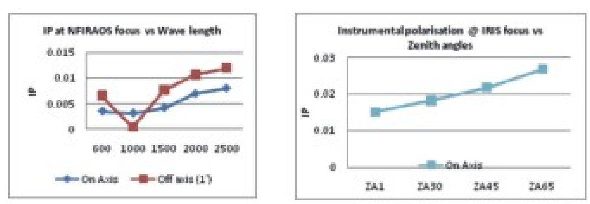


Figure 78. Instrumental polarisation at different wavelengths (left) and at different zenith angles (right).

3. Installation of a new coating plant and the coating of the 3.6 m telescope primary mirror

One of the major activities happened this year was the installation and commissioning of a new coating plant inside the telescope building at Devasthal. The optics team was monitoring the activity. On

Figure 79. Coating plant and washing unit.

February, 2015, the coating of the primary mirror of the telescope was carried out successfully. Before

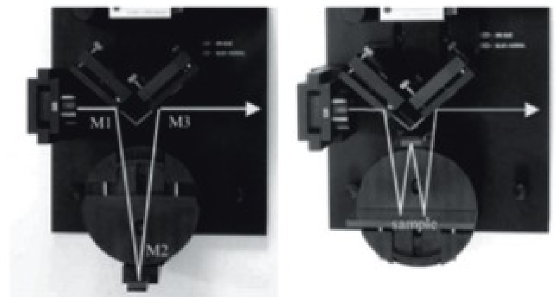


Figure 80. Schematic view of VW experimental set up; V mode (left) and W mode (right)

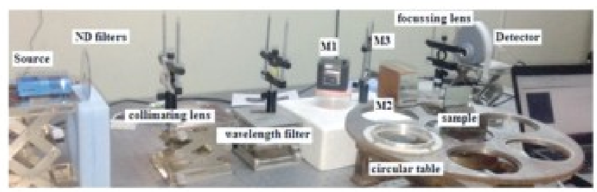


Figure 81. Experimental set up of VW method for reflectivity measurements of coated sample.

Below figure shows the plot of reflectivity variation as a function of radial distance from the centre. The solid lines are from the measurements and the dotted lines are the theoretical values of reflectivity. The lines in the red and the blue represent the results obtained through red and a blue filters. The results show that the reflectivity is almost uniform over the entire radial length of the coating chamber from inside to the outer edges which will be the span of the primary mirror during actual coating.

Optical profiler (Micro-XAM100; KLA Tencor model) was used for **step height measurements** of the coated film. **Figure 83** shows the typical values of coating thickness. The measurements were used to calibrate the coating duration for obtaining the desired thickness of the coating.

After validating the crucial parameters of the coating

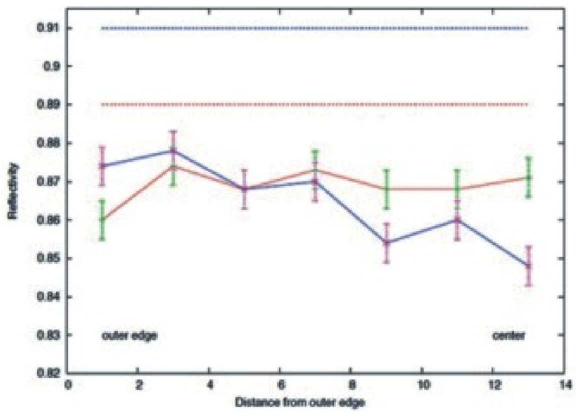


Figure 82. Plot of reflectivity variation as a function of radial distance from the centre.

plant, optics team took up the challenge of washing and coating of the primary mirror of 3.6 m DOT. Primary mirror was placed in the washing unit which is specially designed for cleaning the primary mirror. A thorough cleaning was followed which lasted for about 5 hours. Cleaning was done by using standard cleaning chemicals of high purity grade e.g. KOH, Acetone, HNO_3 etc, soap solution and distilled water. High quality cotton balls were prepared and used during the cleaning procedure. Lint free towels were used to dry the mirror surface after cleaning. After cleaning, the mirror was immediately placed into the coating chamber for the coating. A detailed account of the coating is given separately in this annual report.

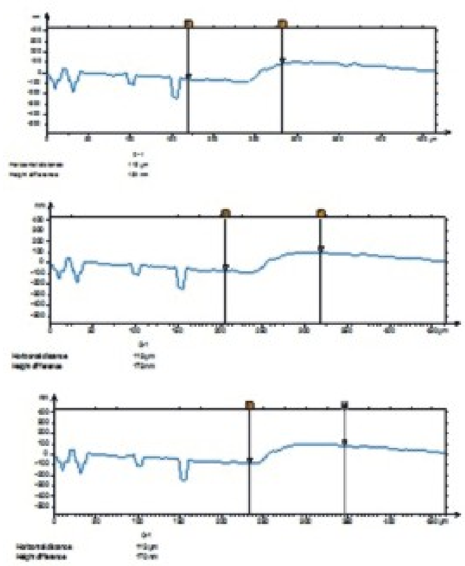


Figure 83. Typical values of the coating thickness.

(4). Testing of the new 4Kx4K CCD of optical imager for the 3.6 m DOT

The 4Kx4K CCD imager which was developed for using it with the 3.6 m DOT was tested in the clean room facility of optics laboratory. Several rounds of

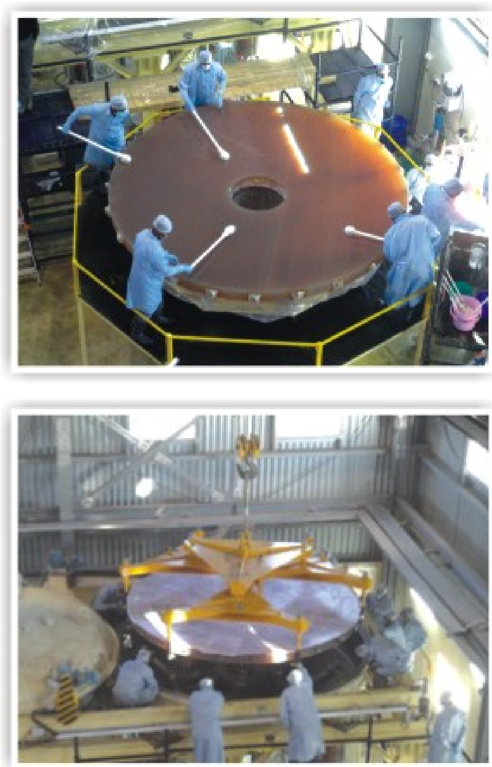
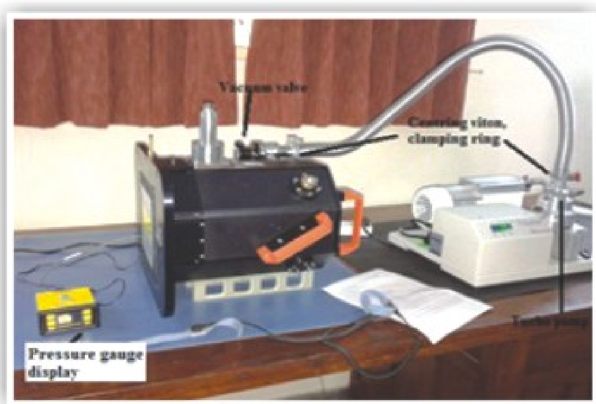


Figure 84. cleaning of the primary mirror (top), placing the mirror inside the coating chamber (bottom).

Figure 85. Chemicals, distilled water, cotton balls and other materials which were used for washing and cleaning of the primary mirror are kept ready before the actual cleaning process.

Helium and Acetone tests were performed and eventually detected a leakage near the CCD chip in the glass window. The CCD was sent back to the supplier and got it repaired. The CCD was evacuated using Edward turbo pump in optics laboratory and cooled to -120 °C by using liquid nitrogen. Flats and bias images were taken and analyzed to characterize the CCD. Later, the imager was mounted at the Cassegrain focus of the 130cm telescope at Devasthal and tested.



(5) Modification of the grism of ADFOSC

ARIES Devasthal Faint Object Spectrograph and Camera (ADFOSC) is going to be the first low and medium resolution spectrograph going to be

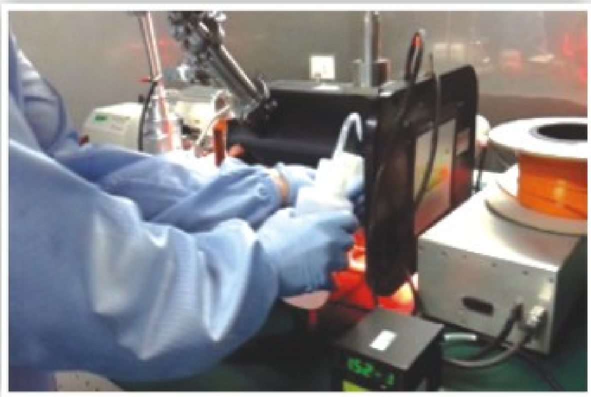


Figure 86. Connecting vacuum pump to CCD dewar (top) and performing leakage test with Acetone (bottam).

available at the main port of the 3.6 m DOT. Recently the optical design of the grism was modified/ re-optimised several times by considering various factors like, the glass material that are available for procurement, grating availability, mechanical space available inside the instrument etc. Grisms from Newport Corporation have been procured. These grisms inside the protective casing are shown below.

(6) Primary mirror and corrector lens of 130 cm Devasthal Telescope was cleaned by using soap solution and distilled water. Then secondary mirror of the telescope was moved manually to achieve

Figure 87. Grisms procured for the ADFOSC are kept inside the protective casing.

acceptable image quality

In addition to the above, various lab items have been procured (Clean room accessories, Distillation plant, ultrasonic cleaner etc.), regular maintenance

Figure 88. Cleaning of primary mirror (Top) cleaning of corrector lens (Bottam)

of the existing facility was carried out, testing and cleaning of optical components were performed. .

Figure 89. mounting filters in filter wheel (left) water distillation plant (right) and experimental set up for measurement of filter transmission (below)

Electronics Lab

Quadrature phase mixer and down converter

ASTRAD system extract Doppler signal from atmospheric returns through FPGA based digital signal processing unit where incoming echoes at 206.5 MHz with Doppler at Hertz is directly digitized to produce in-phase (I) and quadrature phase (Q) signals. The accuracy of Doppler extraction from a signal blends with random noise depends on careful selection of amplification and attenuation factors in the path remains before reaching into digital domain. If the factors in analog path are not precisely controlled then faithful switchover from analog to digital domain not happens. As an example high amplifications in analog domain saturates the receiver beyond its dynamic range which prohibits to sense small variation in carrier frequency. To prepare a profile on the required level of amplification and attenuation in different atmospheric condition, clear understanding of signal and noise profile in analog domain is essential. This understanding can be evolved through theoretical modeling and extensive practical experiments.

To facilitate in carrying out the experiment a quadrature mixer and down convertor is designed and developed in-house. The mixer accepts the combined output of the exciter network of ASTRAD and converts it to I & Q signal in analog domain. The block diagram of the mixer is shown in Fig 1 and the specification is given in Table 1. The measurement of the I Q output on a DSO can give a clear understanding on the level and nature of echo coming from the atmosphere. It also helps to correlate the prevailing atmospheric condition during experiments. Once the understanding is matured enough the amplification and attenuation factors during different environment and atmospheric conditions can be set accordingly. These I Q output can be also be fed to an Analog to Digital (AD) convertor for any in- house development of IF based digital receiver. Fig 2 shows the IQ output collected during experiments.

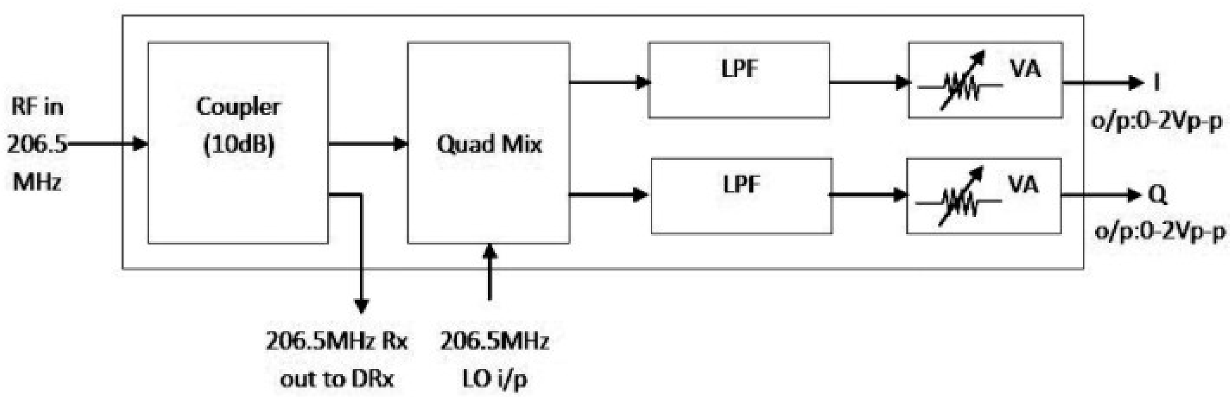


Figure 90. The block diagram of the Mixer and down converter.

Figure 91. Internal circuitry of the Mixer & down Convertor (left); IQ output generated from the unit (right).

Table1: Board specifications of the Mixer and Down Convertor

Sl.No	Parameter	Specifications
1	RF input	+10dBm Max.
2	Coupling Factor	10dB
3	LO input level	+7dBm
4	Low Pass Filter Cut-off frequency	1.5MHz
5	40-dB Bandwidth	3MHz
6	Video amplifier gain adjustment to achieve I & Q o/p	~ +/- 2Vp-p
7	I & Q Power imbalance	0.2dB
8	I & Q Phase imbalance	5deg
9	Panel connectors	TNC female

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 2014 – 2015, the following information resources were added:-

Books	:193
Subscription to Journals	:74 (Print + Online) + Full Text Databases
Publications in refereed journals	: 56
Theses awarded	: 04

The collection at the end of the period is Books : 10,805

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. During 2012 – 13, the LIBSYS 4.0 software of the KRC was upgraded to LIBSYS 7.0. 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 92. KRC Main Reading Hall.

Academic Programmes of ARIES

The Academic Committee (AC) of ARIES is pursuing a goal to invigorate the academic endeavours of the Institute. The present members of the committee are:

Dr. I. Chattopadhyay (Chariman)

Dr. A. C. Gupta

Dr. J. C. Pandey

Dr. Hum Chand

Dr. Narendra Singh

Mr. V. K. Singh, secretary, Academic committee

Major academic activities of 2014-2015 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 2015 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 through his tireless efforts arranged the pre-PhD entrance interview in July 2014. 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 2014, 10 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. Dr. Hum Chand is in the overall management, planning and execution of the visiting students' programme.

(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 2014-2015, AC conducted the examination and project presentations of the first year batch 2013-14. Following students successfully negotiated course work 2013-14, and entered the main PhD programme of ARIES:

[1] Mr. Mukesh Vyas

[2] Ms. Mridweeka Singh

(E) PhD Thesis awarded:

Two students of ARIES defended their PhD thesis during April 2014-March 2015. And they are:

(1) Dr. Brajesh Kumar,

(2) Dr. Ramkesh Yadav,

Apart from these, five students submitted their PhD thesis.

(1) Mr. Ravi Joshi

(2) Mr. Devesh Path Saria

(3) Mr Pradeep Kayshap

(4) Mr. Rajiv Kumar

(5) Ms. Archana Soam

Dr. Yadav, Mr. Ravi Joshi and Mr. Pradeep Kayshap left ARIES and joined post doctoral positions elsewhere, while others joined ARIES as post docs.

(F) Conducting/Managing Post Doctoral Fellows:

All the applications related to postdoctoral fellows are processed throughout the year by AC. 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. Three ARIES students joined as Post docs in ARIES, after the submission of their thesis and presenting their future intend according to the norms of the Institute. The list of Postdocs of ARIES entered through the normal processes conducted by AC are:

(1) Mr. Prashanth Mohan

(2) Mr. Devesh Pathsaria

(3) Ms. Archana Soam

(4) Mr. Rajiv Kumar

(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 2013 the following students have been promoted to SRF after the review process :

(1) Ms. Aditi Agrawal

(2) Ms. Arti Joshi

(3) Ms. Abha Monga

(4) Mr. Parveen Kumar

Orientation Programme 2014

Every year Academic Committee organizes orientation programme to welcome new students, and distributes pre-PhD course certificates to successful and out going first students of ARIES. Here are reminiscence of Orientation 2014.

Figure 93. New students attending orientation programme.

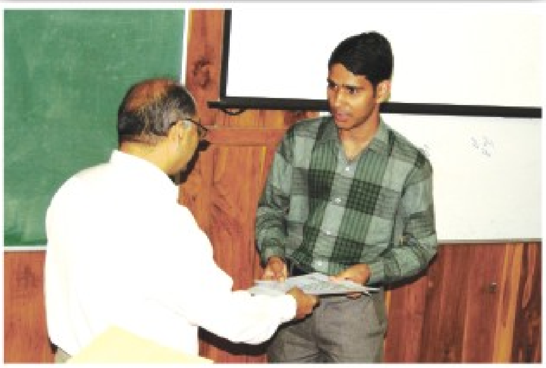


Figure 94. Success in pre-PhD coursework Mukesh.

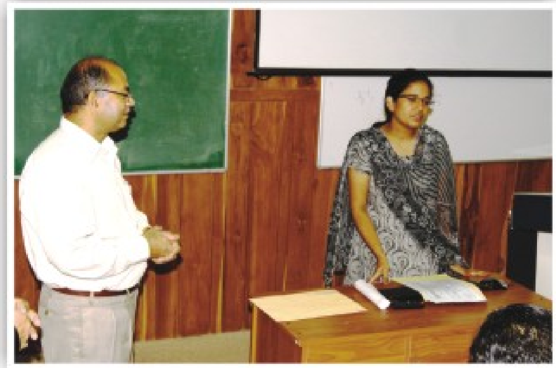


Figure 96. Success in pre-PhD coursework Mridweeka.

Figure 95. Senior student Devesh sharing his experience.

Figure 97. Welcoming the new students to ARIES.

Public Outreach Programmes

ARIES is committed to disseminate the knowledge we acquired through research to the general public especially to the younger generation. There are several schools and colleges in the district of Nainital making it one of the major hubs of education in the whole Uttarakhand. For the purpose of the public outreach, ARIES has established a science center inside its campus in Manora Peak. Facilities are made for arranging regular lectures, scientific movie screening and gallery for displaying science models and posters. The lecture hall has sitting capacity of about 40 people. A small 14 inch telescope was installed to facilitate live night sky monitoring for the general public. In addition to this, we have build a 5m fixed dome planetarium with sitting capacity of about 35 people to show 3D projection of the night sky. The science center has about two dozen 3D night sky collections in total.

The reason that Nainital is a tourist place, many people visit Nainital every year and a good number of them visit ARIES also. We have made provisions to show telescope and other research facilities to the visitors every day. Regular educational tours are conducted for school children and regular popular level talks are delivered along with slide shows for the benefit of the general public. We also make special arrangements during special astronomical events like eclipses and planet transits. This year about 7500 visited ARIES and got benefited from the facilities we provided in our science centre, among them about 60% of the visitors were students from various schools and colleges.

Various Science Programmes conducted by ARIES

Motivational summer workshop on observational Astronomy:

ARIES in association with 'South Howrah citizens' Forum has organized an eight days program from 19-24 May 2014 for 11 senior school students from different schools in the vicinity of BIET, Suri. These students were selected through a written exam. Among the 130 students appeared, only 11 students got selected. They are from class 11. They attended the DST INSPIRE Science and night Observation Programme held at BIET, Suri from 5 to 9 January, 2014. The main goal of this program was to introduce the young, talented school students to the excitements of Astronomy and Astrophysics, beside giving them the flavour of existing and upcoming observational facilities at the national as well as at the international levels.

Astronomical Telescope Making Workshop

Astronomical Telescope Making workshop (ATMW) was an initiative of Vigyan Prasar, and ARIES was also a partner to this programme. The first ATMW was organised in Allahabad during 05-16 January 2015, where about 25 teams consisting of 3-4 member in each team from the outreach centre situated all across the country. The workshop was primarily aimed to attract professionals, amateurs and enthusiasts who would be trained to make their own five inch (5") Dobsonian Telescope from locally available material. For this purpose, ARIES coated the mirror in our coating chamber situated in Manora Peak campus.

Science Day Celebration:

This programme was organised on 28th of February 2015 on the occasion of National Science Day under theme of "Science for Nation Building". In this programme, about 30 students of class 10-12 from Nainital and its nearby places were invited. The programme began with a lecture on the topic "importance of science in nation building" . Beside this a popular level lecture on basic astronomy was delivered along with a show in our new planetarium.

ARIES Training School of Observational Astronomy (ATSOA)

ARIES training school in Observational Astronomy (ATSOA) is an annual programme, where about 30-40 post graduate science students from different universities/institution participate to get training in the field of observational astronomy. This year it was held between March 02- 12, 2015. The main goal of this school was to attract more and more people to take-up observational astronomy as their career as the understanding of our Universe depends not only on continuous growth of observation facilities, but also on how many people get involved into it professionally. Recently there has been a surge in the upcoming observatories, not only at national level, 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 them and interpreting them, is pressing.

The response to this initiated was overwhelming with about 400 applicants from across the nation (even international three application as well) showed their interest. About 44 highly motivated students were selected from various university/college and institute to participate in the school. The focus was to provide hands on experience on observational Astronomy using 1m-ARIES telescope. There were a number of lectures delivered by the faculty members from ARIES and small project were given to the students which were supervised by ARIES research scholar/. Towards the end of the program, all the students gave a small presentation on what they did during the project.

Figure 98. Instructor interacting with the participant.

Figure 99. ATMW group with their hand-made Telescope.

Figure 100. Innougration of the National Seminar at MB college, Haldwani.

Figure 101. Dr. Hum Chand interacting with the participants of the National Science Day celebration.

Figure 102. Popular Science lecture by Dr. Hum Chand during National Science Day Celebration Programme.

Figure 103. Dr. Wahab Uddin addressing the audience.

Figure 104. Popular Science lecture by Dr. Hum Chand during National Science Day Celebration Programme.

Figure 105. R K Yadav interacting with the participants of the National Science Day inside 40 Inch telescope building.

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.

GC Chairman's visit of Devasthal Campus

On 28 November 2014

Our GC chairman Prof S. K. Joshi made a visit to Devasthal campus to witness the progress of the construction work of 3.6m telescope enclosure building. During his visit, installation of aluminizing chamber had just begun. Chairman inspected the telescope technical room, control room and the pier. He moved to the 11m platform and witnessed various components of the building like the aluminium partitions, 12 exhaust fans, dome crain movement, dome and slit movements. He paid a visit to the Devasthal temple before leaving the campus.

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
Sashi 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 (17)

Ravinder Kumar *(form 01-01-2015)*
(Registrar)
Abhishek Kumar Sharma
Bhuwan Chandra Arya
Kundan Singh Bisht *(till 31-10-2014)*
Mohan Singh Bisht
Rajendra Prasad Joshi
Bharat Singh
(Asstt. Registrar)
Anand Singh Bisht
Diwan Ram
Mahesh Chandra Pande
Praveen Solanki
Vijay Kumar Meena
Ashok Kumar Bhatt *(till 06-06-2014)*
Hansa Karki
Manjay Yadav
Rajeev Kumar Joshi
Virendra Kumar Singh

Scientific and Technical (39)

Abhijit Misra
Arjun Singh
Bharat Bhushan
Darwan Singh Negi
Girish Chandra Giri
Hemant Kumar
Kanhaiya Prasad
Manoj Kumar Mahato
Parmatma Saran Yadav
Prashant Kumar
Rajendra Prasad
Anant Ram Shukla
Ashok Kumar Singh
Bipin Chandra Pant
Ganesh Datt Joshi *(till 31-10-2014)*
Girish Kumar
Ishwari Dutt Joshi
Kanti Ram Maithani
Naveen Chandra Arya
Pawan Tiwari
Rajdeep Singh
Ram Lal
Anil Kumar Joshi
Babu Ram
C. Arjuna Reddy
Girija Nandan Pathak
Harish Chandra Tewari
Javed Alam
Lalit Mohan Dalakoti
Nitin Pal
Pradip Chakarborty
Rajan Pradhan
Ravindra Kumar Yadav

Members of ARIES

Sanjay Kumar Singh
Shashank Shekhar
Srikant Yadav
Tileshwar Mahato
Uday Singh
Vinod Kumar Sah

Laboratory Assistant/Attendants (14)

Anil Kumar *(till 12-12-2014)*
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 (7)

Mr. Akash Priya *(till 11-04-2014)*
Dr. Arun K. Awasthi *(till 22-09-2014)*
Mr. Brajesh Kumar *(from 26-02-2015)*
Mr. D. P. Sariya *(from 09-09-2014)*
Dr. N. C. Joshi *(till 11-04-2014)*
Dr. Prashanth Mohan *(from 15-10-2014)*
Mrs. Tapaswini Sarangi *(till 17-04-2014)*

Research Scholars (32)

Ms. Abha Monga
Mr. Abhishek Paswan
Ms. Aditi Agarwal
Ms. Anjasha Gangopadhyay
Mrs. Archana Soam
Ms. Arti Joshi
Mr. Ashwini Pandey
Mr. Brajesh Kumar
Mr. Devesh P. Sariya
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. Pradeep K. Kasyap
Mr. Piyush Bhardwaj
Mr. Rajiv Kumar
Mr. Raman Solanki
Mr. Ravi Joshi
Mr. Ramkesh Yadav
Ms. Raya Dastidar
Ms. Sapna Mishra
Mr. Subhajeet Karmakar
Mr. Subhash Bose
Mr. Sumit K. Jaiswal
Ms. Vidhushi
Mr. Vineet Ojha

Visits made by ARIES Members

International Visits:

Dr. Yogesh C. Joshi (Stemburg Univ., Moscow; SAO, Russia)	Apr. 01 – 08, 2014
(SAAO, South Africa; Univ. of Capetown, South Africa; Univ. of Johannesburg, South Africa)	Mar. 07 – 22, 2015
Dr. Manish Naja (Pokhara, Nepal)	June 07 – 11, 2014
Dr. Santosh Joshi (Univ. of Geneva)	June 23 – 27, 2014
(INASAN, Russia; SAO, Russia)	Aug. 19 – Sept. 10, 2014
Dr. A. K. Pandey (NARIT, Thailand)	Aug. 05 – 12, 2014
	Mar. 23 – Apr. 02, 2015
(UoA, Mitaka, Tokyo; Kiso Observatory, Japan)	Nov. 05 – 23, 2015
Mr. Raman Solanki (Moscow State University, Russia)	Aug. 01 – 10, 2014
Mr. Subhash Bose (CAASTRO, Australia)	Aug. 08 – 16, 2014
Mrs. Archana Soam (KASI, South Korea)	Aug. 18 - 22, 2014
(Republic of Korea)	Nov. 30 - Dec. 07, 2014
(Tokyo, Japan)	Dec. 08 - 11, 2014
Dr. Jeewan C. Pandey (SAO, Russia; IOA, Moscow, Russia)	Aug. 24 – Sept. 05, 2014
Dr. Rupak Roy (OKC, Sweden)	Oct. 29 - 31, 2014
Dr. Shashi Bhushan Pandey (Brussels, Belgium)	Nov. 19 – 25, 2014
(Granada, Spain)	Nov. 26 – Dec. 01, 2014
(Rome, Italy)	Dec. 02 – 06, 2014
Dr. Alok C. Gupta (CAS, Shanghai, China)	Dec. 07, 2014 – Mar. 06, 2015
Dr. Snehlata (TNO, Chiang Mai, Thailand)	Jan. 09 – 19, 2015
Dr. Saurabh (Univ. of Tokyo, Japan)	Feb. 27 – Mar. 15, 2015

National Visits:

Dr. Hum Chand (IIA, Bangalore)	Apr. 05 – 06, 2014
(IISER, Mohali)	Aug. 19 – 21, 2014
(IUCAA, Pune)	Aug. 22 – 29, 2014
	Jan. 12 – 23, 2015
(TIFR Balloon Facility, Hyderabad)	Nov. 25 – 27, 2014
(M.B.P.G. College, Haldwani)	Dec. 27, 2014
Dr. Brijesh Kumar (DST, New Delhi)	June 12 – 15, 2014
(Haldwani, Nainital)	Dec. 27, 2014
(Gorakhpur)	Feb. 28, 2014
Dr. A. K. Pandey (IIA, Bangalore)	June 14 – 17, 2014
(IUCAA, Pune)	Sep. 17 – 19, 2014
(TIFR, Hyderabad)	Nov. 25 – 27, 2014
Mr. Satish Kumar (INFLIBNET, Gandhinagar)	July 16 – 18, 2014
(JNTU, Hyderabad)	Sep. 25 – 27, 2014
(NPL, Pune)	Oct. 13 – 15, 2014

Mr. T. S. Kumar (IIT, Bombay)	Aug. 18 – 24, 2014
(IAO, Hanle and Leh)	Jan. 06 – 12, 2015
Mr. Raman Solanki (Delhi University, Delhi)	Sept. 05, 2014
(SPL, Trivandrum)	Jan. 26 – Feb. 17, 2015
Mr. Pradip Chakraborty (Pawan Udyog, Ghaziabad)	Sept. 22 – 24, 2014
	No. 25 – 26, 2014
(Pedvak, Hyderabad)	Nov. 18 – 23, 2014
Mr. Rajiv Kumar (Goa)	Sept. 24 – 26, 2014
(NCRA, Pune)	Feb. 15 – 21, 2015
Mr. Samaresh Bhattacharjee (Cochin Univ. of S&T, Cochin)	Sept. 20 – 21, 2014
	Jan. 10 – 11, 2015
	Mar. 04 – 07, 2015
Dr. Indranil Chattopadhyay (Goa)	Sept. 24 – 26, 2014
(Bose Institute, Kolkata)	Nov. 10 – 17, 2014
(SINP, Kolkata)	Feb. 02 – 18, 2015
Dr. Umesh C. Dumka (BHU, Varanasi)	Nov. 09 – 14, 2014
(IITM, New Delhi Branch; Amity Univ., Gurgaon)	Jan. 01 – 10, 2015
(Amity Univ., Gurgaon)	Jan. 30 – Feb. 04, 2015
(Goa)	Feb. 05 – 10, 2015
(Shiv Nadar Univ., Noida)	Mar. 30 – Apr. 04, 2015
Dr. Saurabh Sharma (TIFR, Hyderabad)	Nov. 25 – 27, 2014
Dr. Maheswar Gopinathan (TIFR balloon facility,Hyderabad)	Nov. 25 – 27, 2014
(IIA Bangalore)	Dec. 03, 2014
Dr. Mahendra Singh (Goa)	Feb. 05 – 08, 2015
Dr. Shashi Bhushan Pandey (IIA and Avasarala, Bangalore)	Jan. 11 – 15, 2015
(Gorakhpur Univ. and Marwad College, Gorakhpur)	Feb. 23 – Mar. 01, 2015
Dr. Wahab Uddin (IIA and Avasarala, Bangalore)	Jan. 11 – 15, 2015
Mr. Parveen Kumar (IUCAA, Pune)	Jan. 12 – 13, 2015
(IIA, Bangalore)	Feb. 20 – 21, 2015
Dr. Santosh Joshi (Delhi Univ., Delhi)	Feb. 11 – 16, 2015
(NCRA, Pune)	Feb. 16 – 21, 2015
Dr. Brajesh Kumar (NCRA, Pune)	Feb. 12 – 19, 2015
Dr. Jeewan C. Pandey (NCAA, Pune)	Feb. 15 – 21, 2015
Mr. Tarun Bangia (NCRA, Pune)	Feb. 17 – 20, 2015

Visitors at ARIES

From Abroad

Prof. Jean Surdej	Belgium	May 10 - June 02, 2014 June 10 - 17, 2014 Dec. 08 - 19, 2014
Mr. R. Bhatia	USA	July 03 - 07, 2014
Prof. Philippov Boris	Russia	Nov. 05 - 11, 2014
Prof. Ted Williams	SAAO, South Africa	Nov. 12 - 15, 2014
Prof. Nithaya Chetty	NRF, South Africa	Nov. 12 - 16, 2014
Prof. Katsuo Ogura	Kokugakuin University, Japan	Nov. 28 - Dec. 03, 2014
Prof. Naoto Kobayashi	Univ. of Tokyo, Japan	Nov. 28 - Dec. 03, 2014
Prof. Rumen Bachev	IOA, Sofia, Bulgaria	Mar. 01 - 21, 2015
Prof. A. Strigachev	IOA, Sofia, Bulgaria	Mar. 01 - 21, 2015

From Other Indian Institution

Mr. Sunil N. Thool	ECIL, Hyderabad	Apr. 04 - 10, 2014 July 08 - 27, 2014 Jan. 06 - 09, 2015
Mr. K. Ajay Babu	ECIL, Hyderabad	Apr. 08 - May 04, 2014 May 28 - June 14, 2014 Nov. 19 - Dec. 08, 2014
Mr. P. Rusha Rao	ECIL, Hyderabad	Apr. 08 - May 04, 2014 June 14 - July 07, 2014 Aug. 13 - 25, 2014 Nov. 19 - 29, 2014 Jan. 23 -28, 2015
Dr. R. C. Badhani	NPL, New Delhi	Apr. 09 - 11, 2014
Dr. V. Panwar	Delhi University, Delhi	Apr. 10 - 13, 2014
Mr. E. K. Srinivas	HJCS Service, Hyderabad	Apr. 15 - 17, 2014
Mr. S. Srinivas	HJCS Service, Hyderabad	Apr. 15 - 17, 2014 Sept. 08 - 09, 2014 Jan. 19 - 22, 2015
Dr. P. Sanjeeva Rao	DST, New Delhi	Apr. 17 - 20, 2014
Dr. Y. V. Swamy	IICT, Hyderabad	Apr. 16 - 18, 2014
Ms. K. V. Anuradha	ECIL, Hyderabad	Apr. 18 - 20, 2014 May 09 - 13, 2014 July 08 - 27, 2014
Prof. R. Das	ECIL, Hyderabad	Apr. 18 - 20, 2014
Dr. Pankaj	New Delhi	Apr. 19 - 20, 2014
Mr. Uday Bhaskar	ECIL, Hyderabad	Apr. 27 - May 30, 2014 June 01 - 19, 2014 Nov. 21 - 27, 2014
Mr. A. S. Ghanti	PPS, Pune	Apr. 29 - 30, 2014

		May 19 - 20, 2014
Mr. P. M. Hardikar	PPS, Pune	Apr. 29 - 30, 2014
		May 19 - 20, 2014
Prof. Rahul Pandey	Gorakhpur Univ., Gorakhpur	Apr. 29 - May 07, 2014
Mr. M. Devakrishna	ECIL, Hyderabad	Apr. 29 - May 09, 2014
Mr. P. Murthy	ECIL, Hyderabad	May 02 - 15, 2014
Mr. N. A. Swamy	ECIL, Hyderabad	May 02 - 10, 2014
Mr. B. S. Rawat	DST, New Delhi	May 03 - 06, 2014
Mr. U. Satishkumar	ECIL, Hyderabad	May 04 - 13, 2014
Mr. J. Jangiah	ECIL, Hyderabad	May 04 - 13, 2014
Mr. V. Srinivas Reddy	ECIL , Hyderabad	May 01 - June 01, 2014
		July 05 - 31, 2014
		Sept. 03 - 28, 2014
		Dec. 30, 2014 - Jan. 08, 2015
		Feb. 24 - Mar. 06, 2015
Mr. Joginder Kumar	West Bengal	May 22 - 26, 2014
Prof. U. C. Joshi	PRL, Ahmedabad	May 22 - June 04, 2014
		Nov. 09 - 12, 2014
Mr. B. Venkat	NGF, Dehradun	May 22 - 27, 2014
Mr. Vipin Kumar	NGF, Dehradun	May 22 - 27, 2014
Mrs. Rita	DST, New Delhi	May 31 - June 01, 2014
Mr. Somnath Dutta	SN Bose, Kolkata	May 27 - June 07, 2014
		Nov. 11 - 12, 2014
		Nov. 15 - 16, 2014
		Nov. 28 - 30, 2014
		Dec. 02 - 10, 2014
		Dec. 13 - 14, 2014
Mr. D. S. Bisht	IITM, New Delhi	June 11 - 13, 2014
		Aug. 08 - 09, 2014
Dr. S. P. Aggarwal	IIRS, Dehradun	June 14 - 18, 2014
Dr. Abhijit Chakraborty	PRL, Ahmedabad	June 20 - 24, 2014
		Nov. 02 - 04, 2014
Dr. A. K. Ganguly	BHU, Varanasi	June 21 - 26, 2014
Mr. B. Mohan	ECIL, Hyderabad	June 22 - July 01, 2014
Mr. M. Raju	ECIL, Hyderabad	June 22 - July 01, 2014
Mr. Abhay	IUCAA, Pune	July 03 - 04, 2014
		July 09 - 10, 2014
Mr. Amit Ghosh	ECIL, Hyderabad	July 05 - 26, 2014
		Aug. 26 - Sept. 05, 2014
Mr. Pradeep	ECIL, Hyderabad	July 05 - 28, 2014
		Nov. 19 - 29, 2014
		Dec. 23 - 30, 2014
Prof. U. S. Pandey	Gorakhpur Univ., Gorakhpur	July 05 - 12, 2015
Prof. Ranjan Gupta	IUCAA, Pune	July 06 - 07, 2014
Prof. P. Das Gupta	Delhi Univ., Delhi	July 07 - 12, 2014
Mr. B. N. P. Raju	Pedvac, Hyderabad	July 11 - 12, 2014
		Sept. 19, 2014
Mr. S. Nataraj	ECIL, Hyderabad	July 17 - 22, 2014

Mr. F. Gabriel	Tamilnadu	July 20 - 25, 2014
Mr. N. Narya	ECIL, Hyderabad	July 23 - 29, 2014
Mr. D. Naresh	ECIL, Hyderabad	July 23 - 29, 2014
Mr. A. K. Maurya	Allahabad	July 25 - 27, 2014
Mr. K. Venketesh	Allahabad	July 25 - 27, 2014
Mr. C. Sudhir	ECIL, Hyderabad	Aug. 25 - Sept 21, 2014
Mr. M. Uday	ECIL, Hyderabad	Aug. 25 - 31, 2014
Mr. P. Srinivasulu	NARL, Pakala	July 26 - 27, 2014
Dr. V. K. Anandan	ISTRAC, ISRO, Bangalore	July 26 - 27, 2014
Mr. Anil Kulkarni	SAMEER, Mumbai	July 24 - 27, 2014
Dr. Prashanth Mohan	IIA, Bangalore	July 28 - Aug. 04, 2014
Dr. Kuldeep Yadav	BARC, Mumbai	Aug. 12 - 14, 2014
Mr. G. Narsimha	ECIL, Hyderabad	Aug. 16 - 23, 2014
Mr. R. Ganesh	ECIL, Hyderabad	Aug. 16 - 23, 2014
Mr. P. Jayasimha	ECIL, Hyderabad	Sept. 03 - 25, 2014
Dr. Suresh Tiwari	IITM, Delhi	Sept. 24 - 27, 2014
Prof. A. Subramaniam	IIA, Bangalore	Sept. 25 - 30, 2014
		Nov. 04 - 06, 2014
Dr. Ishwar C. Yadav	Bihar	Oct. 11 - 14, 2014
Dr. Pratibha B. Mane	Shivaji Univ., Kolhapur	Oct. 16 - 17, 2014
Prof. A. N. Ramprakash	IUCAA, Pune	Oct. 19 - 21, 2014
		Nov. 04 - 06, 2014
Dr. K. Adeppa	IPL, Lucknow	Oct. 22 - 25, 2014
Mr. S. N. Mathur	PRL, Ahmedabad	Nov. 02 - 04, 2014
Prof. G. C. Anupama	IIA, Bangalore	Nov. 04 - 06, 2014
Prof. B. B. Reddy	IIA, Bangalore	Nov. 04 - 07, 2014
Dr. Soumen Mondal	SN Bose, Kolkata	Nov. 04 - 08, 2014
Dr. P. Manoj	TIFR, Mumbai	Nov. 07 - 09, 2014
Dr. Koshy George	IIA, Bangalore	Nov. 07, 2014
Dr. Ramya M. Anche	IIA, Bangalore	Nov. 07 - 08, 2014
Dr. Varun Bhalerao	IUCAA, Pune	Nov. 04 - 08, 2014
Mr. Prasanna Deshmukh	IIA, Bangalore	Nov. 07 - 08, 2014
Dr. Vijay Mohan	IUCAA, Pune	Nov. 10 - 13, 2014
Dr. P. S. P. Rao	Pune	Nov. 17 - 19, 2014
Ds. Resmi	IIST, Treivendrum	Nov. 17 - 30, 2014
Mr. C. Soodhir Kumar	Bangalore	Nov. 18 - 28, 2014
Prof. M. K. Das	Delhi University, Delhi	Nov. 21 - 25, 2014
Mr. B. Naveen Kumar	Delhi University, Delhi	Nov. 21 - 25, 2014
Prof. P. C. Agrawal	Mumbai	Nov. 27 - 30, 2014
		Mar. 17 - 20, 2015
Prof. S. K. Joshi	NPL, New Delhi	Nov. 27 - 30, 2014
		Mar. 18 - 20, 2015
Prof. S. Anantkrishanan	Pune Univ., Pune	Nov. 27 - 30, 2014
		Mar. 17 - 20, 2015
Mr. Uppal Sen	ECIL, Hyderabad	Dec. 09 - 12, 2014
Mr. M. P. Rameshkumar	ECIL, Hyderabad	Dec. 11 - 12, 2014
Mr. K. P. Singh	Noida	Dec. 17 - 19, 2014

Mr. Arun Thakur	Noida	Dec. 17 - 19, 2014
Mr. Satish Godbole	Wavelet Tech., Pune	Jan. 06 - 08, 2015
Mr. Tushar Purohit	Vigyan Prasar, Noida	Jan. 11 - 13, 2015
Dr. Mahendra Singh	PRL, Ahmedabad	Feb. 01 - 03, 2015
Dr. A. K. Chakraborty	PRL, Ahmedabad	Feb. 01 - 03, 2015
Dr. B. S. Murgal	SAC, Ahmedabad	Feb. 01 - 03, 2015
Dr. D. Subramaniam	SAC, Ahmedabad	Feb. 01 - 03, 2015
Mr. T. Sewang Dorjai	IAO, IIA, Leh	Feb. 05 - 06, 2015
Mr. Shailen Aggrahari	Bangalore	Feb. 12 - 14, 2015
Dr. Himadri S. Das	Assam Univ., Silchar	Feb. 19 - 23, 2015
Mr. P. Deb Roy	Assam Univ., Silchar	Feb. 19 - 21, 2015
Mr. A. Das	Assam Univ., Silchar	Feb. 19 - 21, 2015
Prof. P. S. Goraya	Punjab Univ., Patiala	Feb. 23 - 27, 2015
Mr. S. Jagan	Chennai	Mar. 07 - 09, 2015
Prof. T. P. Prabhu	Bangalore	Mar. 17 - 20, 2015
Prof. S. N. Tondon	IUCAA, Pune	Mar. 17 - 20, 2015
Prof. A. Pramesh Rao	NCRA, Pune	Mar. 17 - 20, 2015
Prof. Swarna K. Ghosh	NCRA-TIFR, Pune	Mar. 19 - 20, 2015
Prof. Dipankar Bhattacharya	IUCAA, Pune	Mar. 20 - 21, 2015
Prof. S. S. Hasan	IIA, Bangalore	Mar. 20, 2015
Mr. Praveen Asthana	DST, New Delhi	Mar. 18 - 21, 2015
Mr. S. Rathna Kumar	Tirunelveli	Mar. 30 - May. 05, 2015

Abbreviations

AC	Academic Committee
AD	Analog to Digital
ADFOSC	ARIES Devasthal Faint Object Spectrograph and Camera
AGN	Active Galactic Nuclei
AIMPOL	ARIES Imaging Polarimeter
AMOS	Advanced Mechanical and Optical Systems
AMSL	Above Mean Sea Level
AOD	Aerosols Optical Depth
ARF	Aerosol Radiative Forcing
ARFE	Aerosol Radiative Forcing Efficiency
ASTRAD	ARIES Stratosphere Troposphere Radar
ASTROSAT	Indian Satellite Mission for Multiwavelength Astronomy
ATM	Atmosphere
ATSOA	ARIES Training school in Observational Astronomy
AU	Astronomical Unit
BAL	Broad Absorption Line
BLD	Boundary Layer Dynamics
BL Lac	BL Lacertae
BOSS	Baryonic Oscillation Spectroscopic Survey
BRCs	Bright-Rimmed Clouds
BVRI	Blue violet Red Infrared
CALIPSO	Cloud Aerosol
CCD	Charged Coupled Device
CGHS	Central Government Health Scheme
CME	Coronal Mass Ejection
CRW	Carina West
CTTSs	Classical T-Tauri Stars
DDRGs	Double-double Radio Galaxies
DDRQ	Double-double Radio Quasar
DH	Decameter-Hectometric
DJF	December-January-February
DOT	Devasthal Optical Telescope
DSS2	Digital Sky Survey 2
ECC	Electrochemical Concentration Cell
FAIs	Field-Aligned-Irregularities

FPGA	Field Programmable Gate Array
GH	Gangetic-Himalayan
GMRT	Giant Meterwave Radio telescope
GOES	Geostationary Operational Environmental Satellite
GRB	Gamma-Ray Burst
GVAX	Ganges Valley Aerosol Experiment
HMXBs	High-Mass X-ray Binaries
HR	Heating Rate
IFDL	Instruments Facility and Development Laboratory
IGP	Indo-Gangetic Plane
INOV	Intranight Optical Variability
IRIS	Infrared Imaging Spectrograph
ITCC	India-TMT Co-ordination Center
IUCAA	Inter-University Centre for Astronomy and Astrophysics
JEST	Joint Entrance Screening Test
JTAC	Joint Time Allocation Committee
KIC	Kepler Input Catalog
KRC	Knowledge Resource Centre
KST	Korean Standard Time
LIDAR	Light Detection and Ranging
LINEAR	Lincoln Near Earth Asteroid Research
LMC	Large Magellanic Cloud
LWPC	Long Wave Propagation Capability
MAMJ	March-April-May-June
MF	Mass Function
NET	National Eligibility Test
NFIRAOS	Narrow Field Infrared Adaptive Optics Systems
NGC	New General Catalog
NIR	Near Infra Red
NKRC	National Knowledge Resource Consortium
NWC	North-West Cape
OCS	Observatory Control System
OPAC	Online Public Access Catalogue
PIT	Project Implementation Team
PMB	Project Management Board
PW	Paczynski-Wiita
PWG	Project Working Groups

QP	Quasi-Periodic
RAWEX	Regional Aerosol Warming Experiment
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
roAp	Rapidly-Pulsating Ap
RQWLQs	Radio-Quiet Weak Line Quasars
SAC	Scientific Advisory Committee
SAO	Smithsonian Astrophysical Observatory
SDO	Solar Dynamics Observatory
SDSS	Solan Digital Sky Survey
SON	September-October-November
SSA	Single Scattering Albedo
SSW	Sudden Stratospheric Warming
ST Radar	Stratosphere Troposphere Radar
ST	Sampurnanand Telescope
TCS	Telescope Control System
TEC	Total Electron Content
TMT	Thirty Meter Telescope
ToD	Target of Opportunity
TRM	Transmit Receive Module
TTSs	T-Tauri Stars
UBVRI	Ultraviolet-Blue-Visual-Red-Infrared
UV	Ultra Violet
VLF	Very Low Frequency
WD	Wilson-Devinney Code
WLS	Wave-Like Signature
WR	Wolf-Rayet
WTTs	Weak-line T-Tauri Stars
W-Uma	W Ursae Majoris
YSO	Young Stellar Object

Audited Statements of Account

(2014-2015)

BANGA & Co.
Membership No: 009741
Firm Regn No: 00106C

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)

We have audited the accompanying Balance sheet of ARIES for the year ended 31st March 2015 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, 2015

(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,

Other matter

1 (a) ARIES is executing a project titled "ST RADAR Project" which has an bank balance of Rs. 62,30,942.00 (including FDR's Rs.50.00 Lakhs) and GSMT (Thirty Meter Telescope) is also under erection for which has an amount of Rs. 7,96,68,368.00 as at March 31,2015. Separate books of accounts have been kept for the project. The project is not reflected in the reported financial statements and accordingly not dealt with by us in our audit.

(b) Other than ST RADAR Project, there are other projects received under the aegis of ARIES which are handled autonomously by several Principal Investigators. Valuable assets are created under such projects which are not reflected in the reported financial statements. In our opinion all such assets must be reflected in the financial statements of ARIES.

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.

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

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

Place : Nainital
Date : September 16, 2015

BANGA & Co
Chartered Accountants

(P L BANGA)
Prop
Membership No: 009741
Firm Regn No: 00106C

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

BALANCE SHEET AS ON 31st MARCH 2015

PARTICULARS	SCH. NO.	CURRENT YEAR F. Y. 2014-15	PREVIOUS YEAR F. Y. 2013-14
CORPUS / CAPITAL FUND AND LIABILITIES			
CAPITAL Funds	1	16872,19,120.57	15481,10,417.27
Deferred Government Grant	1A	395,04,683.22	755,35,257.40
EARMARKED / FUNDS	1B	870,12,026.62	724,38,252.62
CURRENT LIABILITIES & PROVISIONS			
Other Current Liabilities	2	175,20,228.50	205,67,584.50
TOTAL		18312,56,058.91	17166,51,511.79
ASSETS			
NON CURRENT ASSETS			
(a) Fixed Assets			
(i) Tangible assets	3	3779,47,070.03	3884,53,827.02
(ii) Capital work in progress	3A	12827,46,822.00	11971,11,748.00
(b) Non current investments	4	712,77,005.00	692,01,838.00
(c) Long term loans and advances	5	58,70,739.00	54,52,647.00
CURRENT ASSETS			
(a) Inventories	6	37,11,227.67	32,90,198.39
(b) Cash and bank balances	7	813,42,575.21	466,59,493.38
(c) Loans and Advances	8	83,60,620.00	64,81,760.00
TOTAL		**18312,56,058.91**	**17166,51,511.79**
		(0.00)	
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

Wahab Uddin
Acting Director

Ravinder Kumar
Registrar

Bharat Singh
Asstt. Registrar

Abhishek Sharma
LDC

for Banga & Co., Chartered Accountants
Nainital

(CA, P L Banga)
Membership Number : 009741
FRN No. : 106C
Dated 16 September, 2015

BANGA & CO. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31ST MARCH, 2015

PARTICULARS	SCH. NO.	CURRENT YEAR F. Y. 2014-15	PREVIOUS YEAR F. Y. 2013-14
INCOME			
Inventories Decreased/Increased (-/+)	+	4,21,029.28	-
Grants / Subsidies	9	2832,31,000.00	1537,14,742.60
Interest Earned	10	30,75,501.00	38,92,368.33
Other Income	11	10,29,785.00	33,26,667.00
TOTAL (A)		2877,57,315.28	1609,33,777.93
EXPENDITURE			
Establishment Expenses	12	1010,79,988.17	845,53,360.16
Other Administrative Expenses etc.	13	365,08,283.00	374,25,175.30
Depreciation	3	470,90,914.99	469,14,878.14
Prier Year Adjustment (+/-) Deferred		-	-
TOTAL (B)		1846,79,186.16	1688,93,413.60
Balance being surplus/deficit i.e. (B-A)		1030,78,129.12	(79,59,635.67)
BALANCE CARRIED TO CORPUS FUND		**1030,78,129.12**	**(79,59,635.67)**
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

Wahab Uddin, Acting Director

Ravinder Kumar, Registrar

Bharat Singh, Asstt. Registrar

Abhishek Sharma, LDC

for Banga & Co., Chartered Accountants
Nainital

(CA, P L Banga)
Membership Number : 009741
FRN No. : 106C
Dated 16 September, 2015

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

Receipts and Payment Account for year ended March 31, 2015

Receipts	Amount - (Rs)		Payments	Amount - (Rs)	
I Opening Balances			**I Expenditure**		
Cash in hand	18,000.00		ATSOA-2015 (Summer Training)	61,543.00	
Cash in bank	339,81,493.38		Computer Accessories	1,31,195.00	
Amount in L C Account	126,60,000.00	**466,59,493.38**	Consumable (Computer)	3,63,243.00	
			Consumable Expensess	15,58,556.00	
II Grant-in-aid received during the year	2832,31,000.00	**2832,31,000.00**	Convayance Expensess (Devasthal)	5,41,455.00	
			Dispensary (Devasthal)	86,800.00	
III Misc. Project Grant received	6920303.00	**69,20,303.00**	Employer Contribution Towards NPS	32,20,878.00	
			Fellowship	68,54,320.00	
IV Indirect/Other Income Received			Honorarium	2,05,948.00	
Computer Adv Intt. (ARIES)	8,754.00		Internet Maintence Charges	31,68,114.00	
Electricity Receipts	2,86,217.00		JEST	1,00,000.00	
Guest House Rent	3,80,280.00		Leagal Expensess (TAX)	44,730.00	
H B A Intt. (ARIES)	2,000.00		Medical Expensess	1,27,573.00	
House Licence Fee	2,61,359.00		Meeting Governing Council/FC Expensess	7,46,678.00	
Intrest Receipts	29,61,266.00		Observational Facilities of (Consumable)	4,05,885.00	
Intrest Receipts (GPF)	2,50,622.00		Observational Facilities of (LN2 Gas)	1,22,318.00	
OMCA Intt. Receipts	27,919.00		Office Contingency (Schedule-14)	168,18,725.50	
R T I Receipts	1,046.00		Other Scientific Meeting Expensess	21,31,887.00	
Registration Fee	6,100.00		Other Scientific Meeting Expensess (Foreign)	9,78,381.00	
Sundry Receipts	1,235.00		PMB Meeting	4,65,103.00	
Telephone Receipts	3,195.00		Public Outreach Programme	1,98,692.00	
Tender Receipts	1,750.00		Repair & Maintenance Instruments/AMC	2,69,031.00	
Water Receipts	88,603.00	**42,80,346.00**	Repair & Maintenance of Buildings	59,88,212.00	
			Repair & Maintenance of Others	90,000.00	
			Repair & Maintenance of Vehicle	2,37,611.00	
			Salary and Allowance	637,85,834.00	
			Telephone (Employee's)	1,24,881.00	
			Travelling Expensess	8,44,917.00	
			Water Expensess (Devasthal)	2,03,000.00	**1098,75,510.50**
			Misc. Project Grant released	67,71,503.00	
			Add increased in bank balance with us	1,48,800.00	**69,20,303.00**
			Sundry Liabilities Decreased	170,48,367.67	**170,48,367.67**
			Sundry Assets Increased	69,19,200.00	**69,19,200.00**
			Fixed Assets Increased	1189,85,186.00	**1189,85,186.00**
			Closing Balances		
			Cash in hand	6,443.00	
			Cash in bank	784,76,132.21	
			L C with bank	28,60,000.00	**813,42,575.21**
		3410,91,142.38			**3410,91,142.38**

Wahab Uddin
Acting Director

Ravinder Kumar
Registrar

Bharat Singh
Asstt. Registrar

Abhishek Sharma
LDC

for Banga & Co., Chartered Accountants
Nainital

(CA P L Banga, FCA)
Membership Number : 009741
FRN No. : 106C
Dated 16 September, 2015

BANGA & Co. NAINITAL Chartered Accountants

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31st MARCH 2015

BANK BALANCES — **ANNEXURE - 1**

PARTICULARS	CURRENT YEAR 2014-2015	PREVIOUS YEAR 2013-2014
Bank Balances with scheduled Banks		
b) On savings Accounts		
(i) Director Account - SBI , Nainital - 10860840253	578,02,686.35	148,38,951.85
(ii) GPF Account - SBI , Nainital - 10860840300	49,32,052.80	60,41,526.80
(vi) Pension Account (Old) - SBI, Nainital -10860840311	146,48,110.06	10,22,989.06
(v) Pension Account (New) - SBI, Nainital -10860840322 (Closed)	-	24,55,969.67
(vii) Union Bank of India, Nainital -535	10,93,283.00	96,22,056.00
TOTAL	**784,76,132.21**	**339,81,493.38**

LOAN / ADVANCE TO STAFF — **ANNEXURE - 2**

PARTICULARS	CURRENT YEAR 2014-2015	PREVIOUS YEAR 2013-2014
(i) Motor Car	14,62,086.00	4,09,606.00
(ii) Motor Cycle	1,28,840.00	1,05,840.00
(iii) Computer	1,16,050.00	1,60,650.00
(iv) House Building	29,02,395.00	32,50,979.00
(v) Festival	69,000.00	3,000.00
(vi) LTC	63,100.00	37,600.00
(vii) Income tax paid on behalf of employees	(14,555.00)	19,145.00
TOTAL	**47,26,916.00**	**39,86,820.00**

ADVANCES - OTHERS — **ANNEXURE - 3**

S NO.	PARTICULARS	CURRENT YEAR F. Y. 2014-15	PREVIOUS YEAR 2013-2014
1	Advance for Scientific Meeting	1,95,784.00	1,73,673.00
2	Travelling Advance	89,000.00	1,37,248.00
3	Sundry Advance	32,500.00	13,600.00
	Advances to staff (A)	3,17,284.00	3,24,521.00
1	Security Deposits	4,92,243.00	4,61,330.00
2	BSNL Broadband Security	7,03,655.00	7,03,655.00
3	Advance for ILTP Project	27,003.00	27,003.00
4	Advance for Indo- Bulgaria Project(Dr Alok Ku. Gupta)	-	1,92,000.00
5	Indo Russian Project (Dr S B Pandey)	-	(76,163.00)
6	Indo Austria Project (Dr A.K.Srivastava)	36,422.00	36,422.00
7	Car Advance (Tanmoy Bhattacharyya)	-	(75,562.00)
8	Advance to Uttrakhand Power Corporation	15,00,004.00	15,00,004.00
9	TDS Receivable	25,28,221.00	25,28,221.00
10	Other advances	25,87,251.00	8,10,329.00
11	Advance legal fees	50,000.00	50,000.00
12	INDO-US Project (Dr Wahab Uddin)	1,18,537.00	-
	Advances and security deposits (B)	80,43,336.00	61,57,239.00
	TOTAL (A+B)	**83,60,620.00**	**64,81,760.00**

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31st MARCH 2015

Schedule 1 CAPITAL Fund				
Particulars	CURRENT YEAR		PREVIOUS YEAR	
	F. Y. 2014-15		F. Y. 2013-14	
Balance as at the beginning of the year		15481,10,417.27		15560,70,052.94
Grant received during the year		2832,31,000.00		
Add / Deduct : Balance of the net income / expenditure transferred				
from the Income and Expenditure Account		1441,22,296.70		(79,59,635.67)
TOTAL		**16872,19,120.57**		**15481,10,417.27**

Schedule 1A : Deferred Government Grant				
Grant received for asset creation	755,35,257.40		915,00,000.00	
Less : Transferred to Income and Expenditure Account	(360,30,574.18)	360,30,574.18	159,64,742.60	
		395,04,683.22		**755,35,257.40**

Schedule - 1B - Earmarked Funds				
Particulars	CURRENT YEAR		PREVIOUS YEAR	
	F. Y. 2014-15		F. Y. 2013-14	
Superannuation / Pension				
a) New Pension Scheme Fund Account		-		-
b) Old Pension Fund Account		592,05,885.06		455,97,804.06
c) GPF Fund Account		278,06,141.56		268,40,448.56
TOTAL		**870,12,026.62**		**724,38,252.62**

Schedule 2 : Current Liabilities				
Particulars	CURRENT YEAR		PREVIOUS YEAR	
	F. Y. 2014-15		F. Y. 2013-14	
A. Other Current Liabilities				
a) Security and earnest deposits		15,80,854.00		26,85,897.00
b) JIC PAR Research Project		52,650.00		52,650.00
c) Retention and performance security deposits		99,77,150.00		122,55,164.00
d) Vat Collection		(0.50)		4,561.50
e) Money received on account of other projects		57,18,112.00		55,69,312.00
f) Faulad Constraction		20,000.00		
g) INDO-UK Seminar (DST)		(28,000.00)		
h) Women Secientific Scheme (WOS-A)		1,99,463.00		
TOTAL (A)		**175,20,228.50**		**205,67,584.50**

Schedule 3 - Fixed Assets

S. NO.	NAME OF ASSETS	GROSS-BLOCK			Depreciation for the year			NET BLOCK	
		OP. BAL. AS ON 01/04./2014	ADDITION	CL. BAL AS ON 31-03-2015	OP. BAL. AS ON 01/04./2014	DEP FOR THE YEAR	CL. BAL. AS ON 31-03-2015	WDV AS ON 31-03-2015	WDV AS ON 31-03-2014
1	**Land**	1058,50,429.00		1058,50,429.00	-	-	-	1058,50,429.00	1058,50,429.00
2	**Building**	-		-					
	(i) Residential - Manora Peak	289,08,400.60	4,53,439.00	293,61,839.60	25,96,086.66	13,38,287.67	39,34,374.33	254,27,465.27	263,12,313.94
	(ii) Non Residential - Manora Peak	1076,27,691.00	-	1076,27,691.00	426,27,099.00	65,00,059.20	491,27,158.20	58500532.8	650,00,592.00
	(iii) Residential - Devsthal (Guest House)	12,24,022.00	-	12,24,022.00	3,34,582.08	44,472.00	3,79,054.08	8,44,967.92	8,89,439.92
	(iv) Non Residential - Devsthal	88,01,426.00	-	88,01,426.00	31,26,274.22	5,67,515.18	36,93,789.40	51,07,636.60	56,75,151.78
3	**Infrastructure Dev. (Manora Peak)**	93,67,352.70	-	93,67,352.70	38,29,445.76	5,53,790.69	43,83,236.45	49,84,116.25	55,37,906.94
4	**Infrastructure Dev. (Devsthal)**	84,43,962.90	52,93,556.00	137,37,518.90	22,27,011.11	11,51,050.78	33,78,061.89	103,59,457.01	62,16,951.79
5	**Road at Devsthal**	194,48,327.00	-	194,48,327.00	66,84,394.07	12,76,393.29	79,60,787.36	114,87,539.64	127,63,932.93
6	**Furniture & Fixture**	82,41,194.70	3,41,956.00	85,83,150.70	31,84,949.49	5,39,820.12	37,24,769.61	48,58,381.09	50,56,245.21
7	**Office Equipment**	17,10,613.25	5,900.00	17,16,513.25	8,25,044.10	89,146.91	9,14,191.01	8,02,322.24	8,85,569.15
8	**Instruments And Equipments**	-	-	-					
	(i) Telescope	10,45,247.55	-	10,45,247.55	7,26,178.87	47,860.30	7,74,039.17	2,71,208.38	3,19,068.68
	(ii) Telescope (Solar)	13,67,166.00	-	13,67,166.00	8,23,888.63	81,491.61	9,05,380.24	4,61,785.76	5,43,277.37
	(iiia) 1.3 Mt. Telescope	770,16,439.00	-	770,16,439.00	297,11,535.41	70,95,735.54	368,07,270.95	402,09,168.05	473,04,903.59
	(iv)Public Outreach Telescope.	6,07,295.00	-	6,07,295.00	2,34,339.78	55,943.28	2,90,283.06	3,17,011.94	3,72,955.22
	(v) Schmidt Telescope	107,38,623.00	-	107,38,623.00	58,95,611.58	7,26,451.71	66,22,063.29	41,16,559.71	48,43,011.43
	(vi) Electronic Section	90,55,749.55	-	90,55,749.55	62,91,424.41	4,14,648.77	67,06,073.18	23,49,676.37	27,64,325.14
	(vii) Work Shop	2,73,027.45	-	2,73,027.45	1,89,683.86	12,501.54	2,02,185.40	70,842.05	83,343.59
	(viii) Aluiminising / Anodising	1,03,357.45	-	1,03,357.45	71,807.72	4,732.46	76,540.18	26,817.27	31,549.73
	(ix) Optics	27,240.80	-	27,240.80	18,924.97	1,247.37	20,172.34	7,068.46	8,315.83
	(x) Instruments	822,97,583.67	150,84,193.00	973,81,776.67	267,76,892.74	105,90,732.59	373,67,625.33	600,14,151.34	555,20,690.93
	(xi) Modernistion of Backend Inst.	395,20,049.00	46,48,489.00	441,68,538.00	135,97,779.58	45,85,613.76	181,83,393.34	259,85,144.66	259,22,269.42
	(xii) LIDAR.	87,60,465.00	-	87,60,465.00	43,85,192.85	6,56,290.82	50,41,483.67	37,18,981.33	43,75,272.15
	(xiii) ADFOSC (Backend Instrument)	33,13,267.00	-	33,13,267.00	9,50,973.56	3,54,344.02	13,05,317.58	20,07,949.42	23,62,293.44
	(xiv)Solar Section	8,227.00	-	8,227.00	4,066.12	624.13	4,690.25	3,536.75	4,160.88
	(Xv)Projector(Public Outreach)	1,05,000.00	-	1,05,000.00	34,827.19	10,525.92	45,353.11	59,646.89	70,172.81
	(Xvi)Planetarium(Public Outreach)	39,18,714.00	-	39,18,714.00	5,87,807.10	4,99,636.04	10,87,443.14	28,31,270.87	33,30,906.90
9	**Vehicles**	17,75,213.10	11,29,075.00	29,04,288.10	12,33,318.52	2,50,645.44	14,83,963.96	14,20,324.14	5,41,894.58
10	**Electric Installation (Manora Peak)**	35,63,920.00	-	35,63,920.00	11,75,220.08	3,58,304.99	15,33,525.07	20,30,394.93	23,88,699.92
11	**Electric Installation (Devsthal)**	29,22,165.00	-	29,22,165.00	15,09,665.43	2,11,874.94	17,21,540.37	12,00,624.63	14,12,499.57
12	**Computer & Peripherals**	249,27,916.40	44,89,465.00	294,17,381.40	230,70,394.50	38,08,192.14	268,78,586.64	25,38,794.76	18,57,521.90
13	**Computer Software**	14,05,432.00	-	14,05,432.00	11,97,270.72	1,24,896.77	13,22,167.49	83,264.51	2,08,161.28
14	**Library Books**	341,16,226.50	51,38,085.00	392,54,311.50	341,16,226.50	51,38,085.00	392,54,311.50	-	-
	Total	**6064,91,743.62**	**365,84,158.00**	**6430,75,901.62**	**2180,37,916.60**	470,90,914.99	2651,28,831.59	3779,47,070.03	**3884,53,827.02**

Registrar Director

SANGA & CO. NAINITAL Chartered Accountants

Schedule 3A : Capital work in progress

Sl.	Description of assets	Opening balance on April 1, 2014	Addition during year	Assets completed	Balance as on March 31, 2015
1	Building (Dev Sthal)	52,93,556.00	-	5293556.00	-
2	Building (3.60 Telescope)	295,93,133.00	48,13,740.00		344,06,873.00
3	3.60 Mtr Telescope	1116580264.00	585,89,498.00		11751,69,762.00
4	Alumunising Plant (Devsthal)	392,51,856.00	2,71,880.00		395,23,736.00
5	4.00 Mt. International Liquid Mirror Telesco	63,92,939.00	3,78,710.00		67,71,649.00
6	Medium Resolution NIR Spectrograph	-	268,74,802.00		268,74,802.00
	TOTAL	11971,11,748.00	909,28,630.00	52,93,556.00	12827,46,822.00

Schedule - 4 - Non current investments				
Particulars		CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14
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
Total		676,60,862.00		676,60,862.00
Interset accrued on non current investments				
Interest accrued on SBI FDR's (GPF A/c)		16,70,778.00		6,57,058.00
Interest accrued on UBI FDR's (GPF A/c)		19,45,365.00		8,83,918.00
Total accrued interest		36,16,143.00		15,40,976.00
Total non current investments including accrued interest		**712,77,005.00**		**692,01,838.00**
Schedule 5: Long term loans and advances				
(a) Advance for capital items - fixed assets				
For ADFOSC	-		2,62,004.00	
Material Advance (M/s Vidhyawati)	6,36,899.00		6,36,899.00	
For 1.3 mt. Telescope	-		60,000.00	
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	3,80,000.00	14,65,827.00
(b) Advances to staff recoverable from salary (as per annexure 2)		47,26,916.00		39,86,820.00
Total		**58,70,739.00**		**54,52,647.00**
Schedule 6 :Inventories : Spares and consumable stocks				
Particulars		CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14
i. Consumable Stock		17,72,380.72		17,21,913.84
ii. Stationery Stock		2,03,594.06		1,57,908.88
iii. Computer Accessories Stock		16,47,268.80		13,39,797.00
iv. Fuel (POL)		87,984.09		70,578.67
Total		**37,11,227.67**		**32,90,198.39**
Schedule 7 : Cash and bank balances				
Particulars		CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14
Cash on hand		6,443.00		18,000.00
4. Bank Balances :				
On Saving Accounts(As per Annexure-1)		784,76,132.21		339,81,493.38
Total bank balances		**784,76,132.21**		**339,81,493.38**
b) Other bank balances				
Amounts held as margin money against letters of credit opened for import of equipments.		28,60,000.00		126,60,000.00
TOTAL (A)		**813,42,575.21**		**466,59,493.38**
Schedule 8 : Loans and advances				
Particulars		CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14
1. Advances and other amounts recoverable in cash or in kind or for value to be received : (annexure -3)		83,60,620.00		64,81,760.00
TOTAL (A+B)		**83,60,620.00**		**64,81,760.00**

Particulars	CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14	
SCHEDULE - 9 -Grants				
1. From Central Government for asset creation		2832,31,000.00		159,64,742.60
2. From Central Government for purposes other than asset creation		-		1377,50,000.00
3. Less/Add Transfer to Expensess Accounts		-		-
TOTAL		**2832,31,000.00**		**1537,14,742.60**

Particulars	CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14	
Schedule 10 : Interest earned				
1.On Term Deposits & Savings Accounts :		30,36,828.00		38,48,368.33
2. On Loans :				
a) Employees / Staff (Interest on Advances)				
Computer Advance Intt. (ARIES)	8,754.00		6,000.00	
HBA Intt. (ARIES)	2,000.00		24,000.00	
Car Adv. Intt. (ARIES)	-		10,000.00	
OMCA Intt. (ARIES)	27,919.00	38,673.00	4,000.00	44,000.00
TOTAL		**30,75,501.00**		**38,92,368.33**

Schedule - 11 - Other Income

PARTICULARS	CURRENT YEAR F. Y. 2014-15		PREVIOUS YEAR F. Y. 2013-14	
Registration Fee		6,100.00		2,062.00
Residential Buildings / Hostels		2,61,359.00		2,66,833.00
Water Charges		88,603.00		1,51,905.00
Telephone Charges		3,195.00		6,840.00
Electricity / Meter Charges		2,86,217.00		4,16,825.00
Guest House Rent		3,80,280.00		3,82,105.00
Tender Fee		1,750.00		39,677.00
Misc Receipts		1,235.00		950.00
RTI Receipts		1,046.00		2,136.00
Vehicle Income		-		1,890.00
Prior period adjustments		-		20,55,444.00
TOTAL		**10,29,785.00**		**33,26,667.00**

SCHEDULE - 12 - ESTABLISHMENT EXPENSES				
	CURRENT YEAR		PREVIOUS YEAR	
Pay & Allowances	F. Y. 2014-15		F. Y. 2013-14	
Salary Expenses	594,38,987.50		584,70,462.00	
Honorarium A/c	1,46,948.00		1,48,500.00	
Honorarium Visiting Scientist	59,000.00		55,000.00	
Bonus	2,27,964.00		2,34,296.00	
Leave Travel Concession	11,93,576.00		10,14,469.00	
Employer Contribution towards NPS and interest	35,53,842.67		47,55,015.16	
Employer Contribution towards Old Pension Fund	260,89,253.00		80,00,000.00	
Employer Contribution to GPF Interest	58,779.00		63,797.00	
Leave Encashment	12,05,416.00		39,25,723.00	
Over Time	22,172.00		27,397.00	
Medical Reimbursements	9,65,637.00		5,64,243.00	
Dispensary Expenses	2,92,884.00		1,93,396.00	
Fellowship	66,74,320.00		62,42,429.00	
Liveries	44,650.00		6,630.00	
Reimbursement of Tution Fee	9,26,559.00		8,52,003.00	845,53,360.16
Stipend	1,80,000.00	1010,79,988.17		
TOTAL		-		**845,53,360.16**
		1010,79,988.17		
SCHEDULE - 13 - OTHER ADMINISTRATIVE EXPENSES ETC.	CURRENT YEAR		PREVIOUS YEAR	
	F. Y. 2014-15		F. Y. 2013-14	
Advertisement		9,71,468.00		3,51,158.00
ATSOA-2015		61,543.00		2,27,448.00
Auditor's remuneration		46,652.00		36,685.00
Bank Charges		5,450.00		1,09,983.00
Building Repair		59,88,212.00		38,46,448.00
Canteen Expenses		16,19,819.00		13,59,920.00
Cleaning Work		11,27,805.00		10,75,100.00
Computer Accessories		1,31,195.00		8,18,127.73
Consumables Assessories		19,76,571.00		42,02,726.76
Conveyance		23,53,599.00		9,00,553.00
Electricty		34,48,543.00		30,10,312.00
Fuel (POL)		19,49,042.00		17,52,485.00
Garden		4,28,031.00		3,70,163.00
Hospitality		42,402.00		34,743.00
Insurance		56,249.00		55,143.00
JEST		1,00,000.00		1,00,000.00
Legal		15,86,526.00		27,80,605.00
Meeting of Governing Council		12,31,091.00		7,05,527.00
Meeting of Other Scientific Bodies		23,35,188.00		31,80,603.00
Observational Facilities		5,28,203.00		88,640.00
Outsource services		-		22,044.00
Postage		56,610.00		1,33,343.00
Printing & Stationery		3,16,875.00		3,35,083.81
Public Outreach Programme		1,98,692.00		2,52,765.00
Registration		2,95,009.00		5,26,499.00
Repair and Maintainence - instrument		2,79,031.00		6,37,159.00
Repair and Maintainence - others		90,000.00		2,20,102.00
Repair and Maintainence - Vehicles		2,37,611.00		2,53,717.00
Security		21,55,079.00		21,29,679.00
Sundry Expenditure		1,10,715.00		2,64,104.00
Telephone and Communication Charges		41,52,238.00		43,25,306.00
Travel - domestic		9,01,917.00		7,30,868.00
Travel - Foreign		11,48,381.00		21,17,639.00
Water		5,78,536.00		4,70,496.00
TOTAL		**365,08,283.00**		**374,25,175.30**

Schedule-14

Office Contingency, Group Summary

01 April 2014 to 31 march 2015

Particulars	Expenses
Advertisement Expenses	958083.00
Audit Fees A/c	46652.00
Bank Charges	739.50
Canteen Expenses A/c	1595389.00
Cleaning Work Exp.A/c	1127805.00
Consumable (Others)	63428.00
Conveyance Expenses	1812144.00
Dispensary Expenses	197110.00
Electricity Exp. (Devsthal)	381452.00
Electricity Exp. (Manora Peak)	3067091.00
Freight & Cartage A/c	41750.00
Garden Expenses A/c	428031.00
Hospitality A/c	42402.00
Insurance Charges A/c	56249.00
Legal Charges	1541796.00
Leveries Expenses	44650.00
POL A/c	1628318.00
POL (Devasthal)	320724.00
Postage Expenses	56110.00
Printing & Stationary Expenses	316875.00
Registration Expenses	295009.00
Security Expenses	2155079.00
Sundry Expenses	110715.00
Telephone Expenses	155588.00
Water Expenses	375536.00
Grand Total	**16818725.50**

Schedule of consumption of consumables
Financial Year 2014-2015

S. NO.	PARTICULARS	OP STOCK	PURCHASE	TOTAL	CL STOCK	CONSUMPTION
1	2	3	4	5=(3+4)	6	7=(5-6)
1	**CONSUMABLE ACCESSORIES**	17,21,913.84	19,76,571.00	36,98,484.84	17,72,380.72	19,26,104.12
2	**STATIONERY STOCK**	1,57,908.88	3,16,875.00	4,74,783.88	2,03,594.06	2,71,189.82
3	**COMPUTER ACCESSORIES**	13,39,797.00	1,31,195.00	14,70,992.00	16,47,268.80	(1,76,276.80)
4	**FUEL**	70,578.67	19,49,042.00	20,19,620.67	87,984.09	19,31,636.58
		32,90,198.39	**43,73,683.00**	**76,63,881.39**	**37,11,227.67**	**39,52,653.72**

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 2015.

II. 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 Contributory Provident Fund and 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/c. or C.P.F. A/c. 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/c. and C.P.F. A/c. 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.

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 and a

(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.
(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.

(10) Misce. Grants received during the year amounting to Rs. 6920303.00 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) All balances of various banks are subject to confirmation.

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

Wahab Uddin
Acting Director

Ravinder Kumar
Registrar

for Banga & Co., Chartered Accountants
Nainital

Bharat Singh
Asstt. Registrar

Abhishek Sharma
LDC

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