A R I E S Aryabhatta Research Institute of Observational Sciences

## Annual Report 2012-13





Photo Credit : Harish Chandra Tewari

- 1. The main building
- 2. 40" Sampurnanand Telescope
- 3. Atmospheric Science Lab
- 4. Schmidt Telescope

- 5. Auditorium
- 6. Students' Hostel
- 7. Guest House
- 8. Workshop





### ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES (An Autonomous Institute under DST, Govt. of India)

Manora Peak, Nainital - 263 002, India

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#### Front cover:

Fully assembled 3.6-m telescope with dummy mirrors at AMOS workshop.

#### **Back cover:**

Fist batch of Antennae installed at the Radar Side, ARIES.

### November, 2013



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### The Organizational Structure of ARIES





### **GENERAL BODY AND GOVERNING COUNCIL**

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#### **Prof. Ram Sagar**

Director, ARIES, Manora Peak, Nainital – 263 002

#### Mr. T. Bhattacharyya (Non – Member Secretary)

Registrar, ARIES, Manora Peak, Nainital - 263 002



### FINANCE COMMITTEE

### **CHAIRPERSON**

#### **Prof. Ram Sagar**

Director, ARIES, Manora Peak, Nainital - 263 002

### **MEMBERS**

### Ms. A. Mitra

Additional Secretary and Financial Advisor, Ministry of Science and Technology, DST, Govt. of India, New Delhi - 110 016

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### Dr. Wahab Uddin

Scientist-F, ARIES, Manora Peak, Nainital - 263 002

#### Mr. T. Bhattacharyya (Member Secretary)

Registrar, ARIES, Manora Peak, Nainital -263 002



### STATUTORY COMMITTEE

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Dr. Manish Naja (Convener) ARIES, Nainital



### THE YEAR IN REVIEW



It gives me immense pleasure to present the highlights of the achievements made by ARIES in many fronts during the period of 2012-13. This has indeed been a very productive period during which the Institute has made significant contributions in research, instrumentation, academic activities, human resource and infrastructure development and public outreach. While the earlier programmes and projects are continue to progress, several new ones have been initiated. Some of these projects are now at their crucial stages making the period both significant and exciting.

ARIES scientists are actively engaged in research and development, teaching research scholars, thesis supervision, organization of various workshops and other meetings. Faculty members also have very productive collaborations with scientists at others national and international institutes. In addition to these, they are also taking keen interest in popularizing Astronomy & Astrophysics and Atmospheric Sciences among younger generation. The engineers are developing various new instruments and softwares for both the existing and upcoming facilities. A number of these have been entirely developed indigenously. There are a total of 44 faculty members (28 scientists and 16 engineers), 20 administrative and supporting staff, 47 scientific and technical staff, 14 laboratory assistants / attendants, 7 post-doctoral fellows and 24 research scholars . The research activities of the institute are classified into three working groups, namely, Working Group – I, Working Group – II and the Instruments Facility and Development Laboratory. These members have produced about 50 research publications during 2012-13 in high impact, international and national journals. Some of these results and other achievements are summarized below.

Beginning with research on topics related to Astronomy & Astrophysics, one exoplanet system, WASP-12, was observed using our newly installed 1.3 m telescope 61 transit light curves were obtained, many with sub-milli magnitude accuracy. A two planet model was shown to agree well with the observed data. The dark and stable sky available at Manora Peak and Devasthal have enabled our scientists to carry out projects like this and various others like the detection of variable sources in young clusters, variable exotic stars and inter-night variability in AGNs. Research on young open clusters has always been one of those fields in which ARIES scientists have contributed significantly over the past decade and even before. Three HII regions and two young clusters were studied extensively using ARIES telescopes and



those available within the country. Archival data from telescopes elsewhere are used to make multiwavelength investigations of the regions. These regions were studied to estimate basic parameters of clusters like their distance, age and reddening and to make a census of young stars that are forming in this region to estimate the mass function and to get information on the star formation history of the region as a whole.

One of the characteristic features of young stars is the manifestation of variability in brightness on time scales ranging from years to days and even to hours. A total of 53 variable sources are identified towards NGC 1893 and correlations between the amplitude of the brightness variation and the properties of the sources were studied in detail. Variability was also found in some of the main sequence members of intermediate and older open clusters. For instance, in NGC 6866, a relatively large number of stars are identified showing pulsations, solar-like oscillations, eclipsing binaries and stars with possible spot activities. An Am star, HD 297561, was identified based on highresolution spectroscopy. The observations were made using 6.0m telescope at SAO under the Indo-Russian collaborative programme.

Light from background stars is partially linearly polarized when it passes through aspherical interstellar dust grains due to selective absorption. These polarization measurements provide the orientation of the local magnetic field. Linear polarization is also detected in sources where any asymmetry in the distribution of emitting region exists. One of the backend instruments at the 1.04 m Sampurnanad Telescope is an imaging polarimeter commissioned in 2004. This instrument was developed fully using ARIES facilities. Since its induction, a good number of publications have resulted from the instrument. Polarimetry has been shown as a new and additional technique to identify cluster members. It was also used to study the properties of interstellar dust and magnetic field geometry towards the direction of the open clusters and molecular clouds. Multi-wavelength polarization measurements of two sources showed the possibility of the presence of asymmetric distribution of circumstellar material.

A very interesting Globular cluster system was identified in NGC 1316, a prominent merger remnant, in the outskirts of the Fornax cluster. About 6 arc min from the nucleus of NGC 1316 lies an isolated HII region, SH2. Based on a study of this system, the region is possibly dwarf galaxy that might have experienced a burst of extremely clustered star formation. A number of potential double-double sources were identified to show episodic nuclear activities. On the basis of GMRT and VLA observations, two double-double radio galaxies were studied and characterized. The duration of their activities based on the spectra of the inner and outer lobes was examined.

Many AGNs show significant variation in brightness over timescales of years, months, days or even hours. The ARIES extragalactic group has made an optical variability study of radio-loud broad absorption line galaxies, narrow-line Seyfert I galaxies with y-ray emission, flat spectrum radio core-dominated guasars and blazars (including BL Lacs and flat spectrum radio guasars). Optical variability studies of these sources are very important as the timescales of variability will give clues on the size of the energy source in AGNs. Apart from monitoring Gamma Ray Bursts to get optical light curves, scientists in ARIES are involved in modeling the multi-wavelength light curves to understand various physical mechanisms involved in energetic blasts. A two-dimensional hydrodynamical simulation of rotating galactic winds driven by radiation was carried out to characterize the structure and dynamics of the gaseous components of gas mixed with the dust.



In the area of solar physics, ARIES is involved in observations and modeling of transients, space weather phenomena and magneto-hydrodynamic waves in the solar atmosphere. For example, a multi-wavelength study of recurrent surges was performed including the Ha images obtained from the 15 cm telescope of ARIES at Manora Peak, to investigate the role played by surge activities in coronal heating. Another solar surge was observed using SDO and shown to develop vertically from its origin reached to a certain height and then moved down to fade away gradually. Numerical modeling was performed to explain this observed phenomenon. One of the most significant results obtained during 2012-13 is the discovery of sausage-pinch instability which was till now the established only theoretically. Evidence of the presence of the sausage-pinch instability was shown using the data obtained from AIA onboard SDO where a magnetic flux tube visible in 304 Å showed curvature on its surface with variable crosssection and enhanced brightness.

The Atmospheric Science Division of ARIES is mainly concentrating on the morphological characteristics of trace gases, aerosols and meteorology. For example, Surface Ozone measurements carried out over the Central Himalayan region showed some intriguing features which is very different from the Southern India. Moreover, large discrepancies are observed over our region between modelled and satellite based results especially during biomass burning activity dominant season indicating the region is mostly NO, - limited. The results from studies have revealed a strong flow of non-anthropogenic SO<sub>2</sub> to our region originating from a volcanic eruption in the African region. Aerosol extinction profiles were derived using our Lidar facility installed at Manora Peak. An interesting study related to meteors showed altitudinal and latitudinal asymmetry of diurnal variation of sporadic meteors distribution around the globe. Apart from these studies, the atmospheric group is also involved in technical advancements related to instrumentation, for example, a graphical user interface based tool has been developed which is capable of generating and analyzing a pair of complementary codes upto 512. Also, an empirical relation between code length and maximum possible set of complementary pairs has been established.

With regard to projects, the most significant development has been the arrival of our 3.6 m telescope at the Devasthal site. The containers containing the telescope components were despatched from the AMOS factory on November 15, 2012 and arrived at Mundra port, Gujarat, on December 12, 2012. The transportation of the telescope components from Kathgodam to Devasthal was a challenging task as the terrain is difficult to negotiate. I would like to convey my appreciation to Dr. A. K. Pandey for his meticulous planning and co-ordination with the local administration and the Uttarakhand Power Corporation Ltd., for extending their full support for carrying out an otherwise herculean task. Thanks are also due to the local residents who helped us enthusiastically in accomplishing the transportation job.

The containers containing the entire telescope parts are now stored at the base camp of Devasthal which will be assembled by teams from AMOS and ARIES once the telescope enclosure building is completed. The aluminizing chamber which was fabricated by Hind High Vacuum Co. Private Limited, Bangalore is already at the site and set for its installation inside the telescope housing. The M1 (primary mirror of the telescope) will be aluminized in this chamber before it gets integrated with the telescope during the installation of the telescope.

The development of an imager as the first light instrument for the 3.6 m telescope is in its final stage. The filter housing for the imager is getting



fabricated in the ARIES workshop. The optical components for another instrument, ADFOSC, have already been procured and are being assembled at M/s Winlight, France. The fact that it is for the first time that a spectrograph has been designed and developed in-house is indeed a major of achievement for ARIES. The control system for the dome of the 3.6 m telescope has also been developed by ARIES team and is currently under test phase.

Aditya 1, India's first mission to study the Sun is scheduled to launch around 2018. This facility will be dedicated for the solar coronal studies and will contain the Visible Emission Line Space Solar Coronagraph - the main payload to study coronal dynamics. Solar physicists from ARIES are involved in various science working groups formed to generate science projects with the instrument. They are also involved in a new payload, Solar Ultraviolet Telescope for the same mission, proposed by IUCAA.

Another significant development that has happened during the period is the installation of the first batch of TR modules of the ST Radar. Mounting of the cable tray for networking has been carried out and the DSP system has also arrived at the site. The installation of the DSP system is currently in progress. A separate electrical substation has been energized and verification of different subsystems and its commissioning is currently been carried out by the ARIES team.

The Thirty Meter Telescope (TMT) project, of which ARIES is one of the lead institutes along with IIA, Bangalore and IUCAA, Pune is progressing well. ARIES has taken the responsibility of the fabrication of prototypes of Segment Support Assembly systems for the TMT with the help of Indian companies.

ARIES conducts various academic related activities

each year and these are being coordinated by the Academic Committee (AC). The committee conducted two in-house meetings on April 19-20, 2012 and March 18-20, 2013. Faculty members, senior research scholars and post doctoral fellows presented their work during the meetings. The committee also coordinated the third Scientific Advisory Committee (SAC) meeting which was held at Manora Peak during October 5-8, 2012. Prof. Dipankar Bhattacharya (IUCAA), one of the members of our Governing Council, charged the Committee. The other members of the SAC were Annapurni Subramaniam and Dipankar Banerjee from IIA, Devendra Ojha from TIFR, Jayaram Chengalur from NCRA, Biswajit Paul from RRI and Vinayak Sinha from IISER (Mohali).

The Committee was given a flavor of various scientific and developmental activities that are going on at ARIES through presentations made by scientists and engineers. The SAC members visited various facilities of ARIES including Devasthal. Apart from these, SAC members also met faculty members, research scholars, post doctoral fellows and other staff. They had discussion on various welfare related aspects and finally provided their recommendations.

ARIES members made considerable efforts in disseminating the knowledge gathered through our research activities to the general public, especially to young minds, through various public outreach programmes. We are currently in the process of installing a planetarium which would facilitate the public to appreciate various aspects of Astronomy and Astrophysics related events in a much better manner.

ARIES continued its efforts in the implementation of the official language. ARIES also organizes various cultural and sports activities for the staff and their family members on the occasion of Gandhi Jayanti celebrations on 2<sup>nd</sup> October. The Institute continues





to provide a constructive and essential role in building an equitable work environment by safeguarding the interests of SCs and STs as well as women. All the steps necessary to maintain national integration are taken at appropriate occasions at the implementation of important schemes as directed by the Government of India.

Wahab Uddin

Acting Director



## **RESEARCH AT ARIES**

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

- Working Group I (WG I) Galactic & Extragalactic Astronomy
- Working Group II (WG II) Solar Physics & Atmospheric Sciences
- Instruments Facility and Development Lab (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 2012-13, are presented.

### **Research Working Group-I**

All the scientists working on the astrophysical topics related to the Galactic and Extragalactic astronomy are the members of WG – I. The group consists of 19 scientists. The group members are actively involved in collaboration with scientists of national and international institutions in the fields of exoplanetary systems, star formation, star clusters, optical variability in roAp stars, gravitational lensing, AGNs and Quasars, supernovae, X-ray sources, Wolf-Rayet galaxies, Giant Radio galaxies and Gamma Ray Bursts. The extracts of the publications made by the members are briefly presented below.

### **Galactic Astronomy**

### 1. Study of exoplanets

The recent discoveries of extra-solar planets (exoplanets) have opened a new era for the planetary science which now extends beyond our solar system. Precise timing of transiting exoplanetary systems can be used to detect other, possibly non-transiting, planets in the systems from their gravitational interactions with the transiting planet and the resulting perturbations on the times of transit. In collaboration with the European group, members of ARIES have been observing the transiting exoplanets using 1.3-m Devasthal telescope. For one system, WASP-12, the team obtained 61 transit light curves, many of which are with sub-millimag precision. The analysis of the photometric data along with the archival radial velocity data suggests that a two-planet model supports the observational data better than the single planet scenario. The study of WASP-12 revealed that there could be a possibility of a second planet present in the system having a 0.1 M<sub>inn</sub> mass on a 3.6-day eccentric orbit.

### 2. Study of star formation in young open clusters

ARIES scientists have made significant scientific contributions to the fields of star formation and young star clusters. Star formation in our Galaxy is believed to occur mainly in clusters rather than in isolated forms. Therefore it is essential to study these objects in detail to understand the processes involved in star formation basically to understand



the formation of our Galaxy itself. The main objectives of the study of young clusters are to understand their global properties, modes of star formation (whether spontaneous or triggered) and to carry out a census of young stars associated with the individual regions. The mass function of the pre main sequence stars associated with a given region is one of the most important parameters which could provide us vital clues on the dominant physical processes involved in star formation.

In this context, multi-wavelength studies of three HII regions namely, Sh2-252, Sh2-294 and Sh2-297 were conducted. In Sh2-252, the analyses of the stellar contents of the extended H II region were carried out using deep optical UBVRI photometry, slit and slitless spectroscopy and near-infrared (NIR) data from Two-Micron All-Sky Survey (2MASS). In the case of Sh2-294, the study was carried at 3.6, 4.5, 5.8, and 8.0  $\mu$ m observed with the Spitzer Space Telescope Infrared Array Camera (IRAC), coupled with H<sub>2</sub> (2.12  $\mu$ m) observations. Radio continuum observations at 610 and 1280 MHz, Very Large Array archival data at 1420 MHz, slitless spectroscopy and near-IR observations were used to investigate Sh2-297 HII region.

The distance to Sh2-252 is estimated as  $2.4 \pm 0.2$  kpc, and a reddening, E(B - V), estimated based on the results of the massive members is found to vary between 0.35 and 2.1 mag. Of a number of sub-regions found towards Sh2-252 region, majority of them are indeed found to be associated with the HII region. The study also showed an enhancement in the stellar surface density towards them. Within errors, the K-band luminosity functions for all the sub-regions are shown to be similar and comparable to that of young clusters of age <5 Myr. A total of 61 H $\alpha$  emission sources are identified in the region using slitless spectroscopy. These sources along with the ones with near-IR excess

emission, are shown to have ages and masses in the range of 0.1- 5 Myr and 0.3-2.5 M respectively, based on their positions in the V/(V - I) colourmagnitude diagram (**Figure 1**). The mass function of the pre main sequence sources of the sub-cluster regions in the mass range of 0.3-2.5 M<sub>o</sub> was shown to be consistent with the Salpeter value.



**Figure 1.** V/(V – I) CMD for the identified candidate YSOs in Sh2-252. The Class I and Class II sources are shown with red squares and green filled triangles, respectively, and the blue open triangles are the H $\alpha$  emission-line sources. The thick solid curve is the locus of ZAMS from Girardi et al. (2002), dashed curves are the PMS isochrones of age 0.1 and 5 Myr, respectively, and the thin solid curves are the evolutionary tracks for various mass bins from Siess et al. (2000). All the isochrones and tracks are corrected for the distance and reddening. The arrow indicates the reddening vector for A<sub>V</sub> = 2 mag. The average error in (V – I) colour as a function of magnitude is shown in the right-hand side of the figure.



Towards Sh2-294 region, a total of 36 probable pre main sequence sources are identified and classified as Class I, II and I/II based on their positions on the IRAC color-color diagram. These sources are shown to be located at the outskirts of the H II region and mostly associated with enhanced H<sub>2</sub> emission regions. Interestingly, none are found towards the central cluster region. Combining the optical to midinfrared (MIR) photometry of the YSO candidates and using the spectral energy distribution fitting models, the study determined the stellar parameters and the evolutionary status of 33 YSO candidates. Majority of them are low-mass (<4 M<sub>o</sub>) YSOs. However, one massive YSO (~9 M<sub>o</sub>) of Class I nature, embedded in a cloud with an estimated visual extinction of ~24 mag is also identified. The obtained results suggest that the Class I sources found towards Sh2-294 are relatively young population (age ~  $4.5 \times 10^6$  yr). These sources, including the massive YSO, could be most likely of second-generation sources formed due to the trigger provided by the expansion of the H II region powered by a  $\sim 4 \times 10^6$  yr B0 main-sequence star. Similar census of YSOs towards Sh2-297 obtained from the slitless spectroscopy and near-IR colors have resulted in the identification of a number of probable YSOs which are shown to be at their different evolutionary stages. The mean age of these YSOs is found to be about 1 Myr, which is shown to be consistent with the dynamical age of the H II region. The spatial distribution of YSOs indicates an evolutionary sequence, suggesting triggered star formation which could have propagated from the ionizing star to the cold dark cloud LDN1657A located west of Sh2-297.

In addition to these three regions, a multiwavelength study was made for relatively young clusters, namely, NGC 1893 and NGC 1931. In the case of NGC 1893, the main aim is to characterize the pre main sequence sources found in the region based on the optical, near-IR, mid-IR and X-ray data. The identified pre main sequence sources show an age spread of ~5 Myr. The YSOs located near the nebulae at the periphery of the cluster is shown as relatively younger in comparison to those located within the cluster region. The fraction of the disk bearing stars is shown to increase towards the periphery of the cluster indicative of their youthness. The evidence that support the notion that the mechanisms for disk dispersal operate less efficiently for low-mass stars is presented. The sample of Class II sources is found to be relatively older in comparison to that of Class III sources. Further, a comparison of various properties of YSOs in the NGC 1893 region with those in the Trumpler 37/IC 1396 region was also made.

In NGC 1931, using photometry, the cluster parameters such as distance, reddening, age, luminosity/mass function and star formation history of the region were characterized. The region is shown in Figure 2. The stellar density contours revealed two clusters in the region. The results suggest a differential reddening law within the cluster region. The slope of the mass function (-0.98 ± 0.22) in the southern region for the mass range of 0.8 < M/M9.8 < 100 is shallower in comparison to that towards the northern region  $(-1.26 \pm 0.23)$ , which is comparable to the Salpeter value of -1.35. The KLF of the region is found to be comparable to the average value of the slope (~0.4) for young clusters available in the literature; however, the slope of the KLF is steeper in the northern region as compared to the southern region. The region is probably ionized by two B2 main-sequence-type stars. The mean age of the YSOs is found to be 2 ± 1 Myr, which suggests that the identified YSOs are probably younger than the ionizing sources of the region. The morphology of the region, the distribution and ages of the YSOs, and ionizing sources indicate a triggered mode of star formation in the region.

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**Figure 2.** Left panel: color-composite images obtained using the K<sub>s</sub> (blue), 3.6µm (green), and 4.5µm (red) for an area of ~15 × 15 arcmin<sup>2</sup> around NGC 1931. Right panel: the same as the left panel but using the H $\alpha$  (green) and 3.6µm (red).

### 3.Characterizing the variability of sources in young and intermediate open clusters

Several long-term observational survey program to detect variable stars in some unstudied or poorly studied young and intermediate-age open star clusters have been initiated.

Pre main sequence sources exhibit variability in optical wavelengths. In fact this was one of the properties used to define and identify pre main sequence sources in a given region where star formation is currently occurring. Multi-epoch observations (14 nights during 2007-2010) in Vband of relatively young open cluster, NGC 1893, were obtained using our 1.04m telescope located at Manora Peak. A total of 53 sources are identified as variables based on their optical light curves. Using spectral energy distribution, J - H/H - K two-colour diagram and V/V - I colour-magnitude diagram, the sources are identified as low mass T Tauri objects of ages  $\leq$  5 Myr with masses in the range 0.5 $\leq$  M/  $M4 \leq$ . The periods of variability of majority of these sources are shown to be in the range from 0.1 to 20 days. The amplitude of the magnitude variation of Classical T Tauri sources is shown to vary with larger amplitude in comparison to weak line T Tauri stars. In addition to these, the study also found that the amplitude decreases with the increase in mass, which could be due to a faster dispersal of circumstellar material in relatively massive sources. In Figure 3, the amplitude of T Tauri sources identified in NGC 1893 and an another young cluster Berkeley 59 is presented as a function of their masses and ages. Open circles and triangles in red are for sources from Berkeley 59.



The pre main sequence stage of low mass stars in clusters lasts for not longer than ~10 million years when their circumstellar material is either completely accreted on to the star itself or has been put back to the interstellar medium or has been accreted on to planetary systems. Stars in clusters of intermediate and older ages still show variability modulated by the spots due to magnetic activities, stellar pulsations or due to the presence of secondary components/planets. In a study on an intermediate age open cluster, NGC 6866, using

ground based data taken from 1.04m and space based Kepler data, identified 31 Delta-Scuti and 8 Gamma-Dor pulsating variables, as well as 23 red giants with solar-like oscillations. This study also found 4 eclipsing binaries and 106 stars showing rotational modulation indicative of star spots. The asteroseismic study of the members of this cluster revealed that the hot stars up to A-spectral type are following period-colour relation in resemblance with their cooler counterparts.



**Figure 3.** Amplitude of TTSs as a function of mass and age. Open circles in red and triangles represent data for Berkeley 59.



## 4. Polarimetric and multi-wavelength photometric studies of binary sources

One of the instruments available for observations with 1.04m Sampurnanad Telescope is ARIES IMaging POLarimeter (AIMPOL). Since the commissioning of this instrument in 2004, the instrument has produced a number of good scientific results. Various observational projects are undertaken by the scientists of ARIES using AIMPOL. This instrument is an imaging polarimeter in optical BVRI bands. The instrument was constructed fully using ARIES facilities.

The reddening and the linear polarization of starlight occur when it passes through the dust grains that are believed to be aligned with their minor axes parallel to the local interstellar magnetic field. However, the polarization efficiency depends on the degree of the alignment and the smooth distribution of the local magnetic field. Polarization efficiency of the dust grains toward the direction of NGC 1931 is shown to be less than that of the general diffuse interstellar medium. Another interesting polarimetric study was carried out on a K5V-type binary source, V1147 Tau. Twenty years of V-band photometry of this stellar system gave a rotation period of 1.4845±0.0001 days, which is similar to the orbital period of this binary system, implying that it is a synchronous system. The variable shapes and the amplitudes of the light curves indicate temperature inhomogeneities on the surface of V1147 Tau (Figure 4). The amplitude of the brightness variability is shown to be in the range from 0.06 to 0.30 mag. In order to model the entire light curve, all the available observations in V band were divided into 16 sets without gaps on the curve on the phase diagram and without changes of its shape. Each individual light curve was analyzed using an indigenously developed code called iPH. From computed maps, the longitudes corresponding to the maximum values of filling factor (f) were derived. The study showed that the spots are mainly concentrated at two longitudes and the corresponding values are registered as two independent active regions. The difference between two active longitudes is not found to be constant at 180°. The total area covered by the spots is on an average 18 per cent of the total visible stellar



Figure 4. The temperature inhomogeneities map on the surface of V1147 Tau for one set of observations.



surface. During the observations the value of spottedness varied in the range 9–22 per cent for the inclination of 60°. Both the amplitude and the spottedness showed variability on time-scales of about ~ 4000 days. Based on the data presented by them, a back and forth of activity within two active longitudes 180° apart with alternate levels of spot activity is revealed. This phenomenon is commonly known as flip-flop. The study found that the time of flip-flop coincided with the time of maximum surface spottedness. The presence of H $\alpha$  in emission, obtained from optical spectroscopy, indicate a high level of chromospheric activity.

The polarimetric observations yielded an average values of polarization as  $0.40 \pm 0.03$ ,  $0.22 \pm 0.05$ ,  $0.17 \pm 0.07$  and  $0.12 \pm 0.04$  per cent in B, V, R and I bands, respectively, which indicates the possibility of scattering by a thin circumstellar material associated with the system. The X-ray light curve is found to be rotationally modulated and is shown to be anticorrelated with the optical light curves observed at quasi-simultaneous epochs. The corona of V1147 Tau is shown to consists of a two temperature plasma with kT<sub>1</sub> = 0.07 keV and kT<sub>2</sub> = 0.66 keV. The X-ray luminosity in the 0.2–2.4 keV energy band is shown to be 4.4– 6.8 x10<sup>29</sup> erg s<sup>-1</sup>. Flaring features is also shown to exist in the X-ray light curve of this stellar system

Polarimetric studies of FO Hya, a contact binary, was made presumably for the first time, to understand the circumstellar geometry of the system. From the detailed photometric analysis of this stellar system spanning over a period of 65 years, using the data obtained from B, V, R and I band CCD photometric observations, a period of 0.469556± 0.000003 day was derived. On the basis of the long term data, the current study has shown

that the period of FO Hya has increased at a rate of 5.77 x  $10^{-8}$  days yr<sup>-1</sup>, probably caused due to the mass transfer between the components at a rate of 1.67 10<sup>8</sup> Myr<sup>-1</sup>. The mass, radius and luminosity of primary and secondary components are derived as 1.31 ± 0.07 M<sub>a</sub> and 0.31± 0.11M0.03 ± 1.62, R<sub>a</sub> and 0.91 ± 0.02 R<sub>a</sub> and 5.65± 0.21 L<sub>a</sub> and 0.55 ± 0.03 L<sub>a</sub>, respectively. The filling factor of 0.68 is derived in this study. The mean values of degree of polarization and polarization position angle of the system are shown to be 0.18±0.03, 0.15± 0.03,  $0.17 \pm 0.02$  and  $0.15 \pm 0.02$  per cent and  $61 \pm 6$ ,  $115 \pm$ 6, 89 ± 3 and 98 ± 5 degree in B, V, R and I bands, respectively. The level of optical polarization shown by FO Hya could be due to the presence of supplementary sources e.g. binarity and circumstellar material (gas streams).

### 5. Time Resolved Photometry and Spectroscopy of Chemically Peculiar Stars

A time-resolved photometric and spectroscopic analysis of an interesting peculiar star HD207561 were carried out. The time-series photometric observations of this star were conducted on 80 nights during the period of 2000 to 2008 using a three-channel fast photometer attached to the 1.04m telescope. Of these, time-series data of only two nights in year 2000 show clear signature of 6min periodicity. In order to confirm this photometric light variations and to understand the spectroscopic nature of this star, high-resolution spectroscopic observations were carried out with the 6.0-m telescope at SAO. The spectroscopic analysis showed that HD207561 has most of the characteristics similar to an Am star rather than an Ap star, and hence the roAp like oscillations are not expected in the star however the low-overtone pulsation modes might be excited.

ARIES 9<sup>th</sup> ANNUAL REPORT

# 2012-13

### **Extragalactic Astronomy**

### 1. Study of Globular cluster systems in galaxies

Globular clusters (GCs) are aggregates of approximately 10<sup>4</sup>-10<sup>6</sup> gravitationally bound stars, highly concentrated to the center, spread over a volume ranging from a few dozen up to more than 300 light-years in diameter. These objects are largely spherically symmetrical. Our Galaxy hosts about 200 GCs. They form a halo of roughly spherical shape which is highly concentrated around the Galactic center in the Sagittarius-Scorpius-Ophiuchus region. At young ages, GCs are expected to be very bright and blue because of the concentration of many young stars in a compact region. Their high luminosities, blue color and compact size make young GCs easy to detect and identify in imaging surveys.

NGC 1316 (Fornax A) is a prominent merger remnant in the outskirts of the Fornax cluster. The bulge stellar population of NGC 1316 has a strong intermediate-age component. Studies of its globular cluster system may help to further refine its probably complex star formation history. The cluster system has not yet been studied in its entirety. A study was conducted on this source using wide-field observations to investigate the properties in relation to the global morphology. The observations were carried out using the MOSAIC II camera on the 4-m Blanco telescope at CTIO in the filters Washington C and Harris R. The study identified globular cluster candidates and investigated their color distribution and the structural properties of the system as a whole. The cluster system is well confined to the optically visible outer contours of NGC 1316. There are about 640 cluster candidates down to R = 24 mag. The color distribution of the entire sample is unimodal, but the color distribution of bright subsamples in the bulge shows two peaks that, compared with theoretical Washington colors with

solar metallicity, correspond to ages of about 2 Gyr and 0.8 Gyr, respectively. The study concluded that the cluster formation in NGC 1316 has continued after an initial burst that is presumably related to the main merger. A toy model with two bursts of ages 2 Gyr and 0.8 Gyr is consistent with photometric properties and dynamical mass-to-light ratio values. In this model, the older, metal-rich pre-merger population has an age of 7 Gyr, contributes 90 percent of the bulge mass and 70 percent of the luminosity. Its properties are consistent with spiral galaxies, where star-bursts were triggered by major/minor mergers and/or close encounters.

Sh2 has been described as an isolated HII-region, located about 6.5 arc min south of the nucleus of NGC 1316. A study was carried out with the aim to give a first, preliminary description of the stellar content and environment of this remarkable object. The data used in the above study and the HST photometry from the Hubble Legacy Archive were used for a morphological description and preliminary aperture photometry. Low-resolution spectroscopy provided radial velocities of the brightest star cluster in SH2 and a nearby intermediate-age cluster. The results from this study suggest that SH2 is not a normal HII-region, ionized by very young stars. It contains a multitude of star clusters with ages of approximately 10 giga year. A ring-like morphology is striking. SH2 seems to be connected to an intermediate-age massive globular cluster with a similar radial velocity, which itself is the main object of a group of fainter clusters. Metallicity estimates from emission lines remain ambiguous. The study concluded that the present data do not yet allow firm conclusions about the nature or origin of SH2. It might be a dwarf galaxy that has experienced a burst of extremely clustered star formation. The study of sources like these could shed light on how globular clusters are donated to a parent galaxy, see Figure 5.



HST (WFPC2-F555W)

Color map (Washington C-R)



**Figure 5.** Left panel: the region of SH2 as seen on a WFPC2 exposure of 5000 s (filter F555W). The objects for which photometric values are given are indicated. Object 429 is a globular cluster. The other objects in the field are either foreground stars or background galaxies. Right panel: color map in C-R of the same region, constructed from MOSAIC images with lower spatial resolution. Bright is red, dark is blue with a dynamical range 0 < C - R < 2 mag. The background color is typically C - R = 1.3, the darkest spots have C - R = 0.2. The color map is shown with a larger scale to better demonstrate the color homogeneity of the surrounding and the blueish envelope of SH2.

### 2. Study of active galactic nuclei and galaxies

The central region of an active galaxy generates exceptionally large amount of energy. An active galactic nucleus emits over a wide range of wavelengths, from  $\gamma$ -ray to radio, the most powerful examples radiating thousand times as much energy as the galaxies within which they are embedded. The spectrum of the radiation emitted by an AGN is remarkably different from that of an ordinary galaxy which implies that some mechanism other than stellar radiation is required to explain its copious production of energy. Many AGNs appear to be ejecting jets of high energetic particles with one sided jets seen in some cases and two oppositely directed jets in others. It is believed that each and every AGN contains a supermassive black hole with a mass of between  $10^6 - 10^9$  M<sub>o</sub> that is accreting matter from its surroundings. The kinetic energy provided by infalling matter as it ploughs into the disk, and frictional effects within the disk, raise the temperature of the disk to very high values causing it to radiate copious amount of energy radiation. The radiation from all kinds of observed active galaxies such as Seyfert galaxies, radio galaxies, quasars, blazars could be explained based on a unified model. According to this model, the supermassive black hole and its inner accretion disk is surrounded by a thick dusty torus of matter, and the type of active galaxy that is seen depends on the orientation of the



torus and jets with respect to the line of sight of the observer. The extragalactic astronomy group which comes under WG – I carry out active research in active galaxies using the data obtained from national and international facilities.

#### 2.1 Study of double-double radio galaxies

The radio structures and optical identifications of a sample of 242 sources classified as double-double radio sources by Proctor (2011) from a morphological study of sources in the FIRST (Faint Images of the Radio Sky at Twenty centimeters) survey (2003 April release, 811,117 entries) was examined. This study has confirmed that of the total sources only 23 are likely to be double-double radio galaxies (DDRGs), whose structures could be

attributed to episodic nuclear activity in their host galaxies (examples see **Figure 6**). A further 63 require either higher-resolution radio observations or optical identifications to determine whether these are DDRGs. The remaining sources are unlikely to be DDRGs. The luminosities, sizes and symmetry parameters of the DDRGs and the constraints they place on our understanding of these sources were also examined in this study.

In an another study conducted on two well-known double-double radio galaxies, J0041+3224 and J1835+6204, radio observations at frequencies ranging from 150 to 8460 MHz were carried out using both the Giant Metrewave Radio Telescope (GMRT) and the Very Large Array (VLA). These observations, over a large radio frequency range,





Figure 6. Examples of double-double galaxies observed in our survey.



helped to determine the spectra of the inner and outer lobes (see **Figure 7**). Detailed spectral ageing analysis of their inner and outer lobes demonstrated that the outer doubles of double-double radio galaxies are created by the previous cycle of activity, while the inner doubles are due to the present cycle of activity. The (core subtracted) spectra of the inner doubles of both sources are power laws over a large frequency range. The study also found that the duration of the quiescent phase of J0041+3224 is between 4 and 28 per cent of the active phase of the previous activity. The outer north-western lobe of J1835+6204 has a compact hotspot and the regions of both the outer hotspots have close to power-law (rather than curved) spectra, which indicates that the outer lobes are still fed by jet material ejected in the previous episode just before the central engine stopped powering the jet. The duration of the quiescent phase of J1835+6204 is estimated to be  $\leq$ 5 per cent of the duration of the active phase of the previous activity. Therefore, it is concluded that the duration of the quiescent phase can be as short as a few per cent of the active phase in radio galaxies of this type.



**Figure 7**. Full-resolution radio images of J0041+3224 are shown. The frequency of each image and the telescope with which the image is made are given at the top of each image. The peak flux density, grey-scale level, first contour and the contour levels are all given at the bottom of each image. A'+' sign indicates the position of the optical galaxy. We have not shown the 325-MHz image as its quality is not good enough. However, the flux density seems to be consistent when compared with all other frequencies.



### 2.2 Study of the environments of large radio galaxies using SDSS

The distributions of galaxies in the environments of 16 large radio sources have been examined using the Sloan Digital Sky Survey. In the giant radio galaxy J1552+2005 (3C326) which has the highest arm-length ratio, the shorter arm is found to interact with a group of galaxies which forms part of a filamentary structure. Although most of the large sources occur in regions of low galaxy density, the shorter arm is brighter in most cases suggesting asymmetries in the intergalactic medium which may not be apparent in the distribution of galaxies. In two cases with strong and variable cores, J0313+4120 and J1147+3501, the large flux density asymmetries are possibly also caused by the effects of relativistic motion (see **Figure 8**).



**Figure 8.** Radio images towards J1552+2005 and J1113+4017. The image towards J1552+2005 is from the VLA Low-frequency Sky Survey (VLSS; Cohen et al. 2007), while the one towards J1113+4017 is from the NRAO VLA Sky Survey (NVSS; Condon et al. 1998). In all the figures the symbols are as follows: +: the positions of the host galaxies; ×: the positions of galaxies within  $\pm 1500 \text{ km s}^{-1}$  of the host galaxies; □ : positions of galaxies whose absolute recession velocities lie between 1500 and 2500 km s $^{-1}$  of the host galaxies. The magnitude and redshift distributions are given below each contour map. In all the figures, the shaded boxes show the distributions for sources within  $\pm 1500 \text{ km s}^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$  of the nost galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$  of the host galaxies whose absolute relative velocities lie between 1500 and 2500 km s $^{-1}$ 



### 2.3 Incidence of Mg II Absorption Systems toward Flat-spectrum Radio Quasars

The conventional wisdom that the rate of incidence of Mg II absorption systems, dN/dz (excluding "associated systems" having a velocity,  $\beta$ c, relative to the AGNs of less than ~5000 km/s), is totally independent of the background AGNs has been challenged by a recent finding that dN/dz for strong Mg II absorption systems toward distant blazars is 2.2 ± 0.7 times the value known for normal optically selected quasars (QSOs). This has led to the suggestion that a significant fraction of even the absorption systems with  $\beta$  as high as ~ 0.1 may have been ejected by the relativistic jets in the blazars, which are expected to be pointed close to our direction. This scenario was investigated using a large sample of 115 flat-spectrum radio-loud quasars (FSRQs) that also possess powerful jets, but are only weakly polarized. The investigation showed, for the first time, that dN/dz toward FSRQs is, on the whole, quite similar to that known for QSOs and that the comparative excess of strong Mg II absorption systems seen toward blazars is mainly confined to  $\beta < 0.15$ . The excess relative to FSRQs probably results from a likely closer alignment of blazar jets with our line of sight; hence, any gas clouds that are accelerated by the jets are more likely to be in the line of sight to the active quasar nucleus. The results are summarized in the histogram presented in **Figure9**.



**Figure 9.** Left: histogram of the weak  $(0.3\text{\AA} \le w_r (2796) < 1.0\text{\AA})$  "intervening" MgII absorption systems toward the FSRQs, w.r.t. the velocity of the absorber relative to the background FSRQ; thick black curve). The shaded region shows the corresponding histogram of the weak MgII absorption systems found in literature toward the blazars. Right: same as the left panel, but for strong MgII absorption systems ( $w_r (2796) \ge 1.0\text{\AA}$ ). This comparison is carried out using a subset of 15 FSRQs drawn from our FSRQ sample by applying a redshift matching with blazer sample after excluding the systems with  $\Delta v < 5000 \text{ km s}^{-1}$ .



### 2.4 Investigation of optical variability in active galactic nuclei

Many AGNs show significant variation in brightness over time scales of years, months, days or even hours. Because a source of light cannot vary in brightness on a timescale shorter than the time taken for light to cross the diameter of the source, these short-term variations imply that the energy source in AGNs must be very compact. For example, if an AGN varies in one year, its energy source must be not more than a light-year across; similarly if the variation occurs over a day, its energy source must be less than a light-day across.

An optical photometric monitoring programme of 10 extremely radio-loud broad absorption lines (RL-BALQSOs) with radio-loudness parameter, R, greater than 100 and magnitude g\_i < 19 were carried out. Over an observing run of about 3.5 - 6.5 h, the study found a clear detection of variability for one out of 10 RL-BALQSOs with the intranight optical variability duty cycle of 5.1 per cent, while on including the probable variable cases, a higher duty cycle of 35.1 per cent is found; which is very similar to the duty cycle of radio-quiet broad absorption line (BAL) quasars. This low duty cycle of clear variability per cent in radio-loud subclass of BALQSOs can be understood under the paradigm where BALs outflow may arise from large variety of viewing angles from the jet axis or perhaps being closer to the disc plane.

In an another study, an optical photometric monitoring of three narrow-line Seyfert 1 (NLSy1) galaxies from which  $\gamma$ -ray emission was detected by



**Figure 10.** Intranight Differential Light Curves (DLCs) for the  $\gamma$ -NLSy1 galaxy PMN J0948+0022. The variation of FWHM over the course of the night is given in the bottom panel. Above the top panel, the date and duration of observations are given.



the Large Area Telescope (LAT) on-board the Fermi Gamma-ray Space Telescope was carried out. The  $\gamma$ -ray emission in about half a dozen NLSy1 galaxies have been confirmed which indicates the presence of relativistic jets in these sources similar to blazars and radio galaxies. The aim of this study was to investigate the intranight optical variability (INOV) characteristics of these  $\gamma$ -ray-loud NLSy1 galaxies.

The three NLSy1 galaxies that were monitored are 1H 0323+342, PMN J0948+0022 (Figure 10) and PKS 1502+036. These optical monitoring observations in  $R_{\rm c}$  band carried out during 2012 January-May showed the presence of rapid optical flux variations in these sources. The intranight differential light curves of these sources have revealed flux variations on time-scales of hours with amplitudes of variability >3 per cent for most of the time. However, for one source, PMN J0948+0022, the amplitude of variability is shown to be as large as 52 per cent. On using the F-statistics to classify the variability nature of these sources, a duty cycle (DC) of INOV of ~85 per cent is estimated. Alternatively, the more commonly used C-statistics gave a DC of INOV of ~57 per cent. Such high DC of INOV is characteristics of the BL Lac class of active galactic nucleus. The results of this study indicate that there is a similarity between the INOV nature of y-ray-loud NLSy1 galaxies and the BL Lac objects, arguing strongly for the presence of relativistic jets aligned closely to the observer's line of sight in y-ray-loud NLSy1s. In addition to these, the high temporal resolution observations of this study showed a clear detection of some miniflares superimposed on the flux variations during a single night over time-scales as short as 12 min. The detection of short time-scale flux variability in the sources studied here is clearly due to stronger time compression leading to the jets in these sources having large Doppler factors, similar to that of the inner jets of TeV blazars.

An yet another study was conducted to investigate the INOV of powerful flat spectrum radio coredominated quasars (CDQs), with a focus to probe the relationship of INOV to the degree of optical polarization. As the existence of a prominent flatspectrum radio core signifies that strong relativistic beaming is present in all these CDQs, the definitions of the two sets differ primarily in fractional optical polarization, with the LPCDQs showing a very low median  $P_{00} \sim 0.4$  per cent. The study showed an INOV duty cycle (DC) of ~28 per cent for the LPCDQs and ~68 percent for HPCDQs. If only strong INOV with fractional amplitude above 3 per cent is considered, the corresponding DCs are ~7 per cent and ~40 per cent, respectively. From this strong contrast between the two classes of luminous, relativistically beamed quasars, it is apparent that relativistic beaming is normally not a sufficient condition for strong INOV and a high optical polarization is the other necessary condition. Moreover, the correlation is found to persist for many years after the polarization measurements were made. The study also pointed out some possible implications of this result particularly in the context of the recently detected rapid y-ray variability of blazars. The results are summarized in the Figure 11.

A short term optical monitoring program of 13 blazars was made in R band for a total of ~160 hours



**Figure 11.** Distribution of INOV amplitude ( $\psi$ ), for LPCDQs (*upper panel*; vertical stripes) and HPCDQs (*lower panel*; horizontal stripes), estimated from the DLCs drawn using the two comparison stars, CS1 and CS2.



between 2006 and 2011. The study showed that most of these sources could be described as slow, smooth and (almost) linear changes of up to  $\sim 0.1$ mag/hour, but that many objects show no short-term variations at all. In fact, this study found only a  $\sim 2$ per cent chance of observing variability of more than 0.1 mag/hour for the blazars. Hints of quasi-periodic oscillations at very low-amplitude levels are also shown in some of these objects (**Figure 12**).



**Figure 12**. A sketch showing the change of the jet direction and the corresponding angles. It blazars which includes 10 BL Lacertae objects (BL Lacs) and one flat spectrum radio quasar (FSRQ) was conducted. The study was basically made to measure the multiband optical flux and colour variations in these blazars on intraday and short-term time-scales of months and have limited data for two more blazars. These photometric observations were made during 2009-2011, using six optical telescopes, four in Bulgaria, one in Greece and one in India. On shortterm time-scales the study found significant flux variations in nine of the sources and colour variations in three of them. Intraday variability was detected on six nights for two sources out of the 18 nights and four sources for which such data was collected. The new optical observations of these blazars plus data from the literature (for three more blazars) are used to investigate their spectral flux distributions in the optical frequency range. The full sample for this purpose includes six highsynchrotron-frequency-peaked BL Lacs (HSPs), three intermediate-synchrotron-frequency-peaked BL Lacs (ISPs) and six low-synchrotron-frequencypeaked BL Lacs (LSPs; including both BL Lacs and FSRQs). The study also investigated the spectral slope variability and shown that the average spectral slopes of LSPs agreed very well with the synchrotron self-Compton loss dominated model. The results of this study support previous studies that found that the spectra of the HSPs and FSRQs have significant additional emission components.



**Figure 13.** Spectral indices,  $\alpha$ , against  $\log(v_{\text{peak}})$  for LSPs, ISPs and HSPs. Red symbols are  $\alpha$ s calculated from our data and black symbols are  $\alpha$ s taken from literature. Triangles represent LSPs, squares ISPs and filled circles HSPs. Open red circles represent the  $\alpha$ s of four sources (1ES 2344+514, Mrk 421, 1ES 1959+650 and 1ES 1426+428, from left to right) after host galaxy subtraction.



The spectra of all these HSPs and LSPs get flatter when they become brighter, while for FSRQs the opposite appears to hold. This supports the hypothesis that there is a significant thermal contribution to the optical spectrum for FSRQs. The results are presented in **Figure 13**.

A single BL Lac object, S5 0716+714, was monitored for a period of one-week in multiwavelength during 9-16 December of 2009. Nine ground-based telescopes at widely separated longitudes and one space-based telescope aboard the Swift satellite collected optical data. Radio data was obtained from the Effelsberg and Urumqi observatories and X-ray data from Swift. In the radio bands, the source showed rapid [~(0.5-1.5) day] intraday variability with peak amplitudes of up to ~ 10 per cent. The variability at 2.8 cm leads by about 1 d the variability at 6 and 11 cm. This time lag and more rapid variations suggest an intrinsic contribution to the source's intraday variability at 2.8 cm, while at 6 and 11 cm, interstellar scintillation



**Figure 14.** The broad-band (radio through optical to X-ray) variability observed in the source S5 0716+714 over the campaign period. (a) 0.2–10 keV light curve of the source; (b) optical light curves of the source in *B*, *V*, *R* and *I* passbands; (c) flux-density variability at 2.8 cm wavelengths; (d) the flux-density variability at 6.0 cm from two different telescopes (Effelsberg and Urumqi) and (e) flux-density variability at 11.0 cm wavelengths.



(ISS) seems to predominate. Large and guasisinusoidal variations of ~0.8 mag are shown to be detected in the V, R and I bands. The X-ray data (0.2-10 keV) do not reveal significant variability on a 4 d time-scale, favouring reprocessed inverse Compton over synchrotron radiation in this band. The characteristic variability time-scales in radio and optical bands are similar. A quasi-periodic variation of 0.9-1.1 d in the optical data may be present, but if so it is marginal and limited to 2.2 cycles. Cross-correlations between radio and optical bands are discussed in this study. The lack of a strong radio-optical correlation indicates different physical causes of variability (ISS at long radio wavelengths, source intrinsic origin in the optical) and is consistent with a high jet opacity and a compact synchrotron component peaking at ~100 GHz in an ongoing very prominent flux-density outburst. For the campaign period, a quasisimultaneous spectral energy distribution was constructed, including y-ray data from the Fermi satellite. Lower limits for the relativistic Doppler boosting of  $\delta \ge 12-26$ , which for a BL Lac-type object is remarkably high, is obtained in this study. The results are presented in Figure 14.

A GRB is a short-duration pulse of gamma radiation (<20 keV to energies up to tens of GeV). GRB durations range from 10 ms to 1000 s or more, but an average is about 10 s. For this short time, they may be the brightest objects in the gamma-ray sky. Ever since the serendipitous discovery of cosmic GRBs was announced in 1973, a large number of them have been detected. Although some of the basic physics of GRBs is now understood, the field is in many respects in its infancy. Many more observations are required to address the issues like; Can GRBs be used to trace star formation in the early universe?; Can GRBs be detected at redshifts corresponding to the reionization epoch?; What is the relation between GRBs and supernovae?; Why do some bursts display no radio or optical afterglows? and so on. Active research is been carried out in this field in ARIES.

A comprehensive analysis of a bright, long-duration (T  $_{90} \sim 257$  s) GRB 110205A at redshift z = 2.22 was conducted. The optical prompt emission was detected by Swift/UVOT (see **Figure 15**), ROTSE-IIIb, and BOOTES telescopes when the GRB was still radiating in the  $\gamma$ -ray band, with optical light curve showing correlation with  $\gamma$ -ray data. Nearly 200 s of observations were obtained simultaneously



## **Figure 15.** Prompt light curves of GRB 110205A from *Swift* BAT (green), XRT (red), and UVOT (blue). Arbitrary scale. For the UVOT data, the first data point is in *v* but has been normalized to *white* band, the rest of the data are in *white*. The vertical lines partition nine intervals for constructing the prompt spectra, where IntA and B are averaged ones.

### 3. Gamma-Ray Bursts



from optical, X-ray, to y-ray (1 eV to 5 MeV), which makes it one of the exceptional cases to study the broadband spectral energy distribution during the prompt emission phase. In particular, we clearly identify, for the first time, an interesting two-break energy spectrum, roughly consistent with the standard synchrotron emission model in the fast cooling regime. Shortly after prompt emission (~1100 s), a bright (R = 14.0) optical emission hump with very steep rise ( $\alpha \sim 5.5$ ) was observed, which is interpret as the reverse shock (RS) emission. It is the first time that the rising phase of an RS component has been closely observed. The full optical and X-ray afterglow light curves could be interpreted within the standard reverse shock (RS) + forward shock (FS) model. In general, the highquality prompt and afterglow data enabled the researchers to apply the standard fireball model to extract valuable information, including the radiation mechanism (synchrotron), radius of prompt emission ( $R_{GRB} \sim 3 \times 10^{13}$  cm), initial Lorentz factor of the outflow ( $\Gamma_0 \sim 250$ ), the composition of the ejecta (mildly magnetized), the collimation angle, and the total energy budget.

Although the majority of GRB events (27) have been identified by the Fermi-LAT collaboration, four were uncovered by using more sensitive statistical techniques. Three more GRBs associated with high-energy photon emission, GRB 110709A, 111117A, and 120107A have been studied further. These objects are identified using a pipeline that has been developed to work in almost real time utilizing a matched filter approach. Despite the reduced threshold for identification, the number of GRB events has not increased significantly. This relative dearth of events with low photon number prompted a study of the apparent photon number distribution. The study has shown an extremely good fit to a simple power law with an exponent of -1.8 ± 0.3 for the differential distribution (Figure 16). As might be expected, there is a substantial correlation between the number of lower energy photons detected by the



**Figure 16.** Scatter plot of the GBM photon count and LAT photon count for the 17 events with 750 durations greater than 1 s taken from Table 2. The diagonal solid red line indicates the median ratio of LAT to GBM photon counts. The dashed red lines correspond to ratios 3 times larger or smaller.

Gamma-ray Burst Monitor (GBM) and the number observed by LAT. Thus, high-energy photon emission is associated with some but not all of the brighter GBM events. Deeper studies of the properties of the small population of high-energy emitting bursts may eventually yield a better understanding of these entire phenomena.

The Swift era has posed a challenge to the standard blast-wave model of GRB afterglows. The key observational features expected within the model are rarely observed, such as the achromatic steepening ('jet break') of light curves. The observed afterglow light curves showcase additional complex features requiring modifications within the standard model. Optical/near-IR observations, millimetre upper limits and a comprehensive broad-band modeling of the afterglow of the bright GRB 0505025A, detected by Swift was conducted (see **Figure 17**). This afterglow cannot be explained by the simplistic form of the standard blast-wave model. It was attempted to model multiwavelength light curves using (i) a forward-reverse shock model,







(ii) a two-component outflow model and (iii) a blastwave model with a wind termination shock. The forward-reverse shock model cannot explain the evolution of the afterglow. The two-component model is able to explain the average behaviour of the afterglow very well but cannot reproduce the fluctuations in the early X-ray light curve. The wind termination shock model reproduces the early light curves well but deviates from the global behaviour of the late-time afterglow.

### 4. Numerical studies

A two-dimensional (2D) hydrodynamic simulation of rotating galactic winds driven by radiation was carried out. The study investigated the structure and dynamics of the gaseous component ( $T \approx 10^4$  K) which is mixed with dust. The study has taken into account the total gravity of a galactic system that consists of a disc, a bulge and a dark matter halo. It was shown that the combined effect of gravity and



**Figure 18.** Contours of  $\log_{10}(\rho)$  and **v**-field of a radiationdriven wind with  $\Gamma_0 = 2.0$  from an ED. t = 2 corresponds to 98 Myr.

radiation pressure from a realistic disc drives the gas away to a distance of ~5 kpc in ~37 Myr for typical galactic parameters. The outflow speed increases rapidly with the disc Eddington parameter  $\Gamma_0(=\kappa I/(2cG\Sigma))$  for  $\Gamma_0 \ge 1.5$ . The rotation speed of the outflowing gas is shown to be  $\le 100$  km s<sup>-1</sup>. The wind is confined in a cone that mostly consists of low angular momentum gas lifted from the central region. The results from the study are shown in **Figure 18**.

In an another numerical study, the viscous accretion disc around black holes, and all possible accretion solutions, including shocked as well as shock-free accretion branches were studied. The bipolar outflows studied here are shock-driven. One can identify two critical viscosity parameters,  $\alpha_{cl}$  and  $\alpha_{cu}$ , within which the stationary shocks may occur, for each set of boundary conditions. Adiabatic shock has been found for up to viscosity parameter  $\alpha = 0.3$ , while in the presence of dissipation and mass loss



the study found stationary shock up to  $\alpha = 0.15$ . The mass outflow rate may increase or decrease with the change in disc parameters, and is usually around a few to 10 per cent of the mass inflow rate. It is shown that for the same outer boundary condition, the shock front decreases to a smaller distance with the increase in  $\alpha$ . It is also shown that the increase in dissipation reduces the thermal driving in the post-

shock disc, and hence the mass outflow rate decreases up to a few per cent. See **Figure 19** for the results from the study.



**Figure 19.** Variation in *M* with log (*x*) for the accretion solutions with different viscosity parameter *a*. In a, e, i, m we present inviscid solutions corresponding to the O, A, W, I type of solutions from Figs 2(a)–(d). Towards right *E*,  $\lambda_0$  is kept the same but *a* is increased. The flow parameters for which these plots are generated *E* = 0.001,  $\lambda$  = 1.5 (a, b, c, d); *E* = 0.001,  $\lambda$  = 1.68 (e, f, g, h); *E* = 0.001,  $\lambda$  = 1.75 (i, j, k, l) and *E* = 0.005,  $\lambda$  = 1.75 (m, n, o, p). The viscosity parameter *a* is mentioned in the figure. The vertical long–short dashed line shows the location of sonic points.


#### **Research Working Group – II**

All the scientists working on the Sun and Atmospheric Sciences are members of WG – II. The group consists of 8 scientists. The solar physics research group (consisting of 2 scientists) is basically concentrated on the observations and modeling of the transients (e.g., flares and associated plasma processes, jets, spicules, etc.), space weather phenomena, and magnetohydrodyanmic waves in the solar atmosphere. Atmospheric Science group (consisting of 6 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**

### 1. Study of quasi-periodic phenomena associated with a large blowout solar jet

A variety of periodic phenomena were observed in conjunction with large solar jets. The aim of this scientific work was to find further evidence for quasiperiodic behaviour in solar jets and to determine what the periodic behaviour can tell us about the excitation mechanism and formation process of the

large solar jet. Using 304 Å (He-II), 171 Å (Fe IX), 193 Å (Fe XII/XXIV) and 131 Å (Fe VIII/XXI) filters onboard the Solar Dynamic Observatory (SDO) Atmospheric Imaging Assembly (AIA), the intensity oscillations associated with a solar jet were observed. This study provided evidence for multiple magnetic reconnection events occurring between a pre-twisted, closed field and open field lines. Components of the jet were seen in multiple SDO/AIA filters covering a wide range of temperatures, suggesting the jet could be classified as a blowout one (see Figure 20). Two bright, elongated features were observed to be co-spatial with the large jet, appearing at the foot points of the jets. Investigation of these features revealed that they are defined by multiple plasma ejections. The ejecta display quasi-periodic behaviour on timescales of 50 s and have rise velocities of 40-150 km s<sup>-1</sup> along the open field lines. Based on the suggestion that the large jet is reconnection-driven and from the observed properties of the ejecta, it is inferred that these ejecta events are similar to type-II

spicules. The bright features also showed quasiperiodic intensity perturbations on the timescale of 300 s. The existence of the quasi-periodic perturbations in terms of pulse-driven jet dynamics and the response of the transition region were found.



Figure 20. The evolution of the large blow-out jet at south polar corona with some brightening at its base, as well as its whipping-like motion.



### 2. Multiple Surges Associated with Magnetic Activities in AR 10484 on 2003 October 25

Solar surges are a kind of jets mostly associated with active regions and formed with cool plasma typically visible at chromospheric temperatures. they are supported to be formed by low atmospheric magnetic reconnection processes. However their exact triggering mechanisms are still debate. A multi-wavelength study of recurrent surges was performed using observations in Ha from ARIES facilities (see the left panel of Figure 21), UV (Solar and Heliospheric Observatory (SOHO)/EIT), and Radio (Learmonth, Australia) from the super-active region NOAA 10484 on 2003 October 25. Several bright structures visible in Ha and UV corresponding to subflares were also observed at the base of each surge. Type III bursts were triggered and RHESSI Xray sources were evident with surge activity. The major surge was found to contain bunches of ejective paths forming a fan-shaped region with an angular size of  $\approx$  65° during its maximum phase (see the right panel of Figure 21). The ejection speed reached up to  $\sim 200$  km s<sup>-1</sup>. The SOHO/Michelson Doppler Imager magnetograms revealed a large dipole that emerged from the east side of the active region on 2003 October 18-20, a

few days before the surges. On 2003 October 25, the major sunspots were surrounded by "moat regions" with moving magnetic features (MMFs). Parasitic fragmented positive polarities were pushed by the ambient dispersion motion of the MMFs and annihilated with negative polarities at the borders of the moat region of the following spot to produce flares and surges. A topology analysis of the global Sun using the Potential Field Source Surface showed that the fan structures visible in the EIT 171 Å images follow magnetic field lines connecting the present active region to a preceding active region in the southeast. Radio observations of Type III bursts indicated that they were coincident with the surges, suggesting that magnetic reconnection was the driving mechanism. The magnetic energy released by the reconnection was transformed into plasma heating and provided the kinetic energy for the ejections. Lack of radio signature in the high corona suggested that the surges were confined to follow the closed field lines in the fans. In conclusions, these cool surges might have some local heating effects in the closed loops, but probably played a minor role in global coronal heating and the surge material did not escape to the solar wind.





**Figure 21.** The ARIES Hα observations showing the formation of cool-surges (left-panel). The high-energy, hard X-ray sources are visible near the foot-point that reveal the photospheric reconnection driving the plasma along the open field lines (right-panel).



#### 3. A multiwavelength study of an M-class flare and the origin of an associated eruption from NOAAAR 11045

Solar flares are the giant energy explosions in the Sun's atmosphere, while coronal mass ejection (CMEs) are the propulsion of plasma blobs in the outer corona and in the interplanetary space. These are commonly known as space weather condidates and sometimes severely affect the Earth's outer atmosphere. A Multiwavelength study of an M6.4 flare in Active Region NOAA 11045 on 7 February 2010 was performed using the space- and groundbased observations from STEREO, SoHO/MDI, EIT, and Nobeyama Radioheliograph. This active region rapidly appeared at the north-eastern limb with an unusual emergence of a magnetic field. A unique observational signature of the magnetic field configuration at the flare site was identified. Observations showed a change from dipolar to guadrapolar topology. This change in the magnetic field configuration resulted in its complexity and a build-up of the flare energy without any signature of magnetic flux cancellation during this process. The change in the magnetic field configuration as a consequence of the flux emergence and photospheric flows having opposite vortices around the pair of opposite polarity spots, created the magnetic field complexity. The negative-polarity spot rotating counterclockwise broke the positivepolarity spot into two parts. The STEREO-A 195 Å (see Figure 22) and STEREO-B 171 Å coronal images during the flare revealed that a twisted flux tube expands and erupts resulting in a coronal mass ejection (CME). The formation of co-spatial bipolar radio contours at the same location also revealed the ongoing reconnection process above the flare site and thus the acceleration of non-thermal particles. The reconnection might also be responsible for the detachment of a ring-shaped twisted flux tube that further caused a CME eruption with a maximum speed of 446 km s<sup>-1</sup> in the outer corona.



**Figure 22.** The top panel showing the time-series of STEREO 195 displays the build-up of more complexity in the coronal loop fields that forces reconnection and cause the flux-rope eruption responsible for the CME eruption in the outer corona associated with M-class flare. The bottom panel displays the same phenomenon of the building up of the complexity in the photospheric magnetic fields of the active region.

#### 4. Multiwavelength study of Supersonic Plasma Blob Triggered by Reconnection-Generated Velocity Pulse in Ar10808

The magnetic field topology in the localized solar corona plays an important role in the dynamical processes (e.g. flares, plasma eruptions), as well as in the transport of energy via wave activity and confined plasma ejections. The dynamical corona in form of coupled plasma and magnetic fields is important for its heating and formation of supersonic wind. In the present work, using multi-wavelength



observations of Solar and Heliospheric Observatory (SoHO)/Michelson Doppler Imager (MDI), Transition Region and Coronal Explorer (TRACE, 171 Å), and H $\alpha$  from Culgoora Solar Observatory at Narrabri, Australia, a unique observational signature of a propagating supersonic plasma blob before an M6.2-class solar flare in active region 10808 on 9 September 2005 was identified. The blob was observed between 05:27 UT and 05:32 UT

with almost a constant shape for the first 2 - 3 min, and thereafter it quickly vanished in the corona. The observed lower-bound speed of the blob was estimated as  $\approx 215$  km s<sup>-1</sup> in its dynamical phase. The evidence of the blob with almost similar shape and velocity concurrent in H $\alpha$  and TRACE 171 Å images supported its formation by a multitemperature plasma. The energy release by a recurrent three-dimensional reconnection process



**Figure 23.** Top-left panel shows the formation of supersonic plasma blob above AR10808. Top-right panel displays the numerical simulation of the blob due to reconnection generated velocity pulse. Bottom-panel shows the PFSS extrapolation of magnetic field configuration that is associated with the magnetic null point. The reconnection below the null point may cause the formation of the blob.



via the separator dome below the magnetic null point, between the emerging flux and pre-existing field lines in the lower solar atmosphere, was found to be the driver of a radial velocity pulse outwards that accelerated this plasma blob in the solar atmosphere. In support of identification of the possible driver of the observed eruption, the twodimensional ideal magnetohydrodynamic equations were solved numerically to simulate the observed supersonic plasma blob. The numerical modelling closely matched with the observed velocity, evolution of multi-temperature plasma, and quick vanishing of the blob found in the observations. Under typical coronal conditions, such blobs may also carry an energy flux of  $7.0 \times 10^6$  erg cm<sup>-2</sup> s<sup>-1</sup> to balance the coronal losses above active regions. The results are presented in **Figure 23**.

### 5. The Kinematics and Plasm a Properties of a Solar Surge Triggered by Chromospheric Activity in AR11271

Solar surges may be driven by photospheric direct reconnections processes. However, sometime the indirect consequences of the reconnection (e.g. triggering of heating pulse) may be an efficient mechanism to drive these jets in solar active regions. A solar surge was observed in NOAA AR11271 using the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly 304 Å image data on 2011 August 25. The surge arose vertically from its origin up to a height of  $\approx$  65 Mm with a terminal velocity of  $\approx$  100 km s<sup>-1</sup>, and thereafter moved







**Figure 24.** Top-panels : *SDO*/AIA 193 Å (right, yellow-brown map for 1.0 MK plasma) and 304 Å (left, red temperature map for 0.1 MK plasma) EUV images overlaid by HMI magnetic field contours of maximum level ±800 G. Yellow (blue) contours show positive (negative) polarity of the magnetic field. The surge origin is accompanied by heating above its foot point. The observed surge is clearly evident in the He II 304 Å filter that is sensitive to the low-temperature plasma of 0.1 MK. Some heated part of the surge especially near its base up to the height of 20–30 Mm is also evident in the coronal filters (e.g., 193 Å) that are sensitive to the plasma temperature around 1.0 MK. The surge is originated from the western boundary of the positive polarity situated in the northwest direction of the big sunspot with negative polarity as represented by the blue circular contour at  $X = 700^{\circ}$ ,  $Y = 200^{\circ}$ . Bottom-Panels : Numerical simulation of the surge with temperature (right) and density (left) maps overplotted with velocity vectors of the unit of 150 km/s

downward and faded gradually. The total lifetime of the surge was  $\approx$  20 minutes. The measurements of the temperature and density distribution of the observed surge during its maximum rise were done that find an average temperature and a density of 2.0 MK and 4.1  $\times$  10<sup>9</sup> cm<sup>-3</sup>, respectively. The temperature map showed the expansion and mixing of cool plasma lagging behind the hot coronal plasma along the surge. Because SDO/HMI temporal image data did not show any detectable evidence of significant photospheric magnetic field cancellation for the formation of the observed surge, which infer that it was probably driven by magneticreconnection-generated thermal energy in the lower chromosphere. The radiance (and thus the mass density) oscillations near the base of the surge were

also evident, which may be the most likely signature of its formation by a reconnection-generated pulse. In support of observational baseline of the triggering of the surge due to chromospheric heating, a numerical model was devised with conceivable implementation of the VAL-C atmosphere and a thermal pulse as an initial trigger. The pulse steepened into a slow shock at higher altitudes which triggered plasma perturbations exhibiting the observed features of the surge, e.g., terminal velocity, height, width, lifetime, and heated fine structures near its base. See **Figure 24**.

### 6. Pulse-driven Non-linear Alfvén Waves and their Role in the Spectral Line Broadening

Alfvén waves are the true incompressible MHD



waves that can propagate along the magnetic field lines by perturbing the field lines transversely in perpendicular to their plane. These wave can be important in coronal heating and in providing momentum to the solar wind. Although, these wave modes are difficult to be observed in solar corona, and can be detected in form of non-thermal line broadening of spectral lines. Study of the impulsively generated non-linear Alfvén waves in the solar atmosphere was performed that describes the most likely role of such waves in the observed non-thermal broadening of some spectral lines in solar coronal holes. Numerical solutions of the timedependent magnetohydrodynamic equations were performed to find temporal signatures of largeamplitude Alfvén waves in the solar atmosphere model of open and expanding magnetic field configuration, with a realistic temperature distribution (see Figure 25). Calculations of the temporally and spatially averaged, instantaneous



transversal velocity of non-linear Alfvén waves at different heights of the model atmosphere were executed to estimate its contribution to the unresolved non-thermal motions caused by the waves. The pulse-driven non-linear Alfvén waves with the amplitude  $A_{v} = 50 \text{ km s}^{-1}$  were the most likely candidates for the non-thermal broadening of Si viii  $\lambda$ 1445.75 Å line profiles in the polar coronal hole as reported by Banerjee et al (1998). The Alfvén waves driven by comparatively smaller velocity pulse with amplitude  $A_v = 25 \text{ km s}^{-1}$  might contribute to the spectral line width of the same line at various heights in coronal hole broadening. In conclusion, the nonlinear Alfvén waves excited impulsively in the lower solar atmosphere might be responsible for the observed spectral line broadening in polar coronal holes. This was an important result based on which it could be concluded that such large amplitude and pulse-driven Alfvén waves may exist in solar coronal holes. The existence of these waves may impart the required momentum to accelerate the solar wind.

#### 7. Discovery of Sausage-pinch Instability in Solar Corona



In a magnetic cylinder, the radially inward directed

**Figure 25.** Left-panel : Computational domain of Alfven waves and the resulting transverse velocity Vz profile calculated at t = 30 s for Av = 25 km s<sup>-1</sup>. Right-Panel : Profile of FWHM ( $\sigma$ ) for line 1445.75 Å as a function of the amplitude of initial pulse, Av generating transverse waves. The plus marks denote values of  $\sigma$  obtained at y = 20 Mm height, the stars denote those obtained at y = 40 Mm height in coronal-hole.



Loreutz force is balanced by thermal pressure gradient. In the absence of longitudinal magnetic field the plasma segment becomes sausage unstable where the confining field is concave. While at other locations the confined or pinched regions are evident (cf., figure 24 right panel). A very interesting result was reported by the solar group on the discovery of sausage-pinch instability which could be termed as one of the path breaking scientific findings in the current year 2013 among different new discoveries of the solar corona. The sausage-pinch instability that was only established in the theory, was for the first time, identified in the observational base-line of the SDO/AIA in the solar corona (cf., http://www.uksolphys.org/ukspnugget/34-discovery-of-the-sausage-pinchinstability-in-solar-corona/). The first observational evidence of the evolution of sausage-pinch instability in an active region 11295 during a prominence eruption using data recorded by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) on 12 of September 2011 was provided (see Figure 26). A magnetic flux tube visible in AIA 304 Å showed curvatures on its surface with variable crosssections as well as enhanced brightness. These

curvatures evolved and thereafter smoothed out within a timescale of a minute. The curved locations on the flux tube exhibited a radial outward enhancement of the surface of about 1-2 Mm from the equilibrium position. AIA 193 Å snapshots also showed the formation of bright knots and narrow regions in-between at the four locations as that of 304 Å along the flux tube where plasma emission was larger compared to the background. The formation of bright knots over an entire flux tube as well as the narrow regions in <60 s may be the morphological signature of the sausage instability. The flows of confined plasma (propagation of brightness) in these bright knots along the field lines are evident, which indicates the dynamicity of the flux tube that probably causes the dominance of the longitudinal field component over short temporal scales. The observed longitudinal motion of the plasma frozen in the magnetic field lines further vanished the formed curvatures and plasma confinements as well as growth of instability to stabilize the flux tube.

#### **Atmospheric Sciences**



#### 1. Trace Gases, Aerosols and Meteorology



**Figure 26.** Upper-Panel : The right-most composite SDO/AIA image displays AR11295 on 12 September 2011 before a C-class flare, which is showing an activated part of the flux-tube. The zoomed view of the magnetic flux-tube is shown in AIA 193Å (left-top) and 304Å (left-bottom) with the evolution of brightened sausage knots as well as pinched regions inbetween. Bottom-Panel : Schematic of the physical mechanism of sausage instability in z-pinch (a) and  $\theta$ -pinch (b) of the plasma cylinder.



#### 1.1 Surface ozone in the Indo-Gangetic Plane

Surface ozone observations are made at a semiurban site in the IGP region and analyzed together with data from space-borne sensors and model results. Ozone mixing ratios show a daytime photochemical buildup with ozone levels sometimes as high as 100 ppbv. Seasonal variation in 24-h average ozone shows a distinct spring maximum (39.3+/- 18.9 ppbv in May) while daytime average ozone shows an additional peak during autumn (48.7 +/- 13.8 ppbv in November). The daytime, but not daily average, observed ozone seasonality is in agreement with the space-borne observations of OMI tropospheric column NO<sub>2</sub>, TES CO (681 hPa), surface ozone observations at a nearby high altitude site (Nainital) and to an extent with results from a global chemistry transport model (MATCH-MPIC). It is suggested that spring and autumn ozone maximum are mainly due to photochemistry, involving local pollutants and small-scale dynamical processes. Biomass burning activity over the northern Indian region could act as an additional source of ozone precursors during spring. The seasonal ozone photochemical buildup is estimated to be 32-41 ppbv during spring and autumn and 9-14 ppbv during August-September. A correlation analysis between ozone levels at Pantnagar and Nainital along with the mixing depth data suggests that emissions and photochemical processes in the IGP region influence the air guality of pristine Himalayan region, particularly during midday hours of spring. Ozone seasonality over the IGP region is different than that over southern India. Results from the MATCH-MPIC model capture the observed ozone seasonality but overestimate ozone levels. Model simulated daytime ratios of H2O2/HNO3 are higher (Figure 27) implying that this region is coming under a NOx-limited regime. A chemical box model (NACR Master Mechanism) is used to further corroborate this using a set of sensitivity simulations, and to estimate the integrated net ozone production in a day (72.9 ppbv) at this site.

### **1.2 Modelling of the Tropospheric Chemistry over South Asia**

Annual simulations of tropospheric ozone and related species made for the first time using the WRF-Chem model over South Asia for the year



**Figure 27.** MATCH-MPIC simulated seasonal variations in the daytime H2O2/HNO3 ratios at Pantnagar during January-December 2010.

2008. The model-simulated ozone, CO, and NOx are evaluated against ground-based, balloon-borne and satellite-borne (TES, OMI and MOPITT) observations. The comparison of model results with surface ozone observations from seven sites and CO and NOx observations from three sites indicate the capability of the model to reproduce the seasonal variations of ozone and CO, but show some differences in NOx. The vertical distributions of TES ozone and MOPITT CO are generally well reproduced, but the model underestimates TES ozone, OMI tropospheric column NO<sub>2</sub> and MOPITT total column CO retrievals during all the months, except MOPITT retrievals during August-January and OMI retrievals during winter. Largest differences between modeled and satelliteretrieved quantities are found during spring when intense biomass burning activity occurs in this region. The evaluation results indicate large uncertainties in anthropogenic and biomass burning emission estimates, especially for NOx. The model results indicate clear regional differences in the



seasonality of surface ozone over South Asia, with estimated net ozone production during daytime over inland regions of 0-5 ppbv h<sup>-1</sup> during all seasons and of 0-2 ppbv h<sup>-1</sup> over marine regions during outflow periods. The model results indicate that ozone production in this region is mostly NOxlimited. This study shows that WRF-Chem model captures many important features of the observations and gives confidence to using the model for understanding the spatiotemporal variability of ozone over South Asia. For results, see **Figure 28**.

#### 1.3 Tropospheric Study using CO as a tracer:

After successful setup of WRF-Chem for South Asia, this model was modified by incorporating



**Figure 28.** Spatial distribution of WRF-Chem simulated surface ozone during January (winter), April (spring), August (summer-monsoon) and October (autumn) of the year 2008. Monthly mean 10 m wind vectors are also shown.

eleven CO tracers to study CO source contribution. These eleven tracers track CO from different source types and regions. The comparison of model results with CO data from a space-borne sensor (Measurement of Pollution in the Troposphere; MOPITT) shows that the model reproduces the spatial, vertical, and temporal distributions of MOPITT CO retrievals fairly well, but generally overestimates CO retrievals in the lower troposphere. The CO mixing ratios averaged over the model domain at the surface, in the planetary boundary layer, and the free troposphere are estimated as 321+/-291, 280+/-208, and 125+/-27 ppbv, respectively. Model results show that wintertime CO in the boundary layer and free troposphere over India is mostly due to anthropogenic emissions and to CO inflow. In the boundary layer, the contribution from anthropogenic sources dominates (40-90%), while in the free troposphere the main contribution is due to CO inflow from the lateral boundaries (50-90%). The anthropogenic sources in the IGP region are found to contribute, on average, 42% and 76% to anthropogenic surface CO over the Arabian Sea and the Bay of Bengal, respectively (Figure 29). The anthropogenic emissions from western and southern India contribute 49% to anthropogenic surface CO over the Arabian Sea. Anthropogenic emissions contribute only up to 40% over Burma where biomass burning plays a more important role. Regional transport contributes significantly to total anthropogenic CO over southern India (41%), Burma (49%), and even exceeds the contribution from local sources in western India (58%).

#### 1.4 Influence of Volcanic SO<sub>2</sub> over Northern India

Influence of a volcano eruption in Africa (Dalaffilla, Ethiopia) has been shown over northern India as a result of long-range transport. Monthly averaged





**Figure 29.** Spatial distribution of surface CO emitted from anthropogenic sources in Northern India (CO-ANI), Western India (CO-AWI), Eastern India (CO-AEI), Southern India (CO-ASI), Burma (CO-ABUR), and other regions (CO-OTH) averaged at the surface during January–February 2008. Average 10 m wind vectors are also shown.

column SO<sub>2</sub> values over the IGP were observed in the range of 0.6–0.9 Dobson units (DU) during November 2008 using observations from the Ozone Monitoring Instrument (OMI). These concentrations were conspicuously higher than the background concentrations (<0.3 DU) observed during 2005–2010 over this region. These enhanced SO<sub>2</sub> levels were not reciprocated in satellite-derived NO<sub>2</sub> or CO columns, indicating transport from a nonanthropogenic SO<sub>2</sub> source. Wind fields and backtrajectory analysis revealed a strong flow originating from the volcanic eruption site during 4–6 November 2008.

### **1.5 Top-of-atmosphere radiative cooling with white roofs**

Differences in clear-sky upwelling shortwave radiation reaching the top of the atmosphere in response to increasing the albedo of roof surfaces in an area of India with moderately high aerosol loading is evaluated. Treated (painted white) and untreated (unpainted) roofs on two buildings in northern India were analyzed on five cloudless days using radiometric imagery from the IKONOS satellite. Comparison of a radiative transfer model (RRTMG) and radiometric satellite observations shows good agreement (R2 D 0:927). Results show a mean increase of  $\sim$ 50 W m<sup>-2</sup> outgoing at the top of the atmosphere for each 0.1 increase of the albedo at the time of the observations. These results are shown to depend strongly on the atmospheric transmissivity.



#### **1.6 Vertical distribution of Aerosol Extinction Profile**

The aerosol extinction profile was derived in this study. The profile derived using LIDAR shows no extinction below 0.43 km because of the negligible concentration of aerosols due to boundary layer dynamics as the site in free troposphere (**Figure 30**). The integrated aerosol extinction profile by LIDAR is ~ 45% that of derived aerosol optical depth (AOD) by sun photometer. The rest of the optical depth is due to aerosols which are below the 0.43 km. A default profile of aerosol extinction has been considered from Radiative Transfer model below the 0.4 km to fill the gap which was not observed by LIDAR. This result is shown after integrating the derived extinction profile and equated to the aerosol optical depth observed by the sun photometer.

#### 2. Dynamics and Meteorology

### 2.1 Precipitation study using a 404 MHz wind profiler:

This study show the tropical precipitation and classification of precipitating systems into stratiform



Figure 30. The aerosol extinction profile as a function of height.

and convective type, using the UHF wind profiler located at Indian tropical station Pune (18°32′ N, 73° 51′ E). Under moderate rain conditions the two signals arising due to clear air motions and precipitation are clearly distinguished in the power spectra. An algorithm with suitable methodology has been developed that separates clear air and precipitation echoes when they are clearly distinguishable as seen in the power spectrum. The sensitivity of the threshold is tested for the precipitation observed on 25 July 2005. In addition, case studies of stratiform rain (precipitation observed over the site on 26 July 2005, 0800Hrs, local time) and convective system (a thunderstorm observed on 16 May 2004) are studied and



**Figure 31.** The observed parameters during convective rain are vertical velocity in ms<sup>-1</sup>; negative values indicate downward motion (top panel), reflectivity in dBZe (middle panel) and spectral width (ms<sup>-1</sup>; bottom panel).



discussed. This is the major application of UHF radar at Pune to characterize the precipitation events in terms of stratiform and convective rain (see Figure 31).

#### 2.2 The boundary layer evolution and ozone

Collocated measurements of the boundary layer evolution and surface ozone, made for the first time at a tropical rural site (Gadanki 13.5°N, 79.2°E, 375 m amsl), show correlated day-to-day variability in the daytime boundary layer height and ozone mixing ratios. The boundary layer related observations were made utilizing a lower atmospheric wind profiler and surface ozone observations were made using a UV analyzer. Daytime average boundary layer height varied from 1.5 km (on a rainy day) to a maximum of 2.5 km (on a sunny day). Days of higher ozone mixing ratios are associated with the higher boundary layer height and vice versa. A chemical box model simulation indicates about 17% reduction in the daytime ozone levels during the conditions of suppressed PBL in comparison with those of higher PBL conditions. On a few occasions, substantially elevated ozone levels (as high as 90 ppbv) were observed during late evening hours, when photochemistry is not intense. These events are shown to be due to southwesterly wind with uplifting



**Figure 32.** Daily variations in surface ozone and height of the convective boundary layer at Gadanki. Upper and lower sides of box are 75th and 25th percentile and whiskers are 95th and 5th percentiles.

and northeasterly winds with downward motions bringing ozone rich air from nearby urban centers. This was further corroborated by backward trajectory simulations.

#### 2.3 Generation, analysis and evaluation of biphase complementary pairs:

Bi-phase complementary codes are commonly used in radar application to achieve high resolution spatial and temporal measurements with suppressed range side lobes. In this study, a user friendly interactive graphical user interface (GUI) based tool capable of generating and analyzing a pair of complementary sequences of length upto 512 is presented. The effect of code length on key code parameters like merit factor, discrimination etc were evaluated and presented. In addition, ninetysix basic sets of 16-bit complementary pair searched through Monte-Carlo based search routine are tabulated. An empirical relation between code length and maximum possible set of basic complementary pairs is also established.

#### 3. Sporadic meteor flux over Thumba

Altitudinal and latitudinal dependence of the diurnal variation of sporadic meteor flux rate based on radar observations made from Thumba (8.5°N, 77°E), Darwin (12.5°S, 130.8°E), Buckland Park (34.4°S, 138.3°E), and Davis (68.6°S, 78.0°E) are investigated. The most remarkable observation was the occurrence of a secondary peak at Thumba occurring at 0300 LT prior to the occurrence of the commonly observed morning peak occurring at 0600 LT at all altitudes. Surprisingly, the secondary peak has not been observed at Darwin, which is a low latitude station close to that of Thumba but in the southern hemisphere. Moreover, secondary peak has also not been observed at other higher latitude stations (Figure 33). The observed diurnal rates show seasonal and also latitudinal variability, which are interpreted in terms of observing geometry of the



sporadic meteor sources in the local sky. The observations made for this study also suggest that there exists asymmetry in the northern and the southern hemisphere sporadic meteor flux.



**Figure 33.** Altitudinal and latitudinal dependence of the diurnal variation of sporadic meteor flux rate based on radar observations made from Thumba (8.5°N, 77°E), Darwin (12.5°S, 130.8°E), Buckland Park (34.4°S, 138.3°E), and Davis (68.6°S, 78.0°E).



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- Multiwavelength studies of galactic star forming regions, C. Eswaraiah, (Supervisor & Co-Supervisor: A. K Pandey and H. C. Chandola), *Kumaun University*, March, 2013.



### **RESEARCH PROJECTS**

During the year 2012-2013 following research projects were funded from outside.

Project Title: Formation and evolution of star cluster.P.I.: A. K. PandeyFunding Agency: Department of Science and Technology, Govt. of India.

Project Title: Time resolved photometric and spectroscopic study of the chemically peculiar A-type stars.P.I.: Santosh JoshiFunding Agency: Department of Science and Technology, Govt. of India.

Project Title: Search and Study of Variability in Ap and Am StarsP.I.: Dr.Santosh JoshiFunding Agency: Department of Science and Technology, Govt. of India.

**Project Title:** Study of dynamical events in the solar atmosphere during maximum of Solar Cycle 24". **P.I.:** A. K. Srivastava **Funding Agency:** DST-RFBR.

**Project Title:**Multiwavelength Study of Solar Eruptive Phenomena and their Interplanetary Response **P.I.**: Wahab Uddin **Funding Agency:** IUSSTF

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

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

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



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

**Project Title:** Designing & developing of a 4k x 4k CCD camera for astronomical applications. **P.I.:** Amitesh Omar **Funding Agency:** MoU of ARIES & NRC-NSI, Canada

Project Title: Characterization of the 3.6 meter Indian Optical Telescope's active optics mirror under fabrication at Russia.P.I.: Amitesh Omar

Funding Agency: DST-REBR



### **IMPORTANT HIGHLIGHTS OF INTERNATIONAL PROJECTS**

**Title of the Project:** Search and Study of Variability in Ap and Am Stars

**Name of the P.I.:** Dr. Santosh Joshi, AIRES, Nainital and Dr. Peter Martinez, SAAO, South Africa

#### Research output of the project with highlights

More than 200 hundreds candidates stars were monitored in the fast photometric mode from ARIES, Nainital and SAAO, South Africa. The first results of the project were published by Joshi et al. (2009). During the survey mode we found the signature of the photometric variability in an Ap star HD103498. To confirm our results the follow-up photoelectric monitoring of this star was performed from ARIES, Nainital. In order to determine the chemical abundance of this star, the high-resolution spectroscopic observations were carried out from La Palma Spain. The results from the combined photometric and spectroscopic observations were published by Joshi et al. (2010). In the literature there is evidence of the binarity nature of HD103498. To confirm it, the time-series CCD photometric observations were taken from the Maidanak observatory 0.60-m telescope in Uzbekistan. Our data analysis show that HD103498 is a confirm member of the binary system. The results were published in the International meeting on "Magnetic Stars" at Special Astrophysical Observatory (SAO), Nizhny Arkhyz, Russia from 26 August to 01 September, 2010 (Joshi et al. 2011a). We presented the overview of our Indo-South African project in an International Conference entitled "Asia Oceania Geoscience Socity (AGOS)" held at Hyderabad from 5-9 July 2010 and the contribution were published in the proceeding of the conference (Joshi et al. 2011b). In order to search for the photometric variability in Ap and Am stars belonging to the open star clusters we have been monitoring a set of intermediate age open clusters

since last few years. For this the time-series photometric observations of an open star cluster NGC6866 was taken from ARIES, Nainital. We discovered more than 20 new variable stars in this cluster and the results obtained on the detail study of the cluster were published by Joshi et al. (2012). The cluster NGC6866 was also observed by the Kepler space telescope. The Kepler data analysis revealed more than hundreds new variable stars in this cluster and the results of this study are published by (Balona et al. 2013). At the end the results obtained under the Indo-South African project are compiled in the form of an online data base which are now available publically. The detail information on the Indo-South African project can be access through the URL http://www.aries.res.in/ ~cns/

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- Joshi, Y. C.; Joshi, S.; Kumar, B.; Mondal, S.; Balona, A.; Photometric study and detection of variable stars in the open clusters-I: NGC6866, 2012, MNRAS, 419, 2379.



**Title of the Project:** Designing & developing of a 4k x 4k CCD camera for astronomical applications.

**Implementation:** Under Memorandum of Understanding (MoU) of ARIES, Nainital with Herzberg Institute of Astrophysics (NRC-NSI), Canada.

**Name of the P.I.:** Amitesh Omar (PI-India), T.S. Kumar (co-I), David Loop (PI- Canada), Tim Hardy, and Greg Burley (co-Is).

A MoU was signed with National Science Infrastructure (NRC-NSI), Canada on May 31, 2012 to develop a cryogenically cooled CCD camera for applications in back end instruments of the 3.6 meter Devasthal Optical Telescope. Under this program, ARIES gained access to technical expertise and laboratory of HIA, Canada to develop the camera. PI and Co-I visited HIA, Canada in Nov. – Dec. 2012 to start the project work. The major achievements in 2012-2013 are -

- The components (CCD chip, cryo-systems, electronic controller etc.) have been procured and inspected in lab.
- A custom made CCD fan-out electronic circuit board has been designed and completed.
- Initial testing of controller circuit has been successfully completed at Canada.
- A second visit is planned to HIA, Canada between July-September, 2013 to complete the integration and final testing of the camera. The MoU is effective until September 2013.

**Title of the Project:** Characterization of the 3.6 meter Indian Optical Telescope's active optics mirror under fabrication at Russia.

#### Implementation: DST-RFBR (No. B 3.22)

Name of the P.I.: Amitesh Omar (PI), Brijesh Kumar (co-I), Y.Y. Balega (PI), A. Yascovich (Co-I)

DST sanctioned this project under RFBR / ILTP program (Russia) in order to enable ARIES to closely monitor the 3.6 meter active mirror figuring & polishing being carried out at LZOS, Moscow. During the visits to Moscow and afterwards, the progress of the mirror was found to be satisfactory. The data generated from the tests done at factory were inspected and found to be conforming the specifications. The mirror was shipped to Belgium (AMOS, the telescope manufacturer) in June 2012. The major achievements in 2012 - 2013 are -

- The 3.6 meter mirror was integrated into the telescope at AMOS, Belgium.
- The active optics tests were witnessed in March July 2012 and found to be meeting the general specifications.
- The sky tests were carried out and stellar images obtained using the 3.6 meter mirror system were satisfactory within the atmospheric seeing obtained at AMOS factory.

This project has been completed in 2013.

**Title of the Project:** Formation and Evolution of Star Cluster

Name of the P.I.: Dr. A. K. Pandey, ARIES, Nainital and W. P. Chen, NCU, Chung-Li, Taiwan

#### Research output of the project with highlights:

The project "Formation and Evolution of Star Cluster" was successfully completed on March 31, 2013. The duration of this project was three years



and the project was funded by Global Innovation Technology Alliance (GITA)-DST and NSC Taiwan under India-Taiwan S&T Cooperation Programme . The objectives of the collaboration was to study the initial mass function (IMF), star formation scenario and evolution of the clusters. We analyzed the photometric and polarimetric data of young star clusters taken with 1.04-m telescope of ARIES to understand the IMF, variability of T-Tauri stars, dust properties as well as to map the magnetic field orientation in the star forming region.

The Indo-Taiwan S&T Cooperation Programme provided an opportunity to initiate an active collaboration between ARIES (India) and NCU (Taiwan) at the faculty as well as students level. Ten exchange visits by Taiwanese students and 2 exchange visits by Indian students were carried out. Both the sides were benefited by the expertise of other side. NCU, Taiwan research students used the observational facilities available at ARIES. The polarimetric observations carried out by Taiwanese students using the polarimeter developed indigenously at ARIES will be the part of the thesis of Taiwanese students. The Taiwanese collaborator provided near-infrared (NIR) polarimetric data and trained ARIES research student in processing the NIR polarimetric data. The data has been used by ARIES student in his thesis work. The active collaboration under project has produced 8 papers in international refereed journals.

**Title of the Project:** Multiwavelength Study of Solar Eruptive Phenomena and their Interplanetary Response

Indian Pl and Nodal Project Coordinator: Wahab Uddin, Aryabhatta Research Institute of Observational Sciences (ARIES), Manora Peak, Nainital, Uttarakhand, India

**US PI:** Dr. N. Gopalswamy, Astrophysicist, NASA

Goddard Space Flight Center, Greenbelt, USA

This is an Indo-US Science and Technology Forum (IUSSTF) Joint Center Project on Solar Eruptive Phenomena ("IUSSTF/JC-Solar Eruptive Phenomena/99-2010/2011-2012") entitled "Multiwavelength Study of Solar Eruptive Phenomena and their Interplanetary Responses" funded by IUSSTF. Dr. Wahab Uddin is the P.I. and Nodal Project Coordinator from the nodal host institute Aryabhatta Research Institute of the Observational Sciences (ARIES), Manora Peak, Nainital, while Prof. Nat Gopalswamy is the US PI from GSFC-NASA. Other co-investigators are Dr. A.K. Srivastava (ARIES), Prof. Rajmal Jain (PRL, Ahmadabad), Prof. P.K. Manoharan (RAC, NCRA-TIFR, Ooty), Dr. Ramesh Chandra (KU, Nainital), Prof. Debi Prasad Choudhary (The California State University, Northridge, LA, USA), Prof. Markus Aschwanden and Dr. N.V. Nitta (LMSAL), as well as various students and postdoctoral researchers from Indian and US sides.

#### Scientific Objectives of the Projects:

- Origin of Eruptive Events (Initiation, Early acceleration, energy build-up and energy release processes in active region, waves and shocks).
- 2. Propagation of CMEs (Interplanetary Scintillations (IPS), IP type II bursts, in-situ observations of CMEs).
- Geoimpact of Eruptive Events (Solar Energetic Particles, Energetic Storm Particles, Geomagnetic storms, and ionospheric effects, VLF propagation effects).
- Impact on surrounding structures (coronal hole deflection and oscillation in active region loops, interaction of global EUV waves with coronal magnetic structures).



In the duration of the two years of the project (2011-2013), the various scientific research works have been carried out to understand the origin of solar eruptive events (e.g., solar flares, CMEs, eruptive prominences) and associated plasma processes, and their responses to the Earth's outer atmosphere under the prospective of the space weather. Several important papers have been published. Here we are presenting the main results of these various research works.

#### Scientific Results:

 Based on the results from this project Gopalswamy et al. (2013) have reported that it was the height of the shock formation using the radio observations and CME kinematics in the outer corona, which is an important physical scenario in the CME accelerating regions and also crucial for the interplanetary CMEs. We used the wave diameter and leading edge methods (see for example c.f., Figure 34) and measured the CME heights for a set of 32



**Figure 34.** (a) Dynamic spectrum from the Culgoora radio observatory showing the type II burst with fundamental (F) and harmonic (H) structure. The fundamental component starts around 150 MHz. (b) A section of the nearest EUVI A image showing the CME. The CME height can be directly measured from this frame as 1.29 Rs.

metric type II bursts from solar cycle 24. We also chose image frames close to the onset times of the type II bursts, so no extrapolation was necessary. The range of CME heights at type II burst onset in the present study is 1.20–1.93 Rs with a mean value of 1.43 Rs. We conclusively find that the shock formation can occur at heights substantially below 1.5 Rs. In these cases, the starting frequency of the type II bursts was very low, in the range 25-40 MHz, which confirms that the shock can also form at larger heights. The starting frequencies of metric type II bursts have a weak correlation with the measured CME/shock heights and are consistent with the rapid decline of density with height in the inner corona.

2. Joshi et al. (2013) have also studied the source regions of the solar flares, associated CMEs, and the generation of energetic particles and the space weather prospective of this particular solar eruptive phenomenon. We found that the two eruptions consisting of two fast CMEs (~1400 km s<sup>-1</sup> and ~2000 km s<sup>-1</sup>) and M-class flares that occurred in active region 11402 located at ~N28 W36. The two CMEs occurred in quick successions, so they interacted very close to the Sun. The second CME caught up with the first one at a distance of ~11-12 Rsun (c.f., Figure 35). The CME interaction may be responsible for the elevated SEP flux and significant changes in the intensity profile of the SEP event. The compound CME resulted in a double-dip moderate geomagnetic storm (Dst ~-73 nT ). The two dips are due to the southward component of the interplanetary magnetic field in the shock sheath and the ICME intervals. Only a small section of the ICME arrived at Earth because the CME propagation was at an angle to the Sun-Earth line. Therefore the resulting GMS was of moderate intensity.







**Figure 35.** EUVI full disk running difference images superposed on the STEREO-A/COR1 difference images at 03:05 UT, 03:45 UT and 03:50 UT (a–c) showing two CMEs associated with the M1.1 and M8.7 flares respectively. STEREO COR2 base difference images at 03:54 UT, 04:08 UT and 04:24 UT (d–f) showing the CME1, CME2 and compound CME. Height-time plot of the CMEs using STEREO-A COR1 and COR2 (CME1: diamonds; CME2: triangles) (g). The speeds were computed by fitting a straight line to the last five data points. The position angle of our measurement was around 60°. The dark dashed line with cross symbols represents the filament trajectory measured from STEREO EUVI 304 Aimages.

 Choudhary et al. (2013) studied the relation of flare productivity of active regions with their evolution of magnetic flux emergence, flux imbalance (c.f., Figure 36) and free energy



**Figure 36.** Temporal evolution of the flux imbalance of active region NOAA 11283. The dashed vertical lines mark the occurrence of large solar flares.

content. We use the sunspot area and number for flux emergence study as they contain most of the concentrated magnetic flux in the active region. The magnetic flux imbalance and the free energy are estimated using the HMI/SDO magnetograms and Virial theorem method. We find that the active regions evolving active regions, in which large spots (concentrated flux) emerges are flare and CME productive. The flare activity is observed when the free energy exceeds 50% of total energy. Although, the flary active regions show magnetic flux imbalance, it is hard to predict flare activity based on this parameter alone.

 Chandra et al., (2013), presented a comparative study of the properties of coronal mass ejections (CMEs) and flares associated with the solar energetic particle (SEP) events in the rising phases of solar cycles (SC) 23 (1996-1998) (22 events) and 24 (2009-2011) (20 events), which are associated with type II radio bursts. Figure 37, shows the location of all these flares



and CMEs over the solar disk. For this study we used the GOES data for the minor (1pfu <intensity <10 pfu) and major (intensity  $\ge$  10 pfu) SEP events and SOHO/ERNE data for the weak SEP event. We find that most of the major SEP events are associated with halo or partial halo CMEs originating close to the Sun center and western-hemisphere. The fraction of halo CMEs in SC 24 is larger than the SC 23. For the minor SEP events one event in SC23 and one event in SC24 have widths < 120° and all other events are associated with halo or partial halo CMEs as in the case of major SEP events. In case of weak SEP events, majority (more than 60 %) of events are associated with CME width < 120°. We have found a poor correlation between the SEP event intensity and GOES X-ray flare size. We also observed that in cycle 23 most sources are located in the south, whereas during cycle 24 most sources are located in the



**Figure 37:** Distribution of SEP source regions on the Sun during the rise phases of solar cycle 23 (black circle) and 24 (red triangle).

north. This result is consistent with the asymmetry found with sunspot area and intense flares.

5. Awasthi et al. (2013), studied the temporal, spatial and spectral evolution of the M1.8 flare, which occurred in the NOAA active region 11195 (S17E31) on 2011 April 22, in order to explore the underlying physical processes during the precursors and the main phase. Figure 38 shows the temporal variation of the event and its different phases. The study of the source morphology using the composite images in 131 Å wavelength observed by the Solar Dynamic Observatory/Atmospheric Imaging Assembly and 6-14 keV revealed a multiloop 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 loop per second. 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. The energy released in the precursor phase was thermal and constituted  $\approx$  1 per cent of the total energy released during the flare. The study of morphological evolution of the filament in conjunction with synthesized T and EM maps was carried out, which reveals (a) partial filament eruption prior to the onset of the precursor emission and (b) heated dense plasma over the polarity inversion line and in the vicinity of the slowly rising filament during the precursor phase. Based on the implications from multiwavelength observations, we propose a scheme to unify the energy release during the precursor and main phase emissions in which the precursor phase emission was originated via conduction front formed due to the partial filament eruption. Next, the heated leftover S-

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**Figure 38.** Temporal evolution of multiwavelength emission during M1.8 flare on 2011 April 22. Relative intensity estimated from H $\alpha$  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. Px1, 2, 3 and Ph1, 2, 3 represent the corresponding peaks during precursor, impulsive and gradual phases in X-ray and H $\alpha$ , respectively.

shaped filament underwent slow-rise and heating due to magnetic reconnection and finally erupted to produce emission during the impulsive and gradual phases.

Apart from these published papers, the various important scientific results are under review in various journals of international repute, while few papers are still under preparation.

The members thank the Indo US Science and Technology Forum (IUSSTF), New Delhi for providing their support for the above Joint Center project.

**Project Title:** Study of dynamical events in the solar atmosphere during maximum of Solar Cycle 24".

P.I.: A. K. Srivastava, ARIES, Nainital.

The DST-RFBR (Indo-Russian) project entitled "Study of Dynamical Events in the Solar Atmosphere during Maximum of Solar Cycle 24" within ARIES Solar Physics group and the same of IZMIRAN, Russian Academy of Sciences, Troitsk, Russia, has been accepted in July 2012. The project is successfully running in terms of the joint scientific collaborations. The Indian PI is Dr. A.K. Srivastava, while othere team members are Drs. W. Uddin, N.C. Joshi, Ramesh Chandra, as well as Mr. Pradeep Kayshap. The russian P.I. Is Dr. Boris P Fillipov. Russian scientists have been visted twice in ARIES in 2012-2013 to pursue the joint scientific resaearch in this project. Some completely new scientific achievements under the support of this project are outlined as under:

#### Scientific Results:

1. The first observational evidence of the evolution of sausage-pinch instability in an active region 11295 during a prominence eruption has been reported using data recorded on 2011 September 12 by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO). A magnetic flux tube was visible in AIA 304 Å that shows curvatures on its surface with variable cross-sections as well as enhanced brightness. These curvatures evolved and thereafter smoothed out within a timescale of a minute. The curved locations on the flux tube exhibit a radial outward enhancement of the surface of about 1–2 Mm from the equilibrium position. AIA 193 Å snapshots also show the formation of bright knots and narrow regions inbetween at the four locations as that of 304 Å along the flux tube where plasma emission is larger compared to the background. The formation of bright knots over an entire flux tube as well as the narrow regions in <60 s may be the morphological signature of the sausage instability. It was found that the flows of confined plasma (propagation of brightness) in



these bright knots along the field lines, which indicates the dynamicity of the flux tube that probably causes the dominance of the longitudinal field component over short temporal scales. The observed longitudinal motion of the plasma frozen in the magnetic field lines further vanishes the formed curvatures and plasma confinements as well as growth of instability to stabilize the flux tube.



**Figure 39.** The handmade sketches overlaid on AIA 304 Å snapshots to explain the observed scenario. The observed localized dynamics of the flux tube is generated by either of these two physical mechanisms, i.e.,  $\theta$  or z-pinch and associated evolution of sausage instability.

2. Joshi et al. (2013), presented multi-wavelength observations of an asymmetric filament eruption and associated coronal mass ejection (CME) and coronal downflows on 2012 June 17 and 18 from 20:00–05:00 UT. From the SDO/AIA limb observations it is evident that the filament exhibits a whipping-like asymmetric eruption. STEREO/EUVI disk observations reveal a tworibbon flare underneath the southeastern part of the filament that most probably occurred due to reconnection between the coronal magnetic field in the wake of the eruption. The whippinglike filament eruption later produces a slow moving CME and its core with an average speed of  $\approx$  540 km s<sup>-1</sup> and  $\approx$  126 km s<sup>-1</sup>, respectively. The CME core formed by the eruptive flux rope

exhibits outer coronal downflows with an average speed of  $\approx$  56 km s<sup>-1</sup> after reaching  $\approx$ 4.33 Rsun. The plasma first decelerates gradually up to a height of  $\approx$  4.33 Rsun and then starts accelerating downward. Figure 40 shows the kinematics of the CME and its core. Interpretation is given in the context of a selfconsistent model of a magnetic flux rope. This rope loses its previous stable equilibrium when it reaches a critical height. With some reasonable parameters, and inherent physical conditions, the model describes the non-radial ascending motion of the flux rope in the corona, its stopping at some height, and thereafter its downward motion. These results are in good agreement with observations.

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**Figure 40.** (a) Height–time plot of the CME core and leading edge. The solid black line represents the linear fit to the CME leading edge data. The dotted blue curve represents the third order fit to the core height–time data. (b) Speed-time and acceleration-time plots of the CME core. Error bars in panels ((a)–(c)) are the standard deviation computed from three repeated measurements. (c) Distance–velocity and distance–acceleration plots of the CME core. The velocity and acceleration are represented by the black and red points, respectively. The red dotted curve with triangle symbols in panel (c) corresponds to the local gravitational acceleration –GM /r 2.

3. Observation of a small-scale flux tube that undergoes kinking and triggers the macrospicule and a jet on 2010 November 11 in the north polar corona has been performed. The small-scale flux tube emerged well before the triggering of the macrospicule and as time progresses the two opposite halves of this omega-shaped flux tube bent transversely and approach each other. After ~2 minutes, the two approaching halves of the kinked flux tube touch each other and an internal reconnection as well as an energy release takes place at the adjoining location and a macrospicule was launched which goes up to a height of 12 Mm. Plasma begins to move horizontally as well as vertically upward along with the onset of the macrospicule and thereafter converts into a large-scale jet in which the core denser plasma reaches up to  $\sim 40$  Mm in the solar atmosphere with a projected speed of ~95 km s<sup>-1</sup>. The fainter and decelerating plasma chunks of this jet were also seen up to ~60 Mm. We perform a two-dimensional numerical simulation by considering the VAL-C initial atmospheric conditions to understand the physical scenario of the observed macrospicule and associated jet. The simulation results show that reconnection-generated velocity pulse in the lower solar atmosphere steepens into slow shock and the cool plasma is driven behind it in the form of macrospicule. The horizontal surface waves also appeared with shock fronts at different heights, which most likely drove and spread the large-scale jet associated with the macrospicule.

#### Paper published on/by the project:

1. **A. K. Srivastava**, R. Erdélyi, Durgesh Tripathi, V. Fedun, **Navin Chandra Joshi, P. Kayshap**, "Observational Evidence of Sausagepinch Instability in Solar Corona by SDO/AIA", 2013, Astrophysical journal letters, 765, L42.

2. **P. Kayshap, A.K. Srivastava**, K. Murawski, "The Kinematics and Plasma Properties of a Solar Surge Triggered by Chromospheric Activity in AR11271", 2013, ApJ, 763, 24.





**Figure 41**: The left side snapshot displays the formation of the macrospicule and associated polar coronal jet due to the internal reconnection in a small-scale kinked fluxtube. The right snapshot shows the simulated marcospicule and moving warm jet. It was considered that reconnection generated velocity pulse train evolved in the series of the slow shocks and exhibits the observed plasma dynamics.

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# 2012-13

### **IMPORTANT HIGHLIGHTS OF NATIONAL PROJECTS**

**Title of the Project:** ISRO-GBP Atmospheric Chemistry Transport and Modeling (ATCTM) Project

Name of the P.I.: Manish Naja

#### Research output of the project with highlights:

ARIES, Nainital is ideally located to sample pristine air-masses and act as a regional representative site in Northern India. Influence of intercontinental transport are observed here and its latitudinal location is better suited for studies on Stratosphere-Troposphere Exchange processes. In view of this, observations of different trace gases (ozone, CO, NO-NO<sub>y</sub>, SO<sub>2</sub>, CH<sub>4</sub>, NMHCs, CO<sub>2</sub>) were initiated under the ISRO-GBP-ATCTM project. Balloonborne ozone observations are also being made. Apart from observations, an online coupled meteorology-chemistry model, the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) for South Asia is also setup. An annual simulation of tropospheric ozone and related species is made for the first time using the WRF-Chem model over South Asia and are evaluated against ground-based, balloon-borne and satellite-borne (TES, OMI and MOPITT) observations.





**Figure 42:** (left) Instruments for the measurements of ozone, CO, NO<sub>y</sub> and SO<sub>2</sub>. (right) Influence of vertical winds on the variations of ozone, CO and NOy at Nainital during four months.



Diurnal variations in ozone do not show the daytime photochemical build-up typical of urban or rural sites and confirms that this site receives pristine air most of the time. Higher CO/NO, value confirmed the minimal influence of fresh emissions at the site. The CO and NO, levels discern slight enhancements during the daytime, unlike ozone. Influence of mountain valley winds is seen on the observed diurnal variations in ozone, CO and NOy. The downward transport from higher altitudes is estimated to enhance the surface ozone levels over Nainital by 6 - 19 ppbv. The classification based on the air-mass residence time shows significant enhancement in ozone, CO and NO, in the continental air-mass when compared with marine originated air-masses. Net ozone production over Northern Indian Subcontinent in regionally polluted air masses is estimated to be 3.2 ppbv/day in spring but no clear build-up is seen at other times of year. A correlation analysis between ozone levels at Pantnagar and Nainital along with the mixing depth data suggests that emissions and photochemical processes in the IGP region influence the air quality of pristine Himalayan region, particularly during midday hours of spring. Model simulated daytime ratios of H2O2/HNO3 are higher and suggesting that this region is in a NOx-limited regime. Balloonborne measurements of ozone vertical distribution and meteorological parameters show event of a stratospheric intrusion during winter with enhancement of the ozone levels by ~180% in the middle-upper troposphere.

**Title of the Project:** The spectral and photometric monitoring of gamma-ray burst afterglows, core-collapse supernovae and their host galaxies.

#### Name of the P.I.: Dr. S. B. Pandey

#### Status of the Research in Progress:

The photometric and spectroscopic data of corecollapse SNe and Gamma-ray burst were acquired using 1.0m, 1.3m telescopes in Nainital and 6.0m telescope at SAO Russia. During the project period, data of around 6 CCSNe and 4 GRBs were obtained. The analysis of the data is underway and some of the data is already published, for example

Light curve and spectral evolution of the Type IIb SN 2011fu was studied in detail under this project. The photometric follow-up of this event has been initiated a few days after the explosion and covers a period of about 175 days. The early-phase light curve shows a rise followed by steep decay in all bands and shares properties very similar to that seen in case of SN 1993J, with a possible detection of the adiabatic cooling phase. Modelling of the quasi-bolometric light curve suggests that the progenitor had an extended ( $\sim 1 \times 10^{13}$  cm), low-mass (~0.1 M) H-rich envelope on top of a dense, compact  $(\sim 2 \times 10^{11} \text{ cm})$ , more massive  $(\sim 1.1 \text{ M})$  He-rich core. The nickel mass synthesized during the explosion was found to be  $\sim$  0.21 M, slightly larger than seen in case of other Type IIb SNe. The spectral modelling performed with SYNOW suggests that the earlyphase line velocities for H and Fell features were ~16000 km s<sup>-1</sup> and ~14000 km s<sup>-1</sup>, respectively. Then the velocities declined up to day +40 and became nearly constant at later epochs.

#### Paper published on/by the project:

- Vinko J. et al. including Pandey S. B., 2012, "Sn 2010kd -- A Super-luminous, Pairinstability Supernova?", Poster presentation, AAS meeting 219, 436.4
- 2. Kumar B. et al. Including Pandey S. B., Bhatt Vijay, Kumar B., Sokolov V. V., 2013, "Light



curve and spectral evolution of the Type IIb supernova 2011fu", MNRAS, 431, 308

- Subhash Bose et al. Including Pandey S. B., Bhatt Vijay, Kumar B, 2013, "Supernova 2012aw – a high-energy clone of archetypal Type IIP SN 1999em", MNRAS, 433, 1817
- Rupak R. et al. Including Pandey S. B. and Kumar B., 2013, "SN 2007uy – metamorphosis of an aspheric Type Ib explosion", MNRAS, 434, 2032
- Several GCN circulars related with the observations of GRBs and their initial results. The detail analysis is still going on. This includes GRB 130427A (GCNC 14489); GRB 130305A (GCNC 14274); GRB121226A (GCNC 14109); GRB 121128A (GCN 14043); GRB 121117A (GCNC 13980); GRB 121108A (GCNC 13957); GRB 120404A (GCNC 13234); GRB 120211A (GCNC 12928).



#### **INSTRUMENTS FACILITY AND DEVELOPMENT LABORATORY (IFDL)**

All the engineers and scientists involved in instrumentation related projects are members of this group. The group reviews the status of all the projects of the institute every six months. Currently following major projects are actively running and being managed by individual project managers from the institute - (i) 3.6 meter telescope, the largest optical telescope to be installed in the country (ii) Faint Object Spectrograph & Camera, the first light instrument on the 3.6 meter telescope designed and being developed for the first time entirely in the country, (iii) High Resolution Echelle Spectrograph, to be completely designed and developed by ARIES in collaboration with Belgium, (iv) 4kx4k CCD camera, being assembled in collaboration with HIA, Canada group, (v) Indian Liquid Mirror Telescope, of 4-m diameter in major collaboration with Belgium and Canada. (vi) ST-RADAR, the unique system for atmospheric studies in Himalayan region, and several other instrumentation projects for the observing facilities of the institute. The group has also managed to foster new collaborations in the field of astronomical and atmospheric science and related instrumentation with international and national organizations.

Several new and advanced manufacturing and measurement instruments such as a CNC machine for automated precision manufacturing of mechanical components, optical profiler based on interference microscopy for measurement of optical coatings and surfaces, laser interferometer for precise tip, tilt and distance measurements, and several other precision instruments have n recently been acquired in various laboratories of the institute.

#### Major highlights from laboratories:

**Optics Laboratory:** This laboratory is equipped with facilities to carry out optical design and simulations, testing, characterization & verifications of optical instruments being developed for the observing facilities of the institute. The major achievements in 2012-13 are -

- The optical design for the Faint Object Spectrograph & Camera (FOSC), the proposed first science instrument on the 3.6 meter telescope was completed and validated.
- The manufacturing of the optical components for FOSC started at m/s Winlight systems, France.
- Laboratory development plans charted out including setting up of a clean room facility of class 10,000, vibration free optical tables, detector development program, characterization facilities augmentation (laser interferometer, optical profiler, hand held spectrograph, wave front sensing techniques). Procurement of equipment and development is in progress for the above facilities.
- Optical design work for the next generation science instruments namely, high resolution Echelle spectrograph, Adaptive optics, fast CCD photometer, and low resolution fiber fed spectrograph is in progress.
- Laboratory demonstration for the the low resolution fiber fed spectrograph using an offthe-shelf ANDOR spectrograph completed and validated successfully for further implementation on the 1.3 meter telescope at Devasthal.


• Re-aluminization of the 40" telescope mirror carried out. Cleaning of the 1.3 meter telescope mirror carried out.

**Mechanical Workshop:** The workshop caters the needs of the institute for maintenance and new development of scientific instruments for its observing facilities. The workshop also assists in estate maintenance activities of the ARIES and Devasthal campus. The major achievements in 2012-13 are -

- Maintenance of the 1.3 meter telescope enclosure and monitoring activities of the 3.6 meter dome construction work at Devasthal.
- Construction work of planetarium building at ARIES science center nearly completed.
- Design & manufacturing of a CCD imager for the 3.6 meter telescope completed.
- Mechanical design for FOSC, the first science instrument on the 3.6 meter telescope validated.

• Augmentation of new facilities namely a CNC machine, Lathe machine and new measurement instrument for precision jobs namely a coordinate measuring machine (CMM) completed. These facilities are in testing phase.

**Electronics Laboratory:** The laboratory is engaged in designing and developing of new observing facilities for the institute. The upgradation and maintenance of the existing observing facilities is a routine and major activity of this lab. The major achievements in 2012-13 are -

- CCD detector development plan started in the lab to cater the future needs of astronomical camera for telescopes.
- Integration of the ST-RADAR system at Manora Peak campus in progress.
- New measuring and development instruments such as digital signal processor and digital oscilloscope procured and a static free electronic laboratory established.
- Circuit board design and manufacturing for the Schmidt telescope under development at Manora peak completed. Boards are being tested presently.
- A plan to modernizing the sensing and control the existing 40-inch telescope at Manora peak completed for future implementation.
- In-house maintenance of the 1.3 meter telescope system carried out successfully after a minor failure of encoder circuit board and autoguiding system.



### THE UPCOMING MAJOR PROJECTS: STATUS REPORT

### **Devasthal Optical Telescope (DOT)**

### (3.6 m Aperture)

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 also 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 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 of the project director and project manager. The PMB, PIT and PWG meet several occasions to review the progress of the project. During Apr 2012 – Mar

2013, most of the scheduled project activities were carried out successfully.

**The Telescope:** The telescope was manufactured by AMOS Belgium. Two key milestones were completed – i.e. telescope acceptance tests at AMOS and the transport of telescope from Belgium to India. A factory acceptance committee constituted by the PMB met during 7-10 May 2012 at the AMOS workshop. The committee studied and discussed all as-built specifications of the telescope at system as well as sub-system level. The committee members also conducted few on sky tests at the factory. The committee concluded that the performance of the telescope has been tested within the constraints of the environments at the factory. The transportation of the telescope to the Devasthal site has been completed successfully. All the parts of the telescope were packed in 18 wooden crates and 5 standard 20ft containers; and these telescope boxes were shipped from Antwerp, Belgium on 15<sup>th</sup> November 2012 and it arrived at Mundra port, Gujarat on 12<sup>th</sup> December 2012. The transport of telescope boxes from the port to Devasthal site was done by the transport company SDV via road and by 8<sup>th</sup> March 2013, all the boxes were at the site.

**Telescope enclosure and auxiliary building:** The design of the civil work up to plinth level of the telescope house was done by M/s PPS Limited, Pune. The construction of building plinth with bolt grouting was completed in September 2012. The construction of concrete pier was completed in January 2013. For 'Manufacture, supply, erection and commissioning of telescope enclosure structure and equipments for the 3.6m Devasthal Optical Telescope', a contract agreement has been signed with the M/s Pedvak Hyderabad. The work is divided into three parts – extension building structure, dome support structure and dome structure. The fabrication drawings have been



finalized. Procurement of material and construction of structure was completed at M/s Pedvak Hyderabad. The ARIES team reviewed the progress of work at M/s Pedvak workshop on two occasions. Most of the manufactured parts of the building have been transported to the site. The erection work is in progress. The seventy percent of the work related to erection of extension building and the dome support structure have been completed. A latest picture of the 3.6m telescope building is given in **Figure 43**.



**Figure 43.** Picture of 3.6m building taken on 7<sup>th</sup> March 2013. Dome support and extension building is 70% completed, dome structure is remaining. The construction of pier is completed.



### Stratosphere Troposphere (ST) Radar

The ST Radar system (@206.5 MHz) at ARIES, Nainital, is configured as an Active Aperture Distributed Phased Array using state of art Solid State TR module and Digital Signal Processing techniques. This system has array of 588 Yagis of 3 elements in a circular aperture on equilateral triangular grid arrangement. It is important to mention that entire system is developed with-in India and antennae array is installed on a roof top for the first time.

A miniature version (sub-array of the 49 element) of this ST Radar has already been tested. Now, integration of its different subsystem is progressing at the ASTRAD site. The pictures below show the ST Radar building, antennae array on roof top of the ST Radar building and the TRMs suspended with the ceiling.

This ST Radar would provide continuous vertical profile of winds with high temporal and spatial (vertical) resolution. The continuous monitoring of wind field structure at different pressure levels in the vertical is essential to understand the local meteorology and wind dynamics. Moreover, this region experiences western disturbances during winter and spring. Importantly, unlike other observational techniques, the measurements from ST Radar can be made in all weather conditions.



**Figure 44:** (left) ST Radar building at ARIES, Nainital. (Top right) Yagi Antennae array at the ST Radar building roof top and (bottom right) transmit-receive (TR) modules suspended from the ceiling of first floor of the ST Radar building.

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# 2012-13

### **DEVELOPMENT OF NEW INSTRUMENTS FOR TELESCOPE FACILITIES**

**FOSC- A backend instrument for the DOT:** The faint object spectrograph and camera (FOSC) is the first generation instrument at the axial port of the narrow-band imaging capabilities with one-pixel resolution of less than 0.2 arcsec in the whole field of view (10 arcmin diameter) - (ii) low-to-medium resolution spectroscopy with spectral resolution (250-4000) covering the optical wavelength range of 350-1000 nm.

The award of contract for the supply of optics

(collimator and camera) assembly to M/s Winlight France was made in March 2012 and a Preliminary Design Review was held at France on 29<sup>th</sup> June 2012. All the optical components have been manufactured and the final tests have been carried out recently. The assembly of the optical components of the FOSC with the barrel is shown in **Figure 45**. The design for the mechanical assembly has been finalized. The manufacturing of various mechanical components is in progress at ARIES. The lab to test the fully integrated FOSC is being made ready at ARIES optics lab.



Figure 45. FOSC optics after its integration with barrel at M/s Winlight France.



**Optical Imager- First light instrument for the DOT:** In view of some anticipated delay in commissioning of the ADFOSC instrument, the development of a 4kx4k CCD camera with liquid Nitrogen Dewar has been recommended as a first light instrument in the 15<sup>th</sup> PMB meeting of 3.6m DOT. A detailed design report was prepared and it was decided that the CCD camera can be procured while the mechanical and electrical interfaces can be developed in-house. The mechanical interface design for the imager has been completed (**Figure 46**). Most of the mechanical components have already been manufactured in the ARIES workshop. The CCD camera and the controller are ready for dispatch from STA.



**Figure 46.** The mechanical interface design for the imager to test it with 1.3 m telescope.

**High resolution optical spectrograph – A future instrument for the DOT:** The ground work for development of a high-resolution optical spectrograph for 3.6m DOT is complete. The chemical abundance and asteroseismological studies will be two key science goals and to achieve it, the instrument is designed for two resolution mode – 30000 and 60000 with a radial velocity resolution of 5m/s. A national committee has been constituted to monitor progress of the project. The work on optical design of the instrument is complete (**Figure 47**). The mechanical design is in progress.



Figure 47. Preliminary design of ARIES High resolution spectrograph



**High speed time series fast CCD Photometer – A future instrument for the DOT:** Another instrument proposed for the 3.6m telescope is the high speed time series fast CCD photometer. The main scientific objective of this fast photometer is for the asteroseismic study of the rapidly oscillating stars, pulsating white dwarfs etc. Preliminary optical design (**Figure 48**) of fast CCD photometer has been completed for the F/3 beam which covers the field of view of 4.2'X4.2' for 1KX1K detector for the side port of 3.6m devasthal optical telescope. The optical layout of the fast ccd photometer is given below.



Figure 48. Optical layout of the high speed time series fast CCD photometer.

Andor Spectrograph for 1.3m telescope: Modification of an existing spectrograph is in progress for it to be used with the 1.3m telescope. For this purpose a guiding unit was designed to match the focal ratio of the spectrograph with the telescope. In order to guide the star for observations, a guiding unit was also designed. The optical layout of the attachment made for the spectrograph is given in **Figure 49**. With the slit diameter of 50



Figure 49. Optical layout of the modifications made for the Andor spectrograph.



microns, the spectrograph can have a resolving power of 2500. Guiding concept was realized by laboratory setup with existing lenses, watec camera and a glass plate initially. Later the glass plate was replaced with a pellicle beam splitter and images were acquired.

**Wide Field (WiFi) Polarimeter for 1.3m telescope:** Optical design of a wide field imaging polarimeter for the 1.3m FOT is in complete. The design is for a circular field of view of 20 arc min diameter. The design of WiFi-Pol is done with a quartz Wollaston prism. The 4Kx4K CCD which will be used for 3.6m telescope imager initially is going to be the detector that will be used with the polarimeter. The optical design of the WiFi-Pol is given in **Figure 50**.



Figure 50. The layout of the WiFi-Pol for 1.3m telescope.



### DEVELOPMENT OF NEW SOFTWARE FOR UPCOMING OBSERVING FACILITIES

**Observatory control and data archive system :** The development of the dome control system is complete. Demonstration of the as-built dome control system using three homing sensors and an encoder attached to the Schmidt telescope was carried out successfully on 14<sup>th</sup> March 2013. The algorithm to synchronize the motions of dome and the telescope has been developed. The GUI of the DCS is presented in **Figure 51**. The observatory control system for the telescope and an archival system are in the development phase.

ARIES 3.6 DOT Dome Control System				
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Figure 51. GUI for the dome control system of the 3.6m DOT.



#### Observatory Control System for 1.3m telescope:.

OCS provides a common interface to control telescope, instrument and filter unit. It maintains log of all the activities in log files as well as database server. It has both GUI and command interface to send control commands to Telescope Control System, Instrument Control System and Filter Control System. At present the OCS -TCS GUI interface has been completed. OCS-ICS GUI and command interface are under development. OCS-FCS GUI and command interface are also under development. Database log has been implemented. It use MySQL database server for logging. Qt framework has been used to design the application. Instrument Control Server is being developed using Qt network programming module on windows platform. Instrument Control Server is in its final design stage.

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Figure 52. Observatory Control System for 1.3m telescope:.

Antenna array design and analysis tool: A customized machine-independent simulation tool, incorporating all the possible simulation facilities required for ARIES ST Radar active aperture array, has been developed inhouse. Antenna Array Design and Analysis always remained a challenging task and a user friendly simulation tool required to ease the task in different measurements and fault conditions is essential. But unfortunately, no commercial software is available with all the necessary simulation options available as per the user system requirement (in present case it is ARIES ST Radar active aperture array). Therefore, there were no other option left other than to develop a customized simulation tool. This was carried out after having a critical understanding of the system requirements and its utility. The tool is now being extensively used in the installation of the radar. The front panel of the tool is given in **Figure 53**.





Figure 53. The front panel of the analysis tool developed for the ARIES ST Radar.

**ST/MST Radar signal analysis and parameter extraction tool:** The developed package performs the signal analysis in time and frequency domains of the radar backscattered signal. The package is equipped with pre and post-processing of netCDF or binary data files containing in-phase (I) and quadphase (Q) data. The major pre and post-processing steps, the package is capable to perform are – normalization, DC removal, IQ imbalance removal, windowing (hanning, hamming, blackmann, Kaiser etc), coherent integration, fourier analysis, power spectrum, incoherent integration, spectral cleaning, noise level estimation, moment (0<sup>th</sup>, 1<sup>st</sup> & 2<sup>nd</sup>) estimation, UVW wind vector computation, wind speed & direction computation. The algorithm used in the developed package was verified with the widely known packages available with Indian MST radar and United Kingdom NERC MST Radar. Further the package was utilized to validate the wind information extracted from the observations made during the year 2012 using 206.5MHz based miniprofiler (a downscaled version of ARIES ST Radar) with the last 10 years of wind data available at NOAA for local balloon sounding station.

In order to achieve high resolution spatial and temporal measurements with suppressed range sidelobes in ST/MST radar applications, bi-phase complementary codes are commonly used. The developed package also contains a tool capable of



generating and analyzing a pair of complementary sequences of length upto 512. Using this tool, one can evaluate the performance of the generated code through key code parameters like merit factor, discrimination, ISL, PSL etc..



Figure 54. Line plot for the Mini-profiler observation made on April 07, 2012 at 10:45 UTC.

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### ARIES PARTICIPATION TO THE THIRTY METER TELESCOPE PROJECT, STATUS REPORT 2012-13



Figure 55: Artist's Rendering of the Thirty Meter Telescope (Image Source: www.tmt.org)

The primary mirror ("M1") of the Thirty Meter Telescope (TMT) is comprised of 492 hexagonal mirror Segments. Each mirror segment is 1.44 meters measured across corners 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 and passively controlled by the Segment Support Assemblies (SSA). SSAs, thus support each mirror segment with minimum deformations to the optical surface under variable environments and therefore form an important component of the primary mirror cells (see Figure 56).

ARIES, one of the participating institutes to ITCC in collaboration with the TMT head-office, intends to engage 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 gualification. The prototypes will be delivered to ITCC and TMT project for qualification testing and demonstration. ITCC and the TMT project shall provide all of the drawings, specifications, and assembly procedures, making this primarily a build-to-print effort. The vendor has to provide a list of suppliers from whom the bought out items are being planned to be procured and confirm the availability of the required quantity from the vendor and include the same in the quotation. Because this work-scope includes supply chain development and cost estimating for the production program (580 SSAs), it is necessary that the





Figure 56: Complete Segment Support Assemblies (SSA) module with the sub-assemblies.

respondents either have the existing capability for performing the production work, or a credible plan for performing the production work, in order to be qualified for this work. The technical discussions to carry out the required job were discussed in details for several months (during March 2012 to August 2012) with the TMT board and other parameter institutes in India at different forums. The required work is described in detail in the ARIES RFP document no. AO/1719/GSMT/12-13 advertised dated 27 September 2012 and given at http://www.aries.res.in/tenders/tmt\_prototype\_rfp\_SS A\_ARIES.pdf.

### Progress made towards manufacturing prototypes of SSAs for the primary mirror segments of the TMT (2012-13):

Director ARIES (ex-officio PI of the India-TMT related activities) constituted a high level committee on 04/10/12 in the chairman-ship of Prof. Ramesh

Koul from BARC Mumbai and other members from the participating institute to evaluate the technical proposals to award the contract for manufacturing prototypes of SSAs. Against the RFP floated on 27/09/12 describing the work-package and after scrutiny 3 vendors (Avasarala Tech Ltd., Godrej and L&T) were identified and were asked to submit the techno-commercial proposals. The committee met at ARIES during 28Feb-01Mar 2013 to discuss the technical proposals and accordingly financial bids were opened. After opening the financial bid, Avasarala Tech Ltd turned out as L1 whereas Godrej was found to be L2. As it was mentioned in the RFP that the job of prototyping could be allotted to more than one firms, so, Godrej (vendor as L2) was contacted to negotiate if it could do the job on the rates of L1. By March 2013, the contracts were yet to awarded for manufacturing prototypes of SSAs as negotiations with the L2 firm was still continued.

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# 2012-13

### PARTICIPATION OF ARIES IN THE ONGOING NATIONAL PROJECTS IN THE SOLAR PHYSICS

A 2-m class solar telescope (NLST) has been proposed by India under the leadership of Indian Institute of Astrophysics (IIA), which will execute cutting edge solar research aimed to understand the fundamental processes taking place on the Sun, e.g., waves, transients in the solar atmosphere, study of magnetism and helioseismic behaviour, etc. Its state-of-art design and backend instruments will enable the observations of the different parts of the solar atmosphere with an unprecedented high spatial resolution (0.1"/px) that will provide crucial information on the nature of magnetic fields and coupled plasma dynamics in the solar atmosphere, revealing the nature of heating, and drivers of the transient and eruptive processes. ARIES solar physics group is also participating in this national project, and the involvement is on scientific level.

Apart from the first space-borne mission Aditya-I is planned to carry the various payloads to observe the





**Figure 57**: The schematic view of the National Large Solar Telescope revealing the mystery of the solar atmosphere (toppanel), while the optical lay-out of the telescope in the bottom panel (Credit : Indian Institute of Astrophysics and NLST Team).





Figure 58: Optical Design for the EVELC/Aditya-L1 (Credit : Indian Institute of Astrophysics and ADITYA team Team).

Sun in various modes (e.g., imaging, coronagraphic, and in situ particle). The few examples are Solar Ultraviolet Imaging Telescope Enhanced Visible Light Emission (SUIT). Coronagraph (EVELC), etc. The ARIES is involved on the scientific level in both SUIT and EVELC. The SUIT is planned for the imaging of the full-disk Sun in the cool lines formed especially in the chromosphere as well as transitionr egion, and this will enable to understand the driving mechanisms of chromospheric heating, jets dynamics, MHD waves, eruptive processes. While, the EVELC is a coronagraph that will be devoted for both imaging and spectroscopic modes to solve the riddles of CME dynamics, MHD waves in the diffused corona, responses of the jets and waves in the outer corona, etc.

These observatories will provide the

complemntary observational scenario to the various space mission of their time, e.g., IRIS, Solar-C, Solar Orbiter, and therefore, will generate the tremendous international collaborations as well as the enhancement of the science aspects using their state-of-art instrument specifications. The prime goal is to make a synergy between various space and ground based observatories from India and other parts of the globe, and to reveal the physical aspects of the outstanding problems in the solar physics. Few examples are indeed the coronal heating, formation and source region of the nascent solar wind, magnetism and helioseimsology, triggering mechanisms of the transients and eruptive phenomena and their outer coronal responses. ARIES Solar Physics group is participating in these projects. The scientists from the ARIES are involved in the science teams of SUIT and EVELC.

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# 2012-13

### **REPORT ON THE EXISTING OBSERVING FACILITIES**

#### 1. Sampurnanand Telescope – 1.04m aperture

Joint Time Allocation Committee (JTAC) allotted nearly 50% of observing time for the CCD imaging, nearly 40% for the imaging polarimetry and 10% time was reserved for the Target of Opportunity (ToO) proposals. During the period of 2012 – 2013, out of 273 allotted nights, nearly 155 were clear. There were 13 publications based on the data taken from the ST. During the previous off season, the cleaning of the primary mirror of the telescope was performed along with routine maintenance work of the dome and other mechanical structure. Since then the telescope performance has shown to be improved significantly.



**Figure 59.** Primary mirror of the Sampurnanand Telescope after performing the cleaning.

### 2. Devasthal Fast Optical Telescope – 1.3m aperture

The 1.3m telescope is fully functional now and astronomical observations are being carried out. Researchers from ARIES as well as from other institutions are caring-out their scientific observations. A number of new initiatives have been taken to make the telescope operation a much more user friendly and efficient. New filter sets were acquired which include 80 mm SDSS, Bessell as well as Ha and SII narrow band filters. An automated filter movement arrangement has been made indigenously which allows the observers to select the filters from the control room itself. An observatory control system (OCS) for the 1.3m telescope is also under development. This OCS will have arrangements to operate the telescope along with the instrument operation and filter movement. Once this is ready, observations from the telescope can be remotely done by any computer connected through internet. The data archive system is almost complete. All the 1.3m telescope related developments are being updated on its website. (http://aries.res.in/~1.3m/ariesmain.html).

A set of new instruments which are planned for 1.3m telescope are (a) a 4 K CCD camera which can observe a field of view of 26 arcmin square which is suitable for wide field studies of star cluster/star forming regions etc., (b) a wide field imaging, (c) a fast photometer for small time periods variables. A number of infrastructural developments like room for drivers, flooring, paneling, office development etc., have been made in the telescope housing.

There were 214 nights allotted and 13 papers were published.

One of the results obtained from the 1.3 m Telescope is highlight below.

#### Micro-variability studies of AGNs

Micro-variability studies play important role to understand whether phenomena such as relativistic jets are at play around the central engine of Active Galactic Nuclei (AGN) or not. Micro-variability study



for AGNs classes such as blazar and radio-quiet quasars has been carried out extensible; however

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. 250



**Figure 60:** Differential Light Curves (DLCs) of the RL-BALQSOs in the sample studied. The name of the quasar, and the date and duration of the observation are given at the top of each night's data. The upper panel gives the comparison of star–star DLC and the subsequent lower panels give the quasar–star DLCs as defined in the labels on the right-hand side. Any likely outliers (at >3 $\sigma$ ) in the star–star DLCs are marked with crosses, and the data corresponding to such flagged exposure are also removed from quasar–star DLC, for the final analysis.





per year.

In the present year between 01 April, 2012 - 31 March, 2013, one scientific paper based on the study of chromosphere surges using ARIES H $\alpha$  observations has been published. While various H $\alpha$  observations related to 12 June 2010 (6.1/SF) flare, impulsive flare on 23 October 2003 from AR10484, are studied and presented in COSPAR, Mysore, July 2012.



Figure 61. 15-cm Coude Solar tower telescope for solar observations.

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### **KNOWLEDGE RESOURCE CENTRE (KRC)/LIBRARY**



Figure 62: KRC Main Reading Hall.

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. 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.

#### KRC Resource Development

During the period 2012 – 2013, the following information resources were added:-

Books	:89
Subscription to Journals	:76 + 13 Full Tex
t (Print + Online)	Databases
ARIES Publications	:50
ARIES Theses	:5
The collection at the end of the	he period is
Books	:Around 10,506
Bound volumes of Journals	:Over 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 we preserve our Scientist's research articles, Academic Reports, Photographs of special events, Newspaper Clippings, etc.

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. ARIES 9<sup>th</sup> ANNUAL REPORT

## 2012-13

### **ACADEMIC PROGRAMMES**

Academic programs of ARIES are coordinated by the Academic committee (AC). The major programs conducted by AC during 2012-2013 are listed below:

Joint Entrance Screening Test (JEST): One member of Academic Committee (Dr. A. K. Srivastava) managed the JEST 2013 examination at Nainital centre. The committee also participates actively in over all planning of JEST on behalf of the ARIES.

**PhD entrance interviews:** AC organizes the interviews every year to select PhD students as Junior Research Fellows in ARIES. Students who are MSc in physics/astrophysics and have qualified JEST/ NET/ GATE are invited to appear in an interview. Candidates who have successfully qualify the interview are selected as Junior Research Fellows and are inducted in the pre-PhD course work. In the year 2012, 4 students entered ARIES pre-PhD coursework.

**Summer Project Students:** The summer project internship is one of the significant endeavors of the academic committee which provides training to Bachelor/Master level students from various universities and provides glimpses in cutting-edge research and development activities of the Institute. In the summer of 2012-13, many summer project students have been selected for pursuing the project at ARIES followed by submission of their project reports and evaluation as well as open oral talks. There were about 22 project students in the academic year 2012-13, and there were a good number of technical project students.

**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 committee, and evaluate the students as per the criteria made by the committee. The project related evaluations, commissioning of respective committees and experts, and arrangements of the project talks, are also executed by AC. In 2012-2013, AC has conducted the examination, project presentations, and passed the following students : Ms. Neha Sharma, Mr. Abhishek Paswan and Mr. Subhajeet Karmakar.

**Conducting/Managing PostDoctoral 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 positions and the interview cum talk of the applicants. AC also manages the annual reviews of the post-doctoral fellows. At present there are two postdocs at ARIES and they are: Dr. N. C. Joshi, Dr. Bharat Kumar Yerra, Dr. Sanjay Kumar, and four ARIES students were offered post-doctoral positions after submission of their thesis, and on the basis of their applications: Mr. Rupak Roy, Ms. Sumana Nandi Ms. Hartima Gaur, Mr. C. Eshwariah.



**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 2012-2013 the following students have been approved for their SRFs after the review process : Mr. Subhash Bose, Mr. Jai Bhagwan, Mr. Piyush Bhardwaj, Mr. Pradeep Kumar Kashyap.

#### ARIES Inhouse Meeting (AIM) 2012-2013

Academic Committee has organized two in-house Meetings in the year:

- (I) 19-20 April 2012, ARIES Inhouse Meeting was held in the New Lecture Room, and more than 20 scientists presented their work.
- (ii) 18-20 March 2013, ARIES Inhouse Meeting was held in the New Lecture Room, and 24 scientists including the Director, 10 Engineers, 4 senior students, 7 post-doctoral fellows, and the Registrar presented talks on scientific, engineering and administrative aspects of ARIES.



Figure 63. ARIES Inhouse Meeting - 2013, participants



### **PUBLIC OUTREACH PROGRAMMES**

For the purpose of disseminating information to the public as a part of the Public Outreach program, ARIES has set-up a science center comprising of one lecture hall equipped with projector and a sitting capacity of about 40 students and an exhibition hall to display the science models and posters. In addition to these, a small 14 inch telescope has been installed to facilitate live night sky visual observations for the general public.

### **Popular science Programs**

**Transit of Venus observing camp:** One day observing camp was organized during transit of Venus on  $6^{th}$  June 2012. A total of 60 students accompanied by their teachers participated in the camp. The camp consisted of various observing activities carried out by the participants such as (i) path of the Venus on the Sun's disk (ii) Angular size of the Sun and the Venus during the transit etc. The facts and the myths about the transits were narrated to the participants in the camp.

**Vocational Training Programme:** This programme was organized in association with NASI, Allahbad. About 120 talented students from across the country visited ARIES during 18-25th June 2012. The focus of the workshop was (i) to introduce observational sciences to the school children (ii) live sky show to encourage the school children and teachers to build-up their interest in this field (iii) poster exhibition on various exciting astronomical phenomena (iv) a number of lectures were organized to educate the students on the link between astronomy and the technology and also on how to become a successful astronomer. The workshop was inaugurated by Prof. V. P Sharma.

ARIES Training School of Observational Astronomy: ARIES training school in Observational Astronomy (ATSOA) is a regular annual program in which about 30-40 post graduate students with science background from different universities/institution participate to get trained in observational Astronomy. This year it was held between March 03-13, 2013.

### **Outside campus activities**

**Participation in 100<sup>th</sup> Indian Science Congress**: ARIES participated in 100<sup>th</sup> Indian Science congress held in Kolkata during 3-7 January 2013. The main focus was to highlight activities carried out at institutional level as well as to enhance the scientific temperaments among the general public especially from point of views of astronomy related developments happened in recent times.

**Introductory workshop on Astronomy at Gorakhpur University**: ARIES also participated in the workshop organized by the Physics department of Gorakhpur University during 4-9<sup>th</sup> March 2013. Our main contribution in this workshop was to provide the resource persons/experts as well as many models and poster to benefit the participants maximally, so as to sensitize young minds especially under graduate students, regarding the new excitements in the field of astronomy.

### New Facilities for Student and General Public added at the science center

(a) Planetarium plays an important role in the popularization of astronomy. This Year we are going to facilitate our visitors with a 5m planetarium. The planetarium has been procured and the construction of the planetarium housing is in progress. (b) For better visualization of remote astronomical systems and/or concepts, a scaled down model is always a best option. In this regards, popularization group has installed about two dozen of basic science and technology related models/display/activity corners in the Science Centre such as, Indian Rocket, Solar system, Internal structure of Sun, Comparative size of Planets etc. A total of about 8000 visitors have visited the Science center.





Figure 64. ATSOA-2013 Participant during 3ed march 2013-13 March 2013 (Group Photo)



Figure 65. Participation of ARIES in 100th Indian Science Congress



Figure 66. ATSOA-2013 lecture in progress



Figure 67. Participation of ARIES in 100th Indian Science Congress



Figure 68. Transit of Venus Observing Camp



### **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. One doctor is engaged by the ARIES who pays visit to the institute in a week. Facilities like rest bed and pressure machine are readily available in the doctor's chamber. The institute is planning to 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.



### **MEMBERS OF ARIES**

### Academic (28)

Ram Sagar (Director) U. S. Chaubey Alok C. Gupta Brijesh Kumar Manish Naja Jeewan C. Pandey Vimlesh Pant (till 30-04-2012) Snehlata Abhishek K. Srivastava

Satish Kumar (Information Scientist) (from 15-10-2012)

#### **Engineering (16)**

Umesh C. Dumka
Santosh Joshi
Biman J. Medhi
Amitesh Omar
Sashi Bhushan Pandey

Hum Chand

Sashi Bhushan Pandey D. V. Phanikumar Mahendra Singh Ramakant Singh Yadav Indranil Chattopadhyay

Maheswar Gopinathan Yogesh C. Joshi Kuntal Mishra *(from 21-12-2012)* Anil K. Pandey Pitamber Pant *(till 03-07-2012)* Saurabh Narendra Singh Wahab Uddin

Tarun Bangia	Samaresh Bhattacharjee	Krishna Gopal Gupta
Mukeshkumar B. Jaiswar	Mohit K. Joshi	Ashish Kumar
Tripurari S. Kumar	Nandish Nanjappa	Purushottam
Jayshreekar Pant	Chandra Prakash	Om Prakash (till 30-04-2012)
B. Krishna Reddy	Sanjit Sahu	Vishal Shukla (till 31-08-2012)
Shobhit Yadava		

### **Administrative and Support (20)**

(from 01-01-2013)	
Bhuwan Chandra AryaPratap S. Bhainsora (till 30-04-2012)Ashok Kuma	r Bhatt
Anand Singh Bisht Kundan Singh Bisht Mohan Singh	n Bisht
Rajeev Kumar Joshi Rajendra Prasad Joshi Hansa Karki	
Pramod Kumar (till 13-04-2012) Vijay Kumar Meena Mahesh Char	ndra Pande
Akash Raghuvanshi Diwan Ram Abhishek Ku	mar Sharma
Virendra Kumar SinghAsha Tewari (till 31-12-2012)Manjay Yada	V



### **Scientific and Technical (47)**

JavedAlam
Bharat Bhushan
Girish Chandra Giri
Anil Kumar Joshi
Girish Kumar
Ram Lal
Kanti Ram Maithani
Darwan Singh Negi
Deep Chandra Pant
Kanhaiya Prasad
Khim Ram
Uma Shankar
Arjun Singh
Sanjay Kumar Singh
Harish Chandra Tewari
Srikant Yadav

Naveen Chandra Arya Pradip Chakarborty Harish Chandra Harbola Ganesh Dutt Joshi Hemant Kumar Manoj Kumar Mahato Abhijit Misra Nitin Pal Girija Nandan Pathak Rajendra Prasad C. Arjuna Reddy Shashank Shekhar Ashok Kumar Singh Uday Singh Parmatma Saran Yadav Nitin Bharti *(till 03-08-2012)* Lalit Mohan Dalakoti Shamim Jamadar *(till 15-03-2013)* Ishwari Dutt Joshi Prashant Kumar Tileshwar Mahato Bhagwat Singh Negi *(till 30-09-2012)* Bipin Chandra Pant Rajan Pradhan Babu Ram Vinod Kumar Sah Anant Ram Shukla Rajdeep Singh Pawan Tiwari Ravindra Kumar Yadav *(from 04-05-2012)* 

### Laboratory Assistants/Attendants (14) :

Harish Chandra Arya	Suresh Chandra Arya	Ashok
Girish Chandra Badhani	Basant Ballabh Bhatt	Ramdayal Bhatt (from 04-05-2012)
Shyam Giri	Laxman Singh Kanwal	Anil Kumar
Rakesh Kumar	Shyam Lal	Ram Ashish Ram
Mohan Singh Rana	Lalit Lal Sah	

#### **Post-doctoral Fellows / Research Associates (7) :**

C. Eswaraiah	Haritma Gaur	Naveen Chandra Joshi
Sanjay Kumar	Sumana Nandi	Rupak Roy
Bharat Kumar Yerra		



### **Research Scholars (24) :**

Aditi Agarwal Subhash Bose Hema Joshi Pradeep Kumar Kasyap Rajiv Kumar Akash Priya Devesh Path Sariya Archana Soam Jay Bhagwan Sumit Kumar Jaiswal Ravi Joshi Brajesh Kumar Abha Monga Abhishek Paswan Tapaswini Sarangi Raman Solanki

Piyush Bhardwaj
Arti Joshi
Subhajeet Karmakar
Praveen Kumar
Narendra Ojha
Neha Sharma
Krishna Kumar Shukla
Ramkesh Yadav



### **DISTINGUISHED MEMBERS OF ARIES**

### **Adjunct professors**

Prof. Ravi N. Banvar (IIT, Mumbai) Prof. Gopal-Krishna (NCRA, Pune)

#### **Visiting Professors**

Prof. G. Srinivasan (RRI, Bangalore)

### **Visiting Scientist**

Prof. M. Parthasarathy

Prof. Kailash Chandra Sahu (STSI, USA)

### **Distinguished Professor**

Prof. P. C. Agarwal (Mumbai)



### **VISITS BY ARIES MEMBERS**

### Abroad

Dr. M. Naja	ICIMOD, Nepal CSC, Hamburg, Germany ICIMOD, Nepal	Apr. 01 – 03, 2012 June 03 – 11, 2012 Dec. 28, 2012 – Jan. 08, 2013
Prof. R. Sagar	AMOS, Belgium France Amsterdam, Neatherland South Africa Univ. of Texas, USA	May 07 – 15, 2012 June 29, 2012 July 01 – 07, 2012 Aug. 06 – 10, 2012 Feb. 11 – 21, 2013
Dr. W. Uddin	LMSAL, USA; California State Univ., California and NASA-GSFC, USA	May 01 – 31, 2012
Dr. N. C. Joshi	LMSAL, USA; California State Univ., California and NASA-GSFC, USA	May 01 – 31, 2012
Dr. B. Kumar	Marseille, France AMOS, Belgium Amsterdam, Neatherland	June 29, 2012 May 07 – 11, 2012 July 01 – 06, 2012
Dr. A. K. Pandey	NCU, Taiwan NARI, Thailand Univ. of Tokyo and KISO Observatory, Japan	Aug. 27 – Sept. 25, 2012 Sept. 25 – 28, 2012 Dec. 02 – 15, 2012
Dr. T. Bangia	France Amsterdam, Neatherland	June 29, 2012 July 01 – 06, 2012
Mr. V. Shukla	France) Amsterdam, Neatherland	June 29, 2012 July 01 – 07, 2012
Mr. J. Pant	France Amsterdam, Neatherland	June 29, 2012 July 01 – 07, 2012
Dr. A. Omar	France and Amsterdam, Neatherland) Bejing, China IAU, Canada HIA, Victoria BC	June 28 – 07, 2012 Aug. 20 – 24, 2012 Nov. 04 – Jan. 15, 2013 Nov. 17 – Dec. 28, 2012



Dr. S. B. Pandey	Marbella, Spain	Oct. 07 – 17, 2012
Dr. R. K. S. Yadav	Neatherland	June 27 – July 08, 2012
Dr. M. Gopinathan	KASI, South Korea	Oct. 20 – Dec. 22, 2012
Dr. Y. C. Joshi	California Inst. of Tech.,USA AOB, Italy	July 23 – 28, 2012 Sept. 06 – 07, 2012
Mr. T. S. Kumar	Neatherland NRC, Canada	July 01 – 06, 2012 Nov. 04, 2012 – Jan. 15, 2013
Mr. C. Eswaraiah	Beijing, China	Aug. 21 – 30, 2012
Mr. N. Ojha	Beijing, China San Franscisco, USA	Sept. 15 – 21, 2012 Dec. 03 – 07, 2012
Mr. Ramkesh Yadav	France	Aug. 29 – Sept. 10, 2012
Dr. M. Singh	CSIR; DST; Pretoria of SA; Wits Univ.; Stellenbosh Univ.; HMOCA, South Africa	Nov. 04 – 10, 2012
Dr. U. C. Dumka	San Fransisco, USA	Dec. 01 – 10, 2012
Dr. N. Singh	San Franscisco, USA	Dec. 01 – 10, 2012
Dr. S. Joshi Dr. B. K. Yerra	SAAO, South Africa SAAO, South Africa	Dec. 02, 2012 – Jan. 05, 2013 Dec. 03, 2012 – Jan. 06, 2013
Mrs. H. Gaur	China	Dec. 12 – 26, 2012
Mr. P. Bhardwaj	Kathmandu, Nepal	Dec. 27, 2012 - Feb. 19, 2013
Mr. D. P. Sariya	Moscow, Russia	Mar. 11 – 29, 2013

### **Indian Institutions**

Mr. P. Chakraborty	Pedvak, Hyderabad	Mar. 18 – Apr. 16, 2012
		June 06 – 31, 2012
Dr. A. C. Gupta	PRL, Ahmedabad	Apr. 01 – 05, 2012
	BARC, Mumbai	Mar. 29 – 31, 2012



Prof. R. Sagar	Kochi New Delhi	Apr. 09 – 10, 2012 Apr. 11, 2012 Dec. 07, 2012
	DST, New Delhi	June 15, 2012
	IIA. Bangalore	June 21, 2012
	Pune	Aug. 29, 2012
	Hyderabad	Aug. 30, 2012
	Bangalore	Aug. 31 - Sept. 03, 2012
	Darigaiore	Oct 22 = 26 2012
	CSID Dalampur HD	Sont $25, 2012$
	Now Dolbi	$O_{ot}$ 15 2012
	New Delli	Nov 20 21 2012
		Nov. $20 - 21, 2012$
		NOV. 27, 2012
	NASI, Allanabad	Nov. 28 – 30, 2012
	5	Jan. 28, 2013
	Pune	Dec. 09 – 12, 2012
	IISc, Bangalore	Dec. 22 – 31, 2012
	IIIM, Pune	Jan. 31, 2013
	Kolkata	Jan. 05 – 06, 2013
	ISC, Kolkata	Jan. 05 – 06, 2013
	GC Engg. College, Indore	Feb. 02, 2013
	NCRA, Pune	Feb. 26, 2013
	Gorakhpur	Mar. 02 – 04, 2013
	Gurukul Kangri Univ., Haridwar	Mar. 11, 2013
Dr. I. Chttopadhyay	PRL, Ahmedabad	Apr. 23 – 25, 2012
	Mysore	July 14 – 22, 2012
	Kumaun Univ., Nainital	Dec. 12, 2012
	Thiruvananthapuram	Feb. 20 – 22. 2013
	IIT. Guwahati	Mar. 11 – 13. 2013
Dr. J. C. Pandey	PRL, Ahmedabad	Apr. 23 – 25, 2012
	Mysore	July 2012
	MBPG, Haldwani	Nov. 04, 2012
	Kumaun Univ., Nainital	Dec., 2012
	Thiruvananthapuram	Feb. 20 – 22, 2013
Dr. A. K. Pandey	Pedvak, Hyderabad	Apr. 24 – 28, 2012
	Bose Institute, Kolkata	July 09 – 13, 2012
Dr. M. Naia	Hvderabad	Apr. 24 – 28, 2012
	Mysore	July $14 - 19$ 2012
	Debradun	Oct 0.09 - 11 2012
	NPI New Delhi	Nov $07 - 08 2012$
	PRI Ahmedabad	1307.07 - 30, 2012
	I INL, AIIIIIGUADAU	Jan. $27 - 30, 2013$



Dr. A. K. Srivastava	JLP, Allahabad Mysore RAC, Ooty IISER, Pune IIA, Bangalore Thiruvananthapuram Gorakhpur Univ., Gorakhpur	Apr. 25 – 29, 2012 July, 2012 July 23 – 31, 2012 Nov. 06 – 09, 2012 Jan. 19 – 25, 2013 Feb. 19 – 24, 2013 Mar. 05 – 09, 2013
Dr. W. Uddin	Coimbatore, Mysore and RAC, Ooty PRL, Ahmedabad Champawat	July 06 – 30, 2012 Jan. 12 – 21, 2013 Feb. 27 – 28, 2013
Dr. N. C. Joshi	Coimbatore, Mysore and RAC, Ooty PRL, Ahmedabad and RAC-NCRA, Ooty Thiruvananthapuram	July 06 – 30, 2012 Jan. 02 – 20, 2013 Feb. 20 – 22, 2013
Dr. S. B. Pandey	IIA, Bangalore DST, New Delhi SAC, Ahmedabad MBPG, Haldwani Kumaun Univ., Nainital IUCAA, Pune India Inte. Centre, New Delhi Ffort, Raichak, Kolkata Thiruvananthapuram	May $30 - June 01, 2012$ June 16, 2012 Oct. $04 - 05, 2012$ Nov. $03 - 04, 2012$ Dec. $07, 2012$ Dec. $12 - 15, 2012$ Jan. $21 - 22, 2013$ Jan. $07 - 12, 2013$ Feb. $19 - 22, 2013$
Dr. N. Singh	Mysore	July 12 – 22, 2012
Dr. M. Gopinathan	Hyderabad IISST, Thiruvananthapuram	Aug. 29 – 31, 2012 Feb. 19 – 24, 2013
Dr. S. Joshi	Chennai MBPG, Haldwani	Aug. 26 – 28, 2012 Nov. 04, 2012
Dr. S. Sharma	TIFR, Mumbai IIA, Bangalore Tezpur Univ., Tezpur MBPG, Haldwani Thiruvananthapuram	Mar. 03 – 09, 2012 May 30 – 31, 2012 Jun. 04 – 07, 2012 Nov. 03 – 04, 2012 Feb. 20 – 22, 2013
Ms. H. Joshi	ISRO-VSSC, Thiruvananthapuram IIRS, Dehradun	June 20 – 21, 2012 Nov. 18 – 22, 2012



Mr. C. Eswaraiah	SNBIBS, Kolkata	July 10 – 13, 2012
Mr. R. Yadav	SNBIBS, Kolkata	July 10 – 13, 2012
Dr. H. Chand	IIT, Mandi MBPG, Haldwani Kumaun Univ., Nainital IUCAA, Pune and NCRA, Pune) Gurukul Kangri Uniy Haridwar	June 11, 2012 Nov. 04, 2012 Dec. 26, 2012 Dec. 17 – 21, 2012 Mar. 12, 2013
Ms. T. Sarangi	Mysore	July 14 – 22, 2012
Ms. A. Soam	IIA, Bangalore Mysore	June 27 – July 12, 2012 July 14 – 22, 2012
Mr. R. Roy	Mysore Kolkata Thiruvananthapuram IIT, Gwahati	July 09 – 25, 2012 Jan. 07 – 11, 2013 Feb. 20 – 22, 2013 Mar. 11 – 13, 2013
Mr. R. Kumar	Mysore IIT, Guwhati	July 09 – 25, 2012 Mar. 11 – 13, 2013
Mr. P. Bhardwaj	Mysore IIRS, Dehradun	July 09 – 25, 2012 Nov. 18 – 20, 2012
Mr. K. K. Shukla	Mysore	July 09 – 25, 2012
Dr. T. Bangia	Pedvak, Hyderabad ITM, Punjab Thiruvananthapuram	August 29 – 31, 2012 Nov. 26, 2012 Feb. 20 – 22, 2013
Mr. S. Yadav	Pedvak, Hyderabad Pune Thiruvananthapuram	August 29 – 31, 2012 Nov. 21 – 24, 2012 Feb. 20 – 22, 2013
Mr. S. Sahu	Pedvak, Hyderabad	August 29 – 31, 2012
Mr. R. Solanki	Dehradun	Nov. 20 – 22, 2012
Mr. N. Nanjappa	IMT, Punjab Pune Coimbatore and Mumbai Delhi	Nov. 25 – 27, 2012 Dec. 09 – 11, 2012 Dec. 11 – 16, 2012 Dec. 20 – 24, 2012



Dr. U. C. Dumka	BARC, Mumbai	Dec. 11 – 15, 2012
Mr. R. Joshi	IUCAA, Pune	Dec. 17 – 20, 2012
Dr. B. Kumar	Kumaun Univ., Nainital Kolkata Thiruvananthapuram	Dec. 26, 2012 Jan. 07 – 11, 2013 Feb. 20 – 22, 2012
Dr. (Mrs.) K. Misra	Raichak, W. Bengal Thiruvananthapuram IUCAA, Pune	Jan. 07 – 11, 2013 Feb. 20 – 22, 2013 Mar. 04 – 08, 2013
Mr. S. Bose	Kolkata Thiruvananthapuram	Jan. 07 – 11, 2013 Feb. 20 - 22, 2013
Dr. B. K. Yerra	IIA, Bangalore Thiruvananthapuram	Jan. 30 – Feb. 05, 2013 Mar. 19 – 26, 2013 Feb. 18 – 26, 2013
Dr. N. Singh	Gopeshwar Gurukul Kangri Univ., Haridwar Doon Univ., Dehradun	Feb. 17 – 18, 2013 Mar. 11 – 12, 2013 Mar. 22 – 23, 2013
Mr. S. Karmakar	Thiruvananthapuram	Feb. 20 - 22, 2013
Dr. S. Kumar	IITM, Pune	Feb. 12 – 20, 2013
Dr. M. Singh	Thiruvananthapuram	Feb. 20 - 22, 2013
Dr. A. Omar	Thiruvananthapuram	Feb. 20 - 22, 2013
Dr. (Mrs) S. Lata	Thiruvananthapuram	Feb. 20 - 22, 2013
Mr. J. Pant	Thiruvananthapuram	Feb. 20 - 22, 2013
Mr. S. K. Jaiswal	Thiruvananthapuram	Feb. 20-22, 2013
Mr. A. Paswan	Thiruvananthapuram	Feb. 20 – 22, 2013

ARIES 9<sup>th</sup> ANNUAL REPORT

## 2012-13

April 22 – May 21, 2012

June 15 – 30, 2012

July 01 – 18, 2012

July 01 – 18, 2012 July 01 – 18, 2012

July 01 – 18, 2012

July 01 – 18, 2012

July 01 – 18, 2012

Oct. 28 - 30, 2012

Oct. 28 - 30, 2012

Jan. 21 - 30, 2013

Jan. 21 – 30, 2013

Jan. 21 - 30, 2013

Mar. 10 – 12, 2013

Mar. 10 – 12, 2013

Mar. 10 – 12, 2013

Mar. 26 - 30, 2013

Jan. 02, 2013

Jan. 02, 2013

Oct. 22 - Nov. 02, 2012

Oct. 22 - Nov. 02, 2012

Nov. 14 - Dec. 04, 2012

### **VISITORS AT ARIES**

#### **From Abroad**

Mr. P. van Heerden Dr. R. El-Bendory Prof. W. P. Chen Mr. C. C. Lin Mr. C. D. Lee Mr. C. K. Huang Mr. J. K. Guo Ms. J. Chao Dr. B. P. Filippov Dr. O. V. Mortsenyuk Prof. K. Ogura Ms. S. Lalitha Dr. O. Vopvach Dr. (Ms.) M. Bhatt Dr. (Ms.) A. Vaishya Dr. N. Gopalswamy Dr. S. Yashiro Dr. P. Makela Prof. D. Buckluy Dr. H. Harder Dr. M. M. Harder Prof. L. Balona

### NRIAG, Egypt NCU, Taiwan NCU, Taiwan NCU, Taiwan NCU, Taiwan NCU, Taiwan NCU, Taiwan IZMIRAN, Moscow IZMIRAN, Moscow Kokugajuin Univ., Tokyo Humburger Sternwarte, Germany GAO, Ukrain Ireland Ireland NASA, USA NASA, USA NASA, USA SAAO, South Africa MPIC, Germany MPIC, Germany SAAO, South Africa

SAAO, South Africa

#### **From Other Indian Institutions**

Prof. P. C. Agrawal	Mumbai	Apr. 02 – 11, 2012
		Jun. 12 – 16, 2012
		Mar. 21 – 22, 2013
Dr. S. K. Sharma	PRL, Ahmedabad	Mar. 29 – Apr. 03, 2012
Dr. V. Sahani	BARC, Mumbai	Apr. 19 – 22, 2012


May 14 – 23, 2012

Dr. S. Mandal Dr. P. Thakur Dr. B. P. Singh Mrs. S. Jain Mr. A. K. Chattopadhyay Dr. S. P. Taware Dr. C. M. Nautiyal Prof. S. R. Sikdar Prof. S. K. De Prof. C. K. Rao Mr. R. Somashekar Mr. T. Chandrasekhar Mr. B. K. Tyagi Dr. B. N. Tiwari Dr. S. Aggarwal Mr. A. K. Srivastava Mr. N. A. Prakash Dr. N. H. Khadse Dr. S. C. Bordoloi Dr. P. Vishwanath Prof. U. S. Pandey Prof. R. P. Sharma Dr. H. S. Das Prof. R. Banvar Prof. J. N. Goswami Prof. R. Srinivasan

NCRA, Pune

NASI, Allahabad

Kochin Univ., Kochin

Kochin Univ., Kochin

Kochin Univ., Kochin

Dr. N. Kumar Prof. M. Kumar Prof. R. N. Keshawmurthi Prof. A. Jayraman

Prof. P. Rao

**IISST**, Thiruvananthapuram GCU, Bilaspur DST, New Delhi DST, New Delhi DST, New Delhi ARI, Pune **BSIP**, Lucknow Bose Institute, Kolkata IACS, Kolkata IIG, Navi Mumbai **RRI**, Bangalore Vigyan Prasar, Noida Vigyan Prasar, Noida WIHG, Dehradun INSA, New Delhi NASI, Allahabad IAS, Bangalore NATMO, Kolkata IASST, Guwahati CSMR, Bangalore Gorakhpur Univ., Gorakhpur IIT, Delhi Assam Univ., Assam IIT, Mumbai PRL, Ahemdabad VIT, Bangalore

May 29 – June 05, 2012 June 26 – 27, 2012 June 26 - 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 June 26 - 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 June 26 - 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 June 26 - 27, 2012 June 26 – 27, 2012 June 26 – 27, 2012 May 28 – June 07, 2012 May 17 - 20, 2012 May 21 – 25, 2012 May 28 – June 01, 2012 June 09 - 10, 2012 June 14 – 16, 2012 Mar. 20 – 22, 2013 June 11 – 28, 2012 Mar. 18 - 22, 2013 June 21 - 25, 2012 July 11 – 12, 2012 July 11 – 12, 2012 July 11 – 12, 2012



Dr. M. Satyanarayana Prof. B. M. Reddy Dr. P. S. Rao Mr. G. Viswanathan Prof. P. R. Mahapatra Mr. S. Damle Prof. R. Prakash Dr. Mahesh Prof. E. Reddy Prof. D. Bhattacharya Prof. J. N. Chengular Prof. A. Subramaniam Prof. B. Paul Prof. D. K. Ojha Prof. V. Sinha Prof. A. Kembhavi Dr. A. N. Rampraksh Dr. S. Ravindranath Mr. Lee Dr. S. Malladi Prof. R. C. Verma Dr. A. L. Sharma Prof. R. Jain Dr. A. Awasthi Dr. B. E. Reddy Prof. R. Kaul Prof. A. N. Ramprakash Prof. T. Chandrasekhar Dr. H. N. Suresh Kumar Dr. H. S. Das Prof. S. N. Tondon Prof. S. Ananthkrishan Prof. G. Srinivasan

Kochin Univ., Kochin IISC, Hyderabad DST, New Delhi ISRO, Bangalore **IISC**, Bangalore Pune IUCAA, Pune IIA, Bangalore IIA, Bangalore IUCAA, Pune NCRA, Pune IIA, Bangalore **RRI**, Bangalore TIFR, Mumbai **IISER**, Mohali IUCAA, Pune IUCAA, Pune IUCAA, Pune IUCAA, Pune Univ. of Kerala, Trivandrum Punjab Univ., Patiala Indore PRL, Ahmedabad PRL, Ahmedabad IIA, Bangalore BARC, Mumbai IUCAA, Pune PRL, Ahmedabad ISRO, Bangalore Assam Univ., Assam IUCAA, Pune NCRA, Pune Bangalore

July 11 – 12, 2012 Oct. 04, 2012 Oct. 04, 2012 Aug. 01 - 02, 2012 Aug. 01 - 02, 2012 Aug. 01 - 02, 2012 Oct. 05 - 08, 2012 Oct. 05 - 06, 2012 Nov. 14, 2012 Dec. 13 -14, 2012 Jan. 22 - 30, 2013 Jan. 22 - 30, 2013 Mar. 01, 2013 Feb. 28 - Mar. 01, 2013 Mar. 01 – 02, 2013 Feb. 28 - Mar. 02, 2013 Feb. 28 - Mar. 02, 2013 Mar 11 – 14, 2013 Mar. 21 - 22, 2013 Mar. 21 - 22, 2013 Mar. 21 - 22, 2013

## 2012-13

#### **ABBREVIATIONS**

AC	Academic Committee
ADFOSC	ARIES Devasthal Faint Object Spectrograph and Camera
AGN	Active Galactic Nuclei
AIA	Atmospheric Imaging Assembly
AIM	ARIES In-house Meeting
AIMPOL	ARIES Imaging Polarimeter
AMOS	Advanced Mechanical and Optical Systems
AOD	Aerosols Optical Depth
ASTROSAT	Indian Satellite Mission for Multiwavelength Astronomy
ATSOA	ARIES Training school in Observational Astronomy
BAL	Broad Absorption Line
BL Lac	BL Lacertae
BVR	Blue-Violet-Red
BVRI	Blue violet Red Infrared
CCD	Charged Coupled Device
CME	Coronal Mass Ejection
CNC	Computer Numerical Control
COSPAR	Committee On Space Research
CTIO	Cerro Tololo Inter-American Observatory
DC	Duty Cycle
DCS	Dome Control System
DDRGs	Double-double Radio Galaxies
DOT	Devasthal Optical Telescope
DSP	Digital signal processor
DU	Dobson Units
ECIL	Electronics Corporation of India Limited
EUV	Extreme ultraviolet
FCS	Filter Control System
FOSC	Faint Object Spectrograph and Camera
FSRQs	Flat-Spectrum Radio-Loud Quasars
GATE	Graduate Aptitude test in Engineering



GBM	Gamma-ray Burst Monitor
GCs	Globular Clusters
GMRT	Giant Meterwave Radio telescope
GRB	Gamma-Ray Burst
GRS	Global Positioning System
GUI	Graphic User Interface
HMI	Hydrargyrum medium-arc
ICS	Instrument Control System
IFDL	Instruments Facility and Development Laboratory
IGP	Indo-Gangetic Plane
INOV	Intranight Optical Variability
IRAC	Infrared Array Camera
ISS	Interstellar Scintillation Studies
IUCAA	Inter-University Centre for Astronomy and Astrophysics
JEST	Joint Entrance Screening Test
KRC	Knowledge Resource Centre
LAT	large Area Telescope
LIDAR	Light Detection and Ranging
LSPs	Layered Service Provider
MDI	Michelson Doppler Imager
MHD	Magnetohydrodynamic
MIR	Mid Infra Red
MOPITT	Measurement of Pollution in the Troposphere
MST	Mesosphere-Stratosphere-Troposphere
NARL	National Atmospheric Research Laboratory
NERC	Natural Environment Research Council
NET	National Eligibility Test
NGC	New General Catalog
NIR	Near Infra Red
NKRC	National Knowledge Resource Consortium
NLSy1	Narrow-line Seyfert1
NOAA	National Observatory of Astronomy and Astrophysics
OCS	Optical Control System



OMI	Ozone monitoring Instrument
OPAC	Online Public Access Catalogue
PIT	Project Implementation Team
PMB	Project Management Board
PWG	Project Working Groups
QSO	Quasi-Stellar Object
RL-BALQSOs	Radio-Loud Broad Absorption Lines
RRTMG	Rapid Radiative Transfer Model
SAC	Scientific Advisory Committee
SAO	Smithsonian Astrophysical Observatory
SAT	Site Acceptance Test
SDO	Solar Dynamics Observatory
SLL	Side Lobe Level
SOHO	Solar and Heliospheric Observatory
SQL	Structured Query Language
ST Radar	Stratosphere Troposphere Radar
ST	Sampurnanand Telescope
STA	Semiconductor Technology Associates
TIG	Tungsten Inert Gas
TMT	Thirty Meter Telescope
UBVRI	Ultraviolet-Blue-Visual-Red-Infrared
UHF	Ultra high frequency
UV YSO	Ultra Violet Young Stellar Object





Audited Statements of Account (2012-2013)



मनीष खन्ना एण्ड क. सनदी लेखाकार

#### Manish Khanna & Co. Chartered Accountants

30, Pichari Bazar (1st Floor), Mallital, Nainital 263001, Uttarakhand Telefax : +91 5942-238757 Greenmail : ManishCA@fastmail.in

#### INDEPENDENT AUDITOR'S REPORT

To The Director, Aryabhatta Research Center for Observational Sciences (ARIES) We have audited the accompanying Balance sheet of ARIES for the year ended March 31, 2013, and the relative Income and Expenditure Account and the Receipts 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 statements 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 Company's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements. We believe that the 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, 2013

Integrity

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(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 account , of receipts and payments reflected therein.

#### Other matter

(1) (a) ARIES is executing a project titled "ST radar Project" which has a bank balance of Rs 87.00 lacs . Separate books of accounts have been kept for the project. The project is not reflected in the reported financial statements

INITAL

Professionalism

Independence

Fidelity



मनीष खन्ना एण्ड क. सनदी लेखाकार

#### Manish Khanna & Co. Chartered Accountants

30, Pichari Bazar (1st Floor), Mallital, Nainital 263001, Uttarakhand Telefax : +91 5942-238757 Greenmail : ManishCA@fastmail.in

(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. Fixed assets have not been physically verified by the management.

3. During the course of audit , we have come across instances of delayed projects where , by virtue of the terms contained in the contract, penalty or liquidated damages should have been imposed against the contractors . As represented by ARIES, the decision of imposing such damages falls within the purview of the Governing Council and therefore we have not dealt with the instant issue in our audit.

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.

For Manish Khanna & Co. Chartered Accountants Firm Registration Number : 008584C

Manish Khanna, FCA. DISA(ICAI) Proprietor Membership Nos 077858 Dated: December 26, 2013 Place: Nainital

Independence

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Integrity

Professionalism

Fidelity



DADTICULADS	COLL		
PARTICULARS	SCH.	CURRENT YEAR	PREVIOUS YEAR
	NO.	F. T. 2012-13	F. Y. 2011-12
CORPUS / CAPITAL FUND AND LIABILITIES			
Corpus Funds	1	1,556,070,052.94	1,488,704,825.5
EARMARKED / ENDOWMENT FUNDS	1A	99,033,002.46	92,108,481.4
CURRENT LIABILITIES & PROVISIONS	_		
Other Current Liabilities	2	10 100 100 00	
other ourient Elabilities	2	19,168,120.00	11,710,039.0
TOTAL		1,674,271,175.40	1,592,523,346.0
ASSETS			
NON CURRENT ASSETS	1		
(a) Fixed Assets			
(i) Tangible assets	3	347,121,937,16	361 279 080 6
(ii) Capital work in progress	3	1,167,195,488.00	1 051 912 659 0
(b) Non current investments	4	77,843,524,67	75.812 782 6
(c.) Long term loans and advances	5	10,430,224.00	10,067,372.0
CURRENT ASSETS			
(a) Inventories	6	2,342,089.69	2,066,148,8
(b) Cash and bank balances	7	58,167,764.88	80,647,939.8
(c) Loans and Advances	8	11,170,147.00	10,737,363.0
TOTAL		1,674,271,175.40	1,592,523,346.02
Significant accounting policies and notes to accounts	s 14		
	Ir	terms of our report of even date	appayed herete
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or Aryabhatt Research Institute of Observational Science	s	Aller A	NA 3001 2
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Tonmou Phattachan	M	anish Khanna, FCA, DISA(ICA	Charterest A039
Acting Director Registron	M	embership Number : 077858	- STOP
	Pr	oprietor	
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Bharat Singh Abhishek Sharma		ated 1:15	
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#### ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL



#### ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES, NAINITAL

CURRENT YEAR F. Y. 2012-13	PREVIOUS YEAR F. Y. 2011-12
222,550,000.00	220,000,000.0
8,236,596.00	41,362,010.3
2,131,736.00	2,227,121.0
232,918,332.00	263,589,131.3
71,412,277.00	60,557,839.0
40,471,010.16	27,366,814.2
53,669,817.46	45,805,417.0
165,553,104.62	133,730,070.20
67,365,227,38	129,859,061.14
67,365,227.38	129,859,061.14
terms of our report of even date	ANNIA & CO
anish Khanna, FCA, DISA(ICA	NA: 300' Sugar
embership Number : 077858	Chartered Mar
anish Khanna & Co RN : 008584C	
ated : 2 6 DEC 2018	
F	roprietor Ianish Khanna & Co RN : 008584C ated : 26-DEC 2013



SCHEDULE FORMING PA	RT OF BALANCE SHEET AS ON 31st MA	RCH 2013
Schedule 1 : Corpus Fund		
Darticulars		DREVIOUS YEAD
Particulars	E V 2012-13	E V 2011-12
- Callerance	1.1.2012-15	F. 1. 2011-12
Balance as at the beginning of the year	1,488,704,825.56	1,358,845,764.4
Add / Deduct : Balance of the net income		
expenditure transferred		
from the Income and Expenditure Acount	67,365,227.38	129,859,061.1
TOTAL	1,556,070,052.94	1,488,704,825.5
Schedule - 1A - Earmarked Funds		
Particulars		
Particulars	E V 2012-13	E V 2011-12
Superannuation / Pension	1.1.2012-15	1.1.2011-12
a) New Pension Scheme Fund Account	17.320.360.84	11.677.860.8
b) Old Pension Fund Account	51,180,065,06	49,405,634.0
c) GPF Fund Account	30,532,575.56	31,024,986.5
5,642,500.00		
TOTAL	99,033,002.46	92,108,481.4
Schedule 2 : Current Liabilities		
Particulars	CURRENT YEAR	PREVIOUS YEAR
	F. Y. 2012-13	F. Y. 2011-12
A. Other Current Liabilities		
a) Canteen Security	2,000,00	2.000.0
b) IIC PAB Research Project	52 650 00	52 650 0
c) Group Insurance	52,050.00	(3.870.0
d) Earnest Money	1,864,427.00	964.084.0
e) Retention Money	157,245.00	157,245.0
f) Retention Security Deposit	2,371,380.00	1,270,124.0
g) Security Deposit	5,742,075.00	4,301,396.0
h) Performance Security	4,767,494.00	4,964,866.0
i) Mission butter Fly (Kalyan Sammittee)	500.00	500.0
j) Vat Collection	7,888.00	1,044.0
<ul> <li>Money received on account of other projects</li> </ul>	4,202,461.00	
TOTAL (A)	19,168,120.00	11,710,039.00
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Particulars	CURRENT YEAR	PREVIOUS YEAR
	F. Y. 2012-13	F. Y. 2011-12
Investment in SBI FDR's (GPF A/c)	14,385,258.00	14,435,480.0
Investment in UBI FDR's (Old Pension)	48,047,291.00	48,501,384.0
Investment in EDR's SBL& UBL (New Pensi	8,984,791.00 3,773,124,00	8,385,931.0
NSDL - New Pension Scheme Fund	329,816.00	3,773,124.0
Total	75,520,280.00	75,095,919.0
Tatanatian		
investments		
Interest accrued on SBI FDR's (GPF A/c)	1,350,669.00	
Interest accrued on UBI FDR's (GPF A/c)	382,145.00	126,433.0
Interest accrued on SBI (New Pension)	590,430.67	590,430.6
Total accrued interest	2,323,244.67	716,863.6
Total non current investments including accrued interest	77,843,524.67	75,812,782.6
Schedule 5: Long term loans and advan		
Advance for capital items - fixed assets		
For ADFOSC	305,640.00	262,004.0
Material Advance	636,899.00	636,899.0
For 1.3 mt. Telescope	319,685.00	319,685.0
Advance for 3.60 Mtr telescope	324 262 00	60,000.0
Advance to suppliers	102,938.00	168.722.0
Advance for instruments and equipment	8,295,800.00	8,295,800.0
Advance custom duty	385,000.00	,,
	10,430,224.00	10,067,372.0
Schedule 6 :Inventories : Spares and		
consumable stocks Particulars	CURRENT YEAR	PREVIOUS YEAR
i Consumable Stock	F. Y. 2012-13	F. Y. 2011-12
ii. Stationery Stock	1,078,895.60	1,231,382.2
iii. Computer Accessories Stock	1.035.424.73	
iv. Fuel (POL)	70,578.67	34,403,6
Total	2,342,089.69	2,066,148.8
Schedule 7 : Cash and bank balances		
Particulars	CURRENT YEAR	PREVIOUS YEAR
Cash on hand	FY 2012-13	FY 2011-12
	32,742.00	18,153.0
4. Bank Balances :		
<ul><li>(i) On Current Accounts (As per Annexure</li><li>1)</li></ul>	625,057.00	4,807,722.0
(ii) On Saving Accounts (As per Annexure - 1)	33.249.965.88	53 522 064 8
Total bank balances	33,875,022,88	59 330 795 0
b) Other bank balances Amounts held as margin money against	55,075,022,00	50,523,780.88
letters of credit opened for import of equipments.	24,260,000.00	22,300.000.00
TOTAL (A)	58,167,764.88	80,647,939.88
Schedule 8 : Loans and advances	CURRENT YEAR	
Particulars	F. Y. 2012-13	F. Y. 2011-12
1. Loans : a) Staff (Annexure - 2.)	4 454 934 00	4 571 507 0
2. Advances and other amounts	4,404,204,00	4,571,587.00
recoverable in cash or in kind or for value to be received : ( annexure -3)	6,715,213.00	6,165,776.00
TOTAL (A+B)	11,170,147.00	WANNA 10,737,363.00
ase n	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	(3) HITAT
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# 2012-13

	CURREN	IT YEAR		PREVIOUS YEAR
	F. Y. 20	12-13		F. T. 2011-12
SCHEDULE - 9 -Grants				
1. Central Government		222,550,000.00		220,000,000.0
TOTAL		222,550,000.00		220,000,000.0
Particulars	CURREN	IT YEAR	PREVIOUS	YEAR
	F. Y. 20	012-13	F, Y, 201	1-12
Schedule 10 : Interest earned				
1.On Term Deposits & Savings Accounts :		7.841.916.00		41,289,975.3
2. On Loans :				
a) Employees / Staff (Interest on Advances)	)			
Computer Advance Intt. (ARIES)	18,355.00		15,835.00	
HBA Intt. (ARIES)	303,346.00		6,833.00	
Car Adv. Intt. (ARIES)	60,278.00		39,767.00	
OMCA Intt. (ARIES)	12,701.00	394,680.00	9,600.00	72,035.0
TOTAL		8,236,596.00		41,362,010.3
Schodula - 11 - Other Income				
PARTICIII ARS	CURREN	IT YEAR	PREVIOUS	YEAR
PARTEOPARS	F.Y.20	12-13	F.Y.201	1-12
Registration Fee		54.350.00		2.618.0
Residential Buildings / Hostels		233.609.00		189,065.0
Water Charges		192,795.00		158,266.0
Telephone Charges		9,512.00		14,913.0
Electricity / Meter Charges		584,613.00	-	326,667.0
Guest House Rent		316,433.00		191,350.0
Missing Book Value		545.00		
Tender Fee		63,309.00		24,613.0
Scrap sale				1,313,058.0
Misc Receipts		136,717.00		
RTI Receipts		184.00		271.0
Vehicle Charges		8,400.00		6,300.0
Prior period adjustments		531,269.00		
TOTAL		2,131,736.00	ANNA8	2,227,121.0
			101	
Ose n		(	NAMIN NAME STRAT	

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SURESCLE IL LOTADLISHMENT LAFT	CURREN	TYEAR	PREVIOUS	5 YEAR
Pay & Allowances	EV 20	12-13	F Y 201	1-17
Salary Expenses	52 085 088 00 1	12 15	48 652 730 00 1	
DA Arrear	52,005,000.00		254,108,00	
Honorarium A/c	40 764 00		160,500,00	
Honorarium Visiting Scientist	68.078.00		114,500,00	Contraction of the
Bonus	212 133.00		207,240,00	
Leave Travel Concession	751.374.00		812,581,00	
Employer Contribution towards NPS and	102/07 1100		012/002/00	
hterest	2,842,599.00		2,249,498.00	
Employer Contribution towards Old				
ension Fund	6,282,964.00			
Employer Contribution to GPF Interest	101,641.00		155,466.00	
Gratuity			428,710.00	
Commutation			568,326.00	
Leave Encashment	1,740,951.00		423,907.00	
Over Time	26,842.00		29,063.00	
Medical Reimbursements	541,315.00		519,880.00	
Dispensary Expenses	183,498.00		93,898.00	
Fellowship	5,710,376.00		5,031,674.00	
Reimbursement of Tution Fee	824,654.00	71,412,277.00	855,758.00	60,557,839
TOTAL		71,412,277.00		60,557,839
SCHEDULE - 13 - OTHER				
DMINISTRATIVE EXPENSES ETC.	CURREN	T YEAR	PREVIOUS	5 YEAR
	F.Y.20	12-13	F .Y.201	.1-12
Public Outreach Programme		533,083.00		678,771
JEST		125,000.00		184,37
Postage Expenses		204,066.00		247,57
Electricity and Power		2,510,389.00		3,715,34
Water Charges		409,167.00		277,23
Registration Charges		472,355.00		39,39
Building Repair		2,929,817.00		3,110,08
Instruments AMC		244,591.00		526,11
Vehicles		330,741.00		290,42
Repair and Maintainence - others		198,787.00		9,00
Fuel Account (POL)		1,221,065.01		751,64
Telephone and Communication Charges		130,651.00		153,77
Printing & Stationery		650,396.06		341,20
Meeting of Governing Council		306,664.00		48,65
Meeting of Other Scientific Bodies		2,574,814.00		1,959,94
Sundry Services Charges (Internet etc)		4.052.096.00		3,600,16
Auditors Remuneration		30,000,00		15.00
Hospitality Expenses		100,289,00		17.59
Advertisement		991.402.00	· · · · · · · · · · · · · · · · · · ·	577.22
Security Expenses		1 966 999 00		1 633 64
Conveyance		903,776.00		388.87
Bank Charges		177 788 00	1	84 24
Canteen Expenses		1 231 371 00		1 014 24
Consumables Assessories		4 129 045 61		2 375 15
Insurance Charges		50 803 00		198 58
iveries Expenses		50,005.00		11 29
Cont				1 20
Sarden Exnenses		378 515 00		218 24
enal Evnenses		427 283 00		456.00
Cleaning Work Expenses		1 037 200 00		1 230 01
Computer Accessories		1 524 050 48		1 247 47
Sundry Expanses		400 935 00		467 17
Out Source Services		52 760 00		402,12
Obergational Eacilities		7 905 222 00		99.00
Sustan Classes Changes		7,905,222.00		88,90
Custom Clearence Charges		74,525.00		14,76
Freight & Cartage		1 504 442 00	1	25,90
Travel - Foreign		1,594,442.00	til	1,000,290
ravel - domestic		598,925.00	MNA8	3/1,434
TOTAL			The second se	17 766 014

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ARYABHATTA RESEARCH INSTITUTE OF OBSERVA	TIONAL SCIENCES, NA	INITAL
BANK BALANCES		ANNEXURE - 1
	CURRENT YEAR	PREVIOUS YEAR
ACTOULARS	2012-2013	2011-2012
Bank Balances with scheduled Banks		
a) On Cuurent Accounts		/
i) Main Account - SBI , Nainital - 10860835458	625,057.00	4,807,722.00
b) On savings Accounts	1	/
(i) Director Account - SBI, Nainital - 10860840253	522,168.35	3,506,302.35
(ii) GPF Account - SBI, Nainital - 10860840300	5,785,337.80	7,884,129.80
iii) GPF Account - SBI, Nainital - 30728692435	88,454.00	88,454.00
iv) Pension Account (Old) - SBI, Nainital -10860840311	6,605,251.06	4,830,819.06
(iv) Pension Account (New) - SBI, Nainital -10860840322	12,523,968.67	7,212,340.67
(vi) Union Bank of India, Nainital -535	7,724,786.00	30,000,019.00
TOTAL	33875022.88	58329786.88
LOAN / ADVANCE TO STAFF		ANNEXURE - 2
PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
	2012-2013	2011-2012
(i) Motor Car	486,806.00	588006.00
(ii) Motor Cycle	34,340.00	53840.00
(iii) Computer	180,050.00	186250.00
iv) House Building	\$ 3,677,968.00	< 3589241.00
v) Festival	13,500.00	74250.00
(vi) LTC	43,000.00	80000.00
(vii) Income tax paid on behalf of employees	19,270.00	
TOTAL	4,454,934.00	4571587.00
	/	INNA &

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## 2012-13

	ADVANCES - OTHERS		ANNEXURE - 3
	ADVANCED - UTILING		ATTE OTL - U
1	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
0.	and an instrumentation of the second s	F. Y. 2012-13	2011-2012
1	Advance for Scientific Meeting	167,632.00	165,432.00
2	Advance for Scientific Meeting Foreign		2,556.00
3	Travelling Advance	75,926.00	101,926.00
4	Sundry Advance	215,200.00	165,929.00
	Advances to staff (A)	458,758.00	435,843.00
1	Security Deposits	461,330.00	223,700.00
2	Advance to Uttrakhand Jal Sansthan		20,000.00
3	BSNL Broadband Security	2,000,000.00	2,765,015.00
4	Advance for ILTP Project	27,003.00	27,003.00
5	Advance for Indo- Bulgaria Project(Dr Alok Ku. Gupta)	192,000.00	75,000.00
6	Indo Russian Project (Dr S B Pandey)	(76,163.00)	(161,733.00)
7	Advance - Postage	5,500.00	
8	Advance to Uttrakhand Power Corporation	1,000,004.00	2,000,005.00
9	TDS Receivable	1,992,668.00	780,943.00
10	Other advances	511,563.00	
11	Advance legal fees	50,000.00	
12	Advance for consumable Purchase	92,550.00	
	Advances and security deposits (B)	6,256,455.00	5,729,933.00
-	TOTAL (A+B)	6.715.213.00	6 165 776 00

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i vi	NAME OF ASSETS	GF	OSS-BLOCK	-	Depr	eciation for the yea	L.	NET BI	LOCK
0		OP. BAL.	ADDITION	CL. BAL	OP. BAL.	DEP	CL. BAL.	ADA	NOW
		AS ON 01/04./2012		AS ON 31/03/2013	AS UN	YEAR	AS UN 31/03/2013	31/03/2013	31/03/2012
-	Land	105,850,429.00		105,850,429.00	P.		x	105,850,429.00	105,850,429.00
N	Building				0				•
	(i) Residential - Manora Peak	6,528,024.60	1,756,296.00	8,284,320.60	838,960.00	372,268.03	1,211,228.03	7,073,092.57	5,689,064.60
1	(ii) Non Residential - Manora Peak	107,102,600.00		107,102,600.00	27,438,390.00	7,966,421.00	35,404,811.00	71,697,789.00	79,664,210.00
	(iii) Residential - Devsthal (Guest House)	1,224,022.00		1,224,022.00	238,493.00	49,276.45	287,769.45	936,252.55	985,529.00
	(iv) Non Residential - Devsthal	7,596,630.00	•	7,596,630.00	1,928,932.00	566,769.80	2,495,701.80	5,100,928.20	5,667,698.00
0	Infrastructure Dev. (Manora Peak)	8,401,557.70	1,029,718.00	9,431,275.70	2,523,328.00	690,794.77	3,214,122.77	6,217,152.93	5,878,229.70
4	Infrastructure Dev. (Devsthal )	5,616,343.90	430,665.00	6,047,008.90	1,035,042.00	501,196.69	1,536,238.69	4,510,770.21	4,581,301.90
5	Road at Devsthal	15,869,833.00	1,127,291.00	16,997,124.00	3,962,741.00	1,303,438.30	5,266,179.30	11,730,944.70	11,907,092.00
0	Furniture & Fixture	6,195,598.70	1,293,391.00	7,488,989.70	2,082,495.00	540,649.47	2,623,144.47	4,865,845.23	4,113,103.70
~	Office Equipment	1,691,613.25	19,000.00	1,710,613.25	617,318.00	109,329.53	726,647.53	983,965.73	1,074,295.25
00	Instruments And Equipments			x					
	(i) Telescope	1,045,247.55		1,045,247.55	603,630.00	66,242.63	669,872.63	375,374.92	441,617.55
	(ii) Telescope (Solar)	1,367,166.00	2	1,367,166.00	615,225.00	112,791.15	728,016.15	639,149.85	751,941.00
	(iiia) 1.3 Mt. Telescope	77,016,439.00		77,016,439.00	11,542,524.00	9,821,087.25	21,363,611.25	55,652,827.75	65,473,915.00
1	(iv)Public Outreach Telescope	607,295.00		607,295.00	91,094.00	77,430.15	168,524.15	438,770.85	516,201.00
	(v) Schmidt Telescope	10,738,623.00		10,738,623.00	4,035,493.00	1,005,469.50	5,040,962.50	5,697,660.50	6,703,130.00
	(vi) Electronic Section	9,055,749.55		9,055,749.55	5,229,694.00	573,908.33	5,803,602.33	3,252,147.22	3,826,055.55
	(vii) Work Shop	273,027.45		273,027.45	157,673.00	17,303.17	174,976.17	98,051.28	115,354,45
1	(viii) Aluiminising / Anodising	103,357.45		103,357.45	59,690,00	6,550.12	66,240.12	37,117.33	43,667.45
	(ix) Optics	27,240.80		27,240.80	15,731.00	1,726.47	17,457.47	9,783.33	11,509.80
	(x) Instruments	25,300,076.67	17,834,900.00	43,134,976.67	12,363,385.00	4,615,738.75	16,979,123.75	26,155,852.92	12,936,691.67
	(xi) Modernistion of Backend Inst.	25,046,832.00	5,688,628.00	30,735,460.00	5,191,697.00	3,831,564.45	9,023,261.45	21,712,198.55	19,855,135.00
	(xii) LIDAR.	7,212,599.00	1,547,866.00	8,760,465.00	2,704,725.00	908,361.00	3,613,086.00	5,147,379.00	4,507,874.00
	(xiii) ADFOSC (Backend Instrument)	644,863.00	2,541,571.00	3,186,434.00	66,039.00	468,059.25	534,098.25	2,652,335.75	578,824.00
	(xiv)Solar Section	8,227.00		8,227.00	2,468.00	863.85	3,331.85	4,895.15	5,759.00
	(Xv)Projector(Public Outreach)	105,000.00		105,000.00	7,875.00	14,568.75	22,443.75	82,556.25	97,125.00
0	Vehicles	1,775,213.10		1,775,213.10	1,025,186.00	112,504.07	1,137,690.07	637,523.04	750,027.10
10	Electric Installation (Manora Peak )	1,913,384.00		1,913,384.00	549,032.00	204,652.80	753,684.80	1,159,699.20	1,364,352.00
1	Electric Installation (Devsthal)	2,726,780.00		2,726,780.00	1,001,628.00	258,772.80	1,260,400.80	1,466,379.20	1,725,152.00
12	Computer & Peripherals	21,320,973.40	1,377,800.00	22,698,773.40	16,662,119.00	3,621,992.64	20,284,111.64	2,414,661.76	4,658,854.40
3	Computer Software	1,040,712.00	364,720.00	1,405,432.00	104,424.00	780,604.80	885,028.80	520,403.20	936,288.00
14	Library Books	25,326,843.50	4,500,828.00	29,827,671.50	14,758,190.00	15,069,481.50	29,827,671.50		10,568,653.50
	Total	478,732,301.62	39,512,674.00	518,244,975.62	117,453,221.00	53,669,817.46	171,123,038.46	347,121,937.16	361,279,080.62
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ARIES 9<sup>th</sup> ANNUAL REPORT



## 2012-13

S NO	PARTICULARS	OP STOCK	PURCHASE	TOTAL	CL STOCK	CONSUMPTION
+	2	3	4	5=(3+4)	9	7=(5-6)
				A BORDON AND		
	CONSUMABLE ACCESSORIES	1,231,382.21	3,976,559.00	5,207,941.21	1,078,895.60	4,129,045.61
	STATIONERY STOCK	174,996.75	632,590.00	807,586.75	157,190.69	650,396.06
	S COMPUTER ACCESSORIES	625,366.21	1,935,009.00	2,560,375.21	1,035,424.73	1,524,950.48
4	t FUEL	34,403.68	1,257,240.00	1,291,643.68	70,578.67	1,221,065.01
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Opening Balances         18,153,00         18,153,00         18,153,00         18,153,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         23,050,511,00         24,050,510,50         24,050,510,511,50         24,050,511,50         24,050,511,50         24,050,511,50         24,050,510,51,510,51,510         24,050,510,51,510,51,510,51,510         24,050,510,51,510,51,510,51,510,51,510,51,510,51,51,510,51,510,51,51,510,51,51,51,510,51,51,510,51,51,51,510,51,	Receipts	Amount	- (Rs)	Payments	Amount	- (Rs)
Cash in land         18,153.00         58,347,333         Salary Expenses         52,050,010         53,347,333         53,347,333         53,347,333         53,347,330         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,347,300         53,345,300         5	Onening Balances					
Cash in bank         East 235,0,000         Benorarium Aic         39,74,00           Carn in aid received during year         East 1,130         East 1,130         23,74,00           Carn in aid received during year         222,550,0000         Benus         22,350,000         East 1,130         23,740           Carn in aid received during year         222,550,0000         Benus         22,350,000         Benus         23,740         23,740           On Term Deposits & Savings Accounts         6,198,037,33         54,350,00         6,592,717,33         Earth Player Contribution towards NPS and         2,842,590,00         East 1,116,117,00           On Term Deposits & Savings Accounts         394,680,00         6,592,717,33         Earth Player Contribution towards NPS and         2,842,590,00           Constant forms and advances         54,350,00         Gravity         Earth Player Contribution towards NPS and         2,842,590,00           Constantion         Content Receiver         2,335,000         Content Receiver         2,343,000           Content Receiver         S4,330,00         Content Receiver         2,413,100         Content Receiver         2,413,600           Constraints         Savings Accounts         S4,481,00         Contrakted         1,716,174,00         S4,481,00         S4,481,00           Reseiters<	Cash in hand	18,153.00		Salary Expenses	52,050,611.00	
Cart in aid received during year         Eason of the contraint visiting Scientists         66,076,00         Eason of the contraint visiting Scientists         66,073,00         Eason of the contraint visiting Scientists         Eason of the contraint visiting Scientists         66,000         Eason of the contraint visiting Scientists         Eason of the contraint visiting Scientist         Eason of the contraint visiting Scientist         Eason of the contraint visiting Scientist	Cash in bank	58,329,786.88	58,347,939.88	Honorarium A/c	39,764.00	
Grant In aid received during year         222,550,000 0         Bonus         211,133.00           Interest earnings         6,188,037.33         6,188,037.33         5,242,599.00         2,842,599.00           Interest earnings         6,188,037.33         5,350,000         6,592,717         394,680.00         5,322,369.00           On Term Deposits & Sevings Accounts         394,680.00         6,592,717         394,680.00         6,592,717         394,680.00           On Term Deposits & Sevings Accounts         394,680.00         6,592,717         394,680.00         5,92,296.00           On Term Deposits & Sevings Accounts         394,680.00         6,592,717         394,680.00         171,617.00           On Term Deposits & Sevings Accounts         54,350.00         6,592,717         394,680.00         171,617.00           Employer Contribution towards Old         6,198,037.00         6,592,717.30         171,610         171,610           Building Receipts         54,350.00         122,350.00         0         0         171,61.00           Building Receipts         136,413.00         0         0         0         171,61.00           Building Receipts         166,413.00         0         0         0         171,61.00           Building Receipts         166,413.00	· Constant Constant			Honorarium Visiting Scientists	68,078.00	
Interest earnings         Leave Travel Concession         25,745.00           Interest earnings         6,198,037.33         6,198,037.33         5,242,599.00           On Term Deposits & Sawings Accounts         39,468.00         6,582,717.33         Employer Contribution towards NPS and         2,842,599.00           On Term Deposits & Sawings Accounts         39,468.00         6,582,717.33         Employer Contribution towards NPS and         2,842,599.00           On teart floare and advances         34,680.00         6,582,717.33         Employer Contribution towards Old         2,842,599.00           On teart floare and advances         34,680.00         6,582,717.33         Employer Contribution towards Old         2,842,599.00           Registration Fease         54,500         Granuly         Commutation         2,842,590           Using Receipts         2,33,590         Over Time         2,84,3100         2,84,3100           Using Controbution to GPF Interest         1,715,174,400         Over Time         2,84,31500           Using Receipts         2,84,3100         Deerticity Meter Charges         5,41,3100         Deerticity Meter Charges         5,41,3100           Electricity Meter Charges         1,60,4710         Deerticity Meter Charges         5,41,3100         Doer Time           Missionencontrol         1,610,610 <td>Grant in aid received during year</td> <td></td> <td>222,550,000.00</td> <td>Bonus</td> <td>212,133.00</td> <td></td>	Grant in aid received during year		222,550,000.00	Bonus	212,133.00	
Interest earnings         6,188,037.33         6,188,037.33         Employer Contribution towards NPS and 2,942,569.00           On Term Deposits & Savings Accounts         394,680.00         6,592,717.33         Employer Contribution towards Old         2,942,569.00           On staff loans and advances         394,680.00         6,592,717.33         Employer Contribution towards Old         5,942,569.00           On staff loans and advances         394,680.00         6,592,717.33         Employer Contribution towards Old         5,942,569.00           On staff loans and advances         54,350.00         6,592,717.33         Employer Contribution towards Old         5,282,564.00           Other Revenue Receipts         54,350.00         0.592,717.33         Employer Contribution towards Old         5,282,564.00           Valate Charges         54,30.00         5,302,00         Dover Time         7,175.01         2,64,300           Valate Charges         5,10,376.00         Dover Time         7,175.01         2,136,300           Residential Buildings / Hostels         316,433.00         Dover Time         2,136,800         2,136,800           Residence         1,775.174.00         Dover Time         2,136,800         2,136,800         2,136,800           Residence         1,64,00         1,64,00         Dover Time         2,136,800 <td></td> <td></td> <td></td> <td>Leave Travel Concession</td> <td>26,746.00</td> <td></td>				Leave Travel Concession	26,746.00	
On Term Deposits & Savings Accounts         6,198,037.33         Employer Contribution towards MPS and S4,680.00         6,592,717.33         Employer Contribution towards MPS and S4,560.00         2,842,569.00           On staff loans and advances         394,680.00         6,592,717.33         Employer Contribution towards MPS and S4,550.00         2,842,569.00           Other Revenue Receipts         54,350.00         6,592,717.33         Employer Contribution towards MPS and Employer Contribution towards MPS and Employer Contribution to GPF Interest         101,641.00           Building Receipts         54,350.00         6,592,717.33         Employer Contribution towards MPS and Employer Contribution towards MPS and Employer Contribution towards MPS and Building Receipts         17,15,174.00           Building Receipts         54,350.00         0,592,717.33         Employer Contribution towards MPS and Enclored metal         17,151,714.00           Building Receipts         33,68.00         0,592,717.33         Employer Contribution towards MPS and Electricity / Meta Charges         13,151,00           Building Receipts         33,68.00         0,592,717.30         Electricity Receipts         26,461.00           Residence         13,715.00         Other Times         24,431.00         710,265,395.00           Missing Book Value         3,303.00         1,60,467.00         1,600,467.00         1,010,038.00           Missing Book	Interest earnings					
On staff learns and advances         394,680,00         6,592,171,33         Employer Contribution towards Old         6,282,964,00           On staff learns and advances         Other Revenue Receipts         54,350,00         Epension Fund         101,641,00           Registration Fees         54,350,00         6,592,171,33         Employer Contribution to GPF Interest         101,641,00           Registration Fees         54,350,00         Gratufy         Emerion         25,435,00           Registration Fees         333,699,00         Over Time         23,450,00           Valater Charges         132,756,00         Over Time         28,422,00           Valater Charges         35,10,00         Over Time         28,432,00           Valater Charges         53,120,00         Over Time         28,43,00           Telephone Charges         53,120,00         Dispension         57,10,376,00           Residential Bubursements         53,136,00         Dispension         57,10,376,00           Residential Bubursements         53,130,00         Dispension         57,10,376,00           Residential Bubursements         64,530,00         Dispension         57,10,376,00           Residential Bubursements         64,530,00         Dispension         57,10,376,00           Massing Book Value<	On Term Deposits & Savings Accounts	6,198,037.33		Employer Contribution towards NPS and interest	2,842,599.00	
Christential         Employer Contribution to GPF Interest         101,641.00           Other Revenue Receipts         54,350.00         Employer Contribution to GPF Interest         101,641.00           Gratuity         Gratuity         Gratuity         Gratuity         233,609.00         12,715,174.00           Building Receipts         233,609.00         Dover Time         2,632.00         13,715.00         147,15,174.00           Residemital Buildings / Hostels         233,609.00         Dover Time         26,842.00         26,842.00           Water Charges         3,512.00         Dover Time         2,710.376.00         193,748.00           Water Charges         9,512.00         Dover Time         2,84.61.00         70,626,395.00           Water Charges         54.61.30         Dispension         183,486.00         70,626,395.00           Guest House Rent         54.61.30         Dispension         5,710.376.00         70,626,395.00           Guest House Rent         54.61.30         Dispension         6,710.376.00         70,626,395.00           Guest House Rent         54.61.30         Dispension         6,710.376.00         70,626,395.00           Guest House Rent         66,61.00         Dispension         10,100.00         10,100.00           Guest House Ren	On staff loans and advances	394,680.00	6,592,717.33	Employer Contribution towards Old Pension Fund	6,282,964.00	
Other Revenue Receipts         Cartuity         Cartuity         Commutation         1,715,174.00           Registration Fees         54,350.00         54,350.00         54,350.00         54,350.00         1,715,174.00           Buildings Receipts         233,699.00         Over Time         26,942.00         1,715,174.00           Buildings Hostels         233,699.00         Uver Time         26,43.00         233,699.00           Vater Charges         351,200         Dver Time         26,43.00         26,542.00           Vater Charges         354,613.00         Dver Time         26,43.00         70,626,395.00           Felchone Charges         316,433.00         Dver Time         54,60         70,626,395.00           Guest House Rent         545.00         Dver Time         54,100         70,626,395.00           Guest House Rent         54,100         Dispensary Expenses         183,480.00         70,626,395.00           Guest House Rent         54,131.00         Dispensary Expenses         54,1315.00         70,626,395.00           Guest House Rent         54,131.00         Dispensary Expenses         54,1315.00         70,626,395.00           Guest House Rent         54,00         Dispensary Expenses         54,1310.0         100,000.00				Employer Contribution to GPF Interest	101,641.00	
Registration Fees         54,350.00         Commutation         -           Building Receipts         23,3000         Over Time         1/7/5,174.00           Water Charges         23,3000         Over Time         1/7/5,174.00           Nater Charges         23,3000         Over Time         26,420.00           Residential Buildings / Hostels         23,3000         Over Time         26,420.00           Residential Buildings / Hostels         3,512.00         Over Time         26,420.00           Residential Buildings / Hostels         3,512.00         Over Time         26,430.00           Recompose         3,512.00         Dispensary Expenses         343.600           Recompose         54,613.00         Reimbursements         51,710,376.00           Residence Charges         3,512.00         Reimbursements         51,710,376.00           Missing Book Value         3,503.00         Reimbursement of Tution Fees         24,654.00           Missing Book Value         3,303.00         Reimbursement of Tution Fees         24,654.00           Missing Book Value         3,303.00         Reimbursement of Tution Fees         24,654.00           Missing Book Value         3,303.00         Reimbursement of Tution Fees         24,654.00           Missing Book Value	Other Revenue Receipts			Gratuity		
Building Receipts         Eave Encashment         1,715,174,00           Residential Buildings / Hostels         233,693,00         Over Time         26,842,00           Water Charges         1,92,736,00         Over Time         26,842,00           Water Charges         1,92,736,00         Over Time         26,842,00           Water Charges         1,92,736,00         Disedical Reimbursements         5,170,376,00           Water Charges         54,613,00         Fellowinp         5,710,376,00           Under Fea         316,433,00         Electricity / Meter Charges         5,710,376,00           Ussing Book Value         53,000         Reimbursements         5,710,376,00           Missing Book Value         53,000         0,046,00         70,626,336,00           Missing Book Value         5,300,00         106,047,00         24,634,00         70,626,336,00           Missing Book Value         5,300,00         10,000,00         100,000,00         100,000,00           Missing Book Value         5,300,00         15,00         100,000,00         100,000,00           Missing Book Value         5,300,00         15,00         15,00         100,000,00         100,000,00           Missing Book Value         5,300,00         15,00         15,00 <t< td=""><td>Registration Fees</td><td>54,350.00</td><td></td><td>Commutation</td><td></td><td></td></t<>	Registration Fees	54,350.00		Commutation		
Residential Buildings / Hostels         233,609,00         Over Time         26,442.00           Water Charges         192,785.00         192,785.00         193,480.00           Water Charges         192,785.00         193,480.00         541,316.00           Water Charges         193,480.00         541,310.0         541,310.0           Electricity / Meter Charges         584,613.00         Fellowship         5,110,376.00           Electricity / Meter Charges         545.00         Dispensary Expenses         143,480.0           Guest House Rent         316,433.00         Cher revenue payments         5,710,376.00           Guest House Rent         316,433.00         Cher revenue payments         5,45.00           Missing Book Value         6,3,309.00         Cher revenue payments         4,38,415.00           Missing Book Value         6,3,309.00         Job, 204.066.00         70,526,395.00           Missing Book Value         6,3,309.00         Cher revenue payments         4,38,415.00           Value         156,717.00         Job, 204.066.00         100,000.00           Missing Book Value         6,3,309.00         Job, 206.00         204,066.00           Missing Book Value         136,717.00         Job, 206.00         204,066.00           Missing Book Val	Building Receipts			Leave Encashment	1,715,174.00	
Water Charges         132.795.00         Medical Reimbursements         541,315.00           Telephone Charges         9,512.00         9,512.00         541,315.00           Telephone Charges         9,512.00         9,512.00         541,315.00           Electricity / Meter Charges         541,613.00         541,613.00         541,613.00           Electricity / Meter Charges         544,613.00         Electricity / Meter Charges         541,613.00           Cuest House Rent         545.00         Reimbursement of Tution Fees         571,00.376.00         70,526,335.00           Guest House Rent         545.00         0.010.01         542,654.00         70,626,335.00           Missing Book Value         545.00         0.010.01         543.00         70,626,335.00           Missing Book Value         545.00         0.010.01         100,000.00         10,000.00           Missing Book Value         53,309.00         Undue Charges         438,815.00         10,000.00           Wastage Sale         144,00         Undue Charges         1,010,080.00         1,010,080.00           Missing Book Value         63,610         0.1,600,467.00         Undue Charges         1,010,080.00           Missing Book Value         136,717.00         Undue Charges         1,010,000.00	Residential Buildings / Hostels	233,609.00		Over Time	26,842.00	
Telephone Charges         9,512.00         9,512.00         Dispensary Expenses         183,498.00         183,498.00         183,498.00         183,498.00         100,266,395.00         100,266,395.00         70,626,395.00         71,00	Water Charges	192,795.00		Medical Reimbursements	541,315.00	
Electricity / Meter Charges         584,613.00         Fellowship         5,710,376.00         70,626,396.00           Guest House Rent         316,433.00         Reimbursement of Tution Fees         824,654.00         70,626,396.00           Guest House Rent         316,433.00         Reimbursement of Tution Fees         824,654.00         70,626,396.00           Missing Book Value         63,309.00         House Rent         824,654.00         70,626,396.00           Missing Book Value         136,717.00         Public Outreach Programme         438,816.00         70,626,396.00           Missing Sale         136,717.00         Public Outreach Programme         1,010,388.00         1,010,388.00           Missing Sale         184.00         1,600,467.00         Reistration Charges         444,817.00           Vehicle Charges         1,600,467.00         Building Repair         2,929,817.00         2,929,817.00           Receipts Creating liability         2,44,591.00         2,44,591.00<	Telephone Charges	9,512.00		Dispensary Expenses	183,498.00	
Cluest House Rent         S24,654.00         70,626,335.00           Guest House Rent         545.00         76,433.00         70,626,335.00           Missing Book Value         545.00         0.16,433.00         70,626,335.00           Missing Book Value         545.00         0.545.00         70,626,335.00           Missing Book Value         0.545.00         0.100,000.00         100,000.00           Missing Book Value         0.33,09.00         0.165T         438,815.00         100,000.00           Miscelaneous Receipts         136,717.00         156T         100,000.00         100,000.00           Miscelaneous Receipts         184.00         166.10         1,010,388.00         1,010,388.00           Miscelaneous Receipts         184.00         1,600,467.00         Rater Charges         4,03,167.00           KTI Receipts         8,400.00         1,600,467.00         Building Repair         4,03,167.00           Vehicle Charges         8,400.00         1,600,467.00         Building Repair         2,04,591.00           Receipts Creating liability         2,929,817.00         2,929,817.00         2,929,817.00	Electricity / Meter Charges	584,613.00		Fellowship	5,710,376.00	
Guest House Rent316,433.00Missing Book Value545.00Missing Book Value545.00Tender Fee53,309.00Tender Fee63,309.00Wastage Sale100,000.00Wastage Sale136,717.00Wastage Sale136,717.00Miscelaneous Receipts136,717.00Miscelaneous Receipts136,717.00Miscelaneous Receipts184.00Niccelaneous Receipts184.00RTI Receipts8,400.00Vehicle Charges1,600,467.00Building Repair444,817.00Building Repair444,591.00Receipts Creating liability2,929,8177.00Building Repair1,010,000Action Charges1,010,000Receipts Creating liability2,929,8177.00Building Repair1,010,000Mater Charges1,010,000Receipts Creating liability2,929,8177.00Building Repair1,010,000Mater More1,010,000Receipts Creating liability1,000,467.00Mater More1,000,467.00Building Repair1,010,000Mater More1,010,000Mater More1,010,000 <td>· · · · · · · · · · · · · · · · · · ·</td> <td></td> <td></td> <td>Reimbursement of Tution Fees</td> <td>824,654.00</td> <td>70,626,395.00</td>	· · · · · · · · · · · · · · · · · · ·			Reimbursement of Tution Fees	824,654.00	70,626,395.00
Missing Book Value     545.00     Other revenue payments       Tender Fee     53,309.00     100,000.00       Tender Fee     53,309.00     100,000.00       Wastage Sale     -     136,717.00       Wastage Sale     136,717.00     157       Miscelaneous Receipts     136,717.00     160,000.00       Miscelaneous Receipts     184.00       RTI Receipts     184.00       Vehicle Charges     8,400.00       Receipts Creating liability     2,929,817.00       Receipts Creating liability     2,929,817.00	Guest House Rent	316,433.00				
Tender Fee         63,309.00         Public Outreach Programme         438,815.00           Wastage Sale         -         -         438,815.00           Wastage Sale         -         100,000.00         100,000.00           Miscelaneous Receipts         136,717.00         156,717.00         100,000.00           Miscelaneous Receipts         136,717.00         Postage Expenses         100,000.00           Miscelaneous Receipts         184.00         Nater Charges         204,066.00           RTI Receipts         184.00         184.00         Water Charges         409,167.00           Vehicle Charges         8,400.00         1,600,467.00         Building Repair         444,177.00           Receipts Creating liability         2,929,817.00         2,929,817.00         2,929,817.00	Missing Book Value	545.00		Other revenue payments	And	
Wastage Sale         -         JEST         100,000.00           Miscelaneous Receipts         136,717.00         136,717.00         100,000.00           Miscelaneous Receipts         136,717.00         Postage Expenses         100,000.00           Liquidity Damage         136,717.00         Postage Expenses         1,010,388.00           KTI Receipts         184.00         184.00         Water Charges         409,167.00           Vehicle Charges         8,400.00         1,600,467.00         Building Repair         444,817.00           Receipts Creating liability         2,929,817.00         2,929,817.00         2,929,817.00	Tender Fee	63,309.00		Public Outreach Programme	438,815.00	
Miscelaneous Receipts     136,717.00     136,717.00     204,066.00       Liquidity Damage     Liquidity Damage     204,066.00       RTI Receipts     184.00     184.00       Nehicle Charges     8,400.00     1,600,467.00       Vehicle Charges     8,400.00     1,600,467.00       Receipts Creating liability     2,929,817.00	Wastage Sale			JEST	100,000.00	
Liquidity Damage Liquidity Damage 184.00 1467.00 1,600,467.00 409,167.00 409,167.00 409,167.00 244,817.00 229,817.00 224,591.00 Electricity and Power 44,817.00 224,591.00 Electricity and Power 2,929,817.00 244,591.00 Electricity and Power 2,929,817.00 Electricity and Power Electricity and Power 2,929,817.00 Electricity and Power Electricity an	Miscelaneous Receipts	136,717.00		Postage Expenses	204,066.00	
RTI Receipts     184.00     184.00     184.00     184.00     184.00     249,167.00       Vehicle Charges     8,400.00     1,600,467.00     Registration Charges     449,167.00       Vehicle Charges     8,400.00     1,600,467.00     Registration Charges     444,817.00       Receipts Creating liability     1,600,467.00     Instruments AMC     5,929,817.00	Liquidity Damage			Electricity and Power	1,010,388.00	
Vehicle Charges     8,400.00     1,600,467.00     Registration Charges     444,817.00       Receipts Creating liability     2,929,817.00     2,929,817.00	RTI Receipts	184.00		Water Charges	409,167.00	
Receipts Creating liability 2,929,817.00 244,591.00 244,591.00	Vehicle Charges	8,400.00	1,600,467.00	Registration Charges	444,817.00	
Receipts Creating liability 244,591.00				Building Repair	2,929,817.00	
1000 March 100 March 100	Receipts Creating liability			Instruments AMC	<b>坐</b> 244,591.00	
		120	G	2 4 4 52	Plun	
			1	201 ) a rhon		



Receipts	Amount	- (Rs)	Payments	Amount - (Rs)
Contribution to New Pension Fund Scheme	5.642.500.00		Vehicles	330,741.00
Employer Contribution towards Old Pension Fund	6,282,964.00		Repair and Maintainence - others	198,787.00
Balance of Pension transferred from previous	1,641,835.00			1,257,240.00
employers of employees account			Fuel Account (POL)	
Staff contribution to GPF	6,626,599.00		Telephone and Communication Charges	130,451.00
Earnest Moneys	900,343.00		Printing & Stationery	632,590.00
Retention monies	1,101,256.00		Meeting of Governing Council	159,107.00
Security deposits	1,440,679.00		Meeting of Other Scientific Bodies	173,468.00
VATR Collection	6,844.00		Sundry Services Charges (Internet etc)	6,052,096.00
Money received on account of projects	4,202,461.00	27,845,481.00	Auditors Remuneration	30,000.00
			Hospitality Expenses	100,289.00
			Advertisement	991,402.00
			Security Expenses	1,966,999.00
			Transportation (Freight) Charges	
			Conveyance	903,776.00
			Bank Charges	177,788.00
			Canteen Expenses	1,231,371.00
			Consumables Assessories	3,976,559.00
			Insurance Charges	50,803.00
			Garden Expenses	378,515.00
			Legal Expenses	124,783.00
			Cleaning Work Expenses	1,037,299.00
			Computer Accessories	1,935,009.00
			Sundry Expenses	344,332.00
		-	Out Source Services	53,760.00
		CANNA& CO	Training Exp.	
3		A A A A	Obervational Facilities	6,870,755.00

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Ame	1,121,291.0	1,756,296.0	5,289,355.0	477,583.0	17,225,385.0	5,688,628.0	949,500.0	4,961,055.0	1,029,718.0	430,665.0	4,500,828.0	19,000.0	17,514,867.0	1,325,487.0	(11,613,069.3
Payments	Road at Devsthal	Residential building at Manora Peak	Capital Work in progress -Residential building at Manora Peak	Capital Work in progress -Infrastructure development at Manora Peak	Capital Work in progress - building 3.60 Mtr Telescope	Modernisation of back end instrument	ADFOSC - Backend instrument	International liquid mirror telescope	Infrastructure developemnt - Manora Peak	Infrastructure developemnt - Devsthal	Library books	Office equipment	Instruments	Payments of advances Staff advances	Other advances recoverable in cash or in kind for value to be received
Amount - (Rs)														NUNA & CO	THE ASSOCIATION AND AND AND AND AND AND AND AND AND AN
Receipts															Č

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#### ARYABHATTA RESEARCH INSTITUTE OF OBSERRVATIONAL SCIENCES (ARIES) NANITAL - 263129

Schedule - 14

SIGNIFICANT ACCOUNTING POLICIES AND NOTES TO ACCOUNTS ANNEXED TO AND FORMING PART OF FINANCIAL STATEMENTS FOR THE YEAR ENDING 31<sup>ST</sup> MARCH 2013.

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.
- (3). 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.
- (4). 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.

- (5). 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. 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.





#### (6). 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. Assets acquired subsequent to formation of ARIES are stated at cost.

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 prescribed under the income tax rules.; for subsequent years the assets have been considered as income applied for charitable purpose for the computation of income tax liability.

- (7). INVESTMENTS: With Banks: Investment in fixed deposits have been recorded at their face value.
- (8). 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.

- (9) TREATMENT OF FIXED ASSETS FOR INCOME TAX COMPLIANCE: For the purpose of computing the accumulation of income u/s 11(2) of the Income tax Act, 1961, assets acquired during the year, including capital work in progress , are considered as income applied for charitable assets.
- (10) Previous years figures have been re-arranged, regrouped where ever considered NECESSARY



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