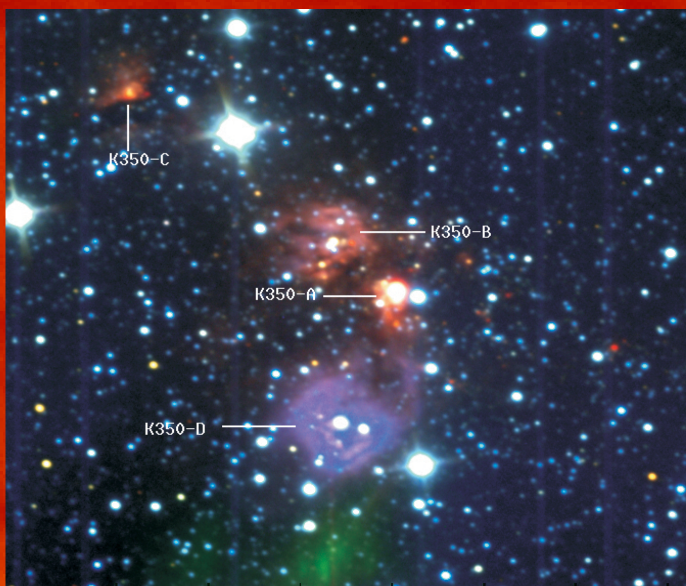
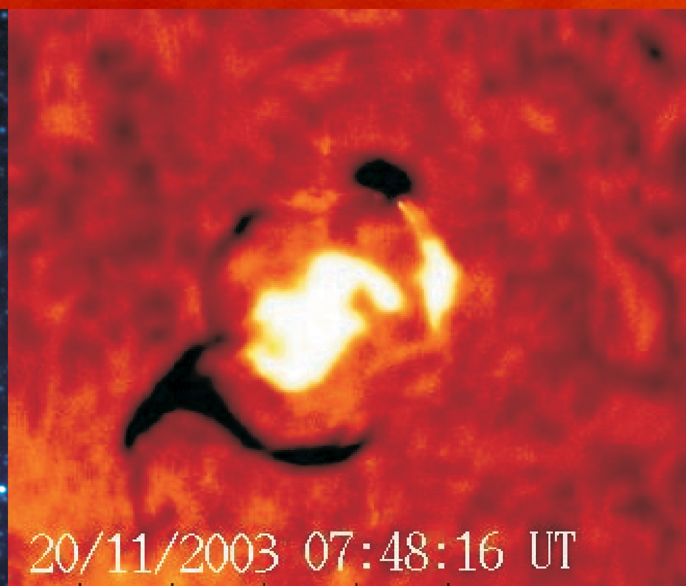
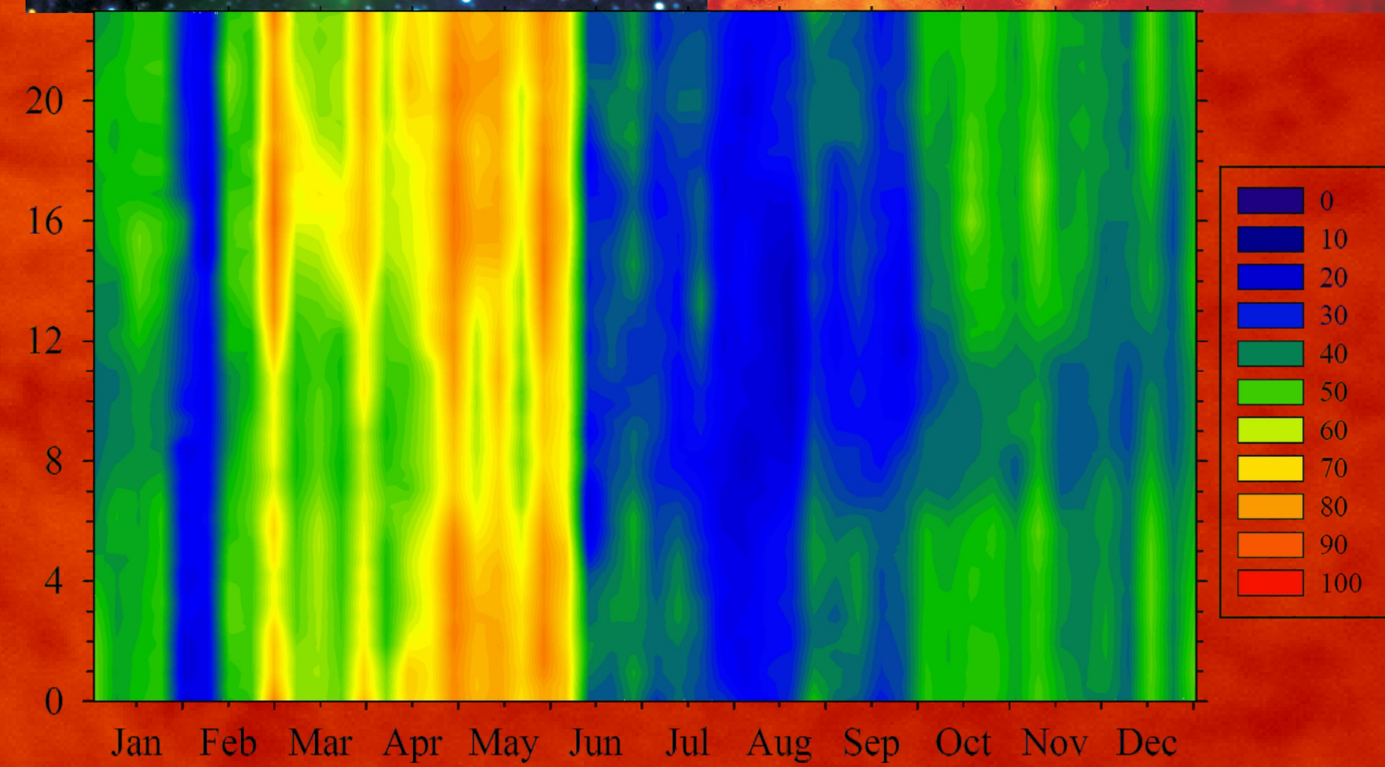
Aryabhatta Research Institute of Observational Sciences

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

Manora Peak, Nainital (India)







Academic Report
2009 – 2010

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES

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

Manora Peak, Nainital - 263 129, India

ACADEMIC REPORT

2009 - 2010

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Front cover:
Upper left : JHKs colour-composite (J, blue; H, green; and Ks , red) image of the Sh2-100 star forming region; **Upper right :** Eruptive solar flare (2B/M9.6) on 20 November 2003 observed in H-alpha at ARIES, Nainital, and **Lower :** Average contour map of surface ozone measured at ARIES, Nainital during 2006-2008. Higher levels during spring is the manifestation mainly of biomass burning and regional pollution.

Back cover:
High resolution Hα filtergram of NOAA 11057 observed at ARIES, Nainital on 28 March 2010 with 15-cm Solar Tower Telescope. **Lower left** : 50-cm B-N Schmidt telescope at ARIES, Nainital.

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ABBREVIATIONS

ABLN&C	Atmospheric Boundary Layer Network and Characterization
ADFOSC	ARIES Devasthal Faint Object Spectrograph and Camera
ADU	Accessory Dwelling Unit
AERONET	Aerosol Robotic Network
AGN	Active Galactic Nuclei
AIMPOL	ARIES Imaging Polarimeter
ALMA	Atcama Large Milimeter Array
AMOS	Advanced Mechanical and Optical Systems
AMSL	Above Mean Sea Leval
AMU	Aligarh Muslim University
AnO	Annual Oscillation
AOD	Aerosols Optical Depth
AR	Active Region
ARCI	International Advanced Research Centre for Powder Metallurgy and New Materials
ARFI	Aerosol Radioactive Forcing over India
ARIES	Aryabhatta Research Institute of Observational Sciences
AsciPOP	ARIES Science Popularization and Outreach Program
ATAC	ARIES Time Allocation Committee
AT – CTM	Atmospheric Trace Gases – Chemistry, Transport and Modeling
ATP	Acceptance Test Procedure
AU	Astronomical Unit
AWESOME	Atmospheric Weather Electromagnetic System for Observation Modeling and Education
BATSE	Burst and Triensient Source Experiment
BC	Black Carbon
BH	Black Hole
BHU	Banaras Hindu University
BL Lac	BL Lacertae
BLL	Boundary Layer Lidar
BNSTP	Baker – Nunn Schmidt Telescope Project
BP	Bright Point
BRCs	Bright-Rimmed Clouds
CCD	Charged Coupled Device
CIRA	Cospar International Reference Atmosphere
CME	Coronal Mass Ejection
CSIR-DST	Council for Scientific and Industrial Research – Department of Science and Technology
CTM	Chemical Transport Model
CTTSs	Classical T- Tauri Stars
DAOPHOT	Dominin Astronomical Observatory Photometry
DAMA	Demand Assigned Multiple Access
DDA	Detector and Data Acquisition
DOT	Devasthal Optical Telescope

DSP	Digital Signal Processing
ECIL	Electronics Corporation of India Limited
EIS	EUV Imaging Spectrometer
EIWG	Earth – Ionosphere Wave Guide
ELF	Extremely Low Frequency
E-ELTs	European Extremely Large Array
EMCCD	Electron Multiplying Charge Coupled Device
EPIC	European Photon Imaging Camera
EUV	Extreme Ultraviolet
EVLA	Expanded Very Large Array
EW	Equivalent Width
FAT	Factory Acceptance Test
FORSA	Forum for Resource Sharing in Astronomy and Astrophysics
FOV	Field of View
FR II	Fanaroff – Riley Type II
FRSGC/UCI	Frontier Research System for Global Change
FWHM	Full Width at Half Maximum
GATE	Gifted and Talented Education
GMRT	Giant Meterwave Radio Telescope
GRB	Gamma Ray Burst
GUT	Grand Unified Theory
GZK	Greisen – Zatsepin - Kuzmin
HVS	High Volume Sampler
IAS	Indian Academy of Science
ICARB	Integrated Campaign for Aerosols, Gases and Radiation Budget
IEEE	Institute of Electrical and Electronics Engineers
IHY/UNBSSI	International Heliophysical Year/United Nations Basic Space Science Initiative
IIAP	Indian Institute of Astrophysics
IIRS	Indian Institute of Remote Sensing
IMF	Initial Mass Function
INAE	Indian National Academy of Engineering
INASAN	Institute of Astronomy, Russian Academy of Science
INOV	Intranight Optical Variability
INSA	Indian National Science Academy
ISCA	Indian Science Congress Association
ISI Web	Institute for Scientific Information
ISRO-GBP	Indian Space Research Organization – Geosphere Biosphere Programme
JEST	Joint Entrance Screening Test
KBOs	Kuiper Belt Objects
KVA	Kilo-Volt-Ampere
LAN	Local Area Network
LIDAR	Light Detection and Ranging
LMC	Large Magellanic Cloud
MCCB	Molded Case Circuit Breaker
MCS-pci	Multi Channel Scaler - Parallel Computer Interface
MDI	Michelson Doppler Imager

MHD	Magnetohydrodynamic
MLTP	Mesospheric Lower Thermosphere Photometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MOU	Memorandum of Understanding
MS	Main - sequence
MWR	Multi Wavelength Radiometer
NASA	National Aeronautics and Space Administration
NASI	National Academy of Sciences, India
NCAR	National Centre for Atmospheric Research
NCP	North Celestial Pole
NET	National Eligibility Test
NGC	New General Catalog
NIES	National Institute for Environmental Studies
NISCAIR	National Institute of Science Communication and Information Resources
NLST	National Large Solar Telescope
NOAA	National Observatory of Astronomy and Astrophysics
ONC	Orion Nebula Cluster
PIT	Project Implementation Team
PMC	Project Management Committee
PMT	Photo Multiplier Tube
PPS	Precision Precast Solutions
PWG	Project Working Groups
QSOs	Quasi-Stellar Objects
RAO	Radio Astronomy Centre
RQQSOs	Radio-Quiet Quasi-Stellar Objects
RRI	Raman Research Institute
RMS WFE	Root-mean-Square Wavefront Error
RS/RW	Radio Sonde / Radio Wind
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
SAO	Semiannual Oscillation
SAAO	South African Astronomical Observatory
SDSS	Sloan Digital Sky Survey
SECCHI	Sun Earth Connection Coronal and Heliospheric Investigation
SED	Spectral Energy Distribution
SKA	Square Kilometer Array
SMC	Small Magellanic Cloud
SOHO	Solar and Heliospheric Observatory
SOT	Solar Optical Telescope
SOXS	X-Ray Spectrometer
ST Radar	Stratosphere Troposphere Radar
SSC	Synchrotron Self- Compton
ST	Sampurnanand Telescope
STEREO	Solar Terrestrial Relations Observatory
SUSY	Supersymmetric
TAOS	Taiwanese – American Occultation Survey

T&E	Test and Evaluation
TIMED	Thermosphere – Ionosphere – Mesosphere Energetic and Dynamics
TMT/GMT	Thirty Meter Telescope/Giant Magellan Telescope
TR	Transition Region
TR	Transmit - Receive
TRACE	Transition Region and Coronal Explorer
TRM	Transmit Receive Module
TSP	Total Suspended Particles
UBVRI	Ultraviolet-Blue-Visual-Red-Infrared
UHECRs	Ultra – High Energy Cosmic Rays
UHF	Ultra High Frequency
UPCL	Uttarakhand Power Corporation Limited
UPS	Uninterruptible Power Supply
USO	Udaipur Solar Observatory
UT	Universal Time
VLF	Very Low Frequency
XMM	X-Ray Multi Meter
YSOs	Young Stellar Objects
WEBT	Whole Earth Blazer Telescope
WR	Wolf - Rayet
WTTSs	Weak-Line T-Tauri Stars

EXECUTIVE SUMMARY

The Academic Report for the year 2009-2010 summarizes the both developmental and academic activities of the Institute during the year. The Institute continued its endeavor to make important scientific contribution in the front-line problems of astronomy & astrophysics and atmospheric sciences. The report presents synopses of the ongoing knowledge creation activities and facilities in the different research groups, which have been published as research papers in refereed National and International scientific journals. The major developments and academic activities carried out during 2009-2010 are summarized below:

1. ARIES is establishing a 3.6 meter Devesthal optical telescope (DOT) as a national facility in optical astronomy at Devesthal to fulfill the major aspiration of the Indian astronomical community. The activities related to the DOT are going in full swing. The Zerodur 3.7 meter blank of the primary (M1) mirror has arrived LZOS, Russia from Schott, Germany for polishing. The M1 mirror is polished within 12 micron. The polishing of Astrositall M2 mirror was completed in March 2010. The design of the enclosure and extension building was completed during the period. The contract for civil work up to plinth level and site development was awarded to M/s Vidyawati, Allahabad.

2. A contract to design and install aluminizing plant for aluminizing mirrors upto 3.7-meter size has been given to M/s HHV, Bangalore. The ARIES Devasthal Faint Object Spectrograph and Camera (ADFOSC) will be the first light instruments at the axial port of the Cassegrain focus of the 3.6-m Devesthal Optical Telescope. The instrument will cover the wavelength range 350-1000 nm and it will have two distinct mode of operation – (i) Direct broad and narrow-band imaging capabilities with spatial resolution of less than 0.2 arcsec in 10 arcmin field of view and. (ii) Low-to-medium resolution spectroscopy with spectral resolution (250-4000) covering the optical wavelengths 360-1000 nm. The optical and mechanical design of ADFOSC is under progress.

3. The 130-cm telescope manufacturing has progressed at the contractor's factory. After the initial testing by the contractor, the telescope was shipped in March 2010. The 130-cm building at Devesthal has been completed. The roll-off-roof has been made operational.

4. The Schmidt telescope was assembled and inspected on dummy steel piers at M/s Avasarala Technologies Ltd., Bangalore. The mechanical parts of the telescope have been delivered at ARIES site in March 2010.

5. The optical alignment of the 38-cm Cassegrain Mie telescope of the LIDAR has been carried out. Department of Science and Technology has approved a Stratosphere Troposphere (ST) Radar at ARIES, Nainital. Foundation stone for ST Radar building was laid by Prof. B. M. Reddy, Emeritus Scientist and Chairman of Project Management Committee (PMC) for ST Radar on 4th November, 2009. Civil work for this building has been

EXECUTIVE SUMMARY

awarded to M/s Zepplin, Indore. The design reviews of ST Radar system are over and it is now on the manufacturing stage by the vendor ECIL, Hyderabad.

6. The construction of hostel building, science centre, Electronics Lab/Lecture Theater, Workshop Buildings, Schmidt telescope building has been completed.

7. Academic staff members continued to pursue vigorously their research in their respective fields. Major parts of the scientific research of the Institute were published in scientific journals of international repute (e.g. Astrophysical Journal, Monthly Notices of Royal Astronomical Society). Forty Five papers were published/accepted in refereed journals, and another seven were published as circulars and conferences proceedings. Two Ph. D. theses have been awarded and another two have been submitted. Academic and technical interaction with various institutions and universities were continued. Following are the major scientific results:

(i) A multiwavelength investigation of star-forming region Sh2-100 reveals that the spatial distribution of infrared excess stars correlates well with the association of gas and dust. The positions of infrared excess stars, ultracompact and compact H II regions at the periphery of an H I shell, possibly created by a WR star, indicate that star formation in Sh2-100 region might have been induced by an expanding H I shell.

(ii) The integrated parameters for synthetic clusters as well as the observed integrated parameters for galactic open clusters, Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) star clusters have been estimated. It is found that the colour evolution of the MS population of star cluster is not affected by the stochastic fluctuations, however, these fluctuations significantly affect the colour evolution of the whole cluster population. Therefore, in the absence of a careful modeling of stochastic effects, age determination of young star clusters by comparing their integrated colours with whole cluster synthetic colours may yield erroneous results.

(iii) X-ray temporal and spectral properties of two WR binaries, V444 Cyg and CD Cru, observed with high-sensitivity EPIC instruments on board the XMM_Newton satellite were analysed. The study of the X-ray spectra reveals cool as well as hot temperature plasma components of binary stars, which are fitted consistently with 2T plasma models. The cooler plasma component was found to be constant at all phases with a mean value of ~0.6 keV for both binaries. The presence of a cooler component could be a result of the distribution of small-scale shocks in the radiation-driven outflows from either the primary or the secondary star in the binary systems.

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(Iv) Using the analysis of H-beta and MgII emission lines of a sample of QSOs, the black hole masses and Eddington ratios were estimated. It is found that both equivalent widths (EW) and FWHM of lines anticorrelate with Eddington ratios. The EW distributions provide no evidence for the hypothesis that a weak jet component in the RQQSOs is responsible for their microvariability.

(v) Using three different techniques to search for periodic oscillations in RXTE ASM data of 24 blazars, an apparently real periodic component of about 17 days and 420 days for the blazers AO 0235+164 and 1ES 2321+419 was found. Most likely detected periodic oscillations arise from the intersections of a shock propagating down a relativistic jet that possesses a helical structure.

(vi) A multi-wavelength analysis of a long duration white-light solar flare(M8.9/3B) occurred on 4 June 2007 indicates that the activation of successive helical twists in the magnetic flux tubes/ropes plays a crucial role in the energy build-up process and triggering of M-class solar flare without a CME.

(vii) Regional population is shown to have maximum contribution (16.5 ppbv) to ozone levels during May-June and it is about 7 ppbv on annual basis while contribution of long-range transport is greatest during January-March (8-11 ppbv). The modeled stratospheric ozone contribution is 2-16 ppbv.

(viii) Analysis of BC mass concentrations, during ICARB, from a network of eight fixed stations showed lowest values of BC over Nainital, even lower than that of Port Blair, indication antropogenic influence over the island site and prevalence of cleaner environment over here.

8. The Institute has a vibrant graduate studies programme with more than twenty research students. The institute continued to host a variety of programmes for man-power development through (i) research and engineer trainee programme, (ii) projects as part of academic course work, (iii) visits of students and staff from other institutions, and (iv) summer project student programme.

9. Several public outreach activities took place during the year including National Science Day on March 22, 2010 which had several exhibitions, talks and viewing of the night sky.

10. The total solar eclipse observations of 2009, July 22nd from Anji, China has been successfully performed by the ARIES expedition team, and the analysed observations will provide the clues of magnetohydrodynamic (MHD) oscillations in the solar corona. In addition, experiments related to atmospheric science were also performed by ARIES team, which

EXECUTIVE SUMMARY

included the measurements of surface ozone along with all the meteorological parameters. These observations will be used to investigate the influence of total solar eclipse on surface ozone variability.

11. A number of scientists and engineers of the Institute participated in national and international conferences/ workshops/colloquia with invited and/or contributed presentations.

A number of young and meritorious scientists and engineers have joined ARIES. ARIES faculty members are actively collaborating with scientists and engineers of other institutes in India and abroad. The continued developments in infrastructure and academic activities at the Institute indicate a bright future of the Institute.

Place: Nainital
Date: 10 August, 2010

RAM SAGAR
Director

THE INSTITUTE

Aryabhatta Research Institute of observational sciencES) (ARIES; formerly known as State Observatory) is one of the leading research Institutes which specializes in observational Astronomy & Astrophysics and Atmospheric Sciences. The main research interests of Astronomy & Astrophysics division are in solar, planetary, stellar, galactic and extra-galactic astronomy including stellar variabilities, X-ray binaries, star clusters, nearby galaxies, quasars, and inherently transient events like supernovae and highly energetic gamma-ray bursts. Research focus in Atmospheric Sciences division is mainly in the lower part of the atmosphere and covers the studies on trace gases and aerosols. Moreover, to strengthen the scientific contribution the Institute has extended its horizon to theoretical and numerical studies in Relativistic Astrophysics.

The unique position of ARIES (79.5° East), places it at almost in the middle of 180° wide longitude band, between Canary Island (20° West) and Eastern Australia (157° East), and therefore complements observations which might not be possible from either of these two places. Additionally, its high altitude location in the central Himalayan region makes it ideal site for better representative of Northern Indian region, including for influences of pollution from Indo-Gangetic Plain region and long-range transport from Europe/Africa.

ARIES has made unique contribution from time to time. To quote examples from the past, the first successful Indian optical observations of the afterglow of gamma-ray burst was carried out from ARIES on January 23, 1999, a few micro-lensing events and quasar variability, new ring systems around Saturn, Uranus, and Neptune were also discovered.

Facilities: There are two 15-cm telescopes dedicated for solar observations. The Institute hosts a 104-cm optical telescope which is being used as a main observing facility by the ARIES scientists since 1972. It is equipped with 2k x 2k, and 1k x 1k liquid N_2 cooled CCD cameras, fast photometer, spectrophotometer, and standard astronomical filters. The telescope uses a SBIG ST-4 camera for auto-guiding through an auxiliary 20-cm telescope.

In order to carry out observations in the frontier areas of astronomy, the Institute is setting up 130-cm and 360-cm optical telescopes at a site called 'Devasthal' at a distance of ~ 60-Km from ARIES, which has the advantages of having dark skies and excellent observing conditions. The Scientists from the Solar group of ARIES are also participating in the national projects like space coronagraph and National Large Solar Telescope (NLST). There are different instruments for observation of physical and optical properties of aerosols. Recently, a lab has been setup for measurement of trace gases like, ozone, CO, NO, NO_y, SO_2 , hydrocarbons and greenhouse gases. An 84-cm micro-pulse LIDAR system for high altitude studies of aerosols and a ST Radar (Stratosphere Troposphere Radar) to measure winds speed up to an altitude of around 20 km is also being setup. A facility for balloon-borne observations (low altitude) of ozone and meteorological parameters is also being setup at ARIES.

Ph.D./PDF Program: ARIES offers Ph. D. program Interested in the field of Astronomy & Astrophysics and Atmospheric Sciences. The minimum qualification for a research scholar is a M. Sc. degree in Physics /Astronomy / Astrophysics/Atmospheric

THE INSTITUTE

Sciences and they should be JEST/NET/GATE qualified. The students can register for the Ph. D. degree at a number of Indian universities that have recognized ARIES as a research centre.

ARIES offers post-doctoral fellowships and visiting positions to work in selected branches of Astronomy & Astrophysics, Atmospheric Sciences, Engineering and Instrumentation and Software development.

Student training and short term visit programme: A few bright students studying in different semesters of the M. Sc. courses can spend 2-3 months at ARIES to work with one of the scientists/engineers of the Institute on topics related to Astronomy & Astrophysics or Atmospheric Sciences. Apart from this, students with an outstanding academic record and an aptitude for instrumentation or software development can also spend a few months at ARIES any time of the year.

Summer School: ARIES organizes a 3-4 weeks summer school every year. The school is aimed at providing introduction to Astronomy/Astrophysics and Atmospheric sciences to young graduate students in their M. Sc. programs. The school consists of lectures and a short-term project.

Evening Program: As a part of science popularization program, ARIES is open to public in the evenings for night-sky viewing using one of the telescopes. Visitors can also attend the slide-shows and view the picture gallery describing celestial bodies. ARIES also participates in other science popularization programs for students and common public.

Areas of Research:

Atmospheric Sciences: Trace gases, aerosols characterization, radiation budget, satellite data analysis and modeling.

Sun and Solar System: Sun, solar activity, comets, asteroids, and planets.

Extragalactic Astronomy: Nearby galaxies, Wolf-Rayet galaxies, active galaxies, optical follow-up of gamma ray bursts (GRBs) and supernova, quasar luminosity variability; Radio astronomy.

Interstellar Matter: Gas (atoms and molecules) and dust between the stars and within interstellar clouds.

Stellar Astronomy: Stars, star clusters, stellar variabilities, ages of the stars and their spectral properties.

Theoretical Astrophysics: Theoretical and numerical studies of relativistic phenomena like accretion onto compact objects, astrophysical jets, GRBs etc.

X-ray Astronomy: X-ray emitting binary stars.

I. GALACTIC ASTRONOMY

a. Star formation

Evolution of the Core mass function:

A model which describes the co-evolution of the mass function of dense gravitationally bound cores and of the stellar mass function in a protocluster clump has been developed. In the model, dense cores are injected, at a uniform rate, at different locations in the clump and evolve under the effect of gas accretion. Gas accretion on to the cores follows a time-dependent accretion rate that describes accretion in a turbulent medium. Once the accretion time-scales of cores of a given age, of a given mass and located at a given distance from the centre of the protocluster clumps exceed their contraction time-scales, they are turned into stars. The stellar initial mass function (IMF) is thus built up from successive generations of cores that undergo this accretion-collapse process. The effect of feedback by the newly formed massive stars through their stellar winds has also been included. A fraction of the wind's energy is assumed to counter gravity and disperse the gas from the protocluster and as a consequence quench further star formation. The latter effect sets the final IMF of the cluster. The model was applied to a clump that is expected to resemble the progenitor clump of the Orion Nebula Cluster (ONC). The ONC is the only known cluster for which a well-determined IMF exists for masses ranging from the sub-stellar regime to very massive stars. The model is able to reproduce both the shape and normalization of the ONC's IMF and the mass function of dense submillimetre cores in Orion. The complex features of the ONC's present-day IMF, namely a shallow slope in the mass range of ~0.3-2.5 $M_{\odot}$, a steeper slope in the mass range of ~2.5-12 $M_{\odot}$ and a nearly flat tail at the high-mass end, are reproduced. The model predicts a `rapid' star formation process with an age spread for the stars of 2.3×10^{5}yr which is consistent with the fact that 80% of the ONC's stars have ages of <~0.3Myr. The model also predicts a primordial mass segregation with the most massive stars being born in the region between two and four times the core radius of the cluster. In parallel, the model also reproduces, at the time the IMF is set and star formation quenched, the mass distribution of dense cores in the Orion star-forming complex. The effects of varying some of the model parameters on the resulting IMF were studied and it is shown that the IMF of stellar clusters is expected to show significant variations, provided variations in the clumps' and cores' physical properties exist. [S. Dib, M. Shadmehri, P. Padoan, **G. Maheswar,** D. K. Ojha and F. Khajenabi].

Triggered star formation:

A multiwavelength investigation of morphology, physical-environment, stellar contents, and star formation activity in the vicinity of star-forming region Sh2-100 has been carried out. It is found that the Sh2-100 region contains seven H II regions of ultracompact and compact nature. The present estimation of distance for three H II regions, along with the kinematic distance for others, suggests that all of them belong to the same molecular cloud complex. Using near-infrared photometry, the most probable ionizing sources of six H II regions were identified. Their approximate photometric spectral type estimates suggest that they are massive early-B to mid-O zero-age-main-sequence stars and agree well with radio continuum observations at 1280 MHz, for sources whose emissions are optically thin at

GALACTIC AND EXTRA GALACTIC ASTRONOMY

this frequency. The morphology of the complex shows a non-uniform distribution of warm and hot dust, well mixed with the ionized gas, which correlates well with the variation of average visual extinction (~4.2-97 mag) across the region. The physical parameters of ionized gas with the help of radio continuum observations were estimated. An optically visible compact nebula located to the south of the 850 μm emission associated with one of the H II regions was detected and the diagnostic of the optical emission line ratios gives electron density and electron temperature of $\sim 0.67 \times 10^{3}$ cm^{-3} and $\sim 10^{4}$ K, respectively. The physical parameters suggest that all the H II regions are in different stages of evolution, which correlate well with the probable ages in

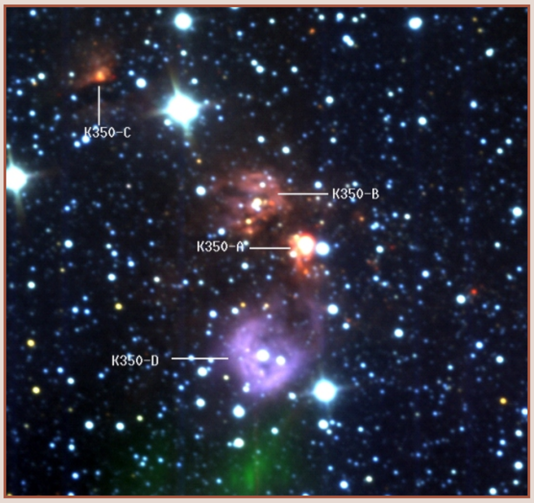

Figure 1. JHKs colour-composite (J, blue; H, green; and Ks , red) image of the Sh 2-100 star forming region. Locations of the associated compact and ultra-compact HII region in the complex are also marked.

the range ~0.01-2 Myr of the ionizing sources. The spatial distribution of infrared excess stars, selected from near-infrared and Infrared Array Camera color-color diagrams, correlates well with the association of gas and dust. The positions of infrared excess stars, ultracompact and compact H II regions at the periphery of an H I shell, possibly created by a WR star, indicate that star formation in Sh2-100 region might have been induced by an expanding H I shell. [**M. R. Samal, A. K. Pandey,** D. K. Ojha, S. K. Ghosh, V. K. Kulkarni, N. Kusakabe, M. Tamura, B. C. Bhatt, M. A. Thompson and **R. Sagar].**

Distances to molecular clouds:

A method is developed to determine distances to molecular clouds using JHK near-infrared photometry. The method is based on a technique that aids spectral classification of stars lying towards the fields containing the clouds into main sequence and giants. In this technique, the observed (J-H) and (H-K_s) colours are dereddened simultaneously using trial values of A_v and a normal interstellar extinction law. The best fit of the dereddened colours to the intrinsic colours giving a minimum value of χ^2 then yields the corresponding spectral type and A_v for the star. The main sequence stars, thus classified, are then utilized in an A_v versus distance plot to bracket the cloud distances. The method was applied to four clouds, L1517, Chamaeleon I, Lupus 3 and NGC 7023 and estimated their distances as 167±30, 151±28, 157±29 and 408±76 pc respectively, which are in good agreement with the previous distance estimations available in the literature. [**G. Maheswar**, C. W. Lee, H. C. Bhatt, S. V. Mallik and S. Dib].

b. Star clusters

Integrated parameters of star clusters:

The integrated parameters for synthetic clusters have been obtained for the whole cluster population as well as for the main-sequence (MS) population. The observed integrated magnitudes and colours of the MS population of galactic open clusters, Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) star clusters have also been estimated. It is found that the colour evolution of the MS population of star clusters is not affected by the stochastic fluctuations, however, these fluctuations significantly affect the colour evolution of the whole cluster population. The fluctuations are maximum in (V - I) colour in the age range $6.7 < \log(age) < 7.5$. Evolution of integrated colours of the MS population of clusters in the Milky Way, LMC and SMC, obtained in the present study is well explained by the present synthetic cluster model. The observed integrated (B - V) colours of the MS population of LMC star clusters having age ≥ 500 Myr seem to be distributed around the Z = 0.004 model, whereas (V - I) colours are found to be bluer than those predicted by the Z = 0.004 model. The (V - I) versus (B - V) two-colour diagram for the MS population of the Milky Way star clusters shows a fair agreement between the observations and present model, however, the diagrams for LMC and SMC clusters indicate that observed (V - I) colours are relatively bluer. Possible reasons for this anomaly have been discussed. Comparison of the synthetic (U - B) versus (B - V) relation with the observed integrated parameters of the whole cluster population of the Milky Way, LMC and SMC star clusters indicates that the majority of the bluest clusters $[(B - V)_0 < 0.0]$ follow the MS population relation. The colour evolution of young Milky Way, LMC and SMC clusters $[6.5 \leq \log(age) \leq 8.0]$ also indicates that a large number of young clusters follow the MS population relation. Therefore, in the absence of a careful modelling of stochastic effects, age determination of young star clusters by comparing their integrated colours with whole cluster synthetic colours may yield erroneous results. [**A. K. Pandey**, T. S. Sandhu, **R. Sagar** and P. Battinelli].

Optical photometry of star clusters:

A deep UBVRI CCD photometry of six open star clusters situated in the Galactic anticenter region (l~ 120-200°) has been carried out. The sample includes three unstudied (Be 6, Be 77, King 17) and three partly studied open clusters (Be 9, NGC 2186, and NGC 2304). The fundamental parameters have been determined by comparing color-color and color-magnitude diagrams with the theoretical models. The structural parameters and morphology of the clusters were discussed on the basis of radial density profiles and isodensity contours, respectively. The isodensity contours show that all the clusters have asymmetric shapes. An investigation of structural parameters indicates that the evolution of core and corona of the clusters is mainly controlled by internal relaxation processes. [**S. Lata, A. K. Pandey, B. Kumar, H. Bhatt,** G. Pace and **S. Sharma]**

Polarization towards the young open cluster NGC 6823:

A multiwavelength linear polarimetric observations of 104 stars towards the region of young open cluster NGC 6823 have been carried out. The polarization towards NGC 6823 is dominated by foreground dust grains. The evidence for the presence of several layers of dust towards the line of sight is also found. The first layer of dust is approximately located within 200 pc towards the cluster, which is much closer to the Sun than the cluster itself (~2.1kpc). The radial distribution of the position angles for the member stars is found to show a systematic change, while the polarization is found to reduce towards the outer parts of the cluster and the average position angle of the coronal region of the cluster is very close to the inclination of the Galactic parallel (~32°). The size distribution of the grains within NGC 6823 is similar to those in the general interstellar medium. The patchy Distribution of foreground dust grains is suggested to be mainly responsible for both differential reddening and polarization towards NGC 6823. The majority of the observed stars do not show evidence of intrinsic polarization in their light. [**B. J. Medhi, G. Maheswar, J. C. Pandey,** M. Tamura and **R. Sagar**].

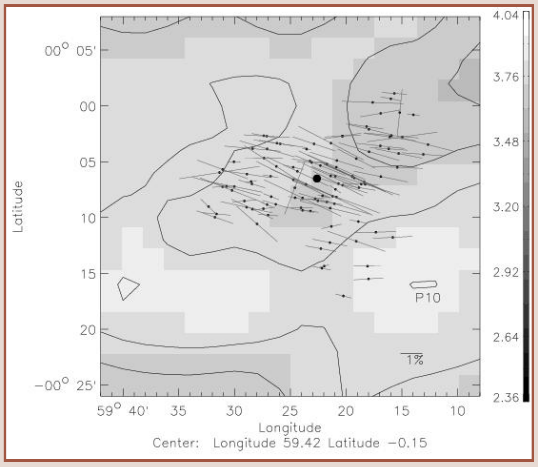

Figure 2. The high resolution extinction map of NGC 6823 (30 x 30 arcmin) produced by Dobashi et al. (2005) using the optical database `Digitized Sky Survey I' and applying traditional star count technique. We overlay V band results from our observations using vectors drawn in black colours. The clump identified by Dobashi et al. (2005) in this region is identified and labeled as P10. The center of the cluster (l=59.40 degree, b=-0.14 degree) is identified using black circle.

c. Variable Stars

New variables in the orion nebula cluster:

The luminosity spread in the colour-magnitude diagram for stars having a similar colour, and hence mass, has been generally associated with the age spread and found to be an effective tool to study star formation history in the young star clusters. Therefore, a long-term observing program to monitor young stellar objects (YSOs) in the Orion Nebula Cluster (ONC) was started in 2004 with an aim of exploring various manifestations of stellar magnetic activity in very young low-mass stars, searching new pre-main-sequence eclipsing binaries and finding any EXor and Fuor-like transient activities associated with YSOs. The high-quality and time-extended photometric data containing about 2000 frames in V, R and I broad-band filters on more than 200 nights reveals that about 72% of classical T Tauri stars (CTTS) in the observed field of view are periodic, whereas only 32% of weak-lined T Tauri stars (WTTS) are periodic variables. This indicates that inhomogeneity patterns on the surface of CTTS of the ONC stars are much more stable than on WTTS. It is suggested that the photometric surveys based on single season are incapable of identifying all periodic variables and multi-season observations are needed to study angular momentum evolution. This program, together with two previous surveys, has resulted in identifications of 148 periodic Variables. [P. Parihar, S. Messina, E. Distefano, N. S. Shantikumar and **B. J. Medhi**].

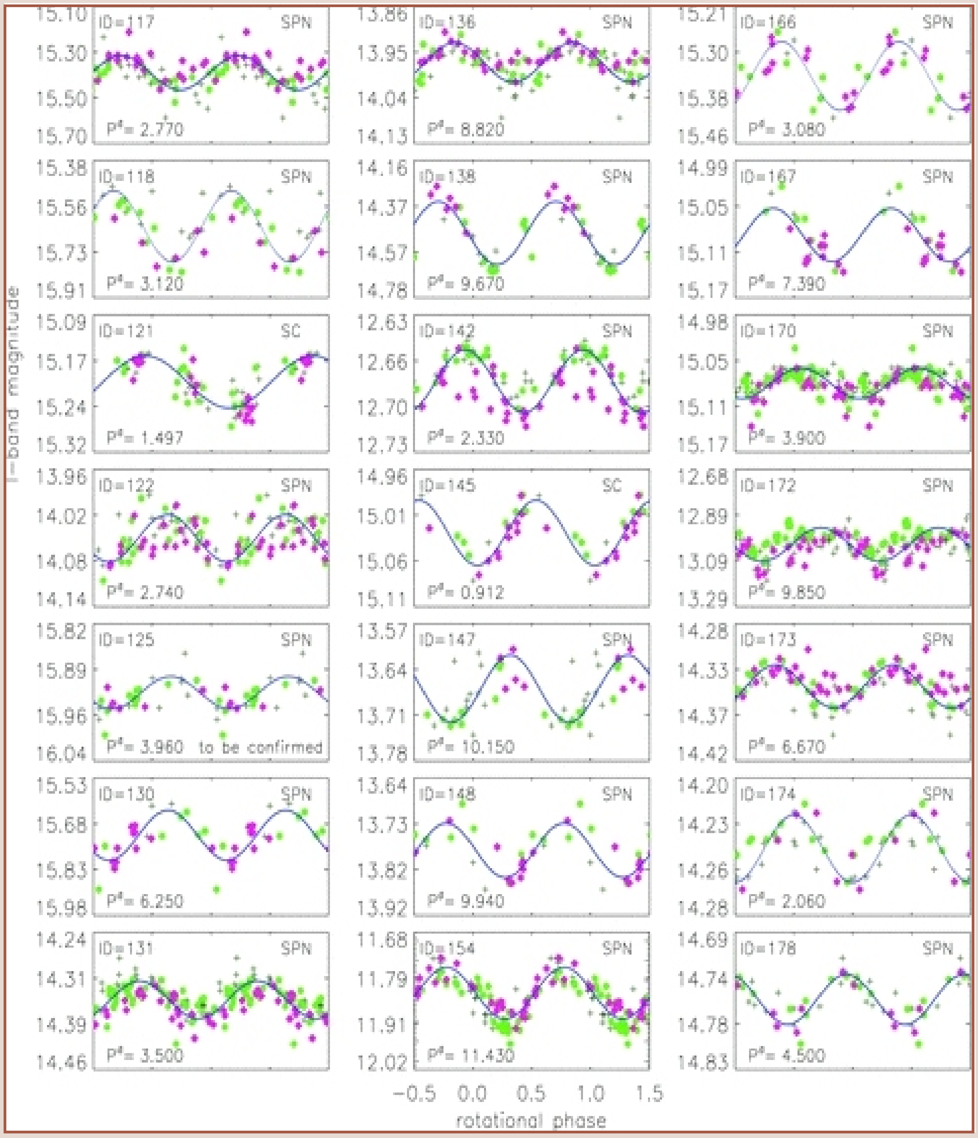

Figure 3. I-band light curves of periodic variables versus rotation phase. Different symbols are used to distinguish data belonging to different time intervals. The solid line represents the sinusoidal fit to the data.

The TAOS project stellar variability -- detection of 15 variable stars:

The Taiwanese-American Occultation Survey (TAOS) project aims to search for stellar occultation by small (~1km diameter) *Kuiper Belt Objects* (KBOs). The KBO population consists of remnant planetesimals in our Solar System, which typically have low to intermediate (below 30 degree) inclination orbits and heliocentric distances between 30 and 50 AU. While the main goal of the TAOS project is to conduct a KBO census by detecting stellar occultations, the plethora of time-series stellar photometry renders the opportunity to identify and characterize variable stars spanning a wide range of timescales, from less than a second to a few years. TAOS project has collected more than a billion photometric measurements since 2005 January. These sky survey data---covering timescales from a fraction of a second to a few hundred days---are a useful source to study stellar variability. A total of 167 star fields, mostly along the ecliptic plane, have been selected for photometric monitoring with the TAOS telescopes. The search for periodic variable stars from the time-series TAOS data on one such TAOS field, No. 151 (RA = $17^{h}\ 30^{m} 6.67^{s}$, Dec = 27° 17' 30" , J2000) had been carried out for more than 47 epochs in 2005. A

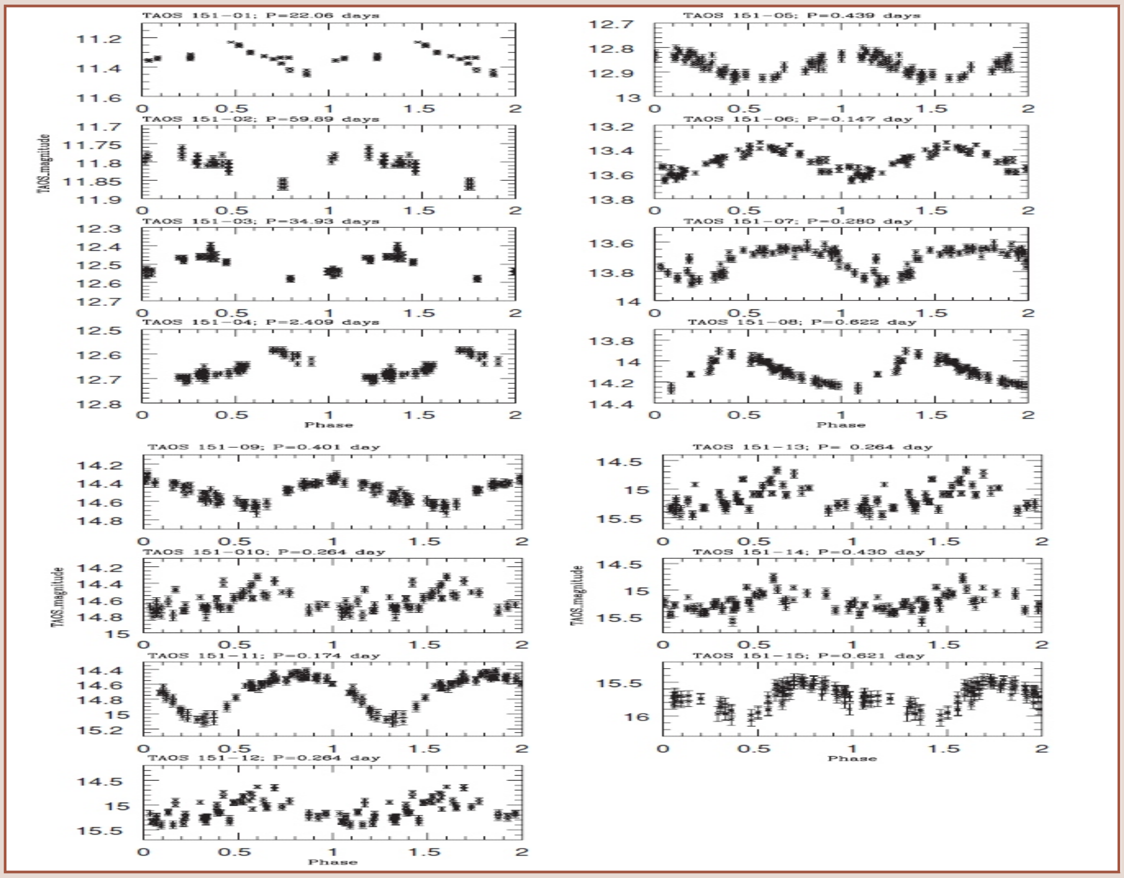

Figure 4. Phase light curve of the newly identified variable stars with the TAOS data over the 3 square degree field of view.

total of 81 candidate variables are identified in the 3 square degree field, with magnitudes in the range 8 < R < 16. On the basis of the periodicity and shape of the light curves, 29 variables, 15 of which were previously unknown, were classified as RR Lyrae, Cepheid, δ Scuti, SX Phonencis, semi-regular and eclipsing binaries. [**S. Mondal**, et al.].

Detection of short period cepheids in the disk of M31:

A survey project 'Nainital Microlensing Survey' was carried out during 1998-2002 using 2Kx2K CCD attached to the 104-cm Sampurnanand telescope at Manora Peak, technique and yielded 39 short-period variables with the period smaller than 15 days. Since pixel analysis method gives only the increase in flux in ADU rather than in magnitude, a technique was devised in which DAOPHOT photometric magnitude of the Cepheid was determined during its maximum brightness phase and compared with the corresponding change in the pixel flux in ADU. By correlating the pixel flux with the DAOPHOT photometric magnitude, the mean magnitude of the Cepheids was determined. In this way, mean R magnitude of all the 39 short-period M31 Cepheids was estimated. The dense phase coverage of the Cepheids also

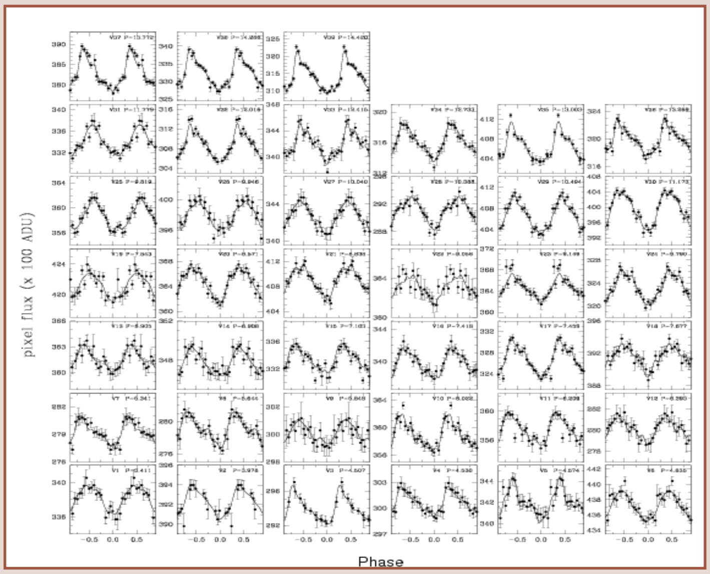

Figure 5. R band phase light curves of the 39 Cepheids. Phase is plotted twice and in such a way that the minimum flux falls near to zero phase

Nainital under the Indo-French collaboration with the aim of detecting microlensing events in the direction of M31. To search for short-period Cepheid variables in the acquired data, whole data taken under the microlensing survey program was re-analysed using the pixel enabled to determine their precise pulsation period hence a detailed study of their frequency-period distribution and period- luminosity relation was carried out. [**Y. C. Joshi**, D. Narasimha, **A. K. Pandey, R. Sagar**].

Search for pulsational variability in chemically peculiar stars:

The Nainital-Cape survey is a dedicated research programme to search for and study the pulsational variability in chemically peculiar stars in the Northern Hemisphere. The main aim of the survey is to search for such chemically peculiar stars that are pulsationally unstable. For this study, observations of HD 25515 were carried out for 58 hours in high-

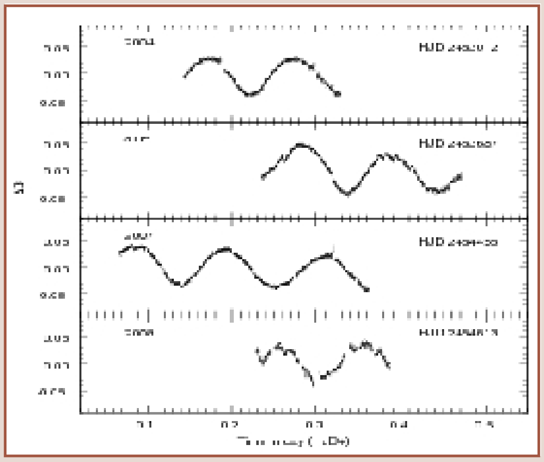

Figure 6. Typical light curves of HD 25515 obtained in four different observing seasons.

speed photometric mode on 13 nights using a three-channel fast photometer attached to the 104-cm Sampurnanand telescope at ARIES. The authors confirmed that the HD 25515 pulsates with a period of about 2.78-hrs. The time-series observations of HD 113878 taken for 36 hours on 11 nights and HD 118660 taken for 41 hours on 11 nights confirmed previously known frequencies for these objects. They estimated the distances, absolute magnitudes, effective temperatures and luminosities of these stars. The positions of these stars in the H-R diagram indicate that HD 25515 and HD 118660 lie near the main-sequence while HD 113878 is an evolved star. [**S. Joshi**, D. L. Mary, N. K. Chakradhari, **S. K. Tiwari** and C. Billaud].

Photometry of the Delta Scuti star HD 40372:

B band photometry of the Delta Scuti star HD 40372 has been obtained using the ARIES three channel fast photometer in the high-speed photometric mode. Based on the high quality photometric data taken on December 13, 2008 for 5 hours, a periodic variation of about 0.067 days was obtained. With this period and the other stellar parameters determined from uvbyβ photometry available in the literature, Q value for the star was calculated which suggests that the star is pulsating in the non-radial p3 mode with l = 2. [**S. K. Tiwari**, H.P. Singh, T.R. Seshadri and **U. S. Chaubey**].

d. X-ray Astronomy

Low-luminosity X-ray pulsators with their Optical and IR-counter part:

Chandra and XMM-Newton observations of five low-luminosity X-ray pulsators (AX J1700.1−4157, AX J1740.1−2847, AX J1749.2−2725, AX J1820.5−1434 and AX J1832.3−0840) with pulse periods >150 s suggest that they are likely members of persistent high-mass X-ray binaries or intermediate polars (Ips). Near IR counter part of the sources AX J1700.1−4157, AX J1740.1−2847, AX J1749.2−2725 were detected using Chandra and European Southern Observatory-New Technology Telescopes observations for the first time. However, the possible optical and IR counterpart for the sources AX

J1820.5−1434 and AX J1832.3−0840 were detected in the Two Micron All Sky Survey and Digitized Sky Survey observations, respectively. The pulse

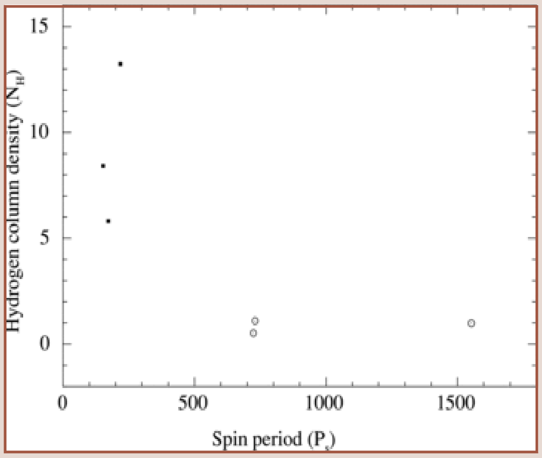

Figure 7. Spin period (P_s) versus the measured neutral hydrogen column density (N_H) of the sources. The sources represented by symbol 'open circles with dot inside' have Fe emission lines in their X-ray spectrum, while the sources represented by symbol 'filled square' do not have Fe emission lines.

profiles and pulse fractional amplitudes from present observations are found to be consistent with the previous observations, indicating that these are stable systems. Present observations also suggest that these sources might form two different groups – with large pulse period having small hydrogen column density and detection of Fe lines and small pulse period having large hydrogen column density and non-detection of any Fe emission line. With the help of multiwavelength observations, it is suggested that AX J1749.2−2725 and AX J1820.5−1434 to be accreting neutron star systems while the remaining three sources could be IPs. [**R. Kaur**, R. Wijnands, B. Paul, A. Patruno and N. Degenaar].

X-ray emission characteristics of two Wolf – Rayet (WR) binaries: V444 Cyg and CD Cru:

X-ray temporal and spectral properties of two WR binaries, V444 Cyg and CD Cru, observed with high-sensitivity EPIC instruments on board the XMM–Newton satellite were analysed. The X-ray light curves in the soft and hard energy bands show the phase-locked variability. Both primary and secondary minima were seen in the hard band X-ray light curves of both binaries. However, in the soft X-ray light curve only the primary minimum was seen. This implies that the hard energy component could be originating from the wind–wind collision zone. The X-ray spectra of both WR binaries show strong absorption below ≈ 1 keV and clear evidence of high temperature plasma, manifested by a visible Fe Kα emission-line complex. The study of the X-ray spectra reveals cool as well as hot temperature plasma components of binary stars, which are fitted consistently with 2T plasma models. The cooler plasma component was found to be constant at all phases with a mean value of ~0.6 keV for both binaries. The presence of a cooler component could be a result of the distribution of small-scale shocks in the radiation-driven outflows from either the primary or the secondary star in the binary systems. The temperature of the hot plasma component and the corresponding column density were found to be variable during the orbital cycle of both binaries. The variation in temperature of hot plasma could be because of the varying circumstellar optical depth along the line of sight owards the shock as the stars revolve around each other. The maximum value of the hot plasma was found to be

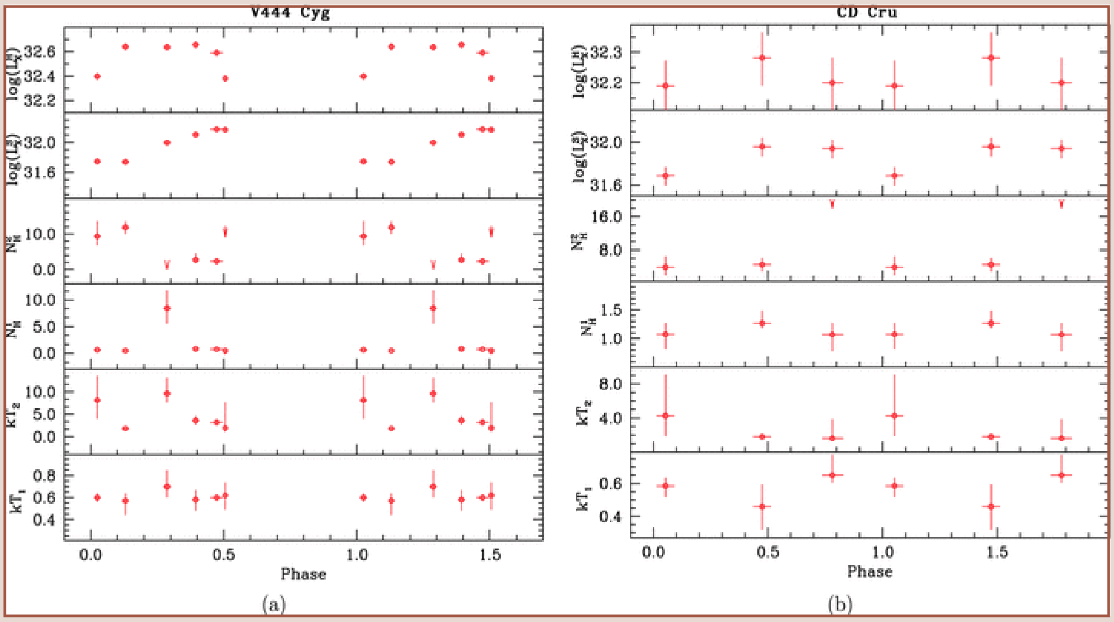

Figure 8. Variation of X-ray luminosity in soft band (L^S_X) and hard band (L^H_X), hydrogen column density related to the cool component (N^1_H) and the hot component(N^2_H), and cool (kT_1) and hot (kT_2) temperatures as a function of the orbital phases of (a) V444 Cyg and (b) CD Cru.

lower than the hottest plasma possible in the binary systems as predicted by colliding wind theory for short period binaries. However, the predicted values of X-ray luminosities are ~ three orders of magnitude more than the observed values and cannot be accounted for in terms of observational errors. [**H. Bhatt, J. C. Pandey, B. Kumar, R. Sagar** and K. P. Singh].

II. EXTRA GALATIC ASTRONOMY

Probing spectral properties of radio-quiet quasars searched for optical microvariability:

Over the past 15 years there have been rather extensive examinations of a significant sample of radio-quiet QSOs (RQQSOs) and Seyfert galaxies for small brightness changes (typically 0.02 mag) over short times (a few hours). This phenomenon of microvariability, or intranight optical variability (INOV) may arise due to jet or from processes on the accretion disc itself. Therefore it is important to compare the observational constraints on the variability properties with the predictions of many theoretical models such as the presence of a weak Doppler boosted jet or blazar component. In this blazar component scenario, spectral properties such as equivalentwidths (EWs) of H-beta and Mg II~ line can be very useful to ascertained that whether weak jet component or processes on the accretion disc are responsible for observed INOV.

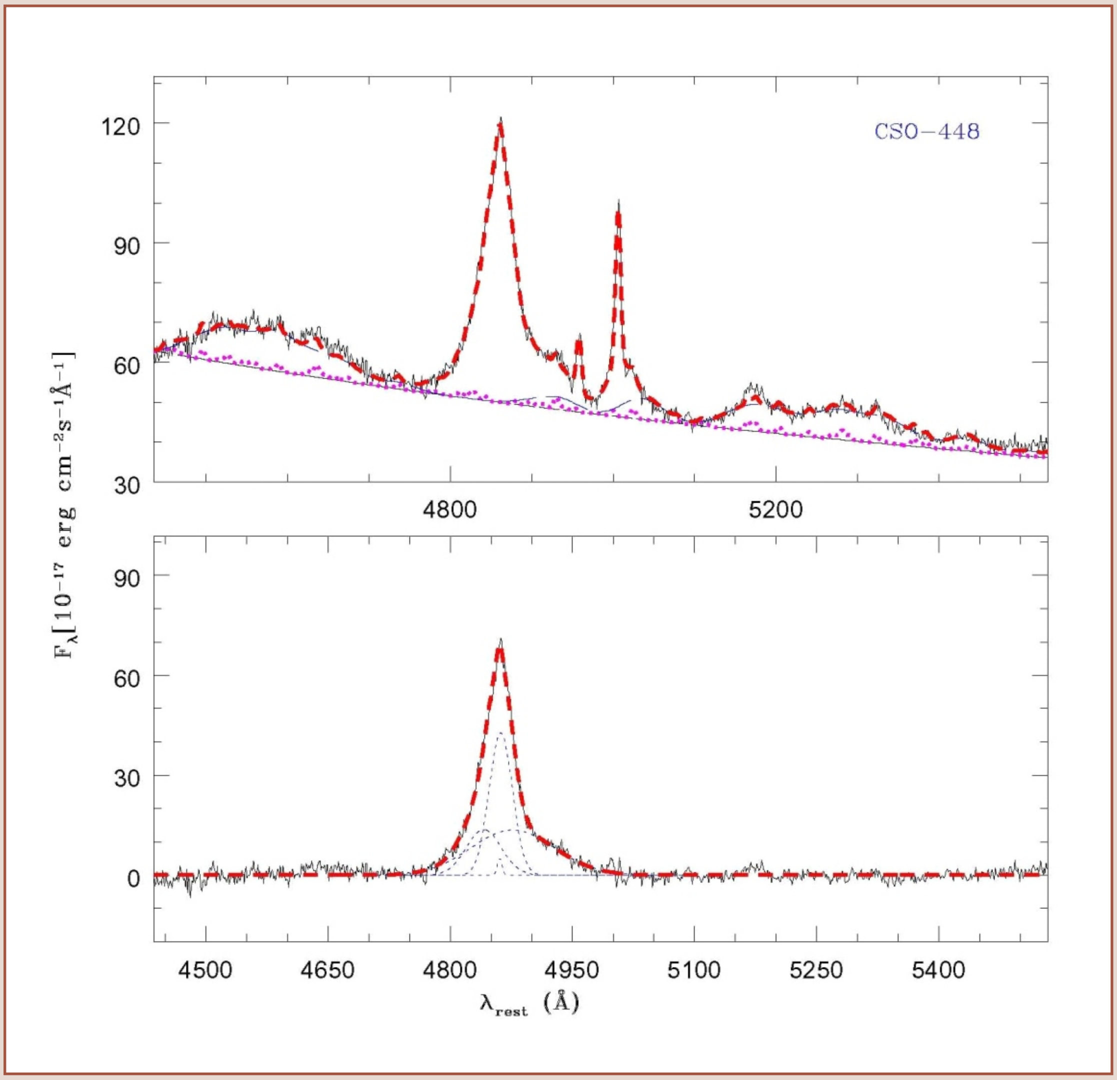

Figure 9. The best fit to the H-beta emission line of the SDSS spectra of the QSO CSO 448. **Upper panel:** Complete spectrum fit (thick dashed/red) and components of the fit:power law continuum (thin dashed/black line), broad Fe II (dot-dashed/blue),narrow Fe II (dotted/magenta) lines.

Lower panel: Continuum, Fe II and metal line subtracted spectrum (solid/black) with the best fit total H-beta profile (thick dashed/red) and H-beta components (dotted/blue) lines. Note that the entire fit is performed simultaneously (not first continuum subtraction then H-beta fit) but these aspects are shown separately for the sake of clarity.

In addition these lines have also been found to be very useful in estimating other key parameters of AGN central engines such as black hole (BH) mass and Eddington ratios. Recently, Chand et. al. (2010) have worked toward these goals by exploiting the optical spectra available from Sloan Digital Sky Survey (SDSS) Data Release 7 with careful spectral modeling of the H-beta and Mg II emission line regions. They obtained SDSS spectra for a set of 37 radio-quiet quasars (RQQSOs) that had been previously examined for rapid small-scale optical variations, or microvariability. Their H-beta and MgII emission lines were carefully fit to determine linewidths (full width at half-maximum) as well as equivalent widths (EW) due to the broad emission-line components. The linewidths were used to estimate black hole masses and Eddington ratios. Both EW and FWHM are anticorrelated with Eddington ratios. The EW distributions provide no evidence for the hypothesis that a weak jet component in the RQQSOs is responsible for their microvariability. [**H. Chand,** P. J. Wiita and **A. C. Gupta**].

Constraining fundamental constants of physics with quasar absorption line systems:

Some of the modern theories of fundamental physics, in particular SUSY, GUT and Super-string theory, suggest the possibility of the variation of fundamental constant such as fine-structure constant, electron to proton ration, thus motivating an experimental search for such variation. The absorption lines seen in the quasar spectra can be used as an effective tool to test any such cosmological time variation, as they allow one to measure its value at different redshifts. Given the important implication of any variation of fundamental constant to fundamental physics, it become important to summarized the result based on various 8-10m class telescope. Recently, Petitjean et al. (2009) have reviewed the various attempts by our group and others to derive constraints on variations of fundamental constants. Most upper limits for the fractional change of fine-structure constant reside in the range 5-15 part per million at the 3 sigma level over a redshift range of approximately 0.5-2.5. It has been shown that future instrumentations on ELTs and TMT/GMT in the optical and/or ALMA, EVLA and SKA pathfinders in the radio will improve the existing result by an order of magnitude, by achieving better signal-to-noise ratios at higher spectral resolution. [P. Petitjean, R. Srianand, **H. Chand,** A. Ivanchik, P. Noterdaeme and N. Gupta].

Non-thermal transient sources from rotating black holes:

Rotating black holes can power the most extreme non-thermal transient sources. They have a long-duration viscous time-scale of spin-down, and produce non-thermal emissions along their spin-axis, powered by a relativistic capillary effect. van Putten et al. report on the discovery of exponential decay in Burst and Triensient Source Experiment (BATSE) light curves of long gamma-ray bursts (GRBs) by matched filtering, consistent with a viscous time-scale, and identify ultra-high energy cosmic rays (UHECRs) about the Greisen-Zatsepin-Kuzmin (GZK) threshold with linear acceleration of ion contaminants along the black hole spin-axis, consistent with black hole masses and lifetimes of Fanaroff-Riley type II (FR II) active galactic nuclei (AGN). They explain the absence of UHECRs from BL Lac objects due to UHECR emissions preferably at appreciable angles away from the black hole spin-axis. Black hole spin may be the key to unification of GRBs and their host environments, and to AGN and their host galaxies. Their model points to long-duration bursts in radio from long GRBs without supernovae and gravitational waves from all long GRBs. [P. Van, H. P. M. Maurice and **A. C. Gupta**].

Nearly periodic fluctuations in the long-term X-ray light curves of the blazars AO 0235+164 and 1ES 2321+419:

Rani et al. have performed a structure function analysis of the Rossi X-Ray Timing Explorer. All-Sky Monitor data to search for variability in 24 blazars using data trains that each exceed 12 yr. Although 20 of them show nominal periods through this technique, the great majority of these "periods" are clearly related to yearly variations arising from the instrument. Nonetheless, an apparently real periodic component of about 17 days was detected for the blazar AO 0235+164 and it was confirmed by discrete correlation function and periodogram analyses. For 1ES 2321+419, a component of variability with a near periodicity of about 420 days was detected by all of these methods. They discuss several possible explanations for these nearly periodic components and conclude that they most likely arise from the intersections of a shock propagating down a relativistic jet that possesses a helical structure. [**B. Rani,** P. J. Wiita and **A. C. Gupta**].

A ~4.6 h quasi-periodic oscillation in the BL Lacertae PKS 2155-304?:

Lachowicz at al. report a possible detection of an ~4.6-h quasi-periodic oscillation (QPO) in the 0.3-10 keV emission of the high-energy peaked blazar PKS 2155-304 from a 64 ks observation by the XMM-Newton EPIC/pn detector. They identify a total modulation of ~5% in the light curve and confirm that nominal period by periodogram, structure function, and wavelet analyses. The limited light curve duration allows the capture of only 3.8 cycles of this oscillation and thus precludes a very strong claim for this QPO, despite a nominally high (3σ) statistical significance. They briefly discuss models capable of producing an X-ray QPO of such a period in a blazar. [P. Lachowicz, **A. C. Gupta, H. Gaur** and P. J. Wiita].

WEBT multiwavelength monitoring and XMM-Newton observations of BL Lacertae in 2007-2008. Unveiling different emission components:

BL Lacertae is the prototype of the blazar subclass named after it. Yet, it has occasionally shown a peculiar behaviour that has questioned a simple interpretation of its broad-band emission in terms of synchrotron plus synchrotron self-Compton (SSC) radiation. In the 2007-2008 observing season Raiteri et al. carried out a new multiwavelength campaign of the Whole Earth Blazar Telescope (WEBT) on BL Lacertae, involving three pointings by the XMM-Newton satellite in July and December 2007, and January 2008, to study its emission properties, particularly in the optical-X-ray energy range. The source was monitored in the optical-to-radio bands by 37 telescopes. The brightness level was relatively low. Some episodes of very fast variability were detected in the optical bands. Flux changes had larger amplitude at the higher radio frequencies than at longer wavelengths. The X-ray spectra acquired by the EPIC instrument onboard XMM-Newton are well fitted by a power law with photon index Γ ~ 2 and photoelectric absorption exceeding the Galactic value. However, when taking into account the Presence of a molecular cloud on the line of sight, the EPIC data are best fitted by a double power law, implying a concave X-ray spectrum. The spectal energy distributions (SEDs) built with simultaneous radio-to-X-ray data at the epochs of the XMM-Newton observations suggest that the peak of the synchrotron emission lies in the near-IR band, and show a prominent UV excess, besides a slight soft-X-ray satellites shows that the X-ray spectrum is very variable, since it can change from extremely steep to extremely hard, and can be more or less curved in intermediate states. They ascribe the UV excess to thermal emission from the accretion disc, and the other broad-band spectral features to the presence ot two synchrotron components with their related SSC emission. They fit the thermal emission with a black body law and the non-thermal components by means of a helical jet model. The fit indicates a disc temperature $\gtrsim$ 20 000 K and a luminosity $\gtrsim$ 6x1044 erg s^{-1}. [C. M. Raiteri, ... et al. (69 authors including **A. C. Gupta** and **R. Sagar**)].

Observation of kink instability during small B5.0 solar flare on 2007 June 4:

Using multi-wavelength observations of SOHO/Michelson Doppler Imager (MDI), Solar Optical Telescope (SOT)-Hinode/blue-continuum (4504 Å), G band (4305 Å), Ca II H (3968 Å), and Transition Region and Coronal Explorer (TRACE 171) Å, the observational signature of a highly twisted magnetic loop has been found in AR 10960 during the period 04:43 UT-04:52 UT on 2007 June 4.

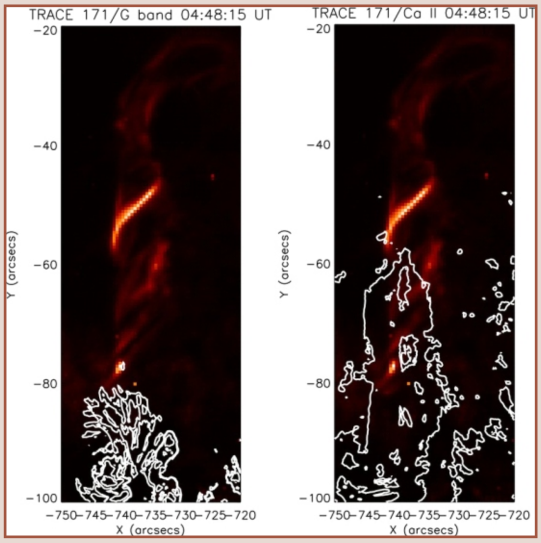

Figure 10. Partial TRACE 171 Å field-of-view (FOV) during 04:48:15 UT on 2007 June 4 in AR 10960, which shows the coronal loop segment with strong helical twist. The co-aligned SOT G band (left panel) and Ca II (right panel) contours are overlayed on the TRACE 171 Å image, which shows the sunspot position and the chromospheric part of the loop, respectively.

SOT-Hinode/blue-continuum (4504 Å) observations show that penumbral filaments of positive polarity sunspot have counterclockwise twist, which may be caused by the clockwise rotation of the spot umbrae. The coronal loop, whose one footpoint is anchored in this sunspot, shows strong right-handed twist in chromospheric SOT-Hinode/Ca II H (3968 Å) and coronal TRACE 171 Å images. The length and the radius of the loop have been estimated as L ~ 80 Mm and a ~ 4.0 Mm, respectively, while the distance between neighboring turns of magnetic field lines (i.e., pitch) is estimated as ≈ 10 Mm. The total twist angle, $\Phi \sim 12\pi$ estimated for the homogeneous distribution of the twist along the loop, is much larger than the Kruskal-Shafranov instability criterion. The detection of double structure of the loop top during 04:47 UT-04:51 UT on TRACE 171 Å images, is consistent with simulated kink instability in curved coronal loops. The observed kink instability of this twisted magnetic loop triggers a B5.0 class solar flare, which occurred between 04:40 UT and 04:51 UT in this active region. [**A. K. Srivastava**, T. V. Zaqarashvili, **P. Kumar** and M. L. Khodachenko].

Multiwavelength study of M8.9/3B solar flare from AR NOAA 10960:

A multi-wavelength analysis of a long duration white-light solar flare (M8.9/3B) has been carried out that occurred on 4 June 2007 from the same NOAA AR 10960. The flare was observed by several spaceborne instruments, namely SOHO/MDI, Hinode/SOT, TRACE and STEREO/SECCHI. The flare was initiated near a small, positive-polarity, satellite sunspot at the centre of the AR10960, surrounded by opposite-polarity field regions. SoHO/MDI images of the AR show considerable amount of changes in a small positive-polarity sunspot of delta configuration during the flare event. SOT/G-band (4305 Å) images of the sunspot also suggest the rapid evolution of the positive-polarity sunspot with highly twisted penumbral filaments before the flare

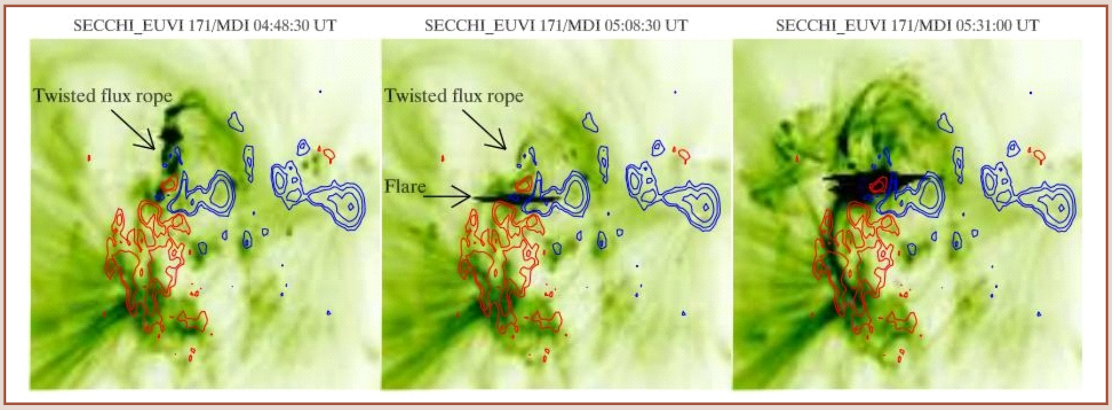

Figure 11. MDI contours overlaid on STEREO/SECCHI 171 EUV images before the flare (left-panel) and during flare progressive phase (middle and right panels). Red contours show the positive polarity, while blue ones show the negative polarity. The size of each image is 200 x 200. The EUV images show the changes in the coronal configuration of AR10960 during the M-class flare, as well as the activation of successive helical twists.

event, which were oriented in the counterclockwise direction. It shows the change in orientation and also remarkable disappearance of twisted penumbral filaments (~35-40%) and enhancement in umbral area (~45-50%) during the decay phase of the flare. TRACE and SECCHI observations reveal the successive activations of two helical twisted structures associated with this sunspot, and the corresponding brightening in the chromosphere as observed by the time-sequence images of SOT/Ca II H line (3968 Å). The secondary-helical twisted structure is found to be associated with the M8.9 flare event. The brightening starts 6-7 min prior to the flare maximum with the appearance of secondary helical-twisted structure. The flare intensity maximizes as this structure moves away from the AR. This twisted flux-tube associated with the flare triggering, is found to be failed in eruption. The location of the flare is found to coincide with the activation site of the helical twisted structures. In conclusions, the activation of successive helical twists in the magnetic flux tubes/ropes plays a crucial role in the energy build-up process and triggering of M-class solar flare without a CME. [**P. Kumar, A. K. Srivastava**, B. Filippov and **W. Uddin**].

Observations from Hinode/EIS of intensity oscillations above a bright point: signature of the leakage of acoustic oscillations in the inner corona:

The intensity oscillations have been studied in the upper chromosphere/transition region (TR) and corona, above a bright point (BP) in the solar atmosphere. The analyses of the time series of HeII 256 Å, FeXII 195 Å and FeXV 284 Å, observed in a 40-arcsec slot close to the centre of the Sun above the BP by the extreme ultraviolet (EUV) imaging spectrometer (EIS) on board Hinode, have been carried out. Using standard wavelet and periodogram tools, the power spectra of intensity oscillations have been

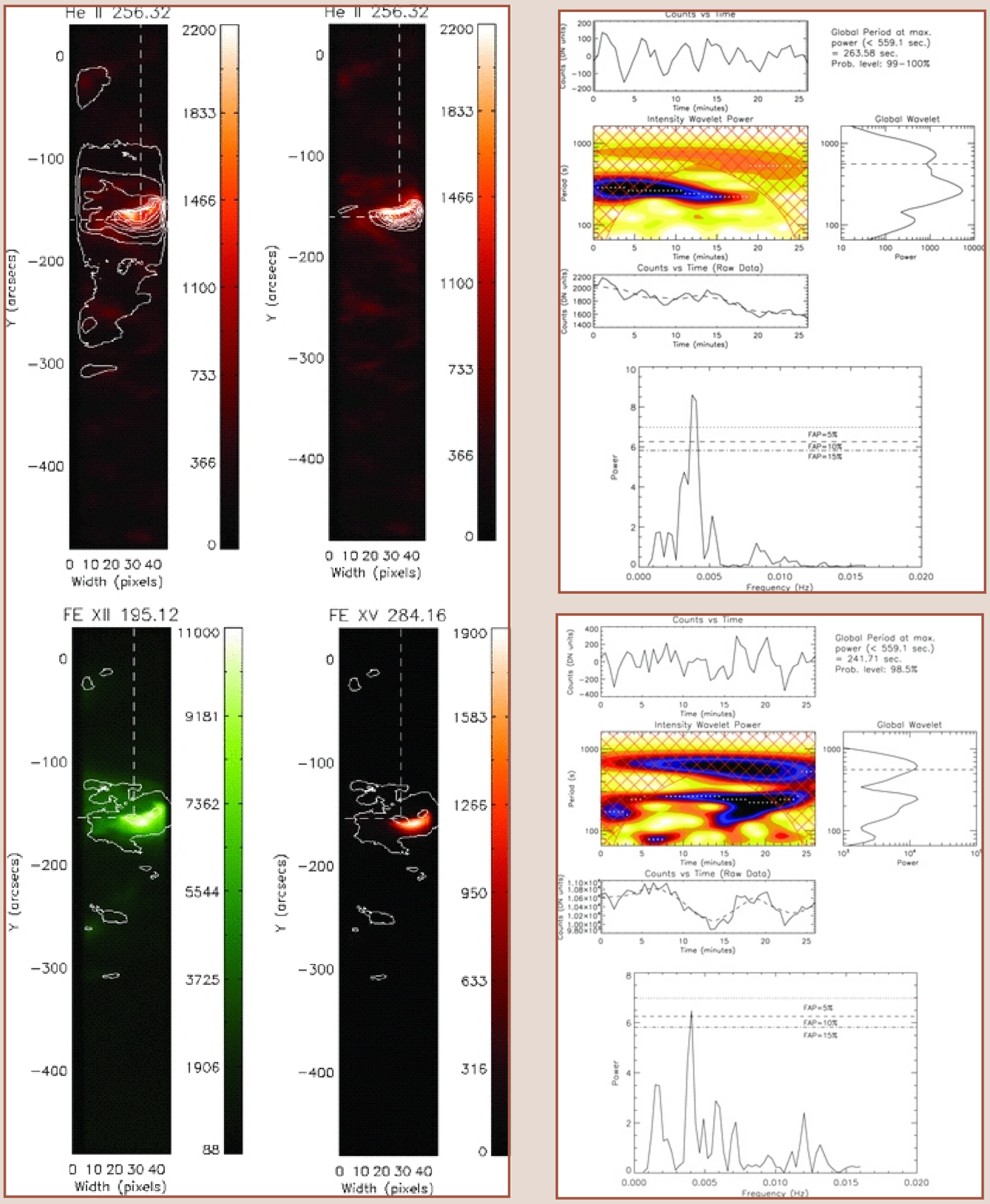

Figure 12. The left most image show the co-aligned view of small-scale bright point as observed by 40"-SLOT of Hinode/EIS at different EUV wavelengths. The right-top panel shows the wavelet and periodogram results of He II 256.32 light curve which estimate the periodicity of ~263 s . The right-bottom panel shows the wavelet and periodogram results of Fe XII 195.12 light curve which estimate the periodicity of ~241 s with the signature of slight amplification. This is the most likely signature of the propagation of damped acoustic waves in the lower solar atmosphere (formation region of He II), which probably resonantly amplified by the transversal waves of double period in the region where plasma beta tends to unity and then exhibit the signature of amplification in the inner corona (formation region of Fe XII).

produced. In the HeII 256.32 Å and FeXII 195.12 Å EUV light curves, the intensity oscillations of the periods ~ 263 s and ~ 241 s have been estimated respectively, with a probability >95% in wavelets, which are also consistent with their periodograms. This provides the most likely signature of the propagation of acoustic oscillations around the ~5.0 min period from the photosphere to the inner corona. The radiative cooling and thus the finite radiative relaxation time are found to be the most likely mechanisms for the reduced cut-off frequency environment above the observed BP. This may allow the transfer of ~5.0 min acoustic oscillations from the upper chromosphere/TR into the corona. The intensity oscillations in HeII 256.32 Å show temporal damping during the total span of the observation, which may be the first most likely observational signature of acoustic wave damping in the upper chromosphere caused by the radiative cooling effect. The intensity oscillations in FeXII 195.12 Å show an amplification, which may be a most likely signature of the mode-coupling and then resonant energy conversion, probably from transverse magnetohydrodynamic (MHD) waves of the double period (e.g. Alfvén waves) to the observed acoustic waves in the lower solar atmosphere where the plasma beta tends to unity. However, there is no evidence of real oscillations around the ~5.0-min period with its amplification in the higher corona where the FeXV 284.16 Å line is formed, which rules out this type of wave activity there. Almost 1.6 per cent of the solar surface is covered with small BPs, probably associated with the small-scale closed-loop system, which may be a subset of expanding flux tubes. Hence, the leakage of ~5.0-min oscillations above such BPs, which is associated with the highest powers of strong convective motions, and probably resonantly amplified by transverse MHD waves (e.g. Alfvén waves), may be significant for heating the solar atmosphere locally. [**A. K. Srivastava** and B. N. Dwivedi].

Evidence of wave harmonics in a brightened magnetic network observed from Hinode/EIS:

The intensity oscillations in the upper chromosphere/TR have been studied to search acoustic wave harmonics in a low-atmospheric solar cavity associated with a brightened magnetic network near the south pole of the Sun. By using wavelet tool, the power spectra of He II 256.32 Å intensity oscillation as observed by EUV Imaging Spectrometer (EIS) onboard Hinode spacecraft, have been produced. A periodicity of ~14.33 min with a probability of 99%–100% has been detected. Using wavelet filtering and reconstruction techniques, the other statistically significant periodicities of ~8.51 min and ~5.51 min with the probabilities 98% and 97% respectively, have also been detected above the brightened magnetic network. These observed periodicities provide the first possible signature of acoustic wave harmonics in a low-atmospheric cavity-canopy system. The ratio of the period of first harmonic (P_1 = 14.33 min) to the period of second harmonic (P_2 = 8.51 min) is 1.68. The difference of this period ratio from 2.0 may be the first signature of a density stratification in low-atmospheric solar cavities, complementing such period ratio differences of acoustic wave harmonics have been reported previously

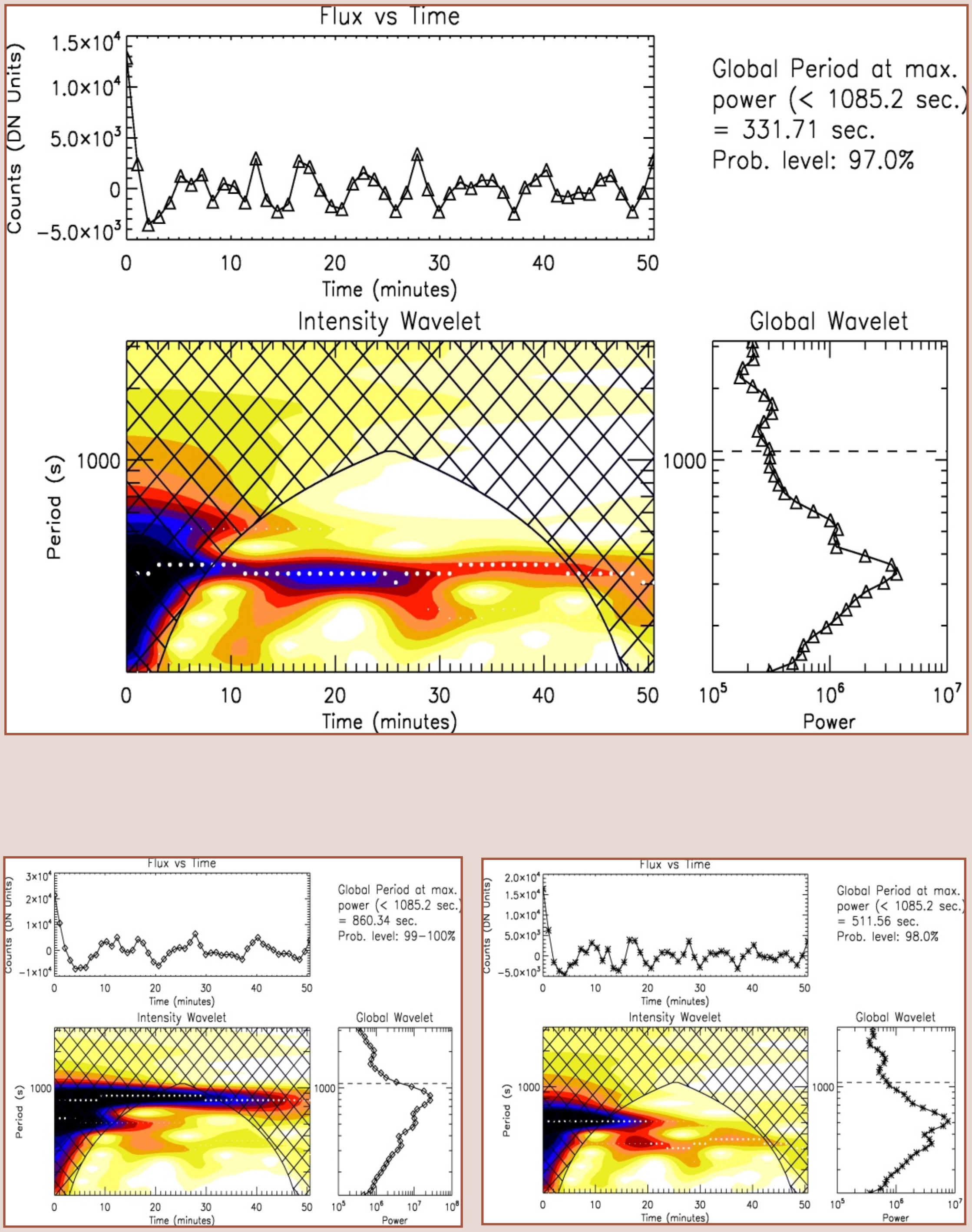

Figure 13. The wavelet results for He II 256.32 light curve extracted from the brightened magnetic network near the south pole of the Sun on 11th march 2007 : The first (top-left), second (top-right), and third (bottom) harmonics of cavity acoustic oscillations are shown in this figure.

in the solar loops as a diagnostic of their density stratification. The seismologically estimated density scale height is found as ~0.57 Mm in the cavity–canopy loop interface. This scale height is low compared to the hydrostatic scale heights estimated at wide range of temperatures that correspond to the considerable formation of He II ion in the lower solar atmosphere. The departure of density scale height estimated by the principle of MHD seismology from the values of hydrostatic scale heights estimated at wide temperature range ($4.2 < \text{Log } T_e < 5.2$), probably indicates non-hydrostatic conditions above the cavity–canopy interface. [**A. K. Srivastava**].

How can a negative magnetic helicity active region generate a positive helicity magnetic cloud?:

The geoeffective magnetic cloud of 20 November 2003 was associated with the 18 November 2003 solar active events in previous studies. In some of these studies, it was estimated that the magnetic helicity carried by the magnetic cloud had a positive sign, as did its solar source, active region (AR) NOAA 10501. It has been found in the present work that the large-scale magnetic field of AR 10501 has a negative helicity sign !. Since coronal mass ejections (CMEs) are one of the means by which the Sun ejects magnetic helicity excess into interplanetary space, the signs of magnetic helicity in the active regions and magnetic clouds must be in the agreement. Therefore, the present finding contradicts what is expected from magnetic helicity conservation. However, using the correct helicity density maps for the first time to determine the spatial distribution of magnetic helicity injections, it has been shown that the existence of a localized flux of positive helicity is presented in the southern part of AR 10501. In conclusions, the positive helicity was ejected from this portion of the AR leading to the observed positive helicity magnetic clouds. [R. Chandra, E. Pariat, B. Schmieder, C. H. Mandrini and **W. Uddin**].

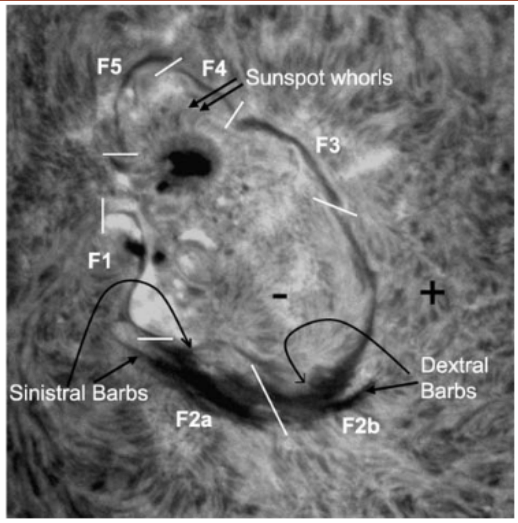

Figure 14. Hα image from ARIES, Nainital, India of AR 10501 on 18 November 2003, at 03:19 UT, before the flares and eruptions of filament material . The observations have been carried out by 6 inch Solar Tower Telescope. The + and − signs indicate the positive and negative polarity regions respectively. The white bars indicate the ends of the different segments of the large-scale circular filament

Evolution of solar magnetic field and associated multiwavelength phenomena: Flare events on 2003 November 20:

The multiwavelength analyses of Hα images, soft X-ray profiles, magnetograms, extreme ultra-violet images and, radio observations have been carried out for two homologous flare events (M1.4/1N and M9.6/2B) on 2003 November 20 in the active region NOAA 10501. The properties of reconnection between twisted filament systems, energy release, and associated launch of coronal mass ejections have been studied. During both events twisted filaments observed in Hα approached each other and initiated the flare processes. However, the second event showed the formation of cusp as the filaments interacted. The rotation of

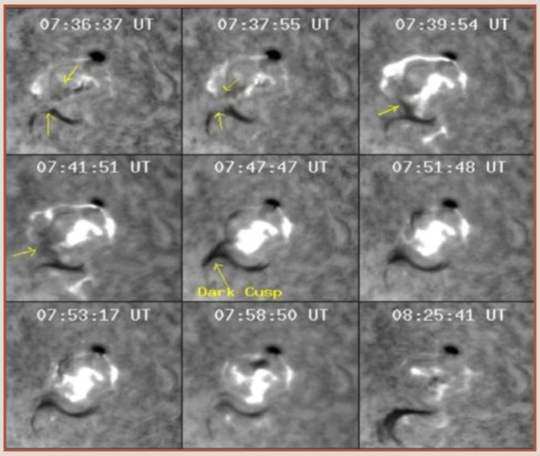

Figure 15. H-alpha temporal image data as observed by 15-cm Solar Tower Telescope at ARIES, Nainital. The images reveal the interaction of two filaments and the formation of the cusp during the M-class flare.

sunspots of opposite polarities, inferred from the magnetograms most likely powered the twisted filaments and injection of helicity. Along the current sheet between these two opposite polarity sunspots, the shear was maximum, which could have caused the twist in the filament. At the time of interaction between filaments, the reconnection took place and flare emission in thermal and nonthermal energy ranges attained its maximum. The radio signatures revealed the opening of field lines resulting from the reconnection. The Hα images and radio data provide the inflow speed leading to reconnection and the scale size of the particle acceleration region. The first event produced a narrow and slow CME, whereas the later one was associated with a fast full halo CME. The halo CME signatures observed between the Sun and Earth using white-light and scintillation images and in situ measurements indicated the magnetic energy utilized in the expansion and propagation. The magnetic cloud signature at the Earth confirmed the flux rope ejected at the time of filament interaction and reconnection. [**P. Kumar**, P. K. Manoharan and **W. Uddin**].

Aerosols characterization study:

To investigate the optical, physical and chemical characteristics of aerosols and trace gases the collocated measurements are carried out on routine basis at Manora Peak (29.4° N; 79.5° E; 1950 m AMSL), Nainital, in the central Himalayas. This site is located geographically in free troposphere and is reasonably sparse from the point of view of major pollution; therefore aerosol and trace gases measurements from such, remote and sparsely inhabited regions have the importance of providing a sort of background level of aerosol parameters against which the impact of aerosol loading can be assessed against other low altitude sites. In this perspective their measurements are carried out in a coordinated manner under ARFI, ABLN&C and AT-CTM as a part of ISRO-GBP, in addition to other routine observations. The observations are mainly comprised of spectral AOD, BC mass concentration, number concentration (0.3 to 20 µm), mass loading (TSP) of composite aerosols, measurements of trace gases and meteorological parameters. The BC mass concentration and number concentration of composite aerosols show almost similar trend in their diurnal variation, indicating low values in the morning hours which gradually increases as the day advances reaching to its summit in late evening and thereafter it again decreases to its minimum level during night hours. The observed trend can be explained on the basis updraft of the polluted emissions from the underlying valley regions to the observing site due to boundary layer dynamics.

Analysis of continuously measured BC mass concentrations during an Integrated Campaign for Aerosols, gases and Radiation Budget (ICARB) from a network of eight fixed stations spread over geographically distinct environments of India, showed large variations across the country, with values ranging from 27 µg m-3 over industrial/urban locations to as low as 0.065 µg m-3 over the Arabian Sea. For all mainland stations, it remained high compared to highland as well as island stations. The highland station Manora Peak Nainital , showed low values of BC, comparable or even lower than that of the island station Port Balir, indicating the prevalence of cleaner environment over there. Diurnal variation of BC over all the mainland stations revealed an afternoon low and a nighttime high. While highland station showed an opposite trend with an afternoon high and a late night or early morning low. [S. N. Begum,… et al. (12 authors including **U. C. Dumka** and **P. Pant**)].

Trace Species over the Central Himalayas:

For the first time, multi years (October 2006 and December 2008) observations of surface ozone are reported from ARIES, Nainital. Diurnal variations in ozone do not show the daytime photochemical build-up typical of urban or rural sites. The seasonal variation shows a distinct ozone maximum in late spring (May; 67.2 ± 14.2 ppbv) with values sometimes exceeding 100 ppbv and a minimum in the summer/monsoon season (August; 24.9 ± 8.4 ppbv). Springtime ozone values in the central Himalayas are significantly higher than those at another high altitude site (Mt Abu) in the western part of India (Figure 16). Seasonal variations in ozone and the processes responsible for the springtime peak are studied using meteorological parameters, insolation, spatial and temporal classifications of air mass trajectories, fire counts, and simulations with a chemical transport model. Net ozone

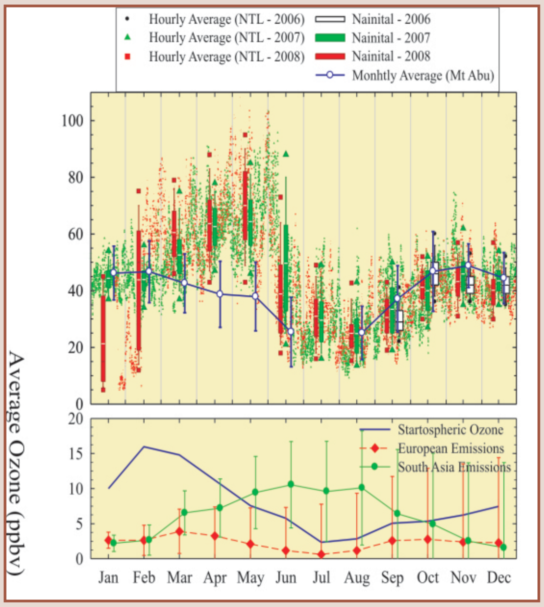

Figure 16. Variations in ozone mixing ratios from October 2006 to December 2008 at Nainital. In box plots, the solid white and black lines inside the box represent the mean and median of the data respectively. The lower and upper edges of box represent the 25th and 75th percentile. The whiskers below and above are 10th and 90th percentile and the outliers in the box plot show 5th and 95th percentile in 15 minutes average ozone data. Monthly average ozone values (1993-2000) at another high altitude site in western India, Mt Abu are also shown for a comparison. Lower panel shows model (FRSGC/UCI CTM) derived contributions of stratospheric ozone, European emissions and South Asia emissions.

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. Annual average ozone values in regionally polluted air masses (47.1 ± 16.7 ppbv) and high insolation days (46.8 ± 17.3 ppbv) are similar. Background ozone levels are estimated to be 30-35 ppbv. Regional pollution is shown to have maximum contribution (16.5 ppbv) to ozone levels during May-June and it is about 7 ppbv on annual basis while contribution of long-range transport is greatest during January-March (8-11 ppbv). The modeled stratospheric ozone contribution is 2-16 ppbv. Both the trajectory analysis and the model suggest that the stratospheric contribution is 4-6 ppbv greater than the contribution from regional pollution. Differences in the seasonal variation of ozone over high altitude sites in the central Himalayas (Nainital) and western India (Mt. Abu) suggest diverse regional emission sources in India and highlight the large spatial and temporal variability in ozone over the Indian region [**M. Naja**, **R. Kumar**, **N. Ojha**, **T. Sarangi**, S. Lal, S. Vemkataramani and O. Wild].

Studies using wind profiler:

UHF wind profiler observations from the tropical station Pune (18.31°N, 73.58°E) has been utilized in estimating the turbulence parameters and a comparison of C_n^2 observed with the wind profiler and that estimated using Radio Sonde/Radio Wind (RS/RW) data of nearby Met station Chikalthana has been made for the month of July 2003. This study is specifically focused on the seasonal, annual and inter-annual variations of the refractive index structure parameter (C_n^2) using three years of radar observations. Energy dissipation rates (ε) during different seasons for a particular year are also computed over the station under study. Doppler spectral width measurements made by the Wind Profiler, under various atmospheric conditions, are utilized to estimate the turbulence parameters. The refractive index structure parameter varies from $10^{-17.5}$ to 10^{-13} $m^{-2/3}$ under clear air to precipitation conditions in the height region of 1.05 to 10.35 km. During

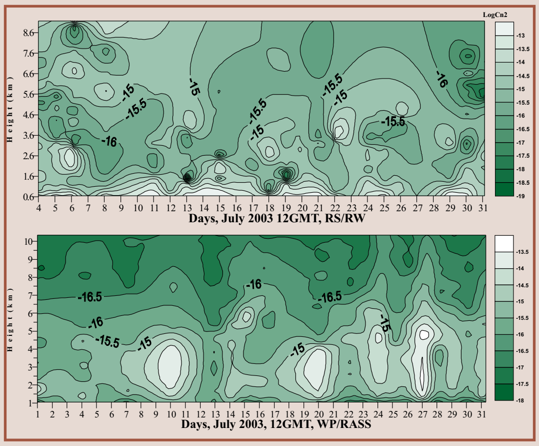

Figure 17. Height profile of C_n^2 as calculated from RS/RW (upper panel) and wind profiler Observations (lower panel). The radiosonde observations start at few meters (0.6 km) above the ground and wind profiler observations at 1.05 km onwards, the contours above 1 km are to be taken for comparison.

the monsoon months, observed C_n^2 values are up to 1-2 orders of magnitude higher than those during pre-monsoon and post-monsoon seasons. Spectral width correction for various non-turbulent spectral broadenings such as beam broadening and shear broadening are made in the observed spectral width for reliable estimation of ε under non-precipitating conditions. It is found that in the lower tropospheric height region, values of ε are in the range of 10^{-6} to 10^{-3} $m^2 s^{-3}$, and in the summer and monsoon seasons the observed values of ε are larger than those in post-monsoon and winter seasons [**N. Singh**, R. R. Joshi, H.-Y. Chun, G. B. Pant, S. H. Damle and R. D. Vashishtha].

Lower and middle atmosphere:

First ground-based mesospheric temperature measurements from a central Himalayan station of India, Nainital (29.4°N and 79.5°E), have been carried out during January 2007 with the help of OH and O2 airglow monitoring during night-time using the mesospheric lower thermosphere photometer (MLTP) designed and fabricated at ARIES, Nainital. The derived temperature

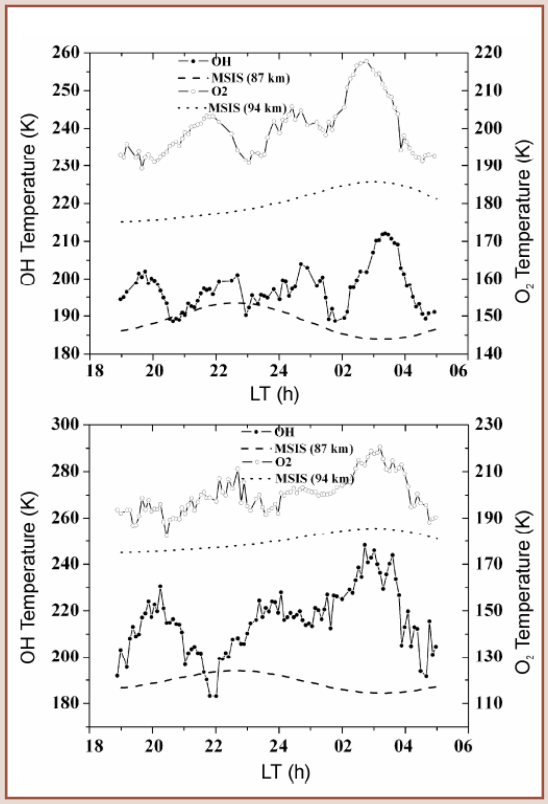

Figure 18. Nocturnal temperature variation for OH (6–2) and O2 (0–1) data over Nainital. The upper panel shows the temperature variability for 15 January, whereas the lower panel represents the temperature for 16 January 2007. The symbol and solid connecting lines are the observed values, whereas dashed lines are the MSIS-00 model estimates.

exhibits large amplitudes of ~3–6 h waves with a longer period nocturnal tide-like feature with periodicity ~8–10 h. The observed temperatures are in agreement with the SABER derived temperatures, onboard the TIMED satellite. The deduced vertical

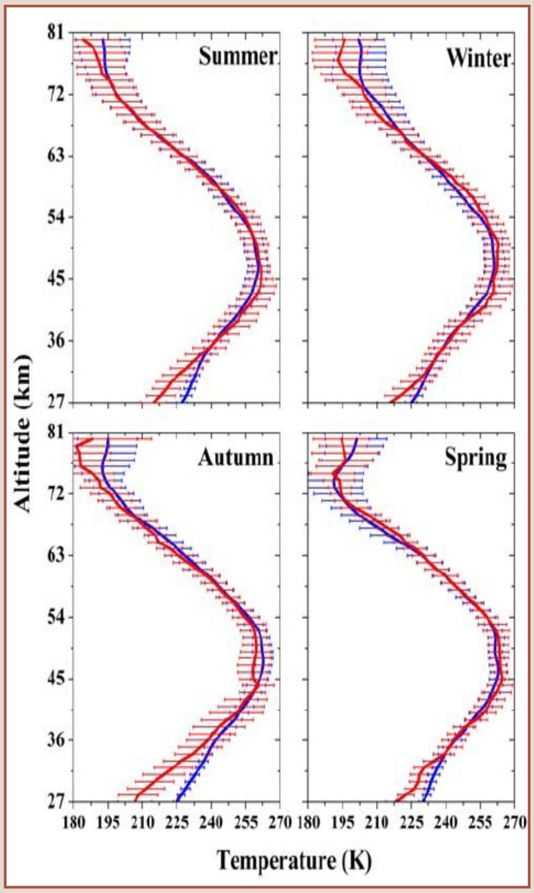

Figure 19. Seasonal average temperature profiles of summer, winter, autumn and spring with standard deviation of lidar (red) and SABER (blue).

wavelengths are found to be ~29.6 ± 11.1 km and 43 ± 21.5 km for O2 and OH respectively, indicating the observed waves to be upward propagating. [**A. Guharay,** A. Taori, S. Bhattacharjee, **P. Pant,** B. Pande and K. Pandey].

Seasonal variability of the middle atmospheric thermal structure has been carried out by comparing ground based lidar and space based TIMES/SABER data from a low latitude station Gadanki (13.5 °N, 79.2 °E) and compared with existing CIRA-86 model. Observed results match nicely among themselves throughout the year, however differ to modeled one. Stratopause temperature shows semiannual oscillation (SAO) in seasonal pattern of variation. [**A. Guharay**, D. Nath, **P. Pant,** B. Pande, J. M. Russell III and K. Pandey].

Analysis of extensively measured middle atmospheric temperature (more than 10 years, 1998–2008) with the help of lidar data and TIMED/SABER data of 7 years (2002– 2008) at low latitude station, Gadanki, India , exhibits the presence of semiannual oscillation (SAO) and annual oscillation (AnO). The AnO component is stronger in the mesospheric region (80–90 km) and the SAO is dominant at stratospheric altitudes (30–50 km). Overall, the AnO possesses higher amplitude ~ 6–7 K, and the SAO shows less amplitude ~1– 2 K. [**A. Guharay**, D. Nath, **P. Pant,** B. Pande, J. M. Russell III and K. Pandey].

Study of Tweeks using VLF signal:

Three new AWESOME (Atmospheric Weather Electromagnetic System for Observation Modeling and Education), VLF receiver were setup in India at Allahabad (16.49°N), Nainital (20.48°N) and Varanasi (15.41°N), during 2007 under IHY/UNBSSI program for sensitive reception of broadband ELF (30–3000 Hz) and VLF (3–30 kHz) radio signals from natural and manmade sources. A total number of 1052 Tweeks recorded during the night of 13 June 2007 at Allahabad and Nainital have been analyzed to understand the night time behavior of lower D region (<90km). The ionospheric reflection heights for tweeks and electron density at these heights for fundamental mode (n=1) have been estimated. The ionospheric reflection height of tweeks at Allahabad and Nainital was found to vary between ~ 60 to 85 km. Electron densities lie between 25 and 35 el /cm^3 (Singh et al. 2010). The estimated equivalent electron density of the D-region has been found to be in the range of ~20 to 25 el/cm^3 at ionospheric reflection height of ~80 to 95 km for the Tweeks recorded at a Allahabad during the night of 23 March 2007. Propagation distance in Earth-Ionosphere wave guide (EIWG) from causative lightning source to experimental site varies from ~1500 to 8000 km. [A. K. Maurya, R. Singh, B. Veenadhari, **P. Pant** and A. K. Singh].

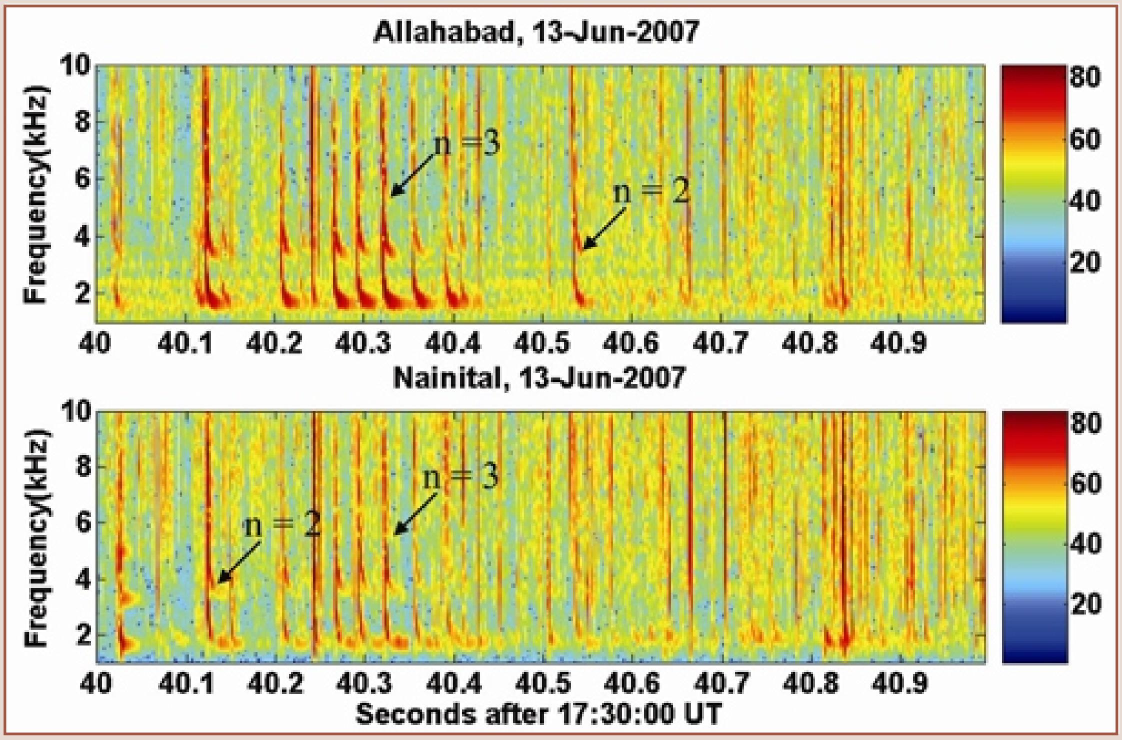

Figure 20. Examples of dynamic spectrograms of tweeks observed simultaneously at Allahabad and Nainital sites on 13 June 2007.

RESEARCH COLLABORATIONS

The following activities are going on in collaboration with various institutions and ARIES:

- Wide field photometry is being pursued around star forming regions and open clusters using the 1.05-m Kiso Schmidt and 1.04-m ARIES telescope in collaboration with Prof. K. Ogura, Tokyo, Japan under Indo-Japan cooperative science program (DST, India and JSPS, Japan) to study the mass function of low mass stars in the coronal regions of clusters.

- Multi-wavelength studies of star forming regions to study the global view of star formation in these regions, in collaboration with Prof. K. Ogura (Japan), Prof. W. P. Chen (Taiwan), Prof. S. K. Ghosh, Dr. D. K. Ojha (TIFR, Mumbai) are being carried out. Deep photometry of small clusters in HII regions with special focus on bright-rimmed clouds (BRCs) in order to examine "small-scale sequential star formation hypothesis" is also being carried out. Quantitative age gradients are found in almost all the BRSs. The global distribution of young stellar objects clearly shows evidence that a series of radiation driven implosion processes proceeded from near the ionization source to the peripheries of H_{II} region.

- To search and study the pulsational variability in chemically peculiar stars, a program in collaboration with D. L. Mary of Labratoire Universitaire d'Astrophysique de Nice, France, Dr. O. Kochukhoz of Department of Physics and Astronomy, Uppsala University, Sweden, Dr. T. Ryabchikova, M. Sachkov of Institute of Astronomy, Russian Academy of Science (INASAN), Russia and N. K. Chakradhari of School of Studies in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur, India is being carried out.

- Solar Physics group of ARIES is actively participating in the INDO-FRENCH Project on "Transient Phenomena in the Sun-Earth System" (Prof. P. Venkatkrishnan, USO, Udaipur is the PI from India, and Prof. G. Molodij, Observatory de Paris, Meudon is a PI from French side). Under this project, active collaboration is being pursued with Dr. Nandita Srivastava, Dr. Ashok Ambastha, Dr. S.K. Mathew, Dr. Sanjay Gosain (USO, Udaipur), Prof. P.K. Manoharan (RAC, Ooty). Collaborative project with Prof. Debi Prasad Choudhary, California State University, Northridge, USA on some major solar flares observed at ARIES in October-November 2003 to study energy build-up and energy release mechanisms is being carried out. The group is also a part of the (a) CAWSES India Project on " Space Weather aspects of Active Region Vector Magnetic Fields", (b) X-ray Spectrometer (SOXS) project with Prof. Rajmal Jain (PRL, Ahmedabad) and Prof. A.R. Rao (TIFR, Mumbai), (c) "Indian Space Coronagraph Project", (d) "National Large Solar Telescope (NLST)" project of 2 meter class. The group is working in an Indo-Russian project on "Multiwavelength Observations and Modeling of Transient Events and Waves in the Solar Atmosphere" with B. P. Fillipov and his team from IZMIRAN, Russia, and is also collaborating with the solar scientists at Armagh Observatory, U.K.; Georgian National Astronomical Observatory, Georgia; Space Research Institute, Austria; Sheffield and Warwick Universities, U.K. The solar-physics group of ARIES also collaborates with Dr. Syed Salman Ali, Aligarh Muslim University (AMU), Prof. Abdul Qaiyum

RESEARCH COLLABORATIONS

(AMU), and Prof. B.N. Dwivedi, (I.T. BHU).

- Observations of trace gases and aerosols are being continued in collaboration with SPL, Trivandrum and PRL, Ahmedabad. Physical parameters of aerosols are being measured at ARIES using AERONET Cimel-photometer in collaboration with NASA. Collaborative work with Dr. Yogesh Kant, IIRS and Dr. K. P. Singh, G. B. Pant University of Agriculture and Technology, Pant Nagar is being continued for ozone and aerosols studies at Dehradun and Pant Nagar, respectively. Recently, research collaboration on modeling studies for tropospheric studies has been started with a group at the National Center for Atmospheric Research (NCAR), Boulder, USA. Collaborative works with NIES, Tsukuba, Japan for greenhouse gas and VLF whistler studies in collaboration with IIG Mumbai are being continued.

1. Observing Facilities

1.1. Stellar Observing Facilities

The optical 104-cm Sampurnanand Telescope (ST) is being used as a main observing facility by the students and faculty members of ARIES since 1972. The Wright 2K X 2K CCD, ARIES imaging polarimeter (AIMPOL) and 3-Channel fast photometer continued to be the main instruments with ST.

Figure 21. The optical 104-cm Sampurnanand Telescope at ARIES.

The preventive maintenance and telescope tests were continued by the astronomers and engineering staff regularly, which included image quality tests,, checks of the mechanical system. The major problem encountered during the last year was with the telescope secondary mirror movement. The problem was rectified by cleaning of the secondary drive assembly.

ARIES time allocation committee (ATAC) alloted about 60% time for CCD imaging, about 20% time for each imaging polarimetry and differential photometry using fast photometer. Out of about 273 alloted nights, we got nearly 200 clear nights (150 photometric and 50 spectroscopic). Twelve papers were published in referred Journal based on the bases of data taken from ST.

The major scientific programs being carried out with this observing facility includes study of star-clusters, young star-forming region, HII region, optical variability in roAp stars, AGN and brown dwarfs, optical counterpart of Gamma-ray-brusts(GRB), supernovae and X-ray sources, Wolf-Rayet Galaxies, Giant Radio Galaxies, polarimetric study of star-forming regions and late type stars.

1.2. Solar Observing Facilities

The main solar observing facility is 15-cm Coudé Solar Tower Telescope equipped with Bernhard Halle Hα filter, and ProEM 1024B (1KX1K, 13 μ^2, 16 bit A/D and 10 MHz read out rate) frame transfer fast imaging EMCCD cameras manufactured by Princeton Instruments Inc., USA. It is an automatic Hα flare patrolling system, which takes fast sequence of images in the flare mode observation. The main objective of the group is to observe the solar eruptive events (e.g., solar flares, filaments and prominences, surges etc.) in the chromosphere of the Sun. The CaII K 3933 Å, G-band 4305 Å observation are also being carried out to

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

Figure 22. 15-cm Coude Solar Tower Telescope for solar observations.

1.3. Atmospheric Observing Facilities

Research in atmospheric science was initiated at ARIES, Nainital during January 2002 when a Multi-Wavelength solar Radiometer (MWR) was installed under Indian Space Research Organization – Geosphere Biosphere Program (ISRO-GBP). Soon after that various instruments like microtops, GRIMM, Aethalometer, HVS and BLL were installed. Further, ARIES has acquired a batter of different analyzers Environmental Observatory Project (Figure 23). Air samples are also being continued at ARIES to analyse other trace gases (e.g. CO, CH_4, SF_6, N_2O, NMHCs). Besides above, the observing facilities for the studies of VLF whistlers and AOD / flux measurements have also been acquired at ARIES in the form of VLF receiver and AERONET.

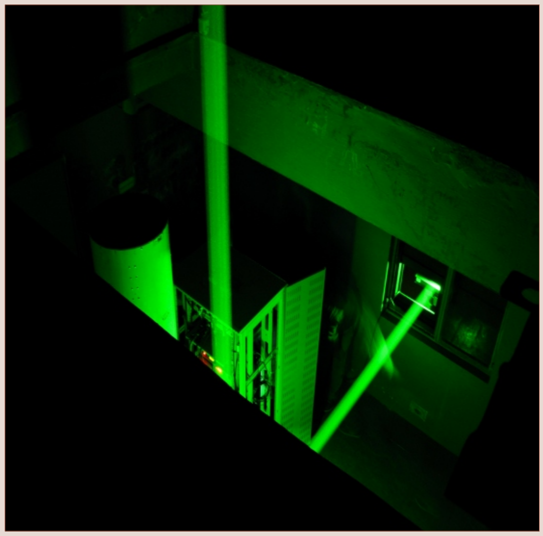

Figure 23. Mie LIDAR observations carried out at ARIES, Nainital.

2. Support Facilities

ARIES has an aluminizing unit, a computer section, a civil works section, an electronics lab, a mechanical workshop, an optics laboratory, and a well equipped library as support facilities for the academic, research and developmental activities of the Institute. They are briefly described below:

2.1. Aluminizing Unit

Four mirrors from All Sky Camera units were re - aluminised and assembled back. The mechanical telescope parts of the Schmidt telescope from M/S Avasarala,

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Bangalore got stored and got tested in aluminising lab. Vixen and Celestron telescopes got stotred, tested and used variously by different projects during the year, making good use of the location and approachability of aluminising lab during days and nights. The 5 ton capacity manual chain pulley system was provided to several locations for different jobs, now the same is under repair at mechanical workshop premises. Routine evacuation of CCD dewars continued with the available Turbomolecular pump. The engineering assistants and supporting staff in aluminising and optics lab have been working in close collaboration, as usual, assisting also the development and planning for the new coating plant at Devasthal and jobs related to LIDAR projects.

2.2. Computer Centre

ARIES website has been modified with a new look & feel. 1 Mbps DAMA internet connection has been discontinued. In stead of DAMA, 10 Mbps Reliance leased line has been finalised at around 60 % of the cost. JEST 2010 has been successfully hosted with the help of third party service provider. CYBEROAM Firewall-cum-Bandwidth Manager has been installed with following features:

- Secure internal LAN.
- Gateway levelAntivirus /Antispam protection
- Bandwidth management among different users.
- Gateway level fault tolerance/ load balancing

LAN connectivity has been extended to newly constructed Electronics Building, Science Center, Workshop & Hostel.

Aswini Guest House has been fully wireless enabled. High end workstations have been procured for Schimidt Project & Mechanical Workshop.

2.3. Library

The mark of a progressive institution is judged by the strength of its library. Ever since the inception of the Observatory in 1954, its library has been steadily building up through the years. The library continued with its basic activities of information resources development by collecting, processing, organizing, storage and retrieval of information; maintaining liaison with other related institute libraries for resource sharing and for exchange of information; providing need based current awareness, reference and bibliographic services; and facilitating on-line access to wide range of information resources in print and electronic versions. The number of Institutions, both from the country and abroad, on exchange list is about 100. The library acquires books and journals mainly related to Astronomy & Astrophysics and Atmospheric Sciences. The library also acquires reference books from time to time.

Library Resource Development

During the period 2009 - 2010, the following information resources were added:-

Book	:127
Bound Volumes of Journals	:100
Subscription of Journals (Print+Online)	:96
ARIES Publications	:33

ARIES Theses :4

The collection at the end of the period is

Books :Around 10,047

Bound Volumes of Journals: Over 10, 500

Apart from books and journals, non-book materials such as slides, charts, maps, diskettes, CD-ROMs, etc. are also available in the library.

Modernization

During 2009 – 10, the LIBSYS software of the library was upgraded. The new features of Online Catalogue are available at Web-OPAC on ARIES home page as well as ARIES Intranet. **DSpace** open source software has been installed successfully for digital repository of ARIES and available at ARIES library home page. The subscribed e-journals, online journals / databases through National Knowledge Resource Consortium, ARIES academic reports and updated list of Publications are also available at ARIES library home page.

Consortia

The ARIES library is a member of FORSA (Forum for Resource Sharing in Astronomy and Astrophysics), which has been established by Indian Astronomy Librarians in 1979. Online subscription of Springer journals and Nature are continued under FORSA Consortium. IOP Journals (print & online) are subscribed under FORSA Consortium. Library and Information Services in Astronomy (LISA – VI) International Conference has been organized by FORSA and first time held at India during February 14 – 17, 2010.

The ARIES Library is also a member of CSIR – DST E-Journals Consortium. Second meeting of DST Librarians/Information Officers on CSIR-DST e-Journals Consortium was organized at ARIES during May 15 – 16, 2009. E-Journals of ***American Institute of Physics, Annual Reviews, Emerald, IEEE, Indian Journals.com, IOP Science, J-Gate, Nature, Nature Photonics, Nature Physics, Optical Society of America, Science, Springer, Taylor & Francis and ISI Web of Knowledge, etc.*** are available through CSIR-DST e-Journals Consortium. The name of CSIR-DST e-Journals Consortium now has been changed as National Knowledge Resource Consortium.

2.4. Civil Works Section

The civil work section looks after the supervision of new upcoming buildings; the routine maintenance, and modifications/renovation of the ARIES office and residence buildings and roads. During 2009 - 10, some of the works done by the section at Manora Peak and Devasthal are:

At Manora Peak

- **Hostel Building:** All the three blocks i.e. PDF block (15 rooms) and dormitory (15 rooms) including Kitchen/Dinning Block have been completed and are occupied.
- **Science Centre** is ready and imparts visitors better understanding of Astronomical and Astrophysics aspects/features. Installation of a 6" telescope is in progress.

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- **Electronics Lab/Lecture Theatre** is a double storey building which houses Electronics lab at first floor and an auditorium at ground floor with seating capacity of about 60 people. The building is ready and has been occupied.
- **Workshop Buildings** comprises of 3 separate blocks i.e. **Mechanical Workshop, Welding Workshop and Carpentry Workshop.** All the three blocks are functional.
- **Schmidt Building is** an Astronomical octagonal double storey building housing the rotating dome for 80 cm Schmidt Telescope. Building is complete and telescope installation is in progress.
- **Site development work for residences** has been completed and the construction work of staff residences is in progress.
- **Driver's Rest Room** is ready.
- Construction of ST Radar building is in progress.
- **Old guest houses has been renovated** into 4 residential units.

At Devasthal

- **Upcoming Scientist Rest Room** : It is a modern guest house with state of art construction housing all modern facilities/ infrastructures. It has five rooms with attached toilets. It has dinning area with a capacity of about 15 persons. Structure is complete and finishing is in progress.
- **Construction of water tanks installation of pump :** laying of pipe line including installation of submersible pump has been completed. Water is now available at the sites 1.3-m and 3.6-m telescopes.

2.5. Electronics Workshop

Electronics and Electrical section caters to the overall electronics and electrical aspects related to instrumentation and infrastructure. In this section a group of engineers and engineering assistants are actively involved in design, development, up gradation and maintenance activities. This section comprises of different electronics labs and related facilities to aid to the above activities. Since electronics has become a vital part in advanced instruments this section plays an important role in all the new projects and installation of new instruments.

This section is responsible for installation and maintenance of facilities vital for effective functioning of the organization like strong communication setup, electric substation, centralized UPS and other useful appliances.

During the year 2009 - 2010 the section was involved in the following activities:

1. Developmental and project work: Section is actively involved in developmental work of different projects.

a. In 3.6-m telescope back end instruments cables to integrate in the cable wrap has been procured and supplied to the M/s AMOS, Belgium. Soil resistivity check around the sites of 3.6 m, 1.3m telescopes, solar survey site and Substation site at Devasthal has been carried out. It will be required for earthing of various high end

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instruments of different facilities. Actively participated in the preparing the tender document for electrical work of the enclosure building.

b. Schmidt Telescope: Installation of electrical control panel for dome and slit of Schmidt telescope has been carried out and successfully completed. Installation of telescope control system has been started. Design and development of servo control mechanism for drive systems has been completed. Design and development of microcontroller based focus drive system and other interface card also has been completed. Factory acceptance test (FAT) of the telescope was carried out and cleared for further action.

c. 1.3-m Telescope: Electrical control mechanism for roll off roof of 1.3 m telescope has been installed successfully. Few necessary test and Measuring instruments were procured for new electronics laboratory of 1.3 -m telescope.

d. LIDAR: Detector and Data Acquisition (DDA) system is finally assembled with the Mie telescope and successful observation has been taken. Four sets of MCS-pci card +pulse discriminator were procured and tested. These four sets will be used four channels DDA of the LIDAR system. Procurement process for one set of the PMT, Laser power meter has been initiated and initial tender enquiry is completed.

e. ST Radar: Actively participated in the developmental and measurement process of the different sub modules like antenna, TRM and DSP. Few high ends measuring instrument has been procured. Preliminary design of ST Radar sub-station & earthing has been done. Soil resistivity check was carried out for earthing of various instruments.

2. Maintenance work:

a. Regular maintenance work of electrical and electronics facilities including different observational facilities of the Institute at Manora Peak and Devasthal were carried out.

3. Training and academic work:
Section is actively involved in the short term and long term training as a part of the academic work. Nineteen B.Tech students and 16 diploma students completed their training under the guidance of the engineers of the section.

4. Infrastructure development :
The section participated actively in th upcoming infrastructure at Manora Peak and Devasthal campus.

5. Seminar / Workshop attended
MST 12 workshop at Canada was attended by the section engineers. One oral and two posters were presented. The engineers actively participated in framing the observational facility with newly acquire CCD for total solar eclipse.. Necessary software has been developed and successful observation had been taken with other team members.

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2.6. Mechanical Workshop

The Mechanical workshop was shifted to the new building near the office. Machines, tools, instruments and raw materials etc. were shifted in the new workshop at their planned locations. The leveling, alignment and grouting of the machines was accomplished successfully. Machines were made operational and necessary repairs and up - gradations in the machines were carried out.

Portable jigsaw cutting machine, portable angle cutting machine, hand drill machine, two ton chain pulleys, tirfor and screw jacks etc. were procured to expedite the works at Manora Peak and Devasthal sites.

Following major activities were accomplished by the Mechanical workshop, i.e. base-frames, platforms and roll-off-roof were designed, fabricated and made operational for carrying out the regular solar observations at Devasthal. The fabrication of the roll-off-roof at 1.3 m telescope building was completed. A pre-fabricated Igloo shaped hut procured by the solar section was assembled and made functional after mounting the solar instruments in it. Flanges and filter attachments were designed and manufactured for the solar telescope at Devasthal. Design and manufacturing of mounts and housings for the LIDAR project and templates, stands, guides and base-frames etc. for the Schmidt project were accomplished. Modification in rail track of MWR at atmospheric section was completed. Beam expander mounting was manufactured for boundary layer clamps etc. were manufactured for the electronics section. Air compressor repairing was carried out at aluminizing section. Instrument frame was designed and fabricated for atmospheric section. Working model of windmill was manufactured for electronics section. Filter attachments were designed and manufactured for 140 mm Vixen telescope used during solar eclipse of 22nd July, 2009 and in polar alignment of Schmidt telescope. Instrument box upgraded for metrology section. Adopters were manufactured for ST7 camera. The maintenance of fine motion of Dec. was carried out and in secondary mirror motion of 40″ telescope. Fabrication of distribution panels and feeder pillars etc. for the upcoming new buildings and sites was carried out. Aluminium housings were manufactured for fitting the electronic cards of the Schmidt telescope control system.

Structural fabrication work done for Schmidt telescope control panel. A jig was designed and developed for mounting motors and encoders etc. of Schmidt telescope for development and testing of closed loop controller. Maintenance of all telescopes of ARIES was carried out. Maintenance of office buildings, Devasthal site and ARIES campus houses was accomplished. Plumbing lines were laid and connected with the newly constructed workshop, optics building, main building and hostel buildings etc.

Three students completed their short term projects in the mechanical section during the period of April, 2009 to March, 2010.

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2.7. Optics Laboratory

The new building of the optics laboratory has been made functional. The procurement for the vibration-free optical tables and workstations has been initiated. The old optical components (lens, filters, gratings etc.) were cleaned and re-packed in order to preserve them. The cleaning of the B-N schmidt telescope corrector plate was completed. An optical setup to measure reflectance and transmission of optical components has been made using an Echelle spectrograph. The non-functioning ST-7E CCD camera has been made operational. An optics design lab has also been setup. This lab provides facilities for optical instrument designing using modern

Figure 24. New Optics Laboratory Building at ARIES, Nainital.

softwares. The lab also provides basic facilities for optical and radio data reduction. The regular maintenance work for 104-cm telescope was carried out. Two new telescopes namely 14" Celestron and Vixon telescopes were tested and being installed for public outreach and general optical test facilities in the institute. The alignment of the LIDAR in the atmospheric science laboratory was completed successfully. The lab also participated in the 2009 solar eclipse expedition. The testing of Proline PL16803 Camera for Schmidt Telescope Project was carried out. Aluminising work of two all sky camera mirrors (8″- 2 Nos. and 2″- 2 Nos.) and their mounting in mechanical assembly was done.

3. Upcoming Facilities

A few years ago, ARIES started several major projects with an aim to establish world-class research facilities in the area of Astronomy & Astrophysics at Devasthal and Atmospheric Sciences at Manora Peak. Following are the description about these ongoing projects.

3.1. Devasthal Site

Devasthal (latitude 29°22'26'' North; longitude 79°40'57'' East, Altitude: 2500 meter above msl) is being developed as an astronomical site. Two optical telescopes with size 1.3-meter and 3.6-meter are to be set up for observations of celestial sources at optical and near infrared wave lengths. The site is far from any urban development and is the most suitable for astronomical observations.

About 3-km long road connecting the state highway, from Jarapani junction to Devasthal site has been constructed. 150 KW hydroelectric power transmission line laid down by Uttarakhand power corporation has been energized. The water requirement has been met successfully by installing a bore well. The bore well is located at the base of Devasthal site. Further, there is a plan to recharge the water level around the bore-well by rain-water harvesting. A plan for tapping roof water is also under progress. In order to enable the transfer of electronic

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data at Devasthal site, optical fiber cables have been installed from the base camp to the proposed telescope site.

3.1.1. 3.6-m Devasthal Optical Telescope (DOT Project)

The 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 3.6 meter DOT will have a number of instruments providing high resolution spectral and imaging capabilities at visible and near-infrared bands. In addition to optical studies of a wide variety of astronomical topics, it will be used for follow-up studies of sources identified in the radio region by GMRT and UV/X-ray by ASTROSAT. Belgium is participating in the 3.6 meter DOT project at 7 percent level.

The design of enclosure and building is being done by M/s awarded to PPS, Pune. The coating plant is being designed by HHV, Bangalore. The development of infrastructure (road, power, internet, water), instruments (a Faint object spectrograph and camera, a high resolution spectrograph), observatory control and data center will be done in-house at ARIES. The project is monitored and advised periodically by a 9-member Project Management Board (PMB) chaired by Professor P.C.Agrawal. The PMB met thrice during the period. The day-to-day activities of the project related to scientific, technical and financial is executed by both a project implementation team (PIT) and project working groups (PWG). The meetings of PIT and PWG had been carried out regularly to monitor the activities. During April 2009 – March 2010, most of the scheduled project activities were carried out successfully.

In April 2009, the zerodur 3.6 meter primary mirror blank arrived at LZOS Russia for polishing and by September 2009, the gluing of all the axial and lateral pads got completed. The M1 was mounted on the technological pads in October 2009 and its asperization (grinding and polishing) is in progress. The M1 mirror is polished within 12 micrometer. The polishing of Astrositall M2 mirror was completed in March 2010 with RMS WFE of 18 nm. A single reference document containing as-designed specifications of the telescope has been prepared jointly by AMOS and ARIES. These specifications shall serve as a reference for preparing acceptance procedure of the telescope and will be replaced with the as-built specifications after commissioning of the telescope. Since March 2009, the work at AMOS workshop entered into manufacturing and integration phase, and all the major mechanical components have been manufactured. The prototype M1 actuator was tested successfully in December 2009.

A Pune based firm M/s Precision Precast Solution (PPS) Pvt., selected for design and consultancy services for the telescope enclosure and auxiliary building, made a satisfactory progress. The design of the enclosure, extension building and civil work for the 3.6 meter telescope was completed during the period and subsequently, a contract for

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civil work up to plinth level and site development was awarded to M/s Vidyawati, Allahabad in June 2009. The draft tender document for the telescope enclosure and auxiliary building had also been prepared.

In November 2009, a contract to design and establish an aluminising plant based on magnetron sputtering and having capacity to coat mirrors up to 3.7m diameter has been awarded to HHV Bangalore. The critical design review of the aluminising plant was completed in March 2010.

The ADFOSC (ARIES Devasthal Faint Object Spectrograph and Camera) will be one of the first light instruments to be mounted at the axial port of the Cassegrain focus of the 3.6 meter DOT. The instrument will cover the wavelength range 350-1000 nm and it will have two distinct mode of operation; (1) Direct broad and narrow-band imaging capabilities with spatial resolution of less than 0.2 arcsec in 10 arcmin field of view. (2) Low-to-medium resolution spectroscopy with spectral resolution (250-4000) covering the optical wavelengths 360-1000 nm. The optical and mehcanical design of ADFOSC is under progress.

The basic requirement and a preliminary plan for the observatory control system of the telescope, data archive center and dome automation has been completed. The preparation of a detailed project report is under progress.

Figure 25. The concept design of the 3.6-m Devasthal Optical Telescope.

3.1.2. 1.3-m Optical Telescope

The 130-cm telescope manufacturing has progressed at the contractor's factory. After the initial testing by the contractor, the telescope was shipped in March 2010. The 130-cm building at Devasthal has been completed. The roll-off-roof has been made operational.

Figure 26. A complete picture of 1.3-m Devasthal Optical Telescope.

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3.2. Projects at Manora Peak

At Manora campus of ARIES, a few Atmospheric Science projects are also shaping up apart from the ones in the area of Astronomy & Astrophysics. They are described below in brief.

3.2.1. High Energy Pulse LIDAR System

The optical alignment of the 380 mm Cassegrain Mie telescope of the LIDAR was carried out. The mechanical axis of the focal plane instrument mounting table was aligned with the optic axis of the telescope. A fixture for holding two lasers in perpendicular direction to the primary mirror for alignment was designed and manufactured in-house. The focus in the vertical position of the telescope was ascertained during day time. The telescope was further aligned during night by focusing the stars in the field of view. The LASER beam was steered precisely by the laser transmitting mirror with fine X, Y, Z and tilt motion to align it with the optic axis of the telescope. In addition, the mountings for the detection optics and electronics were designed and manufactured in-house. The detection optics was mounted and aligned in the mountings at the appropriate distance from the focal plane of the telescope. PMT was mounted after the detection optics. Mobile Test and measuring instruments rack were framed to facilitate LIDAR observations. The settings of the detector (PMT) and data acquisition system (discriminator and MCS-PCI card) were optimized to achieve optimum signal to noise ratio. The night time Mie observations from the system were carried out to obtain raw 20 Km height on which analysis is under progress and Range squared signal, aerosol extinction coefficient and Aerosol optical depth are deduced and compared with MODIS and also with AERONET data at Nainital. The present results are interpreted in the light of current understanding of the aerosol distribution.

3.2.2. Stratosphere Troposphere Radar

Foundation stone for ST Radar building was laid by Prof. B. M. Reddy, Emeritus Scientist and Chairman of Project Management Committee (PMC) for ST Radar on 4th November, 2009. Civil work for this building has been initiated by M/s Zepplin, Indore. The radar will be a monostatic, coherent, pulsed radar operating at 206.5MHz. The phased array comprising of 588 single element yagi's will be planned to install on the roof-top of the building. The inter-element spacing between the individual antenna elements will be 0.7λ. Individual antenna will be powered and controlled through their respective Transmit-Receive (TR) Modules located in the first floor of Radar

Figure 27. Foundation stone for ST Radar building was laid by Prof. B. M. Reddy, Emeritus Scientist and Chairman of Project Management Committee (PMC) for ST Radar on 4th November, 2009 at ARIES, Nainital

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building. The feeder cables between the Antennas and the TRMs will be equi-length and optimized to give uniform performance. The DSP hardware and the Front-end processing units will lie in the ground floor of the radar building. There are individual sub committees for test and evaluation (T&E) of each subsystem consisting of the experts from reputed organizations of the country. During the last academic year three meetings of T &E committee for antennae and two meetings of T& E committee for TRM have taken place at ECIL Hyderabad. Four meetings of PMRC have been convened at ECIL Hyderabad during last year. Acceptance Test Procedure (ATP) and Test & evaluations of TRM, Antenna and DSP are in progress. Initiation has been taken for acquiring a complete balloonsonde system and RF measuring instruments. The balloonsonde system will be used to measure meteorological parameters up to about 30 km altitude region in the atmosphere. Action has been taken to get approval for 400 KVA sub-station from Uttarakhand Power Corporation Ltd (UPCL) required to run the radar.

3.2.3. Environmental Observatory (AT-CTM) under ISRO-GBP

Continuous in-situ observations of ozone and related gases like CO, NO, NO_y, and SO_2 are being made under AT-CTM project of ISRO-GBP. These observations show that daytime photochemical build-up in ozone is not dominating. The seasonal variation shows a distinct ozone maximum in late spring (May; 67.2 ± 14.2 ppbv) with values sometimes exceeding 100 ppbv and a minimum in the summer/monsoon season (August; 24.9 ± 8.4 ppbv). Springtime ozone values in the central Himalayas are significantly higher than those at another high altitude site (Mt Abu) in the western part of India (Figure 16). Seasonal variations in ozone and the processes responsible for the springtime peak are studied using meteorological parameters, insolation, spatial and temporal classifications of air mass trajectories, fire counts, and simulations with a chemical transport model. Differences in the seasonal variation of ozone over high altitude sites in the central Himalayas (Nainital) and western India (Mt. Abu) suggest diverse regional emission sources in India and highlight the large spatial and temporal variability in ozone over the Indian region.

3.2.4. 50/80-cm Baker - Nunn Schmidt Telescope Project (B N S T P)

The Schmidt telescope was assembled and inspected on dummy steel piers at M/s Avasarala Technologies Ltd, Bangalore after the alignment of the North and South bearings using theodolite. The telescope was balanced and rotated by handle mounted on its R.A and Dec. gear boxes. The electronic components viz. motors and encoders etc. were mounted on to the telescope and its functional testing was carried out. The polar axis alignment of the North and South piers was accomplished at the first floor level of the Schmidt telescope building. The templates for the foundation plates of the north and south piers were manufactured in the workshop for the final casting of the telescope piers with pockets. The planning for placing of the different components like electrical panels,

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computers, observer's cabin, doors, windows, filling of vermiculite, fixing of railing and floorings etc. on the ground and first floor of the building with optimal utilization of available space was finalized and accomplished.

The grouting of the bolts and the plates for the rail and the guide rollers of the Schmidt dome on the RCC ring beam was completed after leveling and alignment with the LASER. The assembly and erection of the structural elements of the Schmidt dome as per the detailed design and specifications was carried out at ARIES site along with the technical team from M/s Pedvak, Hyderabad. The bus bars and rollers for opening and closing of the shutter of the dome were designed and manufactured in-house at ARIES workshop. Installation of electrical control panel for dome and slit of Schmidt telescope has been carried out successfully. Electric Hoist of 1 ton capacity was installed in the dome and tested with the dome successfully. The functional testing of the dome was carried out successfully after painting and pasting of insulation on to it.

The telescope was received at ARIES site. It was unloaded and stored at the site. The polar axis alignment of the North and South bearing housings was carried out using theodolite and 140 mm vixen telescope at the site along with the team from M/s Avasarala, Bangalore, M/s Tekcons, Hyderabad and scientists and engineers from ARIES. The astrometry results of the CCD images taken from South jig after final alignment and grouting showed that the difference between North jig center to North Celestial Pole (NCP) is about 2 +/-1 arc min for J2010 epoch.

The development and testing of closed loop controller on the jig designed and manufactured at ARIES workshop was completed successfully at Vemana Institute of Technology, Bangalore under MOU with them. Design and development of servo control mechanism for drive systems has been completed. Design & development of micro controller based focus drive system and other interface cards has been completed. Installation of telescope control system is in progress.

The field flattener lens fitted in the 4k CCD was received from M/s Finger Lakes Instrumentation, USA. Lab testing of the camera system was conducted successfully. The three corrector lens-systems got optically cleaned and inspected.

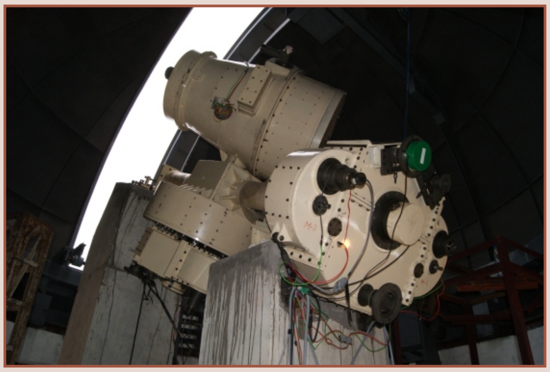


Figure 28. 50-cm B-N Schmidt telescope and dome at ARIES, Nainital.

OTHER ACTIVITIES

1. Conferences/Workshops

2nd Meeting of DST Librarians / Information Officers on CSIR-DST e-Journals Consortium organized at ARIES during May 15 – 16, 2009:

2nd Meeting of DST Librarians / Information Officers on CSIR-DST e-Journals Consortium was organized at Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital during May 15 – 16, 2009. About 20 participants attended the above meeting. Dr. Rajesh Kumar of ARIES was the co-ordinator of this meeting.

Dr. Y. M. Patil, RRI, Bangalore gave introductory remarks about the DST Consortium and its developments. Majority of resources are accessible from all DST Labs. All this could be done with the whole hearted cooperation of DST Librarians and CSIR Coordinating Committee's sustained efforts.

Professor Ram Sagar, Director, ARIES welcomed the participants and briefed recent developments at ARIES. He emphasized on IT applications in the recent times and cautioned libraries to cope with the recent developments in library related IT applications. He stressed that libraries are an integral part of the research institutes and proper care has to be taken for developing sustainable libraries. He appreciated efforts of DST in initiating formation of DST E-Journals Consortium and joining hands with CSIR and expanding existing information resource base and to pool and share resources for use by research workers.

Ms. Nishy, P. of NISCAIR, New Delhi gave talk on "CSIR-DST E-Resource Consortium". She briefed about the consortium developments with various negotiation Committee meetings resulting in providing access to over 14 publishers' journals and over half a dozen databases. She also stressed the need for DST Labs users' surveys to assess their requirements, constraints and suggestions and distributed questionnaire to the effect. She also pointed out about organizing users orientation programmes, avoid duplications and to build unique titles base; to build archive for posterity; build and possess core collection in the system; share resources to help researchers in the country.

Dr. Arun Kumar Chakraborty, Bose Institute, Kolkata gave vote of thanks and thanked ARIES in organizing the meeting and DST for all the support for realizing the CSIR-DST E-Journals Consortium.

Concretizing resources selected during 1st Meeting:

The resources selected during the 1st Meeting held at ARCI, Hyderabad were reviewed and finalized. Out of selected list, negotiations were carried out by the CSIR-DST Coordination Committee and orders have been placed. Review was done for titles ordered as to how many of them are accessible. Nature Publishing Titles were reviewed and was informed that "Nature" has been ordered and accessible by all DST Labs. We have to ascertain accessibility from **administrative nodes** for professional bodies, viz. IAS, INSA, INAE, NASI, ISCA and other sites. Titles were reviewed keeping in view core titles for each potential institute and also to share some titles among the DST Labs. It was also resolved that fresh proposals are to be invited from Elsevier, Wiley – Blackwell and Science as these resources are much in demand from majority of DST Labs. It was also decided that a **Chart for Publisher-wise titles** has to be prepared wherever print, print + online or online only has to be renewed from each Institute from 2010 and onwards indicating deep discount for print titles where applicable.

Figure 29. Inaugural ceremony of 2nd Meeting of DST Librarians / Information Officers on CSIR-DST e-Journals Consortium at ARIES during May 15 – 16, 2009.

It was agreed upon to organize user orientation programmes for DST Labs on region -wise basis keeping in view location of lab/s. This could be looked into in detail by the Coordination Committee of CSIR/DST. On the sidelines of the meeting, discussion was carried out on Open Access. It was felt that each DST Lab may develop Institutional Repository. Few of DST Labs have already developed Repositories using DSpace - open source software, viz. RRI, IIAP, BI, ARIES, etc. This will support Open Access Movement in the country. Some guidelines on this issue may be framed and DST should initiate action on this matter.

Figure 30. Participants of 2nd Meeting of DST Librarians / Information Officers on CSIR-DST e-Journals Consortium at ARIES during May 15 – 16, 2009.

2nd Review Meeting of Atmospheric Trace gases - Chemistry, Transport and Modeling (AT-CTM) Project of ISRO-GBP at ARIES during January 28 – 29, 2010

A two days review meeting of AT-CTM project under ISRO-GBP program was held at ARIES during 28-29 January, 2010. About 70 participants have attended this meeting. Prof. G. P. Brasseur, Director, Climate Service Centre, Hamburg, Germany inaugurated the meeting. Prof. Ram Sagar, Director ARIES welcomed the participants and Dr. C. B. S. Dutt, Dy. Director ISRO-GBP gave a opening remarks. Prof. Shyam Lal, Project Director, AT-CTM briefed about this project. Dr. Manish Naja who organized the meeting at ARIES, Nainital gave a past, present and future overview of air pollution studies in India. Prof. G.P. Brasseur also gave a popular talk on climate change and he emphasised on studies related to glacier melting of Himalayas.

Figure 31. Inaugural of 2nd Review Meeting of Atmospheric Trace gases - Chemistry, Transport and Modeling (AT-CTM) Project of ISRO-GBP at ARIES during January 28 – 29, 2010.

Figure 32. Participants of 2nd Review Meeting of Atmospheric Trace gases - Chemistry, Transport and Modeling (AT-CTM) Project of ISRO-GBP at ARIES during January 28 – 29, 2010.

There are 15 observations sites in this project where traced gases are being measured. Additionally, there are three high altitude sites in India, namely Mt. Abu, Nainital and Ooty. Observations at these high altitude sites will be of regional representatives. During this meeting, it was realized that there is strong requirement of more measurements sites with better regional representativeness. It was also suggested to have Ozone sounding at few more sites in India. At the end, Dr. Manish Naja gave vote of thanks for successfully holding this meeting at ARIES.

2. Pedagogical Activities

Weekly Seminars and Special Talks

Weekly seminars and special talks were organized regularly at the Institute to increase the academic interactions amongst the researchers. About 25 seminars and 35 special talks were delivered during the period April, 2009 to March, 2010 by the Institute's students, scientists, engineers and eminent scholars from India and abroad.

Public Outreach

Public Outreach is an ongoing program at ARIES. Department of Science and Technology (DST) also supports these activities to increase general awareness about astronomy and basic sciences in common people. Nainital and nearby places are full of schools and colleges and are major centers for primary education in this part of the country.

Here at ARIES, people visit on regular basis as well as on the occasions of popular astronomical events like eclipses and other planetary occultations. On the occasions of major astronomical events, special arrangements are made to provide related information to the visitors and the sky-watching programs using the telescopes. Apart from this, we also make use of print and electronic media to communicate information related to astronomical events as and when required as a part of the activities. Popular talks in the nearby schools and collages are also arranged as a part of the programs. The popular talks, science popularization programs are also organized by ARIES on the special occasions e.g. National Science Day.

National Science Day Celebrations – 22 March, 2010

National Science Day was celebrated in ARIES on 22nd March 2010. The elebrations were organized by the ARIES Science Popularization and Outreach Program (AsciPOP). Nine schools attended. We organized a movie, a general talk and quiz for the participants. St. Mary, Nainital won the first prize in quiz competition. The summary of the events took place on the day is presented through pictures.

AsciPOP thank the following personals who were instrumental in making the events successful.

Dr. Amitesh Omar, Dr. Manish Naja, Dr. Biman Medhi, Dr. Indranil C , Dr. Sneh Lata, Mr. Narendra Ojha, Mr. Rajesh Mudgal, Mr. Eswar, Mr. Rupak , Mr. Pankaj, Mr. Ramkesh, Mr. Ravi Joshi, Mr. Kalyan, Mr. Devesh, Mr. Harish Tiwari, Mr. Ahisheak, Mr. V. K. Singh and Mr. Dheerendra Tiwari.

Posters showing various astronomical aspects.

More posters on Moon, Earth, Sun ...

Addressing the gathering by ARIES team.

The students and teachers of 9 schools.

OTHER ACTIVITIES

A visit to solar telescope.

What are sun spots?......

A general talk by Dr. Ametesh Omar.

Science awareness for the public.

Comets and much more through posters.

Explaining formation of stars to students

A grand lunch at Ashwani guest house.

A movie, Tarom ki sayer.

A visit to Sampurnanand telescope.

What is a CCD ?

Quiz competition.

Winners of the Quiz – St. Mary School,

Figure 33. Various activities by ARIES Science Popularization and Outreach Program (AsciPOP) at ARIES, Nainital.

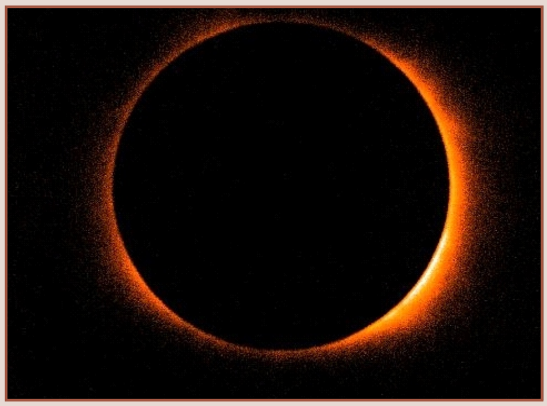
Figure 34. The National Science Day Program held at Champawat, Uttarakhand during 5-6 March 2010. The program was coordinated by Dr. B. B. Sanwal, Dr. Brijesh Kumar, and Mr. Harish Tewari.

Total Solar Eclipse (July 22, 2009)

The total solar eclipse observation on 2009, July 22nd from Anji, China has been successfully performed by the ARIES expedition team, and the analysed observations will provided the clues of magnetohydrodynamic (MHD) oscillations in the solar corona. Such expeditions are not only scientifically valuable, but also very fascinating for the mankind since early age. This eclipse was the ever biggest solar eclipse of this century with the maximum totality of 6 min and 39 s, and has provided significant observing time for the ARIES scientists to solve the mystery of coronal heating.

The ARIES expedition team has performed imaging of the solar corona in the Fe X 6374 A red line and Fe XIV 5303 A green coronal lines during the eclipse time using the two identical 5 inch telescopes. In addition, experiments related to atmospheric science were also performed by ARIES team, which included the measurements of surface ozone along with all the meteorological parameters. These observations will be used to investigate the influence of Total Solar Eclipse on surface ozone variability.

(a)



(b)

Figure 35. (a) ARIES Team [from left to right, P. Kumar, A. Kumar, N. Ojha, W. Uddin (Team leader) and A. K. Srivastava] at Anji, China for observation of Total Solar Eclipse on July 22, 2009; (b) Total Solar Eclipse on July 22, 2009 observed at Anji, China by ARIES Team.

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