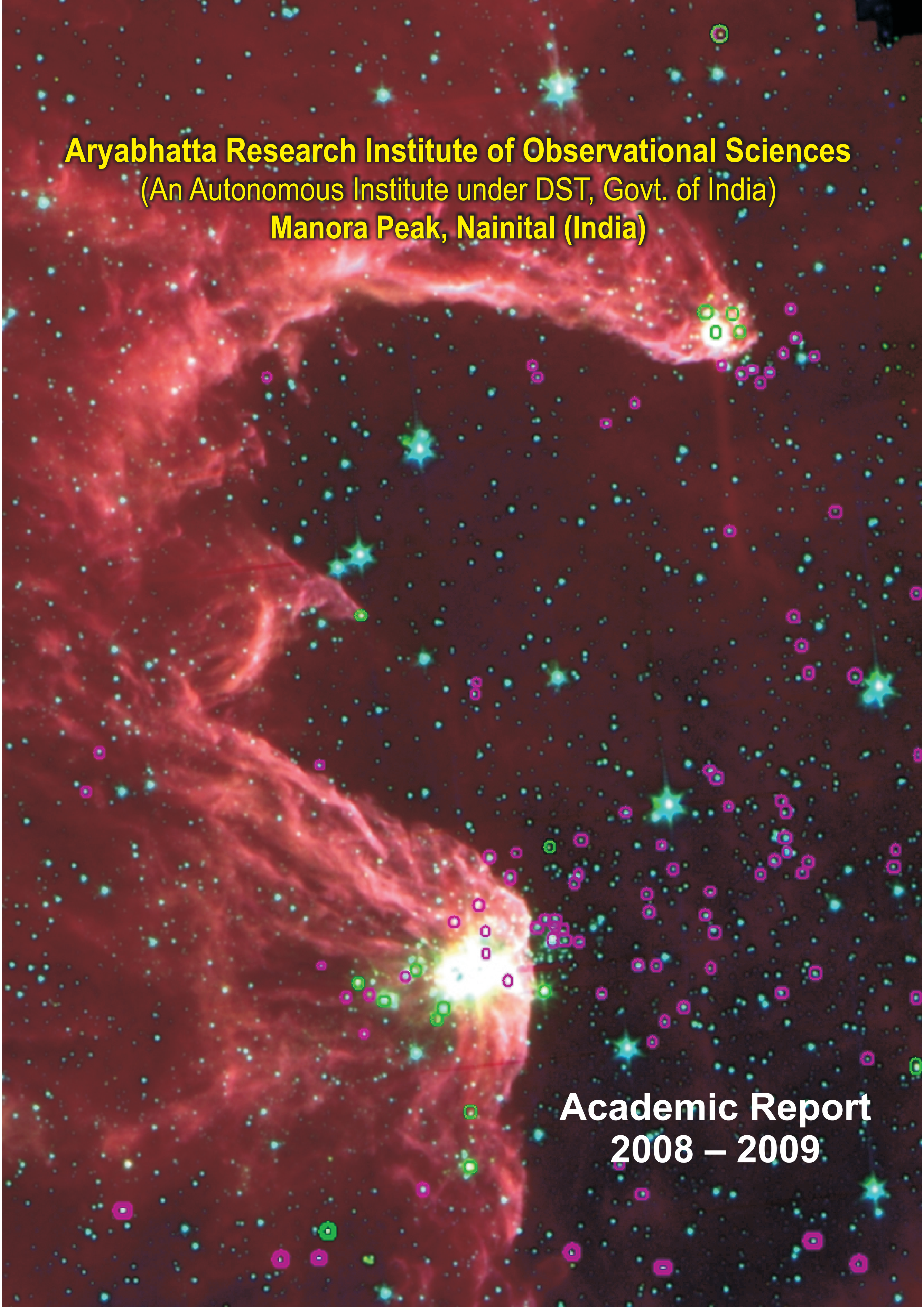


Aryabhatta Research Institute of Observational Sciences

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

Manora Peak, Nainital (India)

Academic Report
2008 – 2009

ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES

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

Manora Peak, Nainital - 263 129, India

ACADEMIC REPORT

2008 - 2009

(1st April, 2008 to 31st March, 2009)

ARIES, 2009, Academic Report: 2008 - 2009
No. 4, 56 pages

Editors : Dr. A. K. Pandey
Dr. Rajesh Kumar
Dr. M. Naja
Dr. Snehlata
Dr. Hum Chand

Phone	:	+91 (5942) 235136
EPABX	:	+91 (5942) 233727, 233734, 233735, 232655
Fax	:	+91 (5942) 233439
E-mail	:	library@aries.res.in
URL	:	http://www.aries.res.in/

Front cover :
Star forming regions associated with bright rimmed clouds (Photograph: courtesy Spitzer Telescope). Spatial distribution of detected young stellar sources is also shown.

Back cover :
Post-flare loops observed at ARIES with 15-cm Solar Tower Telescope in Hα .

ISSN : 0974 - 679X

August 2009

CONTENTS

GOVERNING COUNCIL

Prof. K. Kasturirangan		**Chairperson**
	Director, National Institute of Advanced Studies (NIAS), Indian Institute of Science Campus, Bangalore - 560 012	
Dr. T. Ramasami		**Member**
	Secretary, Ministry of Science and Technology, Department of Science and Technology, Govt. of India, New Delhi - 110 016	**(Ex-Officio)**
Mr. I. K. Pande		**Member**
	Chief Secretary, Govt. of Uttarakhand, Dehradun - 248 001	**(Ex-Officio)**
Mr. K. P. Pandian		**Member**
	Joint Secretary and Financial Advisor, Ministry of Science and Technology, Department of Science and Technology, Govt. of India, New Delhi - 110 016	**(Ex-Officio)**
Prof. R. Subrahmanyan		**Member**
	Director, Raman Research Institute, C. V. Raman Avenue, Sadashivanagar, Bangalore - 560 080	**(Ex-Officio)**
Prof. S. S. Hasan		**Member**
	Director, Indian Institute of Astrophysics, Sarjapur Road, Bangalore - 560 034	**(Ex-Officio)**
Prof. J. V. Narlikar		**Member**
	Emeritus Professor, Inter University Centre for Astronomy and Astrophysics, Pune University Campus, Ganeshkhind, Pune - 411 007	
Prof. P. C. Agrawal		**Member**
	ISRO Professor, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai - 400 005	
Dr. S. D. Sinvhal		**Member**
	91, Vigyan Kunj, I. I. T. Roorkee, Roorkee - 247 667	
Prof. S. Ananthakrishnan		**Member**
	Electronics Science Department, Pune University, Ganeshkhind, Pune - 411 007	

Prof. R. Nityananda — **Member**
Director, National Centre for Radio Astrophysics,
Pune University Campus, Ganeshkhind, Pune - 411 007

Prof. D. Bhattacharya — **Member**
Inter University Centre for Astronomy and Astrophysics,
Pune University Campus, Ganeshkhind,
Pune - 411 007

Prof. Ram Sagar — **Member Secretary (Ex-Officio)**
Director, ARIES, Manora Peak, Nainital - 263 129

FINANCE COMMITTEE

Prof. Ram Sagar Director, ARIES, Manora Peak, Nainital - 263 129	**Chairperson**
Mr. K. P. Pandian Joint Secretary and Financial Advisor, Ministry of Science and Technology, Department of Science and Technology, Govt. of India, New Delhi - 110 016	**Member**
Dr. S. D. Sinvhal 91, Vigyan Kunj, I.I.T. Roorkee, Roorkee - 247 667	**Member**
Dr. B. B. Sanwal Scientist, ARIES, Manora Peak, Nainital - 263 129	**Member**
Maj. S. C. Jhingan Registrar, ARIES, Manora Peak, Nainital - 263 129	**Member Secretary**

ABBREVIATIONS

2MASS	Two Micron All Sky Survey
ABL	Atmosphere Boundary Layer
ABLN&C	Atmospheric Boundary Layer Network and Characterization
ADFOSC	ARIES Devasthal Faint Object Spectrograph and Camera
AERONET	Aerosol Robotic Network
AGL	Above Ground Level
AGN	Active Galactic Nuclei
AIMPOL	ARIES Imaging Polarimeter
AMOS	Advanced Mechanical and Optical Systems
AOD	Aerosols Optical Depth
ARFI	Aerosol Radioactive Forcing over India
ASAS	All Sky Automated Survey
BAT	Burst Alert Telescope
BC	Black Carbon
BRCs	Bright-Rimmed Clouds
BL Lac	BL Lacertae
BSR	Backscatter Ratio
CCD	Charged Coupled Device
CDR	Critical Design Review
CFHT	Canada-France-Hawaii Telescope
CGs	Cometary Globules
CMF	Core Mass Function
CSD	Columnar Size Distribution
CTM	Chemical Transport Model
CTTSs	Classical T- Tauri Stars
DFM	Dr. Frank Melsheimer
DOT	Devasthal Optical Telescope
EIS	EUV Imaging Spectrometer
EIT	EUV Imaging Telescope
ENVObs	Environmental Observatory
EPIC	European Photon Imaging Camera
EUV	Extreme Ultraviolet
EW	Equivalent Width
FLI	Finger Lakes Instrumentation
FORSA	Forum for Resource Sharing in Astronomy and Astrophysics
FRSGC	Frontier Research System for Global Change

FWHM	Full Width at Half Maximum
GBP	Geosphere Biosphere Program
GHz	Giga Hertz
GRB	Gamma-Ray Burst
ICARB	Integrated Campaign for Aerosol, Gases and Radiation Budget
IDV	Intra-Day Variabilit
IMF	Initial Mass Function
IPN	Inter-Planetary Network
IRAS	Infra Red Astronomical Satellite
IRS	Infra Red Survey
IUCAA	Inter University Centre for Astronomy & Astrophysics
LDE	Long Duration Event
LIDAR	Light Detection and Ranging
LISA	Library and Information Services in Astronomy
LZOS	Lytkarino Optical Glass Factory
MF	Mass Function
MHD	Magnetohydrodynamic
MOS	Metal Oxide Semiconductor
MPL	Micro Pulse Lidar
MPLAD	Member of Parliament Local Area Development
MTM	Mesospheric Temperature Mapper
MWR	Multi Wavelength Radiometer
NASA	National Aeronautics and Space Administration
NGC	New General Catalog
NIR	Near Infra Red
NLST	National Large Solar Telescope
NOAA	National Observatory of Astronomy and Astrophysics
ONC	Orion Nebula Cluster
OPAC	Online Public Access Catalogue
QSOs	Quasi-Stellar Objects
PACT	Pachmarhi Array of Cerenkov Telescopes
PMS	Pre Main Sequence
PMT	Photo Multiplier Tube
RDI	Radiation Driven Implosion
RLQSO	Radio-Loud Quasi-Stellar Objects
RQQSOs	Radio-Quiet Quasi-Stellar Objects
RXTE	X- Ray Timing Explorer
SAX	Satellite Astronomic raggi-X
SED	Spectral Energy Distribution

SDIMM	Solar Differential Image Motion Monitor
SIS	Scanning Imaging Spectrograph
SN	Super Nova
SOHO	Solar and Heliospheric Observatory
SOXs	X-Ray Spectrometer
ST	Sampurnanand Telescope
STEREO	Solar Terrestrial Relations Observatory
TTSs	T- Tauri Stars
UNLV	University of Nevada, Las Vegas
UV	Ultra Violet
VBT	Vainu Bappu Telescope
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometer
VLF	Very Low Frequency
XMM	X-Ray Multi Meter
XRT	X-Ray Telescope
YSOs	Young Stellar Objects
WEBT	Whole Earth Blazer Telescope
WTTSs	Weak-Line T-Tauri Stars

EXECUTIVE SUMMARY

The Institute continued to make important scientific contributions in different front-line problems of astronomy & astrophysics and atmospheric sciences with great zeal and ebullience. Fundamental studies were conducted in the field of Astronomy/Astrophysics and Atmospheric Sciences, which include studies of aerosols, trace gases, solar activities, variable stars, star clusters, gamma-ray burst and supernova, extragalactic astronomy etc. The major developments and academic activities carried out during 2008-2009 are summarized below:

1. Dr. T. Ramasami, Secretary, DST laid foundation stone of 3.6-m Devasthal optical telescope house on 6 September 2008. During the ceremony he remarked **"Devasthal will house one of the Asia's most powerful telescope in recent future. We have made a small beginning for a giant step in observational science today. Let ARIES bring glory to India and glow"**.

2. 3.6-m Devasthal Optical Telescope (DOT) Project activities are going on in full swing. The activities include design and construction of a 3.6 meter aperture optical telescope; back-end instruments, an enclosure to house the telescope, an aluminizing plant to coat the mirrors, and an auxiliary building to house the aluminizing plant, instruments and other telescope related accessories. Several scheduled activities viz critical design review of telescope design; acceptance of primary mirror zerodur blank at Schott Germany; award of contract and final design review of telescope enclosure and auxiliary building were successfully completed during the past one-year. The 5-year contract to design and build the telescope completed 2 years in April 2009 and the progress during last one year has been as per the scheduled milestones in the contract. The critical design review (CDR) of the DOT has been done. After detailed discussions and review by an expert committee the CDR-stage has now been completed. A Pune based firm named M/s Precision Precast Solutions (PPS) Private limited has been awarded a contract for design and consultancy services of the telescope enclosure and auxiliary building. A critical review of the telescope enclosure design proposed by PPS has been carried out by an expert committee. Design requirements and road map for the successful completion of the faint object spectrograph, camera and polarimeter are being prepared.

3. The building for 1.3-m telescope (including the telescope pier and rolloff roof) has been completed. Power supply, road connectivity and network connectivity have also been provided to the building. The telescope house is ready for the installation of the telescope well before the arrival schedule of the telescope projected by DFM.

4. Building construction of the high altitude Lidar has been completed. Integration of different Lidar components is in progress. Major activity is optical alignment, which is being done.

5. Preliminary Design Reviews (PDR) of ST Radar is completed and design of ST radar has been frozen. It will have array of 588 Yagis of 3 elements in a circular aperture. These will be setup on the roof-top of building, which would be the first attempt in the world. The construction of building is going to be initiated soon. The T/R modules will be installed in-house. It is visualized that first batch of antenna and T/R modules will be ready by the end of the year 2009. This proposed radar will provide continuous observations of winds with very high vertical resolution and measurements can be made in all kinds of weather.

EXECUTIVE SUMMARY

6. An environmental observatory has been set up at ARIES, Nainital recently. This site will be part of three Indian background stations planned by ISRO. Apart from observations of trace gases, a complete setup for carrying out zero and span of different gases has been arranged. Importantly, these instruments are capable of measurement at very low levels (pptv).

7. The construction work of the Guest house 'Ashwini' and Optics Laboratory is complete. The student hostel 'Rohini' is partially completed and some of the rooms have been allotted to research students.

8. The Computer Centre is being upgraded further to provide facilities for high performance computing. To meet the ever increasing demand of bandwidth, the institute has procured a dedicated 10 Mbps leased line.

9. Academic staff members continued to pursue vigoursly 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. Nature, Astrophysical Journal). Fifty four papers were published/accepted in refereed journals, and another eight were published as circulars and conference proceedings. Three Ph.D. theses have been awarded and another two have been submitted. Academic and technical interactions with various institutions and universities were continued. Following are the major scientific results:

    (i) It is found that the masses of the most massive stars associated with the cometary globules (CGs) are correlated with the masses of the parent cloud but they are systematically larger than expected for molecular clouds of similar masses from the relation $M_{\text{max-star}} = 0.33 M_{cl}^{0.43}$.

    (ii) The global distribution of young stellar objects in HII regions clearly shows the evidence that a series of radiation-driven implosion processes proceeded in the past from near the central O star(s) towards the peripheries of the HII regions.

    (iii) An extended X-ray emission in the cluster region NGC 7419 indicates the presence of ~288 T Tauri stars in the cluster region.

    (iv) The BVR polarimetric study of the cool active star LO Pegasi (LO Peg) is presented for the first time. LO Peg was found to be highly polarized among the cool active stars. It is suggested that the level of polarization observed in LO Peg could be the result of scattering of an anisotropic stellar radiation field by an optically thin circumstellar envelope or by scattering of the stellar radiation by prominence-like structures.

    (v) The presence of supernova signature in long-duration GRB afterglows has further strengthened the fact that the collapse of a massive star gives rise to long-duration GRBs.

EXECUTIVE SUMMARY

(vi) A possible correlated variability between X-ray and J band (1.25 μ) near infrared (NIR) wavelength has been obtained. This is the first case of X-ray and NIR correlated variability in Mrk 421 or any high energy peaked blazar. The correlated variability indicates a similar origin for the NIR and X-ray emissions.

(vii) The multiple sausage oscillations have been observed for the first time in the cool post flare loop.

(viii) Influence of the dust transport from Thar Desert to the Central Himalayan region was shown for the first time. This region is shown to be generally much less polluted and the photochemical ozone production is not significant, except during events of long-range transport and fires.

10. The Institute organized India-South Africa workshop on Astronomy to strengthen the scientific collaboration between the two countries. A summer school on introductory Astronomy, Astrophysics and Atmospheric sciences was held for M. Sc. (Physics) students which aimed at introducing fundamentals of the subjects to motivate them for basic research.

11. 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 programmes, (ii) projects as part of academic course work, (iii) visits of students and staff from other institutions, and (iv) summer project student programme.

12. Several public outreach activities took place during the year including National Science Day on February 28, 2009 which had several exhibitions, talks and viewing of the night sky. ARIES executed a project to set-up an eleven inch diameter optical telescope at St. Joseph's College, Nainital for educational purpose. This project was funded under MPLAD scheme of Dr. K. Kasturirangan, Honorable Member of Parliament.

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

Prof. Ram Sagar has been nominated as a Governing Council Member of the Indian Institute of Astrophysics, Bangalore and of IITM, Pune.

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 bright future of the Institute.

Place : Nainital
Date : 10 August, 2009

RAM SAGAR
Director

THE INSTITUTE

Situated adjacent to the picturesque hill town of Nainital, ARIES (an acronym of **A**ryabhatta **R**esearch **I**nstitute of observational scienc**ES**) 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 aerosols and trace gases. 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° 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. 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:

The Institute hosts two telescopes of apertures 56-cm and 104-cm. There are two 15-cm telescopes dedicated for solar observations. The 104-cm optical telescope 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 130-cm telescope is expected to be operational by the end of 2009, and the 360-cm telescope will be operational by 2012. 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 and trace gas. 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.

Ph.D./PDF Programme:

Interested students participate in the Ph. D. program in the field of Astronomy & Astrophysics and Atmospheric Sciences, which is being offered by ARIES. The minimum qualification for a research scholar is a M. Sc. degree in Physics/Astronomy/Astrophysics/Atmospheric Sciences. Research scholars are selected via an interview of successful JEST/NET/GATE qualifiers. The students can register for the Ph. D. degree at a number of Indian universities that have recognized ARIES as a research centre.

THE INSTITUTE

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 modelling.

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.

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

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

Core mass function: The role of gravity:

The mass distribution of cores formed in an isothermal, magnetized, turbulent, and self-gravitating nearly critical molecular cloud model was analyzed. Cores are identified at two density threshold levels. It is found that the presence of self-gravity modifies the slopes of the core mass function (CMF) at the high-mass end. At low thresholds, the slope is shallower than the one predicted by pure turbulent fragmentation. The shallowness of the slope is due to the effects of core coalescence and gas accretion. Most importantly, the slope of the CMF at the high-mass end steepens when cores are selected at higher density thresholds, or alternatively, if the CMF is fitted with a lognormal function, the width of the lognormal distribution decreases with increasing threshold. This is due to the fact that gravity plays a more important role in denser structures selected at higher density threshold and leads to the conclusion that the role of gravity is essential in generating a CMF that bears more resemblance to the IMF when cores are selected with an increasing density threshold. [S. Dib, A. Brandenburg, J. Kim, **M. Gopinathan** and P. Andre].

Enhanced luminosity of young stellar objects in cometary globules:

The effects of external trigger on the characteristics of young stellar objects (YSOs) associated with cometary globules (CGs) have been investigated. It is found that the masses of the most

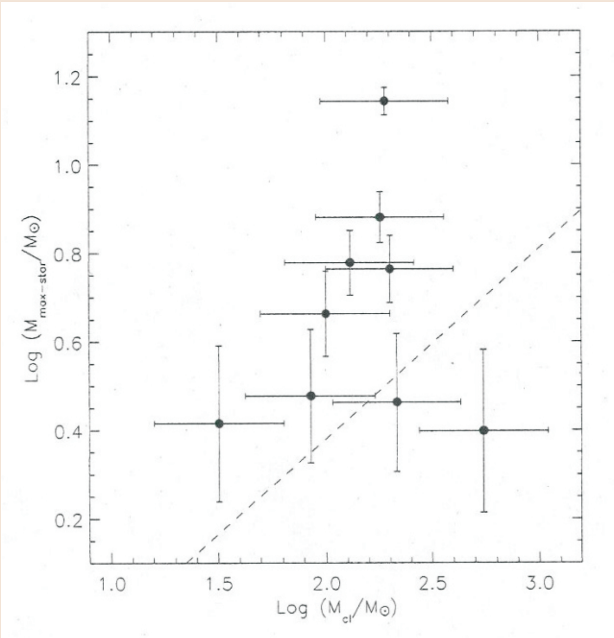


Figure 1. The masses of the most massive star associated with CGs are plotted against parent cloud mass. The dashed line represents the relation for the mass of the most luminous star and the mass of the cloud (see (1)) given by Larson (1982).

massive stars associated with the CGs are correlated with the masses of the parent cloud but they are systematically larger than expected for clouds of similar masses from the relation $M_{max\text{-}star} = 0.33 M_{cl}^{0.43}$. The luminosities of the IRAS sources associated with CGs as a function of cloud mass have also been estimated and have been compared with those of the IRAS sources found associated with isolated opacity class 6 clouds (isolated and relatively away from large star forming regions). It is found that the luminosities of IRAS sources associated with CGs are larger than those of the opacity class 6 clouds. These findings support results from recent simulations in which it was shown that the Radiation Driven Implosion (RDI) process, believed to be responsible for the cometary morphology and star formation, can increase the luminosity 1-2 orders of magnitudes higher than those of protostars formed without external triggering due to an increase in accretion rates thus implying that the massive stars can have profound influence on the star formation in clouds located in their vicinity. [**G. Maheswar** and H. C. Bhatt].

Young brown dwarfs in the core of the W3 main star-forming region:

A deep and high-resolution (FWHM ~ 0".35) *JHK* near-infrared (NIR) observations with the Subaru telescope have been carried out to search for very low mass young stellar objects in the W3 Main star-forming region. The NIR survey covers an area of ~2.6 arcmin^2 with 10σ limiting magnitude exceeding 20 mag in the *JHK* bands. The survey is sensitive enough to provide unprecedented details in W3 IRS 5 and IRS 3a regions and reveals a census of the stellar population down to objects below the hydrogen-burning limit. *JHK* color-color and *J - H/J and H - K/K* color-magnitude diagrams were used to identify very low luminosity young stellar objects and to estimate their masses. Based on these color-color and color-magnitude diagrams, a rich population of embedded YSO candidates with infrared excesses (Class I and Class II) has been identified in the W3 Main region. A large number of red sources (*H-K* >2) has also been detected around W3 Main, which are arranged from the northwest toward the southeast regions. Most of these are concentrated around W3 IRS 5. It is argued that these red stars are most probably pre-main-sequence (PMS) stars with intrinsic color excesses. It is found that the slope of the *K*-band luminosity function of W3 Main is lower than the typical values reported for young embedded clusters. Based on the comparison between theoretical evolutionary models of very low mass PMS objects with the observed color-magnitude diagram, a substantial substellar population is found in the observed region. The mass function does not show the presence of cutoff and sharp turnover around the substellar limit, at least at the hydrogen-burning limit. Furthermore, the mass function slope indicates that the number ratio of young brown dwarfs and hydrogen-burning stars in the W3 Main is probably higher than those in Trapezium and IC 348. The presence of mass segregation, in the sense that relatively massive YSOs lie near the cluster center, is seen. The estimated dynamical evolution time indicates that the observed mass segregation in the W3 Main may be the imprint of the star formation process. [D. K. Ojha, M. Tamura, Y. Nakajima, H. Saito, **A. K. Pandey**, S. K. Ghosh and K. Aoki].

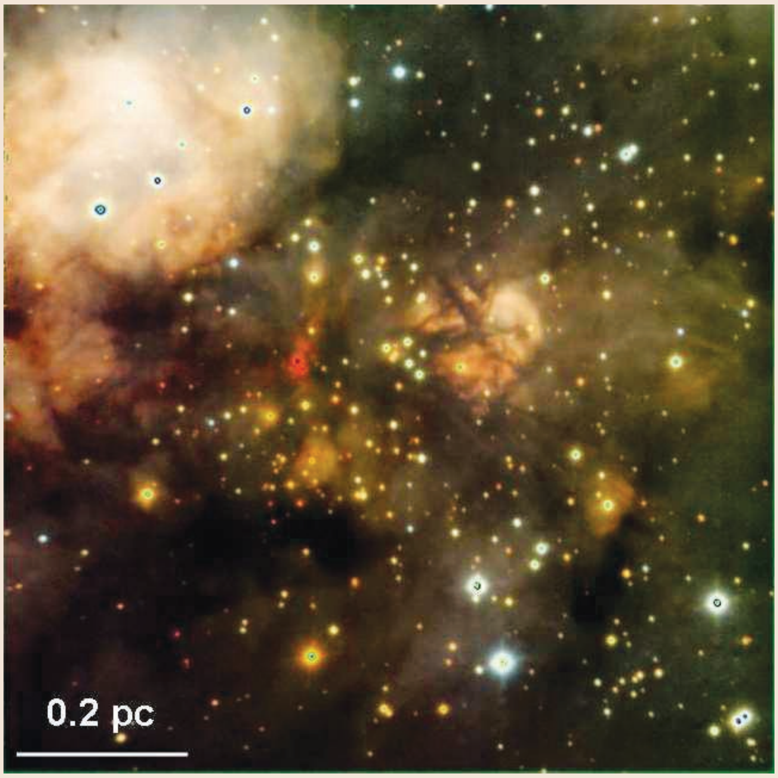


Figure 2. *JHK* composite image of the W3 Main star-forming region (*J*: blue; *H*: green; *K*: red) obtained with the CISCO mounted on the Subaru 8.2-m telescope. The FOV is ~1'.8 x 1'.8 . North is up, and east is to the left.

Triggered star formation and evolution of T-Tauri stars in and around bright-rimmed clouds:

To quantitatively testify the '*small-scale sequential star formation*' hypothesis in and around bright-rimmed clouds (BRCs), *BVIc* photometry of six BRC aggregates has been carried out. Quantitative age gradients are found in almost all the BRCs studied in the present work. Archival *Spitzer*/Infrared Array Camera data also support this result. The global distribution of near-infrared excess stars in each H_{II} region studied here clearly shows evidence that a series of radiation-driven implosion processes proceeded in the past from near the central O star(s) towards the peripheries of the H_{II} region. It is found that in general weak-line T-Tauri stars (WTTSs) are somewhat older than classical T-Tauri stars (CTTSs). Also the fraction of CTTSs among the T-Tauri stars (TTSs) associated with the BRCs is found to decrease with age. These facts are in accordance with the recent conclusion by Bertout, Siess & Cabrit that CTTSs evolve into WTTSs. It seems that in general the equivalent width of Hα emission in TTSs associated with the BRCs decreases with age. The mass function (MF) of the aggregates associated with the BRCs of the morphological type 'A' seems to follow that found in young open clusters, whereas 'B/C'-type BRCs show significantly steeper MF. **[N. Chauhan, A. K. Pandey,** K. Ogura, D. K. Ojha, B. C. Bhatt, S. K. Ghosh and P. S. Rawat].

Figure 3. Spatial distribution of Class 0/I sources (green circles) and Class II sources (pink circles) in the BRCs 13 and 14 region identified in the Spitzer/IRAC data.

b. Star cluster

Optical polarimetric study of open clusters: distribution of interstellar matter towards NGC 654:

New *B*, *V* and *R* linear polarimetric observations for 61 stars towards the region of the young open cluster NGC 654 have been carried out. The study found evidence for the presence of at least two layers of dust along the line of sight to the cluster. The distances to the two dust layers are estimated to be ~200 pc and ~1 kpc which are located much closer to the Sun than the cluster (~2.4 kpc). Both the dust layers have their local magnetic field orientation nearly parallel to the direction of the Galactic plane. The foreground dust layer is found to have a ring morphology with the central hole coinciding with the centre of the cluster. The foreground dust grains are suggested to be mainly responsible for both the observed differential reddening and the polarization towards the cluster. **[B. J. Medhi, Maheswar G., J. C. Pandey, T. S. Kumar** and **R. Sagar].**

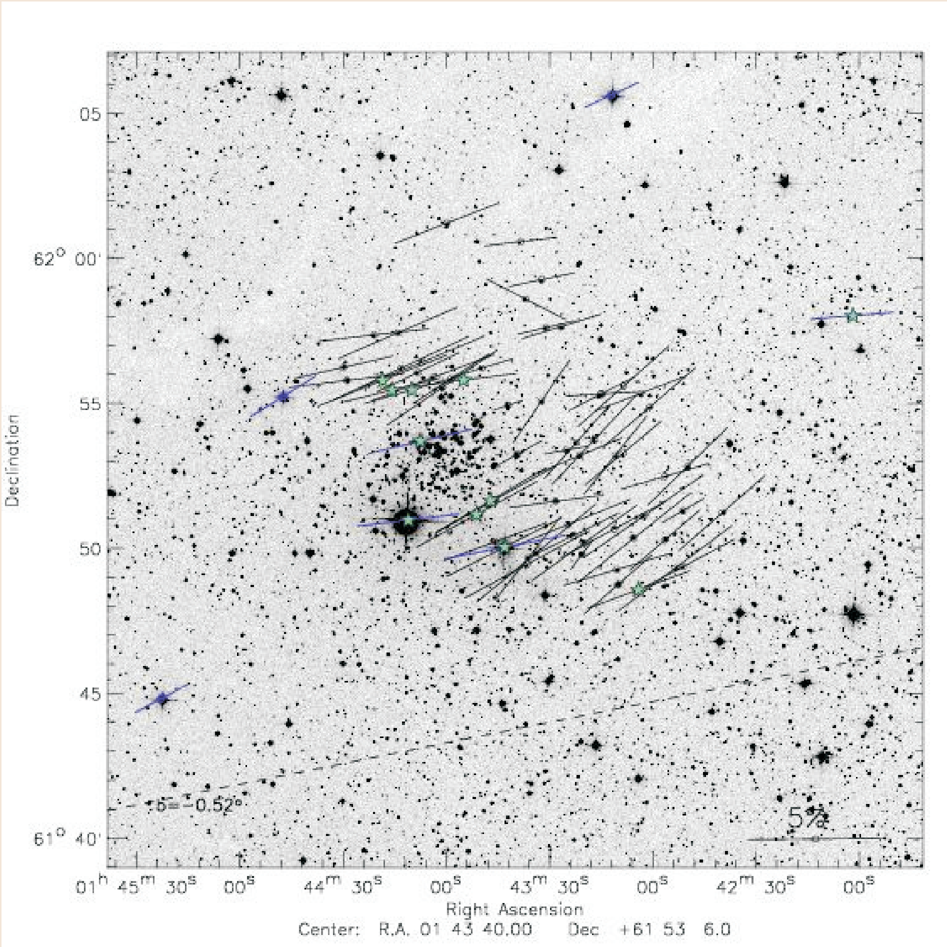


Figure 4. The 28 x 28 arcmin R-band DSS image of the field containing NGC 654, reproduced from Digitized Sky Survey. The position angles, in the equatorial coordinate system, are measured from the north, increasing eastward. The polarization vectors are drawn with the star as the center. Length of the polarization vector is proportional to the percentage of polarization and it is oriented parallel to the direction corresponding to the observed polarization position angle . A vector with a polarization of 5 % is shown for reference. The dashed line represents the Galactic parallel at b=-0.52 degree.

Optical and near-infrared photometric study of the open clusters NGC 637 and 957:

The *UBVRI* CCD photometry in the region of the open clusters NGC 637 and 957 have been used to estimate the fundamental parameters of these two clusters. Comparison with Z = 0.02 isochrones leads to an age of 10 ± 5 Myr for both clusters. Combining the photometry with Two Micron All Sky Survey (2MASS) *JHK* shows the reddening law in these directions to be normal. Mass function slopes of $x = 1.65 \pm 0.20$ and 1.31 ± 0.50 are derived for the clusters, both of which are found to be dynamically relaxed. Spectral and photometric characteristics of three Be stars, two in NGC 957 and one (newly discovered) in NGC 637, indicate them to be of Classical Be type. **[R. K. S. Yadav, B. Kumar,** A. Subramaniam, **R. Sagar** and B. Mathew].

Multi-wavelength study of young open cluster NGC 7419:

A multiwavelength study of young open star cluster NGC 7419 has been carried out. An age of 22.5 ± 3.0 Myr and a distance of 3230^{+330}_{-430} pc are derived for the cluster. The photometric data indicate a higher value of colour excess ratio *E(U - B)/E(B - V)* than the normal one. There is an evidence for mass segregation in this dynamically relaxed cluster and in the range 1.4-8.6 $M_{\odot}$, the mass function slope

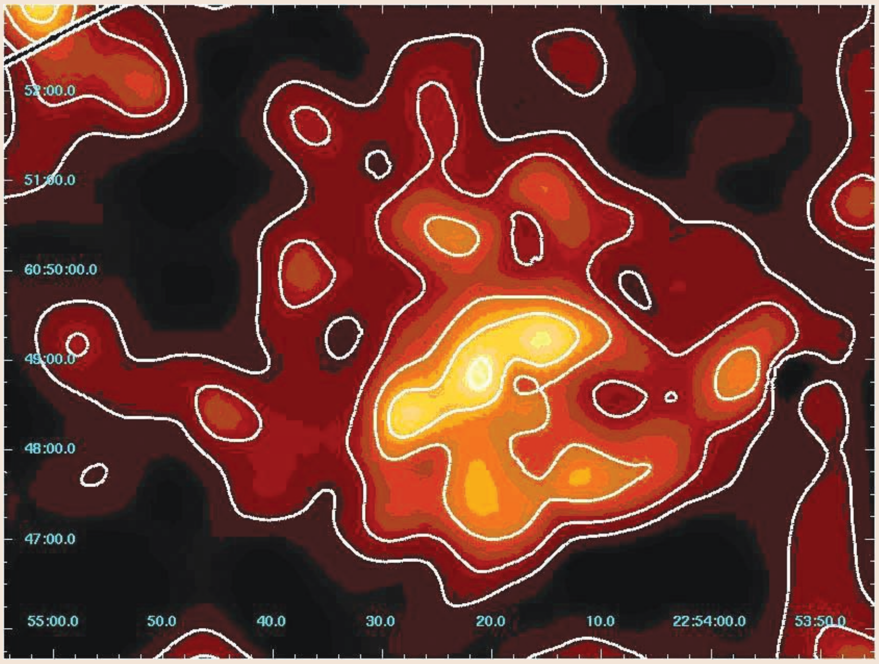


Figure 5. The extended diffuse X-ray emission from the young star clusters NGC 7419. This diffuse X-ray emission is predicted to arise from about three hundred unresolved active young stars.

is in agreement with the Salpeter value. Excess emissions in near-infrared and in Hα support the existence of a young (≤2Myr) stellar population of Herbig Ae/Be stars (≥3.0 $M_{\odot}$) indicating a second episode of star formation in the cluster region. Using *XMM-Newton* observations, several X-ray sources in the cluster region were found but none of the Herbig Ae/Be stars is detected in X-rays. The distribution of upper limits for Herbig Ae/Be stars was compared with the X-ray distribution functions of the T Tauri and the Herbig Ae/Be stars from previous studies, and it was found that the X-ray emission level of these Herbig Ae/Be stars is not more than $L_X \sim 5.2 \times 10^{30}$ erg s^{-1}, which is not significantly higher than for the T Tauri stars. Therefore, X-ray emission from Herbig Ae/Be stars could be the result either of unresolved companion stars or a process similar to T Tauri stars. An extended X-ray emission from the cluster region NGC 7419, with a total X-ray luminosity estimate of ~1.8×10^{31} erg s^{-1} $arcmin^{-2}$ is reported. If the extended emission is due to unresolved emission from the point sources then it is estimated that there should be ~288 T Tauri stars in the cluster region, each having X-ray luminosity ~1.0×10^{30} erg s^{-1}. Investigation of dust attenuation and ^{12}CO emission map of a square degree region around the cluster indicates the presence of a foreground dust cloud which is most likely associated with the local arm star-forming region (Sh2-154). This cloud harbours uniformly distributed pre-main-sequence stars (0.1-2.0 $M_\odot$), with no obvious trend of their distribution with either (*H* -*K*) excess or A_V. This suggests that the star formation in this cloud depends mostly upon primordial fragmentation. [**H. Joshi, B. Kumar,** K. P. Singh, **R. Sagar, S. Sharma** and **J. C. Pandey**].

Abundances of four open clusters from solar stars:

The abundance measurements of several elements (Fe, Ca, Na, Ni, Ti, Al, Cr, Si) for 20 solar-type stars belonging to four Galactic open clusters: NGC 3680, IC 4651, Praesepe, and M 67 have been presented. Oxygen abundances were in addition measured for most stars in each cluster apart from IC 4651. For NGC 3680, accurate abundance determinations using high-resolution spectra covering a large spectral domain are computed for the first time. The most surprising result is a measurement of significant supersolar metallicity for Praesepe ([Fe/H] = 0.27 ± 0.10). A supersolar metallicity for IC 4651 ([Fe/H] = 0.12 ± 0.05), a solar metallicity for M 67 ([Fe/H] = 0.03 ± 0.04) and a slight subsolar metallicity for NGC 3680 ([Fe/H] = -0.04 ± 0.03) is also confirmed. It was found that the abundance ratios of almost all elements are solar, with the notable exception of oxygen in NGC 3680 and Praesepe, supersolar in the former cluster ([O/Fe] = 0.2 ± 0.05) and as low as [O/Fe] = -0.4 ± 0.1 in the latter. [**G. Pace**, L. Pasquini and P. François].

c. Variable Stars

Spectroscopic survey of ASAS eclipsing variables: Search for chromospherically active eclipsing binaries stars (I):

A spectroscopic survey is being carried out to identify new chromospherically active components and low-mass pre-main sequence (PMS) stars in recently

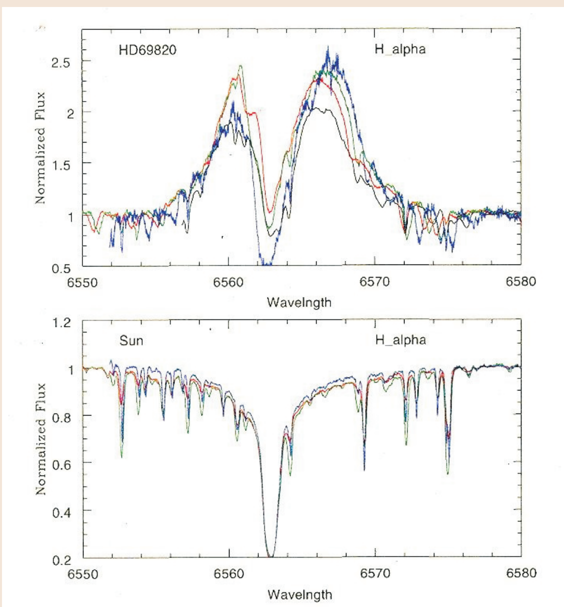


Figure 6. High-resolution spectra of HD 69820 around H-alpha, obtained fromVBT on different nights during 2005-2006. The strength of the red and blue emission peaks varies substantially versus time.

discovered All Sky AutomatedSurvey (ASAS) eclipsing binaries. Using the available observing facilities in India, the spectroscopic observations of a sample of 180 candidate eclipsing binary stars selected from ASAS-I&II releases were carried out during 2004-2006. The strength of Hα emission was used to characterize the level of chromospheric activity. The spectroscopic survey reveals that out of 180 stars about 36 binary systems show excess Hα emission. One of the objects of the sample, ASAS 081700-4243.8, displays very strong Hα emission. Follow-up high-resolution spectroscopic observations reveal that this object is indeed very interesting and most likely a classical Be-type system with K0III companion. [P. Parihar, S. Messina, P. Bama, **B. J. Medhi**, S. Muneer, C. Velu and A. Ahmad].

LO Pegasi: An investigation of multi-band optical polarization:

The *BVR* polarimetric study of the cool active star LO Pegasi (LO Peg) is presented for the first time. LO Peg was found to be highly polarized among the cool active stars. The observations yield average values of polarization in LO Peg: $P_B = 0.387 \pm 0.004$ per cent, $\theta_B = 88° \pm 1°$; $P_V = 0.351 \pm 0.004$ per cent, $\theta_V = 91° \pm 1°$ and $P_R = 0.335 \pm 0.003$ per cent, $\theta_R = 91° \pm 1°$. Both the degree of polarization and the position angle are found to be variable. The semi-amplitude of the polarization variability in *B, V* and *R* bands is found to be 0.18 ± 0.02, 0.13 ± 0.01 and 0.10 ± 0.02 per cent, respectively. It is suggested that the levels of polarization observed in LO Peg could be the result of scattering of an anisotropic stellar radiation field by an optically thin circumstellar envelope or scattering of the stellar radiation by prominence-like structures. **[J. C. Pandey, B. J. Medhi, R. Sagar** and **A. K. Pandey].**

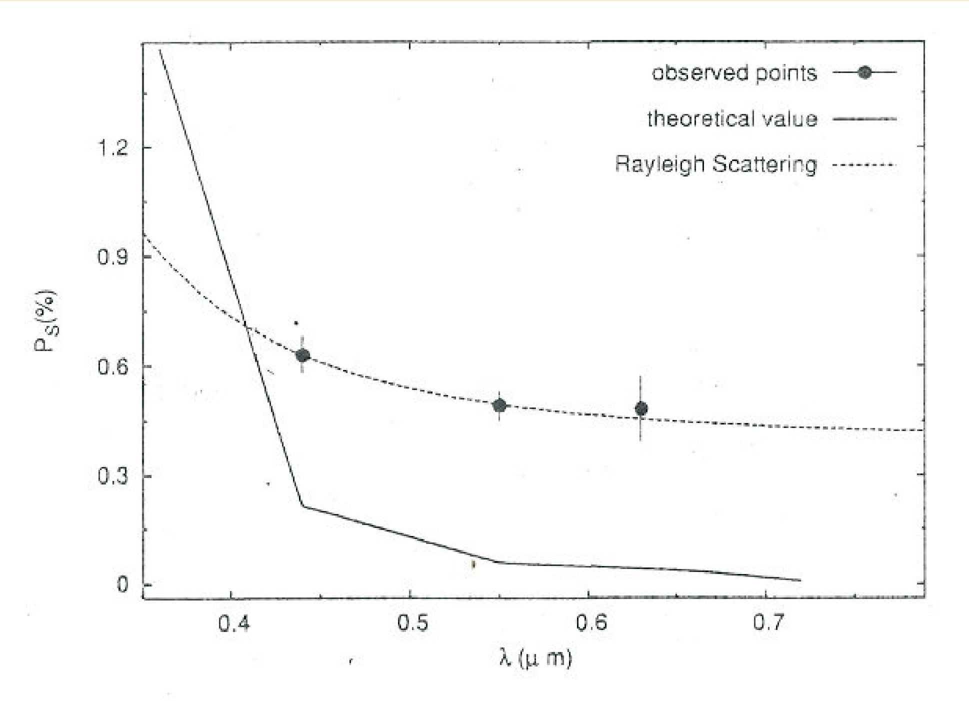


Figure 7. Wavelength dependence of the degree of polarization. The observed data points are represented by solid dots, and solid curve shows the expected theoretical values. Dashed line shows the Rayleigh scattering.

Exploring PMS variables of ONC: The new variables (I):

A long-term photometric observing program is being pursued since 2004 to monitor young stellar objects of Orion Nebula Cluster. About two thousands frames in V, R and I broad band filters were collected during more than two hundreds nights stretched over five consecutive observing seasons. This very precise and complete data give us an opportunity to address various phenomenon associated with the young stars. The prime motivations of this project are to explore various stellar surface activities in very young less massive stars, search for new PMS eclipsing binaries and to look for any transient activities associated with YSO's(EX/FU Ori). A large number of new variables detected from first five years of time-series photometric data are presented. It is emphasized that the single epoch photometric surveys, as carried out earlier, are incapable to identify all periodic variables and makes any such sample incomplete to be used to explore evolution of angular momentum of very young stellar objects. [P. Parihar, S. Messina, D. Elisa, N. S. Shantikumar and **B. J. Medhi].**

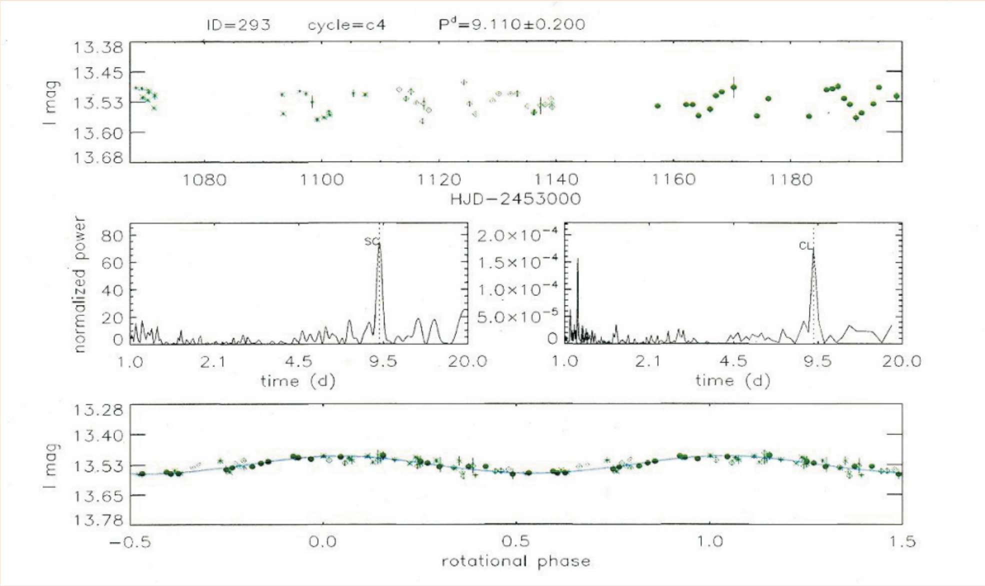


Figure 8. Results of periodogram analyses on the newly discovered periodic variable ID=293. Top panel: I-band time series data from cycle 4. Different symbols are used to better distinguish three different time intervals within the same observations season. Middle panels: Power spectra from Scargle (left) and CLEAN (right) analysis. The horizontal dashed line indicates the 99% confidence level, whereas the vertical dotted line marks the detected periodicity. Bottom panel: phased light curve using the detected period.

d. X-ray Astronomy

A study of X-ray flares - I. Active late-type dwarfs:

Using the observations from the *XMM-Newton* observatory, temporal and spectral characteristics of X-ray flares of six late-type G-K active dwarfs (V368 Cep, XI Boo, IMVir, V471 Tau, CC Eri and EP Eri) were studied. All the stars were found to be flaring frequently and altogether a total of 17 flares were detected above the 'quiescent' state X-ray emission which varied from 0.5 to 8.3 × 10^{29} erg s^{-1}. The largest flare was observed in a low-activity dwarf XI Boo with a decay time of 10 ks and ratio of peak flare luminosity to 'quiescent' state luminosity of 2. The spectral changes during the flares by using colour-colour diagram and by detailed spectral analysis during the temporal evolution of the flares were studied. The exponential decay of the X-ray light curves, and time evolution of the plasma temperature and emission measure are similar to those observed in compact solar flares. The semiloop lengths of flares were derived using the hydrodynamic flare model. The size of the flaring loops was found to be less than the stellar radius. The hydrodynamic flare decay analysis indicates the presence of sustained heating during the decay of most flares. **[J. C. Pandey** and K. P. Singh].

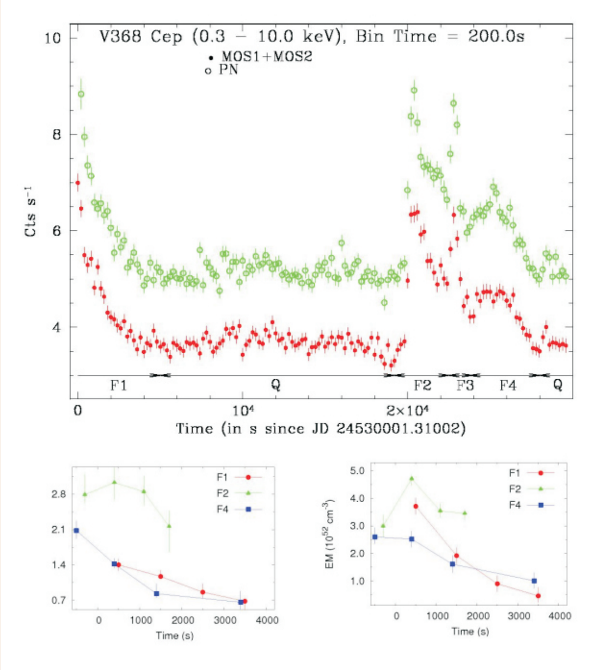


Figure 9. X-ray light curve of the active star V368 Cep. The bottom panles show the evolution of temperature and corresponding emission measure during the flare F1, F2 and F4 as shown on the top panel. The '0' time corresponds to the flare peak.

Chandra and XMM-Newton observations of the low-luminosity X-ray pulsators SAX J1324.4-6200 and SAX J1452.8-5949:

The *XMM-Newton* spectra of two low-luminosity X-ray pulsators SAX J1324.4-6200 and SAX J1452.8-5949, which have spin periods of 172 and 437 sec respectively, can be fitted well with a simple power-law model of photon index, $\Gamma \sim 1.0$. A blackbody model can equally well fit the spectra with a temperature, $kT \sim 2$ keV, for both sources. During *XMM-Newton* observations, SAX J1324.4-6200 is detected with coherent X-ray pulsations at a period of 172.86 ± 0.02 s while no pulsations with a pulse fraction greater than 18 per cent (at 95 per cent confidence level) in 0.2-12 keV energy band are detected in SAX J1452.8-5949. The spin period of SAX J1324.4-6200 is found to be increasing on a time-scale of $\dot{P}$ = (6.34 ± 0.08)×10^{-9} s s^{-1} which would suggest that the accretor is a neutron star and not a white dwarf. Using subarcsec spatial resolution of the *Chandra* telescope, possible counterparts are seen for both sources in the near-infrared images obtained with the son of infrared spectrometer and array camera (SOFI) instrument on the New Technology Telescope. The X-ray and near-infrared properties of SAX J1324.4-6200 suggest it to be a persistent high-mass accreting X-ray pulsar at a distance ≤8 kpc. The near-infrared counterpart of SAX J1452.8-5949 was found to be a late-type main-sequence star at a distance ≤10 kpc, thus ruling out SAX J1452.8-5949 to be a high-mass X-ray binary. However, with the present X-ray and near-infrared observations, any further conclusive conclusion about the nature of SAX J1452.8-5949 could not be made. **[R. Kaur,** R. Wijnands, A. Patruno, V. Testa, G. Israel, N. Degenaar, B. Paul and **B. Kumar].**

Observations of X-ray oscillations in ξ Boo: Evidence of a fast-kink mode in the stellar loops:

The observations of X-ray oscillations during the flare in a cool active star ξ Boo are reported for the first time. ξ Boo was observed by EPIC/MOS of the XMM-Newton satellite. The X-ray light curve is investigated with wavelet and periodogram analyses. Both analyses clearly show oscillations of the period of ~1019 s. These oscillations are interpreted as a fundamental fast-kink mode of magnetoacoustic waves. **[J. C. Pandey** and **A. K. Srivastava].**

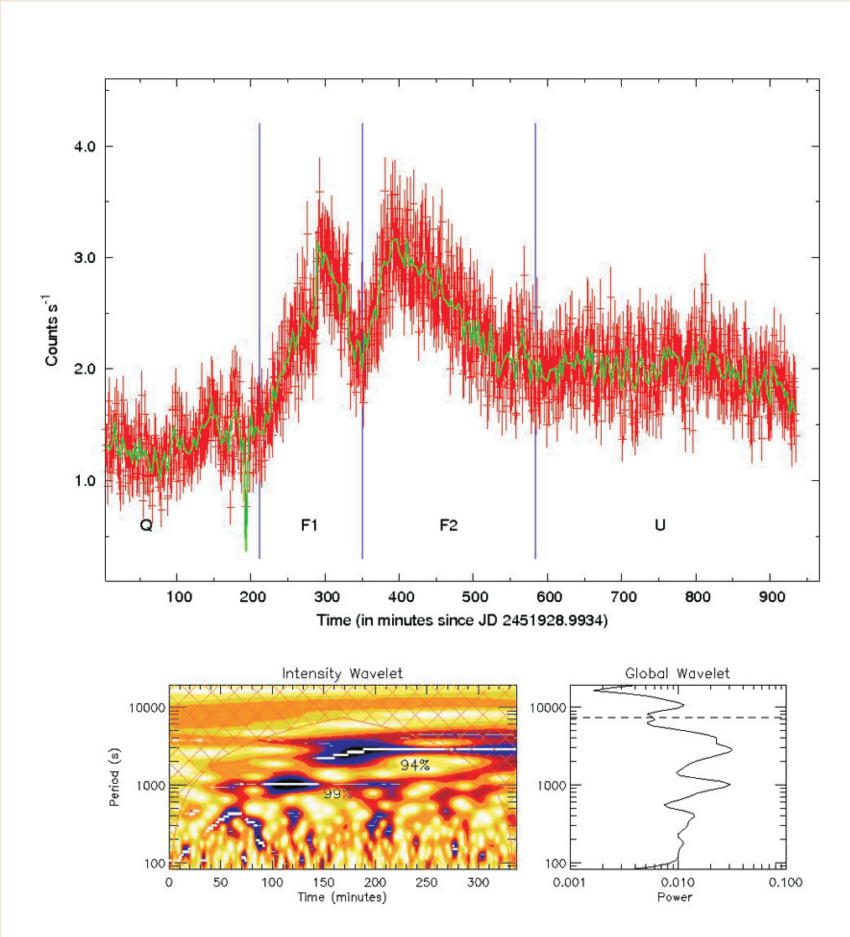


Figure 10. X-ray light curve of the the star xi Boo is shown in top panel. The figures in the lower panels are the wavelet power spectrum during the U part of the light curve as shown in top panel.

II. EXTRA GALATIC ASTRONOMY

Effects of fluid composition on spherical flows around black holes:

Steady, spherically symmetric, adiabatic accretion and wind flows around non-rotating black holes were studied for fully ionized, multicomponent fluids, which are described by a relativistic equation of state. It has been shown that the polytropic index depends on the temperature as well as on the composition of fluids, so the composition is important to the solutions of the flows. It has also been demonstrated that fluids with different composition can produce dramatically different solutions, even if they have the same sonic point, or they start with the same specific energy or the same temperature. It was further pointed that the Coulomb relaxation times can be longer than the dynamical time in the problem considered here, and its mplications were also discussed. **[I. Chattopadhyay** and D. Ryu].

a. GRBs and Supernovae

Two types of softening detected in x-ray afterglows of Swift bursts: Internal and external shock origins?:

The softening process observed in the steep decay phase of early x-ray afterglows of Swift bursts has remained a puzzle since its discovery. The softening process can also be observed in the later phase of the bursts and its cause has also been unknown. Recently, it was suggested that, influenced by the curvature effect, emission from high latitudes would shift the Band function spectrum from a higher energy band to a lower band, and this would give rise to the observed softening process accompanied by a steep decay of the flux density. The curvature effect scenario predicts that the terminating time of the softening process would be correlated with the duration of the process. Using the data from the UNLV GRB (University of Nevada, Las Vegas, Gamma-Ray Burst) group web-site, an obvious correlation was found between the two quantities. In addition, two classes were found for softening process: the early type softening ($t_{s,max} \leq$ '4000' s) and the late type softening ($t_{s,max} >$ '4000' s). The two types of softening show different behaviors in the duration versus terminating time plot. In the relation between the variation rates of the flux density and spectral index during the softening process, a discrepancy between the two types of softening is also observed. According to their timescales and the discrepancy between them, it has been proposed that the two types are of different origins: the early type is of internal shock origin and the late type is of external shock origin. The early softening is related to the steep decay just following the prompt emission, whereas for the late decay one typically conceives the transition from flat decay to late afterglow decay. It has been suspected that there might be a great difference in Lorentz factor between the two classes, which is responsible for the observed discrepancy. [Y-P. Qin, **A. C. Gupta,** J. H. Fan and R-J. Lu].

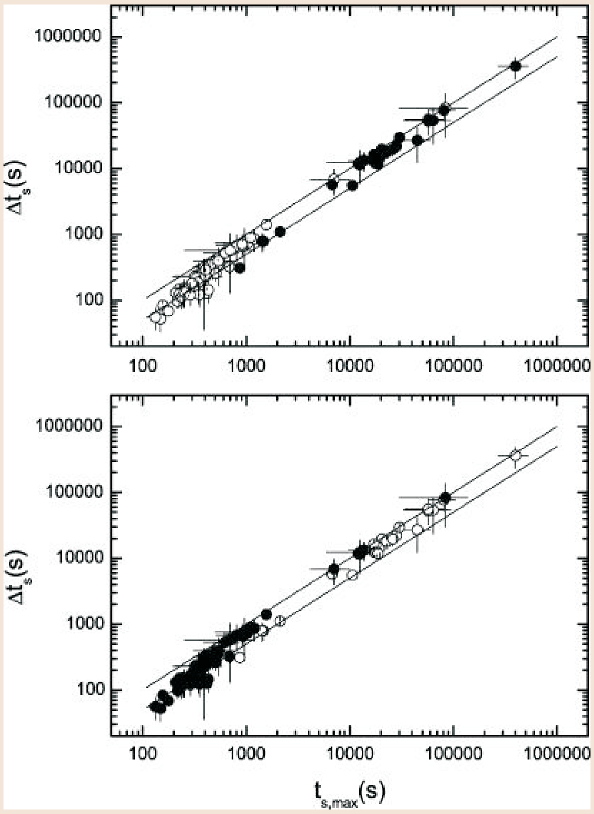


Figure 11. Relation between Δ*t*s and *ts*,max for the newly defined two types of the softening process. Filled circles in the upper panel and open circles in the lower panel represent the process with *ts*,min > 500 s (the newly defined late type softening process). Filled circles in the lower panel and open circles in the upper panel stand for the process with *ts*, min ≤ 500 s (the newly defined early type softening process)

The complex light curve of the afterglow of GRB 071010A:

Results of an extensive observational campaign devoted to GRB071010A, a long-duration gamma-ray burst detected by the *Swift* satellite have been presented. This event was followed for almost a month in the optical/near-infrared (NIR) with various telescopes starting from about 2 min after the high-energy event. *Swift* XRT observations started only later at about 0.4 d. The light-curve evolution has allowed to single out an initial rising phase with a maximum at about 7min, possibly the afterglow onset in the context of the standard fireball model, which is then followed by a smooth decay interrupted by a sharp rebrightening at about 0.6 d. The rebrightening was visible in both the optical/NIR and X-rays and can be interpreted as an episode of discrete energy injection, although various alternatives are possible. A steepening of the afterglow light curve is recorded at about 1 d. The entire evolution of the optical/NIR afterglow is consistent with being achromatic. This could be one of the few identified GRB afterglows with an achromatic break in the X-ray through the optical/NIR bands. Polarimetry was also obtained at about 1 d, just after the rebrightening and almost coincident with the steepening. This provided a fairly tight upper limit of 0.9 per cent for the polarized-flux fraction. [S. Covino,…et al.(including **K. Misra, S. B. Pandey** and **R. Roy)].**

Broadband observations of the naked - eye ϒ - ray burst GRB 080319B:

Long-duration ϒ -ray bursts (GRBs) release copious amounts of energy across the entire electromagnetic spectrum, and so provide a window into the process of black hole formation from the collapse of massive stars. Previous early optical observations of even the most exceptional GRBs (990123 and 030329) lacked both the temporal resolution to probe the optical flash in detail and the accuracy needed to trace the transition from the prompt emission within the outflow to external shocks caused by interaction with the progenitor environment. The observations of the extraordinarily bright prompt optical and ϒ-ray emission of GRB 080319B have been carried out, which provide diagnostics within seconds of its formation, followed by broadband observations of the afterglow decay that continued for weeks. It has been shown that the prompt emission stems from a single physical region, implying an extremely relativistic outflow that propagates within the narrow inner core of a two-component jet. [J. L. Racusin,…et al. (including **S. B. Pandey)]**.

Flares from a candidate galactic magnetar suggest a missing link to dim isolated neutron stars:

Magnetars are young neutron stars with very strong magnetic fields of the order of 10^{14}-10^{15} G. They are detected in our Galaxy either as soft ϒ-ray repeaters or anomalous X-ray pulsars. Soft ϒ-ray repeaters are a rare type of ϒ-ray transient sources that are occasionally detected as bursters in the high-energy sky. No optical counterpart to the ϒ-ray flares or the quiescent source has yet been identified. Multi-wavelength observations of a puzzling source, SWIFT J1955091261406 have been presented. More than 40 flaring episodes in the optical band over a time span of three days, and a faint infrared flare 11 days later were detected, after which the source returned to quiescence. Radio observations confirm a Galactic nature and establish a lower distance limit of ~3.7 kpc. It has been suggested that SWIFT J1955091261406 could be an isolated magnetar whose bursting activity has been detected at optical wavelengths, and for which the long-term X-ray emission is short-lived. In this case, a new manifestation of magnetar activity has been recorded and it led to consider SWIFT J1955091261406 could be a link between the 'persistent' soft ϒ-ray repeaters/anomalous X-ray pulsars and dim isolated neutron stars. [A. J. Castro-Tirado, … et al. (including **S. B. Pandey)].**

Photometric and spectroscopic study of a highly reddened type Ia supernova SN 2003hx in NGC 2076:

The *UBVRI* CCD photometry and optical spectra of the type Ia supernova SN 2003hx which appeared in the galaxy NGC 2076, were obtained till ~ 146 d after the epoch of B-band maximum. The supernova reached at maximum brightness in B band on JD 245 2893 ± 1.0 with an apparent magnitude of 14.92 ± 0.01 mag which was estimated by making template fits to the light curves. SN 2003hx is an example of a highly reddened supernova with $E(B - V) = 0.56 \pm 0.23$. The estimated value of R_v = 1.97 ± 0.54 indicates that the size of dust particles is small as compared to their galactic counterparts. The luminosity decline rate is $\Delta m_{15}(B) = 1.17 \pm 0.12$ mag and the absolute B-band magnitude obtained from the luminosity versus decline rate relation (Phillips et al. 1999) is M^B max =-19.20 ± 0.18 mag. The peak bolometric luminosity indicates that ~0.66 $M_{\odot}$ mass of ^{56}Ni was ejected by the supernova. The spectral evolution indicates the supernova to be a normal type Ia event. **[K. Misra,** D. K. Sahu, G. C. Anupama and K. Pandey].

The rapidly flaring afterglow of the very bright and energetic GRB 070125:

The multiwavelength observations, ranging from X-ray to radio wave bands, of the IPN-localized gammaray burst GRB 070125 were carried out. Spectroscopic observations reveal the presence of absorption lines due to O $_{I}$, Si $_{II}$, and C $_{IV}$, implying a likely redshift of z = 1.547. The well-sampled light curves, in particular from 0.5 to 4 days after the burst, suggest a jet break at 3.7 days, corresponding to a jet opening angle of ~7.0°, and implying an intrinsic GRB energy in the 1-10,000 keV band of around Eϒ = (6.3-6.9) x 10^{51} ergs (based on the fluences measured by the gamma-ray detectors of the IPN).GRB 070125 is among the brightest afterglows observed to date. The SED implies a host extinction of AV < 0.9 mag. Two rebrightening episodes are observed, one with excellent time coverage, showing an increase in flux of 56% in ~8000 s. The evolution of the afterglow light curve is achromatic at all times. Late-time observations of the afterglow do not show evidence for emission from an underlying host galaxy or supernova. Any host galaxy would be subluminous, consistent with current GRB host galaxy samples. Evidence for strong Mg $_{II}$ absorption features is not found, which is perhaps surprising in view of the relatively high redshift of this burst and the high likelihood for such features along GRB-selected lines of sight. [A. C. Updike, … et al. (including **K. Misra)].**

Multiwavelength analysis of the intriguing GRB 061126: The reverse shock scenario and magnetization:

A detailed study of the prompt and afterglow emission from Swift GRB 061126 using BAT, XRT, UVOT data and multicolor optical imaging from 10 ground-based telescopes were presented. GRB 061126 was a long burst (T_{90} = 191 s) with four overlapping peaks in its ϒ-ray light curve. The X-ray afterglow, observed from 26 minutes to 20 days after the burst, shows a simple power-law decay with $\alpha_X = 1.290 \pm 0.008$. Optical observations presented here cover the time range from 258 s (Faulkes Telescope North) to 15 days (Gemini North) after the burst; the decay rate of the optical afterglow shows a steep-to-shallow transition (from $\alpha_1 = 1.48 \pm 0.06$ to $\alpha_2 = 0.88 \pm 0.03$) approximately 13 minutes after the burst. It has been suggested that the early, steep component is due to a reverse shock and show that the magnetic energy density in the ejecta, expressed as a fraction of the equipartition value, is a few 10 times larger than in the forward shock in the early afterglow phase. The ejecta might be endowed with primordial magnetic fields at the central engine. The optical light curve implies a late-time break at about 1.5 days after the burst, while there is no evidence of the simultaneous break in the X-ray light curve. Modeling of broadband emission has shown that some afterglow characteristics (the steeper decay in X-ray and the shallow spectral index from optical to X-ray) are difficult to explain in the framework of the standard fireball model. This might imply that the X-ray afterglow is due to an additional emission process, such as late-time central engine activity rather than blast-wave shock emission. The possible chromatic break at 1.5 days after the burst would give support to the additional emission scenario. [A. Gomboc, … et al. (including **K. Misra)].**

An insight into the progenitors of gamma ray bursts from the optical afterglow observations:

At ARIES, Nainital, detailed investigation for more than 50 gamma ray bursts (GRBs) fields has been carried out since January 1999 and optical afterglow observations for 27 of them were successfully obtained. Upper limits were reported for the rest of the cases. Optical observations of GRB afterglows provide information about GRB distances, nature of emission, surroundings, their environments and progenitors. The presence of supernova signature in long-duration GRB afterglows has further strengthened the fact that the collapse of a massive star gives rise to a long-duration GRBs. However, the observed properties of short-duration GRBs are in agreement with the NS-NS or NS-BH coalescence model. **[K. Misra** and **R. Sagar].**

Optical observations of GRB 050401 afterglow: A case for double jet model:

The afterglow of GRB 050401 presents several novel and interesting features. (i) An initially faster decay in optical band than in X-rays. (ii) A break in the X-ray light curve after ~0.06 day with an unusual slope after the break. (iii) The X-ray afterglow does not show any spectral evolution across the break while the R-band light curve does not show any break. The observed multiband evolution of the afterglow of GRB 050401 were modelled as originating in a two-component jet, and interpreting the break in X-ray light curve as due to lateral expansion of a narrow collimated outflow which dominates the X-ray emission. The optical emission is attributed to a wider jet component. Model has reproduced all the observed features of multib and afterglow of GRB 050401. The optical observations of GRB 050401 were carried out using the 104-cm Sampurnanand Telescope at the Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital. Results of the analysis of multiband data are presented and compared with GRB 030329, the first reported case of double jet. [A. Kamble, **K. Misra,** D. Bhattacharya and **R. Sagar].**

b. Quasars

Simultaneous Multi-Wavelength Observations of the TeV Blazar Mrk 421 during February - March, 2003: X-Ray and NIR Correlated Variability:

The result of simultaneous multi-wavelength observations of the TeV blazar Mrk 421 during February - March 2003 has been reported. Mrk 421 was observed using the Pachmarhi Array of Cerenkov Telescopes (PACT) of Tata Institute of Fundamental Research at Pachmarhi, India. Other simultaneous data were taken from the literature and public data archives. The high quality X-ray (2-20 keV) observations from the NASA Rossi X-Ray Timing Explorer (RXTE) were analysed. A possible correlated variability between X-ray and J band (1.25 μ) near infrared (NIR) wavelength has been obtained. This is the first case of X-ray and NIR correlated variability in Mrk 421 or any high energy peaked (HBL) blazar. The correlated variability reported here indicates a similar origin for the NIR and X-ray emissions. The emission is not affected much by the environment of the surrounding medium of the central engine of Mrk 421. The observations are consistent with the shock-in-jet model for the emissions. **[A. C. Gupta,** B. S. Acharya, Debanjan Bose, Varsha R. Chitnis and Jun-Hui Fan Chin].

A new activity phase of the blazar 3C 454.3: Multifrequency observations by the WEBT and XMM-Newton in 2007-2008:

The Whole Earth Blazar Telescope (WEBT) consortium has been monitoring the blazar 3C 454.3 from the radio to the optical bands since 2004 to study its emission variability properties. The multi-frequency results of the 2007-2008 observing season, including XMM-Newton observations and near-IR spectroscopic monitoring, and compare the recent emission behavior with the past one was presented. The historical mm light curve is presented here for the first time. In the optical band a multi-peak outburst was observed in July-August 2007, and other faster events in November 2007 - February 2008. During these outburst phases, several episodes of intranight variability were detected. A mm outburst was observed starting from mid 2007, whose rising phase was contemporaneous to the optical brightening. A slower flux increase also affected the higher radio frequencies, the flux enhancement disappearing below 8 GHz. The analysis of the optical-radio correlation and time delays, as well as the behaviour of the mm light curve, confirm our previous predictions, suggesting that changes in the jet orientation likely occurred in the last few years. The historical multi-wavelength behaviour indicates that a significant variation in the viewing angle may have happened around year 2000. Colour analysis confirms a general redder-when-brighter trend, which reaches a "saturation" at R ~ 14 and possibly turns into a bluer

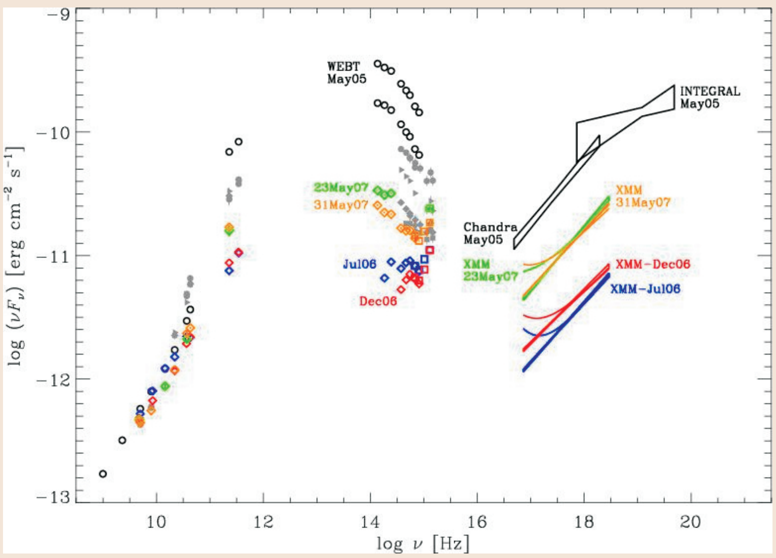


Figure 12. Broad-band SED of 3C 454.3 at various epochs. Radio-to-optical data acquired by the WEBT in May 2005 are displayed as black circles; in the optical they indicate the range of variability observed during the Chandra and INTEGRAL pointings. Grey filled symbols refer to the SEDs presented by Raiteri et al. (2008a), built with WEBT and Swift-UVOT data taken in November-December 2007. Coloured SEDs show data obtained during observations by XMM-Newton; the July and December 2006 data are from Raiteri et al. (2007b). Both a power law and a double power law fits to the EPIC spectra are reported (see text for details); the OM data are indicated by empty squares and the WEBT data by empty diamonds.

-when-brighter trend in bright states. This behaviour is due to the interplay of different emission components, the synchrotron one possibly being characterised by an intrinsically variable spectrum. All the near-IR spectra show a prominent Hα emission line (EW_{obs} = 50-120 Å), whose flux appears nearly constant, indicating that -when-brighter trend in bright states. This behaviour is due to the interplay of different emission components, the synchrotron one possibly being characterisedthe broad line region is not affected by the jet emission. The broad-band SEDs corresponding to the epochs of the XMM-Newton pointings were presented and were compared to those obtained at other epochs, when the source was in different brightness states. A double power-law fit to the EPIC spectra including extra absorption suggests that the soft-X-ray spectrum is concave, and that the curvature becomes more pronounced as the flux decreases. This connects fairly well with the UV excess, which becomes more prominent with decreasing flux. The most obvious interpretation implies that, as the beamed synchrotron radiation from the jet dims, both the head and the tail of the big blue bump can be seen. The X-ray flux correlates with the optical flux, suggesting that in the inverse-Compton process either the seed photons are synchrotron photons at IR-optical frequencies or the relativistic electrons are those that produce the optical synchrotron emission. The X-ray radiation would thus be produced in the jet region from where the IR-optical emission comes. [C. M. Raiteri,...et al. (75 authors including **A. C. Gupta** and **R. Sagar)].**

Results of WEBT, VLBA and RXTE monitoring of 3C 279 during 2006-2007:

The quasar 3C 279 is among the most extreme blazars in terms of luminosity and variability of flux at all wavebands. Its variations in flux and polarization are quite complex and therefore require intensive monitoring observations at multiple wavebands to characterise and interpret the observed changes. In this study, radio-to-optical data taken by the WEBT, supplemented by VLBA and RXTE observations, of 3C 279 were presented. The goal is to use this extensive database to draw inferences regarding the physics of the relativistic jet. The assemble multifrequency light curves with data from 30 ground-based observatories and the space-based instruments SWIFT (UVOT) and RXTE, along with linear polarization vs. time in the optical R band. In addition, a sequence of 22 images (with polarization vectors) at 43 GHz at resolution 0.15 milliarcsec, obtained with the VLBA has also been presented. The light curves and polarization data as well as the spectral energy distributions at different epochs, corresponding to different brightness states were analysed. It was found that the IR-optical-UV continuum spectrum of the variable component corresponds to a power law with a constant slope of -1.6, while in the 2.4-10 keV X-ray band it varies in slope from -1.1 to -1.6. The steepest X-ray spectrum occurs at a flux minimum. During a decline in flux from maximum in late 2006, the optical and 43 GHz core polarization vectors rotate by ~300°. The continuum spectrum agrees with steady injection of relativistic electrons with a power-law energy distribution of slope -3.2 that is steepened to -4.2 at high energies by radiative losses. The X-ray emission at flux minimum comes most likely from a new component that starts in an upstream section of the jet where inverse Compton scattering of seed photons from outside the jet is important. The rotation of the polarization vector implies that the jet contains a helical magnetic field that extends ~20 pc past the 43 GHz core. [V. M. Larionov, ... et al. (71 authors including **A. C. Gupta)].**

Multicolor Near-Infrared Intra-day and Short Term Variability of the Blazar S5 0716+714:

The results of near-infrared (NIR) photometric variability studies of the BL Lacertae (BL Lac) object S5 0716+714 were presented. NIR photometric observations were spread over seven nights during observing run on 2007 April 2-9 at the 1.8 m telescope equipped with the Korea Astronomy and Space Science Institute Near-Infrared Camera System and J, H, and K_s filters at Bohyunsan Optical Astronomy Observatory, South Korea. To search for intra-day variability (IDV), short-term variability, and color variability in the BL Lac object the observations were carried out. No genuine IDV in any of the J, H, and K_s passbands was detected in observing run. Significant short-term variabilities ~32.6%, 20.5% and 18.2% have been detected in the J, H, and Ks passbands, respectively, and ~11.9% in (J - H) color. [**A. C. Gupta**, S-M Cha, S. Lee, H. Jin, S. Pak, Seoung-hyun Cho, B. Moon, Y. Park, In-Soo Yuk, Uk-won Nam and Jae-Mann Kyeong].

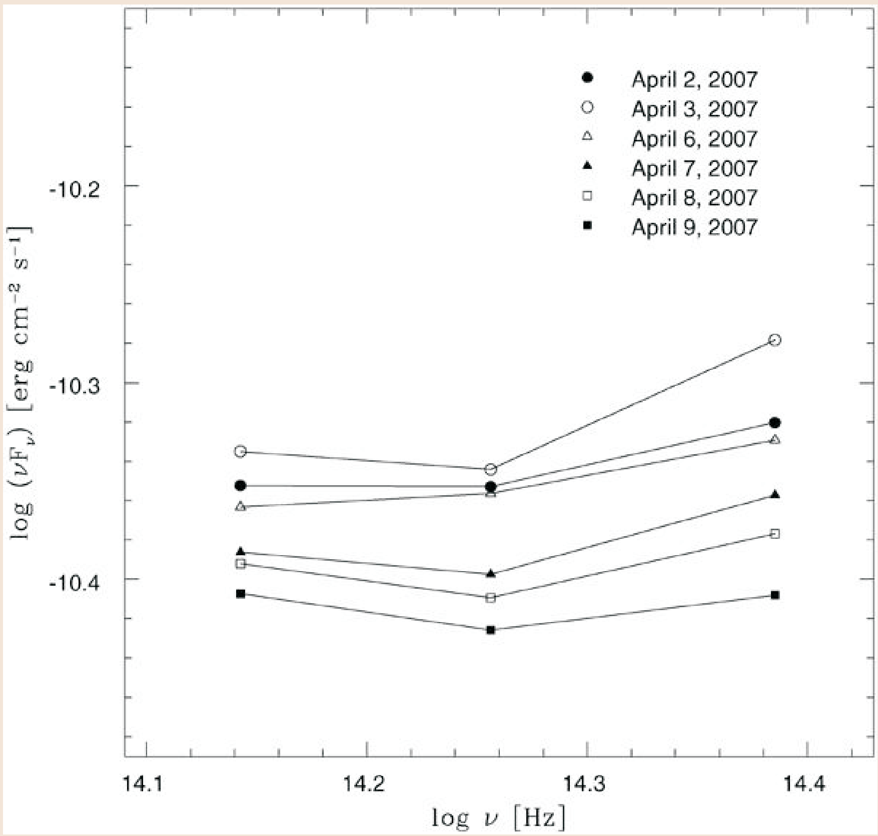


Figure 13. Spectral behavior of S5 0716+714 for six nights during 2007 April 2-9. Different symbols are used for different dates.

Periodic Oscillations in the Intra-day Optical Light Curves of the Blazar S5 0716+714:

The results of a periodicity search of 20 intra-day variable optical light curves of the blazar S5 0716+714, selected from a database of 102 light curves spanning over three years. Using a wavelet analysis technique along with a randomization test, have been strong candidates for nearly periodic variations in eight light curves, with probabilities ranging from 95% to >99% were found. This is the first good evidence for periodic, or more precisely, quasi-periodic, components in the optical intra-day variable light curves of any blazar. Such periodic flux changes support the idea that some active galactic nuclei variability, even in blazars, is based on accretion disk fluctuations or oscillations. These intra-day variabilitytimescales were used to estimate that the central black hole of the blazar S5 0716+714 has a mass >2.5 × 106 $M_{\odot}$. Any correlation was not found between the flux levels and intra-day variability timescales, it appears that more than one emission mechanism is at work in this blazar. **[A. C. Gupta, A. K. Srivastava** and P. J. Wiita].

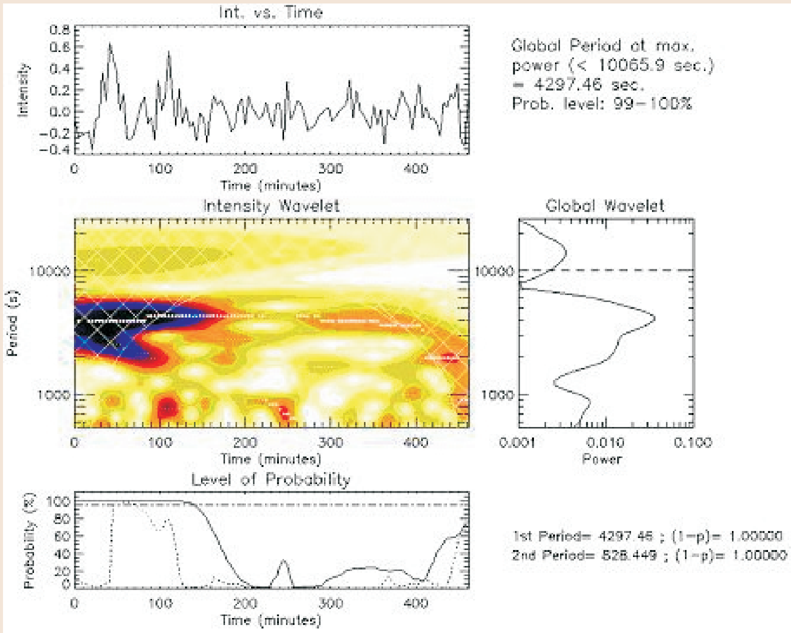


Figure 14. Wavelet analysis for the light curve of the blazar S5 0716+714 for the date 2002 April 22. The top panel shows the variation of fluxes computed from the data of Montagni et al. (2006) with the overall most significant period described at the top right. The wavelet power spectrum is given in the middle panels, with the shortest scales at the bottom. The probabilities of the two strongest peaks being real at different times are plotted in the bottom left panel with the maximum probabilities given at the bottom right.

Quasi-simultaneous two band optical micro-variability of luminous radio-quiet QSOs:

First results of quasi-simultaneous two passband optical monitoring of six quasi-stellar objects to search for micro-variability have been reported. The photometric monitoring of these sources in an alternating sequence of R and V passbands was carried out, for five radio-quiet quasi-stellar objects (RQQSOs), 0748 + 291, 0824 + 098, 0832 + 251, 1101 + 319, 1225 + 317 and one radio-loud quasi-stellar object (RLQSO), 1410 + 429. No micro-variability was detected in any of the RQQSOs, but convincing micro-variability was detected in the RLQSO on two successive nights it was observed. Using the compiled data of optical micro-variability of RQQSOs till date, the duty cycle for micro-variability in RQQSOs was found to be ~ 10%. The present investigation indicates that micro-variability is not a persistent property of RQQSOs but an occasional incident. [**A. C. Gupta** and W. Yuan].

The whole earth Blazar telescope campaign on the intermediate BL Lac Object 3C 66A in 2007-2008:

Prompted by a high optical state in 2007 September, the Whole Earth Blazar Telescope consortium organized an intensive optical, near-IR (JHK) and radio observing campaign on the intermediate BL Lac object 3C 66A throughout the fall and winter of 2007-2008. The data from 28 observatories in 12 countries, covering the observing season from late 2007 July through 2008 February were presented. The source remained in a high optical state through out the observing period and exhibited several bright flares on timescales of ~10 days. This included an

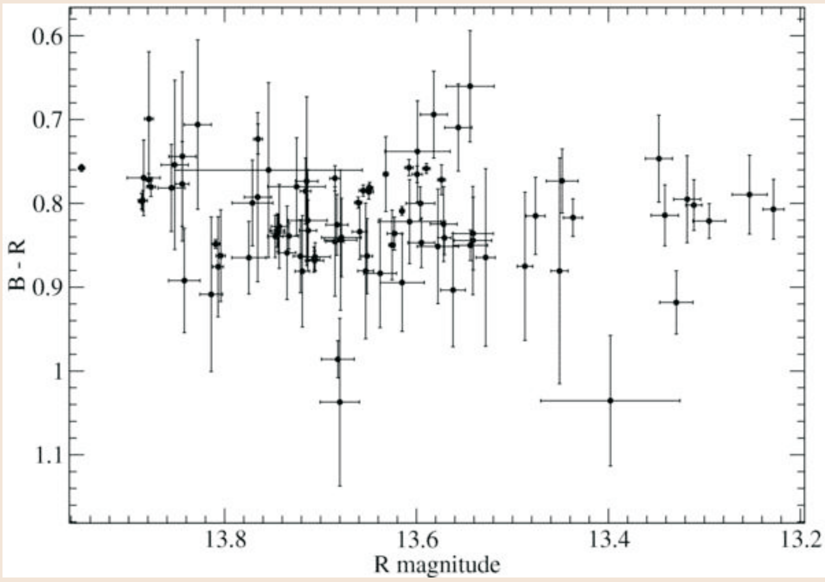


Figure 15. Intrinsic optical hardness-intensity diagram for the complete data set over the entire duration of the campaign. No correlation of the B-R index with R-band magnitude can be identified.

exceptional outburst around 2007 September 15-20, reaching a peak brightness at R ~ 13.4. Our campaign revealed microvariability with flux changes up to $|dR/dt| \sim 0.02$ mag hr^{-1}. The observations do not reveal evidence for systematic spectral variability in the overall high state covered in the campaign, in agreement with previous results. In particular, no evidence for spectral hysteresis in 3C 66A was found, for which hints were found in an earlier campaign in a somewhat lower flux state. No evidence for spectral lags in the discrete correlation functions between different optical bands was found. A value of the magnetic field in the emission region of $B \sim 19\ e^{2/7}B\ -^{6/7}h\ D^{13/7}1$ G was infered, where e_B is the magnetic field equipartition fraction, h is the shortest observed variability timescale in units of hours, and D1 is the Doppler factor in units of 10. From the lack of systematic spectral variability, an upper limit on the Doppler factor, $D \leq 28\ \tau\ -^{1/8}h\ e^{3/16}B$ was derived. This is in perfect agreement with superluminal motion measurements with the VLBI/VLBA of βapp ≤ 27 and arguesagainst models with very high Lorentz factors of 50, required for a one-zone synchrotron-self-Compton interpretation of some high-frequency-peaked BL Lac objects detected at TeV γ -ray energies. [M. Bottcher, ... et al. (55 authors including **A. C. Gupta)].**

Observation of multiple sausage oscillations in cool post-flare loop:

The oscillations in relative intensity were studied to explore the possibility of sausage oscillations in the chromospheric cool post-flare loop using simultaneous high spatial (1.3 arcsec) and temporal (5 and 10 s) resolution Hα observations from the 15 cm Solar Tower Telescope at ARIES. Oscillation periods of ≈587 sec near the loop apex and ≈349 sec near the footpoint were estimated. It is suggested that the oscillations represent the fundamental and the first harmonics of the fast-sausage waves in the cool post-flare loop. Based on the period ratio $P1/P2$~1.68, the density scaleheight in the loop is estimated as ~17 Mm. This value is much higher than the equilibrium scaleheight corresponding to Hα temperature, which probably indicates that the cool post-flare loop is not in hydrostatic equilibrium. Seismologically estimated Alfv´en speed outside the loop is ~300-330 km s^{-1}. The observation of multiple oscillations may play a crucial role in understanding the dynamics of lower solar atmosphere, complementing such oscillations already reported in the upper solar atmosphere (e.g. hot flaring loops). [**A. K. Srivastava,** T. V. Zaqarashvili, **W. Uddin,** B. N. Dwivedi and **P. Kumar**].

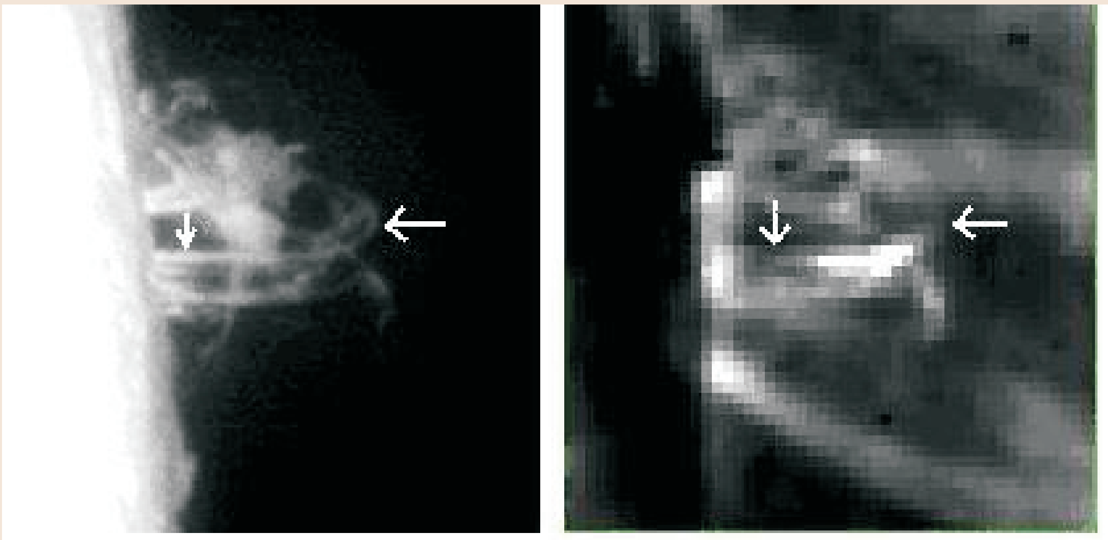


Figure 16. The Hα post-flare loops as observed by 15-cm Solar Tower Telescope. The FOV is 200 × 200 pixel (or 130 × 130 arcsec2) (left panel). The aligned SOHO/EIT Fe IX/X 171 Å image of the same loop system is presented in the right panel.

Hα, EUV and UV analysis of an eruptive 3B/X1.2 flare:

Hα observations of an extremely energetic eruptive flare 3B/X1.2 from superactive region NOAA 10486, taken on 26 October 2003 with 15-cm Solar Tower Telescope show long multi ribbon eruptions along a large twisted (sigmoid) filament in a high gradient (~90°) magnetic field and shear. The evolution pattern of this flare is similar in EUV and UV. Four eruptive centers or kernels in Hα have been chosen, wherein K_1 shows two prominent peaks while K_3 exhibits only one prominent peak with gradual decay. The analysis shows that this is a classical long duration event (LDE). The results have been discussed in the light of existing theories. [S. Pande, B. Pande, **W. Uddin** and K. Pandey].

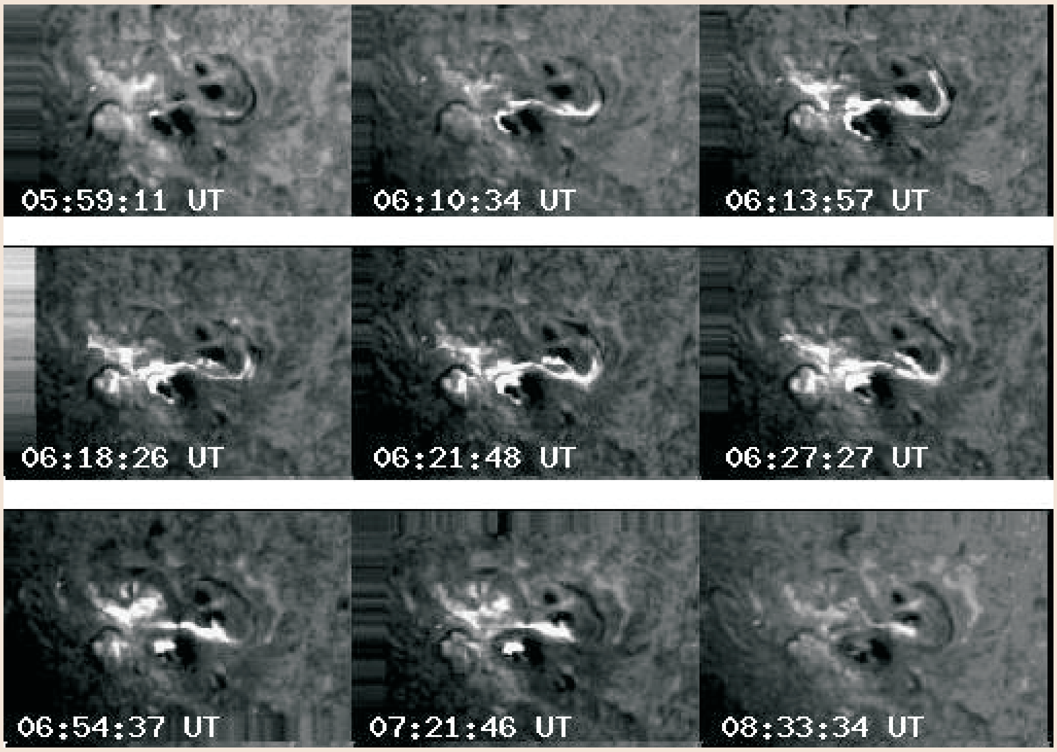


Figure 17. Evolution of 3B/X1.2 class flare in Hα on 26 October 2003 from NOAA 10486 observed at ARIES.

Network loop oscillations with EIS/Hinode:

Analysis of a time sequence of He II 256.32 images obtained with EIS/Hinode has been carried out with sampling of a small magnetic loop in the magnetic network. Wavelet analysis indicates 11-min periodicity close to the apex of this loop. This oscillation is interpreted as forcing through upward leakage by the fundamental acoustic eigenmode of the underlying field-free cavity. The observed loop length corresponds to the value predicted from this mechanism. Using standard wavelet analysis, ~11 min periodicity in the intensity oscillation has been found at the loop apex. This oscillation seems to be excited from eigen-mode oscillation leakage from a field-free cavity under the magnetic loop. Srivastava et. al. (2008,A7A, 481, L95) have solved the ideal MHD equations in cylindrical geometry for such a cavity and an overlying magnetic loop, and merge the solutions at the interface to obtain an analytical dispersion relation. Their plot of this dispersion relation for the fundamental harmonic (m = 1 in cylindrical coordinates) reveals that ~11 min observed periodicity is reproduced when the length of the cavity-loop interface is about 3500 km. This estimate agrees well with the observed loop length. Hence, the conclusion is that indeed the fundamental harmonic of the field-free cavity may force the observed oscillation in the small overlying loop. **[A. K. Srivastava,** D. Kuridze, T. V. Zaqarashvili, B. N. Dwivedi and **B. Rani].**

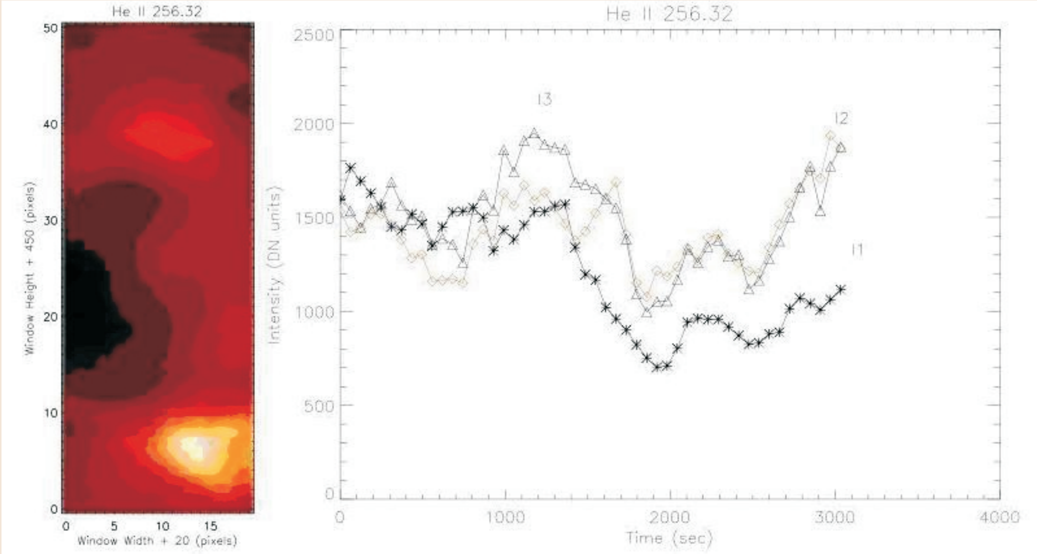


Figure 18. Left : partial image in He II 256.32°A showing bright magnetic network. Right : intensity versus time for the loop apex (I2) and footpoints (I1 and I3). The similarity of the temporal intensity profiles indicates the presence of a closed system such as a small-scale loop in this bright magnetic network.

Characteristics of aerosols over the Central Himalayas during ICARB:

During an integrated campaign for aerosol, gases and radiation budget (ICARB) measurements of aerosol and trace gases were carried out from various platforms. These observations were made mainly in three segments, namely (i) the land-based observations of aerosols and trace gases (over main land, high land and island) (ii) Ship board measurements over the Bay of Bengal and Arabian Sea, and (iii) aircraft measurements of altitude profiles of aerosols and trace gasses. The campaign was basically for a period of two months from March 01, 2006. In the land segment all the Multi Wavelength Radiometers (MWR) at various ISRO-GBP network stations spread all over India and adjoining island regions were operated to get the spectral AOD and their spatial variations. There were eight observatories spread over geographically distinct environments of India, (which included five mainland stations, one highland station, and two island stations (one each in Arabian Sea and Bay of Bengal). The salient results that came out of these inter-institutional collaboration are summarized as under:

The highland station Nainital, in the central Himalayas, showed very low values of AOD and BC, even lower than that of the island station at Port Blair, indicating the prevalence of cleaner environment over there. Additionally, Nainital showed an opposite diurnal pattern in BC, when compared with mainland and island sites, with an afternoon high and a late night or early morning low BC values. Generally, Diurnal Variations at all stations are mainly caused by the dynamics of local Atmospheric Boundary Layer (ABL). The AODs and the derived Ångström parameters showed considerable variations across India during the above period. While at the southern peninsular stations the AODs decreased towards May after a peak in April; in the north Indian regions they increased continuously from March to May. The Ångström coefficients suggested enhanced coarse mode loading in the north Indian regions, compared to southern India. Nevertheless, as months progressed from March to May, the dominance of coarse mode aerosols increased in the columnar aerosol size spectrum over the entire Indian mainland, maintaining the regional distinctiveness. [Beegum, ...et al. (including **P. Pant** and **U. C. Dumka**)].

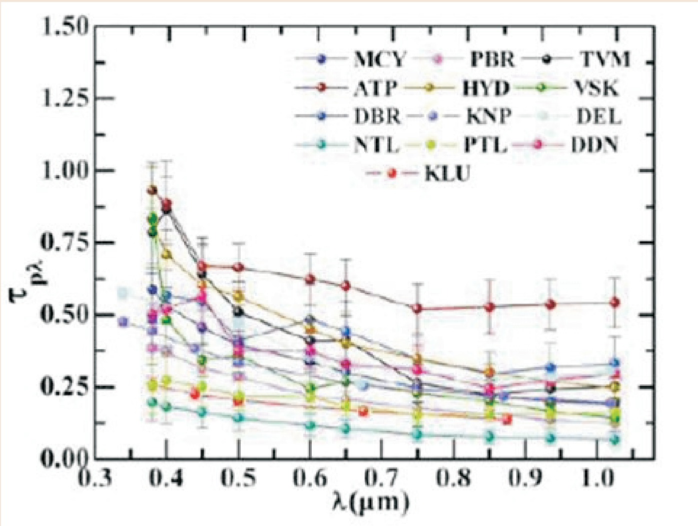


Figure 19. Monthly mean spectral variations of AOD for different land sites during March 2006. (In the above, ATP denotes Anantpur, DBR denotes Dibrugarh, DEL denotes Delhi, etc.).

The spectral AOD measurements at other two site in northern India, Patiala and Mohal-Kullu showed a similar seasonal variation to that observed over Nainital. The higher atmospheric turbidity in May at Patiala is attributed to dust transported by southerly winds. The mean total suspended particulate matter is 334.41 ± 97.56 μgm/m3, an indication of high aerosol loading over Patiala during the campaign period. [M. Singh, D. Singh and **P. Pant]**.

High values of AODs at Mohal-Kullu are suggested to be due to long-range transport from the Great Sahara and the Thar Desert regions and probably by biomass burning and frequent incidents of forest fire at local levels. [J. C. Kuniyal, ...et al. (including **P. Pant)].**

Lidar observations in association with optical properties of aerosols:

In order to study the aerosol backscatter profiles, a portable micro pulse lidar (MPL) system was installed in the year 2006 at Manora Peak, (29°22′N, 79°27′E, ~1960 m amsl) Nainital, a high altitude location in the central Himalayas. In the present

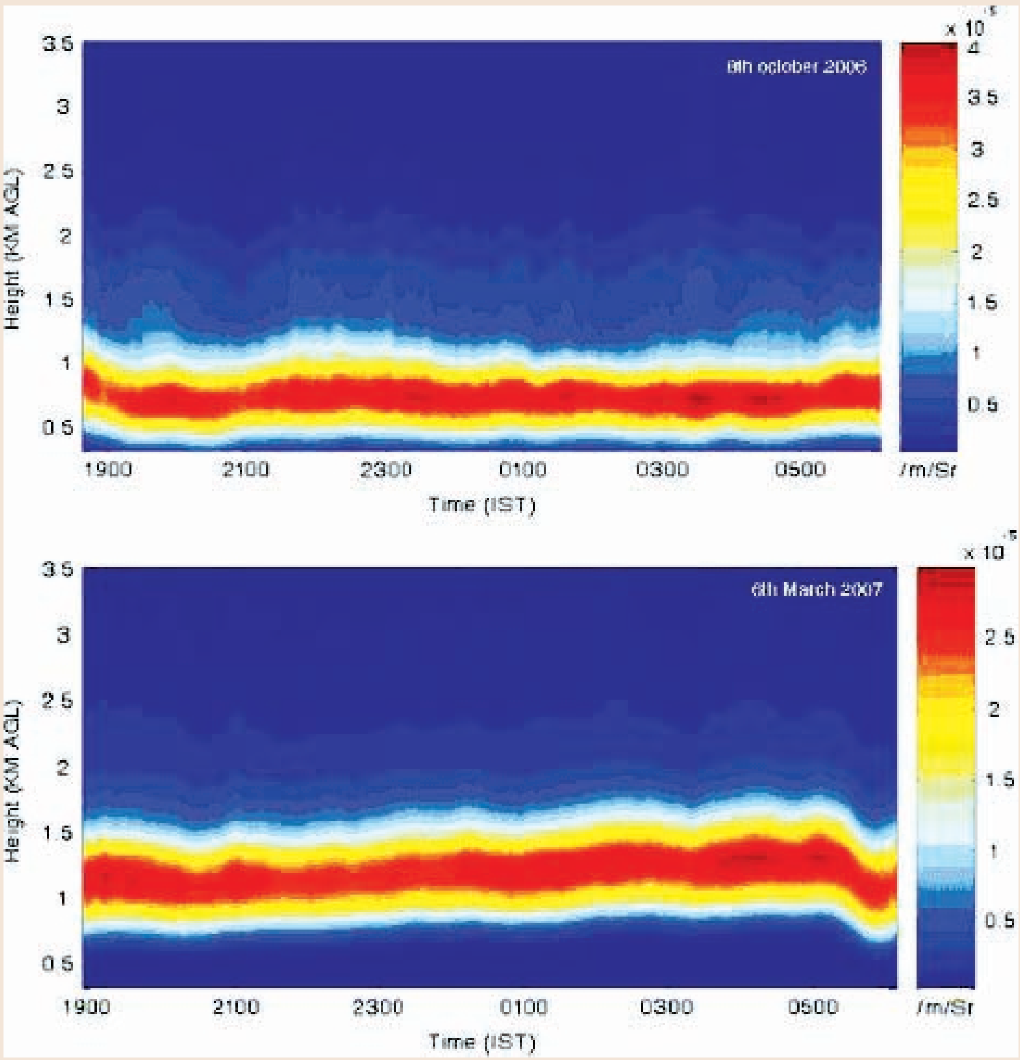


Figure 20. Night-time variation of the attenuated backscatter return, beta (1/m/sr) observed on 8 October 2006 (upper panel) and 6 March 2007 (lower panel).

ATMOSPHERIC SCIENCES

study the results of observed lidar profiles, columnar aerosol optical depths (AOD) and prevailing meteorology during May 2006 to June 2007 are presented. Although the lidar was operated from a sparsely inhabited free tropospheric site, nevertheless the height distribution of aerosol layers is found to be extended up to a summit of ~2 km above the ground level (AGL). The backscatter ratio (BSR) varies from ~10 to ~20 having lowest values during post monsoon and highest during pre-monsoon period. The observed boundary layer height during post monsoon was shallower than in the pre-monsoon period. Occasionally the lidar profiles reveal the presence of cirrus clouds at an altitude of 8-10 km AGL. The extended lidar observations over Manora Peak not only provided the profiles of aerosol extinction coefficient but also significantly substantiate the elevated aerosol layers and clouds, which are important in the study of climate modeling. **[P. Hegde, P. Pant** and Y. B. Kumar].

Retrieval of columnar aerosol size distributions from spectral attenuation measurements:

The columnar size distribution [CSD; nc(r)] function of aerosols has been derived from spectral AOD data for period January 2002 - December 2005. The CSD, retrieved from spectral AODs are, in general, bimodal with a prominent secondary mode occurring at a fairly large value of radius ($r > 0.5\,\mu$m), while the primary mode appearing to show below the radius ≅ 0.1 μm. The effective radius, total aerosol number content and columnar mass loading computed from deduced CSD shows minimum values during winter (November to February) and maximum during summer (March to June) months. The share of sub micron and super micron aerosols to the total aerosol number concentration (Nt) indicates the dominance of sub micron aerosols to the Nt and it accounts for > 90% during the study period. **[U. C. Dumka, R. Sagar** and **P. Pant].**

.

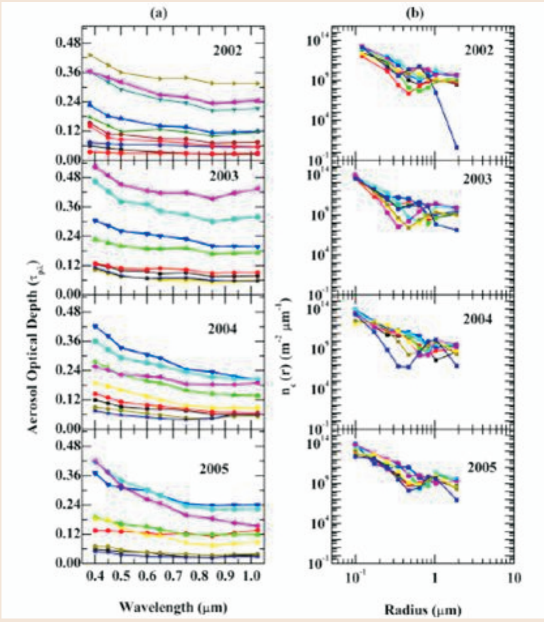


Figure 21. (a) Spectral AOD re-estimated from the retrieved CSD. (b) Composite plot of CSD retrieved from the Spectral AOD.

ATMOSPHERIC SCIENCES

Trace Species over the Central Himalayas:

Observations of trace gases over the central Himalayas show that the photochemical ozone production is generally not significant over this region. Levels of air pollutants are generally lower, except during the occasion of transport of pollutants and forest fires. Influences of long-range transport are observed from Thar Desert, which has affected the air-quality and radiation budget over the central Himalayan region. Analysis of forest fire data from space-borne sensors showed occurrences of maximum fire in spring and those are also contributing to higher levels of trace species over this region and perturbing the regional air-quality. Back air trajectory simulations for many years confirm that air-masses circulate mostly over the Northern Indian region during late spring, which is just prior to the onset of south westerly flow. Such circulations lead to accumulation of regional pollution over the central Himalayan region during late spring. Estimates using meteorological parameters and trajectories based classifications, show that the regional sources in the Northern part of Indian Subcontinent and forest fires may lead to average build-up in ozone by 7-11 ppbv and contribution of nearly similar amount is seen from long-range transport mainly in January-March. 3-D global model (FRSGC/UCI CTM) result also shows similar results for contribution from regional pollution, while lesser contribution (~ 5 ppbv) from long-range transport. Significant contribution (10-15 ppbv) is seen from stratospheric downward transport during January-March. [**M. Naja, R. Mudgal, N. Ojha, T. Sarangi,** S. Venkataramani and O. Wild].

Summer-time nocturnal wave characteristics in mesospheric OH and O2 airglow emissions:

The mesospheric temperature mapper (MTM) measurements on mesospheric OH (6, 2) and O2 (0, 1) band emissions from Maui, Hawaii during July, 2002 show significant day-to-day variability. The nocturnal variability reveals prominent wave signatures with a periodicity ranging from 6 to 13 h. For better characterization of the nocturnal wave in the data, a Krassovsky's η ($\sim|\eta|e^{i\phi}$) analysis was carried out. Deduced Krassovsky parameters show significant variability, with ranges of $|\eta|$ ~ 1.7-3.9 for the OH data and ~4.3-13 for the O2 data. The phase values of Krassovsky parameters exhibit larger variability, with variations from approximately -91° to +23° for the OH data and -45° to -10° for the O2 data. Comparison of these values with existing observations and models shows large deviations from model values and relatively better agreements with the observed values reported by other investigators. The deduced vertical wavelength from $|\eta|$ and ϕ indicates that our data is mostly dominated by upward propagating waves with occasional high values ≥100 km, implying possible evanescent waves. [**A. Guharay, A. Taori** and M. Taylor].

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 H_{II} 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. Peter Martinez of South African Astronomical Observatory (SAAO), South Africa, 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.

- To study the morphology of extragalactic objects, a collaboration with Dr. Joydeep Bagchi of IUCAA, Pune and Prof. Gopal Krishna of NCRA, Pune, is being pursued.

- 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 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 SZMIRAN, Russia, and is also collaborating with the solar scientists at Armagh Observatory, U.K., Georgian National Astronomical Observatory, Georgia. The solar-physics group of ARIES also collaborates with Dr. Syed Salman Ali, Aligarh Muslim University (AMU), Prof. Abdul Qaiyum (AMU), and Prof. B.N. Dwivedi, (I.T. BHU). The solar physics group is also active in data analysis of SOHO, Hinode, STEREO data and in theoretical modeling.

- Observations of trace gases and aerosols are being continued in collaboration with SPL, Trivandrum and PRL, Ahmedabad under the project ARFI, ABLN&C and ISRO-Env. Obs. In addition to this, ARIES has initiated a collaboration study of aerosols with NASA using AERONET Cimel-photometer. Recently Ozone observations have been started at Dehradun in collaboration with IIRS. Additional measurement of BC has been started at Pantnagar with ongoing collaboration at GBPUA&Tech., Pantnagar. Collaborative works with NIES, Tsnkaba, Japan for greenhouse gas and VLF whistler studies in collaboration with IIG Mumbai are being continued.

FACILITIES

1. Observing Facilities

1.1. Stellar Observing Facilities

The optical 104-cm Sampurnanand Telescope (ST) is being used as a main observing facility 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.

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-bursts (GRB), supernovae and X-ray sources, Wolf-Rayet Galaxies, Giant Radio Galaxies, polarimetric study of star-forming regions and late type stars. Details of the studies can be found elsewhere in the report.

Figure 22. The optical 104-cm Sampurnanand Telescope at ARIES.

1.2. Solar Observing Facilities

The main solar observing facility is 15-cm Coudé Solar Tower Telescope equipped with Bernhard Halle Hα filter, and fast imaging CCD cameras. 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 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 23. 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. Recently, ARIES has acquired set of different analyzers for O_3, CO, NO, NO_y, So_2 under ISRO Environmental Observatory Project (Figure 24). Further, air samples are also being continued at ARIES to analyse other trace gases (e.g. CO, CH_4 , SF_6, N_2O, NMHCs).

FACILITIES

Figure 24. Different analyzer for O_3, CO, NO, NOy, SO_2 at ARIES.

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

Since the telescope mirrors lose their reflectivity due to weathering and dust, their realuminization is essentially required. ARIES has been using a self designed and developed aluminizing plant, having a 124-cm diameter vacuum coating chamber, capable of providing a vacuum of 4 micro torr within about six hours for this purpose. Besides many small mirrors, the 106-cm primary mirror of 104-cm Sampurnanand telescope has been successfully aluminized several times in this unit. Many smaller mirrors for LIDAR and amateurs' telescope were also aluminized during the year. A Pfeifer (Germany) make Turbo molecular pump is now being regularly used to evacuate the Dewars associated with various CCD camera systems.

2.2. Computer Centre

With the ever increasing need for better communication with the outside world, be it for collaborations or for other scientific purposes, ARIES requires a modern computational facility. The Institute is keen to make its computing facility, the very best. ARIES Computer centre caters the needs of around 100 users. The Centre has more than 125 Desktops, Laptops and Work-stations. All the computers in the ARIES are connected through a 10/100/1000 Mbps network. The data archival capacity in the institute has increased by several folds. Portable external USB Hard disk, DAT, DVD and CD storage devices are also provided to the users. The latest Color LaserJet printer as well as a colour poster printer are available for all the users.

The Institute is striving to increase its bandwidth capacity, to meet the ever increasing demand of the users. To that end, the Institute has procured a dedicated 10Mbps lease line from BSNL, which has made the connectivity much better now.

With the advent of new researchers who are experts in modeling and simulations, the Institute is increasing its computational facilities, by procuring a high end workstation (32GB RAM, dual xeon processor). The Computer Centre also has Multi-functional devices (scanner, photocopier and printer).

Highlight of the developmental work done during 2008-09

1. Domain name changed from aries.ernet.in to aries.res.in.
2. New mail server based on free open source software implemented.
3. 10 Mbps lease line connection established.
4. Video conferencing system installed.
5. Optical fiber connectivity extended to LIDAR and new guest house.
6. A high performance workstation (2 Xeon processor and 32 GB RAM) installed.

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 2008 - 2009, the following information resources were added:-

Books	:	110
Bound Volumes of Journals	:	125
Subscription to Journals (Print + Online)	:	96
ARIES Publications	:	44
ARIES Theses	:	5

The collection at the end of the period is

Books	:	Around 9920
Bound volumes of Journals	:	Over 10,000

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 2008 - 09, 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. The subscribed journals under consortium E-journals, 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. UCP Journals (print & online) are subscribed under FORSA Consortium. The ARIES Library is also a member of CSIR - DST E-Journals 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 2008 - 09, some of the works done by the section at Manora Peak and Devasthal are:

At Manora Peak

(i) Ashwini Guest House: It is a modern Guest House with the state of art construction having all modern facilities. It has total 6 suites and 10 rooms. It has dinning area with a sitting capacity of about 50 persons. Energy efficient solar heating panels have been installed over roof for energy conservation in the building. The whole area of the guest house is Wi-fi connected. The guest house was inaugurated on September 06, 2008 by Dr. T. Ramasami, Secretary, DST, Govt. of India.

(ii) Optics Laboratory: It is a double storey building and has already started functioning with various optical facilities. The laboratory was inaugurated on January 12, 2009 by Prof. G. Srinivasan, RRI, Bangalore.

(iii) Hostel building: PDF Block of the hostel has been completed and occupied. Remaining work is in progress and is expected to be completed by December 2009.

The construction of various buildings viz. computer/lecture theater, mechanical workshop, science centre and Schmidt telescope building is in progress and is expected to be complete by December 2009.

Figure 25. Inauguration of Ashwini Guest House at ARIES by Dr. T. Ramasami, Secretary, DST, Govt. of India on September 06, 2008

At Devasthal

- Two pre-fabricated huts were constructed as accommodation for the staff.
- Construction of 130 -cm telescope building has been completed.
- Scientist rest room comprising of five rooms and a dinning space is under construction and has been completed up to the plinth level.
- Construction of water tanks is in progress.
- Construction company has been identified to carry out civil work for 3.6 - m telescope building.

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 2008-09 the section was involved in the following activities:

- The Control System of the Schmidt telescope had been designed and initially tested in laboratory.
- Significant contribution has been made in finalizing the antenna array configuration of the ST Radar. Site testing of the different modules like Yagi-Uda antenna, Transmit Receive module, Digital Signal Processing (DSP) and data acquisition system has been performed.
- The section played an important role in the balloon launching for measuring the cn2 and in getting the site clearance of ST Radar from Wireless Planning Commission.
- The section had played an important role in procuring and installation of the high energy pulsed LASER for LIDAR system. The design of the detection electronics of LIDAR and its extensive testing had been performed on the individual components as well as on integrated system.
- The section actively participated in finalizing the electronics and electrical aspects of 3.6-m Devasthal Optical Telescope. Concept design of Electrical requirements for the enclosure of 3.6-m telescope building has also been finalized.
- The controlling circuit of the dome and sutter for 1.3-m optical telescope had been designed and its implementation is going on.
- Under ISRO-GBP Environmental Observatory Project at ARIES, section had installed an observational facility of trace gases with Ozone, NO-NOy, CO and SO_2 analyzer. Complete renovation of the internal electrical wiring including earthing and main distribution panel of the Environmental Observatory Project under ISRO-GBP at ARIES have been carried out.
- The section had installed two substations having capacity of 150 KVA and 65 KVA at Devasthal. Electrical related developmental activities of the upcoming facilities and buildings have been carried out at Manora Peak and Devasthal.
- Ten engineering students successfully completed their industrial training in the Section.

FACILITIES

2.6. Mechanical Workshop

The manufacturing, fabrication, maintenance and modifications in various equipments, telescopes and their accessories along with other miscellaneous jobs were carried out by the mechanical workshop. Mechanical maintenance of the stellar and solar telescopes was done on a regular basis.

The major developmental work carried out by the workshop in this financial year was the design and fabrication of the roll-off-roof for 1.3-m telescope building at Devasthal. This roll-off-roof for 1.3-m telescope has size of about 8m (L) X 8.4 m (W) X 4.75m (H) and rolls over a two-storey building. The roof is fabricated out of I-beams, U-channels, angles and corrugated aluminum sheets. This roof has two motorized shutters in the north and south directions of size 3m (H) X 2.75 (W). The roof rolls on the rails using geared motor arrangements, which are provided on opposite sides to roll the roof smoothly on to the rails of 19m bay length using bus bar arrangement.

The workshop assisted in shifting the 84 cm Rayleigh telescope of LIDAR from the UPS room to the newly constructed LIDAR building. Design and manufacturing of the mountings for the detection optics and the PMT of the Rayleigh telescope of LIDAR were carried out successfully. A fixture for holding two lasers in perpendicular direction to the primary mirror for alignment of the Rayleigh and MIE telescope was designed and manufactured. The mounting for laser transimitting mirror with fine X, Y, Z and tilt motion was designed and manufactured in the workshop.

Workshop was also involved in the upcoming Schmidt telescope at ARIES. The mounting plates for putting the dome drives and the encoder drive were manufactured at the workshop.

Base and platforms for the SDIMM Solar telescope and Coude telescopes were designed and fabricated in the workshop. Filter attachments have also been manufactured for the solar telescope.

Design and development of 1K CCD filter housing and mountings for 2K CCD and 512 CCD were carried out. Design and fabrication of platform for AERONET was completed. During the year 2008-09, one mechanical engineering student from an educational institution completed 36 days vocational training by taking up projects related to mechanical design & developments in the mechanical section.

2.7. Optics Laboratory

The new building for the optics laboratory and workshop was completed. The new building is constructed keeping in mind the future in house activities of the institute particularly in the areas of back-end instrument development such as spectrograph, fibre based devices and providing technical support for the existing 104-cm and the upcoming telescopes. The planning for procurements of some necessary optical systems and laboratory components has been carried out.

The optics workshop carried out routine maintenance activities of the optical telescopes and the back-end instruments at the Institute. The personnels from the laboratory were actively involved in various developmental activities such as LIDAR project, B-N Schmidt telescope, 130-cm and 360-cm Devasthal telescopes. The alignments for the 38-cm and 84-cm LIDAR telescopes and their detectors were successfully carried out for the atmospheric science group. The designs of the B-N Schmidt and 130-cm telescopes were verified in house using the ZEMAX software. ZEMAX-EE was also used to provide analysis data for anticipated performance of 38 cm telescope for LIDAR system. A preliminary design of the FOSC type spectrograph for the 360-cm telescope was proposed after consultations with Prof. David Crampton and Prof. Isobel M. Hook from CFHT MOS / SIS group.

During the period, the optics laboratory assisted in procurement and development of large format CCD camera for the upcoming Schmidt telescope. The laboratory also provided technical assistance to Dr. Ibrahim Selim of NRIAG, Cairo, Egypt for aligning their 74 inch telescope and to City Montessari School, Lucknow for aluminizing the mirrors and correcting their Celestron telescope.

Figure 26. Inauguration of New Optics Laboratory Building at ARIES by Prof. G. Srinivasan, Jawaharlal Nehru Fellow, RRI, Bangalore on January 12, 2009. The partially completed Schmidt telescope building can be seen in the near background.

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 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 project activities include design and construction of a 3.6 meter aperture optical telescope; a suite of backend instruments, an enclosure to house the telescope; an aluminizing plant to coat the mirrors, and an auxiliary building to house the aluminizing plant, instruments and other telescope related accessories. Several scheduled activities viz critical design review for telescope; acceptance of primary mirror zerodur blank at Schott Germany; award of contract and final design review of telescope enclosure and auxiliary building, were successfully completed during the past one-year period. The milestones are briefly described below.

The 5-year contract to design and build the telescope has completed 2 years in April 2009 and the progress during last one year has been as per the scheduled milestones in the contract. The telescope acceptance tests at AMOS Belgium is scheduled in August 2011 while the on-site installation and testing shall take place in June 2012. The critical design review of the telescope's final design was done during 12-15 January 2009. After a detailed discussions and review by an expert committee under the chairmanship of Prof. S. N. Tandon, the CDR-stage has now been completed. The committee had Dr. P. Gillingham from AAO Australia, as an outside expert. The primary mirror blank has been accepted at Schott Germany and it has been transported to LZOS Russia for polishing and figuring.

Figure 27. Foundation stone laying of 3.6-meter Devasthal Optical Telescope House by Dr. T. Ramasami, Secretary, DST, Govt. of India on September 06, 2008.

Through a competitive global bidding a Pune based firm named M/s Precision Precast Solutions (PPS) Private limited has been awarded a contract on 12

FACILITIES

Dec 2008 for design and consultancy services of the telescope enclosure and auxiliary building. This firm had also designed the telescope enclosure for 2-m IUCAA telescope. A critical review of the telescope enclosure design proposed by PPS was done by a committee of astronomers and technical experts under the chairmanship of Prof. S. N. Tandon. Further, the telescope installation requirements were also incorporated in the enclosure design, after discussion with the AMOS team. Now, the process to construct the telescope house as per this design is under progress.

The first aluminization of the primary mirror shall be done at Devasthal. The process of identification of a supplier for the aluminising system is in progress.

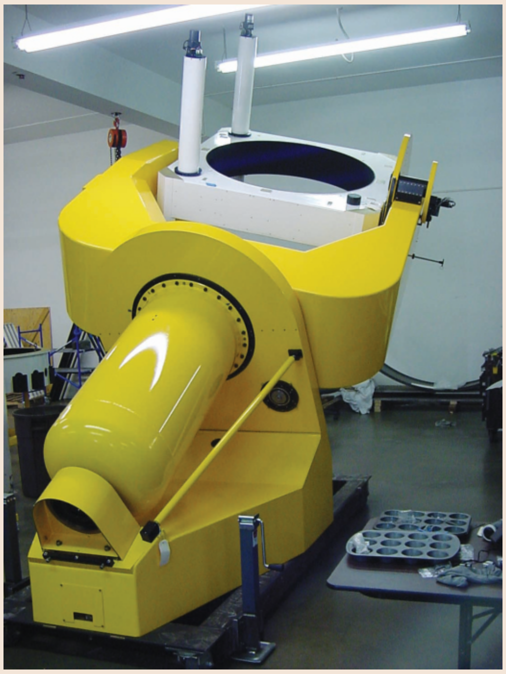
A faint object spectrograph camera and polarimeter instrument is proposed as the first light instrument for the telescope on the axial port. Design requirements and road map for the successful completion of the instrument are being prepared.

3.1.2. 1.3-m Optical Telescope

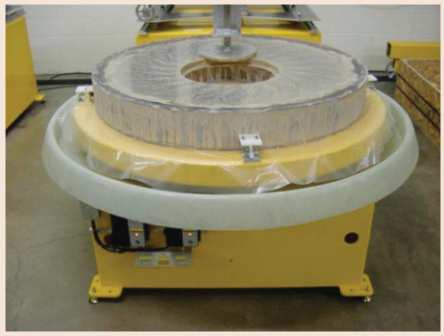
The institute planned in the year 2005-06 for a new modern technology 1-meter class optical telescope for supporting observations which are currently being carried out using the 104-cm telescope. A 130-cm f/4 telescope was decided to be purchased from DFM Engineering Inc. USA. The mechanical and opto-mechanical parts of the telescope were manufactured without much delay, however the mirror figuring and polishing has been delayed substantially. The primary mirror polishing has been completed. The initial results suggest the primary mirror quality is meeting the required specifications. The RMS surface variations are reported as ~11 nm in the inner 25-inch portion. The work on secondary mirror is being actively carried out at the contractor's shop. The telescope is now scheduled to arrive before December 15, 2009.

The civil construction work on 130-cm telescope building at Devasthal was completed during this period. The building has provisions for rest rooms for observing astronomers, an office room and a small library apart from the telescope floor and the observing room. The roll-off roof construction work by the mechanical workshop has progressed and is scheduled to be completed by August 2009. The building has been connected with the power supply and fibre optics data network from the base. The water supply will be operational by July 2009. The road connection has been completed up to the building.

The characterization was carried out for the fast frame transfer 512x512 and full frame 2kx2k CCD cameras. Both the systems are currently being used at 104-cm telescope for the astronomical observations. The Echelle spectrograph was also tested and found to meet the specifications. The plans are to have mounting structures for these systems to be made ready in house before the expected arrival of the telescope.



(a)



(b)

Figure 28. (a) The fork structure of the 130-cm telescope is shown at the contractor's shop. (b) The primary mirror is shown in the polishing stage. The primary mirror has been completed and tested at the contractor's shop.

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

After optical alignment of Mie telescope, the testing of detection electronics with the telescope has now been started. High energy pulsed laser system with 10X beam expander, has been procured and installed in the lidar building. The out put energy of laser source at 1064 nm and 532 nm and 335 nm has been tuned and it is working satisfactorily. Necessary accessories like dehumidifier, AC, UPS and Industrial PC have been procured and installed to support the Lidar operation.

(a) (b) (c)

Figure 29. (a) Nd-YAG lager with 10X beam expander mounted on an optical bench (b) inside view from rooftop (c) Mie and Rayleigh Telescopes .

FACILITIES

3.2.2. Stratosphere Troposphere Radar

Preliminary design of the upcoming stratosphere and troposphere radar (ST Radar) has been frozen. It has been decided to have array of 588 Yagis of 3 elements in a circular aperture on equilateral triangular grid arrangement with inter-element spacing of 0.7 x λ. This radar is being setup at the roof-top of building for the first time in the world. The building work is going to be initiated soon. There will be 588 T/R modules those will be installed in-house. It is visualized that first batch of antenna and T/R modules will be ready by the end of year 2009. To support this upcoming radar facility, balloon-borne observations with meteorological sensors have been carried out successfully. This proposed radar will provide continuous observations of winds with very high vertical resolution and measurements can be made in all weather.

Figure 30. Schematic diagram of upcoming ST Radar, with display of antenna array in a circular aperture, at ARIES, Nainital.

3.2.3. Environmental Observatory under ISRO-GBP

Recently, an environmental observatory has been set at ARIES, Nainital. Continuous in-situ observations of ozone and related gases like CO, NO, NO_y and SO_2 are being made. Apart from observations of these gases a complete setup for zero and span of different gases has been setup. Importantly, these instruments are capable of measurement at very low levels (pptv).

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

The machining, fabrication and inspection of the various components of the Schmidt telescope as per the detailed mechanical design has been carried out at M/s Avasarala Technologies Ltd, Bangalore. The components of the sub-assemblies were released for surface treatments viz. phosphating/paintings and then again assembled for interfacing with electronics for doing fitment and functional tests. The alignment of the North and South bearings was carried out using theodolite with the targets fitted in the bearing housings. The mount was assembled on the dummy piers in North and South bearing housings.

Manufacturing of the various components of the telescope dome as per the detailed design was carried out at M/s Pedvak, Hyderabad. The dome was assembled in tack weld condition on the rails and its testing on rails was carried out at M/s Pedvak, Hyderabad. Parts of the dome have reached ARIES for installation, erection and commissioning. The mounting plates for putting the dome drives, the encoder drive and the plates for the ring beam of the dome for rollers were manufactured at the ARIES workshop.

Figure 31. Assembly and testing of 50-cm B-N Schmidt telescope at M/s Pedvak, Hyderabad.

1. Conferences/Workshops

India - South Africa Workshop on Astronomy organized at ARIES during October 30 - November 01, 2008

An Indo - South Africa Workshop on Astronomy was organized at Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India during October 30 - November 01, 2008 under scientific exchange programme between India and South Africa. There are already a number of ongoing scientific collaborations between the two countries. The theme of the workshop was to highlight the existing and upcoming observational astronomical facilities and strengthen the ongoing scientific collaborations.

Four South African astronomers including Prof. P. A. Charles, Director, SAAO (South African Astronomical Observatory) attended the workshop. About 50 Indian scientists and students from different research institutes and universities (e.g. ARIES, IIA, RRI, NCRA, IUCAA, PRL, Pune University, Patiala University, Gorakhpur University, Meerut College, etc.) participated in the workshop. Dr. Lufuno Mammburu, in-charge of Indo - South Africa scientific exchange programme of the Department of Science and Technology (DST) of South Africa and Dr. Rajiv Sharma of the Department of Science and Technology (DST) of India also attended the workshop.

Figure 32. Inaugural ceremony of India - South Africa Workshop on Astronomy at ARIES during October 30 - November 01, 2008.

The presentations included results from the current Indian and South African astronomical facilities on a wide range of astronomical subjects e.g solar physics, stellar astrophysics, extragalactic astrophysics and cosmology. A session, chaired by Prof. P. C. Agrawal and Prof. P. A. Charles was devoted towards the future of the Indo - South African collaborations.

Prof. P. C. Agarwal, Prof. P. A. Charles, Prof. Ram Sagar, Dr. Rajiv Sharma, Dr. Lufuno Mammburu and all the participants of the workshop unanimously recommended the need to strengthen the close scientific collaboration between the two countries.

Figure 33. Participants of India - South Africa Workshop on Astronomy at ARIES during October 30 - November 01, 2008.

Summer School in Astronomy, Astrophysics and Atmospheric Sciences (May 19 - 30, 2008)

A summer school on introductory Astronomy, Astrophysics and Atmospheric Sciences was held during May 19 - 30, 2008 at ARIES, Nainital. The school was aimed to introduce fundamentals of the above subjects to M. Sc. (Physics) students and to provide them basic training on observational sciences and to motivate them for basic research. Seven students from different Universities of North India attended the school. In this school, apart from about 18 lectures on the fundamentals of Astronomy, Astrophysics and Atmospheric Sciences, students carried out a short fundamental research projects in four different groups. After the completion of projects, the students gave a presentation of their work for about an hour for each project.

Figure 34. Participants of Summer School, ARIES, Nainital, May 19 - 30, 2008.

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 35 seminars and 40 special talks were delivered during the period April, 2008 to March, 2009 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 eventsas and when required as a part of the activities. Popular talks in the nearbyschools 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.

ARIES executed a project to set-up an eleven-inch diameter optical telescope at St. Joseph's College Nainital for educational purpose. This project was funded under MPLAD scheme of Dr. K. Kasturirangan, Honorable Member of Parliament. The telescope, equipped with an eyepiece, was installed on 17th November 2008 and since then it is being used by the college staff to educate the students about the functioning of an optical telescope as well as to encourage them to explore the universe by viewing the planets and other night sky celestial objects like comets, star clusters and galaxies.

Figure 35. Mr. Peter D. Emmanuel, the principal, St. Joseph's College, Nainital, Uttarakhand is viewing Venus through a newly installed 11-inch diameter Celestron optical telescope in the Campus of St. Joseph's College.

The science centre for public outreach activity is under development which will be equipped with modern telescope, auditorium, advanced audio-visual facilities etc.

PUBLICATIONS

REFEREED JOURNALS

A. Published

1. Mass function and photometric binaries in nine open clusters, **S. Sharma**, **A. K. Pandey,** K. Ogura, T. Aoki, K. Pandey, T. S. Sandhu and **R. Sagar,** *Astron. Jr.* 2008, vol. 135, p. 1934.

2. A study of the long-term evolution of quasi-periodic oscillations in the accretion-powered x-ray pulsar 4U 1626-67, **R. Kaur,** B. Paul, **B. Kumar** and **R. Sagar,** *Astroph. Jr.* 2008, vol. 676, p. 1184.

3. CCD photometric and mass function study of nine young Large Magellanic Cloud star clusters, **B. Kumar, R. Sagar** and J. Melnick, *Mon. Not. Roy. Astron. Soc.* 2008, vol. 386, p. 1380.

4. The nature of the intranight variability of radio-quiet quasars, B. Czerny, A. Siemiginowska, A. Janiuk1 and **A. C. Gupta,** *Mon. Not. Roy. Astro. Soc.* 2008, vol. 386, p. 1557.

5. Long period slow MHD waves in the solar wind source region, B. N. Dwivedi and **A. K. Srivastava,** *New Astron.* 2008, vol. 13, p. 581.

6. Multiwavelength study of the transient X-ray binary IGR J01583+6713, **R. Kaur,** B. Paul, **B. Kumar** and **R. Sagar,** *Mon. Not. Roy. Astron. Soc.* 2008, vol. 386, p. 2253.

7. Ground-based CCD astrometry with wide field imagers. II. A star catalogue for M67: WFI@2.2m MPG/ESO astrometry, FLAMES@VLT radial velocities, **R. K. S. Yadav,** L. R. Bedin, G. Piotto, J. Anderson, S. Cassisi, S. Villanova, I. Platais, L. Pasquini, Y. Momany and **R. Sagar,** *Astron. Astroph.* 2008, vol. 484, p. 609.

8. Short period modulations in aerosol optical depths over central Himalayas ; role of mesoscale processes, **U. C. Dumka**, K. K. Moorthy, S. K. Satheesh, **R. Sagar** and **P. Pant,** *Jr. Appli. Meteoro. Climatology* 2008, vol. 47, p. 1467.

9. Co-spatial evolution of photospheric Doppler enhancements and Hα flare ribbons observed during the solar flare of 2003 October 28, P. Venkatakrishnan, B. Kumar and **W. Uddin,** *Mon. Not. Roy. Astron. Soc.* 2008, vol. 387, p. L69.

10. Core mass function: The role of gravity, S. Dib, A. Brandenburg, J. Kim, **M. Gopinathan** and P. Andre, *Astroph. Jr. Lett.* 2008, vol. 678, p. L105.

11. A study of X-ray flares - I. Active late-type dwarfs, **J. C. Pandey** and K. P. Singh, *Mon. Not. Roy. Astron. Soc.* 2008, vol. 387, p. 1627.

PUBLICATIONS

12. Optical polarimetric study of open clusters: distribution of interstellar matter towards NGC 654, **B. J. Medhi, Maheswar G., J. C. Pandey, T. S. Kumar** and **R. Sagar,** *Mon. Not. Roy. Astron. Soc.* 2008, vol. 388, p. 105.

13. CLOUDS search for variability in brown dwarf atmospheres, B. Goldman, …et al. (including **S. Joshi** and **R. Sagar**), *Astron. Astroph.* 2008, vol. 487, p. 277.

14. Enhanced luminosity of young stellar objects in cometary globules, **G. Maheswar** and H.C. Bhatt, *Astroph. Sp. Sc.* 2008, vol. 315, p. 215.

15. Observation of multiple sausage oscillations in cool post-flare loop, **A. K. Srivastava,** T. V. Zaqarashvili, **W. Uddin**, B. N. Dwivedi and **P. Kumar,** *Mon. Not. Roy. Astron. Soc.* 2008, vol. 388, p. 1899.

16. Simultaneous multi-wavelength observations of the TeV Blazar Mrk 421 ring February - March, 2003: X-Ray and NIR Correlated Variability, **A. C. Gupta**, B. S. Acharya, D. Bose, V. R. Chitnis and Jun-Hui Fan, *Chin. Jr. Astron. Astroph.* 2008, vol. 8, p. 395.

17. Characteristics of spectral aerosol optical depths over India during ICARB, S. N. Beegum, … et al. (including **P. Pant** and **U. C. Dumka**), *Jr. Earth Sys. Sci.* 2008, vol. 117, p. 303.

18. Physical and optical characteristics of atmospheric aerosols during ICARB at Manora Peak, Nainital: A sparsely inhabited, high-altitude location in the Himalayas, **U. C. Dumka**, K. K. Moorthy, **P. Pant, P. Hegde, R. Sagar** and K. Pandey, *Jr. Earth Sys. Sci.* 2008, vol. 117, p. 399.

19. Aerosol characteristics at Patiala during ICARB-2006, M. Singh, D. Singh and **P. Pant,** *Jr. Earth Sys. Sci.* 2008, vol. 117, p. 407.

20. The complex light curve of the afterglow of GRB 071010A, S. Covino, … et al. (including **K. Misra, S. B. Pandey** and **R. Roy**), *Mon. Not. Roy. Astron. Soc.* 2008, vol. 388, p. 347.

21. Broadband observations of the naked - eye γ - ray burst GRB 080319B, J. L. Racusin, … et al. (including **S. B. Pandey**), *Nature* 2008, vol. 455, p. 183.

22. Flares from a candidate galactic magnetar suggest a missing link to dim isolated neutron stars, A. J. Castro-Tirado, … et al. (including **S. B. Pandey**), *Nature* 2008, vol. 455, p. 506.

23. Photometric and spectroscopic study of a highly reddened type Ia supernova SN 2003hx in NGC 2076, **K. Misra,** D. K. Sahu, G. C. Anupama and K. Pandey, *Mon. Not. Roy. Astron. Soc.* 2008, vol. 389, p. 706.

24. Summer-time nocturnal wave characteristics in mesospheric OH and O2 airglow emissions, **A. Guharay, A. Taori** and M. Taylor, *Earth Planet Space* 2008, vol. 60, p. 973.

PUBLICATIONS

25. Optical and near-infrared photometric study of the open cluster NGC 637 and 957, **R. K. S. Yadav, B. Kumar,** A. Subramaniam, **R. Sagar** and B. Mathew, *Mon. Not. Roy. Astron. Soc.* 2008, vol. 390, p. 985.

26. Multi-wavelength study of a young open cluster NGC 7419, **H. Joshi, B. Kumar,** K. P. Singh, **R. Sagar, S. Sharma** and **J. C. Pandey,** *Mon. Not. Roy. Astron. Soc.* 2008, vol. 391, p. 1279.

27. A new activity phase of the blazar 3C 454.3 Multifrequency observations by the WEBT and XMM-Newton in 2007-2008, C. M. Raiteri, … et al. (including **A. C. Gupta** and **R. Sagar),** *Astron. Astroph.* 2008, vol. 491, p. 755.

28. Results of WEBT, VLBA and RXTE monitoring of 3C 279 during 2006-2007, V. M. Larionov, … et al. (including **A. C. Gupta**), *Astron. Astroph.* 2008, vol. 492, p. 389.

29. Two types of softening detected in x-ray afterglows of Swift bursts: internal and external shock origins?, Y-P. Qin, **A. C. Gupta,** J. H. Fan and R-J. Lu, *Jr. Cosmo. Astropart. Phy.* 2008, vol. 11, p. 4.

30. Multicolor near-infrared intra-day and short-term variability of the blazar s5 0716+714, **A. C. Gupta**, S. Cha, S. Lee, H. Jin, S. Pak, S. Cho, B. Moon, Y. Park, I. Yuk, U. Nam and J. Kyeong, *Astron. Jr.* 2008, vol. 136, p. 2359.

31. The rapidly flaring afterglow of the very bright and energetic GRB 070125, A. C. Updike, … et al. (including **K. Misra**), *Astroph. Jr.* 2008, vol. 685, p. 361.

32. Multiwavelength analysis of the intriguing GRB 061126: The reverse shock scenario and magnetization, A. Gomboc,…et al. (including **K. Misra**), *Astroph. Jr.* 2008, vol. 687, p. 443.

33. Abundances of four open clusters from solar stars, **G. Pace**, L. Pasquini and P. François, *Astron. Astroph.* 2008, vol. 489, p. 403.

34. Hα , EUV and UV analysis of an eruptive 3B/X1.2 flare, S. Pande, B. Pande, **W. Uddin** and K. Pandey, *Ind. Jr. Radio Sp. Phys.* 2008, vol. 37, p. 386.

35. Quasi-simultaneous two band optical micro-variability of luminous radio-quiet QSOs, **A. C. Gupta** and W. Yuan, *New Astron.* 2009, vol. 14, p. 88.

36. Periodic oscillations in the intra-day optical light curves of the Blazar S50716+714, **A. C. Gupta, A. K. Srivastava** and P. J. Wiita, *Astroph. Jr.* 2009, vol. 690, p. 216.

37. Spatial distribution of aerosol black carbon over India during pre-monsoon season, S. N. Beegum, K. K. Moorthy, S. S. Babu , S. K. Satheesh, V. Vinoj, K. V. S. Badarinath, P. D. Safai, P. C. S. Devara, S. Singh , Vinod, **U.C. Dumka** and **P. Pant,** *Atmos. Environ.* 2009, vol. 43, p. 1071.

38. An integrated analysis of lidar observations in association with optical properties of aerosols from a high altitude location in central Himalayas, **P. Hegde, P. Pant** and Y. B. Kumar, *Atmos. Sci. Lett.* 2009, vol. 10, p. 48.

39. An insight into the progenitors of gamma ray bursts from the optical afterglow observations, **K. Misra** and **R. Sagar**, *Curr. Sci.* 2009, vol. 96, p. 347.

40. Optical observations of GRB 050401 afterglow : A case for double jet model, A. Kamble, **K. Misra,** D. Bhattacharya and **R. Sagar**, *Mon. Not. Roy. Astron. Soc.* 2009, vol. 394, p. 214.

41. Aerosol optical depths at Mohal-Kullu in the northwestern Indian Himalayan high altitude station during ICARB, J. C. Kuniyal,, A. Thakur, H. K. Thakur, S. Sharma, **P. Pant,** P. S. Rawat and K. K. Moorthy, *Jr. Earth Syst. Sci.* 2009, v. 118, p. 41.

42. Young brown dwarfs in the core of the W3 main star-forming region, D. K. Ojha, M. Tamura, Y. Nakajima, H. Saito, **A. K. Pandey,** S. K. Ghosh and K. Aoki, *Astroph. Jr.* 2009, vol. 693, p. 634.

43. Effects of fluid composition on spherical flows around black holes, **I. Chattopadhyay** and D. Ryu, *Astroph. Jr.* 2009, vol. 694, p. 492.

44. The whole earth Blazar telescope campaign on the Intermediate BL Lac Object 3C 66A in 2007-2008, M. Bottcher, … et al. (including **A. C. Gupta**), *Astroph. Jr.* 2009, vol. 694, p. 174.

PUBLICATIONS

B. Papers in Press

1. Non-thermal transient sources from rotating black holes, M. H. P. M. van Putten and **A. C. Gupta** *(Mon. Not. Roy. Astron. Soc.)*

2. Spectroscopic survey of ASAS eclipsing variables: Search for chromospherically active eclipsing binaries stars (I), P. Parihar, S. Messina, P. Bama, **B. J. Medhi**, S. Muneer, C. Velu and A. Ahmad *(Mon. Not. Roy. Astron. Soc.)*

3. Nearly periodic fluctuations in the long term X-ray light curves of the Blazars AO 0235+164 and 1ES 2321+419, **B. Rani**, Paul J. Wiita and **A. C. Gupta** *(Astroph. Jr.)*

4. Observations of X-ray oscillations in ξ Boo: Evidence of a fast-kink mode in the stellar loops, **J. C. Pandey** and **A. K. Srivastava** *(Astroph. Jr. Lett.)*

5. Chandra and XMM-Newton observations of the low-luminosity X-ray pulsators SAX J1324.4-6200 and SAX J1452.8-5949, **R. Kaur,** R. Wijnands, A. Patruno, V. Testa, G. Israel, N. Degenaar, B. Paul and **B. Kumar** *(Mon. Not. Roy. Astron. Soc.)*

6. Retrieval of columnar aerosol size distributions from spectral attenuation measurements over Central Himalayas, **U. C. Dumka, R. Sagar** and **P. Pant** *(Aerosol and Air Quality Research)*

PUBLICATIONS

7. Network loop oscillations with EIS/Hinode, **A. K. Srivastava,** D. Kuridze, T. V. Zaqarashvili, B. N. Dwivedi and **B. Rani** *(Astroph. Sp. Sci. Proc.)*

8. LO Pegasi: An investigation of multi-band optical polarization, **J. C. Pandey, B. J. Medhi, R. Sagar** and **A. K. Pandey** *(Mon. Not. Roy. Astron. Soc.)*

9. Exploring PMS variables of ONC: The new variables (I), P. Parihar, S. Messina, D. Elisa, N. S. Shantikumar and **B. J. Medhi** *(Mon. Not. Roy. Astron. Soc.)*

10. Triggered star formation and evolution of T-Tauri stars in and around bright-rimmed clouds, **N. Chauhan, A. K. Pandey,** K. Ogura, D. K. Ojha, B. C. Bhatt, S. K. Ghosh and P. S. Rawat *(Mon. Not. Roy. Astron. Soc.)*

CIRCULARS/BULLETINS/CONFERENCE PROCEEDINGS

1. Giant radio galaxies: problems of understanding and problems for CMB ?, O. V. Verkhodanov, M. L. Khabibullina, **M. Singh, A. Pirya,** N. V. Verkhodanova and **S. Nandi,** *Proc. Int. Conf. Problems of Practical Cosmology; ed. by Y. V. Baryshev* 2008, vol. II, p. 247.

2. GRB 080430: Optical observations, **S. B. Pandey, R. Roy and B. Kumar,** 2008, *GCN Circular No.* 7663.

3. Effect of plasma composition on accretion on to black holes, **I. Chattopadhyay,** *Proc. of Observational Evidence for Black Holes in the Universe* 2008, vol. 1053, p. 353.

4. Spectroscopic Studies of a few Molecular Bands in Comets, **M. Singh,** *AIP Conf. Proc.* 2008, vol. 1075, p. 193.

5. Nearly Periodic Variability in Both Optical and X-ray Emission from the Blazar S5 0716+714, Paul J. Wiita, **A. C Gupta, B. Rani** and **A. K. Srivastava,** *Bull. Ame. Astron. Soc.* 2009, vol. 41, p. 382.

6. Preliminary design of ARIES - Devasthal faint object spectrograph and camera, **S. Mondal, R. K. S. Yadav** and **M. Singh,** *Proc. Int. Conf. on Trends in Optics and Photonics, ed. by A. Ghosh* 2009, p. 374.

7. Development of ARIES Baker Nunn camera to a wide field imaging telescope with CCD, **S. Mondal, K. G. Gupta, S. Lata, B. J. Medhi, T. Bangia, T. S. Kumar, S. Yadav** and **S. K. Singh,** *Proc. Int. Conf. on Trends in Optics and Photonics, ed. by A. Ghosh* 2009, p. 380.

8. Optical design and stray light analysis for 3.6-m Devasthal Optical Telescope (DOT) at ARIES, Nainital, **S. K. Singh, K. G. Gupta, B. Kumar, V. Shukla, S. B. tyagi, B. C. Pant** and **B. B. Sanwal,** *Proc. Int. Conf. on Trends in Optics and Photonics, ed. by A. Ghosh* 2009, p. 399.

PUBLICATIONS

Ph.D. THESES

Awarded

1. Multi-wavelength studies of energetic cosmic explosions, **K. Misra,** (Supervisors : R. Sagar, D. Bhattacharya and K. Pandey), *Kumaun University,* July 2008.

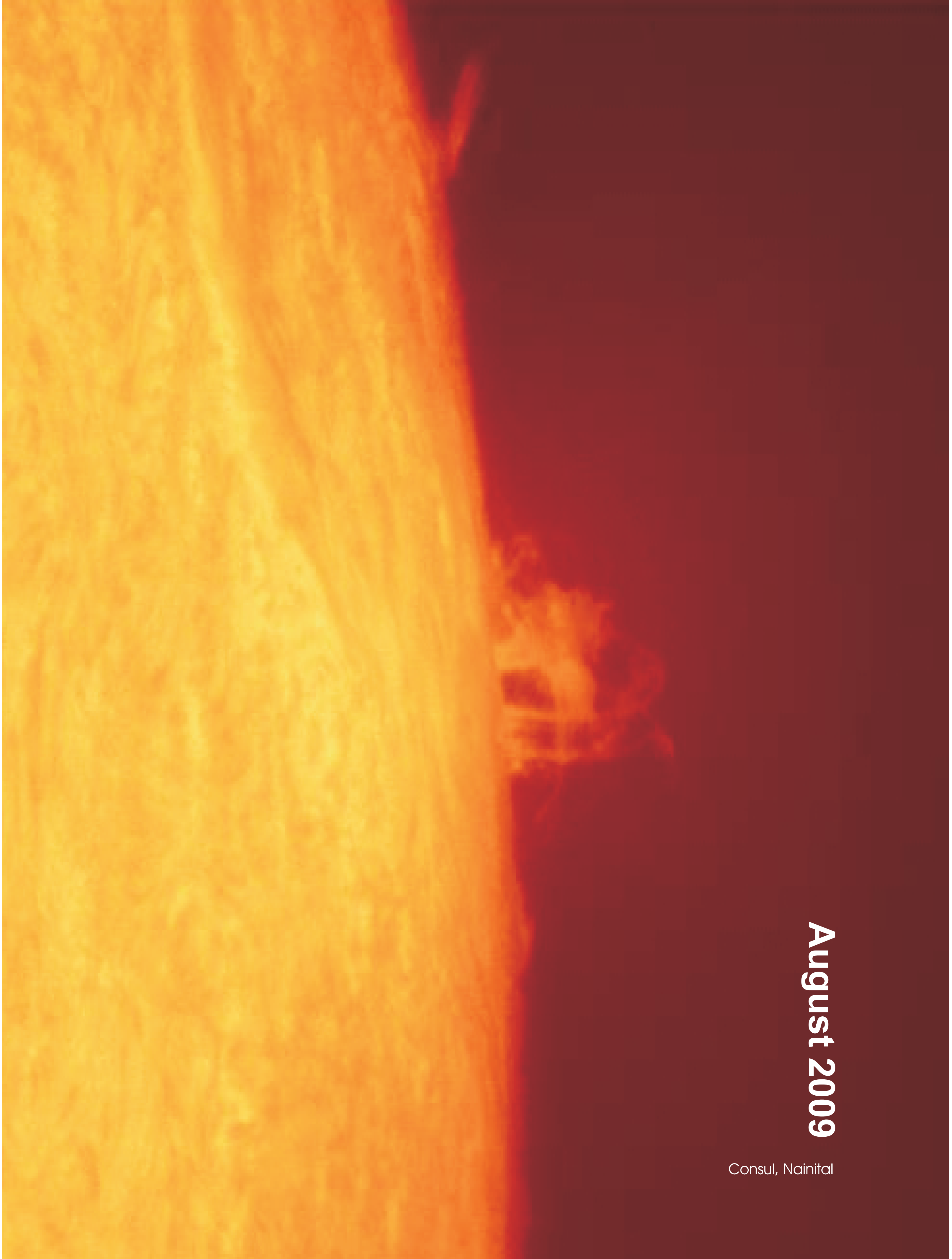
2. Studies of young and intermediate age open star clusters, **Saurabh,** (Supervisors : A. K. Pandey and K. Pandey), *Kumaun University,* July 2008.

3. Characteristics of aerosol spectral optical depths over Nainital - a high - altitude station in the Shivalik ranges of central Himalayas, **U. C. Dumka,** (Supervisors : R. Sagar, K. K. Moorthy and K. Pandey), *Kumaun University,* November 2008.

Submitted

1. Studies of pulsations in chemically peculiar stars, **S. K. Tiwari,** (Supervisors : U. S. Pandey and U. S. Chaubey), *DDU Gorakhpur University*, September 2008.

2. Multi-wavelength studies of X-ray binary systems, **R. Kaur,** (Supervisor : R. Sagar), *Kumaun University,* March 2009.



August 2009

Consul, Nainital