Aryabhatta Research Institute of Observational Sciences

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

Manora Peak, Nainital (India)

Academic Report
2006 – 2007

ARYABHATTA RESEARCH INSTITUTE
OF
OBSERVATIONAL SCIENCES

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

Manora Peak, Nainital - 263 129, India

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August 2007

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EXECUTIVE SUMMARY

The Governing Council (GC) chaired by Prof. K. Kasturirangan envisaged a growth plan for the Institute during first two years of its formation in 2004. In this endeavor, the Council was assisted by the Scientific Advisory and ARIES Building Committees chaired by Prof. P. C. Agrawal and Prof. G. Srinivasan respectively. During 2006-2007, the GC of the Institute met thrice on April 08, 2006 in Nainital; on October 04, 2006 in Bangalore and on March 25, 2007 in Delhi.

This Annual Report gives a brief account of the various activities carried out at the Institute during the period under review. The year 2006-07 will be remembered as a year of achievements in the history of the Institution as a number of activities ranging from the development of infrastructure to the observational facilities were started during this period. Also, the Institute continued to make important scientific contributions in different front-line problems of astrophysics and atmospheric sciences. Studies of fundamental nature were conducted in the areas of aerosols, solar activities, variable stars, star clusters, gamma-ray burst and supernova, extragalactic astronomy etc. The major activities carried out during the period under review are summarized below:

1. The 3.6-meter new technology Devasthal optical telescope Project was started almost after 3 decades of persistent herculean efforts. After obtaining due approvals from the competent authorities on March 29, 2007, ARIES signed a contract with Advanced Mechanical and Optical Systems (AMOS), Belgium for the design, manufacturing, integration, testing, supply and installation of the telescope at Devasthal. The project has both national and international participation. Within the country, Indian Institute of Astrophysics (IIA), Bangalore and Tata Institute of Fundamental Research (TIFR), Mumbai have agreed to participate in the Project. Both plan to provide back end modern instruments for the telescope, namely high resolution spectrograph by IIA and near-infrared imager cum spectrograph by TIFR. From abroad, Belgium and Russia are participating in the project under bilateral collaborative programmes of their respective countries with India in the area of Science & Technology. The cost of the 3.6-meter telescope is 16.2 million Euros (~Rupees 907.2 million) which includes a minimum contribution of 2 million Euros (~Rupees 112 million), by Belgium.

2. ARIES contracted out the design and fabrication of the 130-cm optical telescope as a turn-key project to DFM Engineering Inc., Longmont, Colorado, USA in March 2006. The telescope is expected to be delivered by middle of next year 2008. Foundation stone for the 130-cm optical telescope building was laid by Prof. K. Kasturirangan, Chairman, GC on April 9, 2006. Prof. G. Srinivasan, Council member along with locals and some staff members of ARIES participated in the function.

3. The civil construction work relating to the Guest house, Hostel Building and Optical Workshop has been started. The foundation stone of the Guest house was laid by Prof. K. Kasturirangan on April 8, 2006. The other GC members who graced the occasion were Prof. G. Srinivasan, Chairman, ARIES Building Committee, Prof. P. C. Agrawal, Dr. S. D. Sinvhal, Mr. K. P. Pandian, and Mr. J. S. Kurian. A number of other dignitaries and staff members of ARIES also graced the ceremony of laying the Foundation Stone.

4. The scientific findings of the Institute were mainly published in various journals of international repute. Thirty eight research papers were published/accepted in standard refereed journals and another four were published as circulars and conference proceedings. Two Ph.D. degrees were awarded and one Ph.D. thesis was submitted. Interactions with scientists both within the country and from abroad increased significantly. Consequently, activities of collaborations with institutes and Universities increased. ARIES signed MOU with Kumaun University, Nainital and IIT, Roorkee to increase academic/technical interactions between the institutions. High lights of the scientific results are listed below:

   (i) The highest frequency quasi-periodic oscillations have been discovered in the high mass X-ray binary pulsar XTE J 0111.2-7317.
   (ii) ARIES imaging optical polarimeter developed in house successfully observed the young star cluster IC1805. An analysis of the observations indicates that intra cluster dust component has negligible polarization efficiency as compared to interstellar dust.
   (iii) Pulsation was discovered in a few chemically peculiar stars.
   (iv) An in-house developed and fabricated, mesosphere-thermosphere photometer was installed and tested in September 2006. Successful observations have been obtained on January 15 and 16, 2007 after calibration of the instrument. They have yielded interesting results on the structural changes of mesosphere.
   (v) In addition to the ongoing aerosol characterization, observations of trace gases have been initiated in collaboration with Japan and other Indian institutions so that ARIES can become a complete environmental observatory. The long term variation of the ozone level indicates that its value 40-50 ppbv observed in January 2007 has increased gradually to a value of 88 ppbv in March 2007.

5. Progress in the ongoing 84-cm Backscatter LIDAR and 50-cm Schmidt telescope is satisfactory. A contract for the civil construction of the LIDAR house was awarded while design of the Schmidt telescope was finalized.

6. A number of Scientists and Engineers of the Institute participated in national and international conferences/workshops/colloquia with a number of invited and contributed presentations.

It is heartening to note that Prof. Ram Sagar has been elected as a Council member of the National Academy of Sciences, India for 2007 and nominated a member of Indian Science delegation to South Africa; Programme Advisory Committee of DST, TIFR Ballon facility Board, the Physical Sciences Research Committee of CSIR and of the Governing Council of IITM, Pune. The DST has also nominated him as Indian coordinator in the areas of Physics and Astrophysics under the International Long Term Programme of Cooperation in Science and Technology between Russia and India.

A number of young meritorious Scientists and Ph.D. students belonging to different regions of the country joined the Institute. These along with significant increase of interaction of ARIES Scientists and Engineers with their counterpart from both within the country and abroad indicate a bright future for the ARIES.

Place : Nainital
Date : 10 August, 2007

RAM SAGAR
Director

THE INSTITUTE

The primary objective of ARIES is to provide optical observing facilities to carry out research in the front-line areas of Astronomy & Astrophysics and Atmospheric Sciences. The main research interests are in solar, planetary, stellar, galactic and extra-galactic astronomy including stellar variabilities, star clusters, nearby galaxies, quasars, and transient events like supernovae and highly energetic gamma-ray bursts, study of aerosols, airglow emissions, mesosphere - lower thermospheric regions, and various coupling processes between different atmospheric regions of the Earth. The observations carried out at ARIES are well recognized internationally. The longitude of ARIES (79° East) locates it almost in the middle of about an 180-degree wide longitude band having modern astronomical facilities between Canary Islands (20° West) and Eastern Australia (157° East). The observations which are therefore not possible from Canary Islands or Australia due to day light can be obtained from ARIES. Consequently, unique contributions have been made to many areas of astronomical research, particularly those involving time critical phenomena. For example, the first successful Indian optical observations of the afterglow of gamma-ray burst was carried out from ARIES on January 23, 1999. A few cases of micro-lensing events and quasar variability have been confirmed from the Observatory. In the past, new ring systems around Saturn, Uranus, and Neptune were discovered from the Observatory.

Facilities:

ARIES presently hosts three optical telescopes of apertures 15-cm, 56-cm and 104-cm. The 35 years old 104-cm telescope is used for most of the optical observations. 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. The Institute has two 15-cm telescopes for solar observations.

In order to carry out observations in the frontier areas of astronomy, the Institute is setting up a 130-cm and a 360-cm optical telescopes at a site called 'Devasthal', which has the advantages of having dark skies and excellent observing conditions. Both 130-cm and 360-cm telescopes will be operational by 2008 and 2012, respectively. It is also planned to set up a 84-cm micro-pulse LIDAR system and a ST Radar to carry out research on the atmosphere of the Earth.

Ph.D./PDF Programme:

ARIES offers fellowships to pursue Ph.D. in Astronomy & Astrophysics and Atmospheric Sciences for which research scholars are selected via the JEST, NET and GATE exams. The minimum qualification for a research scholar is an M.Sc. degree in Physics/Astronomy/ Astrophysics or a B.E./B.Tech. degree. The students can register for the Ph.D. degree to a number of Indian universities as they have recognized ARIES as a research centre .

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

THE INSTITUTE

Student Training and Short term Visit Programme:

A few bright students studying in different semesters of the B.E./B.Tech./M.Sc. courses can spend 2-3 months at ARIES to work with one of the scientists 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 Astrophysics and Atmospheric physics to young graduate students in their M.Sc./B.Tech. programs. The school consists of lectures and a short-term project.

Evening Programme:

The Institute 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 science popularization programme for students and the common public.

Areas of Research:

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

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

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

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

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

Atmospheric Sciences: Aerosols characterization, radiation budget, mesosphere, lower thermosphere, coupling processes between different atmospheric regions.

STARS AND STELLAR SYSTEMS STUDIES

1. STAR CLUSTERS

Wide-field CCD photometry around nine open clusters :

The evolution of the cores and corona of nine open clusters have been studied using the projected radial density profiles derived from homogeneous CCD photometric data obtained with the 105-cm Kisso Schmidt telescope . The ages and galactocentric distances of the target clusters vary from 16 to 2000 Myr and 9 to 10.8 kpc, respectively. Barring Be 62, which is a young open cluster, other clusters show a uniform reddening across the cluster region. The reddening E (B- V)in Be 62 varies from 0.70 mag to 1.00 mag. The coronae of six of the clusters in the present sample are found to be elongated (Figure 1). However, on the basis of the present sample it is not possible to establish any correlation between the age and shape of the core. The elongated core in the young cluster Be 62 may reflect the initial conditions in the parental molecular cloud. The other results of the study are : (1) Core radius r_c and corona size r_{cn} /cluster radius r_{cl} are linearly correlated with the number of stars in that region. (2) In the age range 10 - 1000 Myr, the core and corona shrink with age. (3) It is found that in the galactocentric distance range 9 - 10 kpc, the core and corona/cluster extent of the clusters increase with the galactocentric distance. [**S. Sharma**, **A. K. Pandey**, K. Ogura , H. Mito, K. Tarusawa (Japan), and **R. Sagar**]

The population in the background of open clusters : Tracer of the Norma-Cygnus arm :

Using the 105-cm Schmidt Telescope of the Kisso Observatory Japan, the colourmagnitude diagrams of open clusters, located in the range 112° < *l* < 252°, manifesting stellar populations in the background of clusters were studied. Figure 2 shows the TCDs and CMDs for the six observed clusters. Some of the populations are found to be located beyond the Perseus arm and may be the part of the Norma-Cygnus (outer) arm. The outer arm seems to be continued from *l* ~ 120° to ~235°. The background populations follow the downward warp of the Galactic plane around *l*~ 240°. [**A. K. Pandey, S. Sharma** and K. Ogura (Japan)]

Near-infrared JH photometry of young open cluster Be 59 :

Near-infrared *JH* photometric and optical slitless spectroscopic data of stars in the field of the young cluster Be 59 have been studied. The *J*/ (*J* - *H*) colour-magnitude diagram of the cluster yields a distance modulus of $(m\text{-}M)_0$ = 10.0 ± 0.2 mag, which corresponds to a distance of 1.0 ± 0.1 kpc. Using slitless spectroscopy we identified 9 *H* emission line stars in the observed region. The location of *H* stars in the CMD indicates that they may be pre- main sequence stars. Authors have estimated the age of the cluster using the turn-off and turn-on points to lie between ~ 1 Myr to 4 Myr. Two massive stars (~ 25 $M_\odot$) in the cluster region have high membership probability which indicates that the low mass stars (~ 0.8 $M_\odot$) may co-exist with massive stars. [**S. Sharma**, K. Ogura (Japan), **A. K. Pandey**, D. K. Ojha (TIFR, Mumbai) and B. C. Bhatt (CREST, Bangalore)]

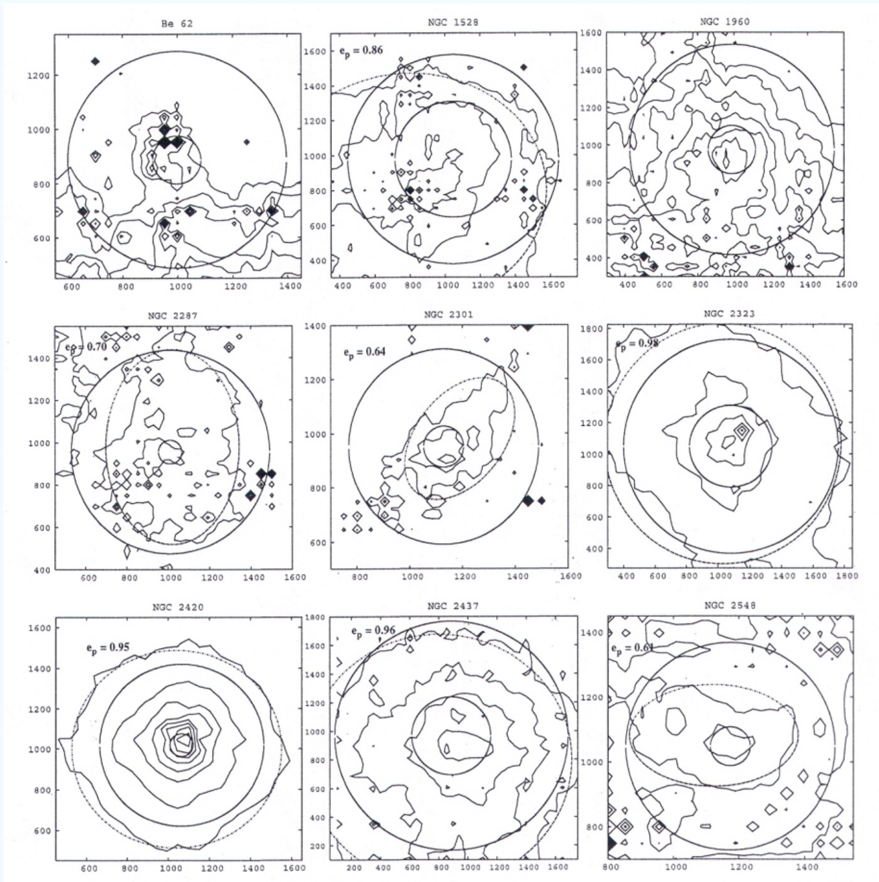


Figure 1. Isodensity contours drawn for the target clusters. The x- and y-axes are in pixels. The inner and outer circles represent the core and cluster radius as obtained in the present study. The dashed curve shows the least-squares fitted curve to the outer region of the clusters, and e_p is the elongation parameter.

Champagne flow and triggered star formation in NGC 1893 :

Using H grism spectroscopy and optical and 2MASS photometry of the fields containing NGC 1893 and two emission nebulae, Sim 129 and Sim 130, authors show the presence a number of H and NIR excess sources towards the region between HD 242935 and the two emission nebulae. Among them a large majority of these pre-main sequence sources are concentrated towards regions closer to Sim 129 and Sim 130. Age distribution of these sources (namely main sequence stars in the cluster, including HD 242935, young sources located in the region between HD 242935 and two nebulae and those located inside Sim 129) obtained from their positions in optical V, V - I colour - magnitude diagram strongly suggest “small scale sequential star formation" along the axes of the clouds caused by the outward advance of ionization/shock front from the HII region. The IRAS source, IRAS 05198+3325, identified with CPM 16 is a Herbig Be (B3) type star showing H and CaII triplet lines in emission. From the orientation of the two emission nebulae it is suggested that HD 242935 is most likely responsible for the cometary morphology of the two nebulae and is the trigger of star formation in the region. From the global distribution of the interstellar material, it is also suggested that the same source is responsible for the outflow causing the entire molecular cloud to have a cometary appearance. [**M. Gopinathan, S. Sharma, B. J. Medhi, A. K. Pandey** and H. C. Bhatt (IIA, Bangalore)]

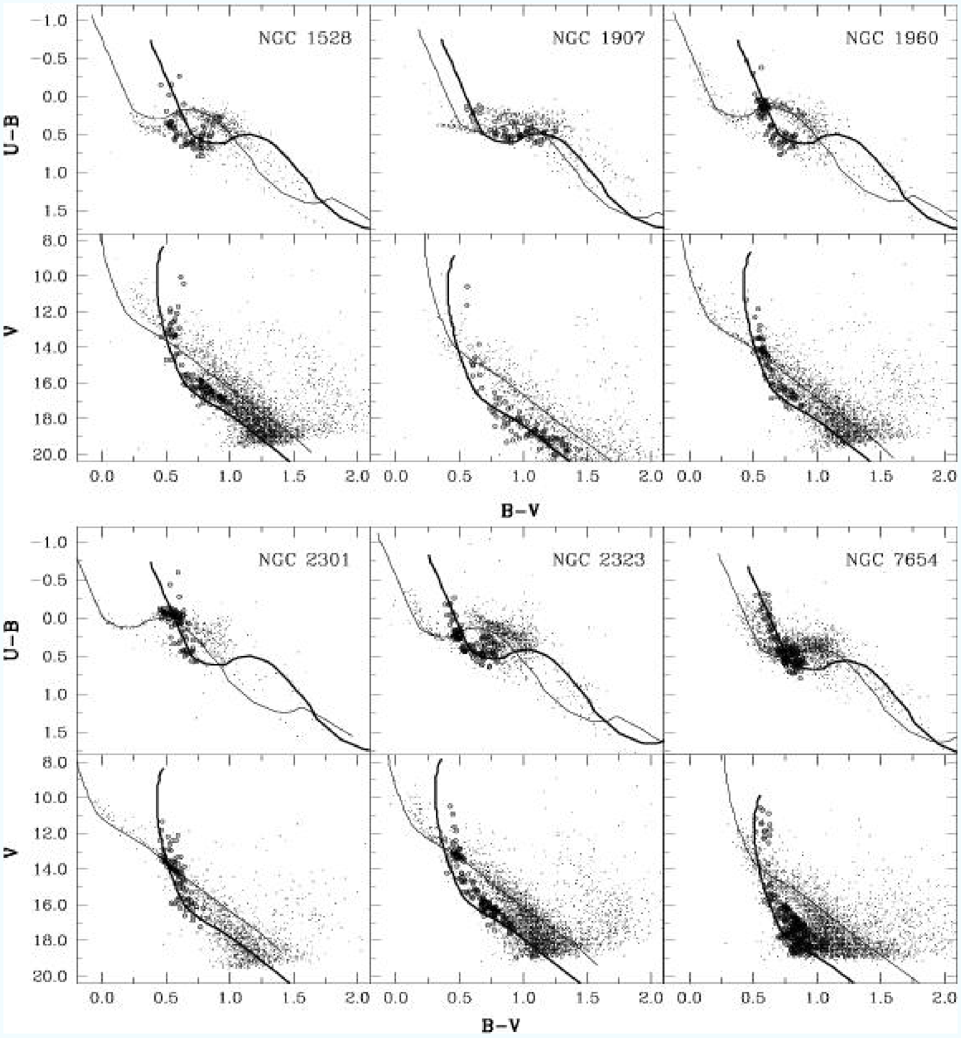


Figure 2. Upper and lower panels of the figure show TCDs and CMDs for the six clusters observed with the 105-cm Schmidt Telescope of the Kisso Observatory Japan. Thin and thick lines represent the ZAMS shifted to match the observed sequence of cluster and background population, respectively. Open circles represent probable background population members.

Broad band optical polarimetric study of IC 1805 :

BVR broad band polarimetric observations of 51 stars belonging to the young open cluster IC 1805 were studied. Along with the photometric data from the literature, the authors have modeled and subtracted the foreground dust contribution from the maximum polarization (P_{max}) and colour excess [E(B - V)]. The mean value of the P_{max} for intracluster medium and the foreground are found to be 5.008 ± 0.005 % and 4.865 ± 0.022 % respectively. Moreover, the mean value of the wavelength of maximum polarization ($_{max}$) for intracluster medium is 0.541 ± 0.003 m, which is quite similar as for the general interstellar medium (ISM). The resulting intracluster dust component is found to have negligible polarization efficiency as compared to interstellar dust. Some of the observed stars in IC 1805 have shown the indication of intrinsic polarization in their measurements (Figure 3). [**B. J. Medhi, G. Maheswar, B. Kumar,** J. C. Pandey (TIFR, Mumbai), **T. S. Kumar and R. Sagar**]

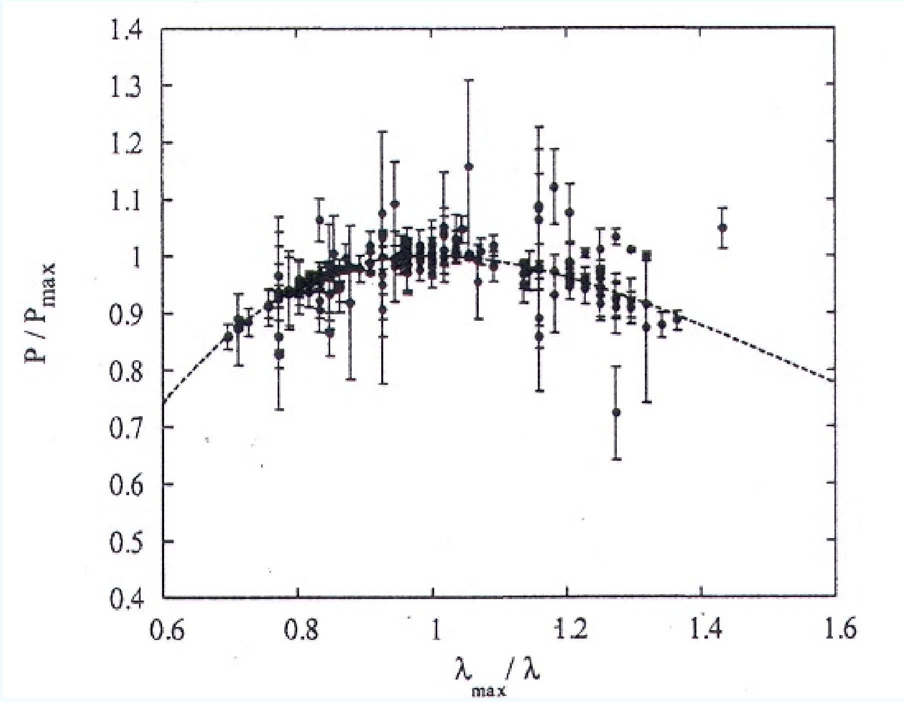


Figure 3. Plot of normalized polarization-wavelength dependence for the observed stars in IC 1805.

2. GAMA RAY BURST AND SUPERNOVA

Physics of the GRB 030328 afterglow and its environment :

To investigate the physical nature of the afterglow emission, the photometric, spectroscopic and polarimetric observations of the optical afterglow of GRB 030328 detected by *HETE - 2* were studied. Photometry, collected at 7 different telescopes, shows that a smoothly broken power law decay, with indices $_1$ = 0.76 ± 0.03, $_2$ = 1.50 ± 0.07 and a break at t_b = 0.48 ± 0.03 days after the GRB, provides the best fit of the optical afterglow decline. This shape is interpreted as due to collimated emission, for which we determine a jet opening angle $_{jet}$ ~ $3^0.2$. An achromatic bump starting around ~ 0.2 d after the GRB is possibly marginally detected in the optical light curves. Optical spectroscopy shows the presence of two rest-frame ultraviolet metal absorption systems at z = 1.5216 ± 0.0006 and at z = 1.295 ± 0.001, the former likely associated with the GRB host galaxy (Figure 4). Analysis of the absorption lines at z = 1.5216 suggests that the host of this GRB may be a Damped Lyman- Absorber. Theoptical *V*-band afterglow appears polarized, with *P* = (2.4 ± 0.6)% and = 170^0 ± 7^0, suggesting an asymmetric blast wave expansion. An X-ray-to-optical spectral flux distribution of the GRB 030328 afterglow was obtained 0.78 days after the GRB and fitted using a broken power law, with an optical spectral slope $_{opt}$ = 0.47 ± 0.15, and an X-ray slope $_X$ = 1.0 ± 0.2. The discussion of the results in the context of the "fireball model" shows that the preferred scenario for this afterglow is a collimated structured jet with fixed opening angle in a homogeneous medium. [E. Maiorano (Italy) et al. (33 authours of 22 institutions including **S. B. Pandey)**]

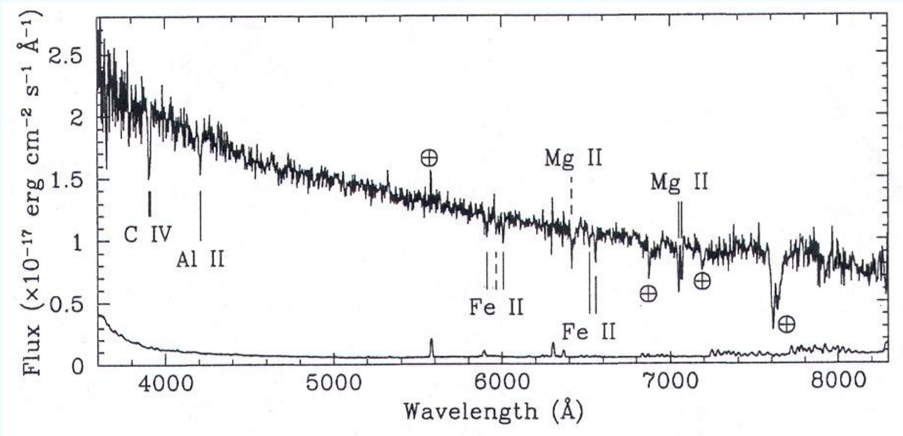


Figure 4. Optical spectrum of the afterglow of GRB 030328.

Multi-wavelength afterglow observations of the high red-shift GRB 050730 :

Five telescopes were used to study the decaying afterglow of GRB 050730 in the *B*, *V*, *r*', *R*, *i*', *I*, *J* and *K* photometric pass bands. A spectral energy distribution was constructed at 2.9 h post-burst in the *B*, *V*, *R*, *I*, *J* and *K* bands. The X-ray data from the satellites *Swift* and *XMM-Newton* were used to study the afterglow evolution at

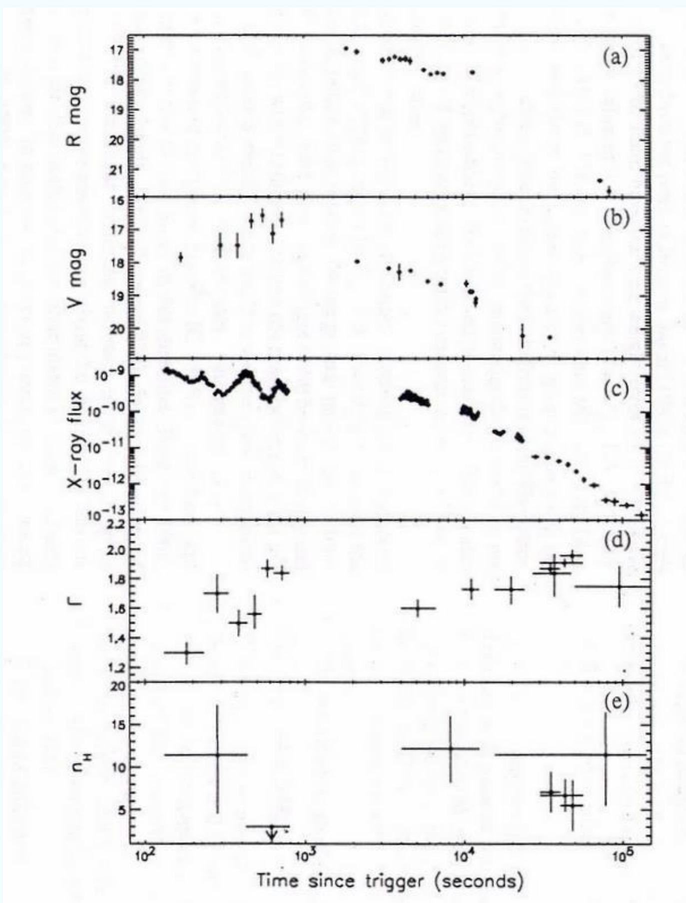


Figure 5. The R, V band and X-ray light curves of GRB 050730 are shown in panels (a), (b) and (c) respectively. The temporal evolution parameters column density N_H and photon index derived from the X-ray afterglow spectrum are shown in panels (d) and (e).

higher energies. The early afterglow shows variability at early times and the slope steepens at 0.1 days in the *B*, *V*, *r*', *R*, i', *I*, *J* and *K* pass bands. The early afterglow light curve decayed with a power law slope index $_1$ = -0.60 ± 0.07 and subsequently steepened to $_2$ = -1.71 ± 0.06 based on the *R* and *I* band data. A millimeter detection of the afterglow around 3 days after the burst shows an excess in comparison to theoretical predictions. The early X-ray light curve observed by *Swift* is complex and contains flares. At late times the X-ray light curve can be fit by a power law decay with $_x$ = -2.5 ± 0.15 which is steeper than the optical light curve. A spectral energy distribution (SED) was constructed at ~ 2.9 h after the burst. An electron energy index, *p*, of ~ 2.3 was calculated using the SED and the photon index from the X-ray afterglow spectra and implies that the synchrotron cooling frequency $_c$ is above the X-ray band. [**S. B. Pandey** et al. (25 authors of 15 institutions including **S. Sharma**)]

Optical observations of GRB 060124 afterglow : a case for an injection break :

Broad band optical afterglow observations of a long duration GRB 060124 using the 1.04-m Sampurnanand Telescope at ARIES, Nainital and the 2.01-m HCT at IAO, Hanle, including the earliest ground-based observations in *R* band for this GRB have been studied. The spectral slope of the afterglow emission in the optical band is estimated. The first *R*-band observations were taken ~ 0.038 d after burst. It is found that all available optical data after this epoch fit well by a single power law, with a temporal flux decay index ~ 0.94. Authors did not find any evidence of a jet break within the data, which extend till ~ 2d after the burst. The X-ray light curve, however, shows a distinct break around 0.6 day. They attribute this break to a steepening of the electron energy spectrum at high energies. It is concluded that the above measurements are consistent with the picture of a standard fireball evolution with no jet break within *t* ~ 2 days after the burst. This sets a lower limit of 3×10^{50} erg to the total energy released in the explosion. [**K. Misra**, D. Bhattacharya (RRI, Bangalore), D. K. Sahu (CREST, Bangalore), **R. Sagar**, G. C. Anupama (IIA, Bangalore), A. J. Castro-Tirado (Spain), S. S. Guziy (Ukraine), and B. C. Bhatt (CREST, Bangalore)]

3. EXTRA-GALACTIC ASTRONOMY

The TullyFisher relations of the Eridanus group of galaxies :

The Tully-Fisher (TF) or the luminosityline width relations of the galaxies in the Eridanus group are constructed using the HI rotation curves and the luminosities in the optical and in the near-infrared bands (Figure 6). The slopes of the TF relations (absolute magnitude *vs* log $2V_{flat}$) are -8.6 ± 1.1, -10.0 ± 1.5, -10.7 ± 2.1, and -9.7 ± 1.3 in the R, J, H, and K bands respectively for galaxies having flat HI rotation curves. These values of the slopes are consistent with those obtained from studies of other groups and clusters. The scatter in the TF relations is in the range 0.5 1.1 mag in different bands. This scatter is considerably larger compared to those observed in other groups and clusters. It is suggested that the larger scatter in the TF relations for the Eridanus group is related to the loose structure of the group. If the TF relations are constructed using the baryonic mass (stellar + HI$^+$ Helium mass) instead of the stellar luminosity, nearly identical slopes are obtained in the R and in the near-infrared bands. The baryonic TF (baryonic mass *vs* log 2*V*flat) slope is in the range 3.5 4.1. [**A. Omar** and K. S. Dwarakanath (RRI, Bangalore)]

Further evidence of intra-night optical variability of radio-quiet quasars :

Although well established for BL Lac objects and radio-loud quasars, the occurrence of intranight optical variability (INOV) in radio-quiet quasars is still debated, primarily since only a handful of INOV events with good statistical significance, albeit small amplitude, have been reported so far. This has motivated us to continue intra-night optical monitoring of bona-fide radio-quiet quasars (RQQs). Here authors present the results for a sample of 11 RQQs monitored by us on 19 nights. On 6 of these nights a given RQQ was monitored simultaneously from two well separated observatories. In all, two clear cases and one probable case of INOV were detected. From these data, they estimate an INOV duty cycle of $\sim$ 8% for RQQs which would increase to 14% if the probable variable case is also included. Such comparatively small INOV duty cycle for RQQs, together with the small INOV amplitudes ($\sim$ 1%), are in accord with the previously deduced characteristics of this phenomenon. [**A. Goyal**, Gopal-Krishna (NCRA, Pune), **R. Sagar**, G. C. Anupama (IIA, Bangalore) and D. K. Sahu (CREST, Bangalore)]

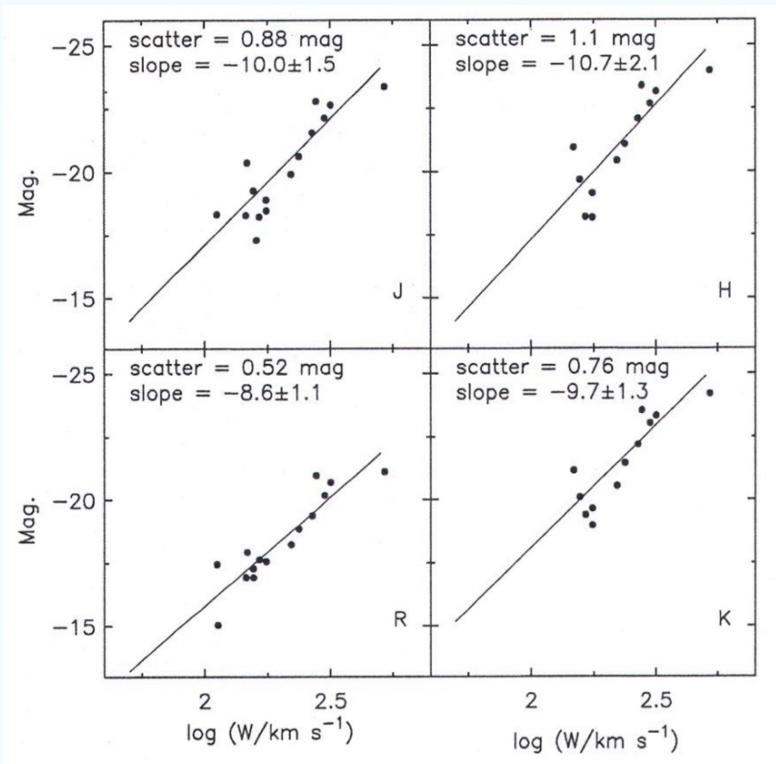


Figure 6. The TullyFisher relations in the R, J, H, and K bands. The values of log*W* (abscissa) and absolute magnitude (ordinate).

Wolf-Rayet Galaxies :

CCD photometric observations for the Wolf-Rayet galaxies NGC 1140, NGC 1156 and NGC 1614 were made using 2k x 2k CCD camera in BVR H and H continum filters on the ARIES 104-cm telescope and during the perid Nov. 2005 to Nov. 2006. Continuum subtracted Há images reveal the direct evidence of various star forming regions. Spectrophotometric observations of a few Wolf-Rayet galaxies were taken using HCT Hanle 2-m telescope. Spectral coverage between 3800Å to 6840Å were recorded on the 2k x 4k CCD camera through Hanle Faint Object Spectrograph

Camera. Oxygen abundances have been estimated from emission-line ratios, and stellar population in the star forming regions are also estimated with spectral synthesis modeling. [**M. Singh and B. B. Sanwal**].

4. VARIABLE STARS

The Nainital-Cape survey :

High-speed photometric observations of Ap and Am star candidates have been carried out from Manora Peak, Nainital using a three-channel fast photometer attached to the ARIES 104-cm Sampurnanand telescope. During the time span of the survey (1999 December to 2004 January) pulsations of the Sct type were also found for the two evolved Am stars HD 102480 and HD 98851. Both HD 102480 and HD 98851 exhibit unusual alternating high and low amplitude maxima, with a period ratio of 2:1. Figure 7 shows the observed light curve of HD 98851. Additionally, the 140 null results of the survey for this time span were reported. The analysis of the null results confirms the photometric quality of the Nainital site. [S. Joshi (IUCAA, Pune), D. L. Mary (Germany), P. Martinez (South Africa) , D. W. Kurtz (UK), V. Girish (TIFR, Mumbai), S. Seetha (ISAC, Bangalore), **R. Sagar**, and B. N. Ashoka (ISAC, Bangalore)]

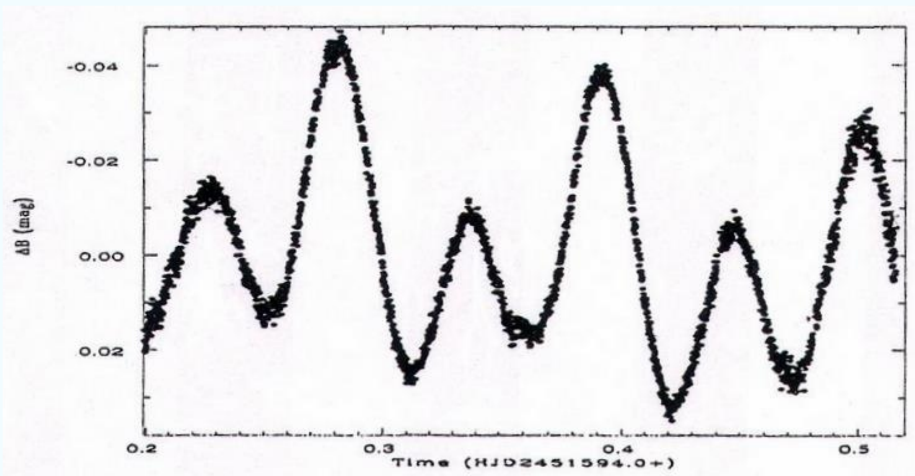


Figure 7. A typical light curve of HD 98851 obtained on HJD 2451594.

The molecular envelope around the red supergiant VY CMa :

Millimeter interferometric observations of the molecular envelope around the red supergiant VY CMa with the Submillimeter Array (SMA) were studied. The high angular resolution (<2”) allows us to derive the structure of the envelope as observed in the 1.3mm continuum, ^{12}CO(2-1), ^{13}CO(2-1), and SO(6_5-5_4) lines emission. The circumstellar envelope is resolved into three components: (1) a dense, compact, and dusty central component, embedded in (2) amore diffuse and extended envelope, and (3) a high-velocity component. Authors have constructed a simple model, consisting of a spherically symmetric slowly expanding envelope and bipolar outflows with a wide opening angle (~120°) viewed close to the line of sight (i =15°). This model can explain the main features of the SMA data and previous single-dish CO multiline observations. An episode of enhanced mass loss along the bipolar direction is inferred from this modeling. The SMA data provide a better understanding of the complicated morphology seen in the optical / IR high-resolution observations. [S. Muller, Dinh-V-Trung, J. Lim, and N. Hirano (Taiwan), **C. Muthu** and S. Kwok (China)]

Results from a spectroscopic survey in the CoRoT fields. I. Search for chromospherically active stars :

The results of a spectroscopic survey, carried out to detect the chromospheric activity of late-type stars in the fields of view of the CoRoT space mission were reported. Figure 8 shows the observed spectrum for the chromospheric active star SW Mon. An accurate MK classification of all targets, which is valuable information on both the main CoRoT projects and additional science programs, by means of cross-correlation with MK standard stars and by using artificial neural networks are given. The presence or absence of excess H emission, determined using spectral subtraction technique is used to characterize the chromospheric activity level. In most cases our MK classification agrees with the spectral classification reported in SIMBAD database; however, there are a few stars that are found to have very different MK classes. Our survey reveals that ~7% of late-type stars in our sample indeed posses a very active chromosphere. The measured H excess and the presence of the 6708Å Li line allow us to confirm the membership of 5 targets in the young open cluster NGC 2264. [**B. J. Medhi**, S. Messina (Italy), P. Parihar CREST, Bangalore), I. Pagano (Italy), S. Muneer (IIA, Bangalore) and K. Duorah (Gauhati Univ., Assam)]

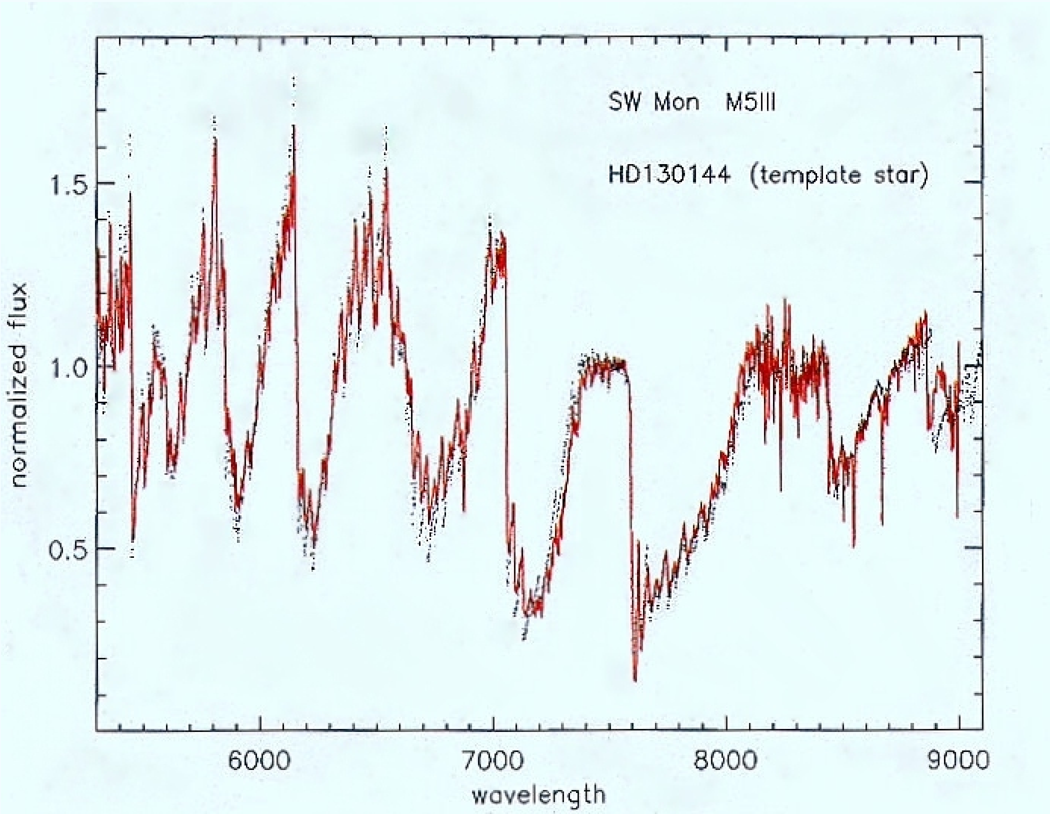


Figure 8. The observed spectrum of SW Mon (dots) with the template spectrum of the M5III star HD 130144 (solid line) over plotted.

STARS AND STELLAR SYSTEMS STUDIES

Multiwavelength studies of five chromospherically active stars :

A multiwavelength study of five chromospherically active stars, including newly obtained optical photometry, low-resolution optical spectroscopy, as well as archival X-ray observations were studied. The bulk of the optical, X-ray, and kinematical data indicate that the stars FR Cnc, HD95559, HD160934 and LO Peg are all active, young stars of ages 100 Myrs or less, whose activity levels are primarily due to their youth. All the photometric, spectroscopic and X-ray observations suggest that the star HD81032 is a newly identified, evolved RS CVn-type binary. [**J. C. Pandey**, K. P. Singh (TIFR, Mumbai), **R. Sagar** and S. A. Drake (USA)]

Quasi periodic oscillations in XTE J0111.2-7317, highest frequency among the HMXB pulsars :

The discovery of quasi-periodic oscillations (QPOs) in the high mass X-ray binary (HMXB) pulsar XTE J0111.2 ± 7317 during a transient outburst of the source in 1998 December has been investigated. Using observations made with the Proportional Counter Array of the Rossi X-Ray Timing Explorer during the second peak and the declining phase of the outburst, authors have discovered a QPO feature at a frequency of 1.27 Hz. They have ruled out the possibility that the observed feature could instead be from the neighboring bright X-ray pulsar SMC X-1. This is the highest frequency QPO ever detected in an HMXB pulsar. In the absence of a cyclotron absorption feature in the X-ray spectrum, the QPO, along with the pulse period and X-ray flux measurement, helps us to constrain the magnetic field strength of the neutron star. [**R. Kaur,** B. Paul, H. Raichur (RRI, Bangalore) and **R. Sagar]**

Pulsations in chemically peculiar stars HD 13079 :

The star HD 13079 (BD+48 2086) is a double star. The Hipparcos Hp magnitudes for both the stars are 8.989 ± 0.007 and 11.311 ± 0.057. The separation and position angle are = 6.173 ± 0.017" and = 254.4°, respectively. It shows below normal concentration of Ca in its spectrum. This star has Stromgren indices as b-y = 0.203, m_1 = 0.211, c_1 = 0.672 and H = 2.759. Using CCD as N-star photometer, this star was observed on two nights in October 2006. It is noted that the light variation of about 0.04 mag in Johnson B filter with pulsation period of about 1.2 hr is present in the star HD 13079. Figure 9 shows the light curve of our observed data taken on Oct 06, 2006. On the basis of Hipparcos parallax, uvby photometry and pulsations taken together suggest that HD 13079 is an Am star near the zero-age main sequence, and that it is a fundamental mode pulsator on the red edge of instability strip. A detailed analysis of the pulsations in this star is in progress. The co-existence of pulsation and metallicism in Am star is important for our understanding of abundance anomalies in the A-type stars and of diffusion processes in general. **[U. S. Chaubey]**

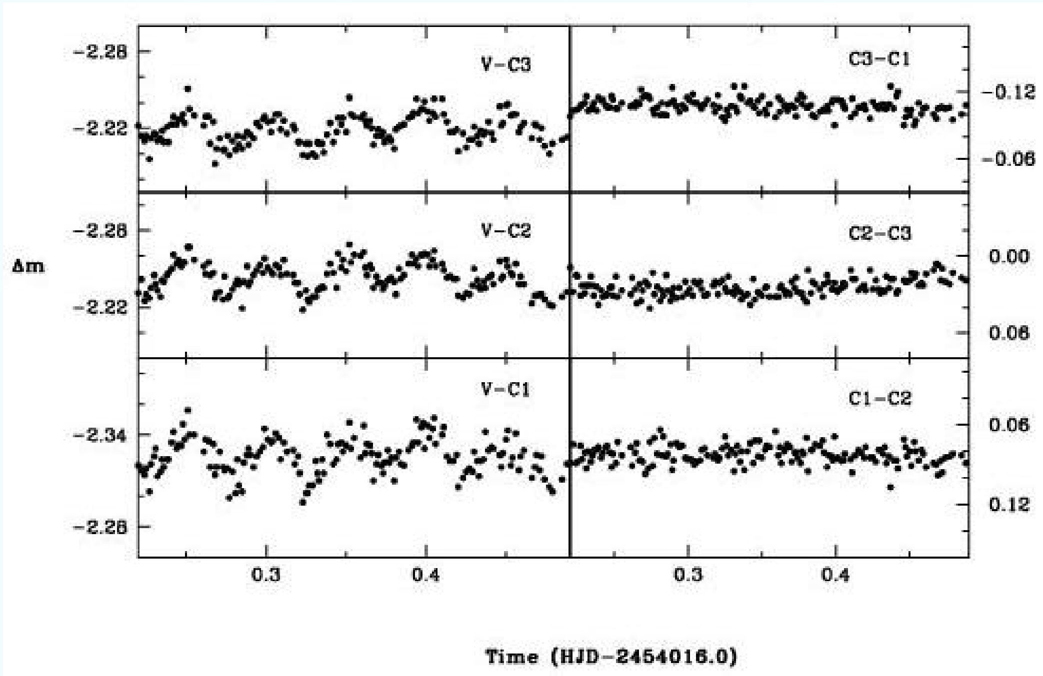


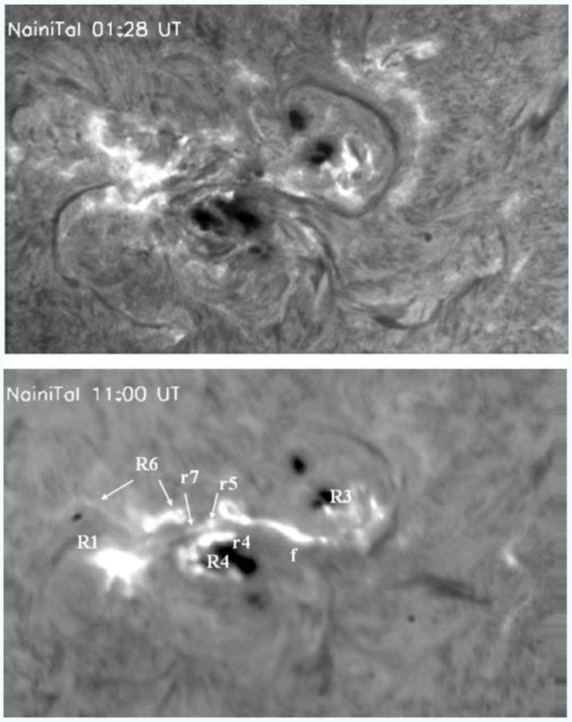
Figure 9. The B light curves of HD 13079 observed on October 06, 2006.

Periodicities in sunspot activity during solar cycle 23 :

The data of sunspot numbers, sunspot areas and solar flare index during cycle 23 are analyzed to investigate the intermediate term periodicities. Power spectral analysis has been performed separately for the data of the whole disk, northern and southern hemispheres of the Sun. Several significant midrange periodicities (~175, 133, 113, 104, 84, 63 days) are detected in sunspot activity. Most of the periodicities in sunspot numbers generally agree with those of sunspot areas during the solar cycle 23. The study reveals that the periodic variations in the northern and southern hemispheres of the Sun show a kind of asymmetrical behavior. Periodicities of ~175 days and ~133 days are highly significant in the sunspot data of northern hemisphere showing consistency with the findings of J. L. Lean during solar cycles 12-21. On the other hand, southern hemisphere shows a strong periodicity of about 85 days in terms of sunspot activity. The analysis of solar flare index data of the same time interval does not show any significant peak. [**B. Joshi**, **P. Pant** and P. K. Manoharan (TIFR, Ooty)]

Companion event and precursor of the X17 flare on 28 October 2003 :

A major two-ribbon X17 flare occurred on 28 October 2003, starting at 11:01UT in active region NOAA 10486 (Figure 10). This flare was accompanied by the eruption of a filament and by one of the fastest halo coronal mass ejections registered during the October - November 2003 strong activity period. Authors focus on the analysis of magnetic field (SOHO/MDI), chromospheric (Naini Tal observatory and TRACE), and coronal (TRACE) data obtained before and during the 28 October event. By combining the data analysis with a model of the coronal magnetic field, authors concentrate on the study of two events starting before the main flare. One of these events, evident in TRACE images around one hour prior to the main flare, involves a localized magnetic reconnection process associated with the presence of a coronal magnetic null point. This event extends as long as the major flare and they conclude that it is independent of it. A second event, visible in H and TRACE images, simultaneous with the previous one, involves a large-scale quadrupolar reconnection process that contributes to decrease the magnetic field tension in the overlaying field configuration; this allows the filament to erupt in a way similar to that proposed by the breakout model, but with magnetic reconnection occurring at Quasi - Separatrix Layers (QSLs) rather than at a magnetic null point. [C. H. Mandrini (Argentina), P. Demoulin, B. Schmieder (France), E. E. Deluca (U.S.A), E. Pariat (France) and **W. Uddin**]



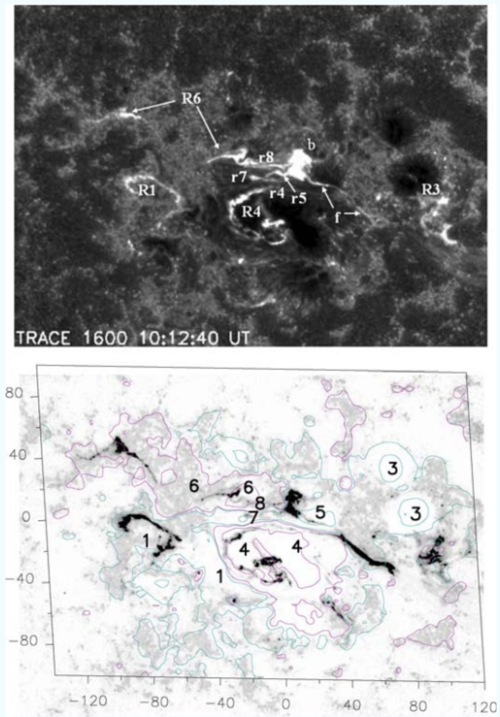


Fig. 10 (a) Fig. 10 (b)

Figure 10. (a) Images showing a large-scale view of the AR in H . An elongated sigmoidal filament is seen on the *top*, the eruption of its central portion accompanies the two-ribbon X17 flare. The image at the *bottom* shows the H ribbons with their associated label starting with "R" and "r" for those associated with a large-scale event and a small-scale event, respectively. The number in the ribbon label indicates the magnetic polarity.
(b) TRACE 1600 °A image. The *top* figure shows the four ribbons for both the large-scale and small-scale events: R1, R3, R4, R6, and r4, r5, r7, r8, respectively. The bottom figure corresponds to the overlay with the MDI magnetogram at 11:11UT. The axes x and y are labeled in Mm. The isocontours of the field are ±100 and 1000 G, shown with continuous *pink* (*blue*) lines for the positive (negative) values.

Multi-wavelength analysis of an X2.7 flare on 3 November 2003 from active region NOAA 10488 :

The evolution of an X2.7 solar flare, that occurred in a complex -type active region on November 3, 2003 is discussed utilizing multi-wavelength data set. The H images taken from solar tower telescope at ARIES, Nainital, India, reveal well-defined footpoint (FP) and looptop (LT) sources. As the flare evolves, LT source moves upward and the separation between the two FP sources increases which is consistent with the reconnection models of solar flares. The coalignment of H with hard X-ray (HXR) images obtained from RHESSI shows spatial correlation between H and HXR footpoints, while the upward moving HXR LT source is always located above H LT source. The EUV images of flaring region at 195 Å taken from SOHO/EIT reveal intense emission from low- lying loops near the active region during the impulsive phase. On the other hand, two bright loops are seen well outside the active region which undergo large scale reorganization during the flare. In radio wavelengths, type III radio bursts are observed few minutes prior to start of HXR LT emission indicating the pre-flare coronal activity. A type II radio burst followed the main phase of the event (Figure 11). The observations support the "break-out" model of solar eruptions proposed by S. Antiochos and co-workers. [**B. Joshi**, P. K. Manoharan (TIFR, Ooty), A. M. Veronig (Austria), **P. Pant** and K. Pandey (KU, Nainital)]

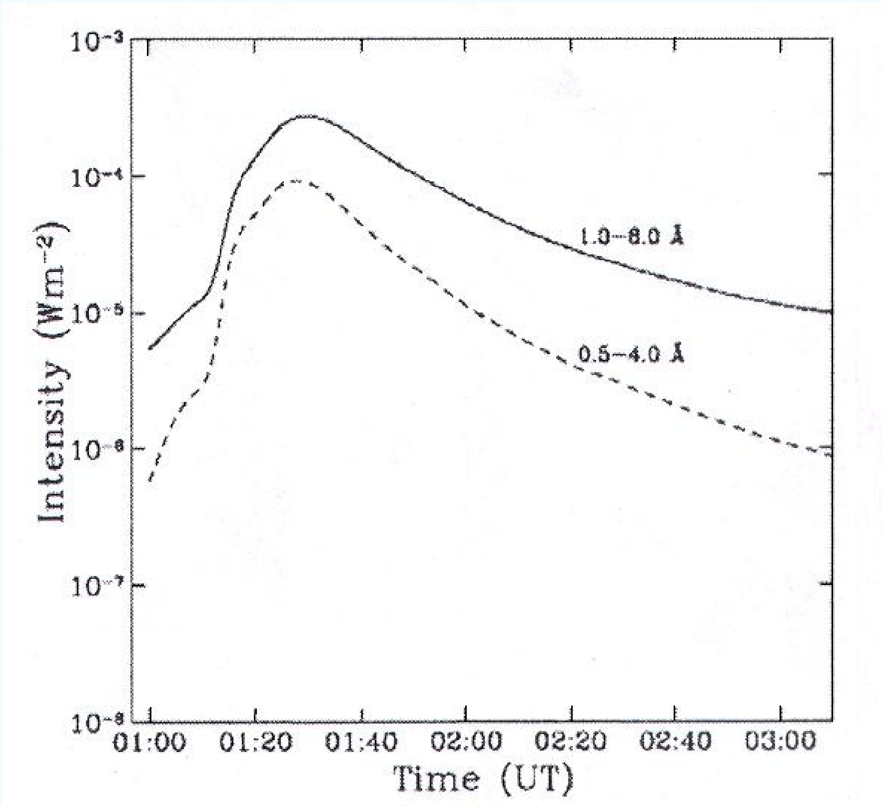


Figure 11. Soft X-ray light curve of the flare obtained from GOES measurements. Solid line is from 1-8 Å channel and dashed line is from 0.5-4 Å channel.

Observations of total solar eclipse on March 29, 2006 from Manavgat, Turkey :

During total solar eclipse on 29 March, 2006 from Manavgat, Turkey, ARIES team carried out high temporal resolution narrow band photometry in FeX red coronal line (6374 Å , pass-band 2 Å) with 12.5-cm f/5 refractor equipped with Photometrics PXL 512x512, 12 bit CCD camera to study the short period oscillation in the solar corona. For the study of changes in the Earth's atmospheric parameters during total solar eclipse, we installed a mini weather station at the observing site. During the totality period of 3 min 45 sec we obtained a total of 250 images with a temporal resolution of 0.9 sec. From the power spectrum of the light curve in the selected region at the solar corona which is at the top of an active region loop system, we found a peak at 88 sec. The detection of such periodic variation may be associated with the oscillations of magneto-hydrodynamic waves that are likely to be responsible for high temperature of the solar corona. During the totality various atmospheric parameters recorded by mini weather station. At the time of totality solar radiation reached almost zero value. The profile of air temperature also shows a gradual decrease in the ambient air temperature with a maximum decrease of ~2.5 ºC. However, the minimum temperature did not occur at the maximum eclipse but ~8 minutes latter. This time lag may be interpreted in terms of the thermal inertia of air and ground. Relative humidity, because of its dependence on temperature, increases as a consequence of decrease in temperature. [**W. Uddin, B. Joshi, T. S. Kumar, S. Sharma and R. Sagar**]

THE SUN AND SOLAR SYSTEMS STUDIES

Surface changes in solar irradiance due to aerosols over central Himalayas :

During a comprehensive aerosol field campaign as a part of the ISRO-GBP, extensive measurements of radiative fluxes at the surface were made during December 2004 at Manora Peak, in the Shivalik ranges of the Central Himalayas. The surface radiative fluxes were used to estimate aerosol radiative forcing. Present analysis clearly shows that during the clean atmospheric conditions over Manora Peak, the observed aerosol radiative forcing is in good agreement to those of modeled ones, while for the higher aerosol optical depths, modeled values are significantly smaller than the observed ones (Figure 12). It was observed that at Manora Peak, the anthropogenic aerosols (from valley below) transported upwards

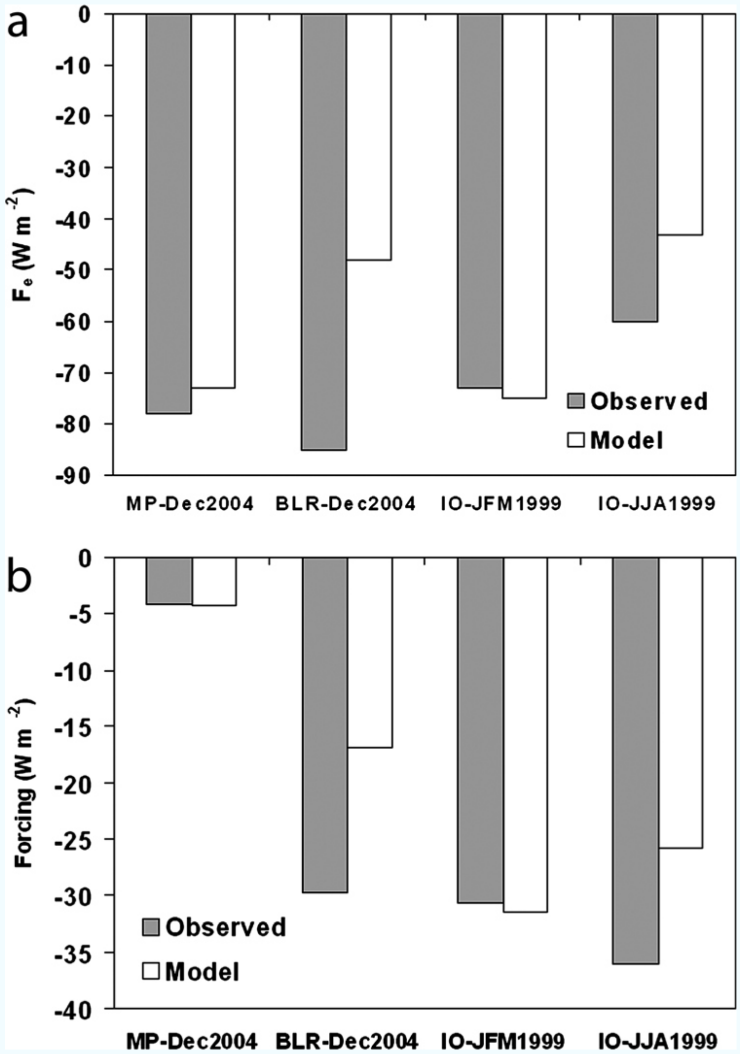


Figure 12. (a) Comparison of modeled and observed aerosol forcing efficiency at Manora Peak (MP), Bangalore (BLR) and Indian Ocean (IO) [during winter months of January, February and March 1999 and summer monsoon months of June, July and August 1999].
(b) Comparison between the modeled and observed aerosol radiative forcing is shown in lower panel

by evolution of boundary layer during the daytime provide an atmosphere conducive for 'mixed' aerosols. Focused efforts are needed to address this issue for which simultaneous observations at high altitude site with those in nearby valley are essential. [**U. C. Dumka**, S. K. Satheesh (IISc, Bangalore), **P. Pant**, **P. Hegde**, and K. K. Moorthy (SPL, Thiruvananthapuram)]

Aerosol characteristics at a high-altitude location during ISROGBP Land Campaign-II :

The detailed analysis of the extensively measured aerosol parameters at ARIES, Manora Peak, Nainital, during ISROGBP Land Campaign-II was completed. This land campaign was focused on the winter month of December 2004, using eight fixed stations distinctly located over the Gangetic belt in the North Indian corridor, where thick fog conditions generally prevail during winter. Among these stations, Manora Peak was selected due to its high-altitude location, at an altitude of ~2 km, having a pristine location in the Shivalik Ranges of Central Himalayas and allowing a free tropospheric site. In this perspective, observations of aerosol optical depths (AODs), black carbon (BC) mass concentration, total columnar ozone (TCO), mass loading of total suspended particulates (TSP), and number concentration of near-surface aerosols have been carried out from Manora Peak. These experiments barring AODs, were made for the first time at this location. The monthly mean AOD at 500 nm was found to be 0.056 (± 0.037). Temporal as well as the diurnal variation of BC mass concentration (Figure 13) show almost similar variation as that of aerosol number (>0.3 μm) concentration, having relatively low values during night and early morning periods, and gradually increasing as the day advances reaching its maximum level around 1600 h local time. The monthly mean BC concentration was found to be 1.36 (± 0.99) $\mu g\ m^{-3}$. Mass loading of TSP was in the range 20-40 $\mu g\ m^{-3}$, with a mean μ value of 27.1 (± 8.3) $\mu g\ m^{-3}$. During the period under study, average BC mass fraction at Nainital was found to be ~6.3 ± 2%. The monthly mean TCO was found to be 268 ± 22 DU. The diurnal variation of BC mass concentration shows a typical behaviour compared with other low-altitude stations, where simultaneous measurements were made by other investigators during the campaign. This behaviour in the diurnal trend of aerosols may be due to the topography and the boundary-layer dynamics over the high-altitude station of ARIES at Nainital. [**P. Pant**, **P. Hegde, U. C. Dumka**, A. Saha (France), M. K. Srivastava (CAPS, Darjeeling) and **R. Sagar**]

On the use of simultaneous measurements of OH and O_2 emissions to investigate wave growth and dissipation :

Simultaneous measurements of mesospheric OH (6-2) Meinel and O_2 (0-1) Atmospheric band emissions from a low-latitude station, Maui, Hawaii (20.8° N, 156.2° W) are utilized to study the wave characteristics and associated processes. Deduced temperatures show large variability in both OH and O_2 data. The seasonal variability in the temperature shows a well-defined, semiannual type of oscillation, which is comparable to the ground-based rocket sounding data (Figure 14). The "Wave Growth Factor", a ratio of normalized perturbation amplitude in O_2 to the OH temperature variability, is estimated for principal as well as residual smaller period components of the nocturnal variability. It is noticed that smaller period

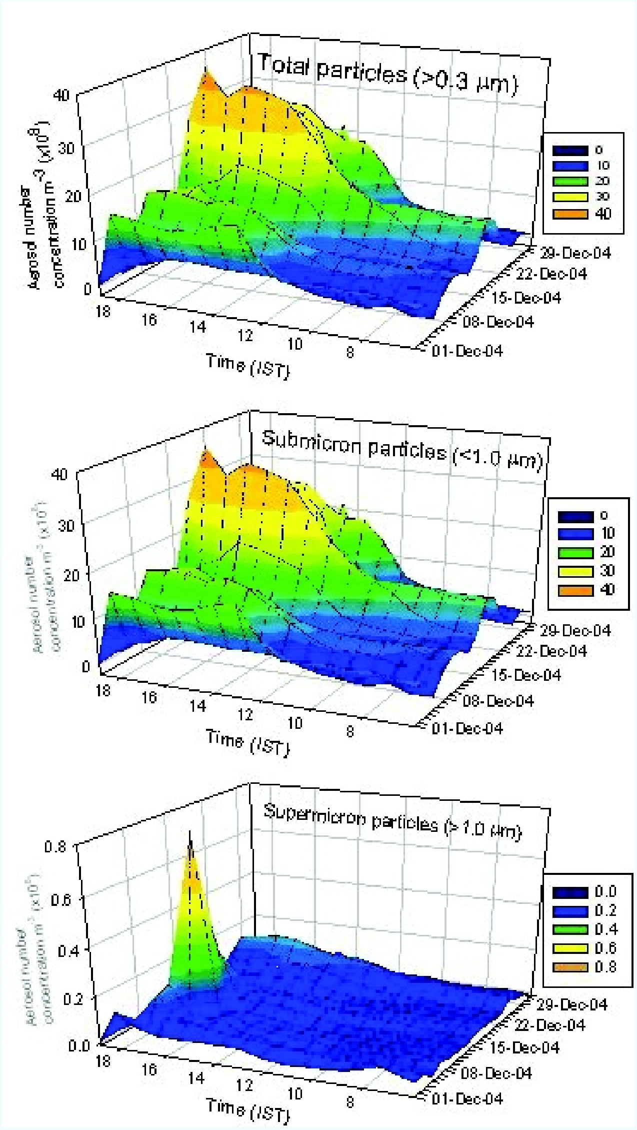


Figure 13. Diurnal variation of composite aerosol number concentrations of representative sizes during December 2004.

waves (< 12 h) occasionally have large growth factors of about 3-4 during equinox transitions, an indication of wave amplitude amplification within the 87-94 km altitudes while a strong wave dissipation occurs throughout the year. [**A. Taori**, **A. Guharay**, and M. J. Taylor (USA)]

Studies on trace gases and aerosols

In order to establish a complete environmental observatory at ARIES, observations of trace gases have been initiated recently in addition to the ongoing aerosols observations. These observations are being carried out using on-line instruments and by collecting the air samples and analyzing them in collaboration with NIES, Tsukuba Japan and PRL, Ahmedabad. An UV absorption based ozone instrument is operational at ARIES since October 2006. Another set of instrument of similar kind is also procured and is being used at Devasthal (altitude ~ 2500-m above msl) and G. B. Pant University of Agriculture and Technology, Pantnagar (altitude ~

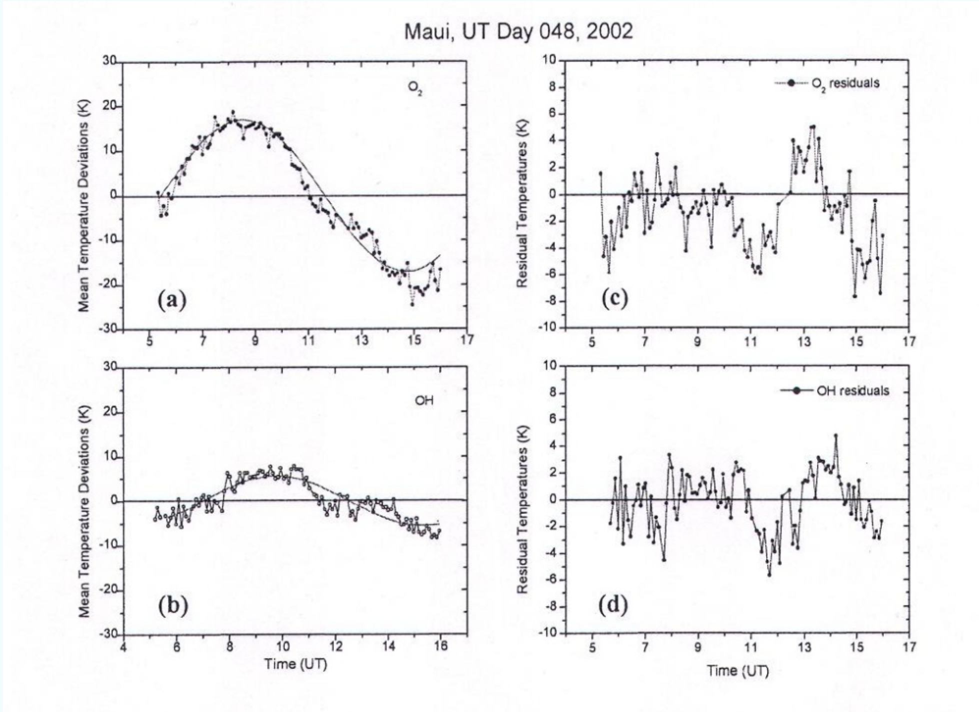


Figure 14. The mean temperature deviations for the O_2 emissions and OH emissions on UT day 48, 2002. The solid line curve is the result of a best-fit sinusoidal analysis. A long period tide-like oscillation is evident in the data with periodicity of about 12 h. The temperature residuals are plotted in the right panels **(c, d)**. Note the large variations in the smaller period wave perturbations with periods ranging from 10 min to 6 h.

231-m above msl) for a site survey. Average ozone level is observed to be 40-50 ppbv until January 2007 and thereafter it showed a gradual increase with showing of ozone values of as high as 88 ppbv in March 2007 at ARIES. Interestingly, ozone variations do not show signature of in-situ photochemical ozone production at this site suggesting that ozone levels might have greater contribution from dynamics (Figure 15). Mountain valley circulation appears to be playing a role in determining the diurnal variations. **[M. Naja,** S. Lal (PRL), H. Mukai (NIES), T. Machida (NIES), **P. Pant and R. Sagar]**

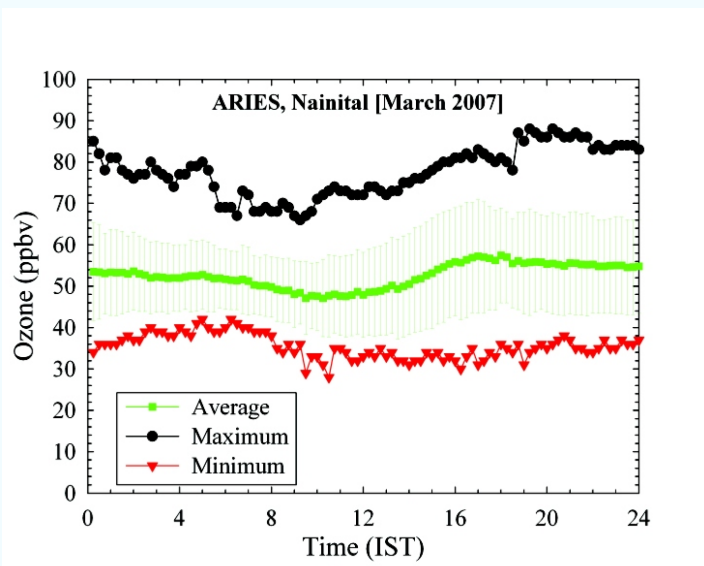


Figure 15. Average diurnal variation in ozone in March 2007 at ARIES, Nainital. Diurnal variations in maximum and minimum values are also shown.

RESEARCH COLLABORATIONS

The following activities are going on in collaboration with various institutions Under the MoU signed with ARIES :

1. Department of physics, Punjabi University, Patiala and ARIES have a collaborative DST sponsored research and development project entitled "Photometric and Spectrophotometric study of variable stars and Be stars". The PI of the project is Dr. P. S. Goraya from Punjabi University and Co-PI is Dr. B. B. Sanwal from ARIES.

The objectives of the project are :

(i) To carryout CCD photometry and spectroscopy of Be stars, RR-Lyrae and Cepheid variables through broad band filters.

(ii) To create image processing facilities and to acquire a CCD camera and spectrograph to be installed with the available telescope in the physics department of Punjabi University.

(iii) To study variability of H , H emission lines in Be stars and to find their correlation with continuum energy distribution.

(iv) To search for the near UV and near IR excess emission from some of the Be stars. Observations for around 200 stars have been obtained using 2-m IUCAA telescope equipped with faint object spectrograph camera. Data analysis is in progress.

2. A collaborative work on Aerosol Climatology and Effects (ACE), under ISRO-GBP in collaboration with Punjabi University, Patiala is going on. ARIES provided and installed the multi wavelength radiometer (MWR) in March 2006 for the aerosol optical depth (AOD) measurements at Punjabi University, Patiala. With the help of this MWR the solar extinction measurements are being carried out at Patiala. Measurements of columnar AODs, and perceptible water vapor content (W) using MWR and suspended particulate matter (TSP), using High Volume air Sampler (HVS; Envirotech Pvt. Ltd make), were carried out from Patiala during an Integrated Campaign for Aerosols, Gases and Radiation Budget (ICARB) under ISRO-GBP from March - June 2006. Temporal variation of daily mean AOD during ICARB is shown in figure 16. Mean AOD values at 500 nm were estimated to be 0.27, 0.36 and 0.69 during March, April and May 2006 respectively. The values of and were evaluated by linear least square fitting of $_p$ - estimates on a log-log scale. The estimated value in the present study ranges from nearly zero to ~ 0.7. Values of close to zero or some times negative indicates the dominance of coarse particles. It was found from the HVS observations that mass concentration of RSPM varies from 34.4 gm/m^3 to 189 gm/m^3 while NRSPM mass lies between 108.42 gm/m^3 and 346.2 gm/m^3. RSP has higher mass concentration in the first week of May but decreases systematically towards the end of the month. On the other hand, there is exceptional increase of NRSP on 1st May and decreases gradually towards the end of May 2006. [Darshan Singh, Manjit Singh, Balbir Singh and **P. Pant** "Aerosol characteristics at Patiala during ICARB"]

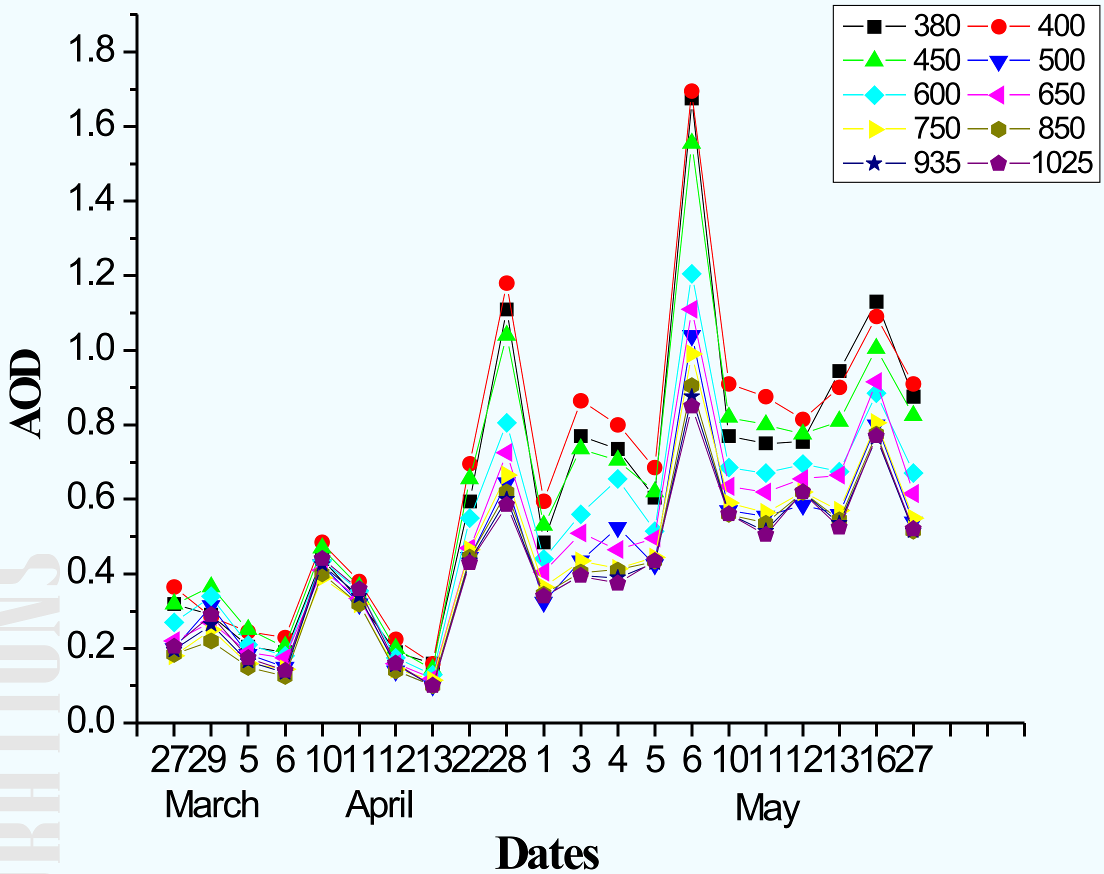
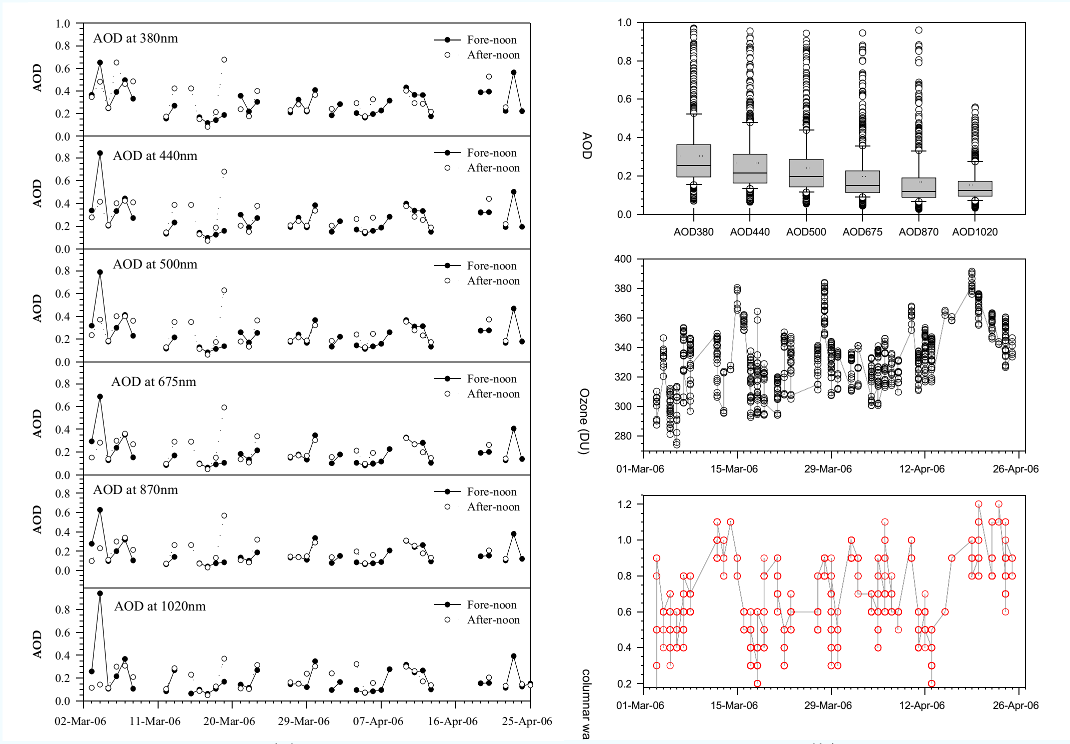


Figure 16. Temporal variation of daily mean AOD at Patiala during ICARB.

3. Columnar AOD, ozone and perceptible water vapor measurements were carried out with the help of Sun Photometer and Ozonometer (Microtops II) in collaboration with G. B. Pant Institute of Himalayan Environment and Development (GBPIHDE), Kullu, during ICARB under ISRO-GBP. MWR set-up was also done at Kullu for the regular AOD measurements under ISRO-GBP network station. During ICARB, total suspended particulate matter (TSP), particulate matter below 10 micron (PM_{10}), sulphur dioxide (SO_2) and nitrogen oxide (NO_2) using Respirable Dust Samplers attached with Impingers (APM-460 & APM-550); surface ozone (O_3) using Ozone Analyzer (Monitor Europe, model ML 9811) and prevailing meteorological parameters using automatic weather station (AWS, Wind Monitor-258) were also carried out from Mohal (31.92^0 N, 77.12^0 E; 1155 msl), 5 km south to Kullu and Kothi (2529 msl), 12 km north to Manali in the Kullu valley of Himachal Pradesh.

Figure 17 shows the temporal variations in columnar AOD, water and ozone during the ICARB. The monthly mean values of columnar AOD was found to be 0.24 ± 0.15 at 500 nm, TCO 326 DU (March 2006) and 339 DU (April 2006) and Water vapour 0.59 cm (March 2006) and 0.75 cm (April 2006). During observational period, mean spectral AODs were evaluated as 0.31 ± 0.17; 0.27 ± 0.16; 0.24 ± 0.15; 0.20 ± 0.14; 0.17 ± 0.14 and 0.15 ± 0.09 at 380, 440, 500, 675, 870 and 1020 nm, respectively.



(a) (b)

Figure 17. (a) Forenoon and afternoon daily variations in AODs at Mohal **(b)** variation in aerosol optical depth (upper panel), columnar ozone (middle panel) and water vapour content (lower panel) as obtained from Kullu site. In the upper panel box points closer to zero indicate the 5th percentile, continuous line and dotted line within the box mark the the median and mean values respectively and the boundary of the box farthest from zero indicate the 75th percentile.

During the study period, the monthly average TCO remained 326 in March 2006 and 339 in April 2006, with a mean value of TCO and W as 333 ± 21 and 0.64 ± 0.22, respectively. The monthly average of columnar water vapour content was 0.59 cm in March and 0.75 cm in April 2006. The mean values of Angstrom coefficient were found to be as 0.70 ± 0.31 and 0.18 ± 0.13 respectively, indicating the relative dominance of fine particles as compared to coarse particles.

The maximum value of TSP at Mohal was observed as 327 μg m^{-3} on June 30, 2006. Whereas, it was 150 μg m^{-3} on April 15, 2006 and 143 μg m^{-3} on January, 2006. On the other hand values at Kothi were 293 μg m^{-3}, 155 μg m^{-3} and 198 μg m^{-3} on May 23, June 22 and June 28, 2006, respectively. The average concentration of surface ozone was of 29.9 ppb. [Jagdish C. Kuniyal, Alpana Thakur, Smita Tripathi, Harinder K. Thakur, Sanjeev Sharma, Santaram S. Oinam, **P. Pant, P. Hegde** and **U. C. Dumka**, "Aerosols Characteristics at High Altitude Locations of Kullu-Manali in the Northwestern Himalaya during ICARB"]

4. Under a collaborative research programme between National Atmospheric Research Laboratory (NARL), Gadanki and ARIES, Nainital, a portable lidar system was installed at ARIES, Nainital during May 2006. The main scientific objective of the lidar is to study the vertical distribution of aerosols in the troposphere and stratosphere and also different types of cloud occurrences and their optical properties such as scattering and extinction. The lidar observations

are first of its kind taken from a high altitude location of Manora Peak, Nainital (29° 22' N, 79° 27' E, elevation - 1960 m), in the central Himalayas. The lidar employs a diode pumped Nd:YAG laser with second harmonic output at 532 nm and operated at 2500 Hz. The lidar receiver employs a 150- mm cassegrainin telescope and a high gain PMT operating in photon counting mode. The backscattered signals are measured with a bin width of 200 ns corresponding to the altitude interval of 0.030 km. A PC based multichannel analyzer (MCA) has been employed for recording the photon returns. The vertical and temporal resolutions of the lidar system were set at 0.030 km and 120 s, respectively.

During the test observations in May 2006, the height distribution of elevated aerosol layers was seen up to the height of ~3 km above the ground level (AGL). The backscattered photon counts profile revealed the presence of high altitude cirrus clouds in the height ranging from ~ 8.5 to 9.5 km AGL on May 16, 2006. A drastic reduction in the height distribution of aerosol particles due to scavenging processes in the atmosphere, caused by heavy rain, was seen in the received laser returns on May 17, 2006. Consequently a significant reduction in the aerosol extinction coefficient and inferred AOD was observed on May 17, 2006. The AOD obtained on May 16, 2006 was about 0.208 at = 0.53 2 m, which significantly reduced to a value of about 0.08 on May 17, 2006. **[P. Pant**, Y. Bhavani Kumar, D. N. Rao and **Ram Sagar** "ARIES-NARL boundary layer lidar observations over a high altitude station, Nainital"]

FACILITIES

1. OBSERVING FACILITIES

1.1. Stellar Observing Facilities

The 104-cm Sampurnanad reflecting telescope is the main observing facility at ARIES for optical astronomers. A 2k x 2k Wright CCD camera, three channel fast photometer, ARIES polarimeter, Puntino SH sensor and 1k x 1k Pixel CCD camera were used for observations. The scientific observing programs conducted during the year 2006-07 are AGN variability, roAp stars survey, optical counterpart of the X-ray sources and Gamma-ray transient events, SN monitoring, photometry and imaging of star forming H II regions, stellar clusters, Gamma-ray star bursts, W-R galaxies and clusters of galaxies.

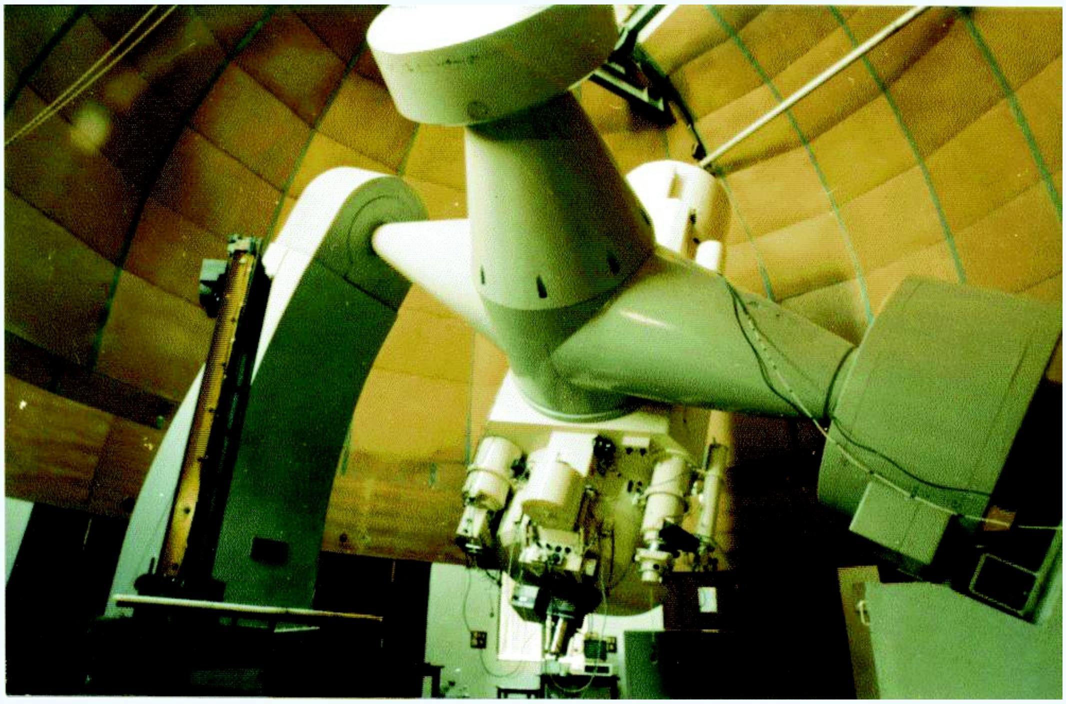


Figure 18. 104-cm Sampurnanand Telescope located at Manora Peak, Nainital.

1.2. Solar Observing Facilities

Institute has two telescopes of 15-cm aperture equipped with H-Alpha, Ca II K and CN filters and CCD cameras for carrying out observations of solar activity phenomena namely sunspot, faculae, plages, flares, prominences, etc. with a time resolution of 25 ms. A GPS clock is connected to Sun Sparc-20 computer to record on the header of the picture frames with an accuracy of one second.

1.3. Atmospheric Observing Facilities

The main observational facilities for atmospheric science group of ARIES are Multi Wavelength Solar Radiometer (MWR), Aerosol Spectrometer, Microtop-II Sun

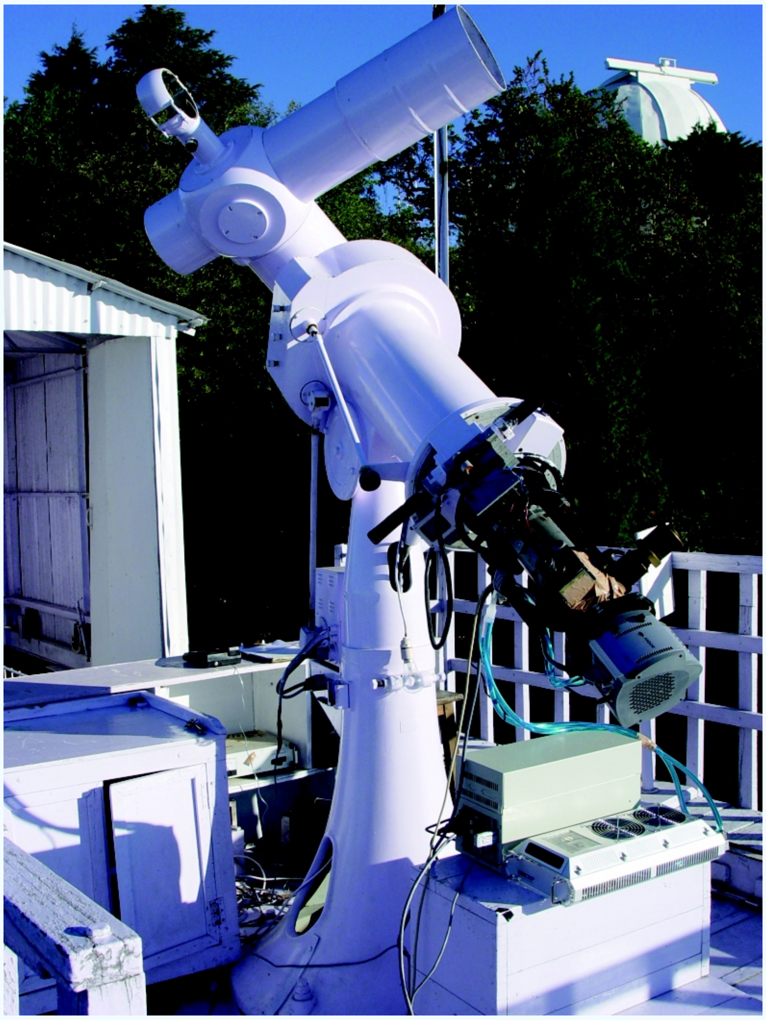


Figure 19. 15-cm Coude Solar Tower Telescope equipped with Bernhard Halle H filter & fast CCD Camera for solar activity observations.

Photometer and Ozonometer, Aethalometer, Solid State Photometer (SSP), Automatic Whether Station and scores of manual ones.

Understanding the importance of mesosphere in the coupling between lower and upper atmosphere and with emergence of mesosphere being the true representative of very long term global weather changes, recently there had been a big move for networking for detection in mesopause changes sponsored by NASA, USA. An airglow project for the development of Mesosphere Lower Thermosphere Photometer (MLTP) was therefore initiated during March-April 2005. The MLTP was a complete in-house development. Its fabrication was completed in September 2006. The associated electronics was completed in December 2006. The noise characterization of MLTP was completed in first week of January 2007 and first set of mesospheric OH (peak altitude ~87 km), O_2 (peak altitude ~94 km) and O (^1S) (peak altitude ~ 100 km) observations were carried out during 12 - 19 January 2007. Quality data for two nights (15^{th} and 16^{th} January) were collected.The photograph and results obtained from the observation of January 16, 2007 are shown in figure 20.

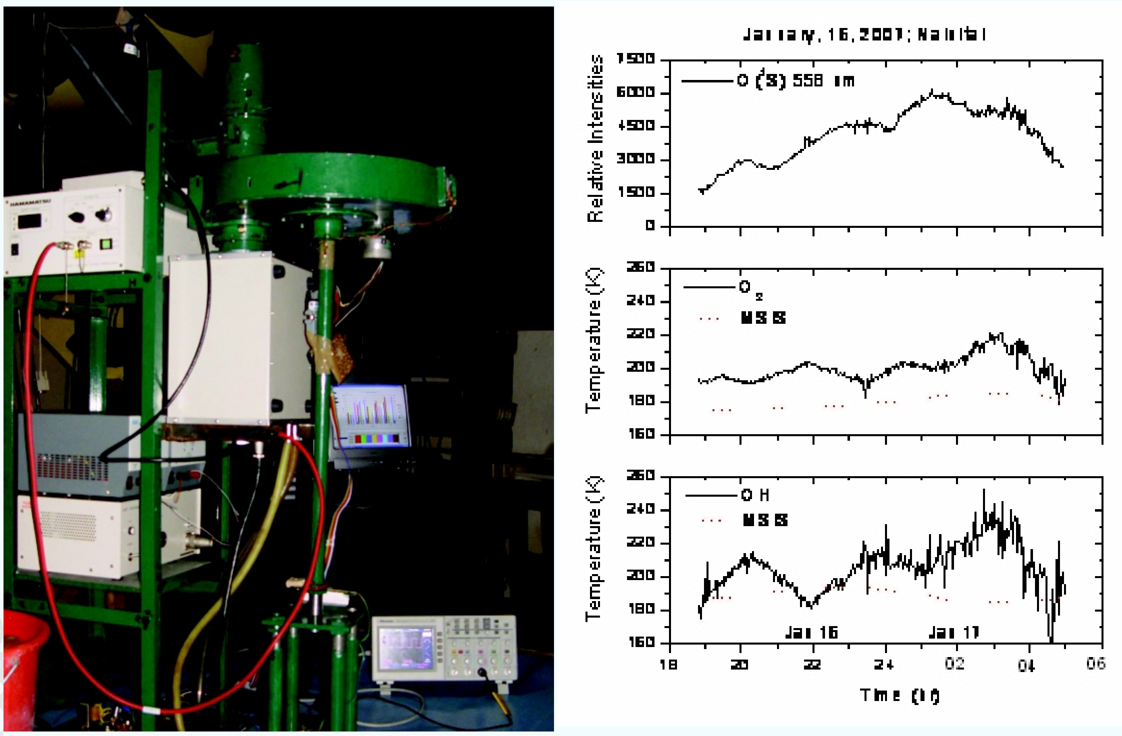


Figure 20. The Mesosphere Lower Thermosphere Photometer (MLTP): Photograph (left) and first result obtained with MLTP (right).

2. SUPPORT FACILITIES

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

2.1. Aluminizing Unit

Since mirrors used in the telescope lose their reflectivity due to weathering etc., their realuminization is a must. To do this, ARIES has an aluminizing plant, capable of taking the jobs up to 124-cm diameter. This unit is used to realuminize the primary mirror of the 104-cm telescope. Another small 30-cm diameter unit has also been used at the institute for small jobs less than 30 cm. Both units are regularly used for aluminizing mirrors under a vacuum of 4×10^{-6} torr. The smaller unit is also used for evacuating the deewars of CCD systems and IR photometer.

2.2. Computer Centre

The Institute has a modern computer centre. There has been a major upgrade in the computational facilities at the institute. Computer Centre caters to the computing needs of the faculty members and the students for their research and teaching. It has a user's base of about 100 users. Computer Centre has many hardware/software facilities as required by the Institute. The Centre has more than 100 Linux and window XP PCs, X-terminals and scientific graphics work-stations. All the computers in the ARIES are connected through a 10/100/1000 Mbps network. The institute developed new website with latest information. The data archival capacity in the institute has increased by several folds. Portable external USB Hard disk, DAT, DVD and CD storage devices are used for backup. The latest Color LaserJet printer with duplex facility is available for all end users.

Internet and web based email services are provided to all the users through a dedicated 512 Kbps Internet link. Computer Centre operates 24 hours a day, 365 days an year.

Hardware in the Centre

Computers in the centre have broadly been divided in various categories based on the activity supported by them. The broad categories of servers is listed below:

Servers

Mail Server
Proxy Server
Internet Web Server
Internet Mail Gateway
File and Print Server
Firewall

Front-end Work Stations and PCs

Digital Workstations
PCs with Linux and X environment, Windows XP, 512 MB RAM, HDD, DVD r/w, DAT drive etc.

Peripheral Equipments

Computer Centre also supports high speed color and B/W duplex laser printers, A4 scanner and plotter.

2.3. 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. 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.

During the period 2006 - 07, the following information resources were added: -

Books	:	295
Bound Volumes of Journals	:	200
Subscription of Journals (Print + Online)	:	91
ARIES Publications	:	34
ARIES Theses	:	3

The collection at the end of the period is

Books	:	Around 9655
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.

During 2006-07, the LIBSYS software of the library was upgraded, added with new features is being used. The new features of Online Catalogue is available at Web-OPAC on ARIES home page as well as ARIES Intranet. The subscribed E-journals are also available at ARIES Library home page. The stack of Books and Periodicals, etc. are re-arranged in the ARIES Library. Online subscription of Springer Journals and Nature are continued under FORSA Consortium. UCP Journals (Print + Online) are subscribed under FORSA Consortium.

FACILITIES

2.4. Civil Works Section

The civil work section looks after the routine maintenance, and modifications/renovation of the ARIES office and residence buildings and roads. During 2006 - 07, some of the works done by the section at Manora Peak are :

(i) Demolition of old walls of optics lab of ARIES,
(ii) Construction of sub-station/generator hall,
(iii) Construction of guest house, hostel building, optics lab. and science centre are in progress,
(iv) Construction of water tank,
(v) Renovation of main building toilet,
(vi) Jungle clearance and making drains along foot-paths of the ARIES campus.

Prof. K. Kasturirangan, Chairman, Governing Council ARIES, visited ARIES Nainital on 8th April, 2006. He laid foundation stone for Guest house at Manora Peak. Prof. G. Srinivasan, member, ARIES Governing Council, Mr. K. P. Pandian, Financial Adviser, Ministry of Science and Technology and local staff and people were also present on these occasions. Prof. Kasturirangan addressed the gathering and expressed his desire to develop the institute to carryout front line research in Astronomy and Astrophysics, equipped with modern instrumentation and facilities.

Figure 21. Foundation stone laying of ARIES - Guest House by Prof. K. Kasturirangan, Chairman of Governing Council of ARIES on April 08, 2006.

2.5. Electronics Workshop

The Electronics workshop supplemented by an electrical wing looks after the routine maintenance, testing, modifications, design and fabrication of electronics/electrical equipments. A new electronics lab which includes embedded systems, computers and sophisticated tools and instruments has been installed. A 60 KVA centralized UPS distribution for the computers and instruments was established. A 15 KVA three phase UPS for 104-cm telescope system was established. New 300 KW substation was installed to meet the growing power requirement of the Institute.

During the year 2006-07, three apprentice trainees completed their one year training successfully. Twenty diploma students completed their 30 days vocational training in February 2007. Two apprentice trainees joined for one year training in January 2007.

2.6. Mechanical Workshop

The fabrication, maintenance and modifications of various equipments, telescope houses and other miscellaneous jobs are carried out by the mechanical workshop. Mechanical maintenance of the stellar and solar telescopes was done on a regular basis. Servicing and maintenance of the institute vehicles and generators was also done as and when required.

During the year 2006-07, three diploma students completed their 45 days vocational training in February 2007.

2.7. Optics Workshop

The optics workshop has an automatic grinding and polishing machine capable of taking the jobs up to 75 cm diameter, two rotating spindles for manual work on jobs to 25 cm diameter, a drilling assembly for scooping holes, a glass slitting machine and a grinding machine capable of taking jobs up to 20 cm. The optics workshop looks after the routine maintenance, testing and modifications of the optical equipments of the institute.

3. UPCOMING FACILITIES

ARIES has started several major projects with an aim to establish world-class research facilities in the area of Astronomy & Astrophysics and Atmospheric Sciences at Devasthal as well as at Manora Peak campus. Following are the description about these ongoing and upcoming projects.

3.1. Devasthal Site

Devasthal is a potential astronomical site for astronomical observations at optical band situated in the central Himalayan range at an altitude of ~ 2500-meters above msl (latitude 29°:22':26'' North, longitude 79°:40':57'' East). The site is far from any urban developments and therefore the light contamination is minimal. Seeing measurements close to ground level coupled with the number of yearly spectroscopic nights (~ 210), photometric nights (~ 160), darkness of the per square arcsec sky (V~ 21.8 mag) and other atmospheric parameters for Devasthal make this site favorably well by the international standards.

The environmental clearance from the Ministry of Environment and Forests, Govt. of India, for setting up the proposed optical observing facilities has been granted to ARIES. Construction of a 6-meter wide and 3.5 km long metalled road connecting the highway to Devasthal site is in progress and expected to be completed by end of the year 2007. The new site has already been connected with the Manora Peak by a high-speed 2.4 GHz microwave link having a bandwidth of 14 Mbps. This link enables the transfer of computer data, INTERNET data, and telephone voice data for communication between the two places. Uttarakhand Power Corporation is also installing a high tension, 150 kW power line as per the ARIES requirements. The requirement of water will be met by tapping the available natural resources by installing hand pumps and also by making use of water harvesting techniques. Other requirements related to the infrastructure and supporting facilities are also being developed.

3.1.1. 3.6-m Devasthal Optical Telescope

The institute, after a persistent effort of about 3 decades, contracted the design, fabrication and installation of the 3.6-m optical telescope, largest in the country, as a modern national observing facility in optical astronomy. Major national research institutions participating in the project are Indian Institute of Astrophysics, Bangalore and Tata Institute of Fundamental Research, Mumbai. Russia and Belgium are also participating in the project under their respective bilateral programs of cooperation in Science and Technology. Special Astrophysical Observatory, Russia has agreed to provide necessary Infra-structural facilities for realization of mirror coating and development of some of the back-end instruments. The Kingdom of Belgium is contributing 2 million Euros to this project. This financial contribution from Belgium will fetch them proportionate amount of observing time on the telescope.

The project is to install the largest new technology optical telescope ever installed in India. It is to address wide range of astronomical problems and also involves considerable amount of technological advancement in the field of precise mechanical and optical systems.

The telescope will be used for carrying out high resolution (/ = 60000) optical spectroscopy and high quality imaging at optical and near infrared bands in a moderate size field of view. The configuration is primarily driven by the scientific objective of the telescope. It will have alt-azimuth mount, F/9, Ritchey-chretien Cassegrain focus, active primary mirror support system and secondary mounted on a hexa pod mechanism. A faint object spectrograph camera, a near infrared imaging camera and a high resolution spetropolarimetric instrument are proposed as first generation back-end instruments.

Advanced Mechanical and Optical Systems (AMOS), Belgium has been awarded the contract on March 29, 2007 for the design, manufacture, integration, testing and installation of the telescope. The optics of the telescope shall be manufactured by LZOS, Russia. The contract price is 14.2 million Euro with an additional cost of 2 million Euros as Belgiam contribution. The project duration is around 48 months.

Considering expertise in various aspects of the project, the Governing Council of ARIES, chaired by Prof. K. Kasturirangan, has constituted a Project Management Board (PMB) with Prof. P. C. Agrawal, TIFR, Mumbai as its Chairman. Members of the PMB are from various reputed organization of the country.

First meeting of the PMB was held on November 17-18, 2006 at ARIES, Nainital. In this meeting outline for execution of the project, optical design of the telescope, requirements for buildings/enclosure and backend instruments were discussed. 2nd meeting of the PMB was held on February 16, 2007 at IIA, Bangalore. Chairman summarized the technical and commercial bids of the project submitted by the telescope vendors. Dr. T. G. K. Murthy, Chairman, Technical evaluation committee summarized the minutes of the meeting held on January 22, 2007 at IIA, Bangalore.

In the 3rd meeting of the PMB held on March 14, 2007, Prof. T. G. K. Murthy presented report on LZOS visit regarding evaluation of mirror blank available at LZOS. Discussions on the identification of vendor for the telescope were held and draft agreement between AMOS and ARIES was also discussed.

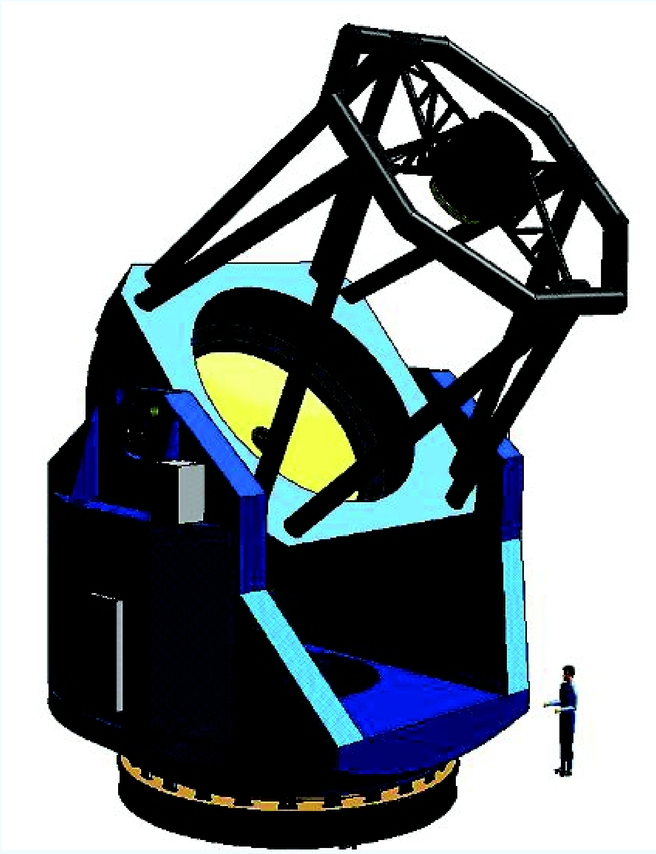
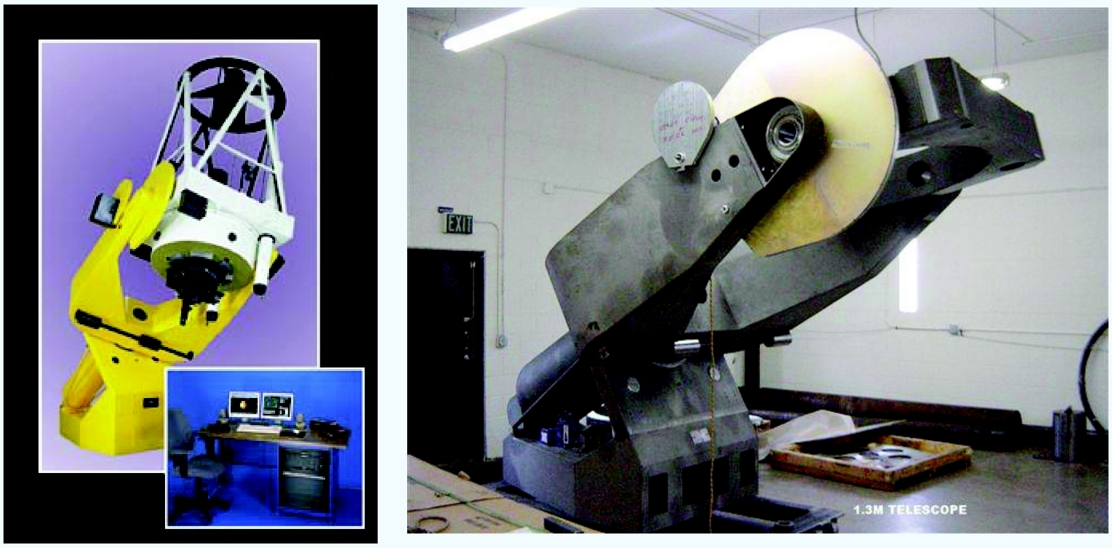


Figure 22. A sketch of the 3.6-meter Devasthal Optical Telescope.

3.1.2. 1.3-m Optical Telescope

The 1.3-meter optical telescope project was contracted to DFM Engineering Inc., USA as a turnkey project at a cost of around Rupees 7 crores in March 2006. Construction of the telescope building and development of other infrastructural requirements (electricity, water, road etc.) have already been started at the site. According to the present status of the project, telescope is expected to arrive at the site during first half of the year 2008 and made operational by end of the year 2008.

Primary scientific objectives of the telescope are to monitor time critical phenomena like transient events (gamma ray bursts and supernova explosions), pulsation and variability studies of both galactic (rapidly oscillating Ap Stars, deltaScuti Stars, white dwarfs and chromospherically active stars), optical monitoring of extragalactic (e.g. active galactic nuclei and microlensing) objects and also to study star formation and stellar evolution. To meet these scientific objectives, the technical specifications of the 1.3-m Devasthal Telescope are outlined as follows. The focal ratio of the optical system is F/4 Ritchey-Chretien Cassegrain with F/2.35 Primary mirror, effective focal length is 520-cm, plate-scale at Cassegrain focus is 40 arcsec/mm and Unvignated FOV at the focus is ~ 66 arcmin. Two fast readout CCD Cameras (a fast frame transfer 512 x 512 CCD camera and a 2k x 2k CCD Camera of low noise, high performance throughput in the visible range) and a low-resolution spectrograph (/ = 5000, equipped with 1k x 1k thermo-electrically cooled CCD camera) were purchased as a first generation back-end instruments for the telescope.



(a) (b)

Figure 23. (a) A sketch of 1.3-meter telescope at Devasthal.
(b) Fork and base of 1.3-m telescope as manufactured at DFM.

Prof. K. Kasturirangan, Chairman, Governing Council of ARIES, visited Devasthal on April 09, 2006. He laid foundation stone for 130-cm telescope house at Devasthal. Prof. G. Srinivasan, member, ARIES Governing Council, local staff and people were also present on these occasions. Prof. Kasturirangan addressed the gathering and expressed his desire to develop the institute and Devasthal site like Kitt Peak National Observatory to carryout front line research in Astronomy and Astrophysics, equipped with modern instrumentation and facilities.

Figure 24. Foundation stone laying of 130-cm Devasthal Optical Telescope House by Prof. K. Kasturirangan, Chairman of Governing Council of ARIES on April 09, 2006.

3.2. Projects at Manora Peak

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

3.2.1. Multi-Wavelength 84-cm Backscatter LIDAR System

A lidar project was started to fabricate and to assemble a powerful Rayleigh and Mie LIDAR (light detection and ranging) to study aerosol characteristics and middle atmospheric dynamics during the year 2005. This has been taken as in house technology development project with estimated budget of about Rs. 1 crore. For monitoring the project, a PMB was formulated by the governing council of ARIES. There had been two reviews by the PMB so far. First phase of the project was to build the mechanical assembly of telescopes (84-cm for Rayleigh and 38-cm for Mie) before going for the next phase (procurement of laser source, electronics and other optical components).

Construction of LIDAR building started in March 2007 and is expected to be completed by the end of year 2007. The fabrication, inspection, assembly and installation of Rayleigh telescope have been completed except the critical optical tests. Optical components (beam splitters, beam expanders, interference filters and lens) have been ordered and a PMT has also been acquired for testing purposes in the electronics section.

FACILITIES

3.2.2. Stratosphere Troposphere Radar

Department of Science and Technology has approved the setting up of a Stratosphere Troposphere (ST) Radar at ARIES, Nainital. Total cost to setup the ST-

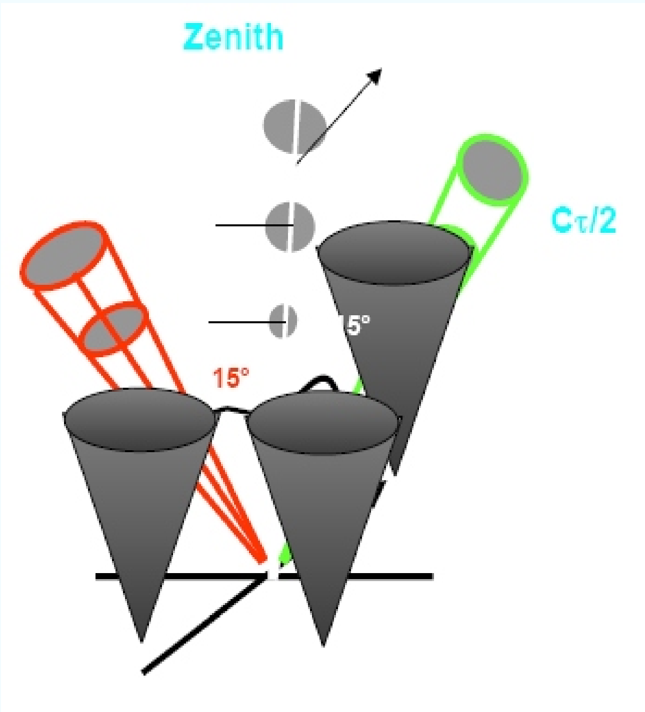


Figure 25. DBS/SAD multi mode clear air profiler.

Radar and its running cost for the period of three years is about rupees 140 millions. This decision has provided a significant boost for research work in atmospheric sciences in this Himalayan region of India. The proposed ST Radar could provide continuous (both time and height) observational data of meteorological parameters. The measurements from ST Radar can be made in all weather conditions. Finally, ST Radar offers an unparalleled opportunity to study not only gross features of the total wind field, but also small-scale, time-varying structures such as gravity waves, exchange process between stratosphere and troposphere and turbulence through the middle atmosphere.

FACILITIES

Following standard purchase norms and regulations of DST, Government of India and several reviews of expert committees, M/S ECIL, Hyderabad has been identified for designing and fabrication of the proposed ST Radar at ARIES. The ST Radar system at ARIES, Nainital, is planned to use the two most popular technique viz. the Doppler Beam Swinging (DBS) and Spaced Antenna Drift (SAD) technique. The ST Radar will be configured as an Active Aperture Distributed Phased Array using state of art Solid State TR module and Digital Signal Processing techniques to cover a height region from about 1 to 20 km.

A Project Management Committee, consisting 11 members and representing experts of international repute in the area from different organization, was formed by DST vide letter No. ESS/63/002/2004, dated: November 22, 2006 to assess the overall progress in the project and provide suggestion to meet scientific objectives.

The Wireless Planning Commission (WPC) has allotted the frequency 206.5 MHz for continuous and round the clock operation (letter No L-14021/430/2004-LR, dated: 4th July, 2007). Location for the installation of this ST Radar has been identified and site survey, including noise survey has also been done, which showed satisfactory results.

3.2.3. 50/80 Baker - Nunn Schmidt Telescope Project (B N S T P)

In April 2005, a unique telescope technology development venture was initiated at ARIES by undertaking: "Design, Development & Installation of 50/80 cm BNSTP" as an institutional project, aiming to provide a 4 degree field of view on a 4 k CCD for frontline astronomical observations, e.g., population of NEOs, detection of extra solar planets and wide field imaging of star clusters.

Four PMB meetings were held till March 2007. During 2006-2007, M/S Tekcons, Hyderabad has finalized the mechanical design while electronics and electrical division of ARIES designed the control systems. The first light on the renovated equatorial telescope is scheduled in November 2008. The project cost is about Rupees 150 lac. Out of which 20 lac was spent during the period under consideration.

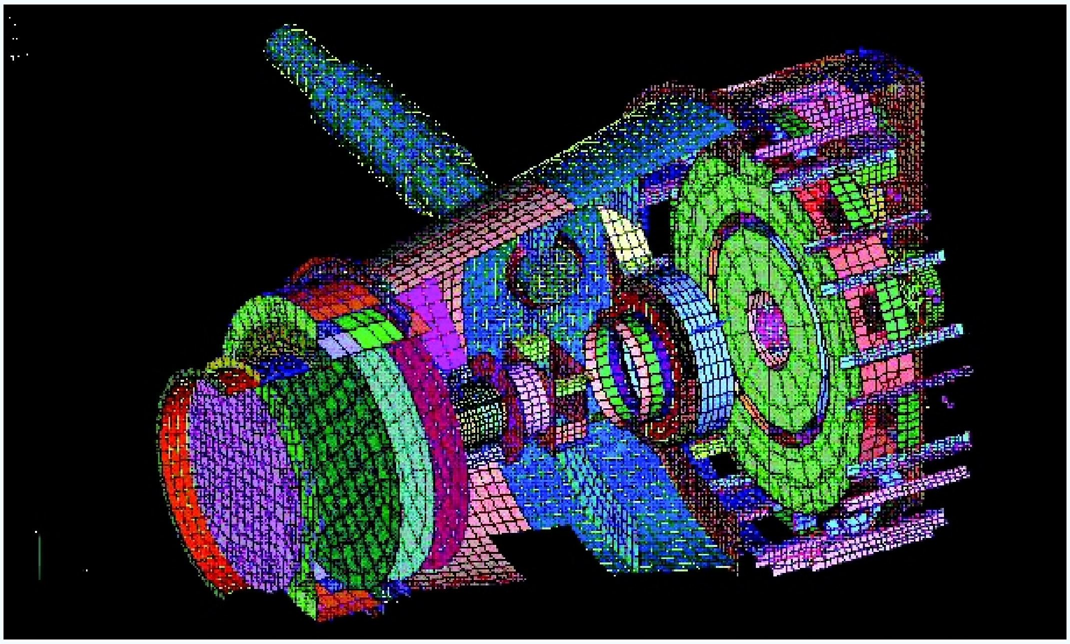


Figure 26. FEM Model of SCHMIDT Telescope.

FACILITIES

1. Conferences/Workshops

Summer School in Astronomy, Astrophysics and Atmospheric Sciences (June 05 - 23, 2006)

A summer school on introductory Astronomy, Astrophysics and Atmospheric Physics was held during June 05 - 23, 2006 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. Seventeen students from different Universities of north India attended the school. In this school, apart from about 17 lectures on the fundamentals of Astronomy, Astrophysics and Atmospheric Physics, students carried out a short fundamental research projects in four different groups. After the completion of projects, summer students gave a presentation of their work for about an hour for each project.

Figure 27. Participants of Summer School, ARIES, Nainital, June 05 - 23, 2006.

2. Pedagogical Activities

Weekly Seminars

The seminars by Institute's students, scientists and engineers were organized regularly every week. In this forum, scientists interact to each other by presenting their work or some important work recently reported by others.

Public Outreach

Various activities were carried out on the campus as well as outside to popularize astronomy and basic science among young students and common people. Slide-shows were organized during the afternoon on all working days. Nearly 4000 visitors visited the observatory during this year. The scientists from the Institute also helped the journalists of local newspapers to report various astronomical events during the year. The Institute also organized the popular talk of several Indian and foreign visiting scientists in ARIES campus as well as other schools/colleges/universities located in Nainital.

Figure 28. A talk on " Indian Astronomical Missions" by Prof. K. Kasturirangan at St. Joseph's College, Nainital on April 10, 2006 organized by ARIES in collaboration with Uttarakhand State Council of Science and Technology, Dehradun, Uttarakhand.

Institute, also, participated in an exhibition on "Dil, Dimag, Hath, Khet, Khalihan, Udyan" held at Nainital during October 14 - 15, 2006 and won First Prize for the Institute. The exhibition was organized by Acharya Narendra Dev Shiksha Nidhi Avam Jan Niyojan Aayog, UP/Uttaranchal.

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