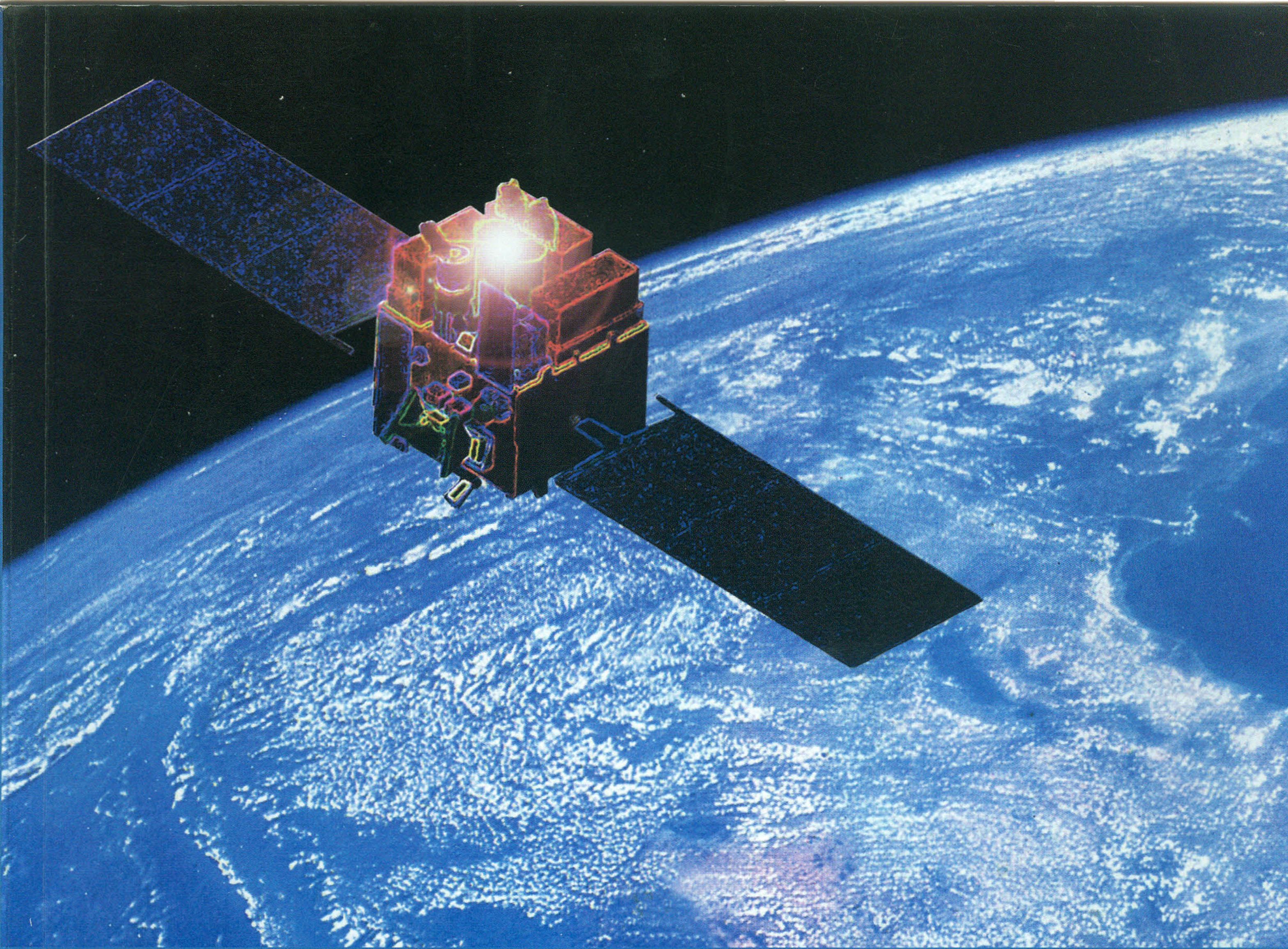


INDIAN INSTITUTE OF ASTROPHYSICS

INDIAN INSTITUTE OF ASTROPHYSICS

An undated photograph of the Madras Observatory building.
On top are two domes housing the 6 inch and 8 inch telescopes

Indian Institute of Astrophysics

Indian Institute of Astrophysics is the country's premier research institution devoted to studies in astronomical sciences. Its main campus is located in the southeastern part of Bangalore. The observational facilities are spread across the country, in four major field stations - Hanle (Ladakh, Jammu and Kashmir), Gauribidanur (Karnataka), and Kavalur and Kodaikanal (Tamilnadu). The Hosakote campus in the Bangalore Rural District houses the Centre for Research and Education in Science and Technology (CREST). The Himalayan Chandra Telescope in Hanle is remotely operated from this centre via a dedicated satellite link.

The Institute traces its origin to an observatory that was first set up in 1786 in Egmore, Madras (now Chennai) by one William Petrie, a civilian in the service of the East India Company. The Company took over its reins in 1790 and moved it to the neighbouring locality of Nungambakkam. The observatory was shifted to Kodaikanal in 1899 and became famous for its work on the sun. It was under the administrative control of the India Meteorological Department which managed the vast network of weather stations and meteorological observatories throughout the country. In 1971, it became an autonomous research institution. It is under the Ministry of Science and Technology of the Government of India.

During the thirty seven years of its existence, IIA's activities have grown manyfold and the Institute is currently in the middle of another major phase of expansion. Its efforts are directed towards developing multi-wavelength capabilities. Today IIA has its own optical, infrared and radio facilities and it has just completed the installation of a high altitude gamma ray array in Hanle. IIA is a major participant in the ASTROSAT mission, the first fully dedicated astronomy satellite of the Indian Space Research Organisation. Its ultraviolet payload, consisting of an ultraviolet imaging telescope (UVIT), and its associated instrumentation with capabilities in both near ultraviolet and visual wavelengths, has been designed in IIA and the Institute has taken the responsibility of the fabrication, testing and the final integration of the payload with the satellite due for launch in 2009. IIA also proposes to build a large solar telescope with an aperture of 2 metres as a national facility.

Starry nights at Kavalur

A notable phase in the history of the Kodaikanal Observatory began in 1960, with the arrival of M K Vainu Bappu as the Director of the observatory. Until that time the observatory specialized in solar astronomy. There was no modern equipment available for work in night time astronomy. Also, Kodaikanal was not the best site in peninsular India for a major optical astronomy observatory. Bappu set out to find a suitable location for an observatory which had access to southern skies as well as proximity to the centres of technology. His efforts bore fruit and an observatory was set up near the village of Kavalur in the Javadi Hills of Tamil Nadu. The beginning was humble, with an indigenous 34-cm reflector that was put to use in 1968. Four years later a 102-cm telescope was purchased from the Carl Zeiss Company and installed there. The Zeiss telescope made its first significant contribution within a month of its installation, when in June 1972, a stellar occultation observation carried out at the telescope indicated the possible existence of an atmosphere around Ganymede, a satellite of Jupiter.

In March 1977, while making photometric observations of the planet Uranus during another stellar occultation event, the astronomers in Kavalur Observatory stumbled upon the discovery of the Uranian ring system.

In January 1987, the Institute launched a project to search for near-earth asteroids, comets and the ever-elusive tenth planet of the solar system. Several objects were identified and tracked systematically over the next few years until the project was wound up in 1993 - 94. No less than six new main-belt asteroids were discovered. The first one confirmed in 1988 itself was named Ramanujan, in memory of the great mathematician.

Bappu was keen on building indigenously an optical telescope of approximately a 2 metre aperture, which necessitated a relocation of the main campus of the Institute to Bangalore. The headquarters formally shifted from Kodaikanal to Bangalore in December 1976. The work on building the 2-m telescope started at the Bangalore campus. The primary mirror was to be shaped out of a low-expansion glass blank purchased from Germany and stored in Kavalur. It was brought with great care to Bangalore where a modern optical laboratory for machining the blank had just been set up. An expert committee recommended that the telescope be located in Kavalur. An additional 60 acres of forest land adjacent to the existing observatory was acquired. However, Bappu did not live to see the telescope completed. He succumbed to a heart condition in August 1982. The telescope was inaugurated by the late Prime Minister Shri Rajiv Gandhi on January 6, 1986. On that occasion, the telescope and the Kavalur Observatory were formally named after their creator Vainu Bappu. For a decade and a half Kavalur became the hub of all observing activity.

Shri Rajiv Gandhi at the inauguration of the 234-cm telescope

The Optics Laboratory of IIA. The 20 metre vertical test tower is seen to the left.

To the wilds of Ladakh

With the growth in astronomical activities and the increase in the number of astronomers vying for time on a handful of telescopes available in the country, a need for setting up new telescopes was keenly felt. The astronomers wanted a large telescope with new technology instrumentation at a site that provided a larger number of clear nights. The initiative to set up such a facility started with a national meeting organized in Bangalore in 1989 by the Department of Science and Technology at the instance of the Planning Commission. A recommendation was made to 'set up a modern large-sized optical telescope in the best possible site in the country'. It was also expected that the new facility would complement the observations carried out with other national facilities such as the Giant Metre-wave Radio Telescope (GMRT), and X-ray and Gamma-ray telescopes on board the satellites.

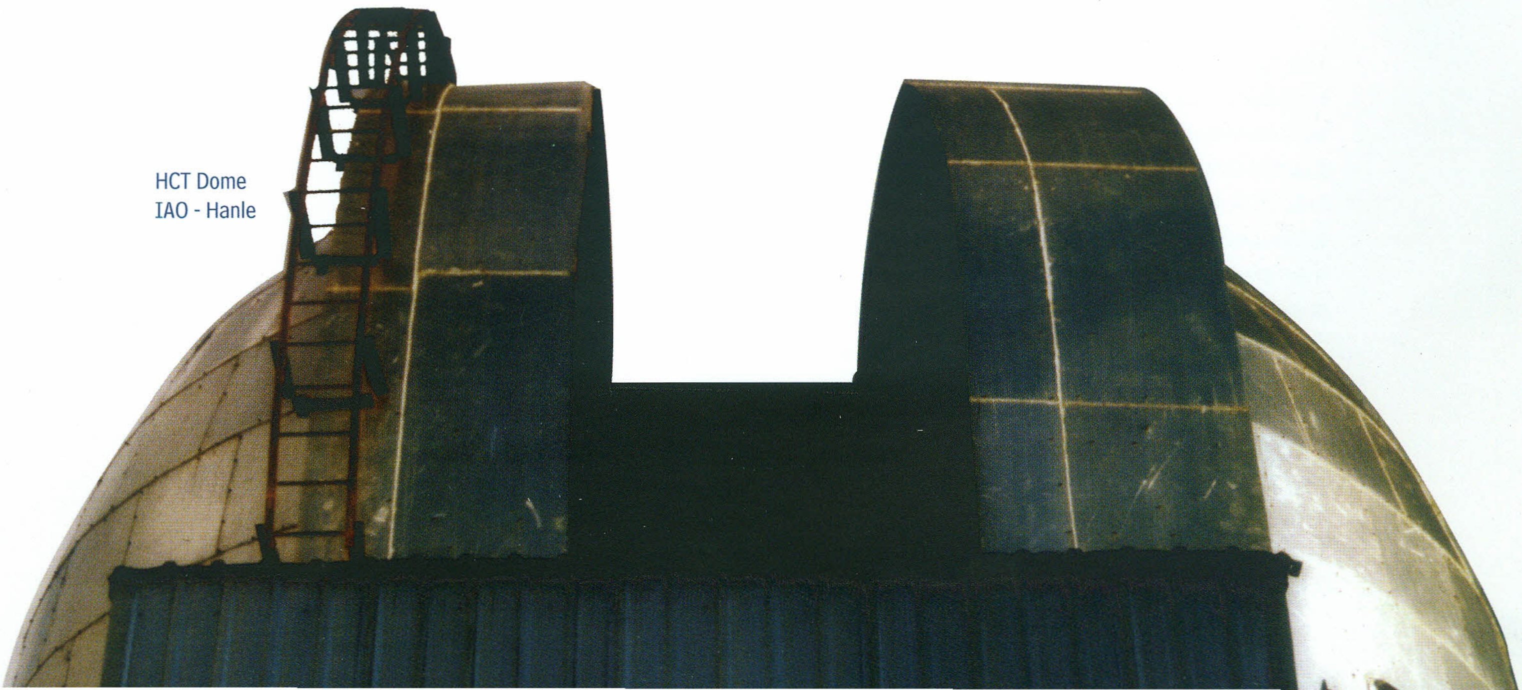
In 1993, IIA made a large investment of manpower and its resources to carry out a systematic survey of high-altitude Himalayan sites and finally, Hanle, a site in the trans-Himalayan desert region of Ladakh was identified. Located at a distance of about 250 km south-east of Leh with scant human habitation, Hanle is one of the darkest sites in the Indian sub-continent.

It was found to have a large number of clear nights and excellent sky transparency. It also qualified as a site for carrying out infrared observations as the water vapour content in the atmosphere was found to be very low. Hanle is a high-altitude desert (longitude : 78° 57' E, latitude : 32°47' N) at 4300 metres above the mean sea level and has good accessibility round the year. The observatory site was chosen to be the peak of a mountain range, Digpa Ratsa Ri, which is a bit off centre in the Nilamkhul Plain. Since November 1994, IIA has had a continuous presence at the site. Nearly 640 acres of land including the Digpa Ratsa Ri mountains and some flat area near its base were transferred to IIA by the Government of Jammu & Kashmir. A permanent laboratory building, named the 'Hanle House' was constructed at the base. An 8.5 km road leads one from Hanle to the peak of the Digpa Ratsa Ri mountains.

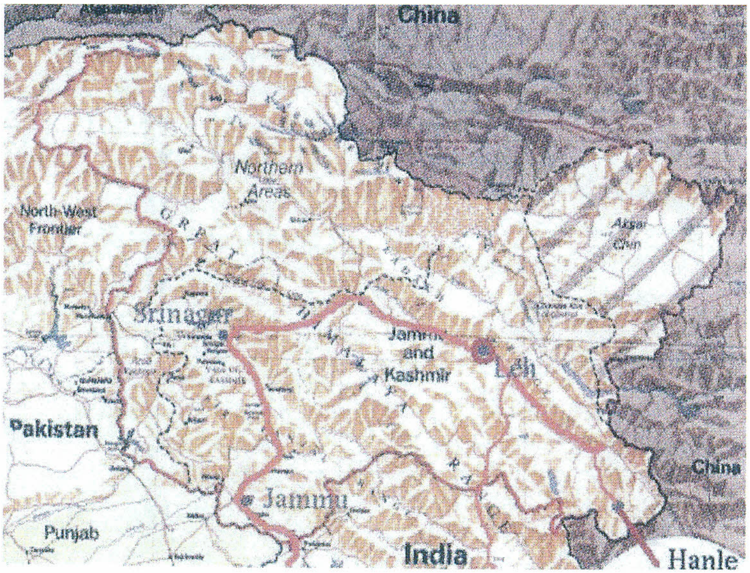
There is no commercial electrical line serving Hanle at present. Two solar power plants with 30 kVA peak capacity were set up. A back-up was also organized with battery and diesel power to last 30 hours at a stretch.

The earliest installation at the site was a 0.3-m site survey telescope which continues to serve as a Differential Image Motion Monitor or a 'seeing monitor'. A 220 GHz radiometer is functional in a tower in a closed dome having a transparent slit. It has been in continuous computer-controlled operation since December 1999. An Automated Weather Station is also functional in Hanle. Every effort was made to ensure that the ecology and environment of the region were not disturbed by any other activity within a 10 km radius of the facility. The site was developed with appropriate infrastructure to install a 2 metre telescope.

The extreme climatic conditions of the Hanle site, where oxygen levels are low and the temperature ranges between +25°C and -30°C, posed challenges to the mechanical design, the optics as well as the installation of the telescope in the hostile site.



HCT Dome
IAO - Hanle



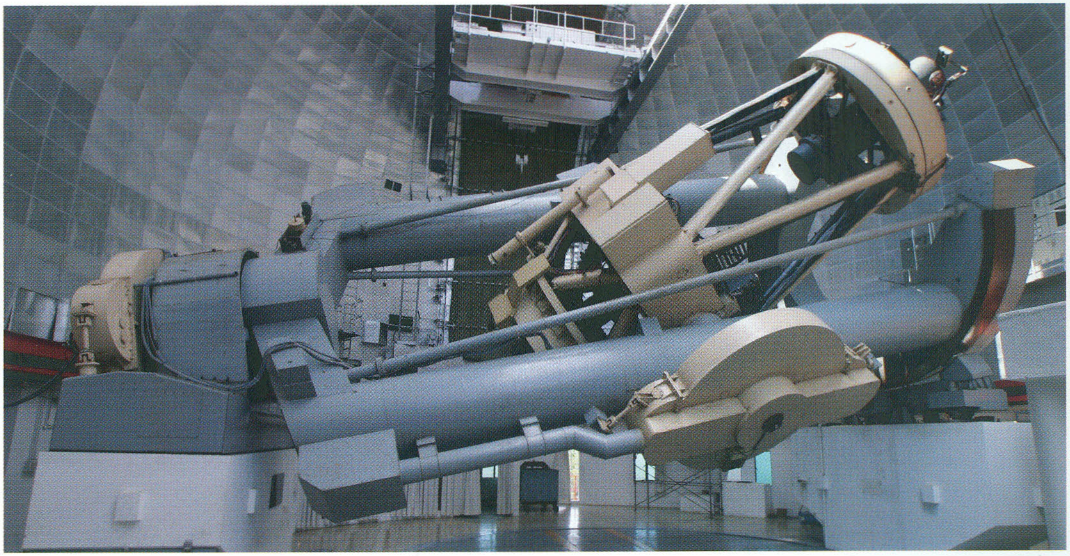
Hanle region : location map

The fabrication and installation of the telescope was contracted out to M/s Electro-Optic Systems Pvt. Ltd. of Australia and the telescope was manufactured by their subsidiary M/s EOS Technologies Ltd., Tucson, Arizona, USA. Installation of the telescope was completed in August 2000. The telescope was named 'Himalayan Chandra Telescope', HCT for short, while the new field station in Hanle was christened the Indian Astronomical Observatory.

HCT operating at an altitude of 4517 metres above the mean sea level was until recently the highest telescope in the world. It is remotely controlled from the Hosakote campus via a dedicated 2 Mbps satellite link. The link was inaugurated by Dr Farooq Abdulla, the then Chief Minister of J & K on June 3, 2001.

The Vainu Bappu Observatory

Vainu Bappu Telescope (VBT)



Technical Details

- Primary Mirror Diameter: 234 cm
- Prime focus: f/3.25 with a scale of 27″.1/mm
- Cassegrain focus: f/13 with a scale of 6″.8/mm
- Guiding: remote, manual
- Detector: 1024x1024 pixels TEK CCD, with a pixel size of 24 microns

Instruments Available

At prime focus:

- High-Resolution Echelle Spectrograph
- Imaging Camera with a 3-element Wynne Corrector

At Cassegrain focus:

- Medium Resolution Spectropolarimeter
- Medium Resolution Spectrograph (OMRS)

1m Zeiss Telescope

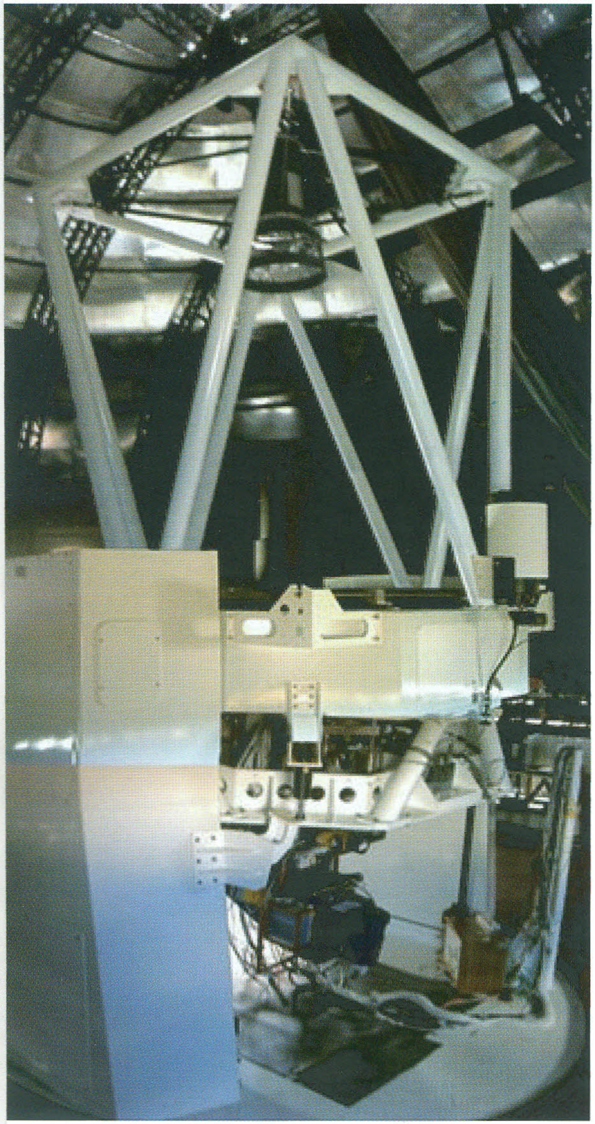
- Primary Mirror Diameter: 102 cm
- Cassegrain focus: f/13
- Coudé focus: f/30
- Guiding: manual

Instruments Available

- Imaging Camera
- Cassegrain Spectrograph
- Coudé Echelle Spectrograph

Indian Astronomical Observatory

Himalayan Chandra Telescope (HCT)



Specifications

Aperture	2.01 metres
Mirror Material	ULE
Optics	Ritchey-Chretien
Mount	Altitude over azimuth
Focus	Cassegrain; provision for Nasmyth
F-ratio	f/1.75 primary; f/9 Cassegrain
Image Scale	$11''.5$/mm
Field of View	$7'$, $30'$ with corrector
Image quality (zenith)	80% power < $0''.33$ dia 90% power < $0''.73$ dia

Instruments available

- Optical CCD Imager
- Near IR Imager
- Himalaya Faint Object Spectograph Camera (HFOSC)

HCT is provided with an autoguider which can guide on a 17th magnitude star in 4-sec integration and uses the HCT Observatory Server interface to close the guiding loop.

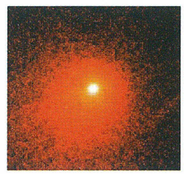
Observational Programmes

VBT, HCT and the Zeiss Telescope have been used individually and complementarily for a varied range of programmes - from studies of solar system objects to studies of stars and stellar systems to studying exotic phenomena such as gamma ray bursts and supernovae and activity of the nuclei of galaxies.

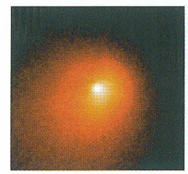
Cometary Studies

IIA astronomers participated in the worldwide campaign to study the effects of the collision of NASA's Deep Impact probe with the comet Tempel 1. Observations were obtained at VBO and IAO of the artificially created crater, 8.9 hours after the impact.

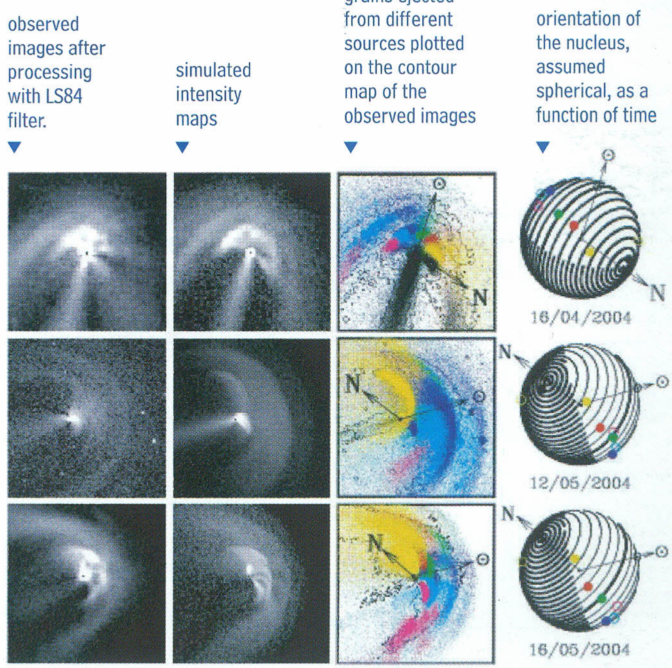
Morphology of the dust shells of the comet C/2001 Q4 (NEAT) was studied in a collaborative programme in which observations from VBO were combined with those obtained at Las Campanas, Chile and Juillan, France. Modelling of trajectories of dust grains ejected from distributed sources on the comet was done to reproduce the observed dust morphology.



Images obtained at VBO of the impact region of the comet before (left) and after (right) the impact.



North points to the top and East is to the left. The impact plume is seen on the western side of the comet.



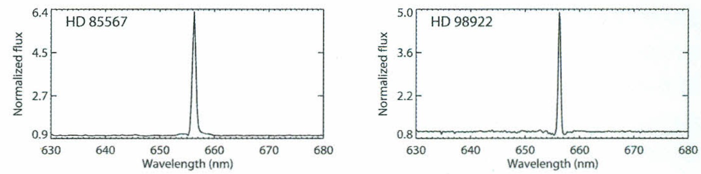
Ref: Vasundhara, R. et al 2007, AJ 133, 612-621.
(Reprinted with the consent of R. Vasundhara and reproduced by permission of the AAS.)

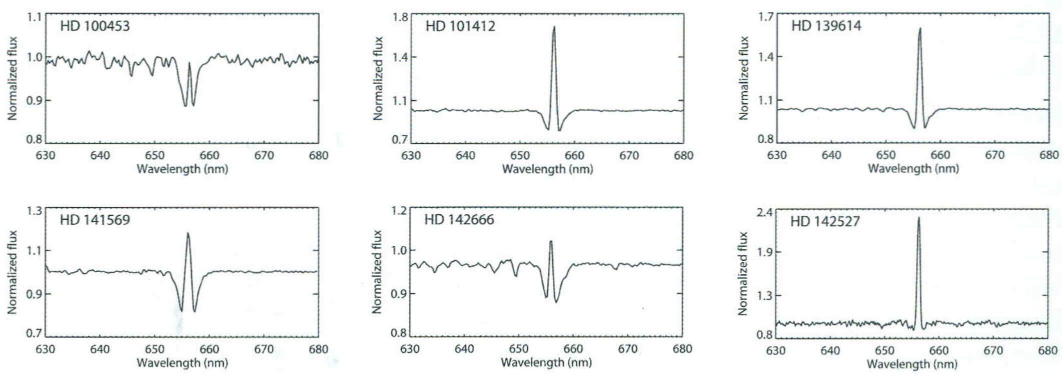
The Work on stellar astonomy has covered avery broad spetrun- form the pre main sequence T T auri stars, Herbig Ae/Be stars to yhe evoloved hydrogrn-deficicent stars AGB and post AGB stars, and central stars of palnetary nebulae. The chemical composition of

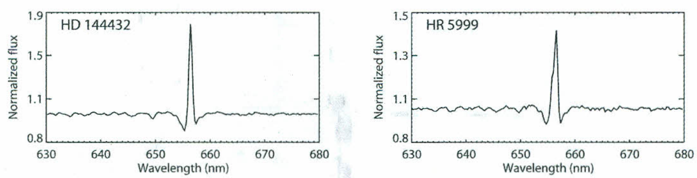
Stellar Studies

The work on stellar astronomy has covered a very broad spectrum — from the pre-main sequence T Tauri stars, Herbig Ae/Be stars to the evolved hydrogen-deficient stars, AGB and post-AGB stars and central stars of planetary nebulae. The chemical composition of these stars, their variability, presence of dust in their environment, mass loss from these stars have all been studied in great detail.

A large sample of pre-main-sequence stars of intermediate mass was studied to trace the evolution of emission-line activity in them.



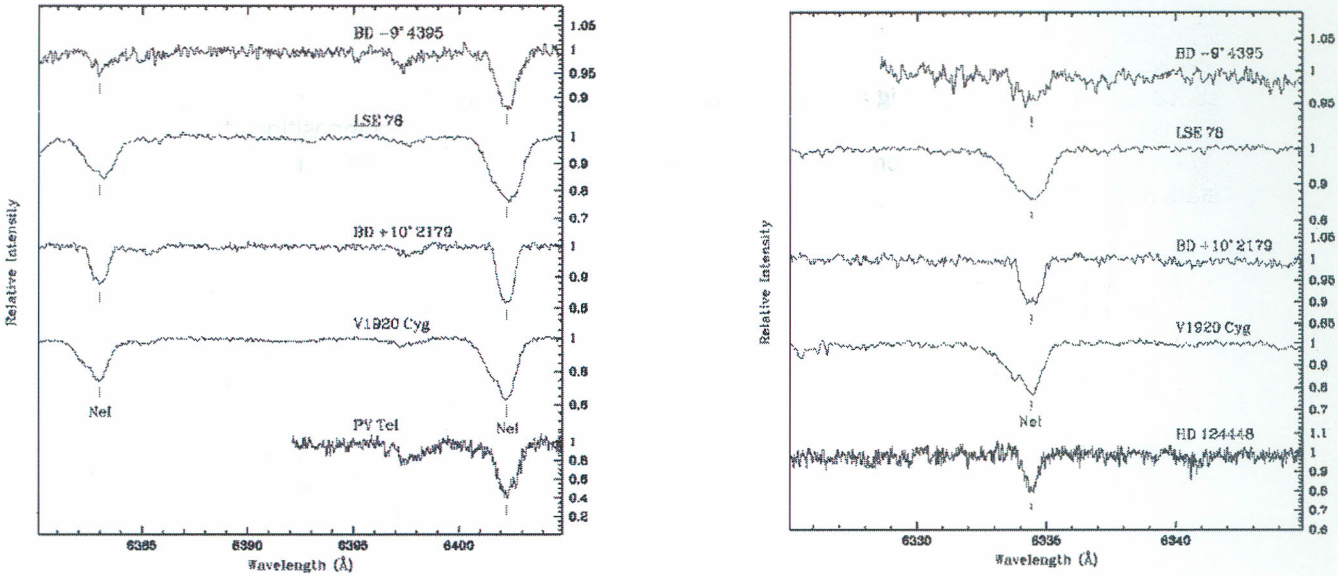




Sample spectra of Herbig Ae/Be stars obtained with the OMR spectrograph attached to VBT.

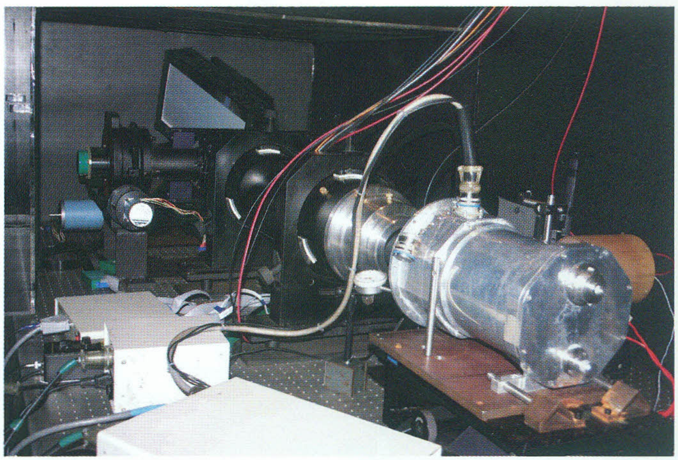
Ref: Manoj, P. et al 2006, ApJ 653, 657.

A non-LTE (NLTE) analysis of Neon and CNO abundances in extreme Helium stars has been carried out using the echele spectrometer, in conjunction with observations made using similar instruments at the McDonald Observatory , USA, and CTIO - Chile.



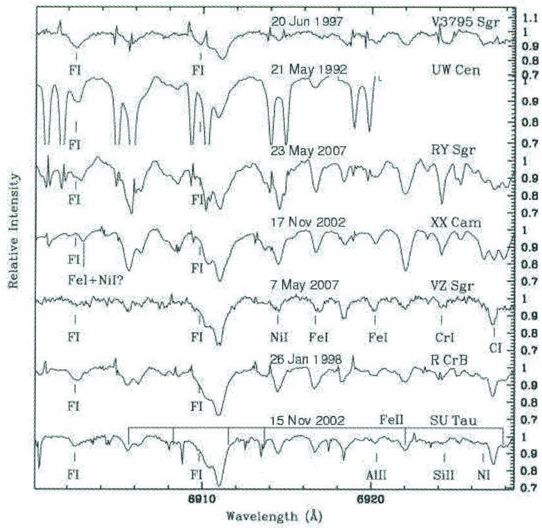
Sample spectra obtained from a programme aimed at studying the abundances of Neon and CNO. The bottom most spectra in both the panels are from the echelle spectrograph at VBO, Kavalur.

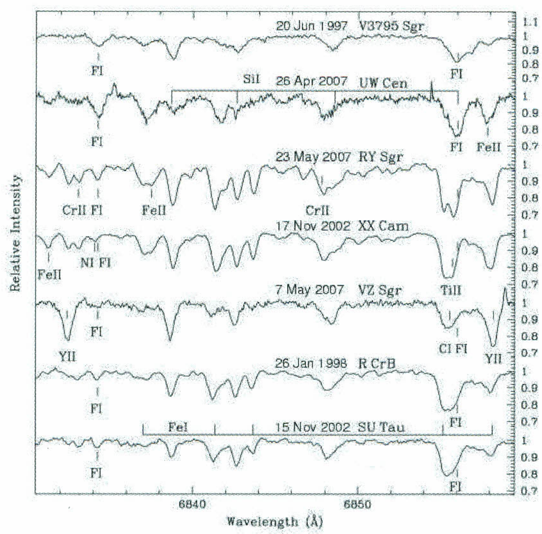
- Ref: Pandey and Lambert 2011, ApJ 727, 122



Fibre-fed Echelle Spectrometer

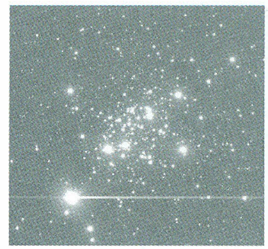
Spectra obtained at VBO and McDonald Observatory, Texas, of R CrB type stars showed for the first time the presence of fluorine in these stars.



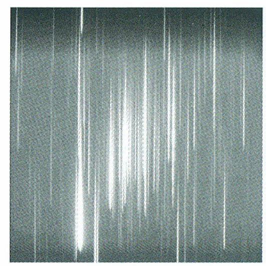


Ref: Pandey, G. et al 2008, ApJ 674, 1068.

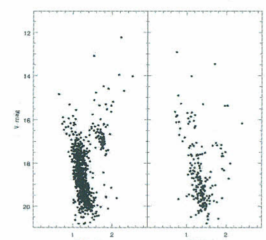
Photometric studies of open clusters are carried out at both VBO and IAO. A detailed investigation of emission-line stars in young open clusters is currently under way.



NGC 7419



Slitless spectral image of the cluster NGC 7419 obtained with HFOSC at IAO

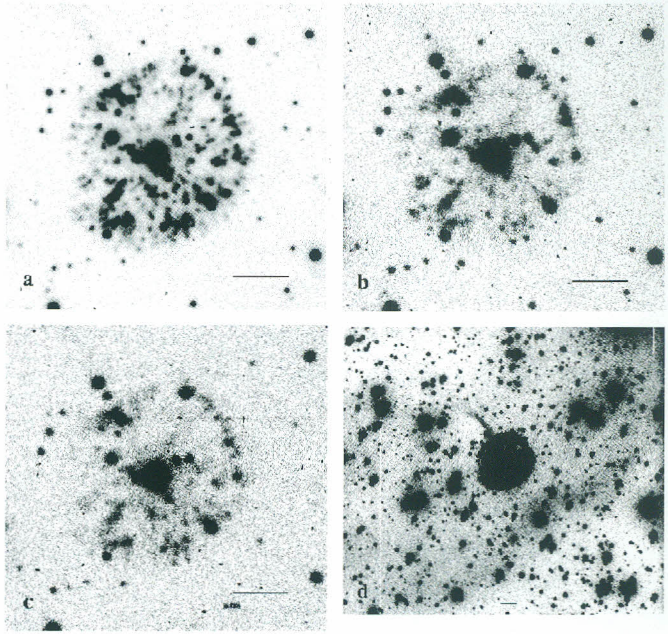


CMDs of the cluster (left panel) and the field (right panel) of IC 166.

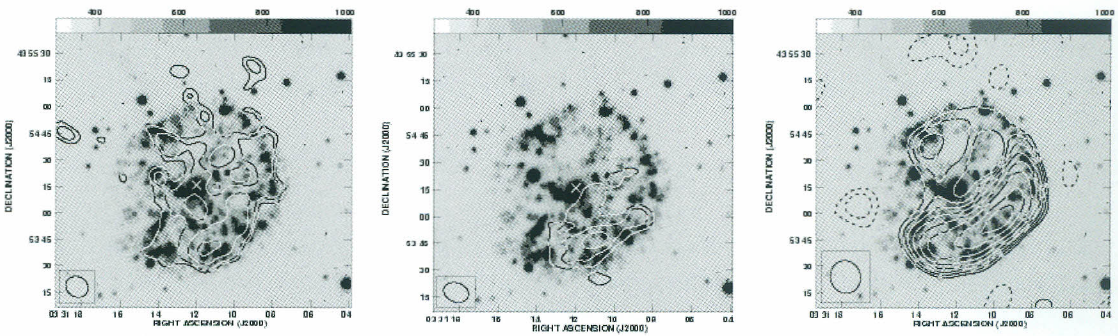
Ref: Mathew, B. et al 2008, MNRAS 388, 1879.

A collaborative study with IA-UNAM, Mexico on RR Lyrae variables in globular clusters is also in progress.

A study of the nebular shell of the old nova GK Per was completed in which data obtained at the Giant Metre-wave Radio Telescope near Pune were combined with optical data obtained at IAO.



Nova remnant in **a**) Hα +[N II] **b**) [O III] **c**) [O II].
d) Extended bipolar nebula in Hα.



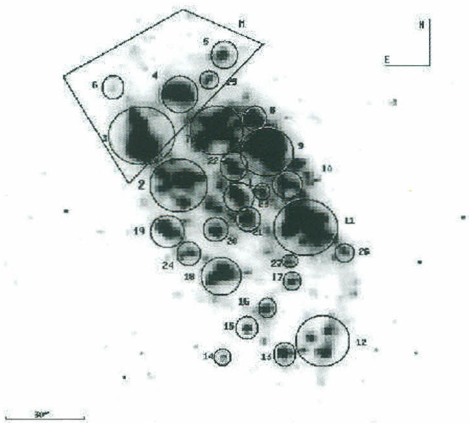
Radio contours in 0.33 GHz (left), 0.61 GHz (centre) and 1.4 GHz (right) superimposed on image of the remnant in Hα +[N II]

Ref: Anupama, G.C. and Kantharia, N.G. 2005, A&A 435, 167

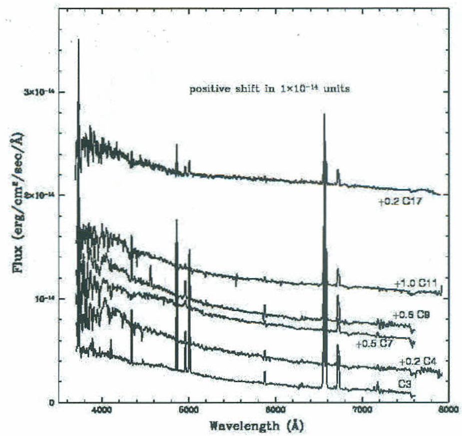
Extragalactic Studies

Study of star forming regions in nearby galaxies, surface photometry of field galaxies and mapping of the absorbing dust and Hα emission in galaxies are among the major programmes carried out at VBO and IAO.

A photometric study of the star forming complexes in NGC 1084 indicated that star formation has taken place in a series of short bursts in the galaxy spread over 40 Myr or so.



Continuum-subtracted Hα image of NGC 1084 reveals 27 star-forming complexes spread over the face of the galaxy



Spectra of a few of the bright complexes

Reference: Ramya, S. et al 2007, MNRAS 381, 511.

HCT was used for monitoring the optical afterglows of Gamma Ray Bursts (GRBs). IIA astronomers are part of the Whole Earth Blazar Telescope (WEBT) group.

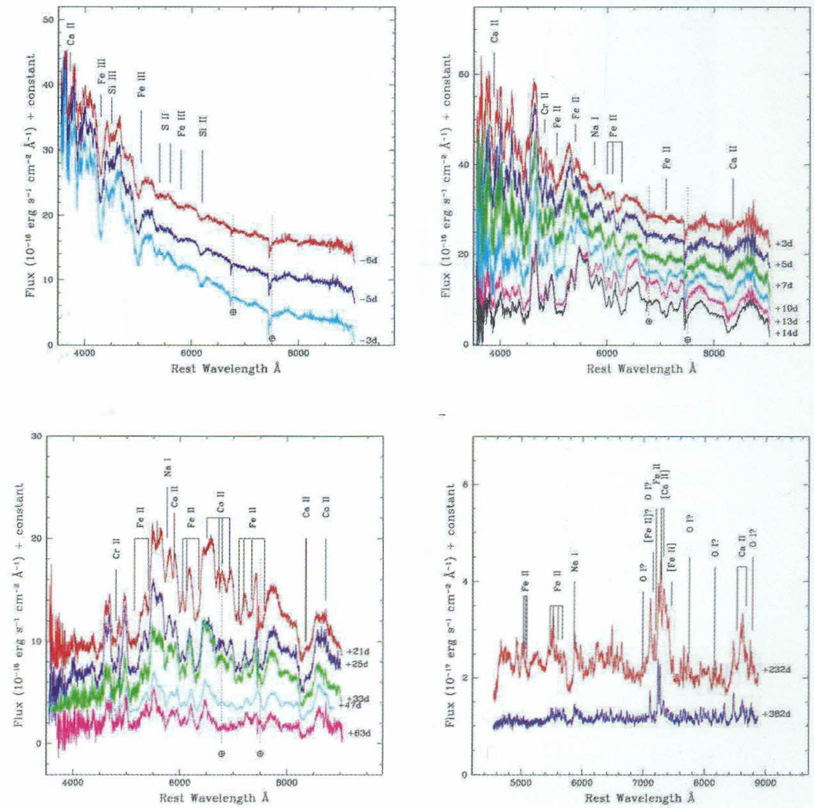
They have also used data from the Far Ultraviolet Spectroscopic Explorer (FUSE) to study the diffuse ultraviolet radiation field in the Galaxy and hot gaseous outflows in Seyfert galaxies.

They participated in a recent campaign on the enigmatic object SS 433 where ground-based data were combined with data from the Rossi X-ray Timing Explorer (RXTE).

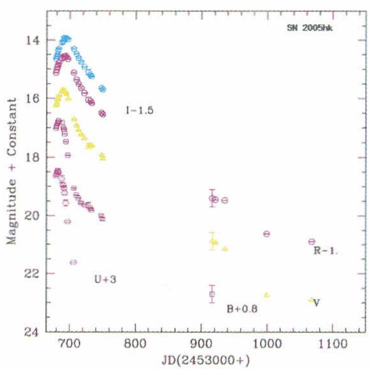
Optical monitoring of low-redshift supernovae is a key project of IIA. A collaboration with the Italian supernova monitoring group has been established.

Light from the peculiar supernova SN 2005hk was observed in various wavebands at IAO, Hanle, from pre-maximum to about 400 days after the explosion. Spectra were also obtained.

Spectra of SN 2005hk



Light curves of SN 2005hk



Ref: Sahu, D.K. et al 2008, ApJ 680, 580

Kodaikanal Observatory

Kodaikanal Observatory is the premier solar observatory in the country. For full disc imaging of the sun, the following instruments are used:

(a) A 15-cm refractor remodelled into a photoheliograph by Grubb in 1898; it has been used to obtain broad band images of the sun since 1904. These images are being used to study solar activity and solar rotation using sunspots as tracers.

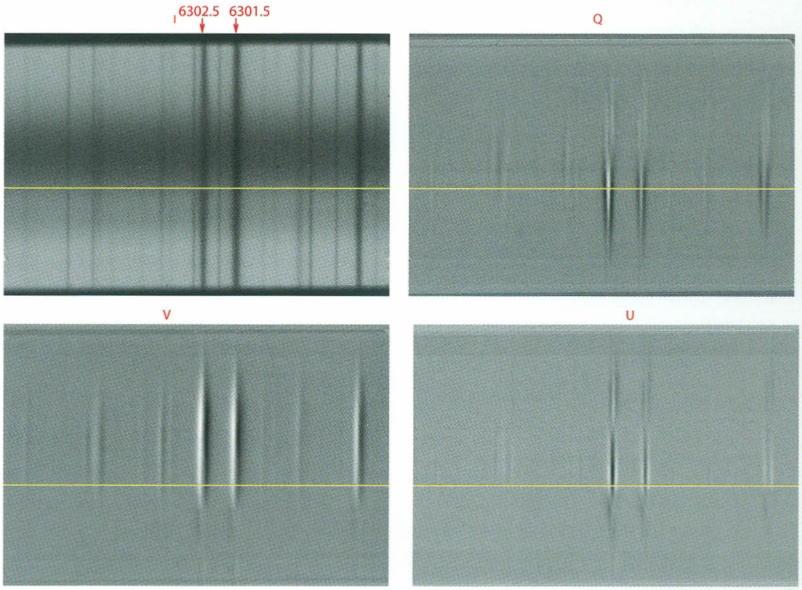
(b) The twin spectroheliographs which give 6-cm solar images in the Ca II K and Hα light. A 46-cm Foucault siderostat feeds the sunlight to a 30-cm, f/22 Cooke triplet lens.
A two-prism dispersing element is used for Ca II K and a grating for the Hα line. Pictures of prominences over the full disc are also obtained in the K line by blocking the solar disc. The data are used to study flares and prominences.

(c) Light from the 46-cm siderostat is diverted to a 15-cm Zeiss achromat which provides an f/15 beam and a 2-cm solar image. A prefilter and a Ca II K narrow band filter are used to record K-filtergrams of the sun on a 1k x 1k CCD system.

Solar and Solar-Terrestrial Studies

The Solar Tower Telescope is used for high spatial resolution and high spectral resolution work. It consists of a 60-cm aperture two-mirror coelostat mounted on a 11 m high tower platform that directs the sunlight via a flat mirror into a 60 m long underground tunnel to a 38-cm f/90 achromat that forms a 34-cm diameter solar image at the focal plane at a resolution of 5.5 arcsec/mm. A Littrow-type spectrograph and a spectroheliograph are the main instruments available. The Littrow spectrograph used with a 600 lines/mm grating gives a dispersion of 9 mm/Å in the fifth order. Recordingis done on a 1k x 1k Photometrix CCD system. The converging beam from the objective can also be diverted to a high dispersion spectroheliograph, available with Littrow arrangement, using a 34.3-cm achromat.

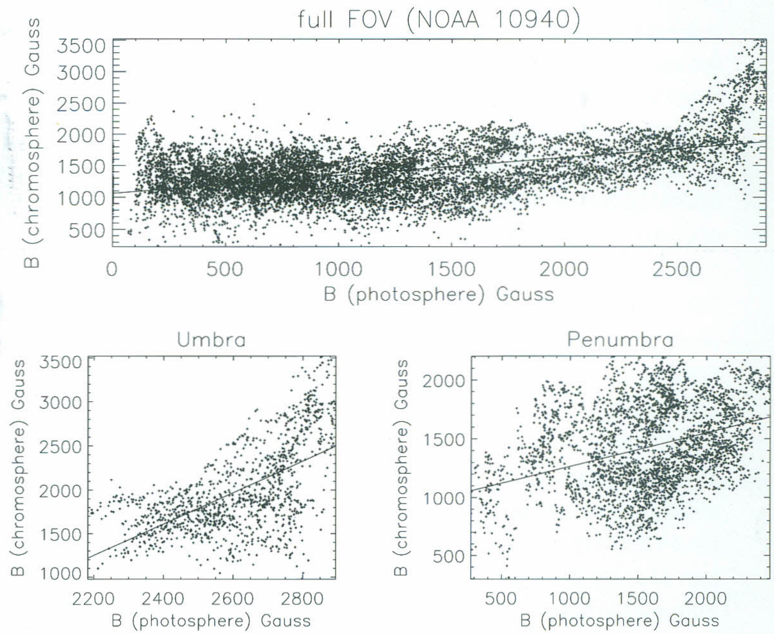
The current programmes include measurement of magnetic fields at different heights in the solar atmosphere, of the solar diameter using Kodaikanal white light images, analysis of molecular rotational lines in sunspot spectra, helioseismology of sunspots, sunspot motions and waves, and of the solar irradiance variability. In addition, studies of the variations of physical parameters and plasma



Recently a dual beam spectropolarimeter has been installed as a back-end instrument to the Littrow spectrograph at the Tower Telescope. The diagram above shows spectral images of the Stokes parameters observed at the umbral region of the sunspot NOAA 0743 using this instrument. The sunspot was located close to the centre of the solar disc during the observations.

condensation in coronal loops, coronal rotation from x-ray data, explosive events in coronal holes, and the solar cycle effects on weather are also being pursued. Using daily photoheliograms obtained at Kodaikanal for the period 1906-1987, the diameter of the solar image was measured along north - south and east-west orientations with a spatial resolution of 0.2 arcsec on the sun. The data so far reduced for three solar cycles indicate that the solar diameter shows variation in anti-correlation with the sunspot cycle and is of the right magnitude to explain the observed variation of the solar surface temperature with sunspot cycle. Simultaneous measurements of the vector magnetic fields at the photosphere and chromosphere have been carried out using spectropolarimetry of the Zeeman sensitive lines.

The magnetic structuring from the photosphere to the chromosphere above several active regions has been studied. A plot of the chromospheric magnetic field strength versus the photospheric field strength is displayed. The spatial variation of the chromospheric magnetic field suggests that these concentrated horizontal fields are nothing but the foot points of omega-shaped magnetic structures, which are conspicuous in the x-ray images of the same active region.



IIA has organized solar eclipse expeditions to locations at home and abroad. In 2003, IIA participated in the Indian expedition to the Maitri station in Antarctica to observe the total solar eclipse of November 23. The solar corona was imaged in both broad band and narrow band filters.

The Institute has taken up a large programme of digitising the Kodaikanal data, originally recorded on photographic plates, which span no less than nine sunspot cycles. This programme is nearing its completion.

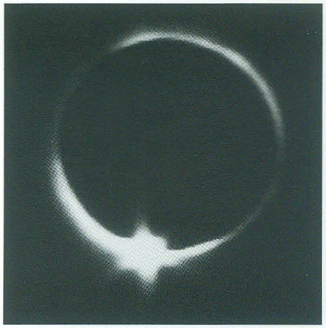
An expedition was organized jointly with ARIES, Naini Tal to observe the March 29, 2006 eclipse from Turkey. High spatial resolution narrow band images of the corona were recorded.

Images of the eastern part of the solar corona in the [Fe XIV] 5303 A and [Fe X] 6374 A lines obtained respectively at the rapid rates of 100 ms and 300 ms indicated intensity variations at some locations with a period of about 26 seconds, confirming similar findings of the coronal continuum intensity variation seen by the IIA astronomers in the eclipse of October 25, 1995.

Preparations have already started for the next eclipse in July 2009.

Total Solar Eclipse on 23rd November 2003 observed from the Maitri station in Antarctica

The Kodaikanal campus has experimental facilities for work on solar-terrestrial relations. Round the clock monitoring of the ionosphere is done with a IPS-42 digital ionosonde and a La Cour variometer is used to monitor the geomagnetic field. The ionospheric and geomagnetic data are used by scientists in India and abroad for investigations of a wide range of problems in solar-terrestrial physics.



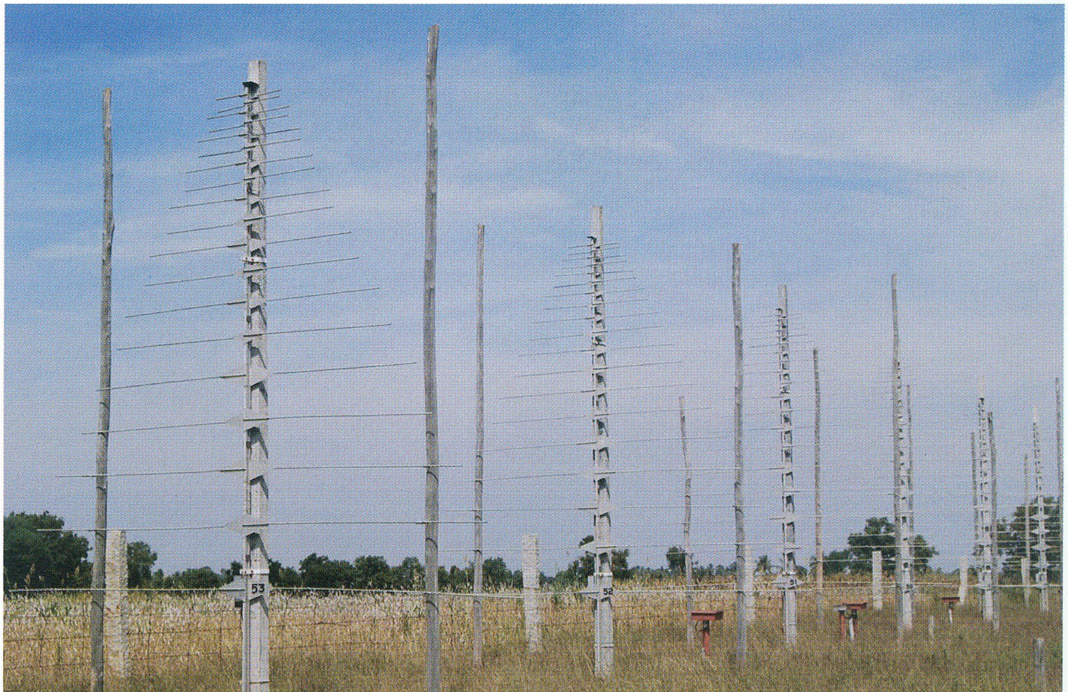
Diamond Ring photograph by IIA team at the 2006 Solar Eclipse in Turkey

Radio Astronomy at IIA

Gauribidanur Radioheliograph (GRH)

A radioheliograph for obtaining two-dimensional pictures of the outer solar corona simultaneously at different frequencies in the range 40 - 150 MHz became operational in 1997. The basic receiving element is a log-periodic dipole and the array consists of 192 of them. The dipoles are arranged in a T-configuration. The present spatial and temporal resolution of the instrument are 5 arcmin and 256 ms, respectively. The array is in daily operation from ~ 9 AM to 3 PM (03:30 - 09:30 UT). A 1024 channel digital correlator is used as the back-end receiver to extract the strength and positional information of radio emission from the solar corona and its various discrete structures. The frequency coverage of GRH is unique in that it provides useful information on the solar corona in the height range ~ 0.2 - 0.8 solar radius above the solar surface, which is difficult to probe using either ground-based or space-borne white light coronagraphs.

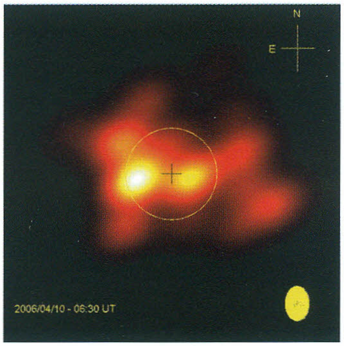
No other radiotelescope in the world currently operates in the above frequency range.



The South arm of GRH

The state of the near-earth space environment is significantly controlled by the Coronal Mass Ejections or CMEs. Though they are primarily observed with white light coronagraphs on board space missions, one needs non-coronagraphic data to obtain information on the early evolution of CMEs, in particular of those directed along the sun-earth axis that lies far from the plane of the sky. GRH is well suited to study CMEs in the range of 1 - 2 solar radius above the solar surface. The picture shows the radioheliogram of a 'halo' CME on April 10, 2006. By carrying out a multi-wavelength study using GRH and data from the space mission SOHO, it was possible to establish that the source region of the event was located on the back side of the solar disc. Data obtained at GRH were used to derive the low corona kinematics of the event.

The radioheliograph has been extensively used to physically characterise CMEs and their pre-event structures. GRH has given estimation of the parameters of a CME at ~ 40 solar radii through angular broadening observation of a distant cosmic radio source. It has also been used for seismological studies of the solar corona using radioburst emission as a tracer.



Gauribidanur Radioheliogram
at 115 MHz on April 10, 2006

A high resolution radio spectrograph is used in conjunction with the GRH for obtaining dynamic spectrum of transient burst emission from the solar corona. The antenna system consists of 8 log periodic dipoles. A commercial spectrum analyzer is used as the back-end receiver to obtain spectral information with an instantaneous bandwidth of ~ 250 KHz. The temporal resolution is ~ 43 ms. The radio spectrograph and GRH together provide spectral and positional information on eruptive solar activity. The observations have provided clues to:

(i) electron acceleration associated with small-scale nonthermal energy releases in the solar atmosphere,

(ii) occurrence of radio bursts associated with successive magnetohydrodynamic shocks in the solar corona, and

(iii) source region of a CME through observations of transient absorption bursts.

Polarization interferometer

Based on theoretical formulations for the response of a correlation telescope to polarized radiation, an east-west one-dimensional array of 32 log periodic dipoles has been set up to probe the coronal magnetic field in the height range ~0.2 - 0.8 solar radius above the solar surface. The dipoles are arranged in 4 groups and they are oriented at 0°, 45°, 90° & 135° with respect to the terrestrial north. This helps in capturing the polarization state of the incident radiation with good accuracy.

A close-up view of 135° and 45° oriented antennas

Brazilian Decimetre Array

The Instituto Nacional de Pesquisas Espaciais (INPE), Brazil is constructing the Brazilian Decimetric array (BDA) at Cachoeria Paulista, Brazil (longitude 45°W ; latitude 22° 41' S) in collaboration with IIA. The T-shaped array, 2.5 km long in the East-West direction and 1.2 km in the South will operate in the frequency range of 1.2 - 5.6 GHz. The telescope consists of 38 4-m diameter antennas in alt-azimuth mount with tracking capability of 340° in azimuth and 0° - 180° in elevation. The system will have 3″ spatial resolution and a sensitivity of ~ 1 Jy. In 2006, 5 antennas with a maximum baseline of 216 m in the East-West direction were used along with a 32 channel digital correlator developed by IIA to obtain one - dimensional images of the sun at 1.6 GHz. By the end of 2008, a total of 26 antennas will be mounted. IIA is developing a 1448 channel digital correlator to correlate the IF signals from these 26 antennas. The system is expected to produce solar images with a resolution of 3′ x 4′ and a sensitivity of ~ 15 Jy by the middle of 2010.

High Altitude Gamma Ray Array (Hagar)

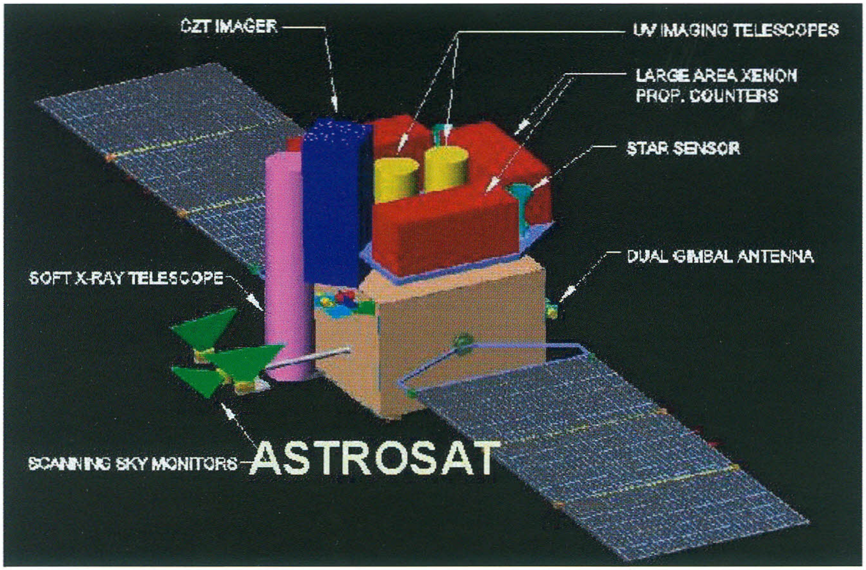
An atmospheric Cerenkov experiment has been set up at Hanle by IIA, in collaboration with TIFR, to study celestial sources of high energy gamma rays. By exploiting the advantage of high altitudes, the experiment intends to explore source characteristics at lower energies where dramatic changes are predicted in the emission of gamma rays. The experiment consists of 7 alt-azimuth telescopes with six of them located on a circle of 50 metre radius with the 7th one located at the centre. Each telescope consists of 7 mirrors, each of area 0.6 square metres, with a fast UV sensitive photomultiplier at the focus of each mirror. The data acquisition system records the absolute time of the event, arrival times of the Cerenkov wavefront at each mirror and the amplitudes of the PMT pulses.

The installation of all the seven telescopes and their synchronized operation were successfully carried out in September 2007 from the control computer at the centre of the array. Test data taken at the end of 2007 showed that an angular resolution of better than about 0.2° can be obtained for the arrival direction of the shower.

Other calibration studies also indicate that the energy threshold can be lowered with this set-up. Observation of sources like the Crab and Geminga pulsars and other interesting Very High Energy gamma ray emitters like Pulsar Wind Nebulae and Active Galactic Nuclei will be undertaken shortly.

A Leap into Space

Ultra Violet Imaging Telescope (UVIT)



ASTROSAT will be the first Indian space mission devoted to astronomy. It is a multi-wavelength space-based observatory with a wide coverage of the electromagnetic spectrum - from hard x-rays and soft x-rays to near ultraviolet and visual wavelengths. A key element of ASTROSAT is the Ultra-Violet Imaging Telescope (UVIT). Along with four other x-ray instruments it will enable internationally competitive research in the forefront of observational astronomy.

The motivations for observations in the ultraviolet are substantial. Most of the resonance lines of the astrophysically important atoms, ions and molecules occur in this range. Hot stars emit most of their energy in the ultraviolet. This emission plays a vital role in the processes of star formation and galaxy evolution and the effects can be studied from afar thereby permitting study of such processes. The spiral structure of galaxies is delineated by young O and B stars and the H II regions surrounding them. In some cases, such as the "H II galaxies", the integrated spectrum is dominated by the recombination spectra due to the ionizing radiation from these hot stars. The energy balance and dynamical state of the interstellar medium in galaxies is significantly affected by the UV (and extreme UV) radiation and the energy inputs from the winds of hot stars. The end stages of the evolution of massive stars produce supernovae which play a vital role in enriching the interstellar medium with heavy elements. They can also be observed to great distances due to their large light output, and serve as standard candles in measuring distances in the universr.

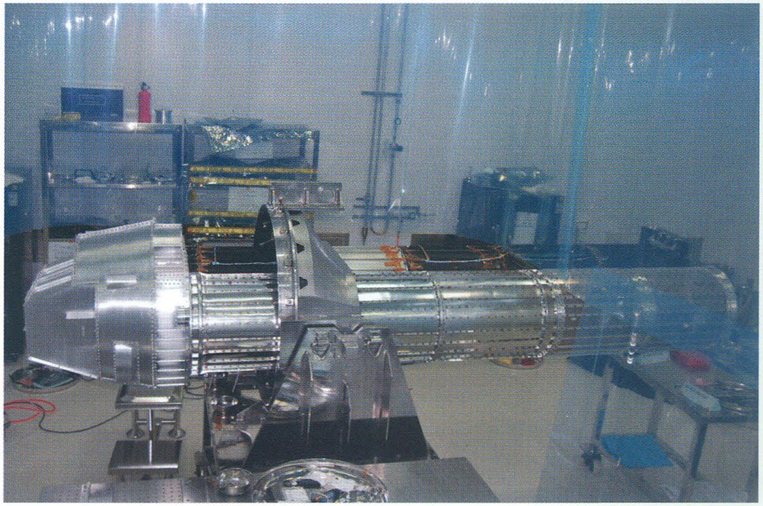
The ultraviolet spectral region is eminently suited for the study of all such events in the evolution of stars and galaxies.

The UVIT was proposed by a group of astronomers in IIA and its initial optical design was worked out by IIA's Photonics Division. At an early stage, astronomers from IUCAA, PRL, and TTIFR joined in this exciting project. Over a period of time, and with support from LEOS of ISRO, the design was optimised with a twin telescope concept, each with an aperture of ~ 380 mm, for the two wavelength ranges 130 -180 nm (FUV) and 180 - 300 nm (NUV); photon counting detectors, ~ 40 mm in diameter, were found to be the most appropriate for imaging at the focal plane. The NUV telescope also provides a visible channel (primarily for tracking aspect of the satellite as required for shift and add operation to get long exposure images from

short exposures) by splitting the light beam into visible and NUV wavelength ranges The design of UVIT aims for a half a degree field of view on the detector with a resolution between 1.5 to 1.8 seconds of arc. A major aim of the UVIT is to do multi-band surveys of large parts of the sky (and fields of particular interest) to limiting magnitudes of 22 to 25 (in the UV). Such surveys will complement contemporary deep surveys over a wide variety of wavelengths. UVIT along with the proposed x-ray detectors on ASTROSAT, will be a unique multi-wavelength observatory for simultaneous monitoring of variable sources such as x-ray emitting binary stars and AGN. Simultaneous monitoring in the UV and x-ray regions for extended periods of time will provide valuable data towards resolving issues regarding the astrophysics of accretion discs, the energy budget and the nature of the energy source.
The complexities of the process of design and fabrication of a space instrument have required the involvement of several centres of the Indian Space Research Organization. The fabrication of the mirrors of UVIT are being done at ISRO's Laboratory for Electro Optic Systems. The photon counting detectors for UVIT are being jointly developed under a collaborative arrangement between ISRO and the Canadian Space Agency.
A large and unique clean room facility has been built at CREST, where the integration and testing of the UVIT will be carried out before delivery to ISRO for launch. Half-scale size optics of UVIT made at IIA has been used at IUCAA for tests of the scattered light of the telescope baffle system, which is required to be less than one part in a billion. Electrical interfaces of the instrument with the satellite are being designed at IIA, IUCAA and TIFR. The software pipeline for producing images of the sky and astronomical data processing is under development at SAC and other centres of ISRO.

Over the last several years there have been many meetings of the instrument science teams, including two larger meetings with the Canadian collaborators, where multi-wavelength and UV programmes have been proposed and whetted.
The engineering model of the payload has been tested at ISAC, ISRO for vibrations. The detector system is ready with calibrations. Assembly of the flight model payload would start in February 2011, and payload is expected to be delivered, after testing at IIA, by the second half of year 2011 to ISAC, ISRO for further testing and integration with the spacecraft.

The observing plans would start with validation and characterization of the UVIT (and indeed the other instruments) in orbit, in the first six months after launch (performance verification phase). After that, observing time would be divided between the instrument science teams and the rest of the science community.



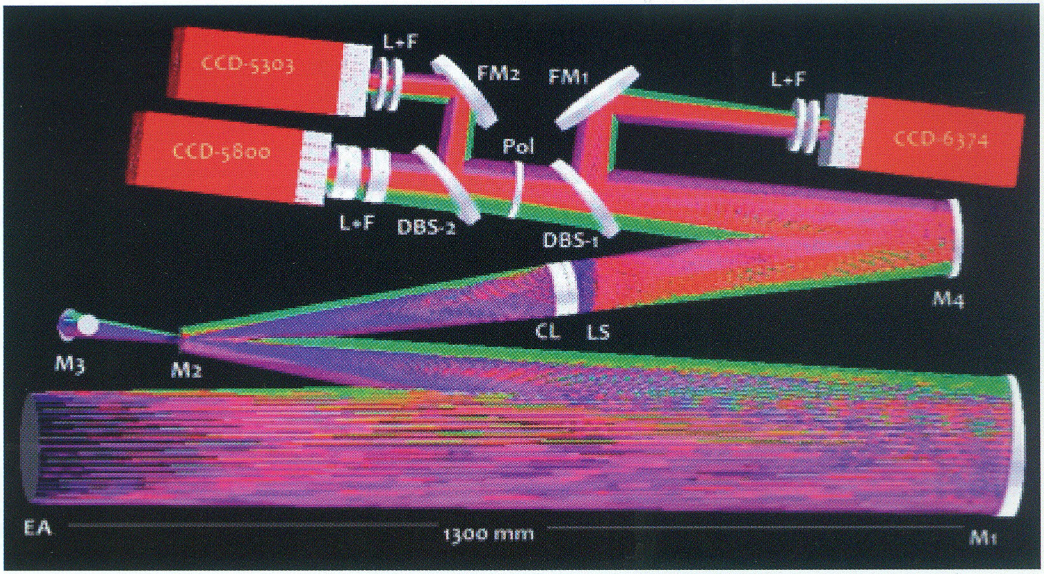
The UVIT payload for ASTROSAT being tested at the clean room of the MGK Menon Lab at the CREST campus of IIA, Hosakote

Visible Emission Line Space Coronagraph (Aditya)

IIA is leading a consortium that has proposed to build a 20cm aperture, space-based coronagraph to image the solar corona in various optical emission lines. The coronagraph is proposed to have an off-axis parabolic mirror which simultaneously images the visible emission lines at 5303 Å [Fe xiv] and at red [Fe x] 6374 Å.

The primary science goals of Aditya mission are:
To detect the existence of waves in the solar corona and the nature of waves,
To investigate the role of waves in heating the solar coronal plasma,
To understand the formation of coronal loops,
To understand the magnetic nature of coronal loops,
To understand the cooling of post flare loops,
To investigate the pre-eruption dynamics of CMEs in detail,
To investigate CMEs role in driving the space weather.

Optical Layout and Ray -path Diagram of Aditya

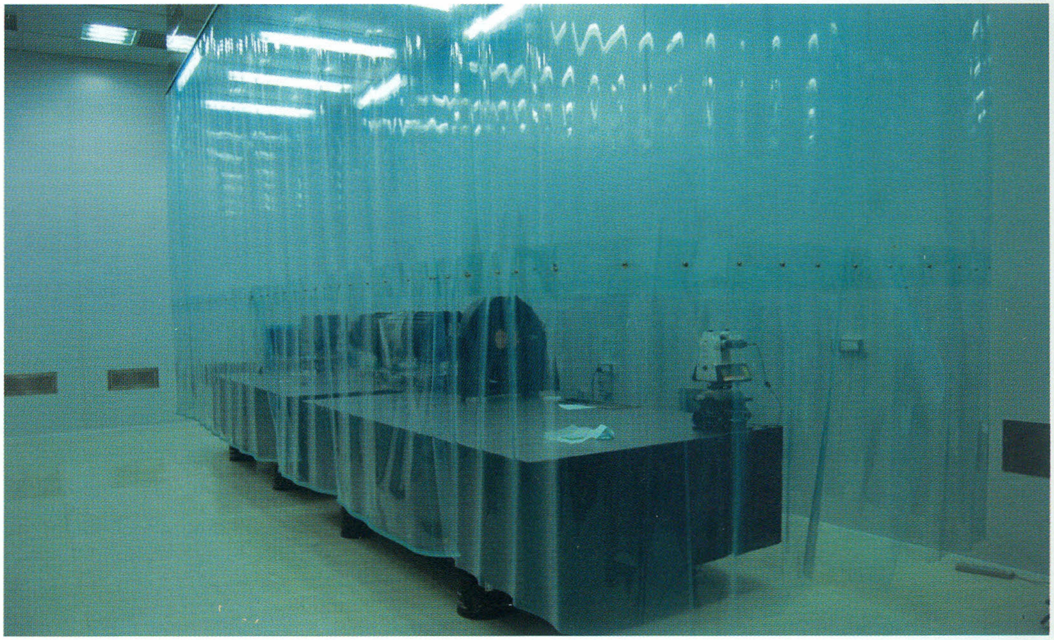


Laboratory Physics at CREST

In addition to being the remote control centre for the 2-m telescope at Hanle, CREST at Hosakote houses the Test and Calibration Facility (TCF) for the UVIT payload as well as personnel working on TAUVEX. The MGK Menon Space Science Laboratory consists of clean laboratories in compliance with international standards. It is a totally automated centre with 24/365 monitoring facility to meet ISO standards. The laboratory will be equipped with a Fizeau interferometer, thermovac chamber, vacuum reflectometer, VUV test chamber, ultra-clean vibration isolation tables, metrology equipment etc. In addition, CREST has general physics laboratories with clean-room environment for work in optics and laser physics. The laboratories have different state-of-the-art lasers and other sophisticated equipment. Work has been going on in areas like high-contrast, all-optical switching in bacteriorhodospin and studies of variation of refractive index with temperature using automated interferometric techniques. The interest in bacteriorhodospin and its mutants stems from the fact that it is possible to store hundreds of billions of bits of data in a cubic centimetre volume and transfer them at the rate of billion or more bits per second. The compact size and faster data processing rate make these devices

MGK Menon Laboratory for Space Sciences

Class 100/1000 Clean Room at MGK Menon Lab, CREST



extremely useful in parallel-processing computers, three-dimensional memories and associative memories for neural networks.

Because of their high sensitivity, interferometers have been used to measure very small displacements, small surface roughness, quality of optical components, accurate indices of refraction etc.

Temperature dependent refractive index changes have been measured in alkali halide filters like BaF_2 and MgF_2 which are widely used in ultraviolet spectral regions. They have extremely sharp transmission cut-off edges in the ultraviolet. These filters are good for solar observations and a study of the variation of refractive index with temperature in them is very important for the same reason. An effort has been made to incorporate advanced control and data acquisition techniques with interferometry, which enable high degree of accuracy in measurements. The entire experimental set-up including motion stages, detectors, temperature control etc is implemented on Lab VIEW platform.

Major areas of theoretical research

The theorists in the Institute work in the areas of solar physics, pulsar physics, nebular physics, star formation, modelling of astrophysical systems, radiative transfer, physics of interstellar grains and of compact objects. There is also a group of physicists who explore the low-energy consequences of the unification of the fundamental forces at high energies through studies of parity and time reversal violations in atoms.

Recent work in solar physics and magnetohydrodynamics (MHD) includes developing multidimensional dynamical models of the magnetic network of the sun, simulation studies of two-dimensional MHD flows and g-mode oscillations in stars in the presence of magnetic fields. The formation of accretion discs in a variety of astrophysical situations has been studied and the role of MHD and of the plasma-physical mechanisms in controlling many of the phenomena have been elucidated.

Programmes in radiative transfer include formation and transfer of polarized radiation in the sun and stars, scattering in the dusty atmospheres of brown dwarfs, study of partial redistribution effects in close binary systems and transfer of radiation in rotating stars.

Problems related to the generation of magnetic fields in astrophysical systems have been investigated. Coherent plasma processes in active galactic nuclei have been studied, as also pulsars, their emission mechanisms and the acceleration processes in their magnetospheres.

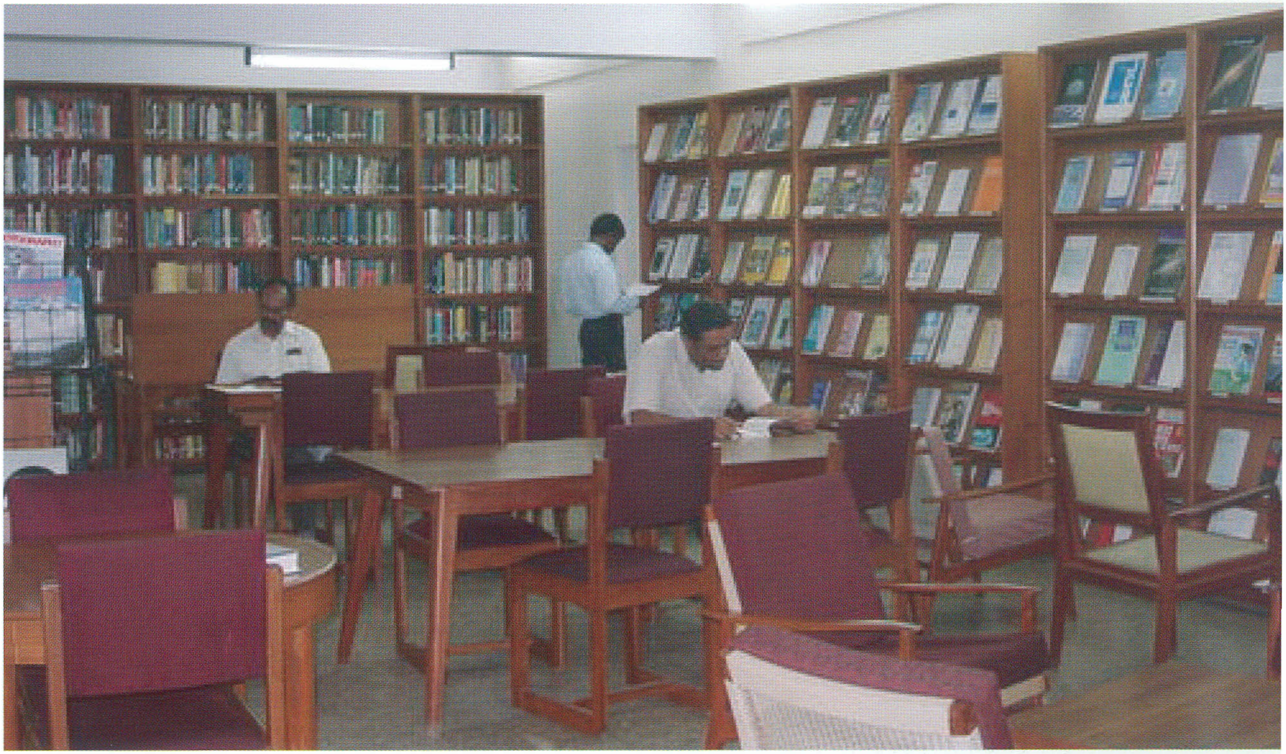
Theoretical models of selected planetary nebulae have been constructed in an effort to understand all the physical processes in these objects and their immediate surroundings.

Modelling of the light variability of regular and irregular variables is another important area of study. Modelling of GRB afterglows, of nova outbursts, and simulation of supernova spectra have been carried out. Recently the problem of the radio-loudness dichotomy in quasars was investigated in detail and a possible solution of it in terms of the mass of the central black hole has been suggested.

Improved calculations on the EDM enhancement factors for rubidium and cesium have opened up a novel direction for finding new physics beyond the Standard Model. The structure of complex atoms and molecules has been studied using a relativistic coupled cluster approach and a many-body perturbative scheme and many astrophysically important results have been obtained.

The library

The library of the Indian Institute of Astrophysics in Bangalore is a fully automated modern library equipped with on-line search facilities. Enriched by the entire collection of the parent Madras and Kodaikanal Observatories, going back more than 200 years, it can boast of housing the largest and most comprehensive collection in astronomy and astrophysics in the country. Over the years it has also accumulated a large collection of books in the allied fields of physics, mathematics, geophysics, electronics and computer sciences. IIA library ensures that the collection and services continue to keep pace with other astronomy libraries across the world, enabling the IIA astronomers to do competitive research at the international level.

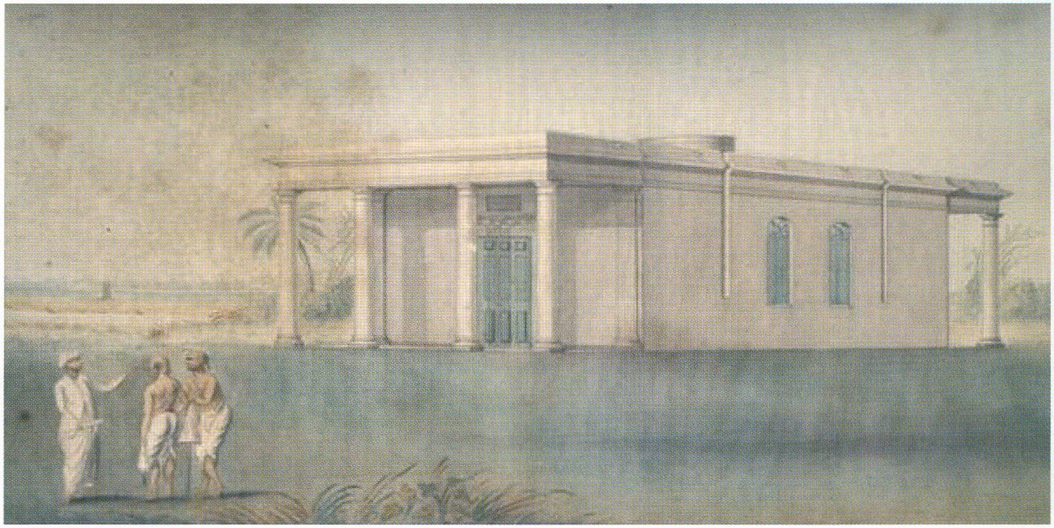


Reading area - Bangalore Library

Kodaikanal Library

The Institute maintains smaller functional libraries in all the centres and field stations. Subscription to multi-site licence for most of the journals has enabled their electronic access in all the locations.The library in Kodaikanal is about 110 years old and has old volumes of several journals. It has a unique shelving arrangement which extends to the ceiling of the library hall.The library at the Vainu Bappu Observatory in Kavalur has a fairly large collection of atlases, catalogues and a small collection of books for the use of observers and resident scientists. The Palomar Observatory Sky Survey is available in the digital form at the observatory. The observatory has electronic access to various astronomical databases. The CREST library at Hosakote has been set up recently and efforts are on to make it a virtual library with on-line access to most of the resources. IIA library has a functional web page on www.iiap.res.in/lib.html, which connects the users to the essential information about the library in addition to connecting them to the various e-journals and databases. The library database on books and journals can be accessed over the internet with a web-based OPAC. The library is an important nodal centre for lending and reference service in astronomy in the country. It extends the reference and document-delivery service to many users in the university sector and also supports the public outreach programme of the Institute. As a member of FORSA (Forum for Resource Sharing in Astronomy and Astrophysics) consortium, IIA library has widened the electronic access to additional journals. It has also compiled a merged catalogue of resources in all the astronomy libraries within the country to keep the users informed about the availability of books and journals within the FORSA fraternity. The library has recently created an Open Access Repository of archival and current IIA publications using the Open Source Software 'Dspace'. This repository is accessible on the internet from http://prints.iiap.res.in.

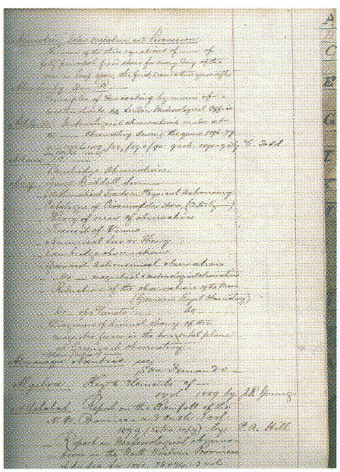
The Historical Collections



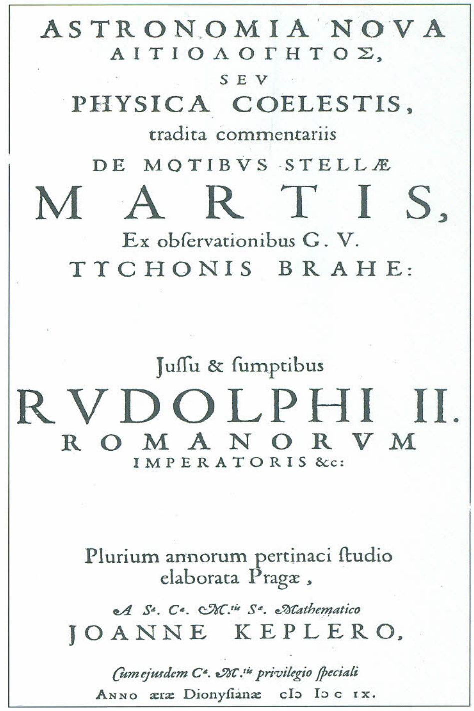
A hand-drawn sketch of the Madras Observatory in Egmore

IIA library is also a great custodian of our scientific heritage because of its rich historic past. With its rare collection of old material, it is in a vantage position to provide valuable service to the astronomers, historians and archivists seeking information about the institution and the astronomical heritage of the country. Recently the IIA Archives was formally set up as a special section of the library at the Bangalore campus, with a display of some of the old material, collected over the past 220 years. With the inherited records of the Madras and Kodaikanal Observatories, the archival collection has grown in time to include more than 5000 items in various formats such as manuscripts, photographs, maps, films, framed materials, hand-drawn sketches, various awards to the scientists belonging to the institution, pictures and instruments. Most of these items are of great historical importance and environmentally sensitive. The library has a rare catalogue of books and journals for the years 1794 - 1812 written by calligraphers during the early years of the Madras Observatory. It lists 102 books and journal volumes and 52 manuscripts. Notable among the books is Astronomia Nova (1609) by Johannes Kepler. It is the oldest book in the collection.

The catalogue also lists 20 books published in the 18th century including three volumes of Flamsteed's 'Historiae Coelestis'. The oldest journal in the collection is the 1794 volume of 'Philosophical Transactions' and the oldest almanac available is the one for the year 1767. The place of pride however goes to the 'Annual Report' of the Madras Observatory for the year 1792. It is a handwritten document which gives a detailed description of the Madras Observatory. A special Pogson collection is available which includes hand-drawn coloured sketches by Norman Pogson of the solar spectrum during the total eclipse of 1868. Ms Cherry Armstrong, the great granddaughter of Norman Pogson donated to the collection several photographs of Mr Pogson and his family and many volumes of handwritten observational data covering the period 1861 to 1891 when Pogson was the Director of the Madras Observatory. IIA library has taken the responsibility of arranging the archival collection systematically contents-wise, taking appropriate care to meet the storage specifications. A reference library of the collection has been created in digital form, accessible from the IIA Open Access Repository. For those contents for which the full text is not available, the texts can be consulted physically in the archives with prior permission.



A page from the library catalogue (1794 - 1812)



ASTRONOMIA NOVA
ΑΙΤΙΟΛΟΓΗΤΟΣ,
SEV
PHYSICA COELESTIS,
tradita commentariis
DE MOTIBVS STELLÆ
MARTIS,
Ex obſervationibus G. V.
TYCHONIS BRAHE:

Juſſu & ſumptibus
RVDOLPHI II.
ROMANORVM
IMPERATORIS &c:

Plurium annorum pertinaci ſtudio
elaborata Pragæ,
A S. C. M.tis S. Mathematico
JOANNE KEPLERO,
Cum ejusdem C. M.tis privilegio ſpeciali
ANNO æræ Dionyſianæ cIↃ IↃ c IX.

The cover of Johannes Kepler's Astronomia Nova

Cyberspace

The computing facilities in IIA are based on an individual model where most users have personal computers and work in their offices with a mix of Microsoft Windows and Linux systems.

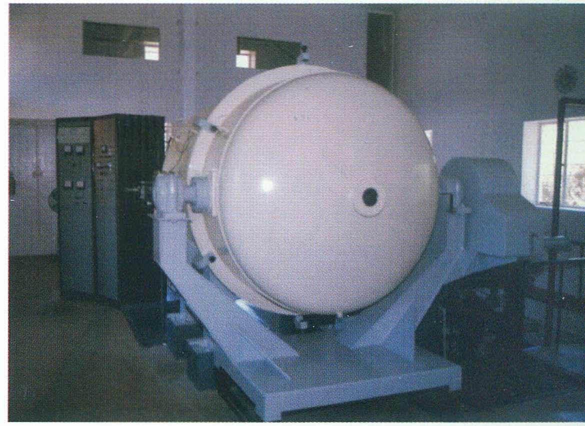
Currently, a new modern Data Center has been planned and is being built at the main IIA campus by a reputed Information Technology company. This new center will accomodate all the servers that support email, IIA webpages, the local area network and data storage. The existing Computer Center will continue to host a mix of Workstations and PCs intended for the use of visitors and other short term program students. High Performace Computing (HPC) is taken up with a renewed vigour at IIA. The existing cluster of 8-node Sunfire system is being replaced with a state-of-the-art 20-node Intel processer based cluster system, with a peak processing speed of about 2.4 TFlops. The design of this cluster system has been chosen so as to be augmented with the latest NVIDIA GPU cards at a later time, which will give a 10 fold increase in processing speed. To make way for the above, a stand-alone GPU server with a peak processing speed of 1 TFlop is also being inducted as a GPU based HPC system. A number of codes performing radiative transfer, hydro- and magnetohydrodynamic simulations and atomic structure calculations are run on HPC systems.

The internal network is run on a CAT5e backbone with wireless throughout the campus. An external 8 Mbps connection provides 24 hour connectivity to the Internet. A 10 TB disk server has been acquired for institutional backups and for large data sets. The Computer Centre at IIA strives to provide a friendly environment encouraging individual users while ensuring that even high end computing needs are met.

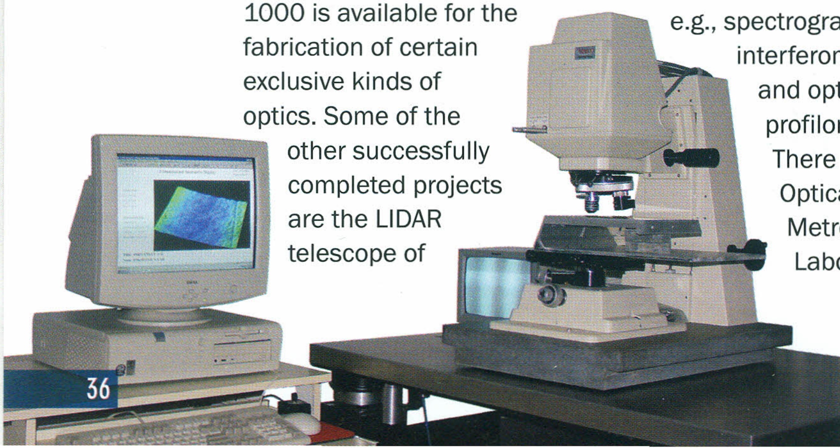
Photonics Division

Optical technology was started in Kodaikanal in 1964 with hand working of optical components. The year 1976 brought a major addition to the facility when the Optical Workshop in Bangalore was established. A machine capable of handling mirrors up to 250 centimetres in diameter was commissioned in Bangalore in 1979 and provisions for an in-situ testing in a 20 metre high vertical tower were also made. This is where the optics of the 234-cm telescope was fabricated and tested in the 1980s. The workshop is air-conditioned for better controlled working of optical polishing and figuring. A clean room facility of class 1000 is available for the fabrication of certain exclusive kinds of optics. Some of the other successfully completed projects are the LIDAR telescope of VSSC, Trivandrum, a space qualified EUV spectroheliometer telescope, X-ray optics for BARC and metal mirrors (passive VHRR cooler) for ISRO.

Expertise is available in the optical designing of single-element to multi-element telescope systems and their suitable correctors. Some of the recently completed optical designs include the field corrector for a 50" (f/1.45) aspherical mirror for a scanner telescope optics and the UVIT payload. The Photonics Division specializes in design and construction of the optical components of astronomical instruments, e.g., spectrographs, interferometers and optical profilometers. There is an Optical Metrology Laboratory attached to the division which facilitates the testing of high precision optics. The laboratory has a Foucault test set-up, an OPD interferometric test set-up, a polarization interferometric test set-up, a fibre optics spectrometer, a WYCO Profilometer, a ZYGO Interferometer, a Long Trace Profilometer and Newton Rings flat testing instruments.



1.6m vacuum coating plant in VBO

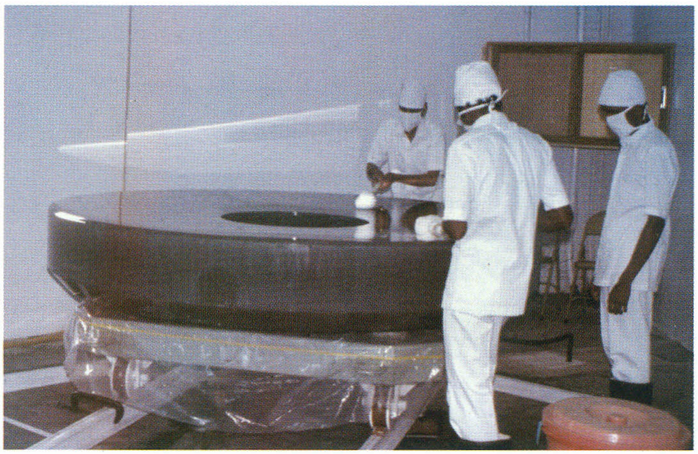


WYCO Profilometer

(a) Thin film Technology

Development of thin film technology for astronomical purposes is the thrust area of the present activity. Large vacuum coating plants have been installed and are functional in Kavalur and Hanle. These are extensively used for the coating of various large and small optics for IIA and for external agencies. A new computer controlled multi-functional 0.3 m coating plant has been recently acquired and is being used for research purposes. The present activity includes development of thin films for infrared photodetectors, photo-voltaics and filters for astronomical purposes. A scanning electron microscope and an electron density spectrometer are being added for thin film characterization and allied research activities.

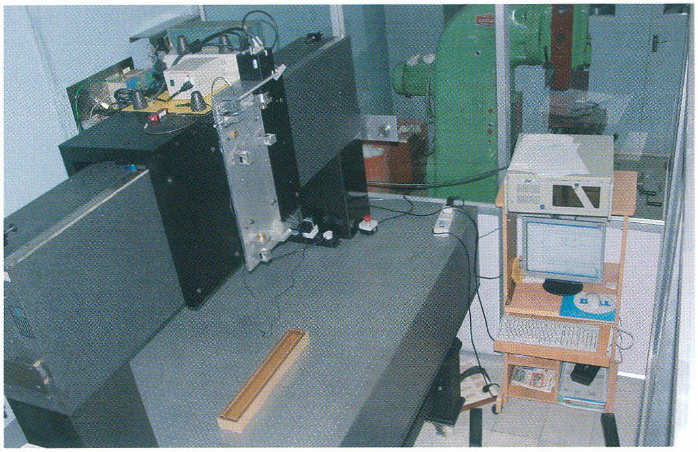
The 234-cm mirror being cleaned for aluminizing in the 2.8-mvacuum coating plant in Kavalur.



(b) Long Trace Optical Profilometer

Another important milestone in the development of optical technology is the building of a Long Trace Profilometer (LTP) to measure the absolute surface figure to nanometer accuracy of long strip flat, spherical and aspherical surfaces. LTP is an optical non-contact instrument which works on the same principle as shearing interferometers. An improved version of the Long Trace Profilometer (Version II), for the metrology of Synchrotron Beam Line Optics was built for the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore. This development has placed India in the world map of LTP builders.

Long Trace Profilometer version II



(c) **Development and specular polishing of metal surfaces for VHRR passive cooler of the Indian Satellites**

The Photonics Division takes pride in contributing to the Indian space programme. Apart from fabricating space-worthy optics, specular polishing of metal surfaces, especially for the sun shield panels of VHRR passive coolers for ISRO's INSAT satellite programme, is an important contribution made by IIA in the last two decades. The process for specular polishing and metrology of these surfaces was established in the early phase of the programme as per specifications provided by ISRO. A micro-finish of the surface better than 15 - 20 Å and thus a specularity of ~ 98% were achieved. The INSAT-2A, B, C,D and the INSAT-3A satellites have flown with these panels. Polishing of the INSAT-3D Imager and Sounder coolers is being currently completed. The Photonics Division is also taking up the very challenging task of polishing conical shields of W2M LNA cooler.

(d) Adaptive Optics Research

A new wavefront sensor using the polarization shearing interferometric technique (PSI) has been successfully established. Developmental activity to build an adaptive optics (AO) system using PSI as a wave front sensor is in progress.

Graduate Studies

The PhD Programme

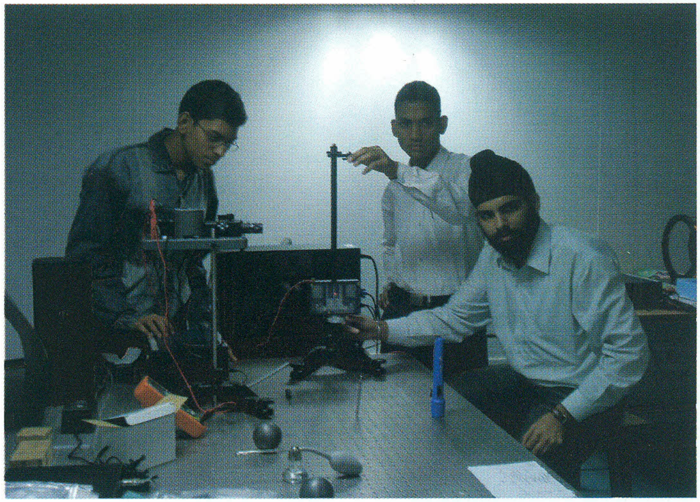
The Iinstitute has trained students for the PhD degree since its inception. Since 1990 it has had a graduate studies programme on a more organized basis. It is a 5-year programme where the first year is spent in taking courses followed by project work, at the end of which a student chooses a research topic and a supervisor. The students are selected through a national selection process and are fully supported with a fellowship, a book grant, residential accommodation and medical facilities. The programme is overseen by the Board of Graduate Studies (BGS). The Institute is also a founding partner along with Raman Research Institute (Bangalore), Tata Institute of Fundamental Research (Mumbai) and the Indian Space Research Organisation (Bangalore) of the Joint Astronomy Programme (JAP) conducted by the Indian Institute of Science, Bangalore. IIA scientists carry a major teaching load in the programme. After the completion of course-work, JAP students join one of the participating institutions to pursue their thesis work. The students in this programme receive their degrees from IISc. IIA is recognised by several Indian universities which provide PhD registration facilities to IIA students and award degrees. During the last 15 years IIA has produced close to 50 doctorates including those in JAP.

The topics have ranged from instrumentation to cosmology. The present student strength is about thirty. BGS runs a summer students' programme during the vacation time of the colleges and universities. The programme attracts very bright students. It lasts for 8 to 10 weeks. In addition, IIA conducts a summer school on Basic Physics and also topical schools in Astronomy in Kodaikanal. Details of the PhD programme are given on the IIA website under www.iiap.res.in/opportunities/graduate.

Integrated PhD Programme

In 2008, IIA has started an integrated PhD programme in physics in collaboration with the Indira Gandhi National Open University (IGNOU). The programme admits students with Bachelor's degrees in Science or Engineering through a national selection process. The selected students are supported with a fellowship and have all the privileges in common with the PhD students. On successful completion of two years of study in the programme, where several courses in astronomy and astrophysics are taught, the students are awarded an

M.Sc. degree in Physics. Those among them, who intend to continue with and qualify for the PhD programme, start their research work in the third year. The normal duration of the programme is six years. A state-of-the-art physics laboratory has been set up in IIA, Banglore for the integrated PhD students.



I-PhD students in the Physics Laboratory

Integrated M.Tech.-Ph.D.(Tech.) Programme

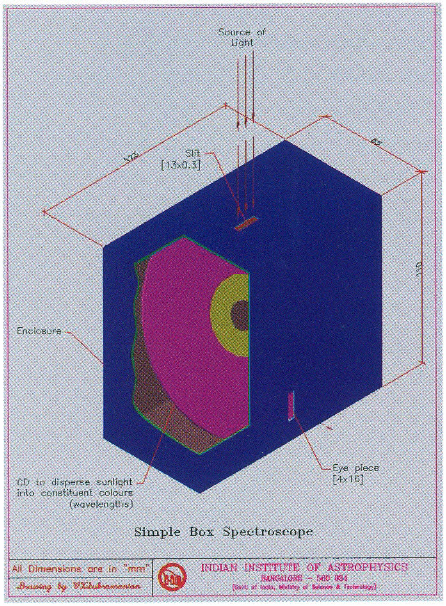
An integrated M.Tech.-Ph.D.(Tech.) programme in astronomical instrumentation has been started in 2008 in collaboration with the Department of Applied Optics and Photonics of the University of Calcutta. The duration of the M.Tech. course work is two years divided into 4 semesters. During the first 2 semesters, the course work is conducted at the Department of Applied Optics and Photonics in Calcutta where introductory astrophysics courses are taught by IIA faculty on short-term visits. During the second year, the students undergo internship training in the laboratories and field stations of IIA. On successful completion of the course of study, the students are awarded the M.Tech. degree of the University of Calcutta. Those among them, who intend to continue with and qualify for the PhD programme, start their research work in the third year. The normal duration of the programme is six years.

Public Outreach Programme

The Public Outreach Programme of IIA is broadbased. Its main purpose is to create awareness about astronomy and astrophysics through exhibitions, lectures, movie shows etc. and to infuse the younger generation with the thrill of doing science. For the last several years, the institute has celebrated the National Science Day on February 28 as an Open House with exhibitions, popular talks, screening of movies on the Institute and on astronomical topics and a sky-watch programme in the evening. Students from various schools and colleges in the Bangalore area have visited IIA in large numbers on the day. IIA is a regular participant in the exhibitions organized by the Department of Science and Technology all around the country. In Bangalore, it has regularly set up stalls at the annual science exhibition of the Visvesvaraya Industrial and Technical Museum. IIA stalls have also been set up in other popular science exhibitions, notably in Kerala. In all such exhibitions, a sky-watch programme in the evening has been an important component and has always been very popular. IIA has also organized celestial shows on the Bangalore campus,with direct viewing through a small telescope, of any unusual event like the close passage of a planet, unusual planetary alignments, comets, lunar eclipses etc. The transit of Venus across the disk of the sun on June 8, 2004 was observed by more than a thousand visitors through an experimental set-up especially rigged up for the purpose.

National Science Day

IIA is pursuing a vigorous Education and Public Outreach Programme in connection with the International Heliophysical Year 2007-08 and the International Year of Astronomy 2009. A simple box spectroscope has been designed to view the solar spectrum and has been used by the visiting students on Open House days. The box spectroscope is available for distribution to schools.



A two-element radio interferometer has been designed to study the sun and other strong cosmic radio sources. Its success with visiting college students prompted more numbers of the equipment to be fabricated at the Gauribidanur Observatory for distribution to colleges and universities. A simple 100-mm f/6 Newtonian telescope has been designed in connection with the Galileoscope Cornerstone Project of IYA. IIA proposes to have the prototype duplicated in large numbers by a skilled engineering company. It will be distributed to educational institutions, science popularisation groups and amateur astronomy organisations across the country.

At VBO, visitors are shown around every Saturday afternoon. They are taken to the Vainu Bappu Telescope where its operation is

Prototype of 100-mm Newtonian

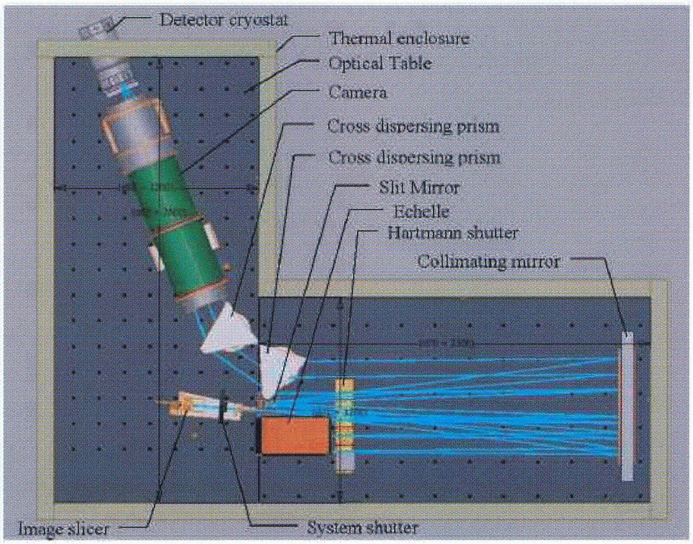
demonstrated. When the skies are clear a sky-watch is also organised through a 15-cm visitors' telescope.

The Kodaikanal campus houses a museum with mostly pictorial displays of the sun and other astronomical objects. A few models including an experimental arrangement to show the Fraunhofer spectrum of the sun are also in the museum. In the evenings, the visitors are shown the sky through a 20-cm refractor.

Looking ahead

While IIA is waiting with anticipation for the launch of the space payloads, it has plans to augment its solar and stellar facilities on the ground. There is a plan to add a high resolution spectrometer to the complement of focal plane instruments at IAO. A 1.3-metre telescope has been ordered for VBO, Kavalur. A more significant development has been the idea of setting up a large solar telescope as a national facility in a suitable site.

The Hanle Echelle Spectrometer (HESP)

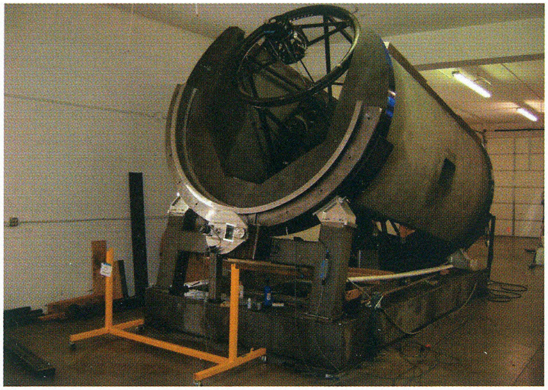


The Hanle Echelle Spectrometer has been conceived as an efficient high resolution instrument attached to HCT, that will provide spectra of stars at a R ~ 60,000 to magnitudes as faint as 12.7. At a lower resolution of R ~ 30,000, the instrument is expected to reach a faint limit of 13.5 magnitude.

The spectrometer is based on a modern design and incorporates additional novel features, such as an atmospheric dispersion corrector, image-slicers and an exposure meter. The design and optical configuration have been chosen to provide continuous spectral coverage (350 nm - 1000 nm) in a single CCD frame to exploit the high ultraviolet-blue and infrared transparency offered by the very dry high altitude site.

A detailed concept design for the instrument has already been prepared through a Memorandum of Understanding between IIA and a consortium led by the Anglo-Australian Observatory. The spectrometer will provide valuable data for asteroseismology, detection of extra-solar objects, abundances of elements and their isotopic ratios, studies of extended envelopes around stars at various evolutionary stages, tomography of accretion disks and stellar winds, studies of spotted stars etc.

The 1.3 metre Telescope Project

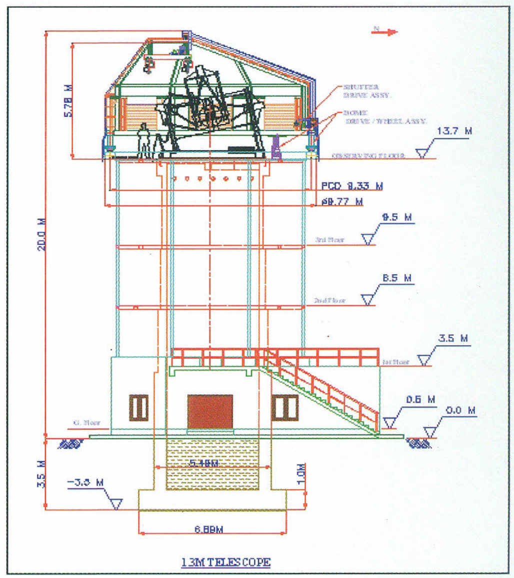


Telescope assembled being tested

A 1.3 metre aperture telescope will be installed by the end of 2011 at the Vainu Bappu Observatory in Kavalur. The telescope, a Ritchey-Chretien system, will be primarily for wide field imaging at an f/8 cassegrain focus with a corrected field of 30 minutes of arc. The telescope is being built to specifications particularly for the VBO, with an equatorial mount utilising a double horseshoe configuration on hydrostatic bearings. The mount is designed to support instruments weighing upto 150 Kg at the cassegrain focus and an additional capacity of 75 Kg for fibre fed instruments mounted on the centre section of the telescope.

The telescope will be equipped with an instrument interface housing an autoguider and providing three ports for mounting imagers or other instruments. The interface will also incorporate filter wheel assemblies for the ports. The first light instrument would be a CCD imager; a mosaic imager of 4K by 4K pixels is being developed in the institute. A simple, long-slit spectrograph as a first generation instrument is also being explored. Second generation instruments being planned are an imaging polarimeter and a fibre fed multi-object spectrograph.

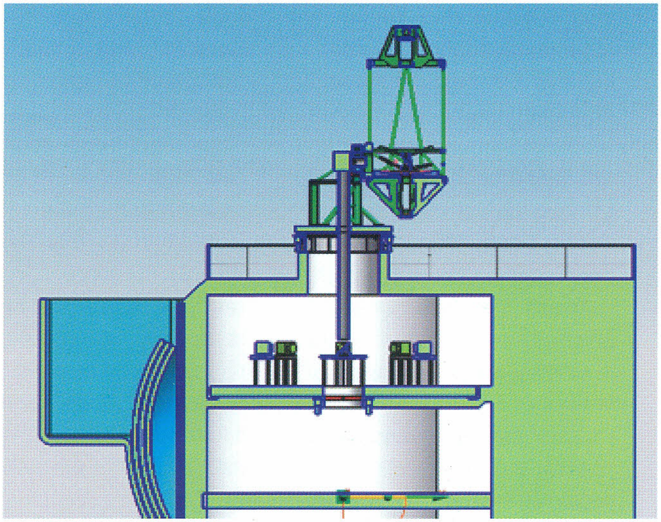
The construction of the enclosure and dome for the telescope at VBO is under way. The building design is unique in that the 20 metre high structure will be entirely of steel above the ground floor level. The building is designed to allow natural venting of air and has minimal enclosed spaces. The dome also has a unique shape allowing quick thermal equilibrium with the ambient.



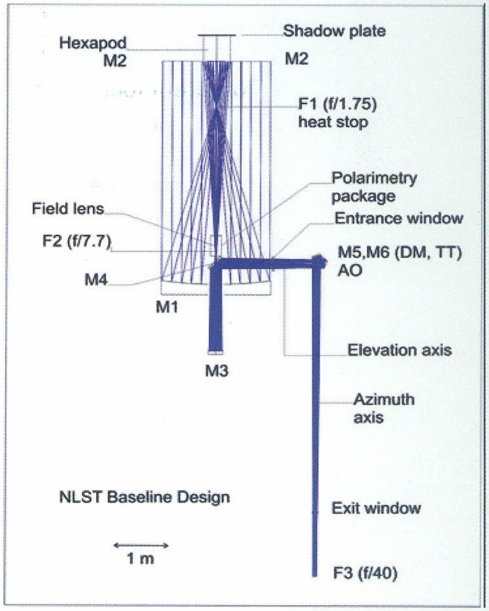
Schematic design of telescope building

National Large Solar Telescope (NLST)

The existing facilities for solar research in India are grossly inadequate for high resolution observations of the sun. A large and versatile telescope can facilitate simultaneous measurements of the solar atmospheric parameters and of the magnitude and direction of magnetic fields with high accuracy. With this in view, IIA has proposed to set up a state-of-the-art 2m-class telescope - the National Large Solar Telescope (NLST), incorporating adaptive optics, for carrying out optical and near-IR observations from a suitable site in the country. NLST will attempt to resolve some of the finest solar features and study their dynamics. It will have infrared capabilities and the opacity minimum at 16000 A will be exploited to look deeper into the solar atmosphere. The diffraction limit of a 2 metre telescope at 500 nanometers is 0.06" which corresponds to ~ 40 km on the solar surface. With the use of adaptive optics, features of the sun can be resolved to this order, provided the 'seeing' conditions of the site where the telescope is located are very good. Sites in the Himalayan region (about 4000 metres above mean sea level) which are not affected by the monsoons are being considered, with a preference for high altitude desert sites. Efforts have been under way to study the number of annual sunshine hours, the number of hours providing a certain range of values of Fried parameter for the "seeing" measurements, the isoplanatic angle provided by the site, and the year round meteorological conditions Sufficient data have been obtained for two high altitude sites in Ladakh - Hanle (field station of IIA) and Merak (Pangong lake site). Significant amount of data has been collected for the sub-Himalayan site Devasthal (field station of ARIES). It emerges from analysis so far that Merak is an excellent world class site for the proposed telescope, while Hanle provides good conditions for significant periods of time.



Design of NLST with observing floor



NLST optical configuration

Specifications of NLST:

Aperture	2m
Focal Ratio	F/2
Configuration	Gregorian, on-axis
Aberration-free field of view	300 arcsec
Wavelength range to be covered	380 nm – 2.5 microns
Spatial Resolution	<0.1arcsec at 500nm
Strehl Ratio within the isoplanatic patch	>0.5

The telescope will be installed on the top of a tower 25 m high above the ground level. The image of the sun will be fed to the different focal plane instruments located at the lower levels. The optical system will be of a modified Gregorian configuration. The final target f-ratio of the telescope is f/40 so that the final magnified image of the sun will have a scale of ~ 2.5 arc sec/mm in the final focal plane. For compactness of design and the cost effectiveness of its fabrication, the telescope will have an alt-azimuth mount.

The NLST is proposed to be a multi-purpose telescope, equipped with instruments such as:

- A spectrograph operating in the Czerny- Turner mode for spectro-polarimetry
- A high resolution spectrograph for simultaneous multi- line spectroscopy
- A Tunable Fabry - Perot filter of pass band 0.02 nm
- Narrow pass band filters for H – alpha , Ca II K , CN band , G band and 1083.0 nm

The installation of the NLST will be a joint effort at a national level under the leadership of IIA. Solar astronomers from other research centres, e.g., ISRO Satellite Centre Bangalore, Udaipur Solar Observatory, and ARIES, Naini Tal will be partners in this project.

The detailed project report of the NLST is already prepared.

The IIA campus in Bangalore

Front Cover: An artist's impression of ASTROSAT above the Indian peninsula
Back Cover : SN 2005cs (↑) in the galaxy M 51.

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