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History of initial fifty years of ARIES : A Major National Indian Facility for Optical Observations

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Abstract: The idea of starting an astronomical observatory in the state of Uttar Pradesh in India germinated through the initiative of a scholarly statesman Babu Sampurnanandji. His interest in astrology coupled with his academic bent of mind got him interested in modern astronomy. Being then Education Minister and later Chief Minister of Uttar Pradesh, he established an astronomical observatory at Varanasi on April 20, 1954. Later on it was shifted to Manora Peak, Nainital. Four reflectors were commissioned at Manora Peak. For solar research an H alpha petrol unit and a horizontal solar spectrograph was setup. A detailed project report for installation of a 4-m class optical telescope was prepared indigenously in late 1980, however, the project could not take off. With the generous support of the Department of Science and Technology, the institute established a 3.6-m new technology optical telescope and a 1.3-m wide field optical telescope at a new observing site called Devasthal. Now a 4-m liquid mirror telescope is also being installed at the same observing site. I present here a brief journey of the observatory beginning right from its birth in 1954 till now.

1 Introduction

Government of India after independence established a chain of national research institutions during the period 1947-1955. However, in the state of Uttar Pradesh Dr. Sampurnanand was interested in nurturing the science of astronomy. It is through his initiative, Uttar Pradesh State Observatory (UPSO) was founded at the Government Sanskrit College Varanasi on April 20, 1954 with Dr. A. N. Singh as its Director. This had the unique distinction of being the only astronomy research institution in the country under a state government. At the initiative of Dr Singh a gravity driven 25cm f/15 Cook refractor, an 8cm transit instrument, a couple of mariners chronometers and other ancillary items from England were purchased in April 1954. About the same time, a standard time installation from Rhode and Schwarz of Munich was done. Owing to sudden death of Dr. A. N. Singh, Dr. M. K. Vainu Bappu, a young, enthusiastic astronomy Ph. D. from Harvard was appointed Chief Astronomer and he took over charge on 1 November 1954. It was due to the vision and initiative of Dr. Bappu that the planning for a full fledged center of astronomical research was put on a sound footing.

It was felt that the dust and haze of any place in the plains of Uttar Pradesh would be unsuitable for establishing a modern observatory there and the 25-cm refractor could only be marginally useful

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as an instrument of research. Installation of larger telescope was also necessary for research in future. Therefore, a survey was undertaken around Nainital, Dehradun and Mussoorie, as these places seemed likely to offer better observing conditions than the other areas in the state. The survey pointed out that Manora Peak, on the outskirts of Nainital, offered comparatively favourable conditions for the operations of an observatory, as compared to other places. From the meteorological standpoint, the records showed that the rainfall at Nainital, though substantial over the year, was concentrated within the monsoon period. Thus the observatory was moved over to Nainital in November 1955 at Devi Lodge and to its present location at Manora Peak (longitude 79°27′ E, latitude 29°22′ N, altitude 1951m), just south of Nainital town, in November 1961. The strong point of this observatory is its geographical location. The longitude locates in the middle of a wide longitudinal band of about 180 degrees between Canary Islands (about 20 degree west) and eastern Australia (about 157 degree east) having reasonably good observing conditions for a good part of the year.

A new state named Uttarakhand was created on November 9, 2000 and the observatory came under the administrative control of Uttarakhand state because of its geographic location and was re-christened as the State Observatory (SO). On 7 January 2004 the Union Cabinet of the Government of India took a decision to convert the 50 year old observatory into an autonomous institute devoted to basic scientific research in the frontier areas of astrophysics and atmospheric physics under the administrative control of Department of Science and Technology (DST) Government of India. The institute is now called Aryabhatta Research Institute of Observational Sciences (ARIES) (Ramachandran 2004).

With the generous support from DST, ARIES has installed a 3.6-m new technology optical telescope at a new site called Devasthal (longitude 79°41′E latitude 29°23′N altitude 2424-m) 50 km east of Nainital. A 1.3-m aperture optical telescope has also been installed at Devasthal in 2010 and a 4-m liquid mirror telescope for deep sky survey of transit sources is also being installed.

2 Observing facilities

2.1 25-cm refractor telescope

This was the first telescope installed at UPSO in 1955 (Figures 1 & 2). This was a 25-cm, f/15 Cook visual refractor on German mounting from United Kingdom. The first photoelectric photometer designed by Dr. M. K. V. Bappu got constructed in 1956. It was put on this telescope for photoelectric B and V photometry of galactic clusters and variable stars. These were believed to be among the first photoelectric astronomical observations made anywhere in India, perhaps in Asia. (cf Sinvhal 2006). The variable stars studies included β Canis Majoris stars, eclipsing variables and short period Cepheids. In some galactic clusters, a survey of H-gamma absorption line intensities in early type stars was made. Photoelectric measurements of the magnitude and polarization of the nuclei of comets Arend-Roland 1956h and Markos 1967d were made through standard B & V filters and narrow band interference filters. A total of 14 research papers were published based on the observations made through this telescope. Now this telescope is not in operation anymore.

2.2 Optical tracking of artificial earth Satellite

A special telescope, named Baker-Nunn (B-N) camera, was used for the optical tracking of the artificial earth satellites in collaboration with the Smithsonian Astrophysical Observatory (SAO), USA. These observations started within the beginning of the International Geophysical Year (1957-58). The telescope was an f/1 system employing a 79-cm aperture primary and a 51-cm diameter corrector disc, and having a 30°× 5°curved field for good focus. This camera along with a Norman quartz

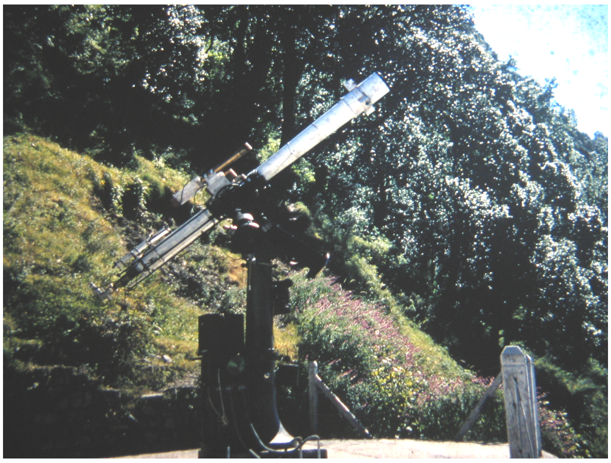

Figure 1: The 25-cm refractor telescope installed at Devilodge in 1955, Nainital

Figure 2: The 25-cm refractor telescope installed at Manora Peak, Nainital in 1956.

clock, recording time with an accuracy of 0.0025s and ancillary electronic equipment were installed in 1958. The camera house to the SAO specifications was expeditiously set up and the first track of an artificial satellite recorded by the B-N camera at our station was on 12 November 1958. This was the only center in India for about two decades for optical tracking of artificial earth satellites. On the basis of monthly statistics provided by SAO, the success percentage of tracked satellite transits at our station was on many occasions the highest among the twelve SAO stations over the globe. The programme continued till 1976. By then over 45 700 satellite transits, including those of the Indian satellite Aryabhatta, were successfully recorded.

The position of the B-N camera at our observatory was determined to an accuracy of better than 10 meters on a world datum (Longitude $79°27'25''.5$ E, Latitude $29°21'39''.0$ N, Altitude 1927 m). It became among the few locations on earth with coordinates so precisely determined. The advent of the Global Positioning System (GPS) has now provided a facility far simpler and universally more useful than the B-N camera. This camera has now been converted into a Schmidt telescope with CCD as detector (Figures 3 & 4).

2.3 38-cm, 52-cm, 56-cm reflector telescopes

The 38-cm reflector was a f/15 cassegrain reflector with German mounting acquired from M/s Fecker, USA and installed in the year 1961 (Fig. 5). A photoelectric photometer with standard U, B, and V filters, DC amplifiers and strip chart recorder were used to record the observations. Till 1997 it was continuously used for the observations of δ Scuti stars, β Canis Majoris stars, and eclipsing binaries.

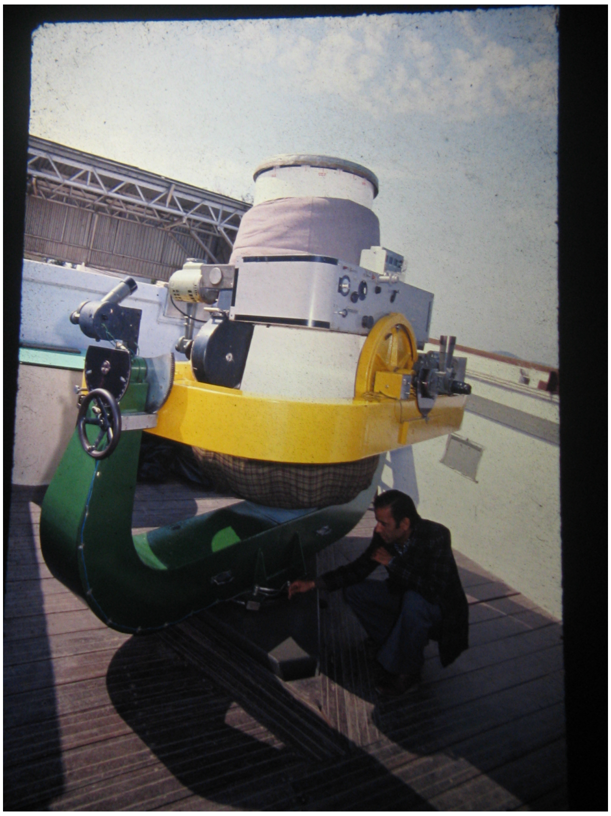

Figure 3: The B-N Satellite tracking Camera installed at Manora peak in 1958.

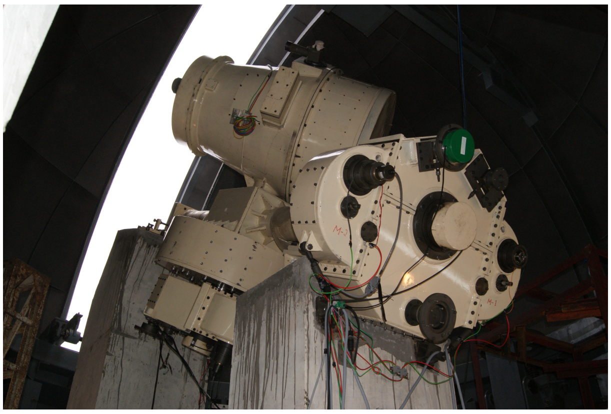

Figure 4: The B-N Camera was converted into Schmidt telescope in 2009.

From 1998 to 2001, the telescope was shifted to the Devasthal site for seeing measurements using the differential image motion monitor (DIMM) technique (Sarazin and Roddier 1990). A total of 79 research publications resulted from the observations taken using this telescope.

The 52-cm reflector telescope was acquired from M/s Cox Hargreaves and Thomson Ltd. UK in the year 1961 (Fig. 6). It was a f/13 folded Cassegrain and F/70 Coude system, mounted on an equatorial fork mounting. The main instrument on this telescope was a low resolution laboratory spectrophotometer. Energy distribution studies of Cepheids, Be stars and comets were carried out till 1995. In December 1996, it was shifted to the Devasthal site to carry out seeing and atmospheric extinction measurements. Observations through this telescope resulted in the publication of 41 research papers.

The primary and secondary mirrors, objective prisms, Barlow lens and telescope tube for the 56-cm f/15 folded Cassegrain reflector were imported from M/s Cox Hargreaves and Thomson Ltd. U. K. in the year 1960. Drawings for the equatorial fork mounting were prepared at the observatory, and the heavy cast-iron parts were fabricated at the Govt. Agricultural Workshop Lucknow. The 56-cm diameter worm wheel for the driving presented an immense problem, because of the very limited facilities available at the institute workshop. Finally it was cut and ground, on a lathe, in the institute workshop. The telescope was commissioned for photoelectric photometry and spectrophotometry in 1968. After a few years the primary mirror developed blemishes, therefore it was replaced by a new primary mirror made in the institute optics shop. Photometry of flare stars and spectrophotometry of comets was done with this telescope. A total of 17 research papers were published using data obtained from these observations.

Now, these telescopes are not in operation any more.

Figure 5: The 38-cm reflector telescope at Manora peak.

Figure 6: The 52-cm reflector telescope at Manora Peak.

2.4 104-cm Sampurnanand Telescope

The 104-cm telescope was acquired from Veb Carl Zeiss Jena and installed in the year 1972 (Fig. 7). The telescope is dedicated to Dr. Sampurnanand - the moving spirit to the establishment of the observatory. The dome of 104-cm telescope was designed, fabricated and installed by M/s Triveni Structural Naini, Allahabad (Fig. 8). In the equatorial English mounting the telescope rests on two piers. It is housed in the first floor of a two story building (Sinha 2005). The center of the telescope is at a height of 8 meters above the plinth level. Back-end instruments used till late eighties were a Cassegrain plate holder, Meinel camera, UBV photoelectric photometer, near infra-red photometer, low resolution laboratory spectrophotometer and Cassegrain spectrograph. In the year 1989 a 384x576 CCD camera system was acquired and installed as a new back-end instrument. This was a quantum jump of about 200-fold in the observing capabilities of the telescope. SBIG ST-4, a small CCD camera system, was installed in 1991 on the 20-cm auxiliary telescope for auto-guiding during long exposures. For spectrophotometric observations, an optical multichannel analyser with 1024 pixel reticon array as detector was also acquired and installed in the year 1991. Large CCD camera systems having 1024x1024 and 2048x2048 pixels were installed in the year 1993 and 1998, respectively. A three channel fast photometer became operational in 2000 and a polarimeter fabricated at the Institute became operational in 2004. Galactic open clusters, binary stars, Be stars, quasars/blazers, occultations by planets and asteroids, optical aftershocks of gamma-ray bursts, active galactic nuclei, roAp stars, IRAS sources, stellar interferometry, microlensing events towards M31 were the main research topics of interest. Scientists from Physical Research Laboratory (Ahmedabad), Tata Institute of Fundamental Research (Mumbai), Indian Space Research Organisation (Ahmedabad), National Physical Laboratory (Delhi), Inter University Center for Astronomy and Astrophysics (Pun)e and also scientists from South Africa, France, UK, Australia have extensively used the telescope for their various research programmes. A total of about 400 research papers and 36 PhD Theses have been published so far based on the observations taken through the telescope.

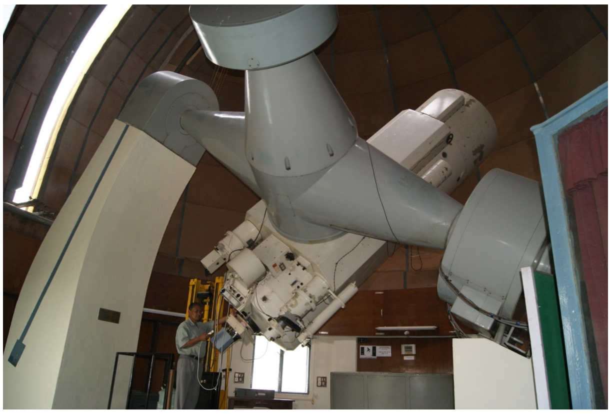

Figure 7: The 104-cm Sampurnanand Telescope installed at Manora Peak in 1972.

Figure 8: The enclosure of 104-cm Sampurnanand telescope.

2.5 Solar Observing Facilities

A 25-cm off-axis f/66 cassegrain telescope was acquired from M/s Cox Hargreaves and Thompson UK (Fig. 9 & 10). A double pass grating spectrograph along with the 46-cm coelostat was made in the optics and mechanical workshop of the institute (Sinha 2005). The gratings having 600 groves/mm and blazed for 1.2 μm were imported. This spectrograph yields 0.25 Å of dispersion per millimeter in the fifth order in single pass mode. This was the basic instrument for solar observations. Another unit consisting of a 25-cm coelostat and a 15-cm f/15 objective lens together with a Bernard Halle 0.5 Å pass band filter with a 35mm movie camera was used to record solar flares and prominences with either a 16-mm or a 24-mm solar image. During the eighties, two 15-cm f/15 Coude refractors from Carl Zeiss Jena were imported and installed to record filtergrams using Daystar H alpha, Ca II K and CN filters in addition to white light imaging of the Sun. One of the telescopes has been put atop a 9 meter high tower. The refractors form a 22-mm image of the Sun and can be puffed up to 42-mm size using a Barlow lens. The filtergrams were obtained photographically using 35-mm Kodak Technical Pan 2415 film with the help of the Olympus camera body and /or the Robot recorder camera. Later in 1993 the solar observing facilities were upgraded by replacing the photographic observations by CCD Camera systems. The fibre bounded camera system is a thermoelectrically cooled TK 1024, class I CCD chip. Each pixel of the CCD chip is connected to a window by fibre optics in such a way that one pixel receives light from a 2.45 times larger area of the window which corresponds to a spatial resolution of approximately 5″. The system is controlled by a SUN SPARC 20 computer. It was successfully used during the total solar eclipse of 24 October 1995. Another high speed CCD camera system for flare observations is used. It has a EE 37 CCD chip with the facility of frame transfer read out.

Figure 9: The 15-cm Coude Refractor telescope for observations of solar events.

Figure 10: A closure view of the 15-cm Coude Refractor Solar Telescope.

3 Support facilities

As the observatory is situated in a location remote from centres of developed technical activity, it became necessary and obligatory to develop first rate facilities of machine shop, electronic shop, aluminizing shop and optics shop. These facilities were set up with all the necessary machines and testing and measuring gadgets to meet the stringent requirements in astronomical instrumentation. In addition, a computer center, a well equipped photographic section and a good library were also established (Sinvhal 2006).

Mechanical Workshop A good amount of activity goes on at the observatory by way of designing and fabrication of instruments required by the observatory staff for their own researches and for developmental purposes. The major achievements of the workshop have been the completion of the roll off roofs for the Baker-Nunn Camera, the 25-cm and 52-cm telescope houses, complete mounting along with the assembly of the 56-cm telescope, all the mechanical components of the horizontal solar spectrograph, a Cassegrain spectrograph, H alpha unit and flare petrol spectrograph, housing for a number of photometers, an observing platform for the 104-cm telescope, three optical grinding and

Figure 11: The coelostat for solar observations.

Figure 12: The aluminising plant at Manora Peak, Nainital.

polishing machines, a glass slitting machine, components of the 30-cm, 60-cm and 124-cm aluminizing units, all the mechanical components of the polarimeter, and components of the three channel fast photometer. During site survey programmes for a large telescope, meteorology stations were installed at 6 sites. During 1996 and 1998, sheds for telescope houses for the 52-cm and 38-cm telescopes, generator rooms, and observing huts were constructed at Devasthal. Microthermal sensor towers and a 25-cm polar trail telescope made in the institute were installed in the eighties at Devasthal for seeing measurements. The workshop also carries out routine maintenance of the available telescopes of the institute.

Optics workshop During the initial years it was realised that precision and specialized optics for astronomy were not commercially available in the country. To overcome this situation, the optics workshop was started in the year 1965 to make optics for the solar telescope and the associated spectrograph and also other optical components needed in the observatory. Grinding and polishing machines capable of taking jobs up to 75 cm in diameter, seven rotating spindles for manual work on jobs up to 25 cm in diameter, a drilling assembly for scooping holes, a glass slitting machine and a grinding machine capable of taking jobs up to 20 cm were installed.

The major achievements of the optics workshop were grinding and polishing of two 46-cm diameter optically flat mirrors, plane parallel plates up to a 8-cm diameter, concave mirrors up to a 25-cm diameter, a 15-cm diameter f/15 Cassegrain system parabolic mirror, a nearly 1.5 degree off axis parabolic mirror of 7.5-cm diameter, small prisms, optics of a 25/15-cm f/2 Schmidt camera, a 15-cm corrector plate, 20-cm diameter f/5 concave mirror of aluminium substrate, two pairs of stainless steel slits of 70-mm length, four achromats of 50-mm diameter, optics of the 20-cm all sky camera, a number of Fabry lenses, optical components for three channel photometer. A 56-cm parabolic mirror as a replacement of the original mirror was also made.

Electronics workshop The electronics workshop was started in the early years at Devi Lodge for the maintenance, testing, and modifications of various equipments. Later a number of instruments were designed and fabricated for the research purpose. The major among these being various kinds of amplifiers, frequency drives, transistorised DC amplifiers and integrators using integrated circuit boards and IC chips. A number of regulated power supplies, frequency drives having variable output for the drives of various telescopes, complete electronics for the automatic guiding unit of the 104-cm telescope, photometric data acquisition system for storing data from the 104-cm telescope on to a

Figure 13: The library at Manora Peak, Nainital.

Figure 14: The computer center at Manora Peak, Nainital.

paper punch tape, control console for the 124-cm aluminizing unit, thermal monitor to record microthermal fluctuations with an accuracy of 0.01 degree Celsius, photoelectric solar guider, remotely controlled filter disc rotator device, electronics for the IR photometer, MOSFET based three phase frequency drive for 104-cm telescope, etc. The electronics and the electrical wings look after the maintenance of the diesel generator, UPS, telephone exchange, and routine maintenance related to the electrical requirements of the institute.

Aluminizing Units The mirrors used in the telescope loose their reflectivity due to weathering, therefore re-aluminization is necessary at regular intervals. Keeping this in view, the programme to develop aluminizing units was initiated at the institute in 1965 and the following facilities were designed and installed to take up mirrors of various sizes. A unit capable of taking jobs up to a 60-cm diameter became operational in 1972 and continued to be in use till 1977. A small 30-cm unit was also designed and the facility was installed. This system was extensively used to evacuate the dewars of the CCD systems and IR photometer. To aluminize the main mirror of the 104-cm telescope, an aluminizing system of taking jobs up to 124-cm in diameter was designed and developed in the institute (Fig. 12). The mild steel chamber was fabricated by M/S Triveni Structural Limited, Allahabad and the vacuum pipe line and butter fly vacuum valves were made in the institute workshop. A freon cooling system was also installed in this unit. The primary mirror of the 104-cm telescope was aluminized in 1997 and every alternate year it is being aluminized (Padalia & Sanwal 1980).

Photographic Section In the earlier years photographic films and plates were used to record astronomical events. This section played an important role in processing the films and the plates. It has also been used to make photographs of the figures required for the publication of the research papers. It also kept records of the important events in the institute.

Library The library has steadily been building up through the years since 1954. It is now one of the best libraries in astronomy related literature in the country (Fig. 13). The library has photocopier machines, a lamination machine, a spiral binder machine, projection facilities like a slide projector, an overhead projector, and a multimedia projector. Library is equipped with PCs, Libsis-3 software and laser printers. Almost all the major astronomy journals are available on line at all the servers in the institute. The facilities of this library are also provided to the research scholars and students of other institutions.

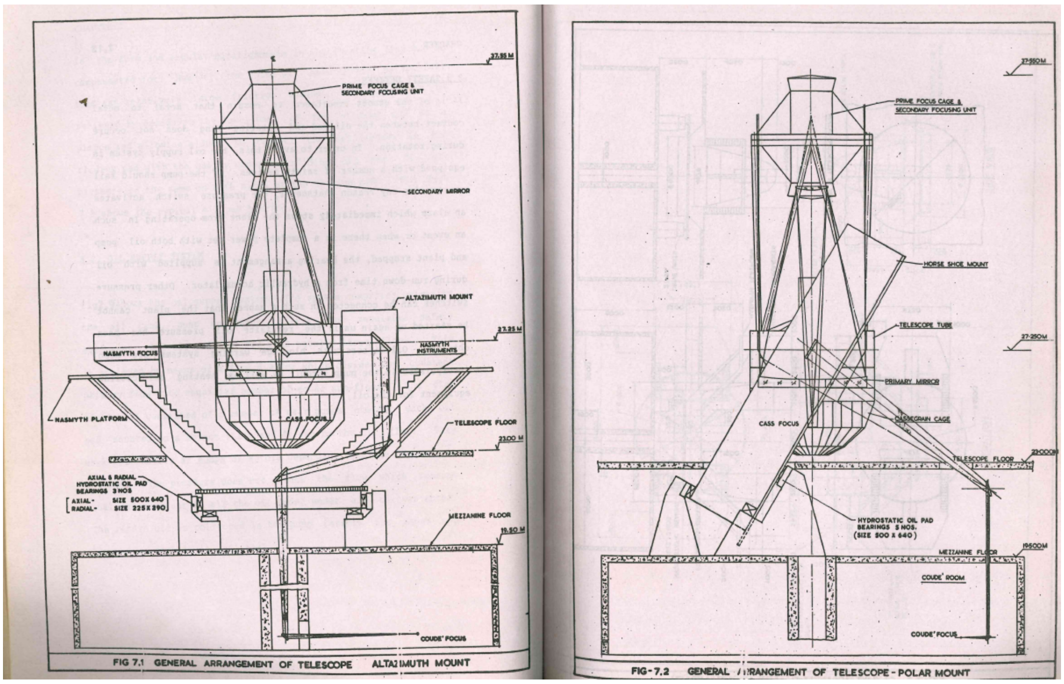

Figure 15: The concept design of 4-m class optical telescope proposed in 1987.

Computer Center The center started with desk calculators in 1955 and the need of processing the observational data, necessitated acquiring programmable desk calculators. These were used till 1976. In 1977, an ECIL Micro-78 system with 32k memory, a storing capacity of 300k bytes and a heavy duty teletypeprinter were acquired. During 1985-1996, three PCs were also acquired (Fig. 14)

A major upgrading of computer facilities occurred in 1989 when a Micro-VAX system was acquired with multi-user capabilities. Since then, a VAX station-3100, a VAX station 4000, a VMS based Alpha workstations, three SUN workstation, ten UNIX based alpha workstation, and about 35 PCs were procured. Image processing software IRAF, MIDAS, AIPS, etc. have also been installed on these computer systems. All these systems were networked. In 1997, a VSAT facility was installed for the internet connectivity.

4 Acquiring a large telescope

After about 25 years after installation of the 104-cm telescope, it was considered that the observatory should upgrade its observing facilities and should go for a telescope large enough to be able to undertake galactic and extra galactic observational projects. In 1976 the advisory committee agreed in principal to provide a 4-m class telescope on the condition that, as far as possible, the telescope should be made in India as a national facility (Sinvhal et al. 1972). A national committee was constituted in 1984. The committee did not approve the 4-m telescope project. The planning commission however recommended a 2-m telescope. A meeting of national experts committee was held in Bhabha Atomic Research Center (Mumbai) in February 1987 and where the project concept report was presented. The committee accepted the report and in 1987 the central planning commission recommended to support the 4-m telescope project as a national facility. It was also recommended that department of Atomic Energy would be fully associated with the preparation of the detailed project report. The funding to the project by the Uttar Pradesh State Government was discontinued from April 1990. However an outcome of the project was a systematic site survey and the preparation of the detailed project report in collaboration with Bhabha Atomic Research Center. A new equatorial mount design and conventional Alt-Az design were put forward in the DPR (Fig. 15). New efforts were initiated in 1997 as Tata Institute of Fundamental Research was also interested in having access to a large telescope. However, before the funds could be released, the observatory came under the administrative control of the newly created state Uttarakhand. A meeting of the project steering committee took place on 22 February 2001 at Delhi. The chief secretary Uttarakhand informed that it was not possible to finance the project and efforts should be made to get resources from the Government of India.

The Union Cabinet of Government of India in its meeting of 7 January 2004 took the decision to convert this State Observatory into an autonomous national research institution financed and controlled by the Department of Science and Technology (DST), Government of India. The institution was renamed as Aryabhatta Research Institute of Observational Sciences (ARIES). The union cabinet also proposed setting up of a 3-m class optical telescope at Devasthal during the next five years. Generous support by DST and financial powers to the director ARIES ultimately resulted in the installation of the 3-6 m telescope at Devasthal as a national facility.

Figure 16: The satellite view of Devasthal site.

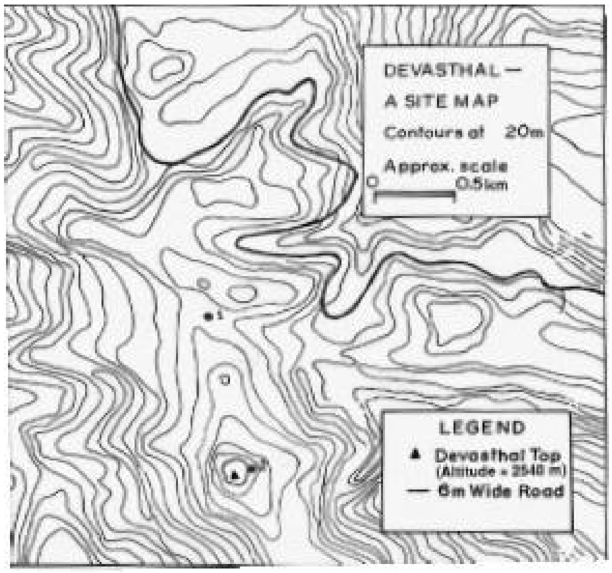

Figure 17: The site survey were conducted at site 1 (present location of 3.6m DOT) and site 2 at Devasthal.

5 Site survey for a 3-m class telescope

A site survey to find a suitable site to install a 3-m class optical telescope was initiated in 1980-81 in the Kumaon and Garhwal region of Uttarakhand. Maps of India were studied and 36 prospective sites were identified and visited to have first hand information about distance from the road, availability of water and power line, and obstruction due to surrounding hills. Based on the logistics, five sites viz. Gananath, Mornaula, Chaukori, Jaurasi and Devasthal having altitude more than 2000 m were identified for preliminary investigations. Meteorological observations at these sites were carried out during 1982-1991. The meteorological instruments installed at these stations were a thermograph, hygrograph, barograph, sunshine recorder, rain gauge, snow gauge, and wind speed and direction recorder. The cloud coverage was recorded visually. The stability of night time temperature, relative humidity, wind speed and direction, and logistics were in favour of Devasthal (Fig. 16 & 17).

The most important parameter for the selection of an optical telescope site is seeing at that site. A polar star trail telescope was made at the observatory with the imported optics (Fig. 18). The

Figure 18: The polar trail telescope made in UPSO, Nainital.

telescope was pointing towards pole star without a tracking facility and Kodak SLR, 35-mm camera body and film were used for recording the star trails. The FWHM profile of the star trail was measured at a number of points using a microdensitometer. The star trails were recorded and measured for the Devasthal and Gananath stations (Fig. 19 & 20). The qualitative estimate showed that most of the time the seeing at Devasthal was better than at Gananath. As a follow up on the site survey, precipitable water vapour, quantitative seeing measurements, and microthermal measurements were carried out at two places at the Devasthal site.

The precipitable water vapour in the atmosphere was measured with the instrument designed and built by Prof. Westphal and loaned to the observatory. The observations were taken between January 1989 to June 1989 at Devasthal. They indicate 1-2 mm, 2-3 mm and more than 3 mm of precipitable water vapour for 21, 43 and 36 percent of time respectively.

For seeing measurements, the differential image motion monitor (DIMM) instruments were used (Sarazin & Roddier 1990). Most of the components for DIMM were made in the laboratories of the observatory. A 52-cm telescope and a 38-cm telescope were used at two locations. The front of the 52-cm telescope tube was covered by a mask having two circular holes each of 6-cm diameter separated by 40 cm. Similarly, a 38-cm telescope tube is covered by a mask having two circular holes of 5-cm diameter separated by 24 cm. One of the holes contains a prism which deviates the incoming star light by about $30''$ in the direction joining the line of the centres of the two holes, so that two images of the same star are formed on the CCD detector. The telescopes were equipped with PCs which control the Santa Barbara Instrument group ST-4 auto guiding CCD camera and thus accumulates image motion data and analyse them on line to provide seeing measurements in mutually perpendicular direction. During February 1997 to November 1998, 88 nights of seeing data with the 52-cm telescope and 37 nights of seeing data with the 38-cm telescope were analysed. For location 1, 88 nights of observation yield a median seeing value of $1''.4$ and for the location 2, 37 nights of

Figure 19: Temporary station for mounting polar trail telescope at Devasthal in the year 1985.

Figure 20: Meteorological station at Devasthal in the year 1984.

observation yield a median seeing value of 1.″1 (cf. Sagar et al. 2000a).

The temperature measurements were made with a continuous recording type thermograph at each site. The Devasthal site has a night time temperature variation of within 2 degrees Celsius for more than 60 percent of the time. Relative humidity during photometric nights generally remains below 60 percent. The wind speed and direction were recorded with continuously recording anemograph installed at 5 meters above ground level. It is found that during more than 75 percent of night hours, the wind speed remains below 3 m/s. The prevailing wind direction is North West. The visual observations of cloud coverage indicate that there are more than 200 spectroscopic nights per year at this site. A large fraction of these are of photometric quality. Microthermal measurements were made using a pair of microthermal sensors made from nickel wire of 25 micron diameter separated by a distance of 1 meter and mounted at 6, 12, 18 meters above the ground. The measurements were recorded on 11 nights simultaneously with DIMM seeing measurements during March - April 1999. It was found that the major contribution to seeing comes from the 6-12 meter slab of the atmosphere. Analysis of data indicated that if the telescope is located at a height of about 13 meter above the ground level, one can achieve sub-arcsecond seeing for a significant fraction of observing time. Therefore the present location was finally selected for the installation of the 3.6-m Devasthal Optical Telescope. For a detailed technical set-up of site testing, we refer to Sagar et al. (2000a, 2000b), Stalin et al. (2001).

6 Summary

The institute started with a 10-inch refractor telescope in 1954 and now it is equipped with an advanced 4-m class optical telescopes at Devasthal. ARIES contributed to the growth of astronomy in general and the growth of astronomy and astronomical instrumentation in India in particular. The institute contributed to the discovery of rings of Uranus, additional rings of Saturn and rings around Neptune. The rapid micro-variability in some stars have been discovered. Such observations indicate excellent observing sky conditions at ARIES. Optical observations of several GRB afterglows were successfully monitored with ARIES telescopes. Optical tracking of artificial earth satellites were done from Manora peak in 1970 and hence the location of Manora peak was determined with a precision of 10 meters in the frame of reference of Standard Earth. Predictions of many new molecular species in the Sun's photosphere, sunspot and faculae were made and some of them have been confirmed observationally. A large number of solar flares have been observed and studied. Optical observations of 14 afterglows of Gamma Ray Bursts have been taken including first one observed in India. More than 14 comets have been observed including the comet Halley.

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