Optical astronomy in India opens new frontiers for celestial science

An astronomical optical telescope is similar in design to a microscope. However, unlike the microscope, which is designed to view objects that are small and nearby, the telescope is designed to view objects that may be large, but are very far away (thousands of light years) at astronomical distances. An optical telescope is therefore used to image celestial objects at its focus just like our eye images the objects on our retina. The importance, potential, and power of optical telescopes in discovering and deciphering the secrets of celestial objects was realised only about four centuries ago in 1609, when the Italian Astronomer Galileo Galilei used an optical telescope with a small aperture of ~ 3 cm and turned it towards the sky and began analysing visual observations of planets such as Venus, Jupiter, Saturn, etc.

Optical telescopes with aperture size larger than about 6-8 mm (size of our eye pupil) collect more photons due to large area, making it possible to study relatively fainter stars. They also increase the apparent angular diameter of the celestial objects and thus provide better angular resolutions. The imperative need and relevance, therefore, of building large optical telescopes was expressed by early astronomers. However, it was limited not only by financial resources but also by available technology. In India, the largest size optical and near-infrared telescope is modern 3.6-meter located at Devasthal, Nainital.

Global importance

The existing Indian moderate size optical telescopes equipped with modern backend instruments have global importance due to their geographical locations (Longitude ~79 deg East) which locate them in the middle of about 180 degree wide longitude band having modern astronomical facilities between Canary Islands (~ 20 deg West) and Eastern Australia (~160 deg East).Therefore, the observations of transient and variable sources which require 24 hours continuous monitoring to understand the complex phenomena e.g. pulsation of white dwarfs but are not possible from either Canary Islands or Australia due to day light or some other reasons can be successfully carried out from the Indian sites. Because of this Indian optical telescopes provide valuable observations and also play a crucial complementary role internationally.

A peek into Indian optical telescopes of aperture size more than a meter:

Vainu Bappu Observatory, Kavalur:- Established in the 1970s, it is located (long. 78.8 deg E, lat. 12.6 deg N, alt. 725 meter) amidst sandalwood forests in Jawadi Hills in the North Arcot District of Tamil Nadu. It is operated as an observing station of the Indian Institute of Astrophysics (IIA), Bangalore. There are three telescopes having aperture size larger than 1 meter. They are 102-cm Carl Zeiss telescope installed in 1972, 2.34 meter Vainu Bappu Telescope (VBT) installed in 1986 (Figure 1) and 130-cm telescope installed in 2014.

Figure 1: A distant view of the 234-cm Vainu Bappu Telescope (VBT)

Indian Astronomical Observatory (IAO), Leh-Hanle: The IIA has developed the IAO, Hanle in the Changthang trans-Himalayan region of Leh Ladakh district of Jammu and Kashmir at an altitude of 4500 m, which is the highest of its kind in the world. The 2-m Himalayan Chandra Telescope (HCT) was installed at Mt. Saraswati (longitude 75.96 deg E; latitude 32.78 deg N; altitude 4500 m) in August 2000 and was opened for observations in October 2001. Figure 2 shows a view of the 2-m HCT. This telescope is operated remotely from the Center for Research and Education in Science and Technology (CREST) at Hosakote near Bangalore, via a dedicated satellite link.

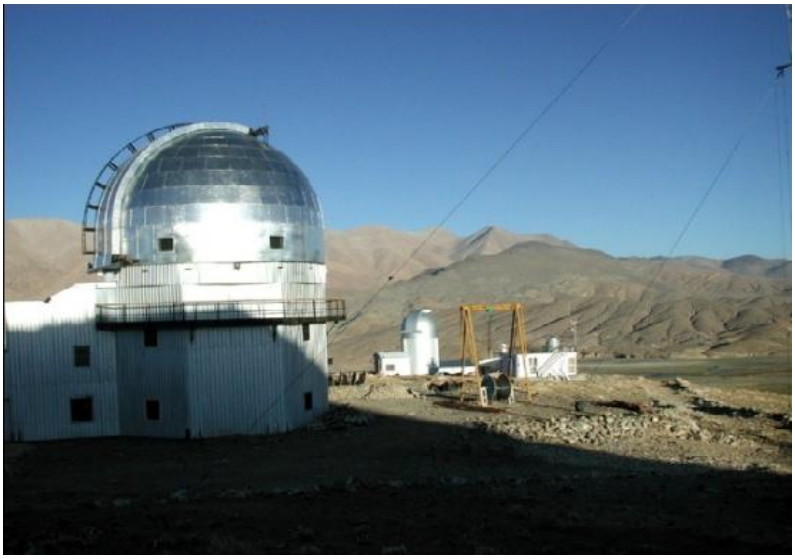

Figure 2: A view of the 2-meter HCT

Gurushikar Observatory, Mount Abu:- It is operated by the Physical Research Laboratory (PRL), Ahmedabad. The 1.2 meter indigenously built optical telescope was installed in the year 1990. The Gurushikhar Observatory is located at an altitude of 1680 m on the highest peak of the Aravalli range with geographic location of Latitude 24.65 N and Longitude of 72.78 E. A panoramic view of the telescope is shown in Figure 3. There is a plan to install a 2.5-meter class optical and near-IR telescope by the PRL at the Mount Abu site.

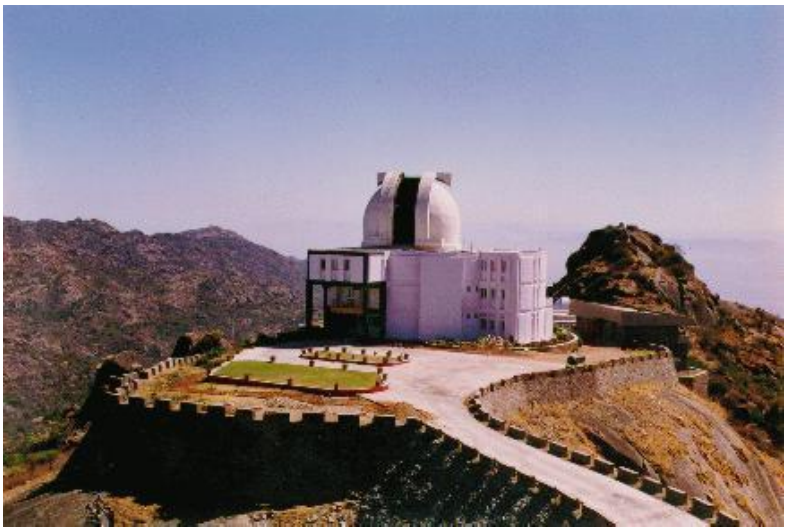

Figure 3: A panoramic view of the 1.2 meter optical and near-IR telescope, Mount Abu

Girawali Observatory:- Inter-University Center for Astronomy and Astrophysics (IUCAA) installed a 2-meter optical and near-IR telescope on Girawali hill near Godegaon ~80 km North of Pune city, off Pune-Nasik Road and near the historical Junnar town. Its geographical location is Lat. 19 deg. 4.35 arc min N; Long. 73 deg. 50.68 arc min E and Altitude: ~1000 meters. The telescope was opened for regular observations in November 2006. A distant view of the telescope is shown in Figure 4.

Figure 4: A view of the 2 meter IUCAA telescope located at Giravali.

The 104-cm Sampurnanand telescope at Manora Peak: Geographical coordinates of the 104-cm optical telescope at Manora Peak are longitude 79.45 deg. E; latitude 29.36 deg. N and altitude 1951 m. Figure 5 show a view of the telescope along with a distant view of the Aryabhatta Research Institute of Observational Sciences (ARIES).

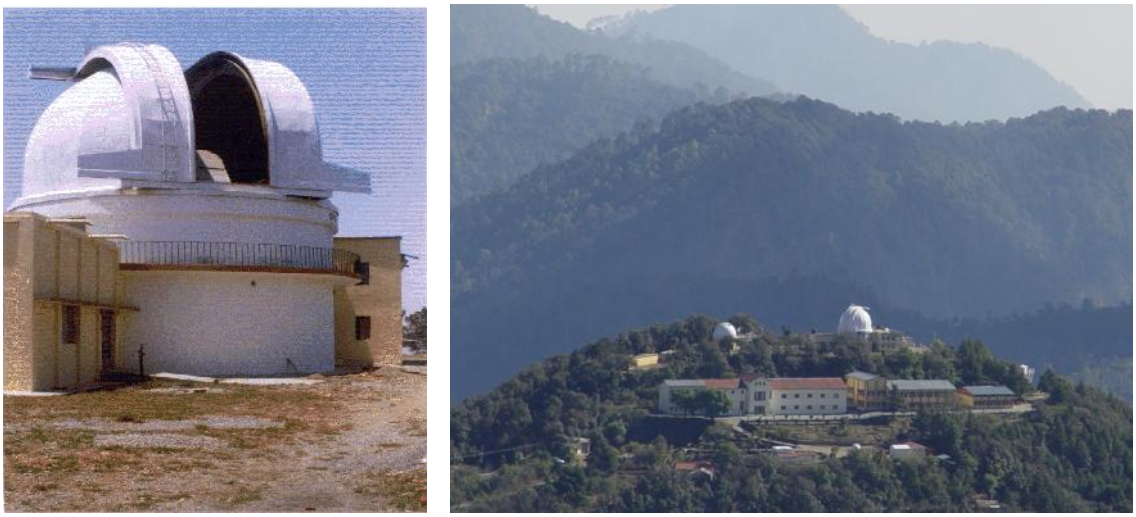

Figure 5: A view of (a) the 104-cm Sanpurnanand Telescope and (b) a panoramic view of the ARIES.

Devasthal Observatory:- ARIES developed Devasthal site (Longitude 79.68 deg. E; Latitude 29.36 deg. N and Altitude 2450 m) as an observatory for optical astronomy. It is about 55 km by road towards east of Nainital. The observatory houses three telescopes of more than 1 meter aperture namely the 1.3-m Devesthal fast optical telescope (DOFT) and 3.6 m glass Devasthal optical telescope (DOT) and 4-m International liquid mirror telescope (ILMT). Locations and buildings housing these telescopes are shown in Figure 6. The 1.3m DOFT was installed and dedicated to the nation in 2010

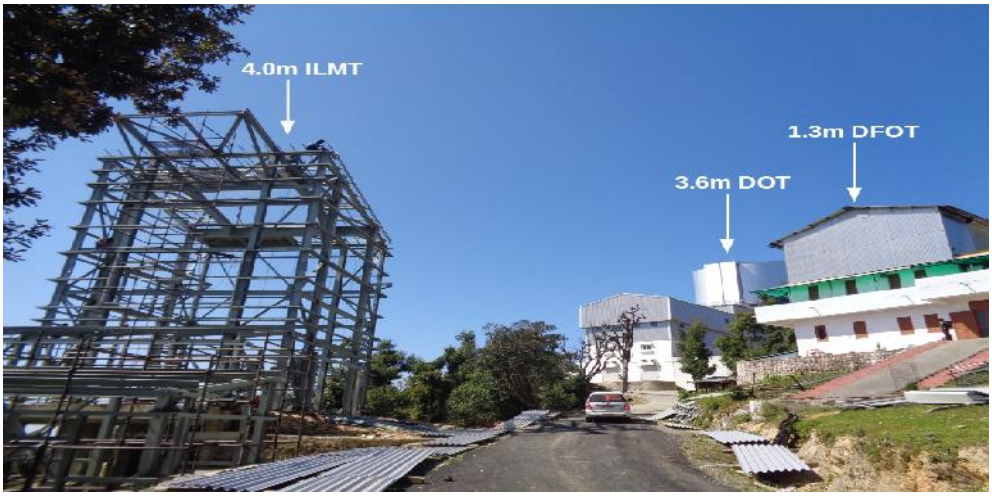

Figure 6: Devasthal Observatory showing location of all three telescopes.

The 3.6-m new technology telescope: India's largest 3.6 meter DOT optical telescope was successfully installed and technically activated in March 2016 by the Prime Minister of India from Brussel, Belgium. This modern 3.6-m DOT is the first new technology telescope in India in which Belgiam, an European country, has contributed 2 million Euro in cash. Such partnerships are extremely valuable for growth of optical astronomy in India.


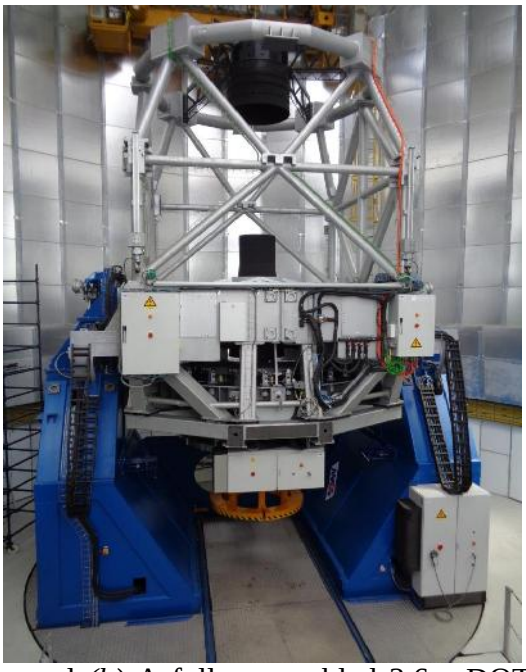

Figure 7: (a) Building of the 3.6 meter telescope and *(b)* A fully assembled 3.6m DOT in its dome at Devasthal.

The 4-m liquid mirror telescope: A liquid mirror telescope of 4 m size is in the process of installation at Devasthal. Since it is a part of an international effort, it is called the International Liquid Mirror Telescope (ILMT). As name suggest, the primary mirror of the telescope is a rotating container with highly-reflecting liquid in it.

Global collaborations

Presently, in the world, a few 8-10 meter size ground-based optical telescopes are being used for observations of the celestial objects. In order to make further front line discoveries in the universe, astronomical community over the globe aims to move from present 8-10 meter class telescopes to the extremely large size (> 20 meter diameter) optical telescopes. Building such observing facilities need not only cutting edge and innovative technologies but also huge funds. Institutions and countries across the globe have therefore started forging both financial and technical collaborations amongst them. There are three international teams to build the next generation of extremely large size optical telescopes that would dramatically dwarf the existing largest size telescopes on Earth today. They are the Giant Magellan Telescope (GMT), the Thirty Meter Telescope (TMT), and the European Extremely Large Telescope (E-ELT) with corresponding sizes of 25, 30 and 39 m respectively.

(With inputs from the articles authored by Prof Ram Sagar – A Global Prospective of the Indian Optical and Near Infrared Observational Facilities in the field of Astronomy and Astrophysics and an editorial by him in the Journal of Astrophysics and Astronomy. Prof Ram Sagar is NASI-Senior Scientist Platinum Jubilee Fellow, Indian Institute of Astrophysics, Bangalore)